Quantification of Libby Reservoir Water Levels Needed to Maintain or Enhance Reservoir Fisheries

Summary Report
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QUANTIFICATION OF LIBBY RESERVOIR LEVELS NEEDED TO MAINTAIN OR ENHANCE RESERVOIR FISHERIES

METHODS AND DATA SUMMARY, 1988-1996

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

River. Blocks indicate when the first bull trout were captured each year.

LIST OF APPENDICES

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EXECUTIVE SUMMARY

The Libby Reservoir study is part of the Northwest Power Planning Council's resident fish and wildlife program. The program was mandated by the Northwest Planning Act of 1980, and is responsible for mitigating for damages to fish and wildlife caused by hydroelectric development in the Columbia River Basin. The objective of Phase I of the project (1983 through 1987) was to maintain or enhance the Libby Reservoir fishery by quantifying seasonal water levels and developing ecologically sound operational guidelines. The objective of Phase II of the project (1988 through 1996) was to determine the biological effects of reservoir operations combined with biotic changes associated with an aging reservoir. This report summarizes the data collected from Libby Reservoir during 1988 through 1996.

During the most frequently sampled months (June through September), the predominant genera of zooplankton collected were *Daphnia, Bosmina, Diaphanosoma, Cyclops* and *Diaptomus*. Copepods (*Diaptomus*, *Epischura* and *Cyclops*) comprised the greatest portion of zooplankton in the reservoir, accounting for 67.6 to 78.8 percent of the samples from 1988 through 1996. Cladocerans (*Daphnia, Bosmina, Diaphanosoma* and *Leptodora*) declined slightly from 1988 through 1990, comprising 21.1 to 32.4 percent of the samples. Inverse correlations in densities between *Cyclops* and *Diaptomus* densities, and *Daphnia* and *Bosmina* densities, were evident throughout the study, which may be indicative of a cyclic kokanee population and size-selective fish predation in Libby Reservoir. *Daphnia* from 0.50-0.99 mm dominated samples in all years, except 1986, when individuals 1.00-1.49 mm comprised a majority of the samples. Total zooplankton densities appeared to be rebounding to near early-1980's densities in 1996, whereas biomass appeared to decline. An alternate explanation for this downward trend could be the reduction of municipal and industrial point sources of nutrient pollution in British Columbia and the U.S. due to improvements in wastewater treatment technology. A source of phosphate in the upper portion of the reservoir (the Corinco Ltd. fertilizer plant on Mark Creek, near Kimberly, B.C.) was closed in 1987, which may have substantially reduced phosphate loading in the upper end of Libby Reservoir (Chisholm et al. 1989).

The number of native salmonids (*Oncorhynchus spp*.) captured in gillnets declined independent of number and size of hatchery fish stocked into the reservoir. Mountain whitefish and redside shiners captured in gillnets showed similar trends to *Oncorhynchus spp*. due primarily to loss of spawning and rearing habitat and competition with kokanee for plankton. Population status of kamloops rainbow trout remained unclear due to limited recruitment to gillnets and creel. Peamouth were the most abundant fish captured in spring gillnets since 1988; with a record 119 per net in 1992. Northern squawfish populations fluctuated widely in spring gillnet catches; catch rates declined from 1988 to 1991, but rebounded to near record highs in 1996. *Catostomus spp*. captured in gillnets have declined since impoundment with longnose suckers documenting consistently low catch and largescale increasing since 1991. Nonnative kokanee salmon populations have fluctuated following introduction in 1980. Numbers of burbot captured in sinking gillnets declined since 1988, but have returned to early post-impoundment levels. Bull trout populations in Libby Reservoir are stable to slightly increasing, based on spring sinking gillnet trends.

Terrestrial insects were the most important food item for trout of all sizes in all years. Diptera (larvae, pupae and adults) and zooplankton were important food depending on the year. Trout utilization of zooplankton declined to near zero from 1987 to 1992, which may be explained by declines of nearly 28% in the density of larger (2-2.5 mm) *Daphnia* (the primary zooplankton taken by trout). Zooplankton (primarily *Daphnia*) were the most important food items for kokanee salmon in all years. Competition for *Daphnia* between trout and kokanee probably did not occur due to differences in size selection for *Daphnia*, habitat utilization, relative abundance, and consumption of alternative food items. Bull trout were predominantly piscivorous, consuming 10 different species of fish from 1983 to 1987, and only five between 1988 and 1991. Trout species (westslope cutthroat, rainbow trout and cutthroat X rainbow trout) comprised nearly 24% of fish consumed in the bull trout diet from 1983 to 1987 and declined to zero by 1991. Kokanee, peamouth and yellow perch were more common in bull trout diets after 1988. Large burbot (>750 mm) fed predominantly on peamouth and yellow perch, smaller burbot (<450mm) consumed diptera larvae.

INTRODUCTION

Libby Reservoir was created under an International Columbia River Treaty between the United States and Canada for cooperative water development of the Columbia River Basin (Columbia River Treaty 1964). The authorized purpose of the dam is to provide power (91.5%), flood control (8.3%), and navigation and other benefits (0.2%).

The Pacific Northwest Power Act of 1980 recognized possible conflicts stemming from hydroelectric projects in the northwest and directed Bonneville Power Administration to "protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project of the Columbia River and its tributaries..." (4(h)(10)(A)). Under the Act, the Northwest Power Planning Council was created and recommendations for a comprehensive fish and wildlife program were solicited from the region's federal, state, and tribal fish and wildlife agencies. Among Montana's recommendations was the proposal that research be initiated to quantify acceptable seasonal minimum pool elevations to maintain or enhance the existing fisheries (Graham et al. 1982).

Reservoirs are best regarded as a distinct type of freshwater ecosystem, differing from both streams and lakes (Baxter 1977). Reservoir water level management is considered to be an important tool for fisheries management (Willis 1986). Acknowledgment of the value of water level management to maintain desirable reservoir fisheries has resulted in a vast amount of research literature (see bibliographies of Triplett et al. 1980 and Ploskey 1982). However, ecological approaches to understanding and predicting the potential affects of hydroelectric facilities are relatively new (Magnuson 1979).

An inter-disciplinary team of experts met in 1980 to discuss incorporating ecological issues in basin-level hydropower planning (Hildebrand and Goss 1981). They concluded that the capability to predict water level changes was adequate, but modeling of biological effects was inadequate. In a national survey of reservoir biologists to identify reservoir fishery research needs, better knowledge of water quality/fish interactions and the ability to predict effects of reservoir drawdowns and water level fluctuations were considered the highest priorities (Hall 1985). Long-term data replicating several management and recruitment events are needed to develop these predictive models (Ploskey 1986).

Research to determine how operations of Libby Dam effect the reservoir fishery and to suggest ways to lessen these effects began in May 1983. The framework for the Libby Reservoir Model (LRMOD) was completed in 1989. Development of Integrated Rule Curves (IRCs) for Libby Dam operation was completed in 1996 (Marotz et al. 1996). The Libby Reservoir Model and the IRC's continue to be refined.

The specific study objectives of Phase II of the Libby Reservoir study are to:

1) Determine changes in the zooplankton community in response to reservoir elevations, changing nutrient status, predation and an aging reservoir,

2) Determine abundance, distribution and changes of fish communities within the reservoir, with special focus on native species,

3) Determine potential factors limiting recruitment of native salmonids from Libby Reservoir tributaries within the United States,

4) Quantify fish use of available food items, and

5) Estimate angling and recreational pressure on Libby Reservoir.

DESCRIPTION OF STUDY AREA

Libby Reservoir (Libby Reservoir) was formed by impoundment of the Kootenai River in March, 1972. Libby Dam is located in Lincoln County, northwest Montana, approximately 27 km (17 mi) upstream from the town of Libby (Figure 1). The Montana portion of the reservoir is bordered mainly by the Kootenai National Forest. The majority of the private property is located near the town of Rexford on the eastern side of the reservoir.

The land adjoining the Canadian portion of the reservoir is primarily owned by private citizens. Kikomun Provincial Park is located on the east bank of the reservoir, 10 miles south of the town of Wardner, British Columbia.

Water Quality

The Kootenai River is the second largest tributary to the Columbia River, with an average annual discharge of 868 m^3/s (30,650 cfs). Libby Reservoir and its tributaries receive runoff from 47 percent of the Kootenai River drainage basin. The reservoir has an annual average inflow of 10,615 cfs; the Kootenai, Elk, and Bull Rivers supply 87 percent of the inflow (Woods 1982).

Cranbrook, Fernie, and Kimberly, British Columbia, and Eureka, Montana, have contributed the major municipal point sources of water pollution. Industrial point source pollution has occurred from the Sullivan lead/zinc mine (Cominco, Ltd.) and its ore concentrator on Mark Creek, from Crestbrook Forest Industries Ltd. bleached kraft pulp mill at Skookumchuk, and from a Cominco Ltd. phosphate fertilizer plant, on Mark Creek near Kimberly, British Columbia. By 1981, these industries had taken major steps toward pollution abatement by installing wastewater purifying and recycling equipment. Cominco, Ltd. closed its phosphate fertilizer plant after 1987.

Morphology

The Kootenai watershed is located within the Northern Rocky Mountain physiographic province, which is characterized by north to northwest trending mountain ranges separated by straight valleys parallel to the ranges (Woods and Falter 1982). These mountains are composed of folded and faulted crystal blocks of metamorphosed sedimentary rocks of the Precambrian Belt Series.
At full pool, the reservoir extends 145 km northward, with 68 km of its length located in British Columbia. Maximum volume and surface area are 7.24 km^3 and 188 km^2, respectively (Table 1).

Reservoir Operation

Libby Dam is a 113-m (370-ft) high concrete gravity structure with three types of outlets: sluiceways (3), operational penstock intakes (5, 8 possible), and a gated spillway. The dam crest is 931 m long (3,055 ft), and the widths at the crest and base are 16 m (54 ft) and 94 m (310 ft), respectively. A selective withdrawal system was installed at Libby Dam to allow for withdrawal of water from the

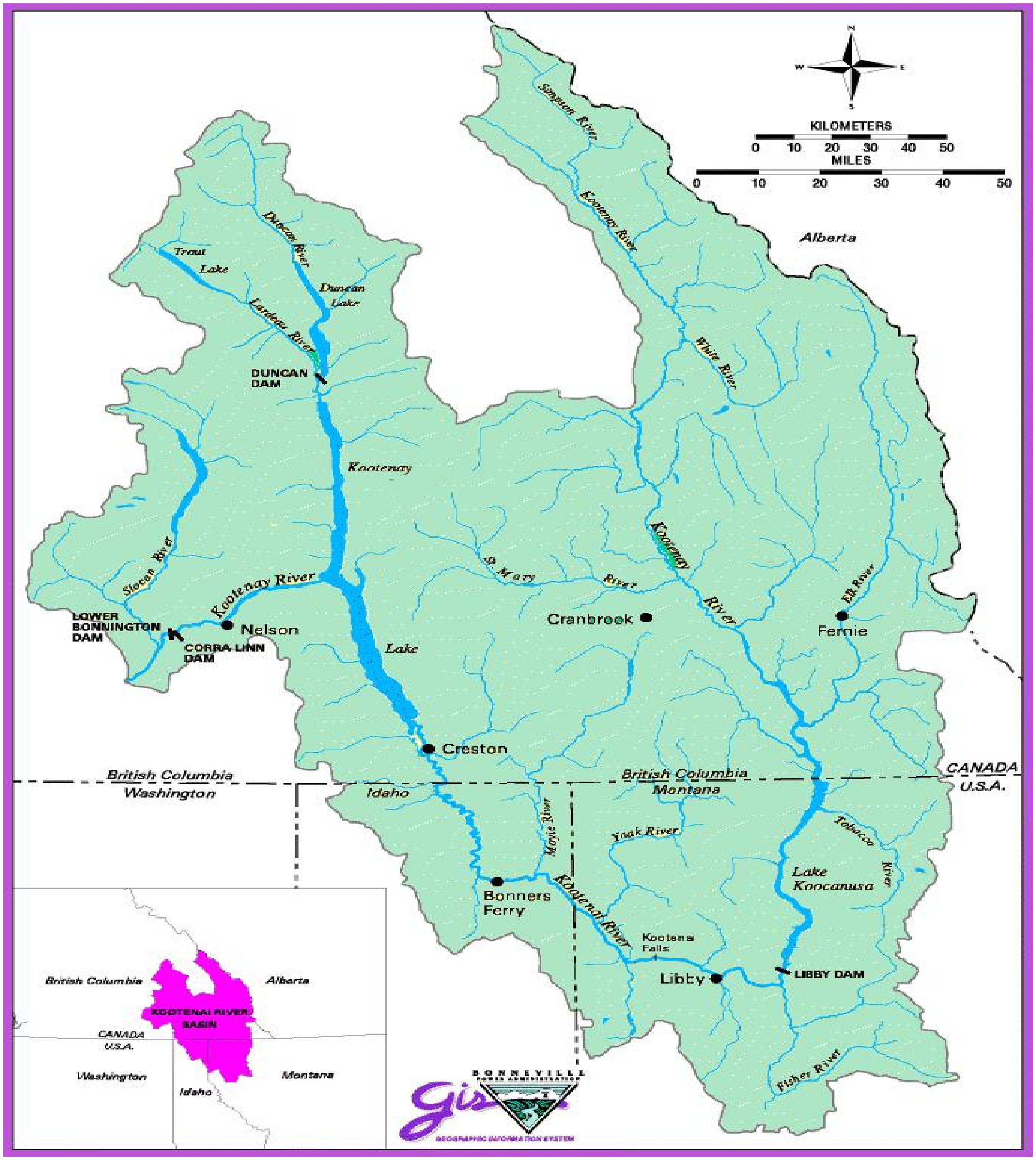


Figure 1. Kootenai River Basin (Montana, Idaho and British Columbia, Canada).

Table 1. Morphometric data for Libby Reservoir.

Surface elevation	
maximum pool	749.5 m (2,459 ft)
minimum operational pool	697.1 m (2,287 ft)
minimum pool (dead storage)	671.2 m (2,222 ft)
Area	
maximum pool	188 sq. km (46,500 acres)
minimum operational pool	58.6 sq. km (14,487 acres)
Volume	
maximum pool	7.24 km^3 (5,869,400 acre-ft)
minimum operational pool	1.10 km^3 (890,000 acre-ft)
Maximum length	145 km (90 mi)
Maximum depth	107 m (350 ft)
Mean depth	38 m (126 ft)
Shoreline length	360 km (224 mi)
Shoreline development	7.4 km (4.6 mi)
Storage ratio	0.68 yr
Drainage area	23,271 sq. km (8,985 sq. mi)
Drainage area:surface area	124:1
Average annual discharge	
pre-dam (1911-1972)	12,170 cfs (Storm et al. 1982)

	or 11,774 cfs (our data)
post-dam (1974-1986)	10,615 cfs

reservoir, ranging from the penstock invert (elevation 677 m, or 2,222 ft) to within about 6 m (20 ft) of the surface at full pool (Bonde and Bush 1982). This system became operational in the spring of 1978.

Libby Reservoir is a headwater storage project operated by the Army Corps of Engineers (ACOE) as an integral part of the Columbia River Basin hydroelectric network. Reservoir elevations are managed primarily for power and flood control purposes (Storm et al. 1982). The ACOE operates Libby Reservoir to reach full pool in July, begins drafting the reservoir in September, reaches a minimum pool elevation in March or April, and begins refilling the reservoir in spring.

Fish Species

Eighteen species of fish are present in Libby Reservoir (Table 2). Libby Reservoir currently supports an important fishery for kokanee *Oncorhynchus nerka* and rainbow trout *Oncorhynchus mykiss*, with annual fishing pressure over 500,000 hours (Chisholm and Hamlin 1987). Burbot *Lota lota* are also important game fish, providing a popular fishery during winter and spring. Bull trout *Salvelinus confluentus* are captured “incidentally”, and provide a unique seasonal fishery.

Table 2. Current relative abundance (A=abundant, C=common, R=rare) and abundance trend from 1975 to 1996 (I=increasing, S=stable, D=decreasing, U=unknown) of fish species present in Libby Reservoir.

Common Name	Scientific name	Relative abundance	Abundance trend	Native
<u>Game fish species</u>				
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	C	D	Y
Rainbow trout	*Oncorhynchus mykiss*	C	D	Y
Bull trout	*Salvelinus confluentus*	C	I	Y
Brook trout	*Salvelinus fontinalis*	R	U	N
Lake trout	*Salvelinus namaycush*	R	U	N
Kokanee salmon	*Oncorhynchus nerka*	A	U	N
Mountain whitefish	*Prosopium williamsoni*	R	D	Y
Burbot	*Lota lota*	C	D	Y
Largemouth bass	*Micropterus salmoides*	R	U	N
White sturgeon	*Acipenser transmontanus*	R	D[Î]	Y[Ï]
Northern pike	*Esox lucius*	R	U	N
<u>Nongame fish species</u>				
Pumpkinseed	*Lepomis gibbosus*	R	U	N
Yellow perch	*Perca flavescens*	C	I	N
Redside shiner	*Richardsonius balteatus*	R	D	Y
Peamouth	*Mylocheilus caurinus*	A	I	Y
Northern squawfish	*Ptychocheilus oregonensis*	A	I	Y
Largescale sucker	*Catostomus macrocheilus*	A	S	Y
Longnose sucker	*Catostomus catostomus*	C	D	Y

[Î] Five white sturgeon were relocated from below Libby Dam to the reservoir. At least one of these fish moved upriver out of the reservoir while two have been accounted for from angler reports and one verified mortality.
[Ï] Numerous anecdotal information exists of white sturgeon above Kootenai Falls although research to date has failed to validate any reports.

RESERVOIR HABITAT

Methods

Libby Reservoir was divided into three areas (Canada, Rexford and Tenmile) for study by the Montana of Fish, Wildlife and Parks (Huston et al. 1984, Chisholm and Fraley 1986). Segregation into three geographic areas was based on reservoir morphometry, effects of reservoir drawdown, and political boundaries (Figure 2).

The 'nearshore' or littoral zone was defined as that portion of the reservoir within 100 m of the shoreline. The remaining area of the reservoir was designated as the limnetic zone.

Contour maps of the area impounded by Libby Dam (ACOE, File Number E53-1-154, Sheets 1-37, 1972 and British Columbia Ministry of the Environment, Drawings M-249-C, Sheets 1-63, 1969) were digitized to allow for computer access and storage. Each ten-foot contour interval was entered for all reservoir maps from full pool elevation (2,459 ft above mean sea level) to 2,190 ft, and 30-foot contours were entered from 2,190 ft to the reservoir bottom. Water surface area and volume were calculated using equations generated from these data, which mathematically defined a cubic spline relationship between elevation and the variables.

Discussion

Reservoir operations have changed dramatically between Phase I (1972-1987) and Phase II (1988-1996). The reservoir reached full pool during 63 percent of the years between 1972 and1987, compared to 33 percent of the years between 1988 and1996. Reservoir drawdowns averaged 118 ft during 1974 through 1987, compared to 119 ft during 1988 through 1996 (Table 3, Figure 3). Full pool (2,459 ft above msl) was first reached in July, 1974, and the reservoir has attained that elevation in only 13 years since. Full pool was maintained for an average of 41.6 days during the ten years full pool was obtained from 1972 through 1987, compared to an average of 22.3 days for the three years full pool was attained from 1987 through 1996. Since 1977, the four deepest drafts have occurred in 1991 (154 ft), 1988 (142 ft), 1989 (138 ft) and 1993 (136 ft); of these four years, the reservoir refilled only during 1991. The average time at full pool was 37.1 d during 1972 through 1996 (this figure does not include those years where full pool was not reached). The mean maximum elevation reached for a non-refill year (post-1974) was 2,451 ft above msl or 7.6 ft below full pool.

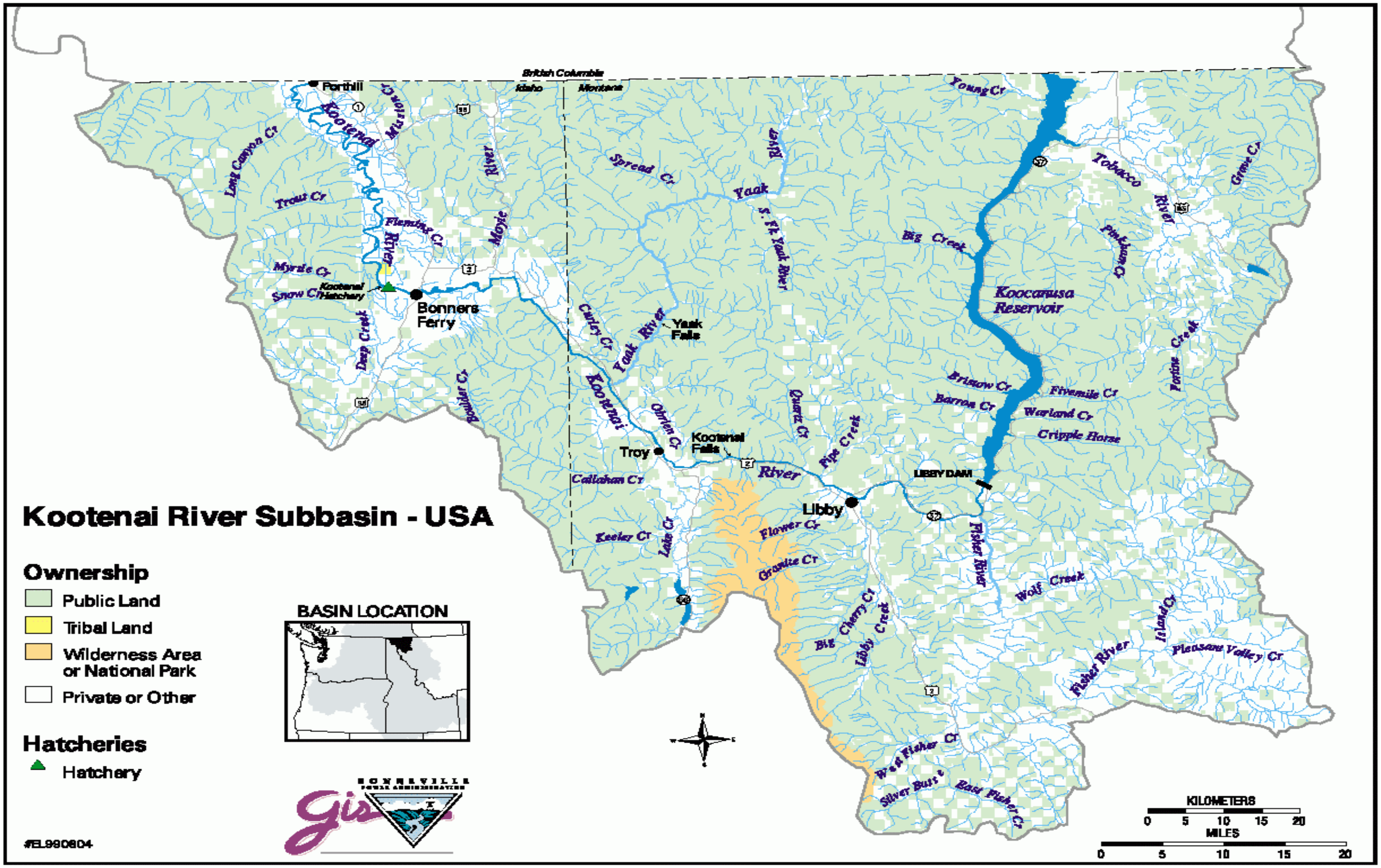


Figure 2. Kootenai River Basin, Montana.

Table 3. Lake-fill time (yrs), hydraulic residence time (yrs), maximum drawdown, number of days held at full pool, and maximum reservoir elevation for Libby Reservoir by year from 1977 through 1996.

	Lake-fill time (yrs)				Hydraulic-residence (yrs)				Maximum		No. of days at full pool	Max pool elevation (ft)
		Monthly				Monthly						
Year	Annual	Mean	Min	Max	Annual	Mean	Min	Max	ft.	m		
1977	0.71	1.09	0.23	1.89	0.52	0.59	0.39	1.29	101	30.8	0	2457
1978	0.42	0.68	0.14	1.10	0.54	0.60	0.26	1.03	130	39.7	15	2459
1979	0.67	1.00	0.18	1.81	0.63	0.95	0.24	2.03	95	29.0	0	2455
1980	0.58	1.24	0.14	2.31	0.61	0.77	0.31	1.75	106	32.3	28	2459
1981	0.45	0.81	0.12	1.57	0.45	0.58	0.24	1.31	109	33.2	47	2459
1982	0.48	0.92	0.11	1.85	0.48	0.53	0.24	0.99	117	35.7	55	2459
1983	0.51	0.79	0.14	1.56	0.50	0.60	0.23	1.57	111	33.9	35	2459
1984	0.61	0.99	0.17	1.98	0.60	0.75	0.26	1.55	89	27.1	12	2459
1985	0.61	1.02	0.13	1.78	0.59	0.83	0.19	1.97	117	35.7	0	2450
1986	0.48	0.74	0.16	1.24	0.48	0.63	0.21	1.38	105	32.0	37	2459
1987	0.58	0.87	0.16	1.61	0.58	0.85	0.24	1.99	101	30.8	25	2459
1988	0.56	0.99	0.13	1.78	0.49	0.81	0.19	2.08	142	43.3	0	2444
1989	0.45	0.67	0.14	1.02	0.49	0.61	0.20	1.12	138	42.1	0	2453
1990	0.39	0.67	0.13	1.40	0.41	0.48	0.17	0.85	134	40.9	35	2459
1991	0.34	0.58	0.07	1.23	0.33	0.35	0.14	0.67	154	47.0	23	2459
1992	0.58	0.83	0.18	1.29	0.49	0.67	0.22	1.60	97	29.6	0	2449
1993	0.44	0.73	0.11	1.15	0.51	0.63	0.26	1.50	136	41.5	0	2448
1994	0.56	0.94	0.18	2.04	0.57	0.80	0.22	1.84	94	28.7	0	2447
1995	0.54	1.14	0.14	2.19	0.56	0.69	0.29	1.18	78	23.8	0	2457
1996	0.38	0.64	0.11	1.20	0.38	0.45	0.20	1.19	97	29.6	9	2459

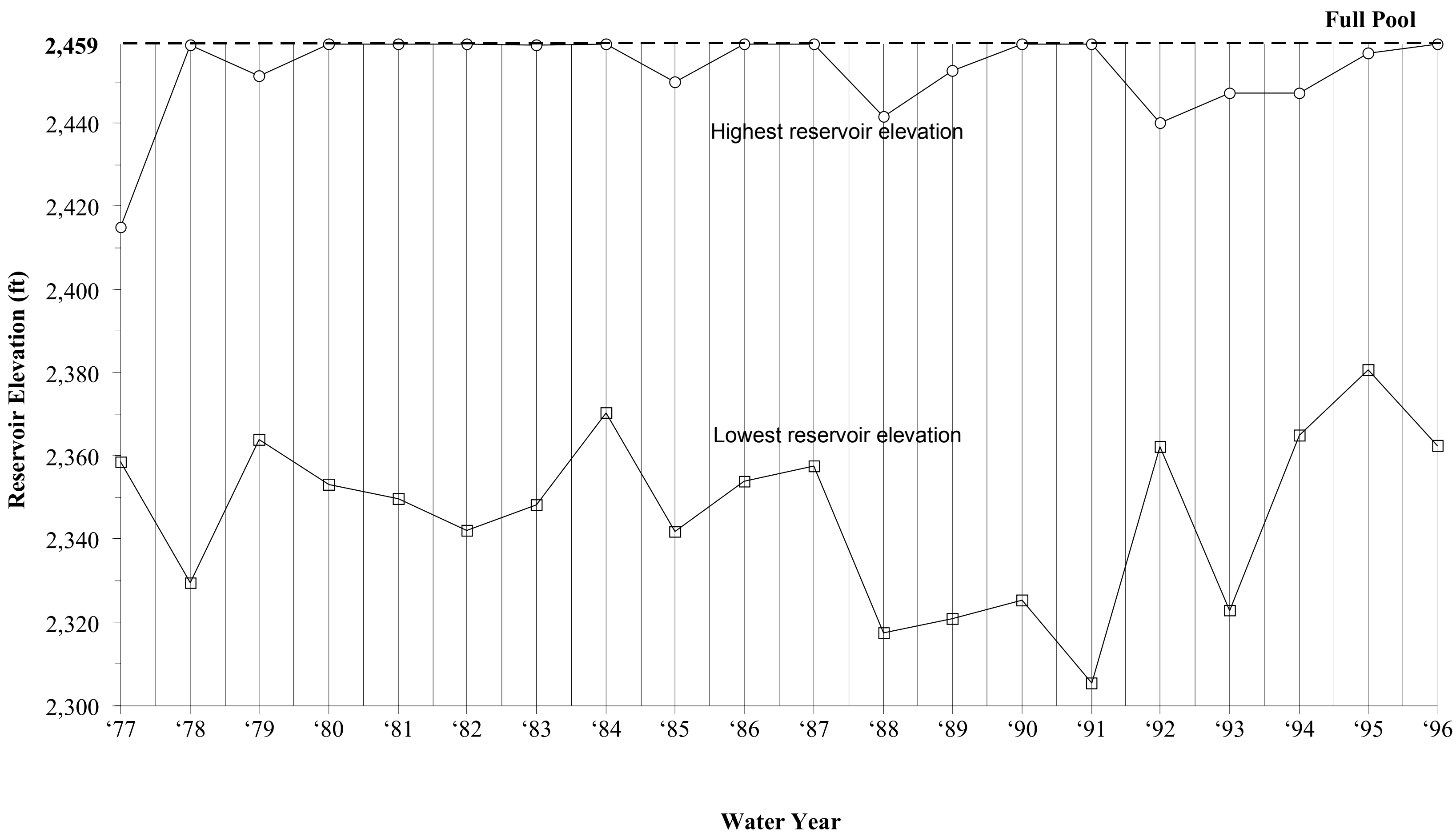


Figure 3. Libby Reservoir elevations (minimum, maximum), 1977 through 1996.

SECONDARY PRODUCTION (Zooplankton)

Methods

Three vertical zooplankton tows using a 0.3 m, 153μ Wisconsin net were performed monthly in each of three reservoir areas (Tenmile, Rexford and Canada) from 1983 to the present. Thirty-meter tows were done unless water column depth was less than 30 m, in which case the entire water column was sampled. After 1989, we sampled only when depths greater than 9 m were available. From 1983 through 1989, one sample was taken from a permanent station and two samples were taken randomly in each area. All samples were chosen randomly after 1989. Orientation (east, west and middle [>100 m from either shore]) for each site was also chosen randomly. All samples were pulled at a rate of 1 m/sec to minimize backwash (Leathe and Graham 1982).

Monthly plankton samples were also taken in each area using a trap that was similar in design to the trap described by Schindler (1969), and sampled 30.0 l. Four permanent sites (Forebay, Tenmile, Rexford and Canada) were sampled at the surface, 3, 6, 9, 12, 15, 20, 25 and 30 m, from 1983 through 1989. In 1990 and 1991, only the Forebay site was sampled, and included additional samples in 5 m intervals deeper than 30 m until depth of withdrawal was exceeded.

River samples were taken concurrently with vertical distribution samples and Schindler trapping in the forebay, and after the removal or addition of selective withdrawal bulkheads. A 0.3 m, 153μ Wisconsin net was lowered to 1 m for a 1-minute horizontal sample in the river current. From 2 June 1989 to 6 February 1990, samples were taken from the David Thompson Bridge, about 0.4 km below Libby Dam. Due to problems with excessive velocity, the sample site was moved downstream about 0.8 km to a USGS trolley, where samples were taken from 10 April 1990 to 18 January 1992.

Zooplankton samples were preserved in a water / methyl alcohol / formalin / acetic acid solution from September, 1986 to November, 1986. After December, 1986, all samples were preserved in 95% ethyl alcohol to enhance egg retention in Cladocerans.

Low density samples (~500 organisms or less) were counted in their entirety. High-density samples were diluted to a density of 80 to 100 organisms in each of five, five ml aliquots. The average of the five aliquots was used to determine density. All genera collected through 1987 were measured using carapace lengths; subsample lengths were extrapolated to calculate the entire sample. From 1988 to present, only *Daphnia*, *Diaptomus*, *Epischura* and *Diaphanosoma* were measured, with the exception of Schindler trap samples, from which no genera were measured after 1990. Prior to 1990, the first 20 zooplankton genera viewed were measured in all Schindlers trap samples following the methods previously discussed. In Wisconsin samples, 33-34 of each genera were measured from a randomly chosen subsample, with additional measurements taken from following subsamples if needed. Biomass / wet weights were estimated using the length / weight relationships described by Shepard (1985; Table 4). After *Diaphanosoma* appeared in Libby Reservoir samples in 1988, a length / weight relationship for *Diaphanosoma* was added using methods described by Bottrell et al. (1976).

Table 4. Regression equations used to estimate dry weights (*u*g) of zooplankters from length data (from Shepard 1985, and Bottrell et al.[1] 1976); Equation:

lnW=lna+blnL

where:

ln = natural log;
W= dry weight (*u*g);
L= length (mm).

Genus	lna	b ± 95% C.I.	Source
Daphnia spp	1.468	2.8292 ± 0.0723	Pooled data (*Daphnia* spp without eggs, embryos)
Bosmina spp	3.0896	3.0395 ± 0.2123	Pooled data
Cyclops spp	1.9526	2.3390 ± 0.0854	Pooled data for all Copepoda
Epischura spp	1.9526	2.3390 ± 0.0854	Pooled data for all Copepoda
Diaptomus spp	1.9526	2.3390 ± 0.0854	Pooled data for all Copepoda
Diaphanosoma spp[1]	1.6242	3.0468 ± 0.3025	Pooled data

* *Leptodora* spp weights were calculated using an assumed mean length of 6.0 mm and a mean weight for this length of 2290 *u*g for males and females combined (from Cummins et al. 1969).

** Wet weights were calculated by multiplying dry weights by a factor of 10 (Bottrell et al. 1976).

To determine statistical differences in zooplankton abundance and distribution among years and reservoir areas, and among months and reservoir areas, the Kruskal-Wallis nonparametric analysis of variance test and nonparametric Tukey-type multiple comparisons were applied (Zar 1996). Multiple comparisons were performed after the Kruskal-Wallis ANOVA revealed statistically significant differences at the 0.05 level.

Results and Discussion

Horizontal Distribution

Data are summarized for 1988 through 1996 and are discussed in this section; data for 1984 through 1987 are reported in Chisholm et al. (1989). For trend analysis, most tables and figures presented here include data collected during all years of the study (1984-1996).

From 1988 through 1996, 625 vertical zooplankton tows were taken from Libby Reservoir. Of these, 17 that were less than 10 m were excluded from analysis. Most sub-10 m samples were from the shallower Canada area, and because zooplankton densities are highest in the top 10 meters of the water column, a sampling bias towards higher zooplankton densities in the Canada area would have been likely. The remaining 608 samples were collected from 10 to 30 m.

Reservoir elevations during the times sampled (Table 5) ranged from full pool (2,459 ft above msl) to 153 ft below full pool (2,306 ft above msl). Reservoir elevation was strongly correlated (Spearman's nonparametric analysis, P=0.01) with *Daphnia* density (r_s = 0.546), and total zooplankton density (r_s.= 0.658)

In addition to the 11 species of zooplankton identified by Irving (1987) in Libby Reservoir (Table 6), *Diaphanosoma leuchtenbergainum* and *Ceriodaphnia* spp were found in small numbers. *Cerioaphnia* remained uncommon, while *Diaphanosoma*, which were first noted in April, 1988, peaked in August, 1988 (4.60/l). After 1989, peak densities declined to less than 1.00/liter and always occurred during August or September (Appendix A1, Tables A1 - A27).

Sample size ranged from 35 tows in 1993 to 126 tows in 1985 (Table 5). During the most frequently sampled months (June through September), the predominant genera were *Daphnia, Bosmina, Diaphanosoma, Cyclops* and *Diaptomus*. *Epischura* and *Leptodora* and combined comprised less than one percent of the zooplankton samples. *Canthocamptus, Chydorus, Alona* and *Ceriodaphnia* were not enumerated due to their rarity. Yearly mean total zooplankton density (Appendix A, Tables A1 - A27) for the overall study period (1984 through 1996) was 9.77 organisms/l (SD=10.30), ranging from 6.86/l (1991; SD=5.39) to 12.98/l (1985; SD=11.48).

Copepods (*Diaptomus*, *Epischura* and *Cyclops*) comprised the greatest portion of zooplankton sampled in the reservoir (Figure 4) accounting for 67.6 to 78.8 percent of the samples from 1988 through 1996. This is similar to species compositions from 1984 through 1987, which ranged from 64.6 to 76.9 percent (Table 7). Among the copepods, *Cyclops* were most dense in 1989 (78.3%), and least dense in 1992 (31.5%). *Diaptomus* peaked at 39.4 percent in 1992, with their lowest densities occurring in the 1988 (0.3%) and 1989 (0.1%) samples (Table 7). Overall, *Epischura* percentages remained consistently low during 1984 through 1996, whereas *Diaptomus*, with the exception of their peak in 1992, declined in 1989 and remained at lower levels through 1996. *Cyclops* densities had no consistent upward or downward trends in percent composition (Table 7).

Table 5. Zooplankton samples (N) and reservoir elevations (ft) for 10-30 m vertical Wisconsin tows in Libby Reservoir, 1988 through 1996.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total N
January	N=0	N=7 2340-2352	N=5 2389	N=3 2391	N=0	N=0	N=0	N=6 2385	N=3 2397	24
February	N=0	N=0	N=6 2379-2380	N=0	N=0	N=0	N=0	N=0	N=0	6
March	N=6 2318	N=0	N=3 2333	N=0	N=0	N=0	N=0	N=9 2383	N=0	18
April	N=9 2318-2332	N=7 2322-2326	N=6 2329	N=6 2306	N=6 2366	N=6 2326	N=5 2371	N=6 2385	N=9 2262	60
May	N=7 2354-2360	N=7 2359-2377	N=6 2357-2359	N=4 2330	N=9 2393	N=0	N=9 2398	N=6 2391	N=9 2378-2389	57
June	N=18 2391-2425	N=9 2428-2431	N=9 2425	N=6 2406	N=9 2415	N=0	N=9 2429	N=6 2434	N=9 2428	75
July	N=9 2434-2435	N=8 2443-2447	N=9 2453	N=9 2453	N=5 2436	N=9 2423	N=9 2441	N=9 2453	N=9 2454	76
August	N=12 2439-2440	N=9 2449-2450	N=9 2459	N=9 2458	N=9 2439	N=8 2343-2344	N=9 2447	N=6 2455	N=9 2455	80
September	N=9 2431-2428	N=9 2444	N=9 2459	N=9 2454	N=9 2426	N=0	N=9 2446	N=9 2453	N=9 2450	72
October	N=12 2416-2408	N=8 2435-2439	N=6 2440-2444	N=0	N=0	N=9 2444	N=9 2438	N=9 2457	N=9 2443	62
November	N=13 2405-2408	N=9 2418-2419	N=5 2429-2430	N=7 2421	N=0	N=3 2420	N=6 2421	N=9 2443	N=0	52
December	N=6 2368-2377	N=9 2408-2410	N=9 2422	N=4 2376	N=0	N=0	N=0	N=9 2433	N=6 2411	43

Table 6. Zooplankton identified in samples collected from Libby Reservoir, Montana, 1977 and 1988 (From Irving 1987).

Genera / **Species**	**Genera** / **Species**
Alona spp	*Daphnia*
Bosmina longirostris	*schlodleri*
Canthocamptus robertcokeri	*galeata mendotae*
Chydorus spaericus	*thorata*
Cyclops bicuspidatus thomasi	*Diaptomus tyrelli*
Epischura nevadensis	*Leptodora kindtii*

Additional zooplankton identified from samples collected from Libby Reservoir, Montana, 1988 through 1996.

Genera / **Species**
Diaphanosoma leuchtenbergainum
Ceriodaphnia spp

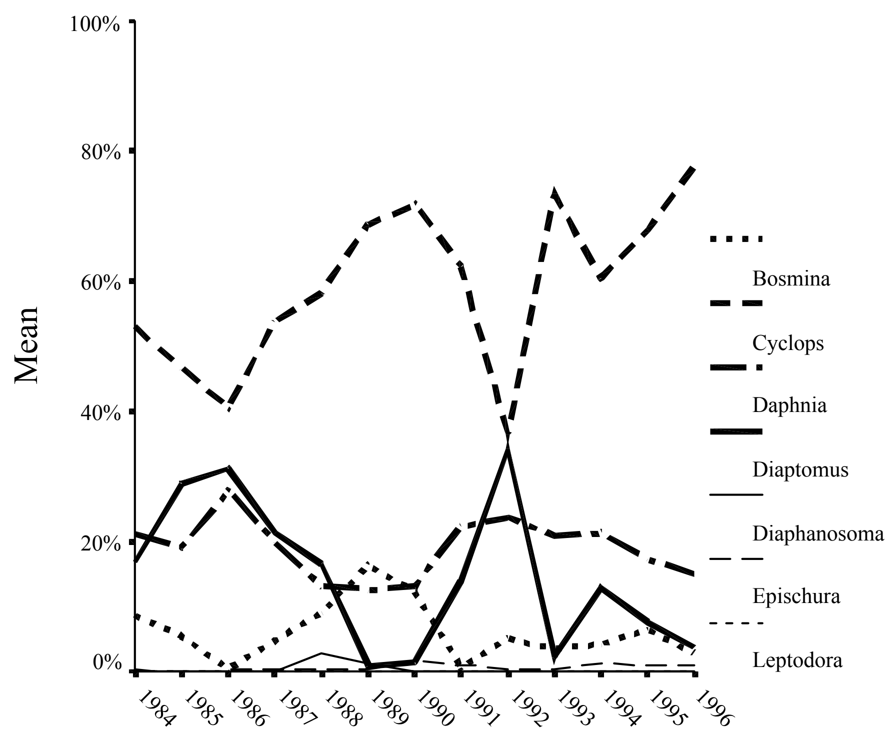


Figure 4. Species composition of major zooplankton in Libby Reservoir, 1984 through 1996.

Table 7. Percent composition of zooplankton genera present in Libby Reservoir during June through September, 1984 through 1996, at 10 - 30 meters.

	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Daphnia	24.9	23.5	22.8	23.8	11.1	8.3	8.1	30.7	20.6	29.8	29.7	20.5	20.8
Diaptomus	11.1	30.7	32.9	11.6	21.8	0.3	0.1	9.7	39.4	0.2	11.3	5.6	0.8
Cyclops	53.2	37.7	43.8	56.1	51.4	78.3	77.6	57.0	31.5	68.8	54.8	71.3	73.9
Bosmina	10.5	7.9	0.2	8.2	6.2	8.9	13.5	0.8	7.0	0.8	1.9	1.1	3.1
Epischura	0.3	0.1	0.2	0.3	0.7	0.2	0.4	1.9	0.3	0.2	1.5	0.8	0.5
Diaphanosoma	0	0	0	0	8.8	3.9	0.2	0	1.2	0.1	0.7	0.6	0.9
Leptodora	0	0.1	0	0	0	0	0.1	0	0	0.1	0.1	0	0.1

Cladocerans (*Daphnia, Bosmina, Diaphanosoma* and *Leptodora*) declined slightly during 1988 through 1990, and comprised from 21.1 to 32.4 percent of the samples. Much of this decline occurred within the *Daphnia* portion of the samples, which decreased from a range of 22.3 to 24.9 percent during 1984 through 1986 to a range of 8.1 to 11.1 percent during 1988 through 1990. This decrease closely corresponded to the decrease in *Diaptomus* densities in 1989 and 1990. *Daphnia* then increased to 30.7 percent of the samples in 1991 and never decreased below 20.5 percent through 1996. *Bosmina* reached a nadir in 1990 (13.5%), and a low in 1986 (0.2%). *Diaphanosoma* peaked to 8.8 percent in 1988 before declining to 3.9 percent in 1989, followed by consistently low densities ranging from 0 to 1.2 through 1996. Overall, Cladoceran species compositions appeared stable from 1993 through 1996 (Table 7).

An apparent inverse correlation between *Cyclops* and *Diaptomus* densities, as well as *Daphnia* and *Bosmina* densities, and to a lesser degree, *Cyclops* and *Daphnia* densities (Figure 4) was evident throughout the study. This correlation, in addition to Chisholm et al.'s (1987) proposal of a relation/correlation between kokanee densities and *Daphnia* size distributions, indicative of a cyclic kokanee population in Libby Reservoir, though certainly other planktivorous fishes in the reservoir affect these relations. Other authors have found size-selective fish predation to be a major influence on zooplankton community structure (Lynch 1979, Zaret and Kerfoot 1975, and Werner and Hall 1974).

Daphnia densities ranged from 0.946/l in 1989 to 2.581/l in 1986, with an overall mean density of 1.923/l (1984 through 1996, SD = 3.363). Densities of *Daphnia* were considerably lower than in 1977 (x = 3.91/l, SD = 4.40) and 1978 (x = 3.40, SD = 2.78), as would be expected, since the reservoir was relatively new during this period. Total zooplankton densities appeared to be rebounding to near early-1980's densities in 1996, whereas biomass declined slightly. An alternate explanation for this downward trend could be the reduction of municipal and industrial point sources of nutrient pollution in British Columbia and the U.S. due to improvements in wastewater treatment technology. A source of phosphate in the upper portion of the reservoir (the Cominco, Ltd. fertilizer plant on Mark Creek, near Kimberly, B.C.) was closed in 1987, which may have substantially reduced phosphate loading in the upper end of Libby Reservoir (Chisholm 1989).

Daphnia abundances were greatest in the Canada area from 1988 through 1991, and from 1994 through 1996. In 1992, the highest density (4.35 *Daphnia*/l.) occurred in August in the Tenmile area. Samples collected in 1993 from the Rexford area contained 6.93 *Daphnia*/l (Appendix A, Tables A1 - A27). Peak mean densities of *Daphnia* ranged between 2.02 and 6.05/l in the Tenmile area, 1.69 to 6.93/l in the Rexford area, and 1.96 to 25.66/l in the Canada area, for the nine years sampled (Table 7). Peak monthly densities were highly variable in all three areas. In general, *Daphnia* densities commonly peaked from July through September for all three areas. Occasional peaks also occurred in October through December in all areas, most commonly in the Canada area. *Cyclops* densities peaked during May through July in the Tenmile and Rexford areas, with peaks in October and November occurring more commonly in the Canada area. *Diaptomus* densities consistently peaked in the fall and winter in all three areas, from September through December (Appendix A, Tables A1 - A27).

Analysis of *Daphnia* length composition revealed that individuals 0.50-0.99 mm dominated samples in all years except 1986, when individuals 1.00-1.49 mm comprised a majority of the samples (Figure 5). Mean length of *Daphnia* differed significantly among years (Kruskal-Wallis ANOVA, P=0.05, Tukey; Table 8 and Figure 6). Mean sample weights of *Daphnia* 0.50-0.99 and 1.50-1.99 were significantly different among years (Kruskal-Wallis ANOVA, P=0.05, Tukey), with pairwise differences as shown in Table 9. As would be expected, mean weights (Figures 7 and 8; Appendix B, Tables B1 and B2) followed seasonal and yearly patterns similar to those of mean densities (Appendix A, Tables A1 - A27).

Total zooplankton, *Daphnia*, and *Diaptomus* densities and weights throughout the reservoir were significantly greater (Kruskal-Wallis ANOVA, P=0.05, Tukey) in Canada (N=404) than in the Rexford (N=371) and Tenmile (N=219) areas (Table 10). When samples collected from the top 20 m (N=19, 72, and 140, respectively) were analyzed, differences in total zooplankton density were not detected, which may suggest a sampling bias favoring higher densities in the Canada samples, due to shallower depths (i.e. greater N/l from shallower samples). However, analysis of progressively shallower samples (5 m incremental exclusions; e.g., 10-30, 10-25, 10-20, etc.) revealed that total *Daphnia* and *Diaptomus* densities remained significantly different between Canada and Rexford until only 10 m samples were analyzed (N=11 and 14, respectively), which suggests differences other than sampling bias having effects on densities (i.e., environmental factors). Combining the Tenmile and Rexford samples did not have any effect on Canada having significantly greater densities of total zooplankton or *Daphnia*. No apparent trends were revealed among years for *Diaptomus, Epischura, Bosmina*, and *Cyclops* densities (N/l), though Kruskal-Wallis ANOVA revealed significant differences, with pairwise differences (Tukey-type, P=0.05) detected as shown in Table 11.

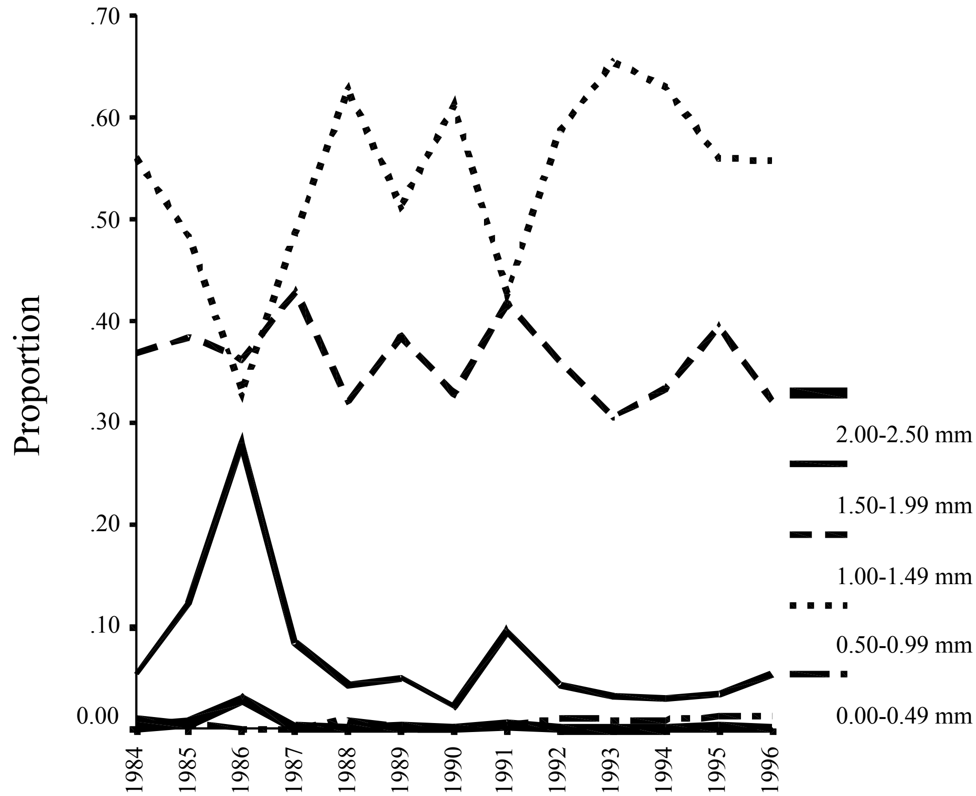


Figure 5. *Daphnia* spp size composition in Libby Reservoir, 1984 through 1996.

Table 8. Nonparametric Tukey-type multiple comparisons for *Daphnia* densities (N/l) for all years. Differences (P=.05) among years are indicated by X.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1984	---	X	X		X	X	X			X	X		
1985		---	X		X	X	X		X	X	X	X	X
1986			---	X	X	X	X	X	X	X	X	X	X
1987				---	X	X	X			X	X	X	X
1988					---			X					
1989						---		X					
1990							---	X					
1991								---	X	X	X	X	X
1992									---				
1993										---			
1994											---		
1995												---	
1996													---

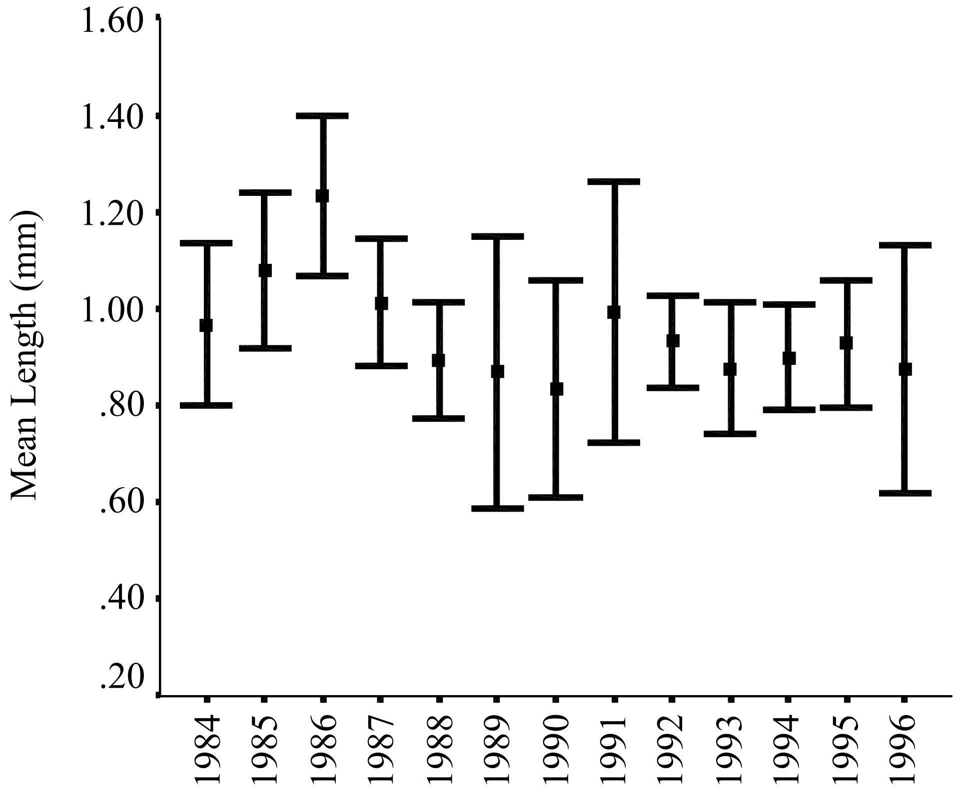


Figure 6. Mean length of *Daphnia* spp in Libby Reservoir, 1984 through 1996, with standard deviations.

Table 9. Nonparametric Tukey-type multiple comparisons for *Daphnia* spp size class wet weights (ug; 1=0.50-0.99 mm, 2=1.50-1.99 mm). Differences (P=.05) among years are indicated by same numbers.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1984	---	2	2		1	1,2	1,2	1		2		1	1
1985		---	2		2	1,2	1,2		2	2	2	2	2
1986			---	2	2	1,2	1,2	2	2	2	2	2	2
1987				---	2	2	2			2	2	2	
1988					---					2			
1989						---		2	1		1		1,2
1990							---	2	1		1		1,2
1991								---		2		2	
1992									---	2			
1993										---			2
1994											---		
1996												---	
1996													---

Table 10. Nonparametric Tukey-type multiple comparisons for total zooplankton, *Daphnia* and *Diaptomus* densities by study area and year. Between-area differences (P=.05) are indicated by different numbers; more than one number indicates similarity to both groups. Same numbers indicate no difference.

Area	Total Zooplankton	*Daphnia*	*Diaptomus*
Tenmile	1	1	1
Rexford	1	1	1
Canada	2	2	2

Table 11. Nonparametric Tukey-type multiple comparisons for *Diaptomus* spp (1), *Epischura* spp (2), *Bosmina* spp (3), and *Cyclops* spp (4) densities by year. Differences (P=.05) among years are indicated by same numbers.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1984	---	1,2	1,3	3		1,2	1	1,3	4	1,3	2,3	1	1,3
1985		---	3	2	1,2	1	1,2	1,3	4	1,3	1,2	1,2	1,2,3
1986			---	1,3	1,3	1,3	1,3	1	3	1,3,4	1,2,3	1,3	1,3,4
1987				---		1,3	1,3	1,3	4	1	2	1	1
1988					---	1	1	1,3	1,4	1	2	1	1,3
1989						---	2	1,3	1,3,4	3	1,2,3	1,2,3	3
1990							---	1,3	1,4	3	1,2,3	1	3
1991								---	1,3	1,4	1,2,3	3	3
1992									---	1,4	1,2,4	1,4	4
1993										---	1,2	1	
1994											---		1
1995												---	1,3
1996													---

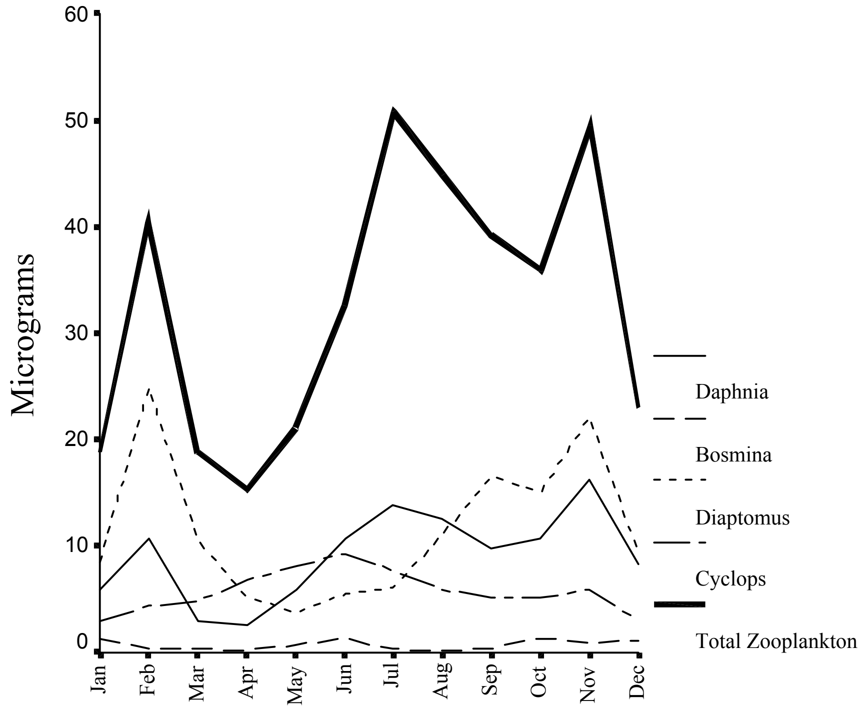


Figure 7. Seasonal abundance (mean weight) of zooplankton in Libby Reservoir, 1984 through 1996.

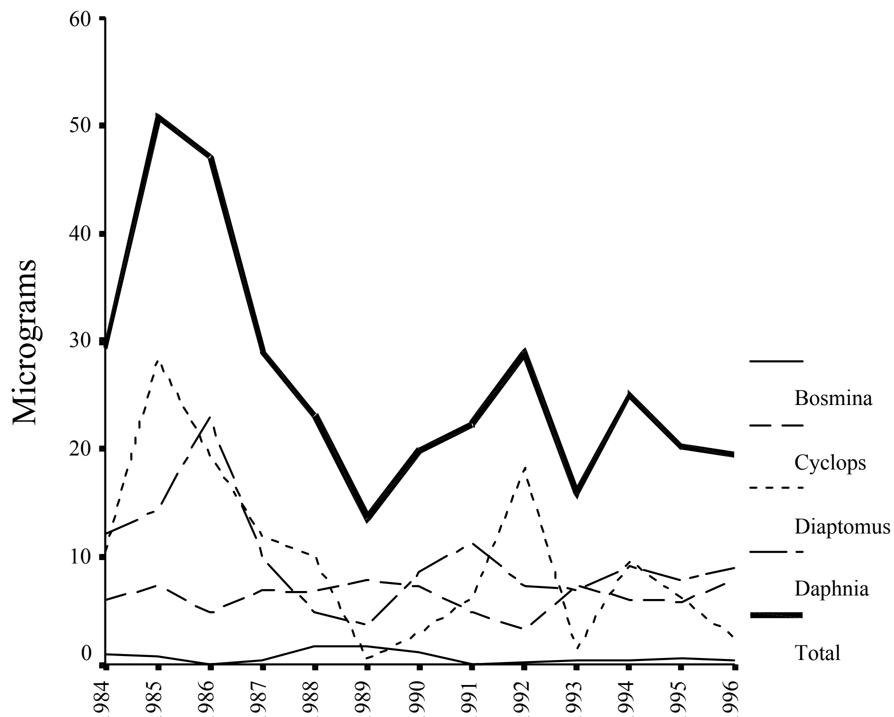


Figure 8. Mean sample weights (micrograms) of zooplankton in Libby Reservoir, 1984 through 1996.

Vertical Distribution

From 3-88 through 4-93, 781 Schindler trap samples were collected from Libby Reservoir. Of these, 757 were taken from 0 to 30 m and 24 were taken from deeper than 30 m in the water column, and were excluded from the analysis. All years sampled (1983-1989) were then combined (N=1,687) to form Appendix C, Tables C1 - C15.

For all samples, 73.8 percent of the zooplankton sampled were found in the 0-12 m samples, with 26.2 percent from 15-30 m samples. As found by Chisholm et al. (1989), the 3 m and 6 m Schindler samples contained the highest densities of zooplankton. The 0-12 m samples contained 79.8 percent of all *Daphnia* sampled, 74.3 percent of the *Diaptomus*, 73.4 percent of the *Cyclops*, 65.1 percent of the *Bosmina*, 62.2 percent of the *Epischura*, and 63.4 percent of the *Diaphanosoma* (Table 12; Appendix C, Tables C1 - C15).

Table 12. Mean densities (N/L) and percentages of zooplankton genera from Schindler trap samples taken in Libby Reservoir, 1983 through 1989.

Depth	*Daphnia*	*Bosmina*	*Diaptomus*	*Cyclops*	*Epischura*	*Diaphanosoma*	Total
Surface	1.00	0.22	1.30	3.15	0.02	0.03	5.72
	5.8%	2.8%	10.5%	5.9%	4.4%	3.0%	6.2%
3m	5.28	1.17	2.78	11.94	0.06	0.10	21.33
	30.8%	14.9%	22.4%	22.3%	13.3%	9.9%	23.1%
6m	3.28	1.51	2.13	10.07	0.05	0.18	17.22
	19.2%	19.2%	17.2%	18.8%	11.1%	17.8%	18.6%
9m	2.37	1.25	1.66	8.02	0.08	0.19	13.57
	13.8%	15.9%	13.4%	15.0%	17.8%	18.8%	14.7%
12m	1.74	0.97	1.34	6.12	0.07	0.14	10.38
	10.2%	12.3%	10.8%	11.4%	15.6%	13.9%	11.2%
15m	1.28	0.83	1.17	5.00	0.06	0.05	8.49
	7.5%	10.5%	9.4%	9.3%	13.3%	14.9%	9.2%
20m	0.83	0.88	0.78	3.77	0.04	0.10	6.40
	4.8%	11.2%	6.3%	7.0%	8.9%	9.9%	6.9%
25m	0.70	0.50	0.64	2.81	0.03	0.08	4.76
	4.1%	6.4%	5.2%	5.2%	6.7%	7.9%	5.2%
30m	0.64	0.54	0.60	2.65	0.04	0.04	4.51
	3.7%	7.87%	4.8%	5.0%	8.9%	4.0%	4.9%
Total	17.12	7.87	12.40	53.53	0.45	1.01	92.38
	100%	100%	100%	100%	100%	100%	100%

Sampling Protocol

The purpose of monitoring zooplankton populations in Libby Reservoir is to relate changes in density and structure of the community to parameters of other aquatic communities, as well as to collect data indicative of reservoir processes, including aging and the effects of water elevation manipulations. Extensive analysis of data collected from 1988 through 1996 revealed possibilities for reducing zooplankton sampling effort. Eighty six percent of the samples collected were obtained during April through November. Analysis of density and size structure throughout the year revealed no points that would be overlooked by sampling only April through November.

In an effort to further standardize sampling regimes, we experimented with the effects of sample depth on the resulting analysis. When we excluded samples of greater than 20 m, the resulting analysis revealed statistically (Kruskal-Wallis, P=0.05) similar results with regards to total zooplankton, *Daphnia*, and *Diaptomus* densities as analyses including depths to 30 m. These findings corroborate with the results of Schindler trap sampling in the reservoir, which revealed that 89.9% of all zooplankton captured were from depths of 20 m or less.

Restricting our sampling to the U.S. portion of the reservoir was another option considered to reduce sampling effort in the future. Eliminating Canada from the sampling regime would save the time required to travel to the sampling areas in that portion of the reservoir, but would eliminate one of the most productive areas of the reservoir from sampling, and would reduce the efficacy of future analysis of reservoir-wide data, and is therefore not justifiable. It appears that Canada samples are statistically unique enough with respect to total zooplankton and *Daphnia* densities to warrant continued sampling. However, eliminating sampling transects above Sand Creek from the list of randomly chosen sites is justifiable, since personnel have rarely been able to obtain samples here due to low reservoir elevations.

Beginning in 1997, the protocol for sampling zooplankton in Libby Reservoir, will include one monthly sample from areas of the reservoir chosen following previous protocols, but will include only the months of April through November (8 months, reduced from 8-9+, depending on reservoir elevations and accessibility). Samples will be taken only from depths of 10-20 m (reduced from 10-30 m). These protocols will allow comparison of future samples with valuable long-term data collected through 1996, and will standardize our sampling schedule without sacrificing the utility of collected data.

TERTIARY PRODUCTION (Fish Abundance)

Methods

Gillnets have been used by MFWP since 1975 to assess annual trends in fish populations and species composition. These yearly sampling series were accomplished using criteria established by Huston et al. (1984). Data presented in this report focus on the period 1988 through 1996, but in several instances the entire database (1975 through 1996) is presented to show long-term catch trends. Data from 1975 through 1987 were published in the previous reservoir report (Chisholm et al. 1989).

Netting methods remained similar to those reported in Chisholm et al. (1989). Netting effort was reduced from 128 ganged (coupled) nets in 1975, to 56 in 1988, and 14 ganged floating and 28 single sinking nets in 1991 (Tables 13 and 14). Netting effort occurred in the spring and fall, rather than the year round effort prior to 1988. Only fish exhibiting morphometric characteristics of pure cutthroat (scale size, presence of basibranchial teeth, spotting pattern and presence of a red slash on each side of the jaw along the dentary) were identified as such; all others were identified as rainbow trout (Leary et al. 1983). Kamloops rainbow trout were distinguished from wild rainbow trout by eroded fins (pectoral, dorsal and caudal); these fish are held in the hatchery until release into the reservoir at age 1+. These fish are also marked (tetracycline) prior to release into the reservoir which allows post-mortem age and origin determination.

Species abbreviations used throughout this report are: rainbow trout (RB), Kamloops rainbow trout (KAM), westslope cutthroat trout (WCT), rainbow X cutthroat hybrids (HB), bull trout (DV), kokanee salmon (KOK), mountain whitefish (MWF), burbot (LING), peamouth chub (CRC), northern squawfish (NSQ), redside shiner (RSS), largescale sucker (CSU), longnose sucker (FSU), and yellow perch (YP).

The year was stratified into two gillnetting seasons based on reservoir operation and surface water temperature criteria:

1) Spring (April - June): The reservoir was being refilled, surface water temperatures increased to 9 - 13^{o}C.

2) Fall (September - October): Drafting of the reservoir began, surface water temperature dropped to 13 - 17^{o}C.

Table 13. Average catch per net in floating gillnets set during the fall in the Tenmile and Rexford areas of Libby Reservoir, 1975 through 1996 Î.

	YEAR																			
	1975	**1976**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Surface Temperature	16.1	17.2	15.6	16.7	15.6	16.7	16.3	15.6	11.4	14.9	17.7	16.7	n/a	16	15	13.8	13.8	16.6	15.8	15.5
Date	9/23	9/23	9/20	10/2	10/1	9/22	9/16	9/25	10/24	9/22	9/20	9/25	9/25	9/25	10/2	9/25	10/5	9/27	10/10	9/23
Number of Floating Nets	129	91	78	73	79	70	24	28	40	58	58	56	56	54	28	28	28	28	28	28
Reservoir Elevation	n/a	2458	2458	2447	2455	2457	2456	2451	2434	2445	2446	2426	2443	2456	2448	2421	2441	2446	2454	2450
Average number of fish caught per net for individual fish species Ï																				
RB	2.8	3.6	6.3	4.9	4.8	2.4	1.9	1.5	2.5	1.9	0.7	1.4	0.1	0.2	0.4	0.1	0.4	0.2	0.6	0.3
WCT	2	2.5	2	1.4	1.2	1.2	0.7	0.7	1.4	0.6	0.2	0.3	0.1	0.2	0.4	0.5	0.9	0.1	0.1	0.2
RB X WCTÐ	0	0	0.1	<0.1	<0.1	<0.1	1.6	0.4	1	1.6	0.8	0.5	0.1	0.3	0.2	0.2	0	0	0	0
SUB-TOTAL	4.8	6.1	8.4	6.3	6	3.6	4.2	2.6	4.9	4.1	1.7	2.2	0.3	0.7	1	0.8	1.3	0.3	0.7	0.5
MWF	2	2.3	1.2	1.4	0.6	1	0.4	0.8	0.2	0.8	0.1	0.3	0.1	0.2	0.5	0.2	0.3	0.4	0.3	0.3
CRC	4	4.2	3	6.5	8.8	15.1	12.6	11	5.5	17.5	40.1	18.7	35.6	18.2	18.4	23.3	17.1	10.4	1.2	11.7
NSQ	4.2	4.7	4.2	2.1	1.9	3.5	1.9	1.3	0.5	1.5	1.3	1.4	2.1	1.8	2.1	1.8	2.2	3.4	2.7	1.8
RSS	3.3	7.9	7.3	2	0.5	0.2	0.7	0.2	0.1	0.2	0.4	0.4	0.1	0	0.1	0	0	0.3	0.2	0.1
DV	<0.1	<0.1	<0.1	0.1	0.2	<0.1	0	0.1	0.2	0.1	0	0.1	0	0	0	0.1	0.3	0	1.2	<0.1
CSU	1.9	2.4	0.9	1.1	1.2	1.2	0.4	0.2	0.1	0.2	0.1	<0.1	0.1	0.1	0.1	0	0.1	0.1	0	0.4
KOK	0	0	0	0.2	0	7.1	0.3	6.5	8.1	3.4	5.7	22.4	11.8	3.9	13.7	5	1	4	7.9	2.3
TOTAL	20.2	27.6	25	19.7	19.2	31.7	20.5	22.7	19.6	31.9	51.1	45.5	50.1	24.9	35.9	31.2	22.3	18.9	14.2	17.1

Î Catches prior to 1988 also reported in Chisholm et al. (1989)
Ï Abbreviations explained in Methods section under Fish Abundance.
Ð Prior to 1983, very few hybrids were identified as such, although they were probably present in the samples.

Table 14. Average catch per net in sinking gillnets set during spring in the Rexford area of Libby Reservoir, 1975 through 1996 Î.

	YEAR																		
	1975	**1976**	**1978**	**1980**	**1981**	**1982**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Surface Temperature	12.8	12.2	11.1	11.1	8.9	11.7	12.7	15	11.9	10.8	12	8.9	11.7	9.8	16.7	14.4	13.3	13.5	8.9
Date	6/9	5/1	5/15	5/5	5/5	5/25	6/12	6/6	5/8	5/5	5/12	5/1	5/10	5/16	5/5	5/17	5/16	5/8	5/12
Number of Sinking Nets	111	41	41	38	35	36	20	23	28	28	24	25	27	28	28	28	28	28	28
Reservoir Elevation	n/a	2373	2367	2389	2378	2363	2412	2415	2379	2390	2344	2355	2358	2330	2333	2352	2405	2386	2365
Average number of fish caught per net for individual fish species Ï																			
RBÐ	0.8	0.3	1.4	0.7	1.6	1.4	2.5	0.3	0.2	1.5	0.5	0.3	0.1	0.1	0.1	0.3	0.2	0.2	0.7
WCT	0.2	0.4	0.4	0.2	0.7	0.4	0.1	0.1	0.0	0.4	<0.	<0.1	<0.1	0.0	0.1	0.0	<0.1	0.1	0.1
RB x WCTÑ	0.0	0.0	0.0	0.0	<0.1	<0.1	0.6	0.1	<0.1	0.6	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
SUB-TOTAL	1.0	0.7	1.8	0.9	2.3	1.8	3.2	0.5	0.2	2.5	0.6	0.3	0.1	0.2	0.2	0.3	0.2	0.3	0.9
MWF	6.6	6.4	7.2	1.0	2.2	2.1	2.9	0.8	5.8	2.3	1.3	0.7	0.2	0.3	0.9	0.1	0.3	1.5	1.6
CRC	0.3	1.0	0.7	7.2	9.6	24.3	59.2	79.7	39.2	32.4	50.8	57.8	104.8	31	119	63.3	94.2	54.1	60.9
NSQ	2.3	1.2	5.8	2.8	2.6	4.3	8.0	9.4	5.5	11.2	6.4	6.5	6.0	2.0	4.2	3.8	7.6	8.0	10.0
RSS	0.0	1.4	2.8	0.7	0.5	1.9	2.5	1.4	0.1	0.4	0.2	0.1	<0.1	0.0	0.5	0.0	0.0	0.0	0.0
DV	1.4	1.9	2.2	0.8	1.3	1.5	1.8	1.3	1.9	1.2	2.0	1.2	1.2	0.5	2.3	1.2	3.0	2.3	3.5
LING	<0.1	0.2	0.3	0.6	0.3	0.5	0.4	0.6	0.7	0.9	1.2	0.5	0.2	0.4	0.6	0.3	0.1	0.1	0.5
CSU	37.3	26.1	23.5	36.3	33.9	18.6	30.2	21.3	8.3	8.5	10.5	9.0	5.8	2.4	12.9	9.8	9.0	12.0	19.9
FSU	7.9	11.1	9.1	5.8	5.9	10.9	5.6	4.3	1.5	1.8	1.9	1.4	1.8	1.1	2.9	4.1	6.5	3.0	4.8
YP	0.0	0.0	0.0	0.0	0.1	0.2	0.8	1.0	2.6	5.5	4.6	8.2	4.7	2.1	1.8	1.1	0.7	2.5	3.7
KOK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.3	1.6	1.8	2.0	1.0	0.4	3.5	0.3	2.1	2.0
TOTAL	56.8	50.0	53.4	56.1	58.7	66.0	114.5	119.8	65.5	55.7	81.7	85.7	120.7	40.0	145.3	84.3	121.9	86.3	107.1

Î Catches prior to 1988 also reported in Chisholm et al. (1989).
Ï Abbreviations explained in Methods section under Fish Abundance.
Ð Rainbow trout includes wild and hatchery rainbow trout (Kamloops).
Ñ Prior to 1983, very few hybrids were identified as such, although they were probably present in the samples.

Seasonal and annual changes in fish abundance within the nearshore zone were assessed using floating and sinking horizontal gillnets. These nets were 38.1 m long and 1.8 m deep and consisted of five equal panels of 19-, 25-, 32-, 38-, and 51-mm mesh.

Fourteen to twenty-eight floating (ganged) and one or two single, sinking nets were set in the fall in the Tenmile, Rexford and Canada portions of the reservoir (Table 13). Spring netting series consisted of 20 to 111 (standardized to 28 in 1991) sinking nets and an occasional floating net set only in the Rexford area (Table 14). Spring floating and fall sinking net data are not included in this report due to a lack of standardization in net placement. Nets were set perpendicular from the shoreline in the afternoon and were retrieved before noon the following day. All fish were removed from the nets and identified, followed by collection of length, weight, sex and maturity data. Scales and a limited number of otoliths were collected for age and growth analysis. Stomach samples were collected from 1983 through 1992 (see Food Habits section). When large gamefish (Kamloops rainbow, cutthroat, bull trout or burbot) were captured alive, only a length was recorded prior to release.

Numbers of fish caught per net (CPN) between 1975 and 1982 were compared by Huston et al. (1984). Catch rates during 1983 through 1987 are reported in Chisholm et al. (1989). Data from 1988 through 1996 were tested for significant differences at p=0.05 using the Kruskal-Wallis and Mann-Whitney ranking tests (Gooch 1977). If significant differences existed between years, catch rates were ranked and tested using the Tukey multiple comparison test (Zar 1996).

Results and Discussion

From 1988 through 1996, 460 floating and 244 sinking gillnets captured 13,801 and 23,938 fish, respectively. A total of 16 species of fish were captured, two of which represented 70 to 90 percent in spring sinking and fall floating gillnets, respectively (Tables 13 and 14).

We documented changes in the assemblage of fish species sampled in Libby Reservoir since impoundment. Kokanee salmon, kamloops rainbow trout and yellow perch did not occur in the Kootenai River prior to impoundment but are now present. Kokanee were released into the reservoir from the Kootenay Trout Hatchery in British Columbia (Huston et al. 1984). Yellow perch may have dispersed into the reservoir from Murphy Lake (Huston et al. 1984). Kamloops were first introduced in 1985 by British Columbia Ministry of Environment (BCMOE). BCMOE and MFWP continue to stock two different strains of rainbow trout into the reservoir; MFWP stocks hatchery reared Duncan strain and BCMOE stocks Gerrard strain. Eastern brook trout are not native to the Kootenai Drainage, but were present in the river before impoundment and rarely appeared in gillnets. Peamouth and northern squawfish were rare in the Kootenai River before impoundment, but have increased in abundance in the reservoir. Mountain whitefish, rainbow trout, westslope cutthroat trout and redside shiner were all common in the Kootenai River before impoundment, but have decreased in abundance since impoundment. Two predacious species, bull trout and burbot, were uncommon in the Kootenai River before impoundment, and subsequent gillnet catches show no clear population trends. Gillnets are not the best gear type for capture of burbot; bull trout are commonly captured in gillnets. More detailed descriptions of changes in gillnet catches by species between 1988 and 1996 are given below.

Peamouth

Peamouth (CRC) were considered rare in the Kootenai River before impoundment (Huston et al. 1984). Three years following the construction of Libby Dam, the catch of peamouth accounted for less than five fish per net. Since 1988, they were the most abundant fish captured in the spring gillnetting series. The highest catch on record (3,332; 119/net) occurred in 1992 (Table 14, Figure 9). Catch increased steadily to an average of 10-20 fish per net and stabilized at this level; catch was within this range 67% of the years sampled since 1988. Two anomalous years, 1989 and 1995, had catch rates of 35.6 and 1.2 fish/net, respectively. Sampling date likely influenced the record low catch in 1995; nets were set on the second latest sampling date on record (10 October). The latest set (24 October) occurred in 1985; the second lowest catch on record occurred that year. Fish may be in colder water (and less active) farther offshore during late sampling dates, resulting in lower vulnerability to gillnetting. In general, catches during 1993 through 1996 were constant to slightly decreasing compared to 1988 through 1992 (20.2 ± 18.3 fish per net and 31.1 ± 20.6 fish per net; Figure 9).

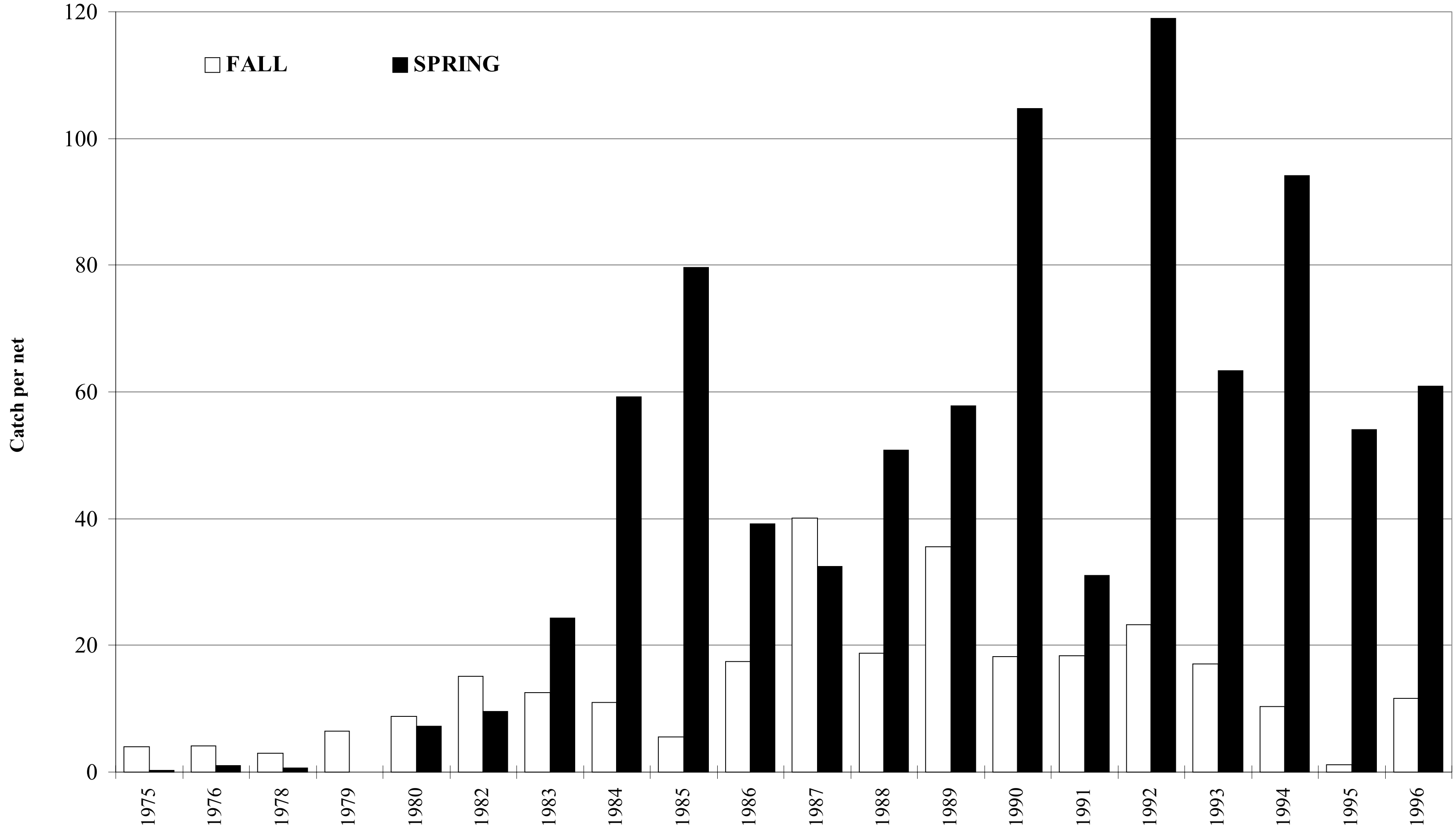


Figure 9. Peamouth (CRC) catch per net in fall floating and spring sinking gillnets in Libby Reservoir, 1975 through 1996.

Kokanee

Since the accidental introduction of 250,000 fry from the Kootenay Trout Hatchery in British Columbia into Libby Reservoir in 1980, kokanee have become the second most abundant fish captured during fall gillnetting. Fluctuations in catch have corresponded to the strength of various year classes. Since 1988, catch rates have varied from 22.4 to 1 fish per net in the Rexford and Tenmile areas. Kokanee averaged 34.8 percent of total catch in fall floating gillnets (Table 13). No significant correlation was found between catch per net and average length of kokanee captured. Kokanee and peamouth comprised 80-90% of the catch in six of the nine years between 1988 and 1996 (Table 13).

Average length of kokanee varied among years. Average length and weight between 1988 and 1996 was 293.3 mm and 2,41.5 gm, respectively (Table 15). While maximum average size occurred in 1992 (350 mm, 411 gm).

Table 15. Average length and weight of kokanee salmon captured in fall floating gillnets (Tenmile and Rexford) in Libby Reservoir, 1988 through 1996.

YEAR	1988	1989	1990	1991	1992	1993	1994	1995	1996	AVG.
Sample size (n)	2150	1259	517	624	250	111	291	380	132	
Length (mm)	315.5	275	257.3	315.8	350	262.7	270.2	300.2	293.7	293.3
Weight (gm)	289.1	137.2	158.4	327.3	411.3	162.3	191.7	261.6	234.5	241.5

More reliable estimates of kokanee density and year class strength are possible by combining hydroacoustic estimates and vertical gillnetting. Kokanee entrainment through Libby Dam has been determined a substantial factor in determination of population abundance and resultant size of adults in Libby Reservoir (Skaar et al. 1996). MFWP will continue to explore these relations with hydroacoustic and entrainment-deterrence studies.

Yellow Perch

Yellow perch comprised an average of 3.3% of the spring gillnet catch between 1988 and 1996 (Table 6). Catch rates were positively correlated with surface temperature (P=0.05), but were independent of reservoir elevation at time of gillnetting. The barren and heavily eroded shorelines of Libby Reservoir lack the debris and aquatic vegetation preferred by spawning yellow perch (Scott and Crossman 1973).

Although difficult to substantiate in Libby Reservoir, perch densities may be influenced by nocturnal predation by ling, which is common elsewhere (Scott and Crossman 1973). Behavioral observations of perch (SCUBA diving) reveal a general lack of activity; perch rested near the substrate and were easily approached (Mike Hensler, MFWP, personal communication). Food habit data support these observations; ling selected yellow perch, even though yellow perch densities were not high relative to other prey species (see Table 23 in Food Habits section)

Mountain Whitefish

Mountain whitefish are one of three native species that have declined in abundance since impoundment of the Kootenai River (Huston et al. 1984, Table 14, Figure 10a). Catches in the initial years following impoundment were high, possibly due to the remnant population from the Kootenai River. Catches in sinking gillnets after 1978 were lower and more variable, ranging from 0.8 fish per net (1985) to 5.8 fish per net (1986). Catch rates after 1988 remained low; mountain whitefish comprised less than 1% of the spring catch during 1988 through 1996. Reasons for whitefish decline in Libby Reservoir may include conversion from lotic to lentic environment, barriers to spawning habitat and poor quality of that habitat, and loss of spawning substrate in the old Kootenai River channel.

Rainbow and Westslope Cutthroat Trout

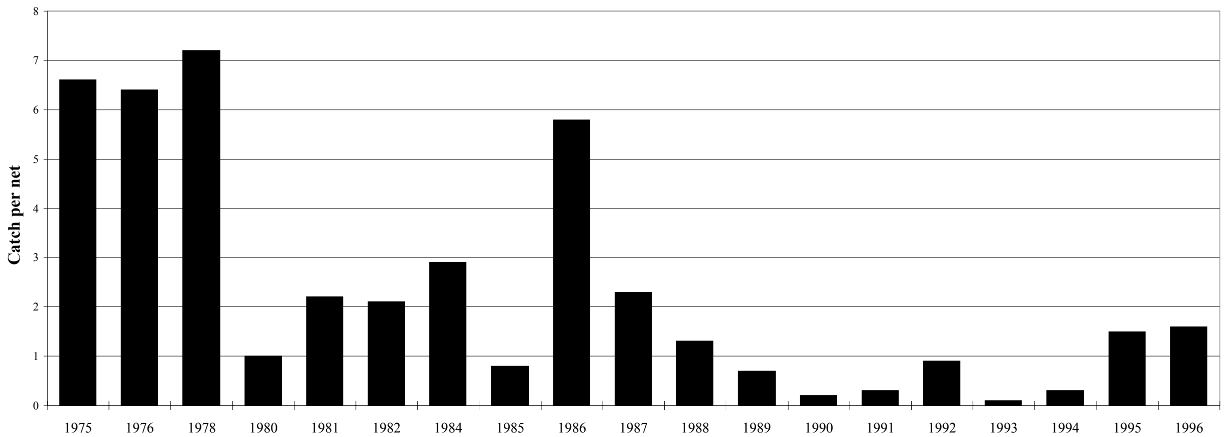
The numbers of rainbow and westslope cutthroat trout caught in fall gillnets declined significantly (Kruskall-Wallis ($P<0.01$) between 1978 and 1982 (Huston et al. 1984; Tables 6b and 6c). Catch of rainbow and westslope cutthroat trout remained relatively stable between 1988 and 1996 (Figure 10b). Westslope cutthroat catch increased slightly from 1990 to 1993 (0.2 to 0.9 per net), which may be related to hatchery stocking ( ). A significant ($P< 0.1$) decline in catch occurred between 1993 and 1994. No hatchery cutthroat trout were released in the reservoir in 1995 or 1996.

Table 16. Westslope cutthroat trout caught in the Rexford and Tenmile areas in fall floating gillnets, average length, average weight, number stocked directly into Libby Reservoir, and corresponding size of stocked fish between 1988 and 1996.

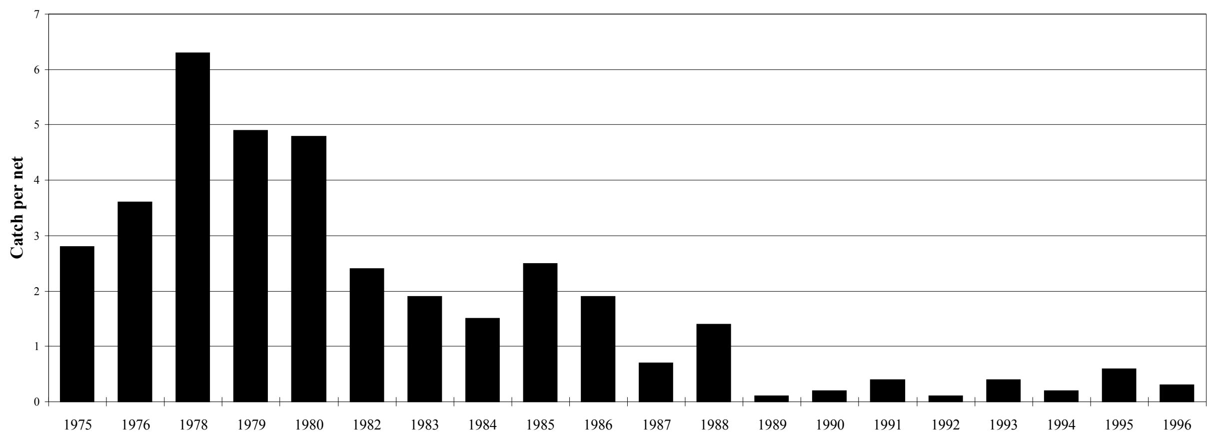
	1988	1989	1990	1991	1992	1993	1994	1995	1996
No. Caught	23	21	17	17	22	31	11	8	11
Avg. Length (cm)	295	264	238	261	275	260	251	314	252
Avg. Weight (gm)	249	196	146	191	211	191	156	316	161
No. Stocked	None	5,779	40,376	67,387	72,376	72,367	1,360	none	none
Length (mm)	None		33	104	216	190	287	n/a	n/a

Causes for decline of rainbow and westslope cutthroat trout may include reductions in hatchery stocking, migration of hatchery stock out of the reservoir into the Kootenai River, and poor habitat quality and reservoir-created barriers in tributaries (Snelson and Muhlfeld 1996). Competition for food with the abundant planktivores (kokanee) in the reservoir, as well as competition in tributaries with nonnative brook trout, likely affects these populations.

a. Mountain Whitefish



b. Rainbow Trout



c. Westslope Cutthroat Trout

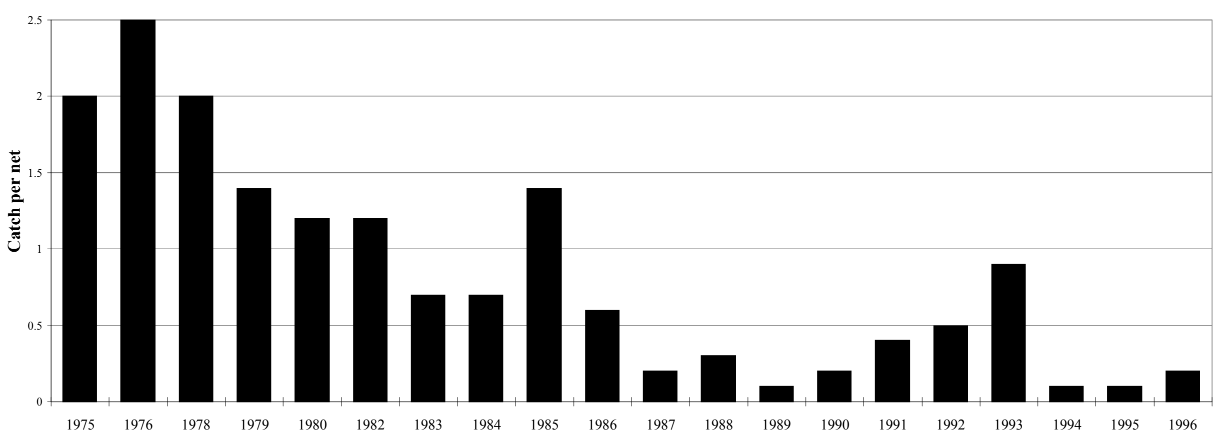


Figure 10. Catch per net of three native species (mountain whitefish (a) in spring sinking gillnets in the Rexford area, rainbow and westslope cutthroat trout (b) and (c) in floating gillnets from Tenmile and Rexford areas) in Libby Reservoir, 1975 through 1996.

Kamloops Rainbow Trout (Duncan Strain)

The current population status of Kamloops rainbow trout is unclear. Kamloops captured in fall floating gillnets was correlated (P=0.02) with number of hatchery fish planted the previous summer (Table 17). Low catch (0 to 18 fish per season) dictates that these data be viewed with caution.

Table 17. Kamloops rainbow trout captured in fall floating gillnets in the Rexford and Tenmile areas of Libby Reservoir, 1988 through 1996.

	1988	1989	1990	1991	1992	1993	1994	1995	1996
No. Caught	3	0	18	6	3	4	0	12	2
Avg. Length (mm)	289	n/a	301	383	313	460	n/a	313	460
Avg. Weight (gm)	216	n/a	243	589	289	373	n/a	311	1192
No. Stocked	20,546	73,386	36,983	15,004	12,918	10,831	16,364	15,844	12,561
Length (mm)	208-327	175-198	175-215	180-190	198-208	165-183	168-185	165-178	170.5

Redside Shiner

Redside shiner density declined similarly to whitefish and trout species (Table 13, Figure 11a). Shiners, though restricted to slow water habitats, were common in the Kootenai River before impoundment. Redside shiners were commonly caught during early impoundment years, possibly due to hold-overs from the Kootenai River occupying an empty niche. Catch averaged fewer than one fish per net in all year sampled between 1988 through 1996.

Spawning substrate for redside shiners, which consists of areas adjacent to riffles in streams and flooded vegetation (Brown 1971), was likely available in the first years after impoundment and facilitated successful reproduction in those years. Extensive shoreline erosion due to varying reservoir water levels has eliminated suitable spawning substrate, and may now be the primary factor limiting redside shiner abundance.

Bull Trout

Few bull trout have been captured in the fall gillnetting series since impoundment. The primary reasons are that sampling dates purposely coincided with the period in which adults were in spawning tributaries (Table 13), and that bull trout are not traditionally captured in floating gillnets. The 1995 fall catch was greater than any year on record, likely due to nets being set after post-spawn adult bull returned to the reservoir (10 October).

Bull trout catches in the spring were statistically different (P<0.01) among years from 1988 through 1996, with an increasing trend from 1 to just less than 3 fish per net. This increase corresponds to the closure of the bull trout season in 1994 in the Montana portion of Libby Reservoir, and special management regulations implemented in the British Columbia portion of the Kootenai Basin.

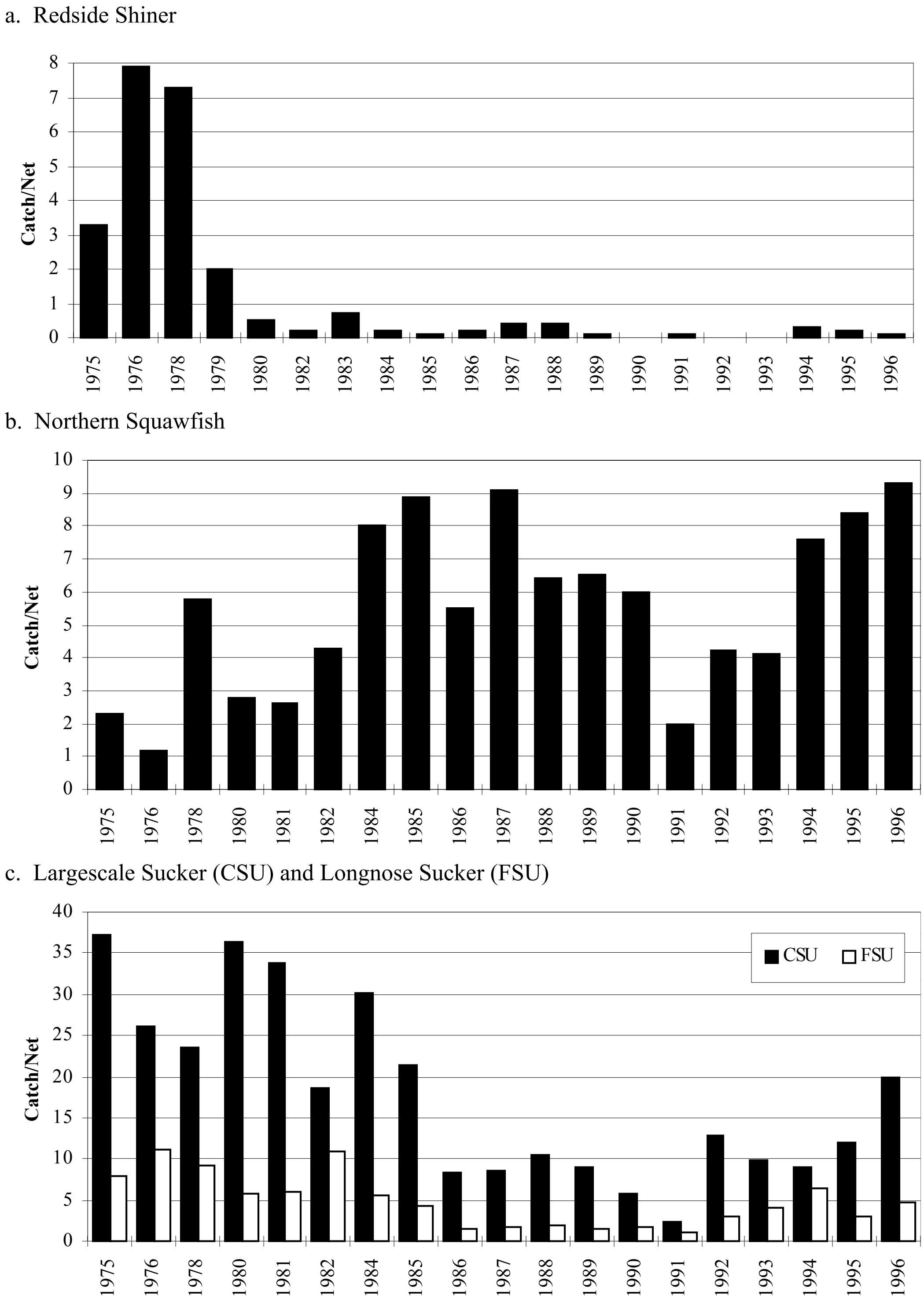


Figure 11. Catch per net of three native species ((a) redside shiner, (b) northern squawfish and (c) two sucker species (largescale and longnose)) captured in floating gillnets (a) and sinking gillnets (b and c) in Libby Reservoir, 1975 through 1996.

Harvest of six trout or char with one fish greater than 30 cm and one fish greater than 50 cm was allowed in Canada from 1994 through 1996. Creel data revealed that Canadian anglers harvested very few bull trout under these regulations. Harvest regulations for the Elk and Wigwam Rivers in Canada prior to 1994 allowed two trout or char greater than 30 cm and one greater than 50 cm. Angler reports from these tributaries indicated substantial harvest of sexually mature individuals prior to entering the spawning tributaries.

A severe flood occurred in the upper Kootenai basin in the spring of 1995, resulting in bedload movement that was of such high magnitude that it likely killed several age classes of bull trout spawning and residing in the tributaries (Bill Westover, BCMOE, personal communication). In response to the flood, a catch-and-release regulation was implemented for the Elk and Wigwam Rivers for three years (through March 1998). The current harvest regulations on bull trout for the entire Kootenai basin in Canada is one fish of any size.

Northern Squawfish

Northern squawfish were uncommon in the Kootenai River before impoundment, but increased in the new reservoir environment. Spring sinking gillnet catches increased from 1974 through 1987, while catches between 1988 and 1996 show no clear trends (Table 14; Figure 11c). Fall catches have followed a similar pattern, with early post-impoundment catches averaging 4.5 fish per net, declining to 1.5 fish per net through the late 1980's, and then increasing to current levels of approximately 3 fish per net.

Largescale Sucker

Largescale suckers were abundant in the Kootenai River before impoundment, and continued to be abundant in the spring gillnet catch from 1975 through 1984. Catch declined from 1985 through 1991 (2.4 fish per net in 1991, the lowest on record). This may be an artifact of later sampling dates in the previous analysis, even though a relatively high number were captured in 1984 with a late sampling date (6/12). Sampling dates since 1988 have remained relatively constant at the first or second week in May, and only surface temperature and water elevation have varied. No clear correlation with either of these variables exists, and while catch has followed the decreasing trend exhibited by the majority of species (excluding peamouth), the latest increase may simply be due to the randomness of gillnet catch and varying year class strengths. From 1988 through 1996, largescale suckers have averaged 10% of the spring gillnet catch (Table 18).

Longnose Sucker

Longnose suckers were uncommon in the Kootenai River before impoundment (Chisholm et al. 1989). Following impoundment, the highest catch rate was in 1976, when 11.1 fish per net were caught in spring sinking gillnets. The lowest catch rate was in 1991, when only 1.1 fish per net were caught (Table 14, Figure 11c). Longnose suckers averaged 3.5% of the spring gillnet catch from 1988 through 1996 (Table 18).

Burbot

Burbot catch in spring sinking gillnets were low in the first years following impoundment; catch averaged 0.47 per net from 1975 through 1987 (Table 14). Numbers gradually increased to 1.2 fish per net in 1988, then declined to levels comparable to early post-impoundment. Average catch rate from 1988 through 1996 was 0.43 fish per net (Table 14). Catch rates varied significantly among years from 1988 and 1996 (Tukey ANOVA; $P < 0.01$), but there was no significant decline in density from 1975 through 1996.

Gillnetting is a poor indicator of burbot population trends. Evidence suggests that baited hoopnets are a more efficient capture method (Jensen 1986, Bernard et al. 1991). Burbot may not be highly active during spring gillnetting periods, thus compounding the inefficiency of gillnets.

Burbot movement, spawning requirements, varial zone use, age and size class composition and angler creel investigations have occurred in Libby Reservoir since 1995. These data are forthcoming in the annual report compiled by the Deep Drawdown Mitigation Project.

Total Fish Abundance

The average total catch of all species in the floating gillnets declined between 1988 and 1996, although no statistically significant differences were found. No significant change occurred in total catch since 1975 (Table 13, Figure 12). Apparent declines since 1988 were primarily due to reduced catch of peamouth and kokanee (~ 80% of catch). Kokanee effectively exploited the new reservoir niche and comprised 49% of the catch by 1988, while peamouth oscillated between 50 and 80 percent of total catch (Figures 9, 5). These declining catch rates can be attributed in part to an aging reservoir which experiences low hydraulic residence times and highly fluctuating varial zones (Table 3).

Fish caught in spring sinking nets increased from 1988 through 1996. The three highest catches occurred in 1992, 1994 and 1990 (Figure 8). Peamouth comprised 82%, 83% and 77% of the catch during these years. Correspondingly, kokanee catch declined through these years (Figure 9, Table 18). The unvegetated varial zone appears to provide an abundance of nondescript habitat necessary for peamouth proliferation.

Fish assemblage changes in Libby Reservoir from 1988 through 1996 have been minor compared to 1975 through 1987, except for increasing peamouth abundance (Tables 13, 14 and 18). Reservoir aging has coincided with the decline of native species (Figures 6 and 7). Species that were dependent on the mainstem river, or are dependent on tributaries, for spawning and rearing continue to decline (Figure 10), while species not reliant on these habitats are increasing (Figure 9). The predicted period of trophic equilibrium (Kimmel and Groeger 1986) has not been observed, primarily due to the introduction of kokanee salmon, which increased in numbers until 1988, but have fluctuated annually since. The introduction of Kamloops rainbow trout has not

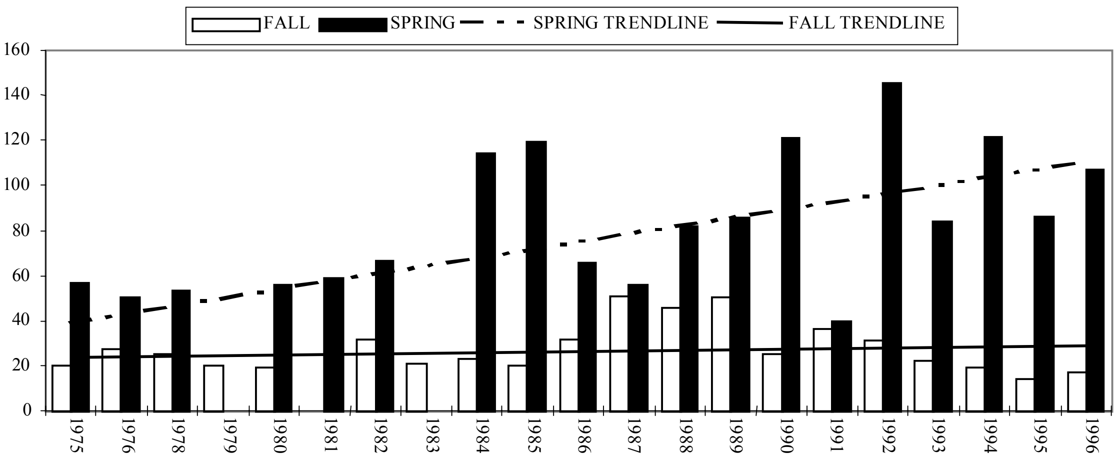


Figure 12. Catch per net (all species combined) in fall floating and spring sinking gillnets and associated trend lines in Libby Reservoir, 1988 through 1996.

provided the expected trophy fishery. Future research efforts should focus on quantification of this population and identification of limiting factors.

Total standing stock of fish in Libby Reservoir, as indicated by spring sinking gillnet captures, is increasing predominantly because of peamouth, which use limnetic production. Jenkins and Morais (1971) found reservoir age (based on observations from 100+ reservoirs) had no effect on total fish standing stock due to increases in clupeid abundance. The numerical dominance of peamouth became apparent in the late 1980's (10-15 years after impoundment) and has continued to dominate the spring catch.

Table 18. Percent composition of major fish species caught in fall floating and spring sinking gillnets in Libby Reservoir, 1988 through 1996. Blank entries in table indicate either no fish were captured or that they occurred in only extremely rare instances.

	1988		1989		1990		1991		1992		1993		1994		1995		1996	
	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.	Fall	Spr.
RB	1.4		0.1		0.2		0.4		0.1		0.4		0.2		0.6		0.3	
WCT	0.8		0.2		0.5		0.6		0.7		0.9		0.1		0.1		0.2	
ONC*	2.2	0.7	0.3	0.4	0.7	0.1	1.0	0.4	0.9	0.1	1.3	0.3	0.3	0.2	0.7	0.4	0.5	1.0
MWF	0.3	1.6	0.1	0.8	0.2	0.2	0.5	0.7	0.2	0.6	0.3	0.2	0.4	0.3	0.3	1.7	0.3	1.5
CRC	18.7	63.8	35.6	66.0	18.2	82.6	18.4	76.5	23.3	81.7	17.1	73.9	10.4	77.0	1.2	62.9	11.7	56.9
NSQ	1.4	7.7	2.1	7.4	1.8	4.8	2.1	5.0	1.8	2.9	2.2	5.0	3.4	6.2	2.7	9.3	1.8	8.7
RSS	0.4	0.2	0.1	0.1	0	0.0	0.1	0.0	0	0.3	0	0.0	0.3	0.0	0.2	0.0	0.1	0.0
FSU		2.3		1.6		1.5		2.6		2.0		5.2		5.3		3.5		4.4
CSU	<0.1	12.7	0.1	10.3	0.1	4.5	0.1	5.9	0	8.8	0.1	9.7	0.1	7.3	0	13.9	0.4	18.6
KOK	22.4	1.7	11.8	2.1	3.9	1.5	13.7	1.6	5	0.3	1	3.4	4	0.2	7.9	2.4	2.3	1.8
YP		5.5		9.4		3.7		5.2		1.2		1.1		0.9		2.9		3.4
DV		2.4		1.4		1.0		1.1		1.7		1.1		2.5		2.8		3.3
LING		1.4		0.5		0.1		1.0		0.4		0.1		0.1		0.1		0.4

*ONC= Combined Rainbow, westslope cutthroat and hybrid trout.

FISH FOOD HABITS

Methods

Fish stomachs were collected from gillnet catches during 1983 through 1992. The stomachs were emptied into labeled plastic vials with a formalin preservative prior to the autumn of 1986, and a 95 percent ethanol solution after the autumn of 1986. Stomach contents were sorted into taxonomic groups, counted and weighed. Analyzing zooplankton and other abundant small food items entailed the sub-sampling methods described previously. Wet weights of all food categories, except zooplankton, were measured to the nearest 0.001 g after blotting excess water.

After separating larger food items from a stomach sample, zooplankton were sorted by genus and counted. The majority of zooplankton in some samples were fragmented and difficult to count, in which case identifiable body parts were used to estimate the number of each genus in the sample. In the earliest samples (summer 1983), lengths of *Bosmina spp*., *Diaptomus spp*., *Epishura spp*. and *Cyclops spp*. were estimated as 0.3, 0.7, 1.2 and 0.5 mm, respectively. These figures were determined from average lengths of zooplankton measured from zooplankton samples taken at the same time. Mean zooplankton lengths from later samples (fall 1983), were calculated directly from stomach samples. Dry weights for zooplankton were estimated using length- weight regressions (sensu Bottrell et al. 1976) and were converted into wet weights using a multiplication factor of 10. This multiplication factor was found to be applicable for wet weights between 10 and 300 mg, the range most frequently found in Libby Reservoir. Estimates of wet weights for *Leptodora spp*. were calculated by applying a standard 6 mm. Length to length-weight tables established by Cummins et al. (1969). Initial lengths of *Daphnia spp.* in stomach samples (summer of 1983) were estimated using measurements of the post-abdominal claw (Leathe and Graham 1982). Later lengths were measured directly from stomach samples.

A relative importance index (RII) was calculated to estimate the importance of particular food items (George and Hadley 1979). RII is the arithmetic mean of the number, frequency of occurrence, and weight of a food item in the diet, expressed as a percentage (FH.1). RII values range from zero to 100, with a value of 100 indicating exclusive use of a food item. Due to problems enumerating parts of insects, the RII's for insect parts were calculated only from the frequency of occurrence and weight data; no fish parts or unidentifiable items were used in the calculations of the RII's.

$$\mathbf{RII=100\ AI/\Sigma_{1-n}\ AI} \quad \text{(FH. 1)}$$

where:

AI = % frequency occurrence + % total number + % total weight

n = number of different food types

The Schoener overlap index (Schoener 1970) was used to determine potential dietary overlap between species. The Schoener index gives values from 0 (no overlap) to 1 (complete overlap).

$$\alpha = \mathbf{1\text{-}0.5}(\Sigma_{i=1\text{-}n} \lvert \boldsymbol{pxi\text{-}pyi} \rvert) \qquad \text{(FH. 2)}$$

where:

α = Schoener overlap index

pxi = proportion of food category *I* in the diet of fish species *x*

pyi = proportion of food category *I* in the diet of fish species *y*

The Schoener index of dietary overlap (FH.2) was calculated to determine possible interspecific competition among eight species in Libby Reservoir from 1988 through 1992. Some ambiguities have been related to combinations of diet measures and dietary overlap indices (Wallace 1981). For this reason, the Schoener index was based for average weights of food items found in the stomachs, resulting in an index which more closely parallels caloric intake of each food item. A Schoener index using RII values was completed to allow comparison between the two indices, as well as to attempt to explain the overlapping values for smaller food items such as *Diptera* and zooplankton.

Analysis was conducted on data collected for all species from 1988 through 1992, although data from 1983 through 1987 for game species (trout, kokanee, burbot and bull trout) were also included for comparison. Stomachs from 490 kokanee captured during 1983 through 1991 were used in food habits analysis. Kokanee stomachs from 1992 were not used in the analysis due to small sample size. Stomachs from 1,045 trout (westslope cutthroat, rainbow, and cutthroat X rainbow hybrids combined) captured in Libby Reservoir from 1983 through 1992 were examined. Trout species samples were combined due to the difficulty of positively identifying the species in the field and similarity of food habits (Chisholm and Fraley 1986, Huston et al. 1984, McMullin 1979). Stomach samples were separated into those from fish <330 mm TL and those from fish >330 mm TL to determine differences in food utilization between sub-adults and adults (McMullin 1979).

Results and Discussion

595 (1988 through 1992) and 2,127 (1983 through 1987) fish stomach samples from Libby Reservoir were collected and analyzed for food habits. Stomachs from all geographic areas of the reservoir were used to insure comprehensive sampling. Empty stomachs were not included in analyses.

Kokanee

Zooplankters were the most important food items for kokanee salmon in all years. RII values for zooplankton ranged from 71 to 98 from 1983 through 1991 (Table 19). With respect to zooplankton, *Daphnia* had the highest RII values for all years except for 1990. RII values for *Daphnia* ranged from 18 in 1990 to 95 in 1986. *Diaptomus* were next in importance, but did not comprise more than 28 percent of the diet (Table 19). *Diptera* (larvae, pupae and adult) were

Table 19. Relative Importance Indices for food items in the stomachs of kokanee salmon in Libby Reservoir, 1983 through 1991.

Year:	1983	1984	1985	1986	1987	1988	1989	1990	1991
Sample Size:	N=21	N=91	N=99	N=70	N=19	N=63	N=53	N=40	N=34
Zooplankton									
Daphnia	60	67	60	95	81	38	44	18	56
Diaptomus	22	25	28	3	11	28	8	21	10
Epischura	5	5	3			8	3	2	9
Cyclops	8	1	1			10	23	27	4
Other plankton	3					12	17	3	19
Total zooplankton.	98	98	92	98	92	96	95	71	98
Terrestrial. Insects									
Hymenoptera							1	2	
Coleoptera		1						3	
Hemiptera								1	
Homoptera							1	2	
Other insects		1	1						
Total terrestrial		2	1				2	8	
Aquatic Insects									
Diptera larvae				1			2	6	
Diptera pupae	2		5		8			6	
Diptera adult							1	3	1
Other *Diptera*									
Insect parts		1	2				1	6	1
Total aquatic	2	1	7	1	8		4	21	2

important during the spring at low levels during all years with the exception of 1990, when use peaked at an RII of 15. This corresponds with reduced use of *Daphnia* and total zooplankton in general (Table 20). Furthermore, *Daphnia,* as a percent of total zooplankton in the reservoir, were at an all time low during 1989 and 1990 (Table 7).

Kokanee selected zooplankton throughout the year. *Daphnia spp*. were the most important food items for all months except February, when *Diaptomus* became the most important. *Diaptomus* were also important as a secondary food source between December and April. *Epischura*, a large copepod, were important sporadically throughout the summer and fall months. These food habit data correspond with those in other lakes (Finnel and Reed 1969, Leathe and Graham 1982, Schneidervin and Hubert 1987).

Table 20. Monthly Relative Importance Indices for food items in stomachs of kokanee salmon in Libby Reservoir, 1983 through 1992.

Sample Size:	56	34	46	37	46	10	9	80	78	40	20	38
Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Zooplankton												
Daphnia	45	41	37	35	37	71	100	72	83	60	68	51
Diaptomus	30	59	47	23	6			3	2	8	4	29
Epischura	4		4		1	11		4	2	8	19	4
Cyclops	16		8	23	7	7		7	6	4	3	6
Other plankton	5		3	5		3		13	7	12	1	9
Total Zooplankton.	100	100	99	86	51	92	100	99	100	92	95	99
Terrestrial Insects												
Hymenoptera					4	3				1		
Coleoptera			1		3	3				1		2
Hemiptera					1					1		
Homoptera					3					1		
Other terrestrials					1					1	3	
Total Terrestrials			1		12	6				5	3	2
Aquatic Insects												
Diptera larvae				9	2			1		1		
Diptera pupae				4	18				1			
Diptera adult				1	5	3				1		
Other *Diptera*										1		
Insect parts				1	12					1	3	
Total Aquatics				15	37	3		1	1	4	3	

Oncorhynchus spp (rainbow, westslope cutthroat and rainbow X cutthroat hybrid)

Terrestrial insects comprised the largest proportion of the diet and had the highest RII values for both size classes (<330 mm and >330 mm) of trout in all years (Table 21). *Diptera* larvae, (pupae and adults) were second in importance and made up the majority of aquatic insects consumed. RII values for zooplankton were relatively high in trout diets, ranging from 7 to 40 prior to 1987. RII values of zooplankton decreased to zero for trout greater than 330 mm and to less than 10 for trout under 330 mm during 1987 through 1992. Aquatic insect use stayed relatively stable throughout the study period, with a minimal increase after 1986. Trout larger than 330 mm ate fish more often after 1987 (Table 21).

The reason for the lack of zooplankton in the diet for the post-1987 period is not fully understood. Density of larger *Daphnia* (2.0-2.5 mm), the primary zooplankton eaten by trout, declined from approximately 30% (1986) to less than 2% (1990). This reduction may have prompted a shift to a more available food source, possibly terrestrial insects. Among insects, *Coleoptera*ns and *Dipterans* showed peak abundance in emergence traps and surface insect tows in Libby Reservoir during spring months (Chisholm et al. 1989), possibly resulting in high RII values during this season.

Terrestrial insects were consistently the most important food item for trout on a seasonal basis, though zooplankton were the most important food item during December through March (Table 22). Aquatic invertebrates were eaten at a relatively consistent level, ranging from 7 during winter to 19 during spring. Trout rarely consumed fish throughout the year; RII values never exceeded 1.

Table 21. Relative Importance Indices for food items in the stomachs of trout in Libby Reservoir, 1983 through 1992.

Year:	**1983**		**1984**		**1985**		**1986**		**1987**		**1988**		**1989**		**1990**		**1991**		**1992**	
Length (mm):	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330	<330	>330
Sample Size:	66	103	95	97	72	135	37	39	22	18	34	11	47	3	27	2	22	9	2	7
Zooplankton																				
Daphnia	30	29	23	13	14	7	37	27			6		1				5			
Diaptomus	1							3			1		1				1			
Epischura	1	1	6	1	2		2				2						1			
Cyclops			2				1													
Other plankton	2	3	2	2	1												1			
Total	34	33	33	16	17	7	40	30			9		2				8			
Terrestrial Insects																				
Hymenoptera	9	9	8	7	15	17	10	9	10	4	13	17	18	14	23	15	13	13	35	25
Coleoptera	6	8	18	22	13	15	9	11	26	30	14	14	14	17	18		14	18	23	26
Hemiptera	4	3	3	5	5	4	7	8		1	10	10	12	12	8		9	11	18	12
Homoptera	12	9	4	3	7	5	7	10			12	12	12	11	6	9	8	10		7
Other Terrestrial	9	10	5	5	9	10	5	5		2	8	9	9	5	7	13	11	13		2
Total Terrestrial	40	39	38	42	49	51	38	43	36	37	57	62	65	59	62	37	55	65	76	72
Aquatic Insects																				
Diptera larvae	1	3	4	8	3	5	1	3	3	3	1	4			1		1			
Diptera pupae	1		5	4	7	11	4	3	30	20	1	2	1		3	4				
Diptera adult	11	9	5	6	5	4	8	7	3	4	10	5	10	5	11	25	10	9		4
Other Aquatic	6	5	6	8	5	3	3	3		2	2	1	2	11	1	9	4	5		
Insect parts	8	11	11	12	13	16	7	7	28	34	18	20	18	15	21	10	22	21	24	19
Total Aquatic	19	17	20	26	20	23	16	16	36	29	14	12	13	16	16	38	15	14		4
FISH																				
Kokanee																				5
Largescale sucker															1					
Peamouth				1		3		1				4		11						
Northern squawfish								1												
Redside shiner				1				1							1	14				
Yellow perch												3								
Total Fish				2		3		3				7		11	2	14				5

Table 22. Seasonal Relative Importance Indices for food items in stomachs of trout in Libby Reservoir, 1983 through 1992.

Season:	Apr-June	July-Sept	Oct-Nov	Dec-Mar
Sample Size:	N=274	N=363	N=440	N=96
Zooplankton				
Daphnia	3	13	19	66
Diaptomus			1	1
Epischura	1	1	2	
Cyclops			1	
Other plankton		1	1	
Total zooplankton.	4	15	24	67
Terrestrial Insects				
Hymenoptera	13	20	8	1
Coleoptera	27	11	9	3
Hemiptera	4	7	6	
Homoptera	2	9	10	4
Other terrestrials	8	7	8	5
Total terrestrials	54	54	41	13
Aquatic Insects				
Diptera larvae	3	1	4	2
Diptera pupae	13	2	2	4
Diptera adult	5	8	9	5
Other *Diptera*	2	2	7	2
Total aquatics	23	13	22	13
Insect parts	19	15	12	7
Fish				
Peamouth		1	1	
Redside shiner				1

Bull Trout

Fish were consistently the most important food item for bull trout throughout the study period; combined RII values were 65 for 1983 through 1987, and 68 for 1988 through 1992 (Table 23). Overall, fish comprised more than 99 percent of the total biomass ingested by bull trout.

Bull trout ate at least 10 different species of fish from 1983 to 1987, but only 5 different species were found in stomachs sampled between 1988 and 1992. Kokanee, peamouth and yellow perch compensated for the loss of diversity from earlier years. Trout species (westslope cutthroat, rainbow trout and cutthroat X rainbow trout) comprised nearly 24% of fish consumed in the bull trout diet from 1983 through 1987, but from 1988 through 1992, consumption of trout species declined to zero (Table 23). Declining gillnets catch of trout species for 1988 through 1996 validate the absence in the diet (Figure 10, Table 13). Increased use of yellow perch and peamouth during 1988 through 1992 may further be explained by sampling location; stomachs during this period were collected primarily from the Rexford area of the reservoir, which traditionally had higher densities of these two species. Further changes occurred in bull trout food habits with respect to insect use; from 1983 through 1987, the cumulative RII value for insects was 35 (primarily *Diptera*ns), compared to an RII of 7 for 1988 through 1992. This decline may be an artifact of sampling location, season, or overall smaller sample size (63 vs. 24). Size of fish sampled could affect prey selection, although no apparent differences in length of bull trout sampled were found between the two sampling periods.

Prey eaten by bull trout in Libby Reservoir were unique when compared to reports from other waters in the region, though some similarities existed. Bull trout are opportunistic predators, feeding on fish species that are in greatest abundance. Leathe and Graham (1981) found that three species of whitefish were important in summer and fall in Flathead Lake, while non-game species were important during winter. Perch were also found to be an important food item for bull trout in Flathead Lake. May et al. (1988) found rough fish to be the most important fish species eaten in Hungry Horse Reservoir, while Carlander (1969) cited examples of bull trout feeding on sockeye and kokanee salmon in Idaho lakes.

Burbot

Stomach samples were collected from 45 burbot caught in Libby Reservoir from 1983 through 1992. Fish were the most important food source for burbot (Table 23); at least ten species were found in stomachs, including one instance of cannibalism. Although burbot ate a variety of fish, peamouth and yellow perch had the highest RII values for both study periods (Table 23). Larval *Diptera*ns were also important throughout, but mainly to smaller burbot (<450 mm).

When comparing early samples (1983 through 1987) with later samples (1988 and 1991), insect use was more than double in the earlier years (22 vs. 9; Table 23). Fish use mirrored the changes that were evident in bull trout. Kokanee and yellow perch remained important through both study periods, while benthic species (peamouth and squawfish) increased in importance, compensating for decreasing use and availability of whitefish and largescale sucker.

Table 23. Relative Importance Indices for bull trout and burbot in Libby Reservoir, 1983 through 1992.

Species:	BULL TROUT	BULL TROUT	BURBOT	BURBOT
Years:	1983-1987	1988-1992	1983-1987	1988-1992
Sample Size:	63	24	39	16
INSECTS				
Hymenoptera	3	3		
Other terrestrials				3
Diptera larvae			14	
Diptera pupae	29	4	3	6
Diptera adult	2			
Other aquatic			5	
Insect parts	1			
Total Insects	35	7	22	9
FISH				
Cutthroat	6		3	
Rainbow	2			
Rainbow X cutthroat	4			
Kokanee	14	35	10	12
Whitefish	2	4	3	
Ling			3	
Longnose sucker	2		3	6
Largescale sucker	3		5	
Peamouth	16	27	17	29
Squawfish	3	3		10
Redside shiner	7		8	13
Yellow perch	5	24	26	22
Other fish	2		3	
Total Fish	66	93	81	92

Burbot ate yellow perch and peamouth during spring, reflecting the likely habitat overlap during this period. Yellow perch spawn in sandy areas in the spring (April - June), when vegetation is scarce (Brown 1971, Scott and Crossman 1973).

Other Fishes

Food habits for northern squawfish, peamouth chub, largescale sucker, yellow perch, and mountain whitefish caught in Libby Reservoir from 1988 through 1992 were also examined (Table 24). Except for perch, these species are native to the Kootenai Drainage, and represent an important component of the fish assemblage. They also are important from a trophic analysis perspective in that they generally overlap with game fish, including species of special concern (i.e., westslope cutthroat and bull trout). The high density of peamouth chub represents a substantial component of tertiary level biomass, and serves as an indicator of the changing trophic status of the reservoir.

Northern squawfish food habits were obtained from samples collected spring through fall during the study period. Squawfish were opportunistic feeders, eating food items ranging from zooplankton to seven different species of fish. Fish were collectively the most important food source (Table 24), comprising no less than 90 percent of the total biomass eaten. Kokanee and peamouth were the most important fish items used by squawfish, with RII values of 19 each.

Peamouth chubs most commonly ate *Daphnia* and aquatic invertebrates, with cumulative RII values of 39 and 24 respectively. Zooplankton (all species combined) accounted for an RII of 29. Terrestrial invertebrates comprised the majority of the remaining food consumed by peamouth chubs.

Largescale suckers ate predominantly *Daphnia* (RII=56) during 1983 through 1987 (Chisholm et al. 1989); less *Daphnia* were eaten during 1987 through 1992 (RII=16). As a group, zooplankton were the most important food source for largescale suckers, with a combined RII of 43. *Diptera* larvae had the highest individual RII value (22) of any food item during 1987 through 1992.

Mountain whitefish ate primarily *Daphnia* (>70%) during 1983 through 1987. They apparently converted to benthic feeding habits during 1988 to 1992, when *Diptera* larvae were their primary food source (RII= 27).

Table 24. Relative Importance indices for food items in the stomachs of non-game species in Libby Reservoir, 1983 through 1991.

Species:	SQUAWFISH	PEAMOUTH	YELLOW PERCH	LARGESCALE SUCKER	WHITEFISH
Sample Size:	40	100	6	19	16
ZOOPLANKTON					
Daphnia	2	24		16	25
Diaptomus	1			8	2
Cyclops				10	4
Other plankton		5		9	1
INSECTS					
Hymenoptera	3	6			7
Coleoptera		5			
Hemiptera	1				
Homoptera	1	4		2	
Other terrestrials	2				
Diptera larvae	3	17	41	22	27
Diptera pupae		11	5	13	2
Diptera adult	4	8			11
Other aquatic	1	3	8	3	
Insect parts	3	16	20	16	22
FISH					
Kokanee	19				
Mountain Whitefish	5				
Longnose sucker	5				
Largescale sucker	7				
Peamouth	19				
Redside shiner	2		26		
Yellow perch	7				
Other fish	14				

Schoener Overlap Index (SOI)

Overlap values among non-piscivorous fish ranged from 0.11 for kokanee and trout to 0.80 for mountain whitefish and peamouth (Table 25). Kokanee, mountain whitefish and trout had minimal overlap values (none exceeding 0.5). Peamouth, whitefish and largescale suckers had the highest overlap values, ranging from 0.71 to 0.8. The most common food items for peamouth, whitefish, and largescale suckers were *Daphnia* and *Diptera* larvae.

Trout and kokanee showed little dietary overlap (SOI=0.11, Table 25). However, this does not reflect potential overlap during winter, when both species ate *Daphnia*. Kokanee maintained a diet primarily of zooplankton during the rest of the year, while trout shifted to macroinvertibrates (Table 22).

Many fish species in Libby Reservoir that showed piscivorous tendencies had relatively high Schoener index values (Table 25). High overlap values among bull trout, burbot and northern squawfish were observed. Bull trout and burbot fed heavily on peamouth and yellow perch, while squawfish were more general in their food selection (Table 23). Trout species showed little dietary overlap with other piscivorous species (Table 21).

Table 25. Schoener overlap index for fish food habits in Libby Reservoir from 1988 through 1992.

				Using weight			
	Trout	Sucker	Peamouth	Whitefish	Bull trout	Burbot	Squawfish
Kokanee	0.11	0.39	0.45	0.37	0	0.01	0.09
Trout		0.45	0.41	0.43	0.03	0.04	0.18
Suckers			0.71	0.74	0	0.02	0.15
Peamouth				0.80	0	0.06	0.17
Whitefish					0	0	0.16
Bull trout						0.69	0.52
Burbot							0.43

				Using relative importance index			
	Trout	Sucker	Peamouth	Whitefish	Bull trout	Burbot	Squawfish
Kokanee	0.13	0.4	0.39	0.4	0.02	0.02	0.11
Trout		0.29	0.48	0.43	0.05	0.06	0.21
Suckers			0.65	0.63	0.04	0.06	0.12
Peamouth				0.74	0.07	0.06	0.19
Whitefish					0.04	0.02	0.17
Bull trout						0.68	0.51
Burbot							0.47

The high Schoener index values (similar percent biomass) in the stomachs of mountain whitefish, peamouth and largescale suckers suggest interspecific competition. Mountain whitefish feed heavily on zooplankton (May et al. 1988, Scott and Crossman 1973), and are also known to eat aquatic insects (Brown 1971). In addition, peamouth and largescale suckers of all sizes, especially juveniles, are known to feed heavily on zooplankton (Carlander 1969, Brown 1971, Scott and Crossman 1973). Godfrey (1955) found that mountain whitefish fed on limnetic plankton mostly when bottom organisms were scarce. The change in feeding habits of mountain whitefish may be indicative of a change in food availability, and may explain declines in spring sinking gillnet catches (Figure 10, Table 14).

BULL TROUT REDD COUNTS

Personnel from MFWP surveyed the Grave Creek drainage in 1983, marking the beginning of ongoing bull trout redd counts in the Kootenai River drainage. Quartz, West Fork of Quartz, and Pipe Creeks were added to the list of surveyed streams in 1984. Due to added concern over diminishing bull trout populations throughout Montana, we began surveying other streams in the Kootenai River and Libby Reservoir basin in 1991. A total of 45 streams and 165 miles have been surveyed for bull trout redds to date. Streams were eliminated from the monitoring list if they lacked suitable spawning habitat and if there was no evidence of adult bull trout use.

Special restrictive fishing regulations were adopted in the early 1990's in response to increasing concern over declining bull trout populations across their range, including Montana. The Kootenai drainage (Quartz Creek) was closed to all fishing from July 15 to the third Saturday in May in 1992. A statewide closure (except the Swan Drainage) was imposed on all bull trout fishing in 1993. No angling has been allowed within 100-yard radius of the mouths of O'Brien and Quartz Creek from 1 June through 30 August since 1996.

Methods

Redd surveys were conducted in the fall, (usually October) after bull trout spawned. MFWP and U.S. Forest Service (USFS) personnel walked streams, counting "positive" and "possible" redds. "Possible" redds were those that did not have fully developed pits and gravel berms. Since 1993, only "positive" redds have been counted, and are included in tables and figures for this report. In addition to counting redds, their size and location were also noted. Surveyors recorded suitable habitat and barriers to spawning bull trout when a stream was surveyed for the first time.

MFWP personnel have placed traps for spawning adult bull trout to monitor upstream migration in several streams. A summary of our trapping effort will be included in "Quantification of Libby Reservoir Levels Needed to Maintain or Enhance Reservoir Fisheries, Kootenai River Investigations, 1990-1997". This report will be completed in 1998.

Results and Discussion

The Montana Bull Trout Scientific Group divided the Kootenai River into three separate core areas; Upper Kootenai River (upstream of Libby Dam), Middle Kootenai River (Kootenai Falls to Libby Dam) and the Lower Kootenai River (downstream of Kootenai Falls). We found the highest concentration of redds in the Middle Kootenai core area in Quartz and West Fork (W.F.) Quartz Creeks. In the Lower Kootenai core area, the highest concentration of redds was in O'Brien Creek. The Grave Creek drainage had the highest concentration of adfluvial bull trout redds in the United States tributaries of the Upper Kootenai River core area. The Wigwam River Basin in British Columbia had the highest concentration of redds for the Canadian tributaries of the Upper Kootenai core area population. Keeler Creek, a tributary of Lake Creek, supports a run of adfluvial bull trout isolated from the Lower Kootenai River. Redd counts in Keeler Creek were initiated in 1996.

Bear Creek, Pipe Creek and East Fork (E.F.) Fisher River are used sparingly by spawning bull trout. Other tributaries of the Kootenai River have little or no spawning habitat for bull trout. Due to the lack of historic data on most streams, it is difficult to know if these streams once supported runs of adfluvial or fluvial bull trout.

Upper Kootenai River

- ***Grave Creek***

MFWP counted redds in the Grave Creek Basin (including Blue Sky, Clarence, Williams and Lewis Creeks) for the first time in 1983, as well as in 1984, 1985, and 1993 through 1996. Grave Creek was surveyed from its confluence with the Tobacco River upstream to near the mouth of Lewis Creek (~13 mi.), where it becomes intermittent. Most redds in Grave Creek were located upstream from the mouth of Clarence Creek to the confluence with Lewis Creek. Surveyors found 10 redds (Table 26) between the confluence with the Tobacco River and one mile below Clarence Creek in 1983. We did not find redds in this reach during the most recent surveys (1993 through 1996).

We found 57 redds in 1994, which was significantly greater than the long-term mean (Figure 13). Beaver activity may have affected redd location in 1994; two large beaver dams were constructed about one mile downstream from the confluence with Grave and Lewis Creeks, resulting in only two redds counted above them. It is probable that these dams were impeding bull trout from moving further upstream. Most redds were located in the first two and half miles above the confluence with Clarence Creek. High precipitation and increased runoff made redd counts difficult in 1995, possibly explaining the low redd count .

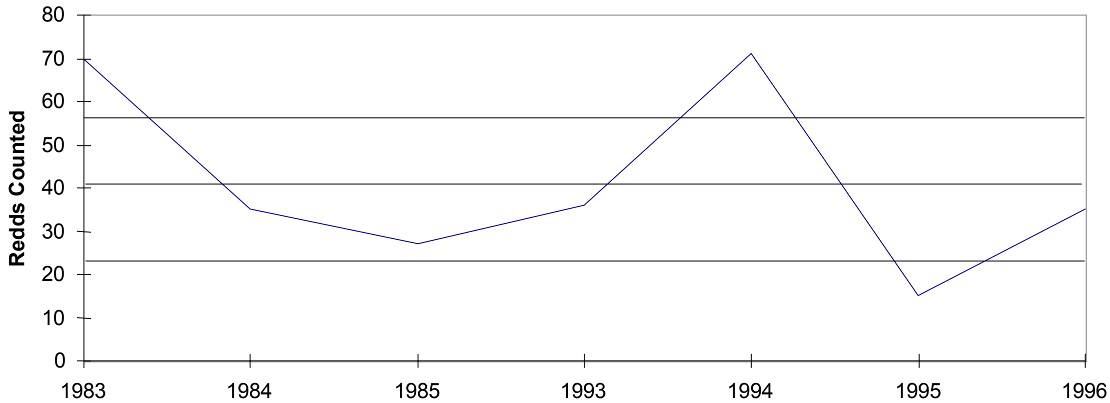
Clarence and Blue Sky Creeks were surveyed in conjunction with Grave Creek. Redd locations in Clarence Creek were similar during each survey, except for 10 redds found above the bridge on road number 7036 in 1983. No redds were found in this reach during later surveys (1993 through 1996). Surveyors found few redds in Blue Sky Creek, which has scattered patches of quality gravel. No redds were found in Lewis, Williams, or Stahl Creeks (Table 27), which were surveyed in 1983 and 1993, though juvenile bull trout were present in each of the streams.

Table 26. Bull trout redd survey summary for all index tributaries in the Kootenai River Basin

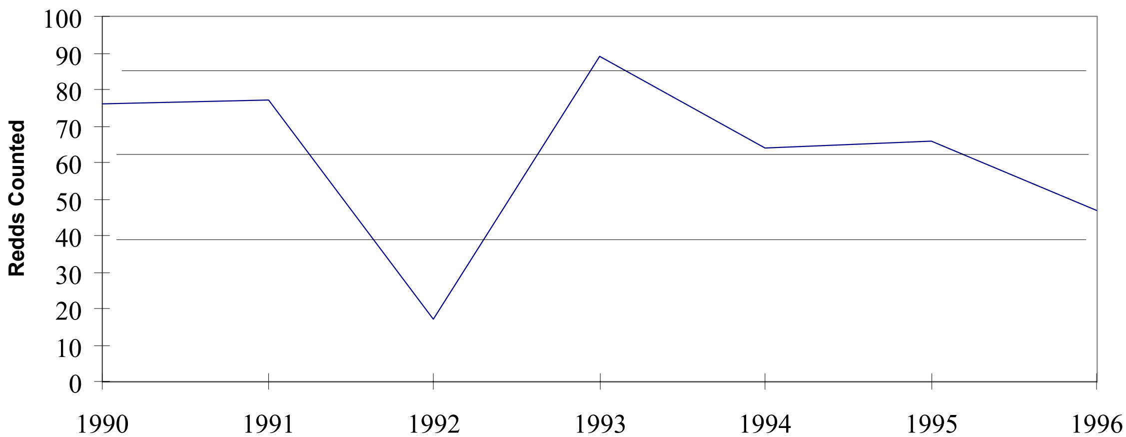
Stream	Year Surveyed	No. of Redds	Miles Surveyed
Grave[a]	1983	70	17
	1984	35	17
	1985	27	9
	1991	27	15
	1993	36	17.1
	1994	71	11.5
	1995	15	9
	1996	35	17
Quartz[b]	1990	76	9
	1991	77	10
	1992	17	10
	1993	89	10.8
	1994	64	12.5
	1995	66	12.5
	1996	47	12.0
O'Brien	1991	25	13.25
	1992	24	8.0
	1993	6	8.0
	1994	7	6.5
	1995	22	4.5
	1996	12	4.0
Pipe	1990	6	10
	1991	5	10.5
	1992	11	11.5
	1993	6	13.5
	1994	7	9.8
	1995	5	10
	1996	17	12.0
Bear	1995	6	3.0
	1996	10	4.5
Keeler[c]	1996	74	9.3
Wigwam (U.S.)	1996	12	2.0
Wigwam (B.C)	1994[d]	105	-----
	1995[d]	247	24
	1996[e]	512	24

a. Includes Blue Sky and Clarence Creeks
b. Includes West Fork Quartz Creek
c. Includes West, South and North Forks of Keeler Creek
d. Includes Ram and Lodgepole Creeks
e. Includes Bighorn, Desolation, Lodgepole, Rabbit Creeks[a]. Grave Creek (Grave, Clarence and Blue Sky Creeks)

a. Grave Creek (Grave, Clarence and Blue Sky Creeks)



b. Quartz Creek (Quartz and West Fork Quartz Creeks)



c. O'Brien Creek

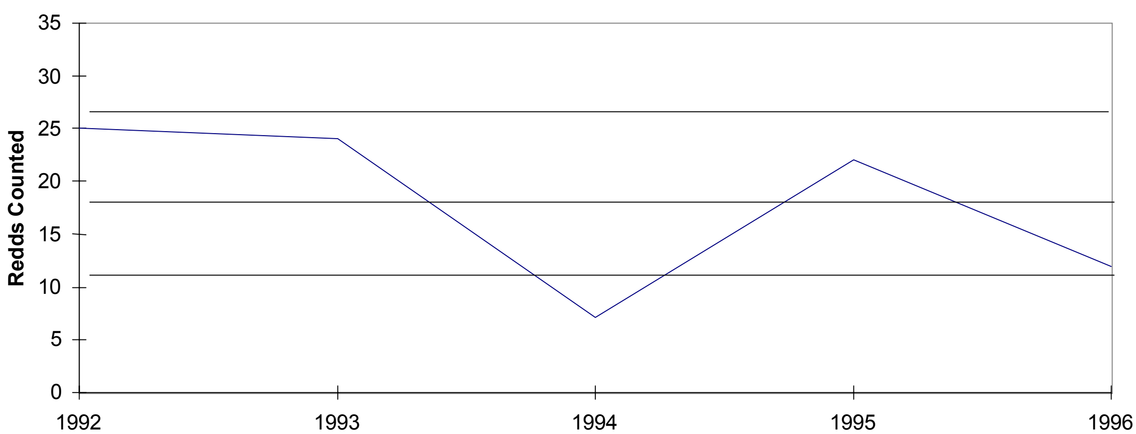


Figure 13. Bull trout redd counts for principal index streams in the three bull trout core areas, including mean, and upper and lower 95% confidence intervals.

Table 27. Summary of redd surveys (MFWP & USFS) in the Kootenai River Basin streams with limited use by spawning bull trout.

Tributaries to Kootenai River Below Dam				Tributaries to Libby Reservoir			
Stream	Years	Redds	Miles	Stream	Years	Redds	Miles
Big Cherry	91	0	5.0	Baree	91	0	0.5
Cable	91	0	2.7	Barron	92	0	4.0
Callahan	91	0	8.5	Bristow	92	0	3.0
Deep	91	0	1.0	Canyon	92,95	0, 0	0.5, 0.5
Dunn	91, 93	0, 0	0.25, 0.5	Cripple Horse	93	0	0.25
E. Fork Fisher	91, 93, 95	1, 4, 0	4.0, 4.0, 8.0	Deep	95	0	4.0
E. Fork Pipe	90 - 96	0	2.0	Five Mile	92	0	4.5
Granite	91, 96	0, 0	6.0, 1.0	Jackson	92	0	1.0
Libby	91, 95	0, 0	5.0, 10.0	Lewis	83, 93	0, 0	1.0, 1.0
Little Cherry	95	0	2.0	Stahl	93	0	2.0
Fisher River	92, 93	0, 1	2.5, 1.0	Warland	93	0	0.25
N. Callahan	91	0	2.0				
Richards	93	0	0.25				
Ruby	92	0	0.25				
Silver Butte Fisher	91, 93, 95	0, 0, 0	3.0, 7.0, 7.0				
S. Callahan	91	0	3.0				
Stanley	96	0	3.0				
Star	92	0	0.25				
Swamp	91	8	2.0				
Trail	95	0	4.75				
W. Fk. Fisher	95	1	8.0				
W. Fk. Keeler	96	0	0.5				
Yaak River	91	0	10.5				

- ***Wigwam Drainage***

Bill Westover of British Columbia Ministry of Environment (BCMOE) flew the Wigwam Drainage to count bull trout redds in 1994. This was a follow-up survey to compare bull trout use to numbers estimated from trapping efforts during 1979 (515). A total of 77 redds were counted on the October, 1994 flight. These redds were never ground-truthed, but the percent difference between redd numbers by plane and on ground in 1995 was used to calculate a "true" number of redds in 1994. By using this ratio, 105 redds were estimated for the Wigwam Drainage in 1994 (Table 26, Westover 1995).

In 1995, the Wigwam River, along with Ram and Lodgepole Creeks, was surveyed by plane and then ground-truthed in 1995. Ground-truthing revealed 36.9 % more redds than the air counts (Bill Westover, BCMOE, personal communication). In 1996, personnel from BCMOE and MFWP surveyed the Wigwam River basin (including Bighorn, Desolation, Lodgepole and Rabbit Creeks) and counted 512 redds (Table 26), the highest number in the Wigwam to date. MFWP personnel counted 12 redds (Table 26) in 1996 in a 2 mi. reach of the U.S. portion of the Wigwam (first redd survey for this reach).

- ***Other Streams***

We surveyed 11 other tributaries in the Upper Kootenai River core area (Table 27). Most of these streams are small and drain directly into Libby Reservoir. These 11 streams provide little adequate spawning habitat for adfluvial bull trout, and no bull trout redds were found in these streams.

Middle Kootenai River

- ***Quartz Creek***

MFWP personnel surveyed W.F. Quartz Creek for the first time in 1985. Later surveys included both Quartz and W.F. Quartz Creeks (Marotz et al. 1988). Bull trout use of W.F. Quartz was heavier than the main stem of Quartz Creek, which is consistent with recent survey results. Of the 35 redds counted in 1987, 20 were identified as "positive" and 15 as "possible". Redd numbers have been consistent since 1990; only 1992 counts were significantly lower than the long-term mean (Figure 13). There are no obvious explanations for this low count (17), but since bull trout mature at four to six years of age, this weak spawning run could effect future bull trout runs in Quartz Creek.

Although redd numbers have remained stable (Table 26), distribution of redds in Quartz and W. F. Quartz Creeks have varied. Counts in Quartz Creek upstream from the confluence with the W.F. declined. The upper W.F. Quartz Creek, which usually had a high number of redds, had only three in 1994, possibly due to low water and a high concentration of beaver activity in Quartz Creek approximately 1.5 miles downstream from the W. F. confluence. MFWP counted 33 bull trout redds, and 15 adult bull trout in this section of Quartz Creek. The gravel used by bull trout in this section was recently collected by the beaver dams and appeared to be of poor quality (Mike Hensler, MFWP, personal communication, 1994). There is historic beaver activity in Quartz Creek, but spring runoff typically kept the main channel clear of obstructions. As evidenced by redd survey observations and limited electrofishing, Quartz Creek is the only bull trout spawning tributary below Libby Dam which does not support a large population of brook trout.

- ***Pipe Creek***

Pipe Creek has been surveyed for bull trout redds since 1991. Redds were consistently found in the same five mile reach during the 1991 through 1996 surveys; counts were consistently low, ranging from 17 in 1996 to 5 in several other years (Table 26). Only 7 miles of the 13.5 miles surveyed appear to have adequate bull trout spawning habitat. No suitable spawning gravels exist in the lower 5 miles of Pipe Creek. Some redds counted as bull trout redds may have actually been large brook trout redds, or several superimposed brook trout redds. Beaver dams and high sediment have degraded the bull trout spawning habitat in Pipe Creek.

We surveyed the lower two miles of E.F. Pipe Creek concurrently with the Pipe Creek surveys. No positive bull trout redds have been found, though surveyors counted 45 brook trout redds in 1995. Most spawning gravel in E.F. Pipe Creek is small and present only in small patches.

- ***Fisher River Drainage***

The Fisher River and it's tributaries have been surveyed by MFWP and USFS personnel every year since 1991. Much of the Fisher River drainage has gravel substrate, but high amounts of sediment degrade this gravel for spawning fish. Extensive land-use problems exist in the Fisher drainage, including logging, grazing, railroad and road building activities. Land use problems are exacerbated by soil that has moderate to high substratum and surface erodibility (Kuenhen and Gerhart 1984). Fine materials in the substrate and high flows are common causes of mortality to bull trout eggs and alevins (Weaver and Fraley 1991). Based on our trapping data, the Fisher River Basin appears to support a small, late run of bull trout. Fisher River traps captured bull trout from September 9 through October 9, which is much later than traps in O'Brien and Quartz Creeks. Temperatures in excess of about 59^0 F are thought to limit bull trout distribution (Rieman and McIntyre 1993). High water temperatures during late summer months may deter bull trout from migrating up the Fisher River. Bull trout were not captured until the maximum water temperature decreased to about 62 ^{0}F in 1993 and 1994 (Figure 14).

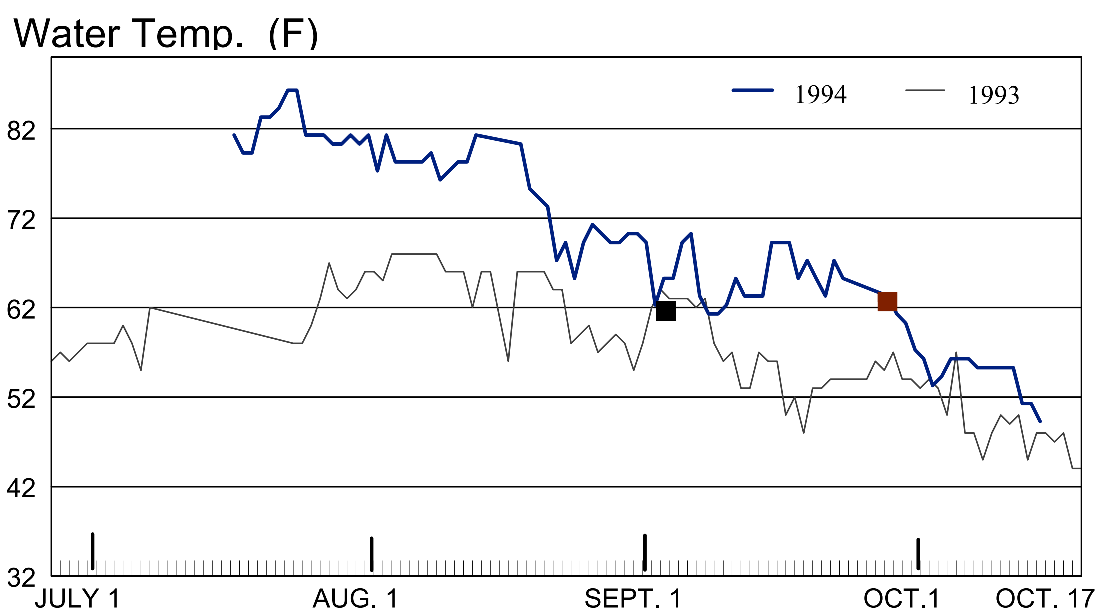


Figure 14. Peak water temperatures during bull trout trapping in the Fisher River. Blocks indicate when the first bull trout were captured each year.

- ***Libby Creek***

Migrating adult bull trout were trapped in Libby Creek during the summer of 1996. The trap was effectively operated from 16 July to 12 September, capturing only two adult bull trout. In spite of the small number of bull trout captured, ten bull trout redds were counted in Bear Creek, which is the only tributary to Libby Creek above the trap where bull trout redds have been found during all redd surveys (Table 27). It is likely that we set up the trap after most bull trout had moved upstream. In future years, other tributaries of Libby Creek will be surveyed for redds and suitable spawning habitat. Libby Creek has a very unstable channel with little spawning habitat, and a lack of woody debris and overhead cover, which are important rearing habitat components (Baxter 1996, Thomas and McPhail 1992).

Lower Kootenai River

- ***O'Brien Creek***

Bull trout in the Kootenai River were isolated from O'Brien Creek by a log dam constructed in the 1930's for sawmill operations. Electrofishing data from the 1960's indicates bull trout migrated above the dam. It is uncertain to what level the dam impeded migration of fluvial bull trout due to its deteriorating condition in the 1950's and 1960's. The dam was removed in 1977, allowing unrestricted access for fish to upper O'Brien Creek. MFWP personnel counted redds and trapped bull trout migrating upstream in O'Brien Creek in 1992. Personnel counted 25 redds, most of which were close to the trap location (Table 26). The trap was operated from June 23 to September 28; 20 adult fluvial bull trout were captured, tagged and released. Twelve of the redds in O'Brien Creek were below the trap; thus, 13 redds were constructed by 20 bull trout above the trap, resulting in a 1.5 fish/redd ratio. For comparison, the Wigwam River fish/redd ratio was 2.1 in 1996 (Westover 1996). One brook trout x bull trout hybrid was captured in our trap in 1992. In 1993, all redds were located above the 1992 trap location. It is possible that the 1992 trap may have interrupted the migrating bull trout and forced them to use less suitable gravel.

A combination of new beaver dam construction and low water may have contributed to the lack of bull trout spawning in O'Brien Creek in 1994 (only 7 redds, the lowest on record; Figure 13). The increased beaver activity appears to have created more suitable habitat for brook trout and less spawning habitat for bull trout; 87 brook trout redds were counted by surveyors in O'Brien Creek in 1994. More monitoring efforts are needed on O'Brien Creek to effectively evaluate the potential effects of brook trout on spawning bull trout in O'Brien Creek.

- ***Keeler Creek***

Keeler Creek (including the North, South and West Forks), a tributary to Lake Creek, was included in our 1996 survey effort; a total of 74 redds were counted in 9.3 miles of stream (Table 26). Bull trout in this system are adfluvial, migrating downstream out of Bull Lake into Lake Creek, then up Keeler Creek. This downstream spawning migration is somewhat unique when compared to other bull trout populations (Montana Bull Trout Restoration Team 1996). Lake Creek, a tributary of the Kootenai River, has an upstream waterfall barrier isolating this population from the mainstem Kootenai River population. A micro-hydropower dam constructed in 1916 covered the upper portion of the waterfall. A series of high gradient waterfalls are still present below the dam, and are barriers to all upstream fish passage (Mike Hensler, personal communication). Keeler Creek may supply some recruitment to the Kootenai River through downstream migration. No redds were found upstream from South Fork Keeler, yet there were redds found in the South Fork itself. We will continue to survey Keeler Creek yearly as an index stream.

- ***Other Tributaries***

We surveyed several other tributaries in the lower Kootenai River including the Yaak River, and Callahan, Ruby and Star Creeks. None of these streams appear to provide spawning habitat for the Lower Kootenai River core area. The Yaak River is a large system with an average daily discharge of 100 to 200 cfs during July through September. Surveyors found no bull trout redds from the mouth of the Yaak to Yaak Falls, located about seven miles upstream. Most of the channel contains large substrate with high gradient and no adequate spawning habitat for bull trout. However, abundant rearing habitat is present. Surveyors found no redds in the nine miles walked on Callahan Creek, which has similar characteristics as the Yaak River. However, one bull trout was captured in our migrant trap in 1994, and MFWP personnel observed three large adult (20 to 30 inch) bull trout below a waterfall approximately 2 miles from the mouth of the stream. This waterfall is a potential barrier to migrating bull trout. Both Ruby and Star Creeks have waterfall barriers within one mile of their mouths.

Discussion

Long-term monitoring of bull trout redd numbers are important in monitoring bull trout population trends (Rieman & McIntyre 1993). Index streams such as Quartz, Grave, O'Brien, Wigwam, Keeler and Bear Creeks will continue to be surveyed yearly. Annual monitoring of these index streams allows management agencies to evaluate the success or failure of recovery efforts. Streams with potential to provide bull trout spawning will be monitored semi-annually to determine bull trout use and changes in land use status. Habitat enhancement efforts by MFWP will target stream reaches identified as bull trout core areas, with the goal of increasing total miles of stream in the Kootenai Basin used by bull trout. We will continue to assist in monitoring British Columbia tributaries to Libby Reservoir to quantify bull trout spawning and determine contribution of these streams to Montana waters.

CREEL SURVEY

Creel surveys of Libby Reservoir were conducted during the summer of 1985, 1988, and 1990. A synopsis of the methods and results of these surveys are presented in this section of the report. For further information, reference Chisholm and Hamlin (1987), and Skaar (1991, Interoffice Memorandum). Data for 1988 were not reported beyond a rough draft form, but may be obtained by contacting MFWP in Libby, MT. Creel methods were similar for all creels; the 1985 creel (Chisholm and Hamlin, 1987) served as a model for both subsequent surveys.

Methods

Dates of survey were from 13 May through 31 October, 1985, 28 May through 28 October, 1988, and 24 April through 30 September, 1990 (Table 28). The creel was stratified by day type (weekend/weekday; all holidays were sampled), by two-week period, and by geographic reservoir area (Tenmile, Rexford, and Canada).

Effort estimates were calculated by using electronic "car-counter" counts from all creeled access sites (chosen randomly with replacement) on the reservoir, calibrated each creel day to assign a number of clicks per angler, and extrapolated for all creeled and non-creeled periods. Counters were also checked every Friday evening and Monday morning to differentiate between weekend and weekday effort. Car-counters were chosen in lieu of airplane flight counts for reasons of cost, coverage, and political boundaries.

In 1985, data were collected at major access sites, at check stations along access highways, and with a roving boat survey used to determine the ratio of boat and shore anglers. Subsequent surveys (1988 and 1990) included only access site surveys, and the 1990 survey used only boat anglers for estimates, since it was determined from previous surveys that ≥ 95% of anglers were fishing from boats. Completed trip interviews were conducted for four hours at two different access sites on each sample day. Three creel clerks worked seven to eight 10-hour days during each two-week stratum; two in the U.S. portion of the reservoir, and one in the Canada portion. Creel clerks gathered information to determine rates of catch and harvest (total number caught or kept / total effort), residence status, and various economic data, reported by the MFWP Research Bureau in Bozeman, Montana. Clerks also measured and weighed all game fish observed, when possible.

Statewide angler-effort surveys (McFarland, MFWP, Bozeman, MT, personal communication) were conducted for entire fishing years (March through February) during 1989, 1991, 1993, and 1995. Surveyed anglers were randomly selected among three groups (resident, non-resident, and "SYD" {senior, youth, disabled}) from license records, and were asked to return questionnaires regarding their fishing effort on Montana waters, including Libby Reservoir. These data were used in this report as an indicator of angler-effort trend, and we assume that seasonal effort (creeled periods) is comparable.

Table 28. Selected statistics from creel surveys of Libby Reservoir during the summer months of 1985, 1988, and 1990. Statewide effort surveys (McFarland, MFWP, Bozeman,

MT, personal communication) are presented for 1989, 1991, 1993, and 1995.

	1985	1988	1989	1990	1991	1993	1995
DATES	5/13 - 10/31	5/28 - 10/28		4/24 - 9/30			
EFFORT							
Angler Days (A)	93,560	42,824		15,892			
Mean Trip Time (B, hrs)	5.20	5.98		2.26			
Angler Days (AD, A x B)	518,916	256,087		35,916			
Statewide Survey (AD)			43,906		47,320	29,224	35,867
% Resident Anglers	54.1	53.1		56.9			
Statewide Survey			44.3		47.5	46.0	50.6
% Non-Resident Anglers	54.9	46.9		43.1			
Statewide Survey			55.7		52.5	54.0	49.4
KOKANEE							
Mean length (mm) – angler	314	270.5		224.9			
Mean length (mm) – gillnets		314.0	275.0	257.0	316.0	263.0	300.2
HPUE (#/hr)	1.11	1.15		1.36			
Reported Harvest (a)	597,380	271,104		48,729			
Calculated Harvest (b)	575,997	294,500		48,845			
% of Total Fish Harvest	96.0	95.1		96.3			
OTHER GAME FISH							
Harvest / angler hour							
Rainbow Trout	0.02	0.02		0.04			
Westslope Cutthroat Trout	0.01	0.02		0.01			
WCT x RBT	0.01	0.13		<0.01			
Kamloops Rainbow	<0.01	none		0.01			

a) From Chisholm et al., 1987 (1985), Unfinished draft (1988), and Skaar, et al., 1991.
b) Calculated by authors for this report.

Discussion

Sharp decreases in total estimated angler effort occurred from 1985 to 1990 (Table 28), and may be attributable to one or a combination of four factors: 1), a steady decline in average length of kokanee harvested (Table 28); 2), major highway construction between Troy and Libby, MT, on U.S. Highway 2 during 1988 through 1990, which served to limit access to anglers from Idaho and Washington, and thus reduced the proportion of out-of-state anglers creeled (Table 28); 3) the relative “newness” of the kokanee fishery in 1985 (kokanee were first caught consistently in gillnets in 1984), producing inflated effort for kokanee; and 4), the impending extreme decline of the kokanee fishery in nearby Flathead Lake (Deleray 1996). Data from statewide voluntary mail surveys (Table 28) show a corresponding decreasing trend in angler days during years creel surveys were not implemented (1989 and 1991). The proportion of out-of-state anglers creeled (Table 28) ranged from a high of 47,320 angler-days in 1991 to a low of 29,224 angler days in 1993. Angler effort increased from the low in 1993 to 35,867 angler-days in 1995 (Table 28), which represents the 15th highest angler use in the state and the 2nd highest in MFWP's Region 1 for that year.

Kokanee salmon were the primary species sought by anglers for all years surveyed, and accounted for 95.1 to 96.3% of the total estimated harvest (Table 28). Mean length of kokanee harvested declined steadily from 314.0 mm in 1985 to 224.9 mm in 1990 (Table 28). Conversely, harvest per angler hour (HPUE) steadily increased during the same period (Table 28), perhaps correlating directly with a greater percentage of knowledgeable, local anglers fishing for kokanee on the reservoir. HPUE of other trout species remained relatively stable for all surveys (Table 28); no ascertainable differences were detected due to relatively small sample sizes.

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APPENDIX A

Tables A1 through A27

Mean zooplankton densities and variances estimated from 0 to 30m
vertical tows made in three areas of Libby Reservoir,
1988 through 1996

Table A1. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m. vertical tows made in the Tenmile area of Libby Reservoir during 1988. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
March	(3)	0.65	0.22	4.07	1.68	0.00	0.00	0.00
		0.20	0.02	1.94	0.00	0.00	0.00	0.00
April	(3)	0.32	0.10	0.88	0.18	6.67	0.00	0.00
		0.06	0.01	1.72	0.07	133.33	0.00	0.00
May	(2)	3.04	4.41	19.54	1.57	19.00	0.00	0.00
		1.20	2.08	27.83	0.08	722.00	0.00	0.00
June	(7)	1.33	5.40	16.56	0.67	103.29	0.41	0.06
		0.10	58.58	224.85	0.21	8784.90	0.48	0.00
July	(3)	1.72	0.19	4.44	1.31	165.67	1.57	0.12
		0.19	0.01	3.85	0.09	28456.33	2.04	0.02
August	(3)	0.83	0.01	3.36	1.31	99.80	0.33	0.49
		0.06	0.00	0.22	0.11	6754.12	0.08	0.07
September	(4)	0.50	0.08	2.21	1.76	12.35	0.25	2.05
		0.05	0.00	0.33	0.08	359.42	0.08	0.61
October	(4)	1.01	0.24	4.99	0.36	35.00	0.00	0.02
		0.46	0.02	13.97	0.07	4900.00	0.00	0.00
November	(4)	0.86	1.17	4.84	0.12	36.99	1.43	0.02
		0.05	0.40	3.80	0.01	1299.44	8.12	0.00
December	(3)	0.81	0.50	1.21	0.07	1.27	0.17	0.00
		0.00	0.26	0.36	0.00	4.81	0.08	0.00

Table A2. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1989. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	6	0.33	2.36	2.01	0.12	20.68	0.08	0.00
		0.03	3.08	1.82	0.01	476.20	0.04	0.00
April	4	0.10	0.80	4.12	0.01	0.00	1.65	0.00
		0.03	0.32	32.95	0.00	0.00	10.89	0.00
May	4	0.24	2.43	14.90	0.00	93.37	0.00	0.00
		0.12	9.50	208.14	0.00	8494.22	0.00	0.00
June	3	0.17	5.27	24.62	0.00	0.00	0.00	0.00
		0.05	5.69	28.27	0.00	0.00	0.00	0.00
July	2	0.20	0.58	10.48	0.01	0.00	0.00	0.00
		0.00	0.03	3.64	0.00	0.00	0.00	0.00
August	3	2.02	0.21	19.92	0.00	0.00	0.00	0.35
		0.63	0.00	3.67	0.00	0.00	0.00	0.36
September	3	0.39	0.48	5.50	0.00	5.19	0.00	0.15
		0.00	0.12	4.85	0.00	80.70	0.00	0.03
October	2	1.52	6.60	8.57	0.08	9.43	1.18	0.04
		0.63	19.03	22.45	0.00	177.85	2.78	0.00
November	3	0.52	0.51	1.14	0.01	83.30	1.14	0.02
		0.00	0.34	0.62	0.00	2280.65	0.62	0.00
December	3	1.07	0.42	2.06	0.09	29.67	0.00	0.00
		1.17	0.12	5.39	0.02	78.68	0.00	0.00

Table A3. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m.vertical tows made in the Tenmile area of Libby Reservoir during 1990.*Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	2	0.16	0.13	1.49	0.01	50.93	0.00	0.01
		0.00	0.00	0.86	0.00	256.06	0.00	0.00
February	3	0.16	0.49	2.55	0.07	31.44	0.00	0.00
		0.03	0.10	2.40	0.00	2964.79	0.00	0.00
March	3	0.04	0.43	1.17	0.01	65.04	0.00	0.00
		0.00	0.02	0.01	0.00	12690.60	0.00	0.00
April	3	0.05	0.22	3.76	0.01	7.54	0.00	0.00
		0.00	0.02	22.75	0.00	170.71	0.00	0.00
May	3	0.02	0.40	2.88	0.01	3.15	0.78	0.00
		0.00	0.08	4.03	0.00	7.43	0.29	0.00
June	3	0.04	1.87	5.56	0.00	3.14	0.47	0.00
		0.00	3.38	63.61	0.00	29.64	0.22	0.00
July	3	0.64	4.96	10.86	0.01	30.81	19.33	0.00
		0.00	0.68	2.72	0.00	1.18	138.82	0.00
August	3	1.94	0.15	14.14	0.00	0.00	2.67	0.01
		0.46	0.01	8.42	0.00	0.00	5.40	0.00
September	3	1.08	0.18	4.90	0.01	51.87	1.73	0.08
		0.04	0.00	0.26	0.00	266.77	3.63	0.00
October	3	1.62	2.94	2.94	0.02	171.01	0.78	0.00
		0.04	0.41	0.34	0.00	986.74	0.52	0.00
November	1	2.04	0.85	3.20	0.07	113.17	0.00	0.00
		****	****	****	****	******	****	****
December	3	1.01	0.03	0.90	0.01	23.26	0.00	0.00
		0.11	0.00	0.05	0.00	428.12	0.00	0.00

Table A4. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1991. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	3	1.40	0.10	3.71	0.45	0.00	0.00	0.00
		0.24	0.00	1.96	0.10	0.00	0.00	0.00
April	3	0.10	0.04	2.87	0.03	0.00	0.00	0.00
		0.00	0.00	0.40	0.00	0.00	0.00	0.00
May	1	0.18	0.03	3.20	0.03	0.00	0.00	0.00
		****	****	****	****	****	****	****
June	3	0.67	0.14	5.36	0.00	12.57	0.47	0.00
		0.58	0.03	71.24	0.00	292.81	0.22	0.00
July	3	6.05	0.31	7.24	0.00	160.64	8.80	0.00
		1.07	0.12	1.55	0.00	21446.05	29.86	0.00
August	3	0.69	0.00	1.13	0.03	42.38	0.47	0.00
		0.12	0.00	0.62	0.00	3696.66	0.66	0.00
September	3	1.84	0.01	3.90	0.42	208.11	0.31	0.00
		0.67	0.00	0.26	0.18	9840.81	0.29	0.00
November	3	0.43	0.00	0.90	0.76	3.14	0.00	0.00
		0.02	0.00	0.13	0.01	8.30	0.00	0.00
December	1	3.81	0.03	3.90	6.20	0.00	0.00	0.00
		****	****	****	****	****	****	****

Table A5. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1988. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
March	1	0.51	0.22	5.02	1.12	0.00	0.00	0.00
		****	****	****	****	****	****	****
April	3	0.19	0.39	2.63	0.21	5.33	0.00	0.01
		0.05	0.36	7.16	0.02	85.33	0.00	0.00
May	4	0.17	0.09	5.27	0.32	79.33	0.00	0.03
		0.03	0.02	13.63	0.19	16420.22	0.00	0.00
June	6	0.82	0.58	4.84	1.08	29.50	0.32	0.21
		0.16	0.17	5.35	0.49	598.70	0.60	0.14
July	3	0.93	0.03	3.02	2.48	0.00	0.80	0.25
		0.23	0.00	1.13	1.01	0.00	0.27	0.04
August	3	0.85	0.00	4.65	3.39	30.00	0.80	1.79
		0.25	0.00	1.58	0.31	700.00	0.97	0.78
September	4	0.34	0.07	2.77	1.49	0.00	0.00	0.86
		0.01	0.00	1.29	0.15	0.00	0.00	0.18
October	3	0.66	0.34	2.82	0.20	1.90	0.00	0.02
		0.06	0.10	1.23	0.01	10.83	0.00	0.00
November	3	0.85	2.64	4.04	0.17	134.19	0.27	0.01
		0.40	8.08	8.47	0.01	45318.57	0.21	0.00
December	3	2.00	8.68	9.73	1.72	11.00	0.00	0.00
		1.27	3.10	14.49	2.50	363.00	0.00	0.00

Table A6. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1989. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	1	0.79	7.17	1.27	0.29	0.00	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
		****	****	****	****	****	****	****
April	3	0.01	0.01	2.23	0.02	0.00	0.00	0.00
		0.00	0.00	1.44	0.00	0.00	0.00	0.00
May	3	0.00	0.03	0.50	0.00	3.80	0.00	0.00
		0.00	0.00	0.33	0.00	38.25	0.00	0.00
June	3	0.34	5.44	17.80	0.00	14.24	0.79	0.01
		0.01	1.68	11.42	0.00	608.33	1.86	0.00
July	3	0.23	0.24	8.46	0.00	0.00	0.00	0.66
		0.00	0.07	9.21	0.00	0.00	0.00	1.32
August	3	1.69	0.17	6.39	0.00	0.00	0.00	0.28
		0.38	0.00	0.94	0.00	0.00	0.00	0.04
September	3	0.65	0.93	3.03	0.01	3.14	0.00	0.07
		0.04	0.02	0.18	0.00	29.64	0.00	0.00
October	3	2.86	0.01	3.43	0.13	0.00	0.00	0.35
		2.51	0.00	4.14	0.01	0.00	0.00	0.15
November	3	2.66	1.76	3.72	0.16	2.20	0.00	0.00
		1.09	1.34	2.55	0.03	14.52	0.00	0.00
December	3	2.00	0.19	3.66	0.32	0.00	0.00	0.26
		0.59	0.02	0.67	0.01	0.00	0.00	0.01

Table A7. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1990. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	3	1.14	1.09	7.82	0.17	0.00	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
		0.27	0.45	9.51	0.02	0.00	0.00	0.00
February	3	0.22	0.86	4.96	0.08	54.33	0.00	0.00
		0.01	0.04	6.92	0.00	303.27	0.00	0.00
April	3	0.00	0.02	0.13	0.00	1.02	0.00	0.00
		0.00	0.00	0.01	0.00	0.02	0.00	0.00
May	3	0.00	0.13	0.68	0.01	160.55	1.80	0.02
		0.00	0.00	0.03	0.00	23706.73	2.45	0.00
June	3	0.35	13.12	15.62	0.02	0.00	1.57	0.00
		0.01	13.10	2.88	0.00	0.00	5.40	0.00
July	3	0.53	1.43	9.81	0.00	12.57	17.13	0.00
		0.01	0.39	8.19	0.00	474.27	99.17	0.00
August	3	2.63	0.02	10.61	0.00	0.00	12.42	0.06
		2.11	0.00	15.98	0.00	0.00	37.87	0.00
September	3	0.20	0.03	3.39	0.02	3.14	1.73	0.00
		0.03	0.00	0.04	0.00	29.64	2.30	0.00
November	1	1.77	1.36	6.25	0.20	226.33	0.00	0.00
		****	****	****	****	******	****	****
December	3	3.02	0.75	6.75	1.03	16.66	0.00	0.00
		17.16	0.67	21.39	2.10	832.67	0.00	0.00

Table A8. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1991. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.03	0.00	5.11	0.09	0.00	0.00	0.00
		0.00	0.00	14.03	0.01	0.00	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	2	0.00	0.00	0.04	0.00	0.00	0.39	0.00
		0.00	0.00	0.00	0.00	0.00	0.46	0.00
June	3	1.18	0.08	11.81	0.01	61.11	1.57	0.00
		0.67	0.01	50.74	0.00	3258.99	2.08	0.00
July	3	3.70	0.09	5.22	0.01	20.43	13.20	0.00
		2.61	0.02	1.83	0.00	363.13	24.67	0.00
August	3	1.69	0.00	2.16	0.16	25.15	1.10	0.00
		1.88	0.00	0.81	0.01	179.12	0.07	0.00
September	3	0.10	0.00	1.28	0.62	286.85	0.00	0.00
		0.00	0.00	0.06	0.05	8370.16	0.00	0.00
November	3	1.14	0.00	2.26	2.82	2.83	0.00	0.00
		1.53	0.00	5.29	5.71	24.03	0.00	0.00
December	3	2.70	0.02	4.58	2.14	0.00	0.00	0.00
		1.29	0.00	0.53	0.11	0.00	0.00	0.00

Table A9. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1988. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	2	0.19	0.01	0.34	0.46	12.00	0.25	0.02
		0.05	0.00	0.20	0.32	8.00	0.13	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	2	2.88	0.00	9.67	3.39	0.00	0.70	1.48
		12.95	0.00	120.90	7.18	0.00	0.98	2.10
August	3	2.26	0.00	6.19	3.50	20.00	0.47	2.79
		6.14	0.00	22.66	1.75	1200.00	0.20	2.55
September	1	2.18	0.74	6.11	3.73	28.00	0.00	0.45
		****	****	****	****	*****	****	****
November	3	4.20	6.57	18.30	3.35	7.67	8.53	0.00
		9.43	37.46	195.63	8.94	176.33	203.45	0.00

Table A10. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1989. *Epischura* and *Leptodora* were measured as number m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	0.24	0.99	5.68	0.05	57.07	0.00	0.02
		0.00	1.01	10.05	0.01	4071.15	0.00	0.00
July	3	0.23	0.17	5.34	0.00	0.67	0.00	0.78

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
		0.05	0.09	22.70	0.00	1.36	0.00	1.51
August	3	2.60	0.17	6.15	0.01	0.00	1.34	2.16
		0.01	0.00	0.79	0.00	0.00	0.40	2.09
September	3	1.10	0.93	8.35	0.12	0.00	1.66	0.01
		1.07	1.89	5.26	0.02	0.00	8.30	0.00
October	3	1.64	2.00	2.56	0.10	13.83	0.00	0.00
		0.21	0.34	0.08	0.01	147.06	0.00	0.00
December	1	4.25	2.54	10.49	0.29	108.92	0.00	0.00
		****	****	*****	****	******	****	****

Table A11. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1990. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	0.00	0.18	8.42	0.00	0.31	0.00	0.00
		0.00	0.02	197.58	0.00	0.29	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	3	0.96	0.41	11.02	0.00	0.00	8.02	0.00
		1.03	0.12	143.58	0.00	0.00	52.72	0.00
August	3	2.09	0.09	6.47	0.00	20.83	7.31	0.05
		2.99	0.01	29.62	0.00	367.30	42.49	0.00
September	3	0.10	0.25	6.26	0.01	110.69	0.00	0.00
		0.02	0.06	14.04	0.00	12907.45	0.00	0.00
October	3	1.64	2.00	2.56	0.10	13.83	0.00	0.00
		0.21	0.34	0.08	0.01	147.06	0.00	0.00
November	3	25.66	1.36	26.00	7.34	1156.85	9.43	0.13
		1815.85	1.53	1514.39	156.46	3037279.68	266.77	0.05
December	3	4.63	0.92	9.88	0.87	754.04	0.00	0.00
		6.54	0.01	0.76	0.07	31037.29	0.00	0.00

Table A12. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1991. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	3	9.34	0.00	7.80	0.04	10.56	10.64	0.01
		8.01	0.00	1.78	0.00	334.75	10.30	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
August	3	2.61	0.00	5.56	1.84	0.00	1.69	0.01
		0.13	0.00	8.96	0.17	0.00	1.06	0.00
September	3	1.32	0.03	1.47	2.56	6.29	0.78	0.01
		0.11	0.00	0.24	1.73	33.21	0.52	0.00
November	1	1.95	0.00	5.91	2.60	0.00	0.00	0.00
		****	****	****	****	****	****	****

Table A13. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1992. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	1.08	0.01	3.13	1.21	1.89	0.00	0.00
		1.98	0.00	11.70	2.45	10.68	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	3	2.46	0.04	8.38	0.69	376.45	0.16	0.01
		0.28	0.00	22.14	0.19	54891.50	0.07	0.00
June	3	4.35	0.21	5.33	1.39	12.07	0.16	0.00
		18.84	0.01	10.86	0.26	437.05	0.07	0.00
July	3	1.88	0.19	3.96	4.97	121.92	1.26	0.01
		0.60	0.01	0.22	2.09	9369.70	1.41	0.00
August	3	2.28	0.76	2.76	5.22	60.11	0.00	0.03
		0.34	0.16	0.16	0.59	1201.20	0.00	0.00
September	3	0.90	0.70	1.89	2.64	20.62	2.04	0.00
		0.44	0.08	0.62	1.91	464.57	2.08	0.00

Table A14. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1992. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	1.31	0.02	2.38	0.98	6.37	1.41	0.00
		3.90	0.00	13.87	2.20	31.52	2.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	3	1.60	0.03	1.33	1.12	13.46	0.00	0.00
		0.37	0.00	0.15	0.17	146.08	0.00	0.00
June	3	1.50	0.11	1.89	0.63	20.14	0.19	0.00
		0.22	0.00	0.20	0.08	474.14	0.11	0.00
July	2	0.63	0.52	1.57	2.17	0.00	3.77	0.01
		0.00	0.00	0.05	0.00	0.00	0.44	0.00
August	3	1.69	0.19	1.95	5.20	7.17	1.57	0.41
		0.01	0.02	0.08	0.58	154.08	0.08	0.00
September	3	0.57	0.24	1.70	3.85	0.00	1.10	0.01
		0.02	0.01	0.17	0.33	0.00	0.29	0.00

Table A15. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1992. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	3	1.15	0.05	1.29	1.04	0.00	0.00	0.00
		0.01	0.00	0.41	0.01	0.00	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	0.81	0.77	1.44	0.62	0.00	0.53	0.00
		0.60	0.43	1.38	0.37	0.00	0.32	0.00
August	3	1.96	0.54	1.07	3.67	10.06	1.22	0.59
		0.41	0.43	0.31	4.53	303.61	1.30	0.01
September	3	1.71	0.55	1.45	3.55	0.00	1.45	0.01
		3.93	0.40	0.32	3.10	0.00	1.47	0.00

Table A16. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1993. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.02	0.16	7.97	0.00	0.00	0.00	0.00
		0.00	0.00	23.57	0.00	0.00	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	3	1.19	0.08	9.59	0.00	26.72	5.50	0.01
		0.42	0.01	8.53	0.00	2141.90	16.10	0.00
August	3	3.61	0.04	7.36	0.00	29.86	6.91	0.00
		0.71	0.00	1.95	0.00	855.87	25.43	0.00
October	3	1.78	2.76	5.98	0.19	73.56	0.79	0.00
		0.31	1.64	1.77	0.15	3999.20	0.97	0.00
November	3	0.45	0.01	5.48	0.68	2.33	0.00	0.00
		0.10	0.00	8.04	0.34	16.24	0.00	0.00

Table A17. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1993. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.02	0.03	2.98	0.00	0.00	0.31	0.00
		0.00	0.00	1.58	0.00	0.00	0.29	0.00
July	3	1.07	0.00	7.08	0.00	0.00	8.49	0.01

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
		0.27	0.00	3.84	0.00	0.00	10.89	0.00
August	2	6.93	0.05	7.60	0.02	0.00	7.78	0.00
		17.05	0.00	4.84	0.00	0.00	13.42	0.00
October	3	1.18	0.81	6.20	0.64	60.23	2.98	0.01
		0.28	0.05	4.81	0.12	886.77	2.08	0.00

Table A18. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1993. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	3	0.58	0.00	1.90	0.01	0.00	8.17	0.00
		0.20	0.00	3.07	0.00	0.00	106.95	0.00
August	3	5.72	0.11	5.01	0.06	16.84	10.64	0.02
		8.04	0.03	10.42	0.01	850.76	32.83	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
October	2	3.47	0.23	6.51	0.57	32.73	1.37	0.05
		11.38	0.07	13.52	1.24	9.10	0.90	0.00

Table A19. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1994. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.34	0.14	11.16	0.13	2.07	0.00	0.00
		0.03	0.02	161.10	0.03	12.90	0.00	0.00
May	3	1.13	1.62	7.90	0.06	43.53	0.31	0.00
		0.10	1.51	17.12	0.00	142.83	0.29	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	1.40	0.07	5.22	0.02	21.02	2.62	0.01
		0.29	0.01	6.41	0.00	439.33	3.76	0.00
July	3	1.89	0.00	6.71	0.15	171.93	9.27	0.01
		0.05	0.00	0.31	0.02	14479.80	5.86	0.00
August	3	0.67	0.42	6.21	0.55	143.03	0.47	0.00
		0.05	0.01	0.04	0.14	5639.00	0.22	0.00
September	3	4.24	0.20	5.93	1.57	251.85	2.60	0.01
		2.12	0.00	1.98	0.09	15745.50	0.06	0.00
October	3	1.45	0.19	5.38	3.18	71.42	0.31	0.00
		0.12	0.01	1.92	4.39	1041.80	0.29	0.00
November	3	0.59	0.13	1.93	1.31	38.98	0.00	0.01
		0.04	0.01	0.28	0.01	289.51	0.00	0.00

Table A20. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1994. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	2	0.09	0.08	1.73	0.01	3.54	0.00	0.00
		0.01	0.01	4.38	0.00	24.99	0.00	0.00
May	2	0.40	1.67	5.06	0.09	235.02	5.97	0.00
		0.08	1.64	15.05	0.00	50923.83	63.23	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	2.72	0.02	6.61	0.04	34.27	16.35	0.00
		0.61	0.00	6.77	0.00	2078.52	73.18	0.00
July	3	2.97	0.01	6.47	0.26	69.54	5.42	0.00
		0.90	0.00	1.67	0.02	6982.00	3.39	0.00
August	3	0.41	0.31	5.11	1.28	258.59	0.47	0.06
		0.01	0.12	1.42	0.13	7120.50	0.66	0.00
September	3	5.69	0.30	7.20	3.92	49.98	3.28	0.15
		1.39	0.03	0.60	0.00	3556.80	2.03	0.02
October	3	0.91	0.08	3.39	2.07	69.70	0.00	0.05
		0.06	0.00	0.45	0.00	394.54	0.00	0.00
November	3	0.30	0.08	3.01	0.86	9.24	0.00	0.01
		0.00	0.01	1.92	0.04	11.56	0.00	0.00

Table A21. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1994. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	3	0.28	1.02	3.26	0.16	89.28	4.28	0.00
		0.06	0.01	0.69	0.00	2907.50	1.47	0.00
June	3	0.87	0.00	2.06	0.01	1.12	15.27	0.00
		2.01	0.00	11.41	0.00	1.19	599.11	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
July	3	2.20	0.00	0.68	0.59	102.60	6.04	0.00
		5.89	0.00	0.78	0.51	12486.90	93.30	0.00
August	3	4.43	0.32	1.98	2.58	337.44	16.11	0.25
		4.45	0.04	4.17	1.31	30399.00	23.57	0.02
September	3	7.02	0.35	3.32	4.99	34.70	8.31	0.65
		5.59	0.05	4.25	6.73	55.32	1.89	0.04
October	3	5.04	0.11	11.14	3.97	19.72	2.08	0.00
		11.26	0.01	27.77	5.00	436.36	3.26	0.00

Table A22. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1995. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	3	0.88	0.27	4.69	0.30	4.41	0.00	0.00
		0.21	0.01	7.90	0.01	22.25	0.00	0.00
March	3	0.18	0.39	3.08	0.04	10.34	0.00	0.00
		0.01	0.07	9.30	0.01	82.10	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.09	0.27	1.34	0.02	19.70	0.24	0.00
		0.00	0.01	0.06	0.00	283.10	0.17	0.00
May	3	0.33	1.87	6.68	0.05	26.37	0.84	0.00
		0.15	0.72	34.31	0.01	846.90	0.72	0.00
June	3	1.55	0.04	3.86	0.06	13.84	1.67	0.00
		4.89	0.00	22.42	0.01	160.19	0.78	0.00
July	3	2.25	0.00	5.79	0.04	58.63	8.96	0.01
		1.77	0.00	6.61	0.00	259.76	0.88	0.00
August	3	1.00	0.02	7.40	0.14	173.84	0.47	0.04
		0.21	0.00	0.64	0.01	10007.20	0.66	0.00
September	3	5.14	0.61	9.73	1.41	0.00	1.73	0.10
		3.42	0.25	5.10	0.39	0.00	0.52	0.02
October	3	0.90	0.20	3.23	0.93	51.52	0.16	0.01
		0.10	0.01	0.56	0.04	1483.60	0.07	0.00
November	3	0.66	0.14	2.78	0.54	249.32	0.00	0.00
		0.13	0.02	2.78	0.20	857.04	0.00	0.00
December	3	0.77	0.02	1.70	0.31	67.05	0.00	0.00
		0.01	0.00	0.83	0.01	65.40	0.00	0.00

Table A23. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1995. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	3	0.87	0.71	2.86	0.55	2.98	0.00	0.00
		0.04	0.04	1.51	0.02	26.64	0.00	0.00
March	3	0.65	0.99	3.19	0.16	4.79	0.00	0.00
		0.13	0.39	3.95	0.02	68.83	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.16	0.61	3.90	0.00	21.02	0.38	0.00
		0.04	0.05	12.74	0.00	101.59	0.43	0.00
May	3	0.17	0.71	3.15	0.02	109.66	0.16	0.00
		0.01	0.05	2.69	0.00	2594.00	0.07	0.00
June	3	1.44	0.06	6.13	0.02	21.66	2.45	0.02
		0.10	0.00	1.45	0.00	136.05	4.13	0.00
July	3	1.40	0.00	6.28	0.06	61.42	15.56	0.00
		0.33	0.00	10.91	0.00	2023.30	182.09	0.00
August	3	0.72	0.01	5.47	0.72	145.81	2.62	0.15
		0.07	0.00	12.61	0.24	3884.20	8.76	0.00
September	3	2.10	0.43	5.06	0.91	105.94	0.47	0.04
		0.00	0.02	1.11	0.02	752.76	0.22	0.00
October	3	4.81	1.43	6.18	2.79	12.57	1.95	0.01
		24.06	1.61	7.07	3.60	474.27	3.26	0.00
November	3	1.26	0.49	4.50	1.10	0.00	0.00	0.00
		0.51	0.03	9.95	0.63	0.00	0.00	0.00
December	3	1.03	0.23	4.18	0.68	11.61	0.00	0.00
		0.56	0.08	13.30	0.45	107.50	0.00	0.00

Table A24. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1995. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
January	3	0.27	0.27	7.43	0.08	0.00	0.00	0.00
		0.10	0.12	36.04	0.01	0.00	0.00	0.00
April	3	0.65	0.00	5.37	0.07	9.42	6.23	0.04
		0.01	0.00	0.29	0.00	66.82	13.75	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
May	3	4.00	0.04	6.68	2.64	112.79	1.89	0.02
		3.07	0.00	13.65	0.67	19122.70	0.89	0.00
June	3	3.04	1.60	5.53	1.49	327.05	2.33	0.01
		1.39	2.23	5.27	0.41	12813.50	4.21	0.00
July	3	8.98	0.59	14.10	5.70	13.58	3.54	0.01
		191.68	0.33	400.44	72.62	138.64	37.52	0.00
August	3	1.62	0.38	3.36	1.04	0.00	0.00	0.00
		0.49	0.01	1.64	0.48	0.00	0.00	0.00

Table A25. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Tenmile area of Libby Reservoir during 1996. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.01	0.02	1.97	0.01	1.13	0.00	0.00
		0.00	0.00	2.00	0.00	3.85	0.00	0.00
May	3	0.02	0.00	3.06	0.04	19.10	0.00	0.00
		0.00	0.00	5.46	0.00	123.80	0.00	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	0.19	0.11	5.21	0.02	0.00	2.52	0.00
		0.02	0.02	38.20	0.00	0.00	5.64	0.00
July	3	4.03	1.56	8.31	0.00	7.32	25.10	0.01
		0.32	0.25	3.29	0.00	160.90	84.10	0.00
August	3	1.97	0.17	8.12	0.03	21.20	2.51	0.01
		0.21	0.01	5.63	0.00	1350.87	0.97	0.00
September	3	0.66	0.28	5.36	0.13	33.30	0.16	0.07
		0.10	0.01	1.99	0.00	1444.71	0.07	0.00
October	3	2.44	0.14	6.47	0.65	146.40	0.16	0.10
		2.15	0.01	15.10	0.08	9402.36	0.07	0.00

Table A26. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Rexford area of Libby Reservoir during 1996. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.02	0.00	1.57	0.00	1.18	0.00	0.00
		0.00	0.00	1.22	0.00	4.18	0.00	0.00
May	3	0.08	0.03	23.40	0.01	108.30	1.16	0.06
		0.01	0.00	270.60	0.00	4217.56	2.20	0.01

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
June	3	0.54	0.03	8.97	0.01	0.00	1.73	0.00
		0.03	0.25	2.55	0.00	0.00	3.63	0.00
July	3	6.43	0.05	8.13	0.04	0.00	68.50	0.00
		16.50	0.01	0.90	0.00	0.00	1361.87	0.00
August	3	3.16	0.11	5.77	0.04	31.10	1.73	0.01
		4.59	0.00	5.16	0.00	2905.99	4.74	0.00
September	3	0.72	0.25	7.18	0.16	61.30	1.51	0.14
		0.17	0.04	37.60	0.00	2390.93	1.73	0.00
October	3	4.71	0.56	12.90	2.01	55.80	0.68	0.20
		8.18	0.33	22.90	2.32	2550.44	0.13	0.01

Table A27. Mean zooplankton densities (no./l) (top line) and variances (bottom line) estimated from 10-30 m vertical tows made in the Canada area of Libby Reservoir during 1996. *Epischura* and *Leptodora* were measured as number per m^3.

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
April	3	0.00	0.00	0.03	0.00	3.97	0.00	0.00
		0.00	0.00	0.00	0.00	2.23	0.00	0.00
May	3	0.26	0.00	14.00	0.00	3.14	1.51	0.00
		0.18	0.00	457.90	0.00	20.40	6.84	0.00
June	3	0.16	0.21	5.36	0.00	0.00	0.43	0.00

Month	(N)	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Epischura*	*Leptodora*	*Diaphanosoma*
		0.07	0.08	74.10	0.00	0.00	0.55	0.00
July	3	4.53	0.02	7.48	0.02	16.10	17.50	0.00
		12.30	0.00	34.50	0.00	780.20	257.10	0.00
August	3	9.07	0.02	10.10	0.09	29.40	7.95	0.00
		13.50	0.00	9.44	0.01	790.80	33.70	0.00
September	3	1.25	0.12	5.73	0.23	182.10	1.26	0.40
		1.53	0.02	22.70	0.01	8061.07	1.86	0.04
October	3	3.25	6.02	10.20	1.14	83.40	0.00	0.18
		0.31	21.80	37.10	0.04	19868.94	0.00	0.01

APPENDIX B
Tables B1 and B2

Yearly and total mean sample weights of *Daphnia* and total zooplankton in the Tenmile, Rexford and Canada areas of Libby Reservoir, 1984 through 1996.

Table B1. Yearly mean sample weights (micrograms) of *Daphnia* in the Tenmile (1), Rexford (2) and Canada (3) areas. Values in parenthesis are standard deviations.

	YEAR													
AREA	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**TOTAL**
1	8.71 (3.70) n=24	11.08 (7.78) n=26	21.13 (16.34) n=24	6.26 (2.81) n=10	4.97 (2.85) n=17	3.04 (3.43) n=11	4.50 (5.44) n=12	13.75 (11.92) n=12	10.26 (9.76) n=12	8.43 (5.67) n=6	9.73 (6.47) n=12	12.95 (11.76) n=12	7.87 (8.22) n=12	10.23 (10.01) n=190
2	8.29 (5.23) n=24	17.68 (14.56) n=24	12.42 (10.68) n=21	12.78 (7.97) n=9	3.25 (2.57) n=16	3.49 (3.43) n=12	4.32 (5.57) n=12	8.37 (8.03) n=12	4.33 (2.71) n=11	9.30 (9.45) n=5	13.30 (9.65) n=12	6.11 (2.09) n=12	15.08 (18.81) n=12	9.63 (10.32) n=182
3	19.98 (16.32) n=17	26.27 (21.46) n=22	36.33 (34.90) n=21	26.60 (13.39) n=9	8.07 (9.82) n=8	5.89 (7.35) n=12	2.97 (4.95) n=12	27.81 (24.59) n=9	6.99 (6.59) n=9	12.09 (13.16) n=6	17.76 (18.02) n=12	8.68 (5.74) n=6	17.34 (22.13) n=12	19.03 (21.85) n=155
TOTAL	11.50 (10.35) n=65	17.92 (16.28) n=72	23.19 (24.48) n=66	14.89 (12.22) n=28	4.90 (5.07) n=41	4.17 (5.13) n=35	3.93 (5.22) n=36	15.63 (16.88) n=33	7.30 (7.34) n=32	9.97 (9.45) n=17	13.59 (12.47) n=36	9.36 (8.34) n=30	13.43 (17.41) n=36	12.61 (15.15) n=527

Table B2. Yearly mean sample weight (micrograms) of total zooplankton in the Tenmile (1), Rexford (2) and Canada (3) areas. Values in parenthesis are standard deviations.

YEAR													
1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**TOTAL**
24.12	52.63	51.83	18.81	43.66	25.10	31.31	29.57	44.21	33.92	35.56	34.89	34.91	37.51
(9.68)	(48.41)	(30.46)	(7.31)	(21.54)	(13.01)	(25.56)	(25.19)	(18.17)	(14.25)	(16.44)	(19.57)	(35.51)	(28.60)
n=24	n=26	n=24	n=10	n=17	n=11	n=12	n=12	n=12	n=6	n=12	n=12	n=12	n=190
25.68	57.86	39.77	39.57	37.33	20.33	38.29	28.78	35.11	36.85	51.46	32.80	68.28	39.80
(10.94)	(30.41)	(22.09)	(25.27)	(22.59)	(9.77)	(22.59)	(18.66)	(19.51)	(13.69)	(21.51)	(22.82)	(92.83)	(33.09)
n=24	n=24	n=21	n=9	n=16	n=12	n=12	n=12	n=11	n=5	n=12	n=12	n=12	n=182
36.71	95.17	78.62	58.00	63.07	29.97	22.97	55.15	35.53	38.41	71.84	38.10	46.31	56.28
(28.38)	(85.09)	(66.39)	(18.91)	(54.56)	(29.28)	(23.78)	(29.51)	(24.92)	(28.60)	(56.93)	(17.41)	(42.58)	(54.04)
n=17	n=22	n=21	n=9	n=8	n=12	n=12	n=9	n=9	n=6	n=12	n=6	n=12	n=155
27.99	67.37	56.52	38.08	44.98	25.14	30.85	36.26	38.64	36.37	52.95	34.70	49.84	43.82
(17.49)	(60.13)	(45.73)	(24.16)	(31.43)	(19.35)	(24.16)	(26.34)	(20.48)	(19.23)	(38.41)	(19.97)	(62.22)	(39.89)
n=65	n=72	n=66	n=28	n=41	n=35	n=36	n=33	n=32	n=17	n=36	n=30	n=36	n=527

APPENDIX C
Tables C1 through C15

Monthly and yearly average densities and yearly average lengths
of zooplankton samples from Schindler traps
in three areas of Libby Reservoir,
1983 through 1989.

Table C1. Monthly average density (N/L) of *Daphnia* in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=1.60, SD=2.67, N=493. Samples were not collected during February.

Depth	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=55	0.08	0.01	0.04	1.17	0.73	0.54	0.39	0.20	0.62	0.12	0.12
avg=0.41	(0.07)	(0.02)	(0.05)	(1.80)	(0.95)	(0.34)	(0.53)	(0.10)	(0.71)	(0.08)	(0.10)
SD=0.77	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
3m, N=55	1.01	0.10	0.31	8.39	8.64	7.68	3.38	1.55	3.17	0.94	0.71
avg=3.65	(1.26)	(0.06)	(0.05)	(9.38)	(5.09)	(5.43)	(1.72)	(1.40)	(3.40)	(0.69)	(0.62)
SD=5.01	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
6m, N=55	0.84	0.19	0.29	2.85	6.50	6.64	3.66	1.66	3.57	1.41	0.77
avg=2.82	(0.84)	(0.03)	(0.24)	(3.48)	(4.28)	(2.16)	(1.44)	(1.04)	(3.65)	(1.00)	(0.57)
SD=3.10	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
9m, N=55	1.03	0.29	0.19	4.42	3.97	4.36	3.49	1.95	2.61	1.37	0.59
avg=2.42	(0.73)	(0.37)	(0.17)	(8.41)	(4.01)	(1.07)	(1.71)	(1.35)	(2.72)	(0.49)	(0.57)
SD=3.41	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
12m, N=55	0.81	0.54	0.16	2.80	2.42	2.24	3.83	1.42	1.74	1.70	0.52
avg=1.75	(1.24)	(0.81)	(0.10)	(5.19)	(2.12)	(0.61)	(1.88)	(1.14)	(1.41)	(1.10)	(0.16)
SD=2.19	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
15m, N=55	0.82	0.34	0.20	1.27	1.11	1.84	1.63	1.22	1.32	1.34	0.64
avg=1.12	(0.84)	(0.49)	(0.08)	(1.46)	(0.83)	(1.06)	(1.80)	(1.12)	(1.11)	(0.22)	(0.36)
SD=1.05	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
20m, N=55	0.65	0.38	0.22	0.89	0.87	1.04	0.86	0.66	0.93	1.50	0.52
avg=0.78	(0.61)	(0.60)	(0.16)	(0.83)	(0.54)	(0.54)	(0.32)	(0.61)	(0.74)	(0.53)	(0.22)
SD=0.59	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
25m, N=55	0.48	0.48	0.18	0.99	0.86	0.61	0.40	0.49	0.85	1.35	0.61
avg=0.67	(0.33)	(0.45)	(0.19)	(0.86)	(0.77)	(0.69)	(0.31)	(0.33)	(0.55)	(0.14)	(0.40)
SD=0.56	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
30m, N=53	0.46	0.10	0.17	0.77	0.64	2.01	0.40	0.30	0.78	1.54	0.71
avg=0.73	(0.34)	(0.14)	(0.21)	(0.71)	(0.50)	(2.75)	(0.26)	(0.29)	(0.77)	(0.31)	(0.47)
SD=1.01	N=5	N=2	N=3	N=6	N=6	N=5	N=4	N=7	N=6	N=3	N=6

Table C2. Monthly average density (N/L) of *Bosmina* in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=1.01, SD=3.09, N=493. Samples were not collected during February.

Depth	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=55	0.21	0	0	0.10	0.49	0.38	0.04	0.10	0.20	0.08	0.12
avg=0.17	(0.41)	(0)	(0)	(0.16)	(0.38)	(0.50)	(0.07)	(0.22)	(0.24)	(0.08)	(0.18)
SD=0.29	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
3m, N=55	0.19	0.02	0.02	0.35	8.75	1.81	0.12	2.44	2.52	0.43	0.30
avg=1.83	(0.34)	(0.02)	(0.02)	(0.71)	(14.04)	(2.29)	(0.11)	(4.63)	(5.25)	(0.53)	(0.49)
SD=5.53	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
6m, N=55	0.39	0	0	0.72	8.12	4.55	0.26	0.81	3.50	0.70	0.36
avg=2.00	(0.67)	(0)	(0)	(1.51)	(9.61)	(8.05)	(0.32)	(1.30)	(7.61)	(0.89)	(0.58)
SD=5.09	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
9m, N=55	1.00	0.03	0.03	0.80	4.81	4.18	0.42	0.74	2.86	0.67	0.48
avg=1.62	(1.90)	(0.06)	(0.04)	(1.77)	(6.56)	(7.36)	(0.48)	(1.26)	(5.92)	(0.76)	(0.86)
SD=3.85	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
12m, N=55	0.25	0.03	0.01	0.51	3.21	1.86	0.80	0.54	1.96	0.76	0.36
avg=1.04	(0.34)	(0.06)	(0.02)	(0.90)	(4.60)	(3.13)	(1.08)	(0.71)	(3.69)	(1.05)	(0.64)
SD=2.29	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
15m, N=55	1.50	0.02	0.02	0.25	2.32	1.19	0.14	0.48	1.28	0.60	0.39
avg=0.82	(3.19)	(0.04)	(0.04)	(0.47)	(3.36)	(2.00)	(0.16)	(0.68)	(2.19)	(0.74)	(0.59)
SD=1.78	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
20m, N=55	0.82	0.05	0.05	0.19	2.33	0.51	0.16	0.41	0.91	0.58	0.27
avg=0.63	(1.76)	(0.05)	(0.05)	(0.38)	(3.05)	(0.65)	(0.19)	(0.60)	(1.35)	(0.65)	(0.38)
SD=1.35	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
25m, N=55	0.81	0.06	0	0.17	1.84	0.43	0.06	0.45	0.49	0.47	0.29
avg=0.51	(1.73)	(0.10)	(0)	(0.31)	(2.27)	(0.49)	(0.05)	(0.65)	(0.78)	(0.50)	(0.42)
SD=1.05	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
30m, N=53	0.76	0	0	0.08	0.94	0.47	0.08	0.23	0.68	0.74	0.32
avg=0.42	(1.59)	(0)	(0)	(0.16)	(1.15)	(0.46)	(0.10)	(0.37)	(1.10)	(0.70)	(0.46)
SD=0.78	N=5	N=2	N=3	N=6	N=6	N=5	N=4	N=7	N=6	N=3	N=6

Table C3. Monthly average density (N/L) of *Diaptomus* in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=1.61, SD=2.88, N=493. Samples were not collected during February.

Depth	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=55	0.29	0.10	0.39	7.52	0.78	0.59	0.99	0.89	1.41	0.69	0.22
avg=1.43	(0.29)	(0.16)	(0.34)	(10.59)	(1.23)	(0.64)	(0.83)	(1.49)	(1.49)	(0.68)	(0.22)
SD=3.98	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
3m, N=55	1.13	0.48	1.53	7.13	2.04	5.36	2.76	5.73	2.17	0.72	0.96
avg=3.06	(0.92)	(0.37)	(0.31)	(7.16)	(1.62)	(6.19)	(2.42)	(8.75)	(2.07)	(0.33)	(1.78)
SD=4.76	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
6m, N=55	1.38	1.02	1.39	1.65	1.42	3.63	2.40	4.44	3.21	1.04	0.54
avg=2.17	(1.62)	(0.96)	(0.72)	(1.33)	(1.04)	(2.60)	(1.70)	(6.50)	(3.58)	(0.47)	(0.80)
SD=2.97	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
9m, N=55	1.14	1.03	0.94	1.29	0.77	2.23	2.97	4.42	3.05	1.03	1.10
avg=1.98	(1.03)	(0.77)	(0.51)	(0.99)	(0.89)	(1.59)	(2.77)	(5.87)	(3.86)	(0.58)	(1.85)
SD=2.85	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
12m, N=55	1.04	1.15	0.70	0.89	0.48	1.37	3.00	3.87	2.48	1.31	0.43
avg=1.62	(1.27)	(1.35)	(0.72)	(1.13)	(0.48)	(0.94)	(2.79)	(5.42)	(3.35)	(0.35)	(0.69)
SD=2.59	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
15m, N=55	1.19	0.83	0.81	0.90	0.43	1.30	1.93	4.09	1.79	1.29	0.68
avg=1.50	(1.74)	(0.92)	(0.44)	(0.78)	(0.54)	(1.02)	(1.83)	(5.41)	(2.90)	(0.77)	(1.14)
SD=2.46	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
20m, N=55	0.75	0.79	0.80	0.66	0.33	0.93	1.41	1.87	0.92	1.65	0.42
avg=0.95	(0.91)	(0.72)	(0.94)	(0.42)	(0.34)	(0.91)	(1.26)	(2.17)	(1.01)	(1.19)	(0.49)
SD=1.12	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
25m, N=55	0.66	0.83	0.68	0.68	0.20	0.48	1.11	1.42	1.23	1.82	0.83
avg=0.89	(0.79)	(0.72)	(0.65)	(0.49)	(0.17)	(0.60)	(1.02)	(1.68)	(1.79)	(1.56)	(1.15)
SD=1.10	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
30m, N=53	0.56	0.43	0.62	0.59	0.22	1.52	0.90	1.22	0.90	1.72	0.65
avg=0.84	(0.52)	(0.62)	(0.67)	(0.54)	(0.20)	(1.96)	(0.60)	(1.46)	(1.36)	(1.53)	(0.67)
SD=1.07	N=5	N=2	N=3	N=6	N=6	N=5	N=4	N=7	N=6	N=3	N=6

Table C4. Monthly average density (N/L) of *Cyclops* in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=5.27, SD=9.87, N=493. Samples were not collected during February.

Depth	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=55	1.51	0.13	0.31	9.60	4.41	2.46	2.44	1.47	2.45	1.13	0.49
avg=2.70	(1.59)	(0.11)	(0.40)	(13.46)	(4.69)	(3.42)	(3.64)	(1.22)	(2.00)	(0.76)	(0.40)
SD=5.37	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
3m, N=55	4.81	0.61	2.10	35.23	31.90	17.82	12.27	6.41	5.42	2.83	1.75
avg=12.40	(4.90)	(0.28)	(1.60)	(35.81)	(36.45)	(12.02)	(14.57)	(7.96)	(6.62)	(1.07)	(O.85)
SD=20.80	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
6m, N=55	4.88	2.18	2.51	16.43	28.33	14.13	9.87	4.33	6.02	3.97	1.19
avg=9.32	(4.16)	(2.33)	(1.44)	(21.47)	(31.88)	(7.81)	(10.37)	(3.12)	(6.67)	(0.72)	(0.66)
SD=15.00	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
9m, N=55	6.65	2.75	1.66	9.89	12.77	10.08	7.48	4.09	5.09	3.35	2.45
avg=6.44	(4.87)	(3.48)	(1.06)	(9.31)	(11.88)	(6.00)	(6.27)	(1.48)	(5.11)	(0.95)	(2.39)
SD=6.67	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
12m, N=55	4.33	3.34	1.30	5.65	9.29	6.91	7.56	3.11	3.95	4.16	1.26
avg=4.78	(4.13)	(4.91)	(0.96)	(5.34)	(10.14)	(3.12)	(4.21)	(1.86)	(3.12)	(2.49)	(0.65)
SD=4.91	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
15m, N=55	4.74	2.98	1.60	5.16	5.33	4.80	4.94	3.74	3.08	3.47	2.03
avg=3.93	(3.84)	(3.88)	(0.90)	(4.77)	(4.94)	(3.16)	(3.96)	(1.69)	(2.37)	(0.75)	(1.58)
SD=3.24	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
20m, N=55	3.11	2.09	1.26	3.68	5.89	2.47	3.51	2.35	2.22	3.75	1.49
avg=2.96	(2.52)	(2.55)	(1.36)	(3.66)	(8.69)	(0.71)	(3.35)	(1.72)	(1.75)	(0.98)	(0.88)
SD=3.50	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
25m, N=55	2.53	1.74	0.95	4.67	3.27	1.61	1.25	3.52	1.85	4.70	2.16
avg=2.64	(1.50)	(1.30)	(1.17)	(5.91)	(3.24)	(1.32)	(0.42)	(4.78)	(1.14)	(1.97)	(1.95)
SD=3.03	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
30m, N=53	2.66	0.39	0.74	2.71	2.03	3.74	1.37	1.76	1.37	4.91	1.89
avg=2.18	(2.51)	(0.45)	(0.57)	(2.62)	(1.72)	(4.38)	(0.28)	(1.70)	(1.10)	(2.55)	(1.02)
SD=2.20	N=5	N=2	N=3	N=6	N=6	N=5	N=4	N=7	N=6	N=3	N=6

Table C5. Monthly average density (N/L) of *Epischura* in the Tenmile area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=0.03, SD=0.04, N=493. Samples were not collected during February.

Depth	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=55	0.01	0	0	0.05	0.01	0.01	0.02	0	0.04	0	0.01
avg=0.01	(0.01)	(0)	(0)	(0.09)	(0.03)	(0.02)	(0.04)	(0)	(0.04)	(0)	(0.01)
SD=0.04	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
3m, N=55	0.01	0	0	0.26	0.02	0.05	0.02	0	0.01	0	0.05
avg=0.04	(0.03)	(0)	(0)	(0.27)	(0.04)	(0.07)	(0.03)	(0)	(0.02)	(0)	(0.08)
SD=0.12	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
6m, N=55	0	0	0	0.15	0.05	0.07	0.01	0.01	0.02	0.01	0.01
avg=0.03	(0)	(0)	(0)	(0.32)	(0.07)	(0.06)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
SD=0.11	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
9m, N=55	0.02	0	0	0.02	0.02	0.15	0.05	0.02	0.01	0	0.02
avg=0.03	(0.04)	(0)	(0)	(0.03)	(0.04)	(0.14)	(0.07)	(0.04)	(0.01)	(0)	(0.02)
SD=0.07	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
12m, N=55	0	0	0	0.05	0.02	0.13	0.13	0.03	0.01	0.01	0.03
avg=0.04	(0)	(0)	(0)	(0.09)	(0.03)	(0.07)	(0.26)	(0.03)	(0.07)	(0.02)	(0.04)
SD=0.09	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
15m, N=55	0	0	0	0.03	0.09	0.08	0.03	0.02	0	0	0.01
avg=0.03	(0)	(0)	(0)	(0.05)	(0.23)	(0.09)	(0.04)	(0.03)	(0)	(0)	(0.01)
SD=0.08	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
20m, N=55	0.03	0	0	0.02	0.03	0.07	0.11	0.02	0	0.01	0.01
avg=0.03	(0.08)	(0)	(0)	(0.05)	(0.08)	(0.11)	(0.23)	(0.03)	(0)	(0.02)	(0.02)
SD=0.09	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
25m, N=55	0	0	0	0.01	0.03	0.02	0.09	0.01	0.03	0	0.01
avg=0.02	(0)	(0)	(0)	(0.02)	(0.07)	(0.04)	(0.18)	(0.01)	(0.04)	(0)	(0.01)
SD=0.06	N=5	N=3	N=3	N=6	N=6	N=5	N=5	N=7	N=6	N=3	N=6
30m, N=53	0.01	0	0	0.01	0.02	0.06	0.21	0.01	0.01	0	0.05
avg=0.03	(0.03)	(0)	(0)	(0.02)	(0.04)	(0.12)	(0.41)	(0.01)	(0.02)	(0)	(0.08)
SD=0.12	N=5	N=2	N=3	N=6	N=6	N=5	N=4	N=7	N=6	N=3	N=6

Table C6. Monthly average density (N/L) of *Daphnia* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=1.91, SD=4.84, N=436.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=51 avg=1.58 SD=6.97	0.18 (0.06) N=2	1.21 (0) N=1	0.03 (0.07) N=4	0.01 (0.02) N=4	0.16 (0.25) N=5	9.86 (17.63) N=7	0.40 (0.53) N=3	0.52 (0.81) N=6	0.13 (0.14) N=4	0.22 (0.31) N=5	0.32 (0.41) N=6	0.27 (0.34) N=4
3m, N=51 avg=4.19 SD=8.79	3.11 (3.05) N=2	3.17 (0) N=1	0.90 (1.02) N=3	0.83 (1.02) N=4	4.23 (6.97) N=5	15.03 (19.43) N=7	4.48 (1.91) N=3	4.63 (6.38) N=6	3.52 (5.08) N=5	1.20 (0.57) N=5	0.93 (0.64) N=6	0.41 (0.33) N=4
6m, N=51 avg=3.58 SD=6.77	2.00 (1.87) N=2	3.70 (0) N=1	2.58 (2.98) N=3	0.94 (0.71) N=4	2.18 (3.07) N=5	13.04 (14.93) N=7	4.81 (1.04) N=3	3.04 (2.30) N=6	3.47 (4.73) N=4	0.81 (0.47) N=5	1.16 (0.84) N=7	0.64 (0.44) N=4
9m, N=48 avg=2.20 SD=3.33	2.00 (2.63) N=2	3.27 (0) N=1	0.71 (0.94) N=3	1.53 (1.51) N=4	1.80 (2.36) N=5	5.74 (7.70) N=7	4.87 (2.53) N=3	1.78 (1.06) N=6	1.90 (1.71) N=4	0.67 (0.31) N=4	0.56 (0.28) N=5	0.57 (0.48) N=4
12m, N=50 avg=1.51 SD=2.06	1.60 (2.01) N=2	1.17 (0) N=1	0.70 (0.71) N=3	0.73 (0.57) N=4	1.65 (2.19) N=5	4.24 (4.15) N=7	1.15 (1.00) N=3	1.28 (0.76) N=6	1.02 (0.66) N=4	0.69 (0.52) N=5	1.06 (1.02) N=6	0.72 (0.49) N=4
15m, N=49 avg=1.15 SD=1.37	1.17 (1.36) N=2	0.39 (0) N=1	0.51 (0.56) N=2	0.78 (0.63) N=4	1.10 (1.52) N=5	2.69 (2.82) N=7	1.25 (0.28) N=3	0.98 (0.77) N=6	1.02 (0.41) N=4	0.69 (0.62) N=5	0.87 (0.76) N=6	0.74 (0.67) N=4
20m, N=47 avg=0.93 SD=1.23	1.35 (1.06) N=2	0.50 (0) N=1	0.33 (0.01) N=2	0.24 (0.20) N=4	0.61 (0.65) N=3	2.34 (2.71) N=7	0.99 (0.42) N=3	0.76 (0.58) N=6	0.71 (0.48) N=4	0.63 (0.58) N=5	0.78 (0.38) N=6	0.67 (0.41) N=4
25m, N=45 avg=0.89 SD=1.27	0.91 (1.08) N=2	0.60 (0) N=1	0.21 (0) N=1	0.13 (0.11) N=3	0.89 (1.13) N=4	2.12 (2.89) N=6	0.51 (0.14) N=3	0.65 (0.79) N=6	0.69 (0.55) N=4	0.67 (0.61) N=5	0.95 (0.98) N=6	0.86 (0.62) N=4
30m, N=44 avg=0.81 SD=1.05	1.26 (1.23) N=2	0 (0) N=1	0.39 (0) N=1	0.07 (0.12) N=3	1.11 (1.46) N=3	1.68 (1.97) N=6	0.46 (0.20) N=4	0.77 (1.05) N=6	0.56 (0.58) N=4	0.42 (0.35) N=5	1.08 (1.03) N=6	0.54 (0.29) N=3

Table C7. Monthly average density (N/L) of *Bosmina* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=0.73, SD=2.05, N=436.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=51	0	0.07	0	0	0.03	1.04	0.21	0.14	0.13	0.31	0.11	0.31
avg=0.25	(0)	(0)	(0)	(0)	(0.08)	(1.43)	(0.38)	(0.28)	(0.18)	(0.47)	(0.12)	(0.37)
SD=0.63	N=2	N=1	N=4	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
3m, N=51	0.02	0.14	0.01	0.03	0.17	3.54	0.38	0.84	0.46	0.84	0.40	1.02
avg=0.88	(0.03)	(0)	(0.02)	(0.02)	(0.16)	(6.46)	(0.63)	(1.52)	(0.51)	(1.48)	(0.47)	(1.67)
SD=2.62	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=5	N=5	N=6	N=4
6m, N=51	0.05	0.11	0.02	0.10	0.13	4.55	0.52	0.80	0.91	0.85	0.61	2.26
avg=1.19	(0.07)	(0)	(0.04)	(0.17)	(0.17)	(7.55)	(0.73)	(1.44)	(0.87)	(1.09)	(0.66)	(3.96)
SD=3.22	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=7	N=4
9m, N=48	0.10	0	0.01	0.12	0.16	2.80	0.52	0.49	0.77	0.51	0.20	2.35
avg=0.86	(0.14)	(0)	(0.02)	(0.07)	(0.15)	(4.10)	(0.55)	(0.81)	(0.74)	(0.87)	(0.21)	(4.16)
SD=2.11	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=4	N=5	N=4
12m, N=50	0.07	0.04	0.03	0.10	0.12	2.53	0.34	0.32	0.51	0.22	0.44	2.85
avg=0.78	(0.09)	(0)	(0.03)	(0.13)	(0.12)	(3.19)	(0.43)	(0.52)	(0.43)	(0.33)	(0.49)	(5.13)
SD=1.99	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
15m, N=49	0.14	0.07	0.06	0.06	0.08	3.22	0.46	0.21	0.35	0.45	0.34	2.01
avg=0.82	(0.13)	(0)	(0.08)	(0.06)	(0.07)	(4.55)	(0.51)	(0.32)	(0.35)	(0.45)	(0.46)	(3.20)
SD=2.13	N=2	N=1	N=2	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
20m, N=47	0.07	0	0.04	0.06	0.05	3.12	0.47	0.17	0.39	0.29	0.28	1.44
avg=0.75	(0.04)	(0)	(0.05)	(0.10)	(0.06)	(4.05)	(0.61)	(0.26)	(0.40)	(0.41)	(0.28)	(2.52)
SD=1.94	N=2	N=1	N=2	N=4	N=3	N=7	N=3	N=6	N=4	N=5	N=6	N=4
25m, N=45	0.15	0	0	0.02	0.03	2.44	0.66	0.17	0.40	0.12	0.21	1.05
avg=0.57	(0.11)	(0)	(0)	(0.04)	(0.03)	(2.22)	(0.82)	(0.31)	(0.53)	(0.14)	(0.26)	(1.90)
SD=1.23	N=2	N=1	N=1	N=3	N=4	N=6	N=3	N=6	N=4	N=5	N=6	N=4
30m, N=44	0.04	0	0.11	0.01	0.05	2.27	0.24	0.31	0.29	0.21	0.21	0.04
avg=0.46	(0.05)	(0)	(0)	(0.02)	(0.05)	(2.74)	(0.27)	(0.44)	(0.30)	(0.23)	(0.28)	(0.08)
SD=1.21	N=2	N=1	N=1	N=3	N=3	N=6	N=4	N=6	N=4	N=5	N=6	N=3

Table C8. Monthly average density (N/L) of *Diaptomus* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=1.80, SD=3.84, N=436.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=51	1.19	1.64	0.33	0.17	0.20	5.66	0.41	2.90	0.29	1.62	0.71	0.20
avg=1.56	(0.97)	(0)	(0.42)	(0.31)	(0.17)	(8.78)	(0.33)	(4.73)	(0.26)	(1.85)	(0.68)	(0.18)
SD=3.92	N=2	N=1	N=4	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
3m, N=51	5.30	2.10	1.32	1.14	1.14	4.25	2.73	3.40	10.60	2.92	1.04	0.44
avg=3.15	(5.08)	(0)	(1.31)	(1.35)	(1.50)	(4.62)	(1.10)	(2.65)	(21.37)	(2.85)	(1.02)	(0.32)
SD=7.03	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=5	N=5	N=6	N=4
6m, N=51	3.20	2.53	3.13	1.21	1.19	3.28	2.81	5.41	10.54	2.42	1.14	0.48
avg=3.08	(3.11)	(0)	(2.64)	(1.48)	(1.77)	(3.72)	(1.54)	(4.18)	(17.23)	(1.61)	(1.41)	(0.29)
SD=5.43	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=7	N=4
9m, N=48	2.10	1.92	1.49	0.66	0.94	1.65	2.92	3.32	6.81	2.05	1.41	0.32
avg=2.12	(2.87)	(0)	(1.98)	(0.68)	(1.25)	(1.78)	(3.05)	(3.24)	(10.89)	(1.72)	(1.74)	(0.39)
SD=3.64	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=4	N=5	N=4
12m, N=50	1.52	0.71	1.98	0.44	0.81	1.14	0.56	2.37	4.07	1.87	1.49	0.41
avg=1.51	(1.99)	(0)	(2.51)	(0.36)	(1.29)	(0.89)	(0.80)	(3.23)	(6.17)	(2.04)	(1.73)	(0.36)
SD=2.37	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
15m, N=49	0.94	0.28	2.51	0.54	0.66	0.79	0.98	2.06	3.12	1.78	1.52	0.30
avg=1.33	(1.12)	(0)	(3.20)	(0.51)	(1.18)	(0.81)	(1.11)	(1.92)	(4.57)	(1.66)	(2.22)	(0.23)
SD=1.90	N=2	N=1	N=2	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
20m, N=47	0.98	0.82	1.36	0.38	0.69	0.73	0.66	1.37	2.54	2.18	1.77	0.38
avg=1.23	(0.59)	(0)	(1.57)	(0.39)	(0.99)	(0.82)	(0.55)	(1.40)	(3.86)	(2.29)	(2.50)	(0.22)
SD=1.74	N=2	N=1	N=2	N=4	N=3	N=7	N=3	N=6	N=4	N=5	N=6	N=4
25m, N=45	1.26	0.75	0.21	0.03	0.43	0.53	0.71	1.35	2.09	1.85	1.48	0.39
avg=1.04	(1.43)	(0)	(0)	(0.04)	(0.71)	(0.52)	(0.68)	(1.18)	(3.20)	(2.62)	(2.49)	(0.23)
SD=1.66	N=2	N=1	N=1	N=3	N=4	N=6	N=3	N=6	N=4	N=5	N=6	N=4
30m, N=44	1.24	0	0.07	0.05	0.50	0.82	0.45	0.94	1.79	1.01	1.88	0.24
avg=0.93	(1.11)	(0)	(0)	(0.08)	(0.75)	(1.31)	(0.44)	(0.76)	(3.04)	(0.74)	(3.51)	(0.16)
SD=1.68	N=2	N=1	N=1	N=3	N=3	N=6	N=4	N=6	N=4	N=5	N=6	N=3

Table C9. Monthly average density (N/L) of *Cyclops* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=5.22, SD=7.91, N=436.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=51	0.83	1.67	0.38	0.08	1.77	16.02	4.57	3.11	1.17	3.11	1.91	1.96
avg=3.88	(0.89)	(0)	(0.27)	(0.09)	(0.92)	(14.52)	(6.52)	(1.83)	(0.39)	(3.09)	(1.72)	(1.04)
SD=7.33	N=2	N=1	N=4	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
3m, N=51	3.16	1.89	2.05	6.09	10.32	25.68	13.15	9.76	6.24	2.58	2.71	3.04
avg=8.64	(0.47)	(0)	(0.55)	(8.37)	(10.08)	(19.49)	(9.73)	(8.37)	(3.18)	(1.55)	(1.88)	(1.21)
SD=11.30	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=5	N=5	N=6	N=4
6m, N=51	1.94	3.24	4.99	10.07	10.35	23.77	10.17	9.58	5.84	2.51	2.59	3.84
avg=8.59	(0.47)	(0)	(2.37)	(15.38)	(12.37)	(17.21)	(2.67)	(6.77)	(1.71)	(1.25)	(1.12)	(3.25)
SD=10.70	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=7	N=4
9m, N=48	0.93	2.35	2.26	8.26	9.05	16.06	8.61	6.97	5.38	2.31	1.94	3.32
avg=6.73	(0.95)	(0)	(0.14)	(9.07)	(9.11)	(17.51)	(3.06)	(3.44)	(0.99)	(1.44)	(1.33)	(2.86)
SD=8.74	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=4	N=5	N=4
12m, N=50	0.90	0.89	1.93	2.43	8.58	13.77	2.11	4.21	4.02	2.28	2.77	4.11
avg=4.99	(0.47)	(0)	(0.90)	(2.80)	(8.74)	(13.31)	(2.28)	(1.95)	(1.73)	(2.30)	(1.20)	(3.43)
SD=6.86	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
15m, N=49	0.59	0.43	1.46	2.82	6.92	12.73	2.75	2.88	3.76	2.16	2.48	3.74
avg=4.50	(0.19)	(0)	(0.35)	(3.43)	(8.07)	(13.50)	(1.48)	(1.48)	(1.23)	(1.83)	(1.86)	(3.16)
SD=6.66	N=2	N=1	N=2	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
20m, N=47	1.28	0.89	1.09	2.79	4.36	9.25	2.57	2.44	2.61	2.23	2.49	2.93
avg=3.52	(1.06)	(0)	(0.19)	(4.74)	(6.28)	(9.06)	(0.88)	(1.68)	(1.52)	(2.11)	(1.78)	(2.27)
SD=4.67	N=2	N=1	N=2	N=4	N=3	N=7	N=3	N=6	N=4	N=5	N=6	N=4
25m, N=45	0.78	0.64	0.75	0.34	3.27	7.44	1.91	2.96	2.60	1.95	2.58	3.02
avg=2.95	(0.01)	(0)	(0)	(0.45)	(5.36)	(6.46)	(0.97)	(2.03)	(0.38)	(2.22)	(2.32)	(2.13)
SD=3.53	N=2	N=1	N=1	N=3	N=4	N=6	N=3	N=6	N=4	N=5	N=6	N=4
30m, N=44	0.95	0	0.28	0.24	4.20	6.16	1.59	2.27	1.90	1.54	2.56	1.99
avg=2.48	(0.64)	(0)	(0)	(0.41)	(6.50)	(9.07)	(0.68)	(1.88)	(0.58)	(1.08)	(3.01)	(0.57)
SD=4.03	N=2	N=1	N=1	N=3	N=3	N=6	N=4	N=6	N=4	N=5	N=6	N=3

Table C10. Monthly average density (N/L) of *Epischura* in the Rexford area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=0.02, SD=0.07, N=436.

Depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Surface, N=51	0	0	0	0	0.09	0	0	0.01	0	0	0	0.04
avg=0.01	(0)	(0)	(0)	(0)	(0.19)	(0)	(0)	(0.02)	(0)	(0)	(0)	(0.05)
SD=0.06	N=2	N=1	N=4	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
3m, N=51	0	0	0	0	0.07	0.01	0.01	0.09	0.03	0.02	0.01	0.02
avg=0.03	(0)	(0)	(0)	(0)	(0.13)	(0.04)	(0.02)	(0.12)	(0.05)	(0.04)	(0.02)	(0.02)
SD=0.07	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=5	N=5	N=6	N=4
6m, N=51	0.02	0	0	0	0.09	0	0.07	0.05	0.03	0.01	0	0.02
avg=0.02	(0.03)	(0)	(0)	(0)	(0.21)	(0)	(0.09)	(0.06)	(0.03)	(0.01)	(0)	(0.04)
SD=0.07	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=7	N=4
9m, N=48	0	0	0	0	0.14	0.07	0.11	0.06	0.01	0.01	0.02	0.01
avg=0.04	(0)	(0)	(0)	(0)	(0.31)	(0.12)	(0.12)	(0.09)	(0.01)	(0.01)	(0.03)	(0.01)
SD=0.12	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=4	N=5	N=4
12m, N=50	0	0	0	0	0.04	0.04	0.02	0.07	0.06	0.01	0.01	0.02
avg=0.03	(0)	(0)	(0)	(0)	(0.09)	(0.09)	(0.04)	(0.10)	(0.12)	(0.01)	(0.01)	(0.04)
SD=0.06	N=2	N=1	N=3	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
15m, N=49	0	0	0	0	0.03	0	0.01	0.03	0.07	0.01	0.02	0.08
avg=0.02	(0)	(0)	(0)	(0)	(0.08)	(0)	(0.02)	(0.03)	(0.07)	(0.02)	(0.03)	(0.14)
SD=0.06	N=2	N=1	N=2	N=4	N=5	N=7	N=3	N=6	N=4	N=5	N=6	N=4
20m, N=47	0	0	0	0	0	0.01	0.02	0.03	0.01	0.01	0.02	0.04
avg=0.01	(0)	(0)	(0)	(0)	(0)	(0.03)	(0.04)	(0.04)	(0.01)	(0.01)	(0.03)	(0.04)
SD=0.03	N=2	N=1	N=2	N=4	N=3	N=7	N=3	N=6	N=4	N=5	N=6	N=4
25m, N=45	0	0	0	0	0	0	0.02	0.01	0	0.01	0.05	0.04
avg=0.02	(0)	(0)	(0)	(0)	(0)	(0)	(0.02)	(0.02)	(0)	(0.03)	(0.09)	(0.03)
SD=0.04	N=2	N=1	N=1	N=3	N=4	N=6	N=3	N=6	N=4	N=5	N=6	N=4
30m, N=44	0	0	0	0	0	0	0.02	0.01	0.01	0.01	0.04	0
avg=0.01	(0)	(0)	(0)	(0)	(0)	(0)	(0.04)	(0.03)	(0.02)	(0.02)	(0.08)	(0)
SD=0.03	N=2	N=1	N=1	N=3	N=3	N=6	N=4	N=6	N=4	N=5	N=6	N=3

Table C11. Monthly average density (N/L) of *Daphnia* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=3.75, SD=10.45, N=215. Samples were not taken during December - May.

Depth	Jun	Jul	Aug	Sep	Oct	Nov
Surface, N=29	1.04	12.91	0.87	0.16	0.67	0.82
avg=1.96	(1.95)	(20.78)	(1.89)	(0.30)	(0.76)	(1.50)
SD=6.84	N=4	N=3	N=7	N=6	N=4	N=5
3m, N=28	41.73	36.49	9.51	8.00	3.47	1.74
avg=14.48	(48.34)	(42.10)	(3.62)	(5.47)	(3.38)	(3.37)
SD=25.00	N=4	N=3	N=7	N=5	N=4	N=5
6m, N=29	4.67	10.07	7.20	3.67	4.48	1.70
avg=5.09	(6.60)	(3.25)	(2.85)	(3.08)	(3.13)	(2.76)
SD=4.16	N=4	N=3	N=7	N=6	N=4	N=5
9m, N=28	1.27	7.83	4.46	2.35	1.59	1.62
avg=3.10	(1.64)	(3.74)	(2.45)	(2.56)	(1.61)	(3.03)
SD=3.07	N=4	N=3	N=7	N=6	N=4	N=4
12m, N=23	2.46	5.37	3.33	1.50	1.22	1.30
avg=2.59	(1.79)	(0.49)	(4.27)	(0.92)	(0.19)	(2.26)
SD=2.78	N=2	N=3	N=7	N=5	N=3	N=3
15m, N=23	2.45	3.00	3.22	0.96	0.38	0.96
avg=1.97	(1.16)	(1.73)	(3.17)	(0.89)	(0.36)	(1.66)
SD=2.21	N=2	N=3	N=7	N=5	N=3	N=3
20m, N=19	0	0.55	0.50	0.12	0	0
avg=0.24	(0)	(0.49)	(0.48)	(0.21)	(0)	(0)
SD=0.38	N=2	N=3	N=5	N=3	N=3	N=3
25m, N=18	0	0	0	0.05	0	0
avg=0.01	(0)	(0)	(0)	(0.08)	(0)	(0)
SD=0.03	N=2	N=2	N=5	N=3	N=3	N=3
30m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3

Table C12. Monthly average density (N/L) of *Bosmina* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=0.24, SD=0.96, N=215. Samples were not taken during December - May.

Depth	Jun	Jul	Aug	Sep	Oct	Nov
Surface, N=29	0.12	0.01	0.05	0.32	0.09	0.08
avg=0.12	(0.14)	(0.02)	(0.07)	(0.72)	(0.10)	(0.08)
SD=0.33	N=4	N=3	N=7	N=6	N=4	N=5
3m, N=28	0.05	0.05	0.13	2.04	0.17	0.12
avg=0.45	(0.06)	(0.04)	(0.23)	(4.12)	(0.17)	(0.20)
SD=1.76	N=4	N=3	N=7	N=5	N=4	N=5
6m, N=29	0.34	0.06	0.23	1.57	0.24	0.14
avg=0.49	(0.62)	(0.06)	(0.54)	(3.45)	(0.23)	(0.21)
SD=1.60	N=4	N=3	N=7	N=6	N=4	N=5
9m, N=28	0.08	0	0.31	0.71	0.30	0.12
avg=0.30	(0.08)	(0)	(0.52)	(1.37)	(0.36)	(0.09)
SD=0.69	N=4	N=3	N=7	N=6	N=4	N=4
12m, N=23	0.05	0.02	0.14	1.13	0.83	0.06
avg=0.41	(0.07)	(0.04)	(0.25)	(1.48)	(1.38)	(0.10)
SD=0.90	N=2	N=3	N=7	N=5	N=3	N=3
15m, N=23	0.01	0.01	0.09	0.28	0.33	0.23
avg=0.16	(0.02)	(0.02)	(0.07)	(0.46)	(0.52)	(0.39)
SD=0.30	N=2	N=3	N=7	N=5	N=3	N=3
20m, N=19	0	0.02	0.06	0.01	0	0
avg=0.02	(0)	(0.04)	(0.09)	(0.02)	(0)	(0)
SD=0.05	N=2	N=3	N=5	N=3	N=3	N=3
25m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3
30m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3

Table C13. Monthly average density (N/L) of *Diaptomus* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=2.30, SD=4.75, N=215. Samples were not taken during December - May.

Depth	Jun	Jul	Aug	Sep	Oct	Nov
Surface, N=29	5.11	9.54	0.39	0.66	2.83	1.03
avg=2.49	(10.19)	(13.57)	(0.53)	(0.76)	(2.57)	(1.71)
SD=5.84	N=4	N=3	N=7	N=6	N=4	N=5
3m, N=28	5.96	12.49	3.20	10.78	2.25	1.51
avg=5.50	(10.92)	(16.38)	(4.12)	(10.25)	(1.66)	(2.87)
SD=8.39	N=4	N=3	N=7	N=5	N=4	N=5
6m, N=29	2.17	3.31	2.84	5.77	3.43	1.11
avg=3.18	(4.17)	(1.74)	(3.29)	(7.65)	(3.34)	(1.99)
SD=4.36	N=4	N=3	N=7	N=6	N=4	N=5
9m, N=28	0.98	3.40	3.21	3.43	1.42	1.39
avg=2.44	(1.83)	(2.84)	(4.98)	(3.61)	(1.47)	(2.24)
SD=3.29	N=4	N=3	N=7	N=6	N=4	N=4
12m, N=23	1.76	3.43	2.88	2.37	1.50	0.81
avg=2.29	(2.31)	(3.02)	(6.08)	(2.37)	(1.27)	(1.40)
SD=3.63	N=2	N=3	N=7	N=5	N=3	N=3
15m, N=23	1.55	1.99	3.10	1.79	1.18	0.75
avg=1.98	(2.09)	(0.97)	(6.64)	(1.45)	(2.00)	(1.29)
SD=3.73	N=2	N=3	N=7	N=5	N=3	N=3
20m, N=19	0	1.45	0.66	0.38	0	0
avg=0.46	(0)	(1.44)	(1.14)	(0.66)	(0)	(0)
SD=0.91	N=2	N=3	N=5	N=3	N=3	N=3
25m, N=18	0	0	0	0.09	0	0
avg=0.02	(0)	(0)	(0)	(0.16)	(0)	(0)
SD=0.07	N=2	N=2	N=5	N=3	N=3	N=3
30m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3

Table C14. Monthly average density (N/L) of *Cyclops* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=3.84, SD=6.24, N=215. Samples were not taken during December - May.

Depth	Jun	Jul	Aug	Sep	Oct	Nov
Surface, N=29	2.27	9.88	1.56	2.12	4.49	1.02
avg=2.95	(3.73)	(12.49)	(2.27)	(2.17)	(5.88)	(1.31)
SD=5.12	N=4	N=3	N=7	N=6	N=4	N=5
3m, N=28	13.57	16.38	10.66	16.48	8.60	1.71
avg=10.83	(16.80)	(11.82)	(8.51)	(13.19)	(8.52)	(3.17)
SD=10.90	N=4	N=3	N=7	N=5	N=4	N=5
6m, N=29	6.80	7.23	5.88	6.16	9.73	1.12
avg=5.91	(9.83)	(1.06)	(4.25)	(4.62)	(12.13)	(2.02)
SD=6.40	N=4	N=3	N=7	N=6	N=4	N=5
9m, N=28	2.38	5.04	5.10	4.20	3.92	1.43
avg=3.82	(3.22)	(2.23)	(5.28)	(2.67)	(4.42)	(2.14)
SD=3.67	N=4	N=3	N=7	N=6	N=4	N=4
12m, N=23	4.43	4.05	4.52	3.10	3.98	0.96
avg=3.61	(3.87)	(1.25)	(7.15)	(1.69)	(4.30)	(1.66)
SD=4.31	N=2	N=3	N=7	N=5	N=3	N=3
15m, N=23	5.17	2.72	3.85	2.03	0.83	0.52
avg=2.60	(5.37)	(0.94)	(4.32)	(1.16)	(0.75)	(0.91)
SD=3.01	N=2	N=3	N=7	N=5	N=3	N=3
20m, N=19	0	2.01	1.63	0.24	0	0
avg=0.78	(0)	(2.33)	(1.84)	(0.41)	(0)	(0)
SD=1.47	N=2	N=3	N=5	N=3	N=3	N=3
25m, N=18	0	0	0	0.11	0	0
avg=0.02	(0)	(0)	(0)	(0.18)	(0)	(0)
SD=0.08	N=2	N=2	N=5	N=3	N=3	N=3
30m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3

Table C15. Monthly average density (N/L) of *Epischura* in the Canada area of Libby Reservoir at discrete depths, 1983 through 1989. Values in parentheses are the standard deviations. For entire population: avg=0.04, SD=0.16, N=215. Samples were not taken during December - May.

Depth	Jun	Jul	Aug	Sep	Oct	Nov
Surface, N=29	0	0	0.02	0.01	0.04	0
avg=0.01	(0)	(0)	(0.04)	(0.03)	(0.05)	(0)
SD=0.03	N=4	N=3	N=7	N=6	N=4	N=5
3m, N=28	0.08	0.02	0.11	0.07	0.02	0.01
avg=0.06	(0.17)	(0.04)	(0.13)	(0.05)	(0.04)	(0.02)
SD=0.10	N=4	N=3	N=7	N=5	N=4	N=5
6m, N=29	0.02	0	0.09	0.04	0.01	0
avg=0.04	(0.04)	(0)	(0.09)	(0.07)	(0.02)	(0)
SD=0.06	N=4	N=3	N=7	N=6	N=4	N=5
9m, N=28	0.56	0	0.14	0.04	0.02	0
avg=0.13	(1.10)	(0)	(0.16)	(0.06)	(0.04)	(0)
SD=0.42	N=4	N=3	N=7	N=6	N=4	N=4
12m, N=23	0	0	0.10	0.03	0.02	0
avg=0.04	(0)	(0)	(0.14)	(0.05)	(0.04)	(0)
SD=0.09	N=2	N=3	N=7	N=5	N=3	N=3
15m, N=23	0	0.01	0.05	0.01	0	0
avg=0.02	(0)	(0.02)	(0.05)	(0.02)	(0)	(0)
SD=0.04	N=2	N=3	N=7	N=5	N=3	N=3
20m, N=19	0	0	0	0.02	0	0
avg=<0.01	(0)	(0)	(0)	(0.04)	(0)	(0)
SD=0.02	N=2	N=3	N=5	N=3	N=3	N=3
25m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3
30m, N=18	0	0	0	0	0	0
avg=0	(0)	(0)	(0)	(0)	(0)	(0)
SD=0	N=2	N=2	N=5	N=3	N=3	N=3