May 1987

DWORSHAK DAM IMPACTS ASSESSMENT AND FISHERY INVESTIGATION

Annual Report 1987

DOE/BP-35167-1

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do not necessarily represent the views of BPA.

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Maiolie,Melo A.; Senior Fishery Research Biologist, Idaho Department of Fish and Game, Fred Holm, Project Manager, U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Project No. 1987-99, Contract No. DE-AI79-1987BP35167, Columbia River Basin Fish and Wildlife Program Measure 903, 47 electronic pages (BPA Report DOE/BP-35167-1)

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DWORSHAK DAM IMPACTS ASSESSMENT

AND FISHERY INVESTIGATION

Annual Report FY 1987

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Project No. 87-99
Contract No. DE-AI79-87BP35167
Columbia River Basin Fish and Wildlife Program Measure 903(e)(4)

May 1988

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Job Performance Report

State of Idaho: Idaho   Title: Dworshak Dam Impacts Assessment And Fishery Investigation

Period Covered: August 5, 1987 to May 31, 1988

ABSTRACT

A total of 7,071 kokanee spawners were counted during the peak of the spawning run in five tributaries to Dworshak Reservoir during 1987. Both size and numbers of fish were fairly average. During years when numbers of fish were large, total length of age 3t kokanee was as low as 25 cm. Conversely, small numbers of kokanee resulted in an average length of 37 cm. Zooplankton densities during November of 1987 averaged 17.92 organisms/L, but decreased to 3.96 organism/L during December. These densities are similar to values obtained during 1972, although the percentage of cladocerans in the samples may have declined. Kokanee preferred *Daphnia* over 1 mm in length. Concentrations of orthophosphate and nitrate appear to have declined since the reservoir filled. Kokanee catch rates for boat anglers changed from 1.4 fish/h during November to 2.7 fish/h during December to 0.0 fish/h during January. This declining trend may have been temperature related. Harvest for these 3 months was an estimated 1,612 kokanee.

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INTRODUCTION

Bonneville Power Administration is funding two 4-year research projects designed to develop management schemes to improve the sport fishery on Dworshak Reservoir. Both projects were initiated during August 1987 and are a cooperative effort between the Idaho Department of Fish and Game and the Nez Perce Tribe. The Nez Perce Tribe is researching smallmouth bass and rainbow trout, whereas the Idaho Department of Fish and Game is evaluating kokanee population dynamics and documenting changes in reservoir productivity. This report covers only Idaho Department of Fish and Game findings from August 1987 to February 1988. Since results are preliminary, further conclusions and management recommendations will be provided in forthcoming years.

Dworshak Reservoir was initially filled during 1971. Many changes occur in new reservoirs as they age which result in changing abundance of sport fish. Early data on the fishery resources was gathered by Pettit et al. (1975) 9 Ball and Cannon (1974), and Horton (1980, 1981); and on the limnology by Falter et al. (1979) and Falter (1982). Comparison of our data to these earlier works should indicate the effects of reservoir aging and its resulting changes in the sport fishery.

OBJECTIVES

1. To assess the status of kokanee stocks, particularly with respect to age, growth, recruitment, escapement, abundance, and mortality rates (fishing and natural).
2. To document losses of kokanee through the turbines at Dworshak Dam and relate to various discharge and reservoir levels.
3. To assess basic limnological parameters of Dworshak Reservoir and relate to fish production.
4. To evaluate size and species composition, relative abundance, and distribution of zooplankton in Dworshak Reservoir.
5. To evaluate the impacts of reservoir management on primary productivity, the zooplankton community, and the kokanee population.
6. To recommend management techniques for the kokanee fishery.

RECOMMENDATIONS

Due to the limited time since research began, management recommendations will be withheld until more data can be collected.

DESCRIPTION OF STUDY AREA

Dworshak Dam was built across the North Fork of the Clearwater River 3.2 km upstream from its mouth (Figure 1). The dam is approximately 5.2 km northeast of Orofino in Clearwater County, Idaho. It is the largest straight axis concrete dam in the United States, is 219 m high, and contains three turbines with a total operating capacity of 450 megawatts. Water passes through the dam by going through these turbines, by passing through a set of outlet gates, or by passing through a set of tainter gates on the spillway.

The reservoir behind the dam is 86.2 km long and has 295 km of characteristically steep-sided shoreline. Maximum depth in the reservoir is 194 m, and it has a volume of 4.28 x 10^9 m^3. Surface area is 6,644 hectares, and mean depth is 56 m. Considering the volume and a mean annual stream flow of 162 m^3/s, the reservoir has a mean retention time of 10.2 months. Retention time is quite variable and ranged from 22 months in 1973 to 6 months during 1974 (Falter 1982). The reservoir is also characterized by seasonal drawdowns of up to 47 m which reduce the surface area 52% (7,689 hectares to 3,663 hectares).

The Army Corps of Engineers began filling Dworshak Reservoir on September 27, 1971, and it reached full pool on July 3, 1973. Horton (1981) documented 19 fish species in the reservoir (Appendix A). Of these 19 species, the main sport fish are kokanee *Oncorhynchus nerka*, rainbow trout *Salmo gairdneri*, smallmouth bass *Micropterus dolomieui*, largemouth bass *Micropterus salmoides*, bull trout *Salvelinus confluentus*, cutthroat trout *Salmo clarki*, brook trout *Salvelinus fontinalis*, mountain whitefish *Prosopium williamsoni*, and brown bullhead *Ictalurus nebulosus* (Appendix A). In addition, anglers have also reported catching crappie, genus *Pomoxis*.

METHODS

Kokanee Spawning Escapement

Visual counts of kokanee spawners were made by walking upstream on selected tributaries to Dworshak Reservoir during the fall of 1987 to obtain a relative index of kokanee abundance. Isabella, Skull, Quartz, Dog, Breakfast, Beaver, and Elk creeks were surveyed. Surveys were conducted during September and November to count both early and late spawning kokanee races. In Isabella, Skull, Quartz, and Dog creeks, the surveys ran from the creek mouth upstream to where the last spawners were sighted. In Breakfast Creek, the survey was conducted from the mouth upstream approximately 0.8 km to the first road bridge. This section was also surveyed by Horton (1981) during 1979 and 1980.

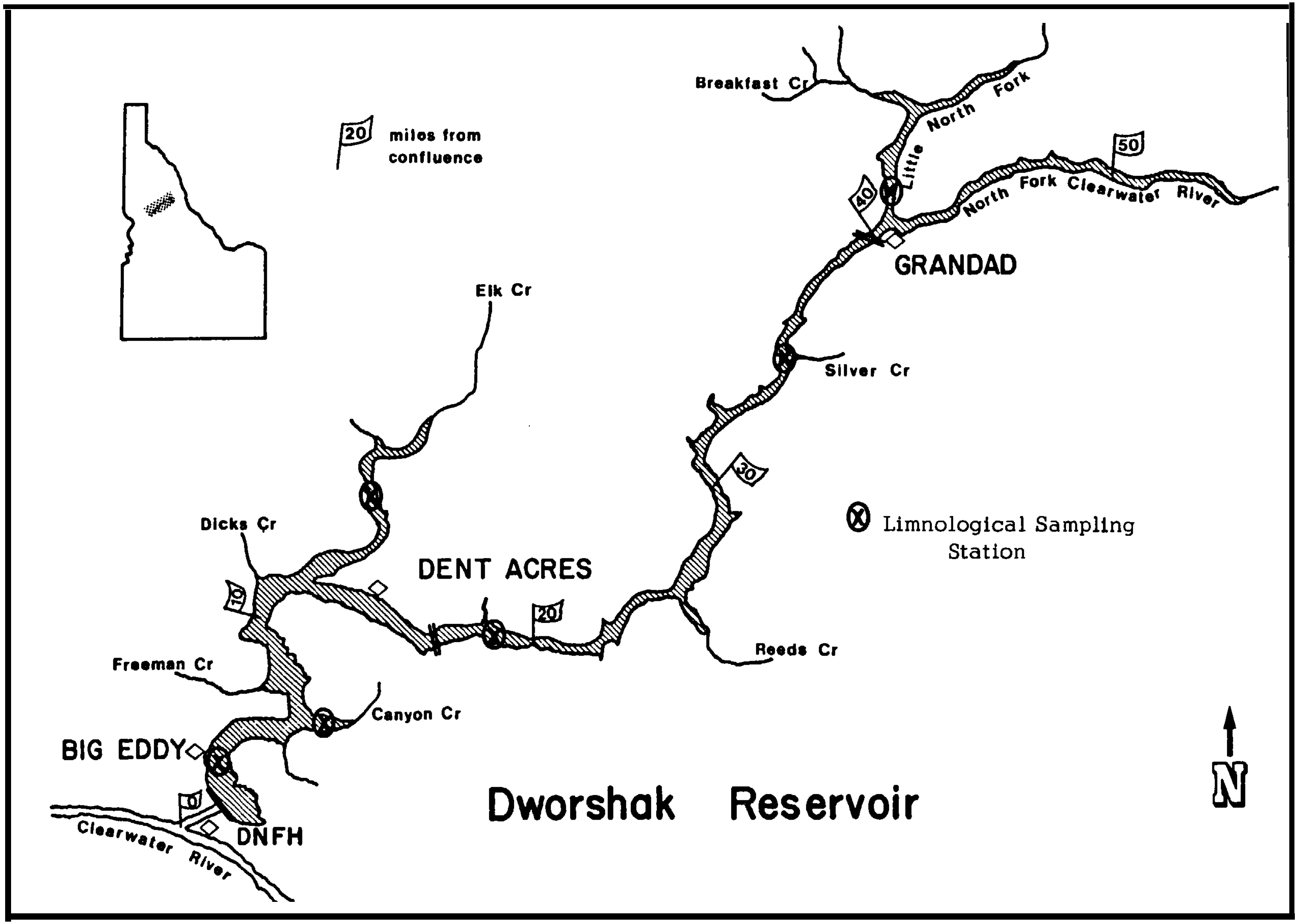

Figure 1. Dworshak Reservoir and major tributaries, North Fork Clearwater River Idaho Horton 1[illegible]

Personnel from the U.S. Fish and Wildlife Service, Fishery Assistance Office, with aid from the U.S. Forest Service and project- personnel, electrofished kokanee spawners from Breakfast Creek, Dog Creek, Skull Creek, Isabella Creek, and the North Fork of the Clearwater River. Fish were examined at Dworshak National Fish Hatchery for the disease Infectious Hemopoietic Necrosis (IHN) and were also used for length-frequency data. Spawner length-frequency data from previous years were also obtained from the Fishery Assistance Office.

Reservoir Limnology

Six limnological sampling stations were chosen in Dworshak Reservoir (Figure 1). Three of these stations were on the main body of the reservoir at river kilometers 5, 31, and 56, (named RK-5, RK-31, and RK-56). Three other stations were located in major arms of the reservoir: 6 km up Elk Creek (EC-6), 2 km up the Little North Fork (LNK-2), and near the Canyon Creek boat ramp (CC). Five of these stations were used by Falter et al. (1979). The Canyon Creek station was added to evaluate smallmouth bass habitat. Due to the remote location of these stations, surveys sometimes took 3 days to complete. Sampling was conducted near the middle of each month.

Measurements at each station included dissolved oxygen and temperature taken with a Yellow Springs Instrument Company meter (Model 57). Readings were taken at the surface, 1 m, and all even meter depths thereafter to a depth of 60 m. Light transparency was measured with a black and white Secchi disc 20 cm in diameter. Plankton was collected with a l/2 m net, 130-150 micron mesh (Size l0), equipped with a pygmy flowmeter. Plankton tows were made by pulling the net vertically from 12.2 m to the surface. Zooplankters were enumerated by family and measured to the nearest 0.05 mm using an ocular micrometer in a dissecting scope at 30 power. In addition, two 1 L water samples were collected at the surface of RK-5 and analyzed by the Idaho Public Health Department for nitrates and orthophosphates.

Creel Survey

A stratified, two-stage probability sampling creel survey design (Malvestuto 1983) was used to sample anglers and record harvest. Days were stratified into weekend and weekdays, and the reservoir was divided into three set t ions : the dam to Dent Bridge, Dent to Grandad Bridge, and Grandad Bridge to the inflow. One section was chosen for sampling on a given day. The random selection of each area was weighted by the expected pressure an area was to receive. Use estimates were obtained from the Army Corps of Engineers. Thus, the lower reservoir, which has the highest amount of use, received the most sampling effort. Ten survey days were selected per month, and pressure and harvest were estimated for monthly intervals.

Reservoir drawdown eliminated access to all boat ramps except the Big Eddy Ramp during winter. Under these conditions, a creel survey clerk remained at the boat ramp throughout the day and obtained completed trip information for all boat anglers. A second clerk traveled to the Dent area and Canyon Creek to check bank anglers. Creel surveys were conducted in cooperation with the Nez Perce Tribe. Our principal interest in the creel survey was to obtain kokanee harvest data and catch rates.

RESULTS

Kokanee Spawning Escapement

A total of 7,071 spawning kokanee were counted during the surveys (Table 1). The largest number of fish counted was in the lower 4.3 km of Isabella Creek, but the greatest density of kokanee was found in the lower end of Dog Creek. No kokanee were seen during November in any of the streams checked.

Two distinct size groups were noted in the 1987 length-frequency distribution (Figure 2). The smaller size group was mostly males and averaged 254 mm long. The larger size group contained a more equal proportion of males and females and averaged 326 mm. The smaller fish were age 2+, and the larger size group was comprised of age 3t and 4t fish.

In order to compare kokanee density and growth, the average size of kokanee in the larger size group was regressed by the least squares method against the number of spawners in Isabella Creek during the peak of the run. The regression was described by the equation:

$$y = -767.8x \text{ t } 30016.99$$

Where, y = the number fish in Isabella Creek, and x = the average length (cm) of 3 and 4-year-old spawners (Figure 3). The correlation coefficient (r) was -0.91.

A similar comparison was made between kokanee size and the number of spawners in Skull, Quartz, and Isabella creeks (Figure 4). The regress ion equation was:

$$Y = -1283.2x + 50133.4$$

Where, y = the numbers of kokanee in the three tributaries, and x = the average length (cm) of 3 and 4-year-old kokanee spawners. Correlation coefficient was r = -0.94.

Table 1. Number of spawning kokanee observed in selected tributaries to Dworshak Reservoir, 1987.

Stream	Date surveyed	Distance surveyed	Surveyed to end of run?	Number counted
Isabella Creek	9/24/87 11/19/87	4.3 km spot checked	yes --	3,520 0
Skull Creek	9/25/87 11/19/87	1.4 km spot checked	yes --	1,351 0
Quartz Creek	9/25/87 11/19/87	1.9 km spot checked	yes --	1,477 0
Dog Creek	9/25/87 11/19/87	0.3 km spot checked	yes --	700 0
Breakfast Creek	9/30/87	0.8 km	no	23
Beaver Creek	11/19/87	spot checked	--	0
Elk Creek	11/15/87	1.6 km	--	0
Total				7,071

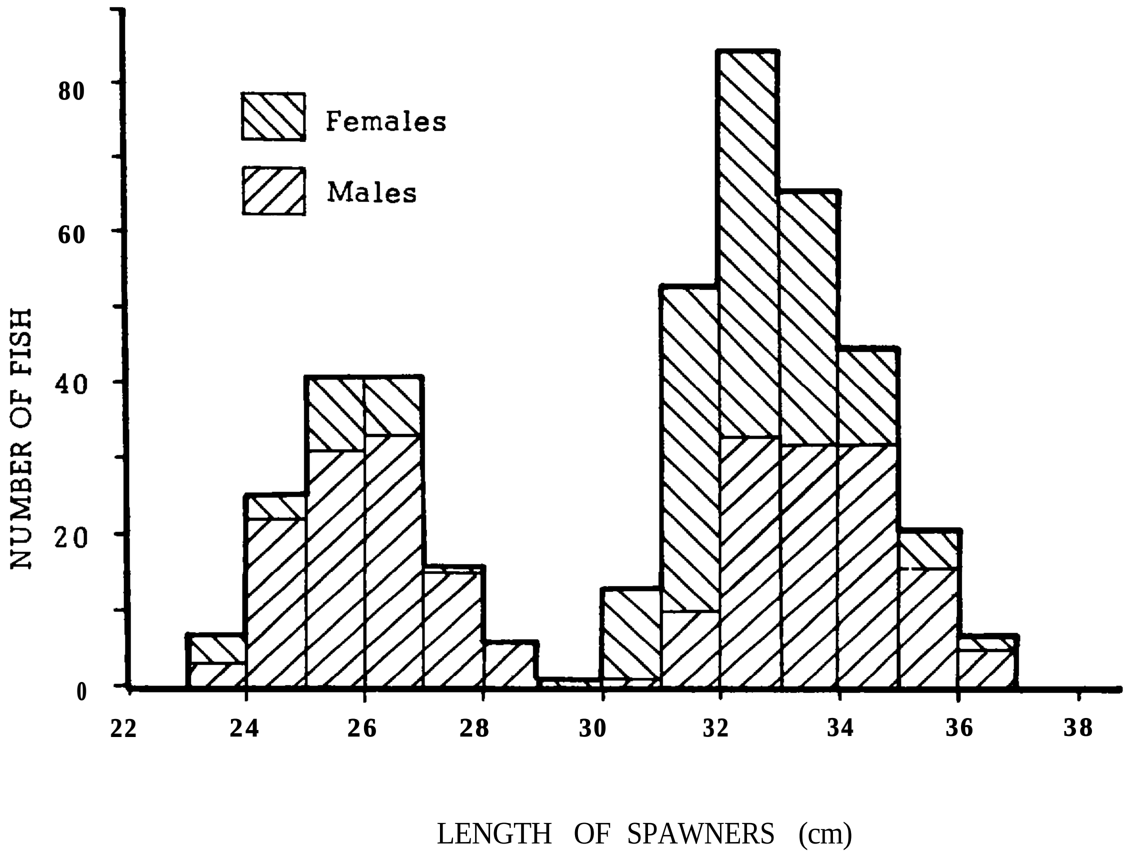

Figure 2. **Size composition of kokanee spawning run in selected tributaries to Dworshak Reservoir during the fall of 1987.**

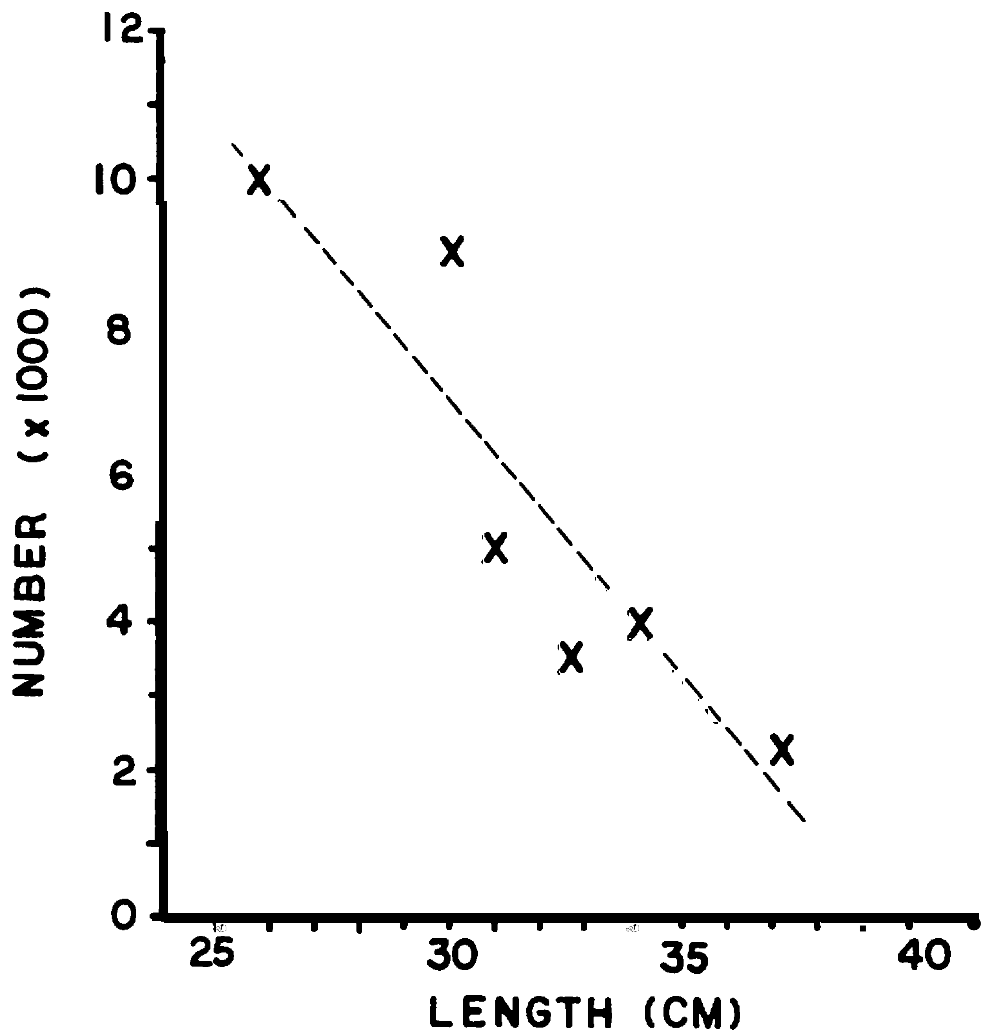

Figure 3. Mean length of age 3+ and 4+ kokanee correlated with the number of spawners in Isabella Creek, 1981-1987.

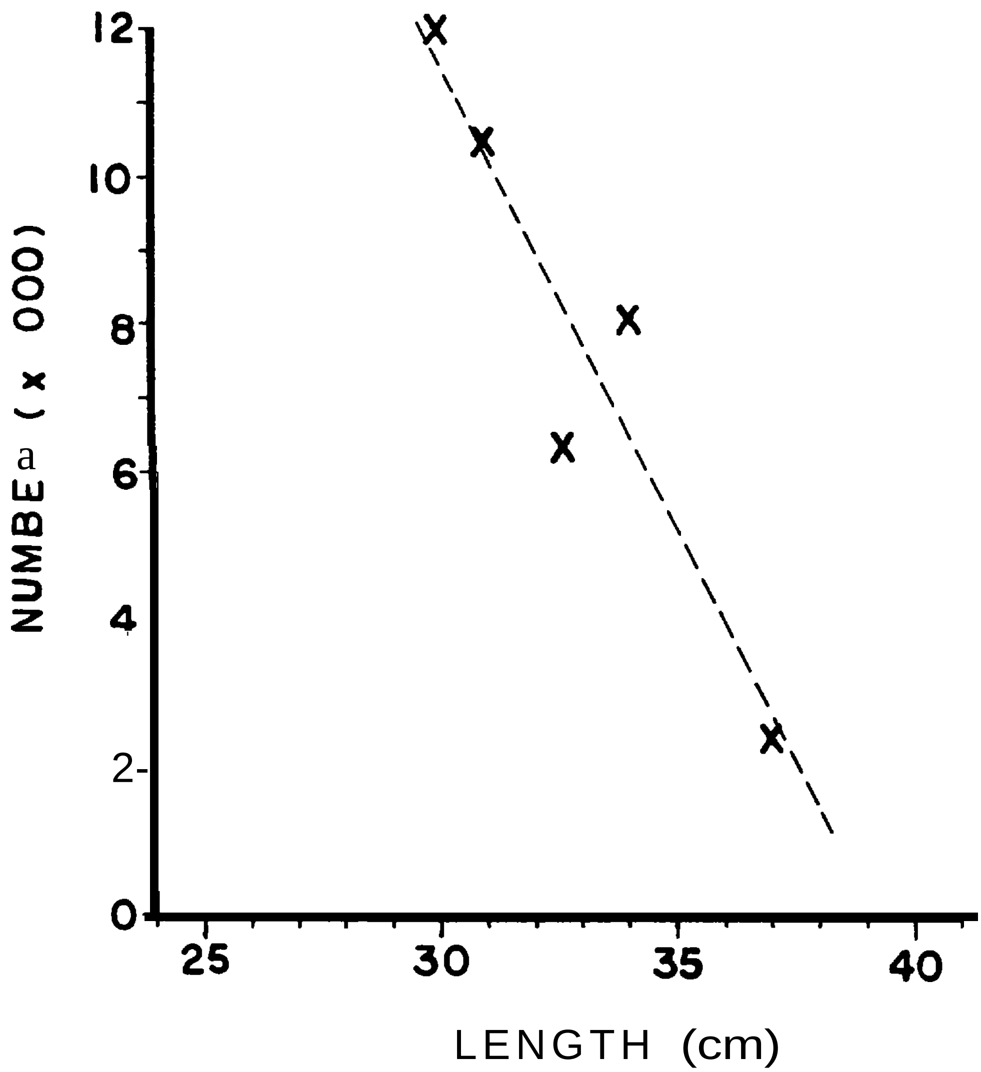

Figure 4. Mean length of age 3+ and 4+ kokanee in the spawning run correlated with the number of spawners in Isabella, Quartz, and Skull creeks: 1981, 1982, 1983, 1984, and 1987.

Reservoir Limnology

The lower end of Dworshak Reservoir was warmer than other stations during the winter of 1987-1988 (Appendix B). The upper water column (O-10 m) was approximately l°C warmer here than at Station RK-31 and from 1 to 4°C warmer than RK-56. RK-5 remained isothermal near the maximum density of water (4°C) during January and February and could thus be classified as monomictic. The Elk Creek Arm (EC-6) was similar in temperature to RK-56. Both of these stations were ice covered during January and February and were inversely stratified. The upper reservoir is therefore dimictic.

The coldest location on the reservoir was the Little North Fork Arm (LNF-2). This bay started to freeze during November and could not be reached by boat for subsequent sampling due to ice cover. The ice sheet extended down the reservoir to river kilometer 43 on February 18.

Dissolved oxygen readings within the reservoir ranged from 8.1 to 11.2 mg/L at Station RK-5 in the top 60 m of water (Appendix C). The only exception to this was directly on the reservoir bottom where readings were aslow as 2.2 mg/L. A similar range of oxygen levels were recorded at RK-31. The Elk Creek Arm had the most variable readings and ranged from 6.8 mg/L at the 22 m depth in November to 12.2 mg/L at the surface in February.

The limnological sampling station at Canyon Creek was near an area used to hold rafts of floating logs. Oxygen values here were measured as low as 9.9 mg/L during December at the 16 m depth and as high as 11.2 mg/L on the surface during January.

Secchi transparency was greatest during the November survey with a maximum reading at RK-5 of 7.1 m (Table 2). RK-5 was the clearest station during 3 of 4 surveys. Transparency decreased at all stations as winter progressed. Generally, the major arms had less visibility than the main reservoir. The lowest, reading occurred in the Elk Creek Arm (0.9 m) during February at a time when warm weather was decreasing the snowpack.

Nitrate nitrogen concentration at RK-5 declined from 0.071 to 0.016 to <0.001 mg/L during November, December, and January ,respectively (Figure 5). Orthophosphate changed from 0.003 mg/L during November to <0.003 mg/L in December, but then increased to 0.009 mg/L during January (Figure 5).

Zooplankton densities showed marked declines between November and January (Table 3) . RK-5, for example, dropped 78X from 6.95 to 1.54 organisms/L. Similar reductions were noted at stations RK-31 and EC-6. Substantial increases in zooplankton density were recorded during February.

The zooplankton population was composed of four families: Daphnidae, Bosminidae, Cyclopodidae, and Ergasilidae. The size distribution ranged from 0.2 mm to 1.5 mm (Figure 6). Thirty-two percent of the zooplankton were larger than 1 mm during November at RK-31, but this percentage dropped to 16% at RK-5 during December (Figure 7).

Table 2. Secchi depths at six sampling stations within Dworshak Reservoir, November 1987 to February 1988. RK-5 = 2 km above dam, RK-31 = 28 km above dam, RK-56 = 53 km above dam, CC = Canyon Creek, EC-6 - 6 km into Elk Creek Arm, LNF-2 = 2 km into Little North Fork Arm.

	Date			
Location	Nov 87	Dec 87	Jan 88	Feb 88
RK-5	7.1	5.9	3.9	4.8
RK-31	6.8	4.3	4.2	4.1
RK-56		3.1	2.2	
CC		3.4	3.6	4.6
EC-6	5.9	4.1	1.7	0.9
LNF-2		2.8		

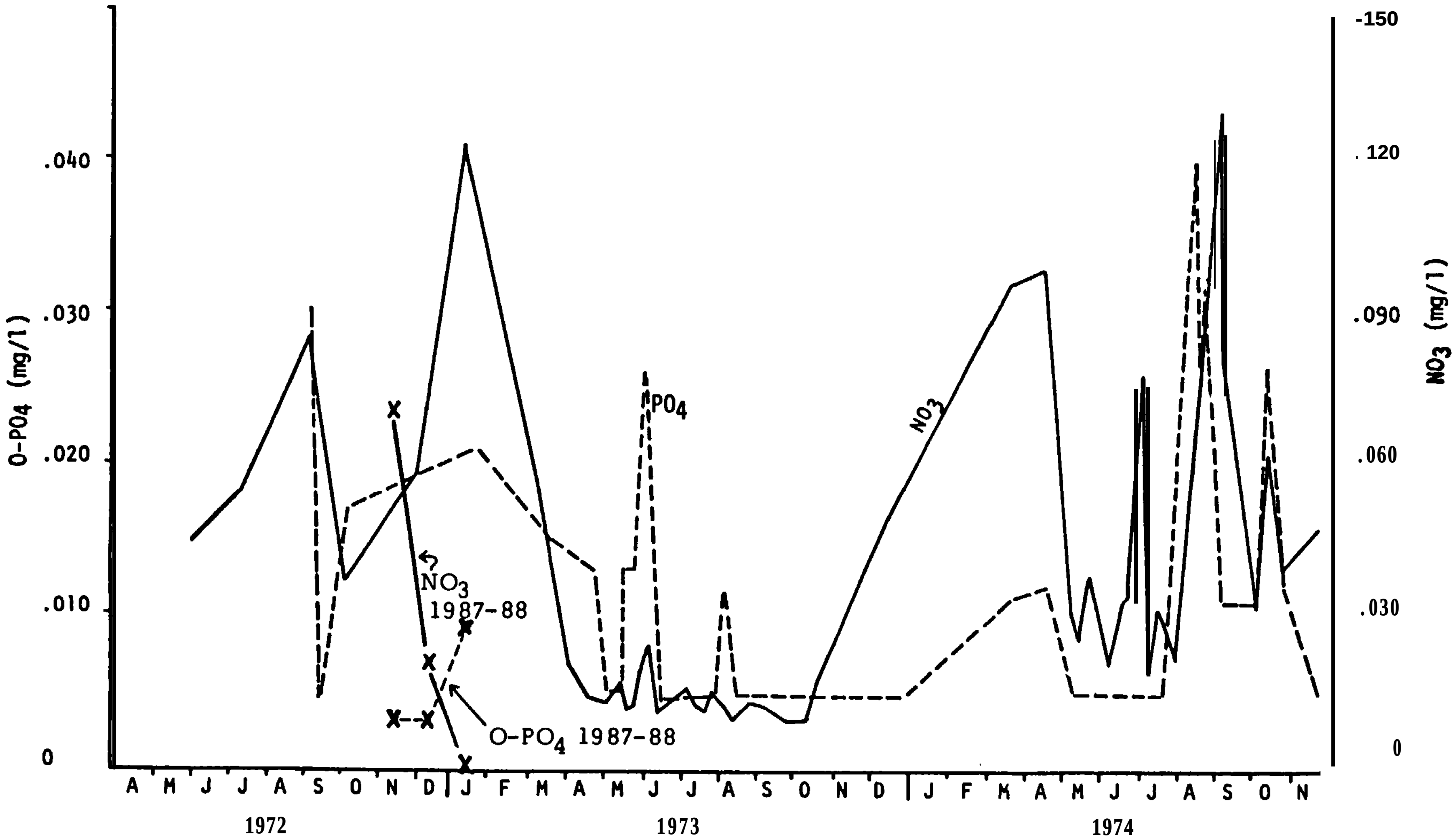

Figure 5. NO3 and O-PO4 concentration (mg/L) in Dworshak Reservoir from the surface to 12.2 m at river kilometer 5, 1972-1974 (Falter et al. 1979). Data from 1987-1988 added for comparison.

Table 3. Total zooplankton densities (organisms /L) in Dworshak Reservoir from the surface to 12.2 m. RK-5 = 2 km above dam, RK-31 - 28 km above dam, RK-56 - 53 km above dam, EC-6 = 6 km into Elk Creek Arm, LNF-2 = 2 km into Little North Fork Arm.

	Date			
Location	Nov 87	Dec 87	Jan 88	Feb 88
RK-5	6.95	3.37	1.54	10.99
RK-31	33.84	4.24	1.45	2.10
RK-56	--	2.93	--	--
EC-6	12.97	3.19	4.65	6.03
LNF-2	--	6.09	--	--

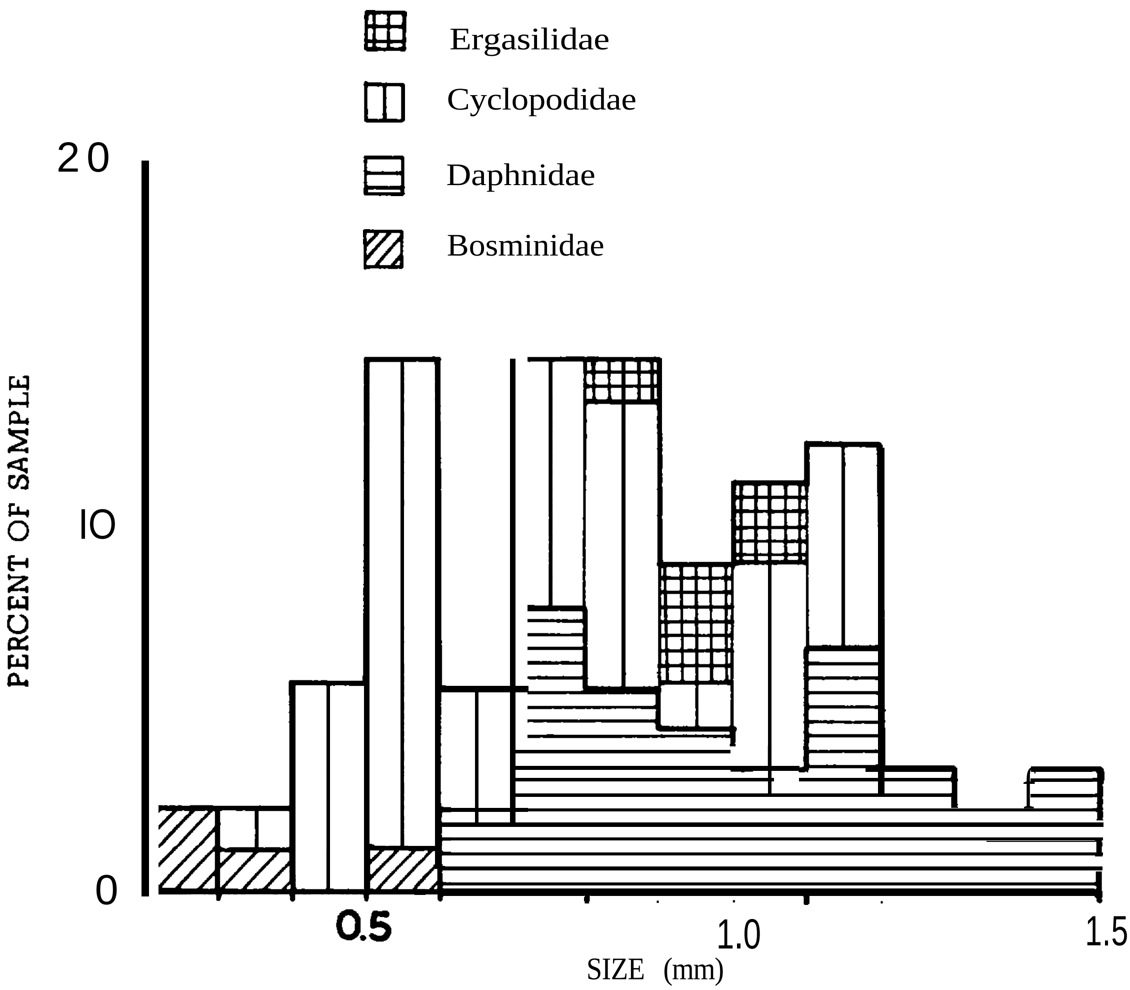

Figure 6. Length-frequency distribution of zooplankton families collected at Station RK-31 on Dworshak Reservoir, November 18, 1987.

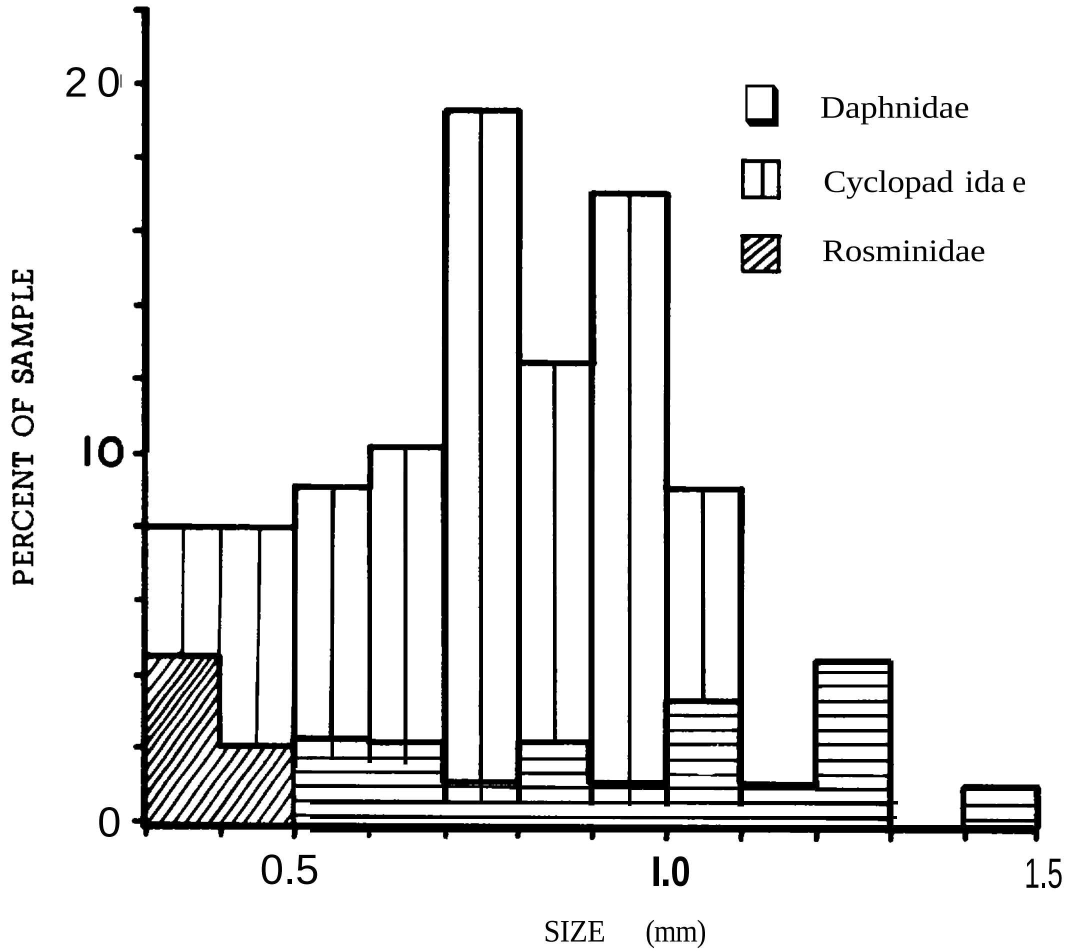

Figure 7. Length-frequency distribution of zooplankton families collected at Station RK-5 on Dworshak Reservoir, December 14, 1987.

Zooplankters were examined from the stomachs of kokanee caught by anglers during November. Zooplankton larger than 1 mm comprised 93% of the samples. Most of the plankton (92%) were Daphnidae and the remainder Cyclopodidae (Figure 8).

Creel Survey

The estimated hours of boat fishing effort declined from 1,012 h during November to 82 h during December. Pressure increased to 388 h during January (Table 4). During these 3 months, the estimated kokanee harvest steadily declined from 1,392 to 220 to 0 fish, respectively. Kokanee catch rates were good during November (1.4 fish/h) and December (2.7 fish/h), but dropped to 0.0 fish/h during January (Table 4). (A total of 141.5 h of boat angling effort was used in the January catch rate calculation.)

Mean total length of kokanee harvested during November was 245 mm, with fish ranging from 165 mm to 319 mm (n - 106) (Figure 9). Scale analysis was used to determine that the catch was comprised of three age classes : l+, 2+, and 3t. Mean size of kokanee decreased during December to 239 mm, and size ranged from 201-262 mm (n - 24) (Figure 10).

DISCUSSION

Kokanee Spawning Escapement

Tributary spawner counts are an index of year-class strength. Compared to counts in previous years, the 1987 spawning run was average. Numbers of fish were smaller in Skull Creek and Breakfast Creek, but larger in Isabella, Dog, and Quartz creeks (Figure 11). Spawner size was also average. The age 3+ and 4t fish averaged 326 mm, larger than in 1982 (310 mm), 1984 (300 mm), and 1985 (260 mm), but smaller than than in 1981 (340 mm) and 1983 (370).

A negative relationship existed between kokanee size and numbers in the spawning tributaries (Figures 3 and 4). R^2 values for these relationships indicated 83% and 88% of the variation within spawner length can be explained by the run size. Association between these variables was surprisingly good considering spawning counts were made on a variety of dates and by a variety of people. Good correlation is also surprising because this simplistic relationship does not account for annual fluctuations in reservoir productivity, nor does it allow for interaction between several year classes. If size and density of fish in the spawning run are indicative of size and density of fish in the reservoir, then this relationship would have strong management implications. For example, if the primary goal was to manage for 370 mm kokanee in their third year of life when they comprise the bulk of the sport harvest, then fish density within the reservoir would need to be reduced to one-fifth the level needed to grow fish to 300 mm. Conversely, if growing kokanee to 300 mm

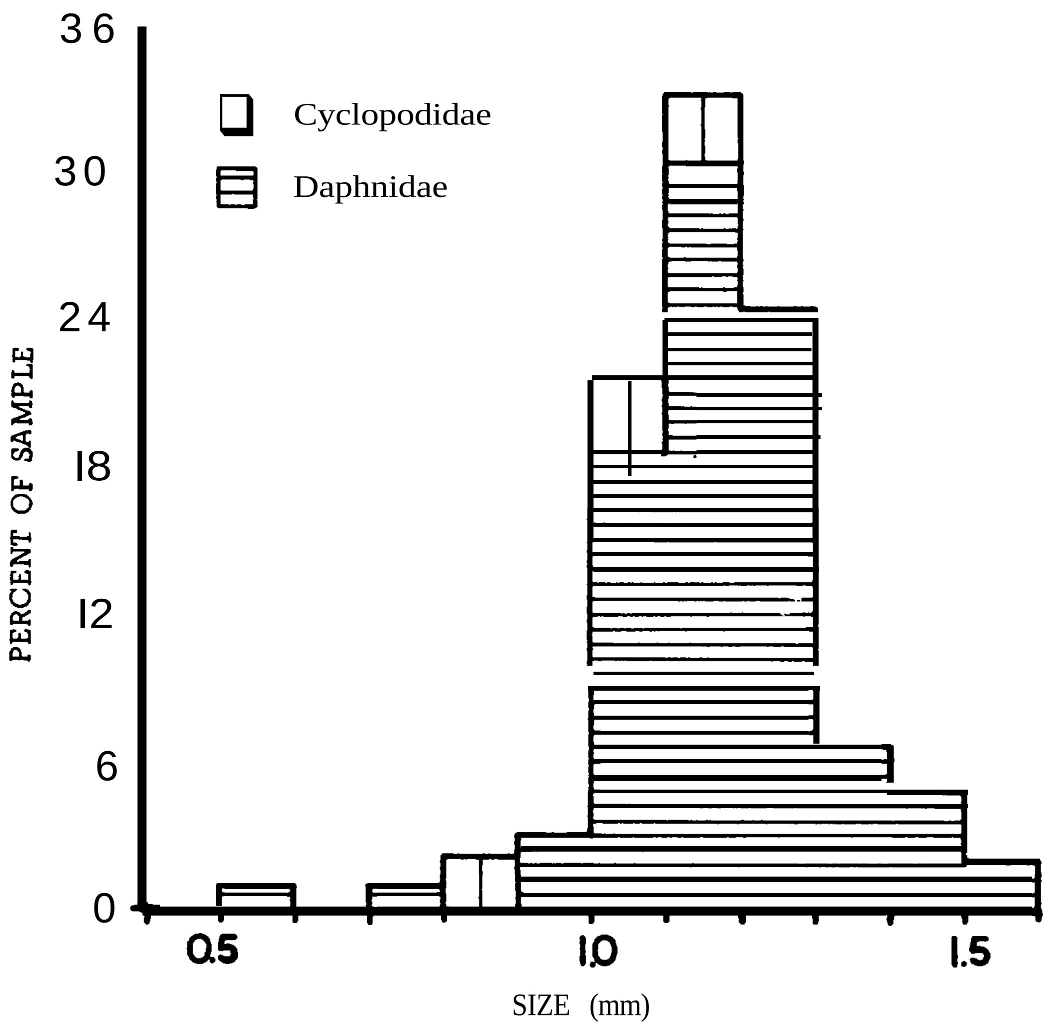

Figure 8. Length-frequency distribution of zooplankton in kokanee stomachs collected during November 1986.

Table 4. Estimated fishing effort and kokanee harvest from Dworshak Reservoir.

Date	Boat effort (h)	Kokanee harvested	Catch rate (fish/h)
Nov 1987	1,012	1,392	1.4
Dec 1987	82	220	2.7
Jan 1988	388	0	0.0
Jan 13-Feb 9, 1974	3,810	1,394	0.4[a]
Nov 4-Dec 2, 1973	2,736	101	0.04[b]
Nov 1979	--	424	--[c]

[a] Pettit et al. 1975.
[b] Ball and Pettit 1974.
[c] Horton 1980.

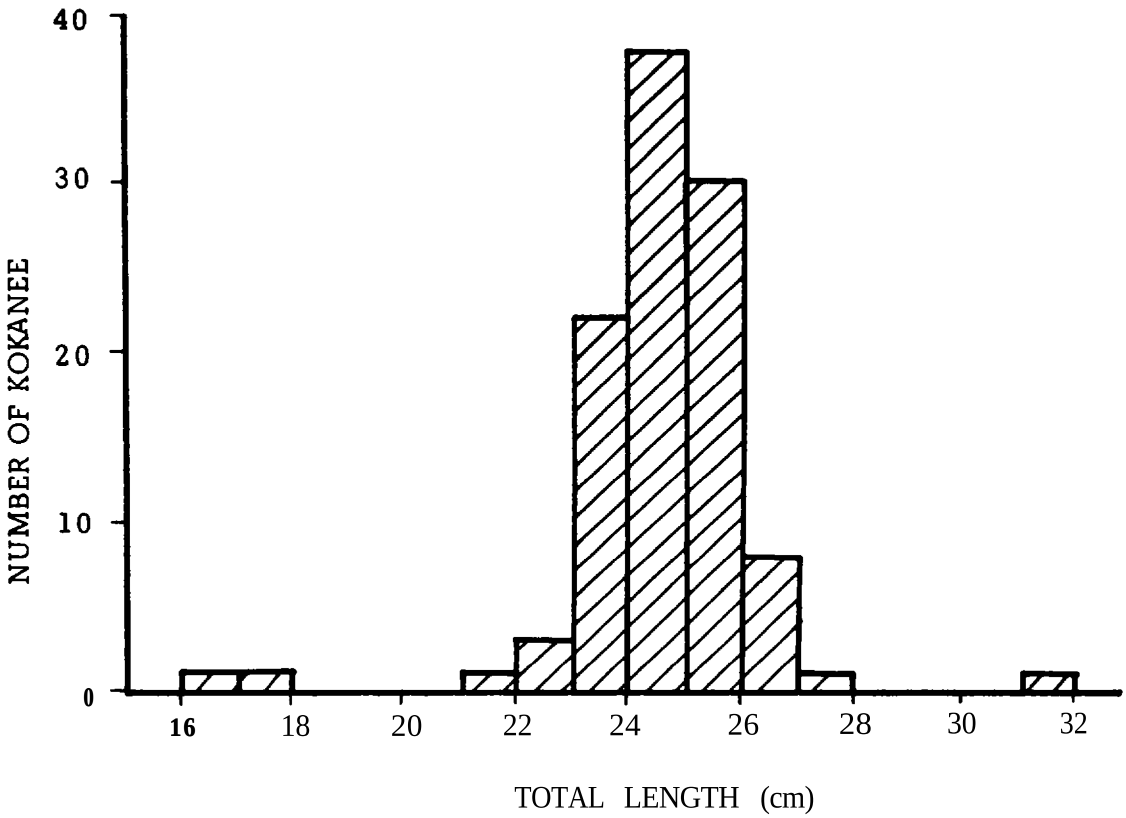

Figure 9. Length-frequency distribution of kokanee creeled from Dworshak Reservoir during November 1987.

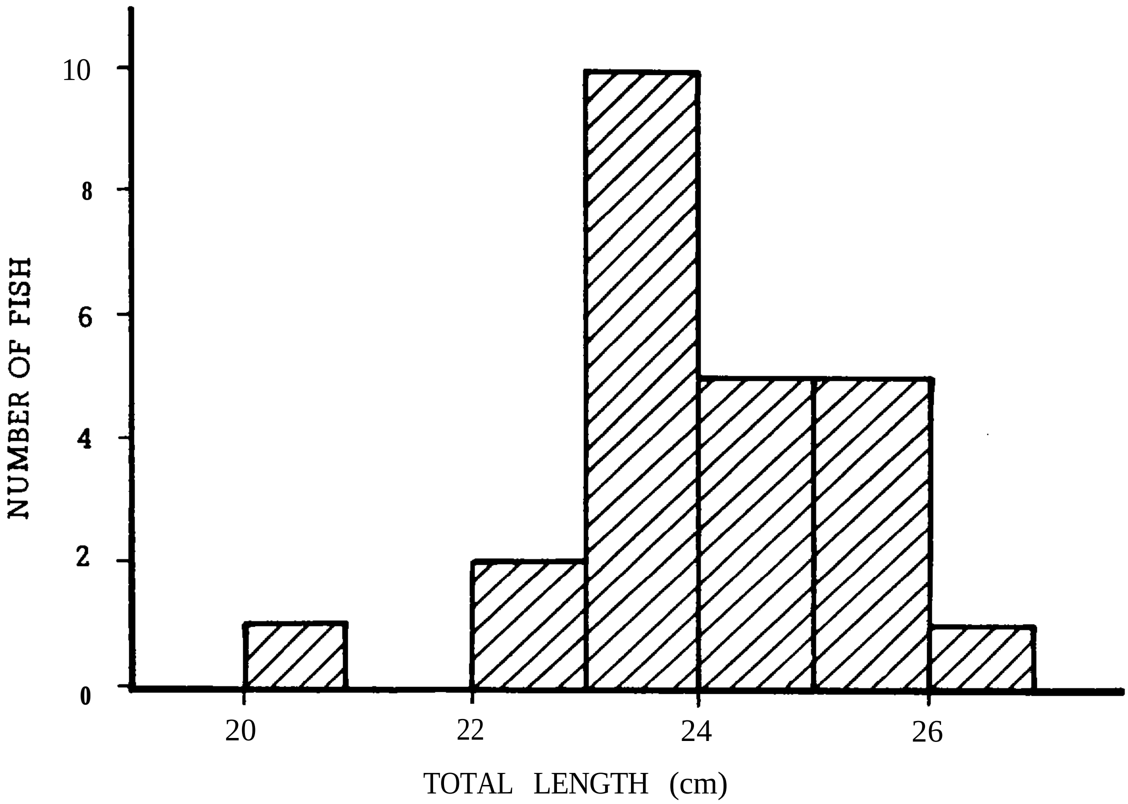

Figure 10. Length-frequency distribution of kokanee creeled from Dworshak Reservoir during December 1987.

was satisfactory, then the reservoir could support five times the number of fish. The additional fish would need to come from stocking, additional (or improved) spawning areas, or decreased mortality (e.g., entrainment losses). Data from future years will be added to Figures 3 and 4 to help define the environmental factors that affect size and number of a given year class.

The North Fork drainage currently contains numerous logging operations, and more are planned. Spawning counts can be used to note habitat degradation in various tributaries. Breakfast Creek could be an example. During 1979 and 1980, Horton (1981) counted 994 and 5,264 kokanee, respectively, in the lower 0.8 km of the creek. During 1987, only 23 fish were seen in the same reach (Figure 11). Siltation appeared to severely limit the amount of available clean gravel: however, spawning counts were conducted after the peak of the run, which may account for the low number of fish seen. Spawning surveys during 1988 will be made closer to the peak of the run to better examine the possibility of declining abundance.

The 1987 spawning run contained an unusually high proportion of age 2t fish (the 23 to 28 cm group in Figure 2) . In anadromous fish studies, large numbers of returning “jacks” would indicate a strong year class, and high numbers of fish would be expected the following year. The opposite may be true for kokanee. Good growth (230 to 280 mm length for age 2t fish) may result in earlier maturation and also would indicate lower densities of fish in the reservoir. Therefore, a prediction for 1988 would be for larger-than-average age 3+ fish, but fewer of them.

Reservoir Limnology

Falter et al. (1979) noted that an increasing trend in mean summer Secchi disc depth from 1972 to 1974 paralleled a decline in reservoir productivity. Transparency is largely dependent on the amount of suspended organic (zooplankton and phytoplankton) and inorganic (silt, clay, etc.) particles. The concentration of both could be decreasing. As reservoir water levels fluctuate annually, fine soil particles are washed from littoral areas into the deeper basin. Organic particles would also be expected to decrease as the reservoir ages and becomes more nutrient poor. It will be important to compare current annual average Secchi depths to those reported by Falter et al. (1979). The four readings for November through February would not be a sufficient comparison. Also, Falter (1982) did not collect Secchi depth data between December and March and had only one reading for November (Station RK-5). Comparisons are, therefore, difficult at this time.

Data gathered for nutrients would indicate a declining trend (Figure 5). Concentration of nitrates during January and orthophosphates during November and December were as low or lower than recorded at any time between 1972 and 1974. Nitrate nitrogen was also lower than mean values recorded in 1977; NO3 = 0.067 mg/L in 1977 versus an average of 0.029 mg/L in 1987-1988. Orthophosphate averaged 0.005 mg/L in both 1977 and 1987-1988. Preliminary indications are that the reservoir has continued to become more oligotrophic from 1972 through 1988.

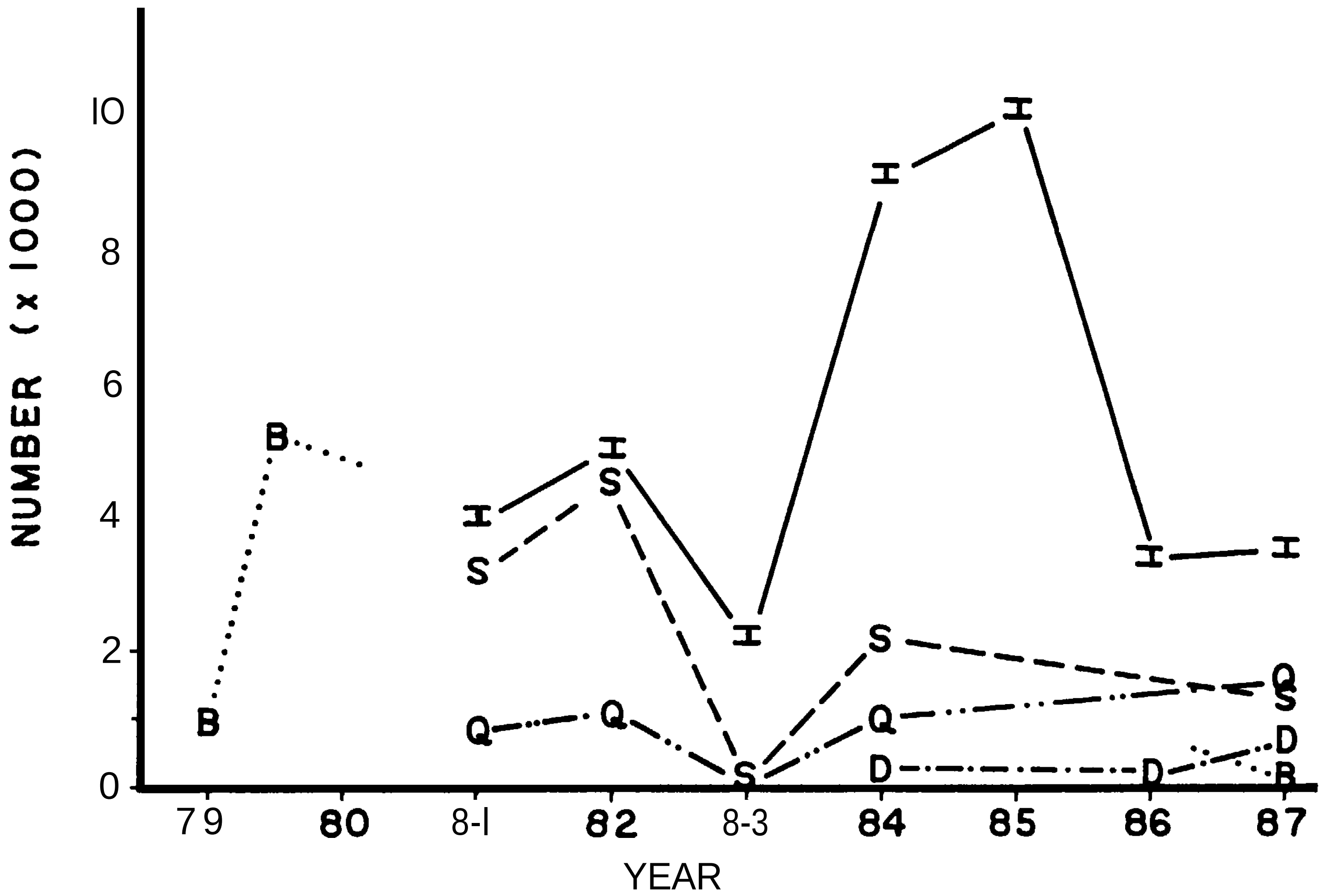

Figure 11. Number of kokanee spawners observed in tributaries to Dworshak Reservoir. I = Isabella Creek, S = Skull Creek, Q = Quartz Creek, D = Dog Creek, and B = Breakfast Creek. Pre-1987 data collected by U.S. Forest Service employees.

Despite nutrient declines, zooplankton densities between November and January were comparable to densities recorded during 1972 (Figures 12 and 13). Although this is an encouraging finding, it is important to measure zooplankton densities throughout the summer in order to fully characterize the kokanee food base.

Falter (1982) concluded that the high percentage of cladocerans in the zooplankton (71%) indicated little cropping by planktivorous fish. Percentage of cladocerans in our samples has declined to 23% (mean of five samples collected during December), but it is unclear whether this is due to increased cropping or seasonal change in species composition. If overall cladoceran abundance is low, then the reservoir may not support many more kokanee.

Hypolimnetic relative area1 oxygen deficit is a measurement of the oxygen consumed in the hypolimnetic water of a stratified reservoir (Wetzel 1975). Values of >l.0 $mg/cm^2/month$ would indicate a eutrophic lake. Dworshak Reservoir was characterized by this method as eutrophic during 1972, but tended towards mesotrophy in 1973 and 1974 (Falter et al. 1979). Oxygen readings collected this summer will be used to calculate oxygen deficits to note if this trend has continued. During winter, deep water oxygen concentrations were recharged and approached 9 to 11 mg/L during February surveys (Appendix C).

Canyon Creek was used during 1987 as an area to store floating log rafts. Oxygen concentrations here (9.9 to 11.2 mg/L) during fall were apparently not reduced due to the increased organic material. Additional readings will be taken here to see if this situation persists during summer.

Creel Survey

Kokanee were caught exclusively by boat anglers: therefore, only boat fishermen interviews were used to determine harvest and catch statistics. A separate report by the Nez Perce Tribe discussed the harvest of the other sport fish as well as bank angling success.

Catch rates for kokanee were well above the management goal of 1 fish/h during November and December, but declined dramatically during January. Lewis (1972) found that periods of reduced catch rates were associated with maximal aggregation, reduced feeding intensity, and restricted vertical distribution. These periods generally coincided with limited food availability and surface temperatures outside the optimal 9 to 15°C range. All of these factors may have contributed to the low January catch rate. If this is the case, fishing should improve as the water warms and feeding activity increases.

Earlier studies examined kokanee harvest and catch rates during at least part of the winter. Catch rates during November and December 1987 were much better than during the early 1970s when kokanee populations were becoming established (Table 4). (The first kokanee release was 1,012,745 fish from Anderson Ranch Reservoir stocked during 1972 [Horton 1981].)

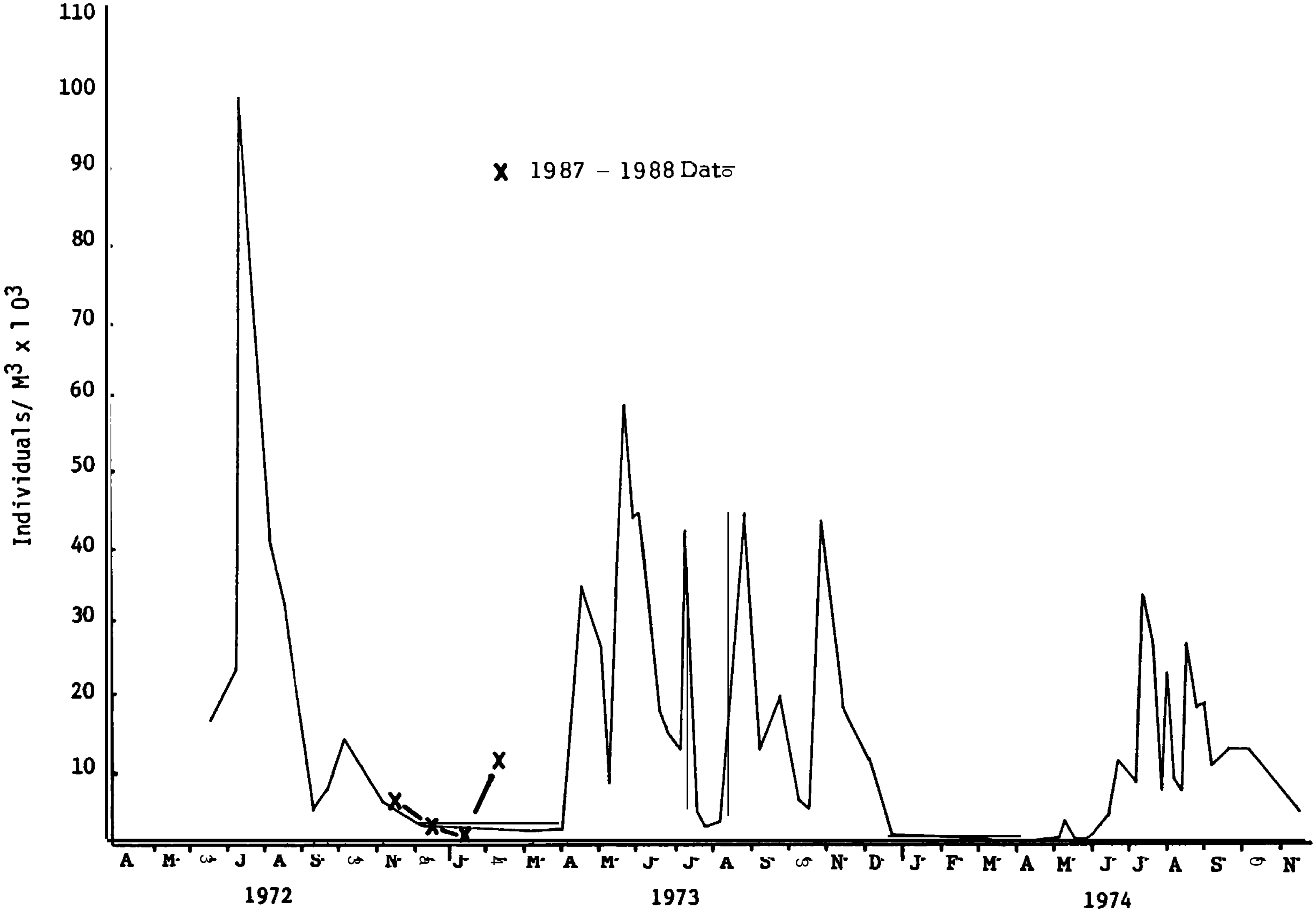

Figure 12. Mean total zooplankton densities from the surface to 12.2 m depth at RK-5 in Dworshak Reservoir, 1972-1974 (Falter et al. 1979). Data from 1987 added for comparison.

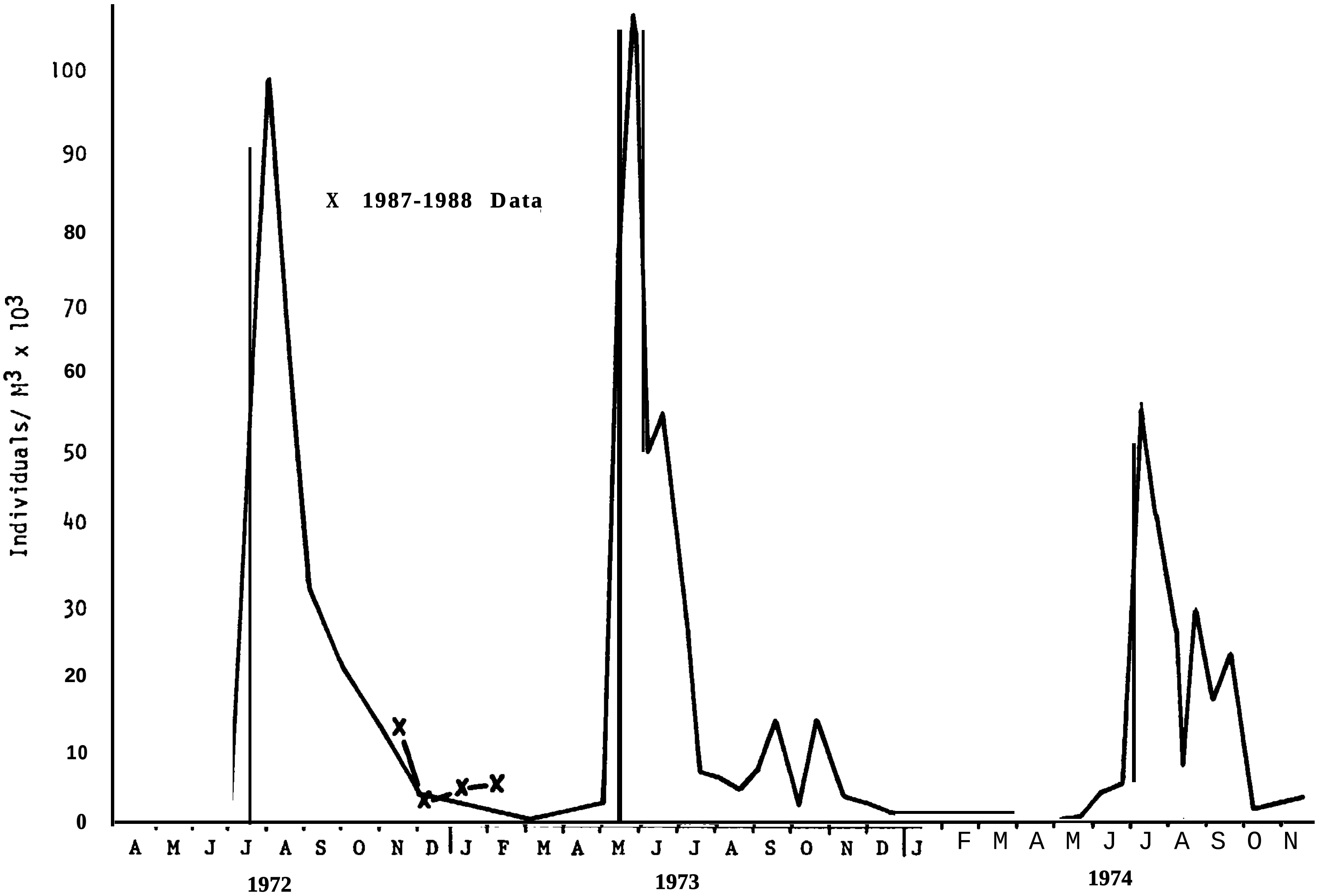

Figure 13,. Mean total zooplankton densities from the surface to 12.2 m depth at EC-6 in Dworshak Reservoir, 1972-1974 (Falter et al. 1979). Data from 1987 added for comparison.

The November 1987 harvest of 1,392 fish was also much higher than the 424 kokanee harvested in 1979 (Horton 1980). From this preliminary data, the kokanee fishery has improved, although a full year's census is needed for comparisons.

Monthly increases in the mean size of kokanee harvested from a given year class would usually reflect actual growth. This was not possible, however, based on our November to January data. Size actually decreased slightly between November and December, and no kokanee were examined during January. Growth rates will become more apparent with time and larger sample sizes. Age 2+ kokanee were approximately 240 mm in total length during November and December. Horton (1981) found harvested kokanee averaged 290 mm during May and June 1980, and by scale analysis, estimated that 2t fish were 270 mm long, presumably during early summer. The present cohort of 2t kokanee exhibit similar growth to those in 1980.

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A P P E N D I C E S

Appendix A. Fish species inhabiting Dworshak Reservoir (Horton 1981).

Common name	Generic name
Chiselmouth[a]	Acrocheilus alutaceus
Bridgelip sucker	Catostomus columbianus
Largescale sucker	Catostomus macrocheilus
Sculpin	Cottus spp.
Northern pike	Esox lucius
Pacific lamprey	Lampetra tridentata
Brown bullhead	Ictalurus nebulosus
Smallmouth bass	Micropterus dolomieui
Largemouth bass	Micropterus salmoides
Kokanee	Oncorhynchus nerka
Mountain whitefish	Prosopium williamsoni
Northern squawfish	Ptychocheilus oregonensis
Speckled dace	Rhinichthys osculus
Longnose dace	Rhinichthys cataractae
Redside shiner	Richardsonius balteatus
Cutthroat trout	Salmo clarki
Rainbow trout	Salmo gairdneri
Eastern brook trout	Salmo fontinalis
Bull trout	Salvelinus confluentus

[a]Chiselmouth documented prior to impoundment, but may have been eradicated in the 1971 squoxin treatment.

Appendix B. Temperature (^{o}C) profiles in Dworshak Reservoir, November 1987 to February 1988.

River kilometer 5	Date			
Depth (m)	Nov 87	Dec 87	Jan 88	Feb 88
Surface	9.4	6.2	4.0	3.9
1.0	9.4	6.1	4.0	3.9
2.0	9.2	6.1	4.0	3.9
4.0	9.2	6.1	4.0	3.9
6.0	9.2	6.1	4.0	3.9
8.0	9.2	6.1	4.0	3.9
10.0	9.2	6.1	4.0	3.9
12.0	9.2	6.1	4.0	3.9
14.0	9.2	6.1	4.0	3.9
16.0	7.1	6.0	4.0	3.9
18.0	6.6	5.9	4.0	3.9
20.0	6.0	4.9	4.0	3.9
22.0	5.8	4.6	4.0	3.9
24.0	5.4	4.5	4.0	3.9
26.0	5.0	4.4	4.0	3.9
28.0	4.9	4.4	4.0	3.9
30.0	4.8	4.4	4.0	3.9
32.0	4.5	4.4	4.0	3.9
34.0	4.2	4.3	4.0	3.9
36.0	4.2	4.4	4.0	3.9
38.0	4.1	4.4	4.0	3.9
40.0	4.0	4.4	4.0	3.9
42.0	4.0	4.3	4.0	3.9
44.0	4.0	4.3	4.0	3.9
46.0	3.9	4.3	4.0	3.9
48.0	3.9	4.2	4.0	3.9
50.0	3.9	4.2	4.0	3.9
52.0	3.9	4.2	4.0	3.9
54.0	3.9	4.2	4.0	3.9
56.0	3.9	4.2	4.0	3.9
58.0	3.9	4.1	4.0	3.9
60.0	3.9	4.0	4.0	4.0

Appendix B, continued.

River kilometer 31	Date			
Depth (m)	Nov 87	Dec 87	Jan 88	Feb 88
Surface	8.8	5.2	3.8	3.1
1.0	8.8	5.2	3.8	3.1
2.0	8.5	5.2	3.8	3.1
4.0	8.6	5.2	3.8	3.1
6.0	8.5	5.2	3.8	3.1
8.0	8.5	5.2	3.8	3.1
10.0	8.2	5.2	3.8	3.1
12.0	8.2	5.4	3.8	3.1
14.0	8.0	5.4	3.8	3.1
16.0	7.2	5.4	3.8	3.1
18.0	6.2	5.4	3.8	3.1
20.0	5.5	5.4	3.8	3.1
22.0	5.2	5.4	3.8	3.1
24.0	5.2	5.2	3.8	3.1
26.0	4.7	5.2	3.8	3.2
28.0	4.4	5.1	3.8	3.2
30.0	4.1	4.9	3.8	3.2
32.0	4.1	4.8	3.8	3.4
34.0	4.0	4.5	3.8	3.4
36.0	3.9	4.5	3.8	3.4
38.0	3.9	4.2	3.8	3.4
40.0	3.9	4.2	3.8	3.5
42.0	3.9	4.2	3.8	3.5
44.0	3.9	4.2	3.8	3.5
46.0	3.9	4.2	3.8	3.5
48.0	3.8	4.2	3.8	3.5
50.0	3.8	4.2	3.8	3.5
52.0	3.8	4.1	3.8	3.6
54.0	3.8	4.1	3.8	3.6
56.0	3.8	4.1	3.8	
58.0	3.8	4.1	3.8	
60.0	3.8	4.1	3.8	

Appendix B, continued.

Elk Creek arm Depth (m)	Date Nov 87	Dec 87	Jan 88	Feb 88
Surface	9.0	6.0	1.0	1.5
1.0	9.0	6.0	2.3	1.9
2.0	9.0	6.0	3.5	2.0
4.0	9.0	6.0	3.7	3.2
6.0	9.0	6.0	3.8	3.5
8.0	9.0	6.0	3.9	3.5
10.0	9.0	5.8	4.0	3.5
12.0	8.8	5.9	4.0	3.5
14.0	7.8	6.0	4.0	3.5
16.0	7.0	6.0	4.0	3.5
18.0	6.8	6.0	4.0	3.5
20.0	6.2	6.0	4.0	3.5
22.0	5.8	6.0	4.0	3.6
24.0	5.4	5.5	4.0	3.8
26.0	5.2	5.5	3.9	3.6
28.0	5.0	5.5	3.9	3.8
30.0	4.9	5.5	3.9	3.8
32.0	4.9	5.4	3.9	3.8
34.0	4.8	5.3	3.9	3.6
36.0	4.7	5.2	3.9	3.6
38.0	4.7	5.2	3.9	3.5
40.0	4.5	5.1	3.9	3.4
42.0	4.4	5.1	3.9	3.4
44.0	4.4	5.1	3.9	3.4
46.0	4.4	5.1	3.9	3.3
48.0	4.3	5.1	3.9	3.3
50.0	4.2	5.0	3.9	3.3
52.0	4.2		3.9	3.4
54.0	4.2		3.9	3.4
56.0	4.2		3.9	3.4
58.0			3.9	3.4
60.0			3.9	3.4

Appendix B, continued.

River kilometer 56 Depth (m)	Date Dec 87	Jan 88	Feb 88
Surface	5.0	0.2	Ice
1.0	5.0	0.2	Covered
2.0	4.9	0.4	
4.0	4.9	1.0	
6.0	4.9	1.2	
8.0	4.9	2.6	
10.0	4.9	2.9	
12.0	4.9	3.0	
14.0	4.9	3.3	
16.0	4.9	3.5	
18.0	4.9	3.8	
20.0	4.9	3.9	
22.0	4.9	3.9	
24.0	4.9	3.9	
26.0	4.9	3.9	
28.0	4.9	3.9	
30.0	4.9	3.9	
32.0	4.9	3.9	
34.0	4.9	3.9	
36.0	4.9	3.9	
38.0	4.9	3.9	
40.0	4.9	3.9	
42.0	4.9	3.9	
44.0	4.9	3.9	
46.0	4.8	3.9	
48.0	4.8	3.9	
50.0	4.8	3.9	
52.0	4.8	3.9	
54.0	4.7	3.9	
56.0	4.5	3.9	
58.0	4.5	3.9	
60.0	4.5	3.9	

Appendix C. Dissolved oxygen profiles (mg/L) in Dworshak Reservoir, November 1987 to February 1988.

River kilometer 5	Date			
Depth (m)	Nov 87	Dec 87	Jan 88	Feb 88
Surface	9.7	10.5	9.7	11.2
1.0	10.0	10.5	10.0	10.6
2.0	10.0	10.5	10.0	11.1
4.0	10.0	10.6	9.8	11.0
6.0	10.0	10.6	9.8	11.1
8.0	10.0	10.6	9.8	11.0
10.0	10.1	10.6	9.8	10.8
12.0	10.0	10.6	9.6	10.7
14.0	10.1	10.6	9.6	10.8
16.0	9.8	10.6	9.6	10.9
18.0	10.2	10.4	9.6	10.8
20.0	10.2	9.9	9.6	10.8
22.0	10.2	9.8	9.6	10.8
24.0	10.4	9.6	9.6	10.8
26.0	10.4	9.6	9.7	10.6
28.0	10.3	9.7	9.6	10.7
30.0	10.2	9.7	9.6	10.6
32.0	10.4	9.6	9.6	10.6
34.0	10.2	9.6	9.6	10.6
36.0	10.1	9.6	9.6	10.7
38.0	10.2	9.7	9.5	10.6
40.0	10.2	9.6	9.3	10.6
42.0	10.0	9.6	9.2	10.6
44.0	10.2	9.5	8.8	10.6
46.0	10.0	9.5	8.8	10.6
48.0	9.9	9.4	8.6	10.6
50.0	9.8	9.4	8.8	10.5
52.0	9.8	9.3	8.4	10.5
54.0	9.6	9.3	8.3	10.4
56.0	2.2	9.2	8.2	10.4
58.0		9.2	8.1	10.2
60.0		9.2	8.0	3.8

Appendix C, continued.

River kilometer 31	Date			
Depth (m)	Nov 87	Dec 87	Jan 88	Feb 88
Surface	10.2	9.9	9.6	10.3
1.0	10.2	9.8	9.6	10.3
2.0	10.4	9.8	9.6	10.3
4.0	10.3	9.8	9.6	10.3
6.0	10.4	9.8	9.8	10.2
8.0	10.4	9.6	9.8	10.3
10.0	10.4	9.6	9.6	10.2
12.0	10.3	9.8	9.6	10.2
14.0	10.3	9.6	9.6	10.1
16.0	10.0	9.6	9.6	10.1
18.0	10.1	9.5	9.5	10.1
20.0	10.2	9.5	9.6	10.1
22.0	10.4	9.4	9.6	10.1
24.0	10.5	9.4	9.6	10.0
26.0	10.6	9.4	9.6	10.0
28.0	10.5	9.2	9.6	10.0
30.0	10.4	9.0	9.5	9.8
32.0	10.4	8.8	9.5	9.7
34.0	10.3	8.7	9.5	9.7
36.0	10.2	8.6	9.5	9.6
38.0	10.2	8.5	9.5	9.7
40.0	10.2	8.5	9.5	9.6
42.0	10.0	8.5	9.5	9.4
44.0	10.0	8.4	9.5	9.4
46.0	10.0	8.4	9.5	9.3
48.0	9.8	8.4	9.5	9.3
50.0	9.8	8.4	9.5	9.3
52.0	9.7	8.4	9.5	9.2
54.0	9.6	8.4	9.5	7.2
56.0	9.6	8.4	9.4	
58.0	9.6	8.4	9.4	
60.0	9.6	8.4	9.4	

Appendix C, continued.

Elk Creek arm Depth (m)	Date Nov 87	Dec 87	Jan 88	Feb 88
Surface	9.8	10.1	11.2	12.2
1.0	10.0	10.1	10.7	12.2
2.0	10.1	10.3	10.0	12.0
4.0	10.0	10.4	9.9	10.8
6.0	10.1	10.4	9.8	10.5
8.0	10.0	10.2	9.7	10.5
10.0	10.0	10.4	9.7	10.4
12.0	10.0	10.3	9.6	10.4
14.0	9.0	10.3	9.5	10.3
16.0	8.2	10.1	9.6	10.4
18.0	7.6	10.3	9.6	10.3
20.0	7.0	10.3	9.6	10.3
22.0	6.8	10.2	9.5	10.2
24.0	7.0	10.3	9.6	10.0
26.0	7.4	10.4	9.4	10.2
28.0	7.1	10.4	9.6	9.8
30.0	7.4	10.3	9.5	9.6
32.0	7.3	10.2	9.5	9.6
34.0	7.2	10.2	9.5	9.8
36.0	7.2	9.9	9.5	9.7
38.0	7.2	9.5	9.5	9.8
40.0	7.2	9.2	9.5	9.9
42.0	7.4	9.3	9.4	10.0
44.0	7.4	9.4	9.4	10.0
46.0	7.4	9.3	9.4	10.1
48.0	7.5	9.2	9.3	10.0
50.0	7.5	1.3	9.3	10.0
52.0	7.5		9.3	9.9
54.0	7.5		9.2	10.0
56.0	2.2		9.2	9.9
58.0			9.2	9.9
60.0			9.2	3.2

Appendix C, continued.

River kilometer 56	Date		
Depth (m)	Dec 87	Jan 88	Feb 88
Surface	9.2	10.6	Ice Covered
1.0	8.9	11.0	
2.0	8.9	10.8	
4.0	8.8	10.3	
6.0	8.8	10.1	
8.0	8.9	9.8	
10.0	8.8	9.8	
12.0	8.8	9.8	
14.0	8.8	9.8	
16.0	8.8	9.7	
18.0	8.8	9.6	
20.0	8.8	9.2	
22.0	8.8	9.3	
24.0	8.8	9.2	
26.0	9.0	9.4	
28.0	9.0	9.3	
30.0	9.0	9.3	
32.0	9.1	9.3	
34.0	9.0	9.3	
36.0	9.0	9.3	
38.0	9.1	9.3	
40.0	9.0	9.3	
42.0	9.2	9.3	
44.0	9.2	9.2	
46.0	9.0	9.2	
48.0	9.0	9.2	
50.0	8.8	9.2	
52.0	8.8	9.2	
54.0	8.8	9.1	
56.0	8.9	9.1	
58.0	8.8	9.0	
60.0	8.8	9.0	

Appendix C, continued.

Canyon Creek Depth (m)	Date Dec 87	Jan 88	Feb 88
Surface	10.3	11.2	10.2
1.0	10.1	11.0	10.1
2.0	10.1	11.0	10.2
4.0	10.1	10.9	10.1
6.0	10.0	10.9	10.2
8.0	10.0	10.6	10.1
10.0	10.0	10.6	10.1
12.0	10.0	10.6	10.2
14.0	10.0	10.4	10.1
16.0	9.9	10.4	10.0
18.0	9.9	9.6	8.0

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