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DWORSHAK DAM IMPACT ASSESSMENT AND FISHERY INVESTIGATION

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ABSTRACT

Kokanee abundance, estimated from late June trawl data, was 540,000 fish in 1989. There were 294,000 fry, 100,000 yearlings, 140,000 two-year-olds, and 4,500 three-year-olds. Anglers fishing specifically for kokanee harvested 160,000 kokanee at a rate of 1.25 fish per hour. Creeled fish averaged 25 cm and 120 g in 1989 compared to 26 cm and 140 g fish in 1988. Total kokanee yield was 2.95 kg/ha in 1989 and 4.5 kg/ha in 1988.

Spawning escapement was similar to 1988. We counted 37,000 kokanee in five tributaries of the reservoir in mid-to-late September. Two-year-old spawners made up most of the run and averaged 28 cm total length.

Zooplankton densities averaged 14 organisms/L in 1989. Cladocerans made up 45% of the zooplankton sampled.

Daphnia and *Cyclops* were the most important kokanee food items. *Daphnia* was the prime food organism, except in May when *Daphnia* fell below 4% of total zooplankton present.

Water clarity, primary productivity, and concentrations of phosphorous and nitrogen indicated Dworshak has become more oligotrophic since the 1970s.

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INTRODUCTION

The Bonneville Power Administration (BPA) funded two 4-year research projects to develop recommendations for improving the sport fishery on Dworshak Reservoir. Research began during 1987 as a cooperative effort between the Idaho Department of Fish and Game (IDFG) and the Nez Perce Tribe of Idaho. The Nez Perce Tribe examined smallmouth bass and rainbow trout fisheries. The IDFG evaluated kokanee population dynamics and documented changes in reservoir productivity.

Dworshak Reservoir filled during 1971, and has declined in productivity. Dramatic changes in the sport fishery resulted (Pettit et al. 1975, Ball and Cannon 1974, and Horton 1980, 1981). Limnology of the reservoir was examined by Falter et al. (1979) and Falter (1982). Comparison of new data to earlier information should show effects of reservoir ageing and changes in the sport fishery.

In 1990, we will count kokanee in the North Fork of the Clearwater River below Dworshak Dam to get an index of entrainment losses. We will correlate relative losses with discharge parameters (timing, rates, selector gate elevation) and reservoir levels.

The completion report will address kokanee management with recommendations based on stock status, entrainment losses, reservoir productivity and operation, and zooplankton abundance.

OBJECTIVES

1. Assess kokanee stock status: age, growth, recruitment, harvest, mortality, abundance, and escapement.

2. Assess basic limnological parameters. Relate to fish production.

3. Evaluate impacts of reservoir management on primary productivity, zooplankton, and kokanee. Assess zooplankton size, species composition, relative abundance, and distribution.

4. Document losses of kokanee through the dam. Relate to discharge and reservoir levels.

5. Recommend management programs for the kokanee fishery.

STUDY AREA

Dworshak Dam is located on the North Fork of the Clearwater River 3.2 km upstream from its mouth (Figure 1). The dam is about 5.2 km northeast of Orofino in Clearwater County, Idaho. At 219 m, it is the largest straight-axis concrete dam in the United States. Three turbines have a total operating capacity of 450 megawatts. Water passes through the turbines, outlet gates, or tainter gates on the spillway.

Dworshak Reservoir is 86.2 km long and has 295 km of steep shoreline. Maximum depth is 194 m with a corresponding volume of 4.28 x 10^9 m^3 at full pool. Surface area when full is 6,644 hectares and mean depth 56 m. Mean annual outflow is 162 m^3/s. The Reservoir has a mean retention time of 10.2 months. Retention time is quite variable, and has ranged from 22 months in 1973 to 6 months during 1974 (Falter 1982). Drawdowns of 47 m reduce surface area as much as 52% (3,663 hectares). Dworshak Reservoir initially reached full pool on July 3, 1973.

Horton (1981) documented the presence of 19 fish species in the reservoir. Primary sport fish include kokanee Oncorhynchus nerka rainbow trout Oncorhynchus mykiss and smallmouth bass Micropterus dolomieui. Largemouth bass Micropterus salmoides bull trout Salvelinus confluentus westslope cutthroat trout Oncorhynchus clarki lewisii brook trout Salvelinus fontinalis mountain whitefish Prosopium williamsoni and brown bullhead Ictalurus nebulosus are also present.

The reservoir has a strong fishery. Harvest has ranged from 60,000 to 250,000 game fish annually. Angling effort has varied from 50,000 to 190,000 hours, with catch rates of 0.5 to 1.5 fish per hour. Kokanee have provided most of the fishing on the reservoir since the late 1970s (Figure 2).

METHODS

Kokanee Abundance

We used a midwater trawl to estimate kokanee densities. The net was 13.7 m long with a 3 x 3 m mouth. Stretch meshes graduated from 32, 25, 19, and 13 mm in the body of the net to 6 mm in the cod end.

Trawling was conducted on the nights of June 5-8, 27-30 and September 25-28 during the dark phase of the moon to reduce net avoidance. Tow speed was 1.34 m/s using a 8.5 m boat powered with a 140 horsepower engine. We made timed tows in 3.5 m strata through the vertical distribution of kokanee as determined by echosounding. The number of tows necessary to sample the band of kokanee made up an oblique haul.

The ratio of volume of water encompassing the band of kokanee to average trawl volume was used to expand kokanee densities (Scheaffer et al. 1979).

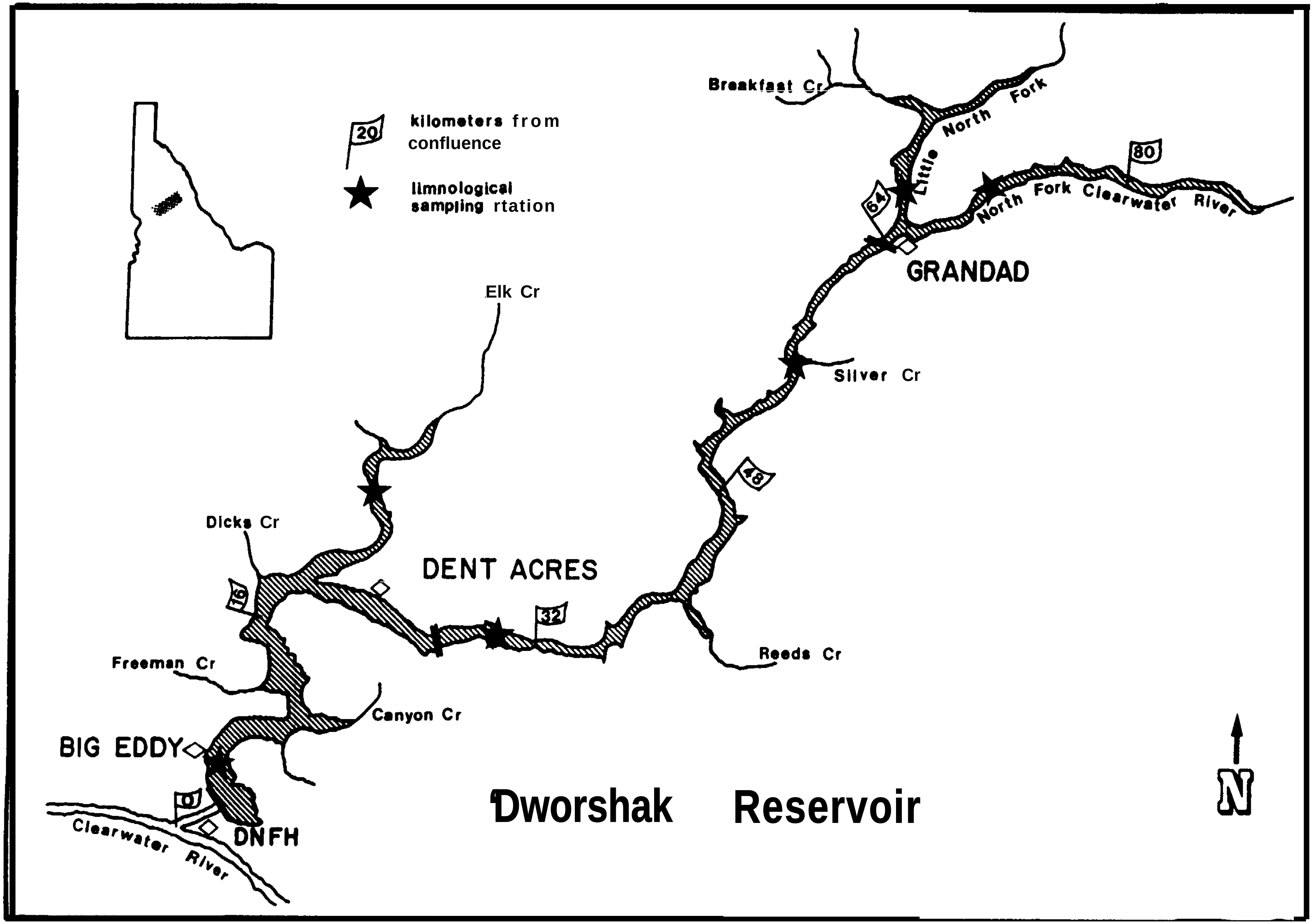


Figure 1. Dworshak Reservoir and major tributaries, North Fork Clearwater River, Idaho.

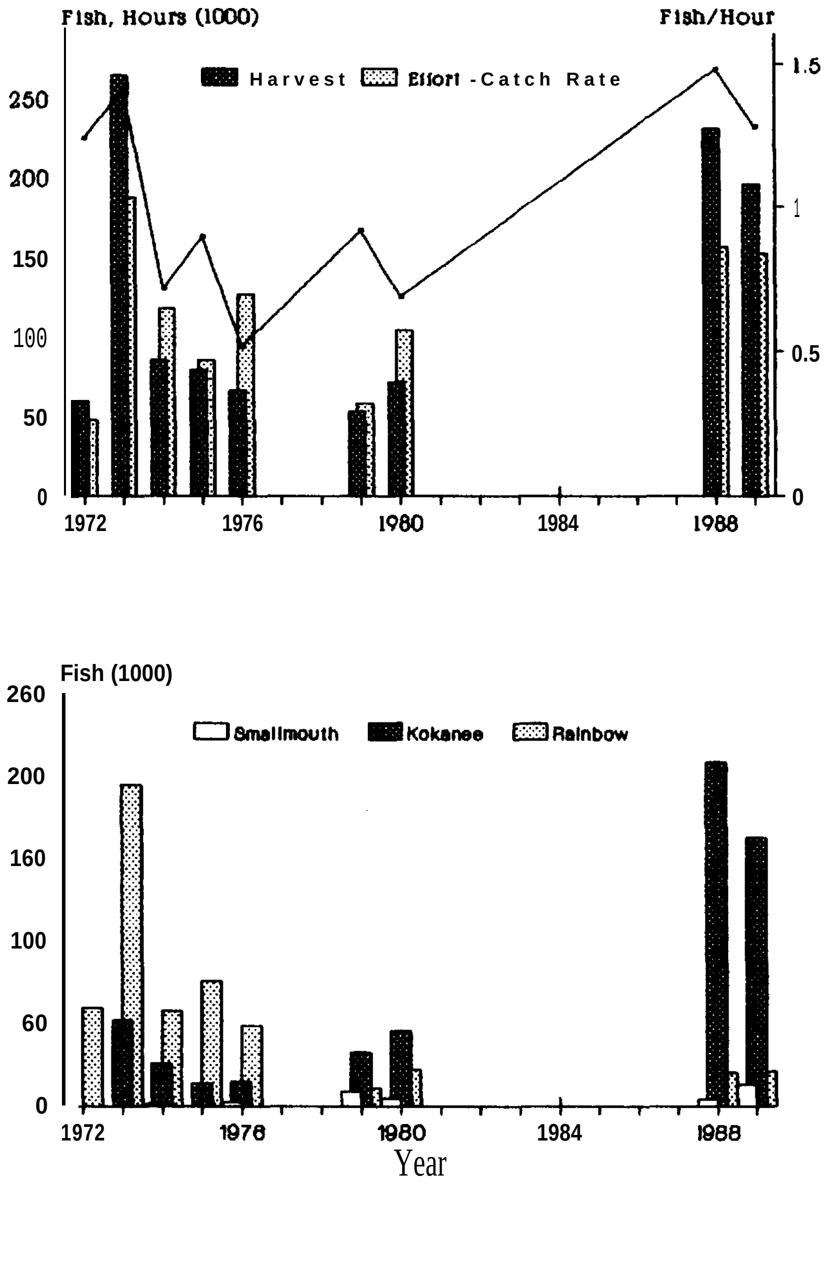


Figure 2. Catch, angling effort, and catch rate for all species, and harvest levels for kokanee, rainbow trout, and smallmouth bass from Dworshak Reservoir, 1972-1989.

Angler Use and Harvest

We used a stratified, two-stage probability creel survey to count and interview anglers (Malvestuto 1983). Census days were stratified into weekends and week days. The reservoir was divided into three sections: the dam to Dent Bridge, Dent Bridge to Grandad Bridge, and Grandad Bridge to the inflow (Figure 1).

One section was chosen for census on a given day. The random selection of each area was weighted by the expected pressure an area was to receive (Maiolie 1988). Ten survey days were selected per month, and pressure and harvest were estimated for monthly intervals.

We conducted creel surveys in cooperation with the Nez Perce Tribe.

Spawning Trends

We counted kokanee spawners September 18-22 in Isabella, Skull, Quartz, Dog, and Breakfast Creeks from each creek mouth upstream to kokanee migration barriers.

Limnology

Six limnological stations were sampled monthly (Figure 1). Four stations were on the main body of the reservoir at river kilometers 5 (RK5), 31 (RK31), 56 (RK56), and 70 (RK70). Three stations were in major arms of the reservoir: 6 km up Elk Creek (EC6) and 2 km up the Little North Fork (LNF2).

At each station, we took dissolved oxygen and temperature readings at the surface, 1 m, and at even meter depths to 60 m. Transparency was measured with a 20 cm Secchi disk. We sampled plankton with a 0.5 m net of 130-150 micron mesh (size 10) equipped with a pygmy flowmeter. Five vertical tows were taken from 12.2 m depth to the surface. Zooplankters were classified by family and counted. We measured a subsample of organisms to the nearest 0.1 mm with an ocular micrometer in a dissecting scope at 30 power.

Water samples were collected from the surface at river kilometer 5 (RK5). The Idaho Department of Health and Welfare analyzed nitrate and phosphate levels. Three stations (RX 5,56,70) were used for chlorophyll analysis. Samples were filtered in the field, frozen, and analyzed by the lab at Eastern Washington State University in Cheney, Washington.

Food Habits

We got kokanee stomachs from trawl catches, anglers, and project fishing. Stomachs were removed and preserved in ethanol until analyzed. Stomachs were cut open and washed free of all contents, which were examined under a binocular microscope. Items were counted and a subsample of these measured to the nearest 0.1 mm.

Food habits were analyzed by season and location. Percent composition by number was calculated.

RESULTS

Xokanee Abundance

In 1989, kokanee abundance was 471,662 in early June, including 148,338 fry, 148,388 yearlings, and 174,886 II+ fish. Late June produced an estimate of 538,825 kokanee, including 294,316 fry, 99,615 yearlings, 140,366 II+, and 4,528 III+ fish. The September estimate was 647,984 fry, 165,443 yearlings, and 44,897 II+ fish for a total of 858,234 (Figure 3). Densities ranged from 80 to 200 kokanee per hectare. Young-of-the-year kokanee ranged from 20 to 99 mm and age I+ fish from 120 to 249 mm. Older kokanee measured 220 to 299 mm (Figure 4).

Ancrler Use and Harvest

Xokanee anglers fished 128,703 hours to harvest 161,175 kokanee at 1.25 fish/h. Harvest was 2,235 fish in April and 21,688 fish in May. Levels increased to 56,177 in June and 59,457 in July, then declined to 19,869 in August. Harvests were below 1,500 kokanee/month the remainder of the year (Appendix A). Creeled kokanee averaged 246 mm and 121 g (Figure 5). Total yield of kokanee was 2.95 kg/ha, including incidental harvest by anglers seeking other species.

Spawninq Trends

We counted a total of 37,016 adult kokanee in five streams in 1989. We found 14,402 fish in Breakfast Creek, 11,830 in Isabella Creek, and 6,094 spawners in Skull Creek. Remaining streams supported fewer than 3,000 fish each. Counts were very similar to those of 1988. However kokanee spawners were II+ fish in 1989, distinctly different from the normal preponderance of III+ spawners (Figure 6).

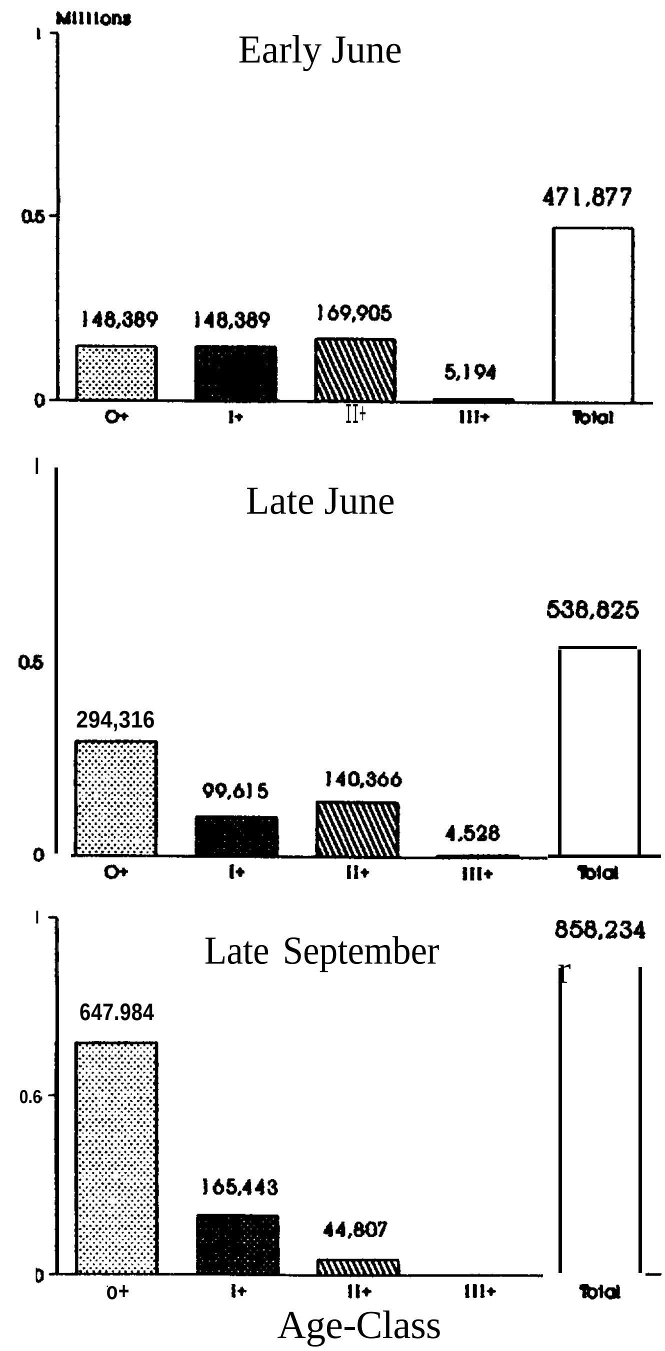


Figure 3. Estimated abundance of kokanee in Dworshak Reservoir in 1989.

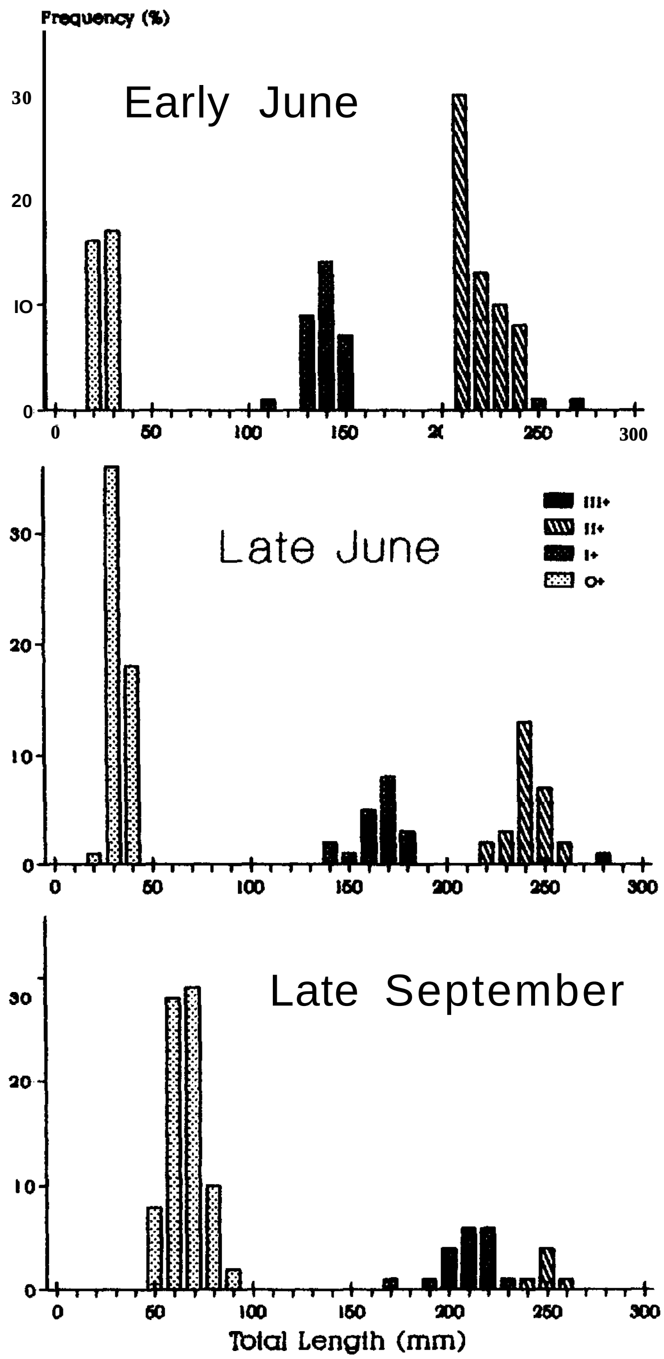


Figure 4. Length-frequencies of trawl-caught kokanee from Dworshak Reservoir in 1989.

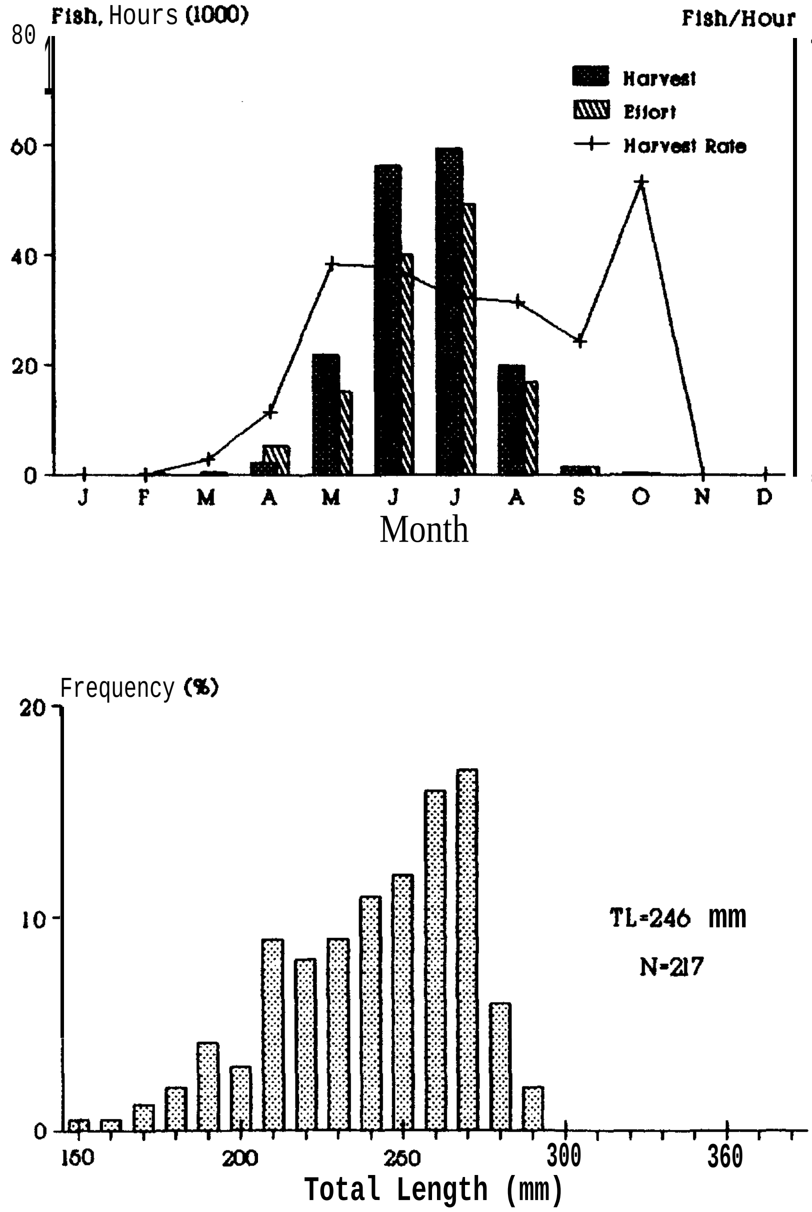


Figure 5. Catch rate, estimated monthly effort, and harvest from Dworshak Reservoir by anglers seeking kokanee, and length-frequency of kokanee in the harvest in 1989.

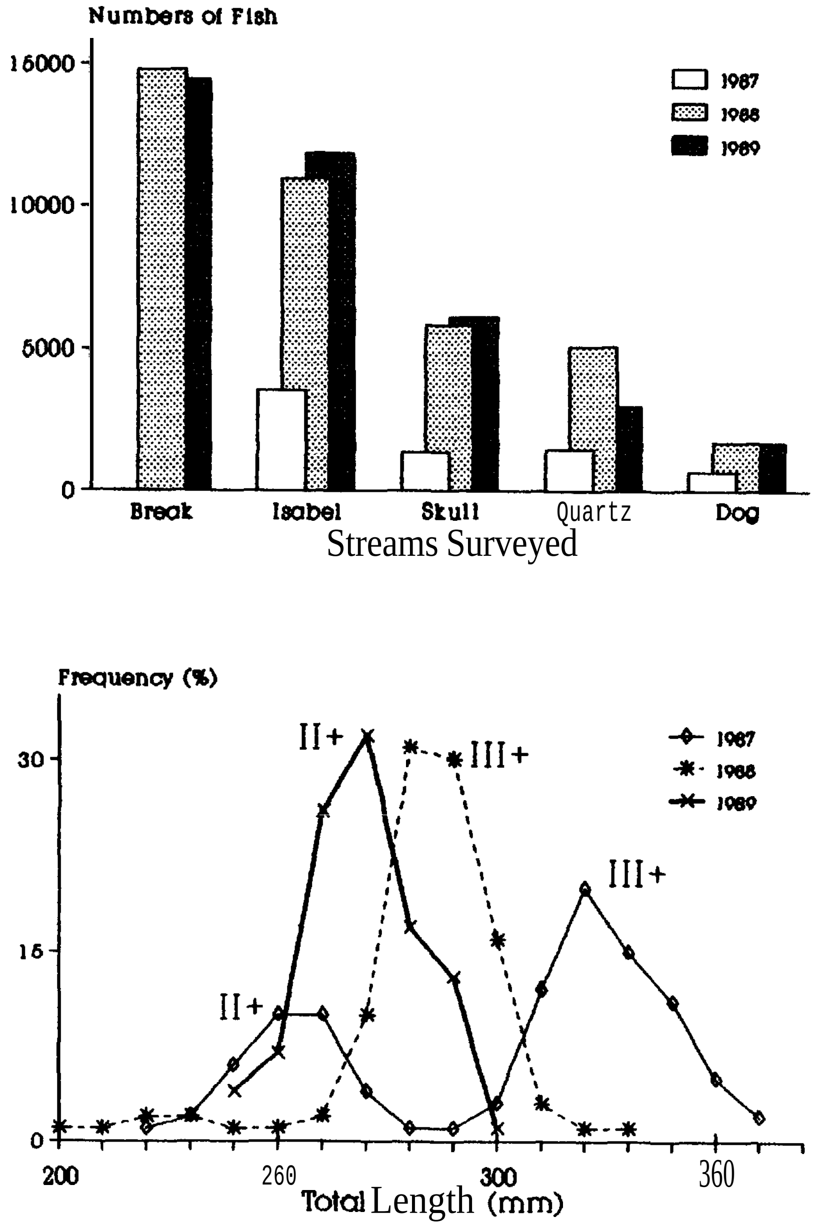


Figure 6. Abundance and size of adult kokanee sampled from tributaries of Dworshak Reservoir in 1987, 1988, and 1989.

Limnology

Nutrients

Nitrate nitrogen averaged 60 ug/L. Nitrate concentrations varied between 4 ug/L in July and 135 ug/L in February. Ammonia values averaged 33 ug/L and varied from 1 ug/L in October to 97 ug/L in April. Kjeldahl nitrogen ranged from 50 to 260 ug/L with an April to October mean of 140 ug/L. Mean annual NO_2+NO_3 value was 14 ug/L.

Total Phosphorous as P was less than, or equal to, 50 ug/L throughout 1989. Ortho-phosphate as P was 3 ug/L in January and less-than, or equal-to, 1 ug/L in February, June, and July. Dissolved o-Phosphate as P was 3 ug/L in May and June and 7 ug/L in October. In July and August values were less-than, or equal-to, 1 ug/L (Figure 7).

Chlorophyll

Chlorophyll A values at RK5 averaged 1.1 mg/m^3 for the growing season (Figure 7). This was 25% of comparable values in 1977 (Falter 1982).

Transparency

Mean secchi depth was 3.95 m compared with 3.46 m in 1988 and 3.09 m in 1977 (Figure 8).

Zooplankton

Zooplankton densities averaged 14.3 organisms/L compared to 27.3 organisms/L in 1972, 18.5 organisms/L in 1973, 10.8 organisms/L in 1974, and 10.3 organisms/L in 1988. Cladocerans made up 45% of the zooplankton community (92% in 1972, 56% in 1973, 84% in 1974 and 35% in 1988). Contribution of the Cladocerans Daphnia and Bosmina was about equal in 1989 (Figure 8). Daphnia densities in 1989 were twice as high as in 1988 (Figure 9).

Temperature

Dworshak Reservoir warmed more slowly and cooled more rapidly in 1989, with mean annual surface temperatures 1.2 C lower than in 1988 (Figure 9).

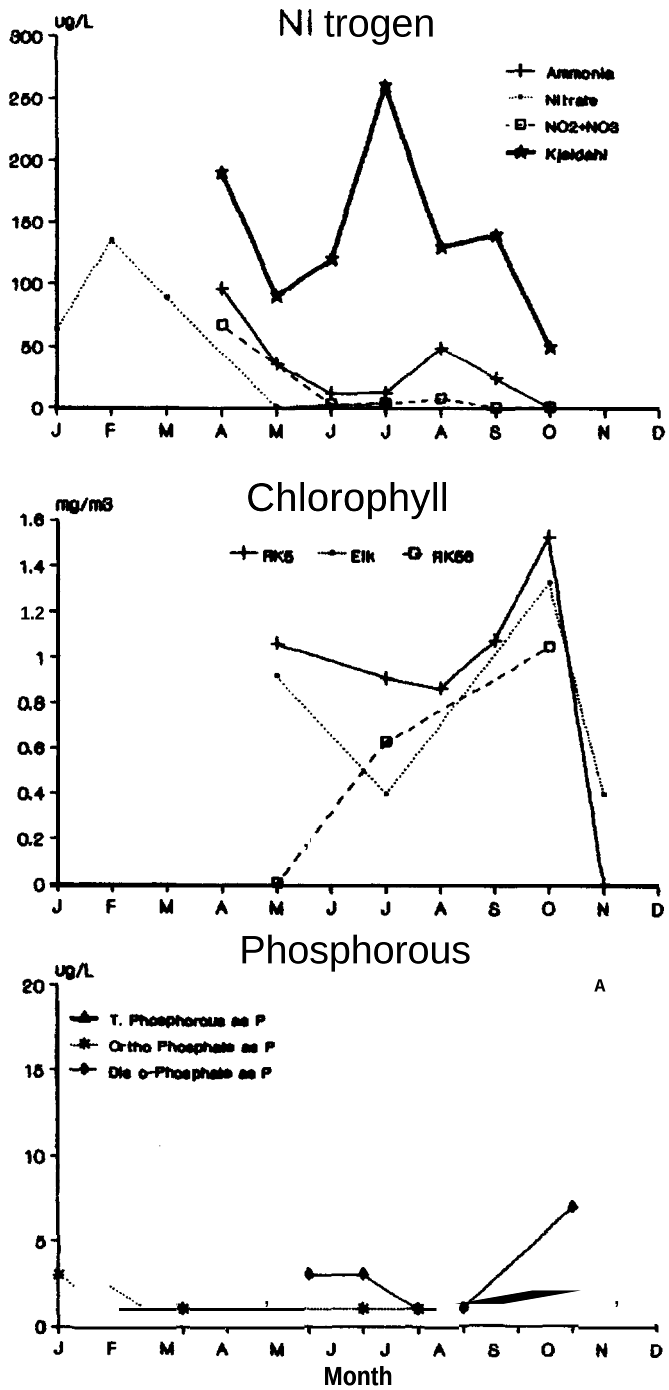


Figure 7. Levels of nitrogen, chlorophyll, and phosphorous in Dworshak Reservoir in 1989.

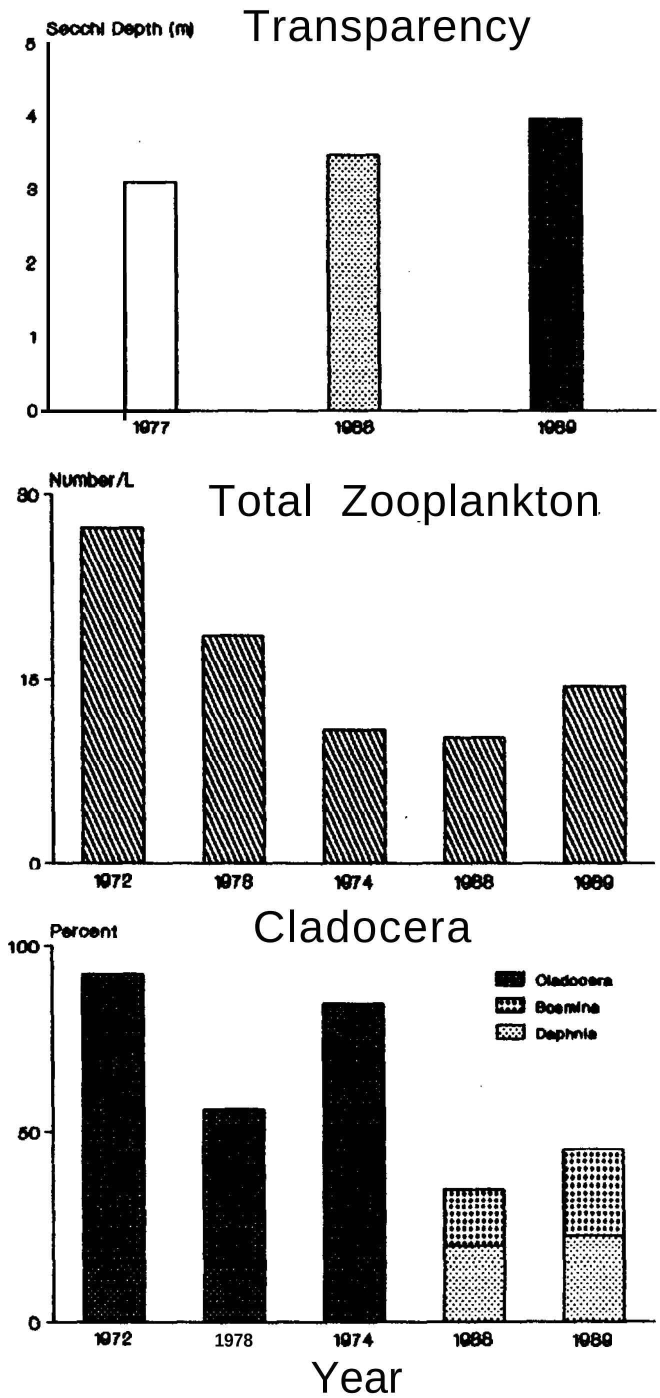


Figure 8. Water clarity, zooplankton densities, and contribution of Cladocera for Dworshak Reservoir, 1972-1989.

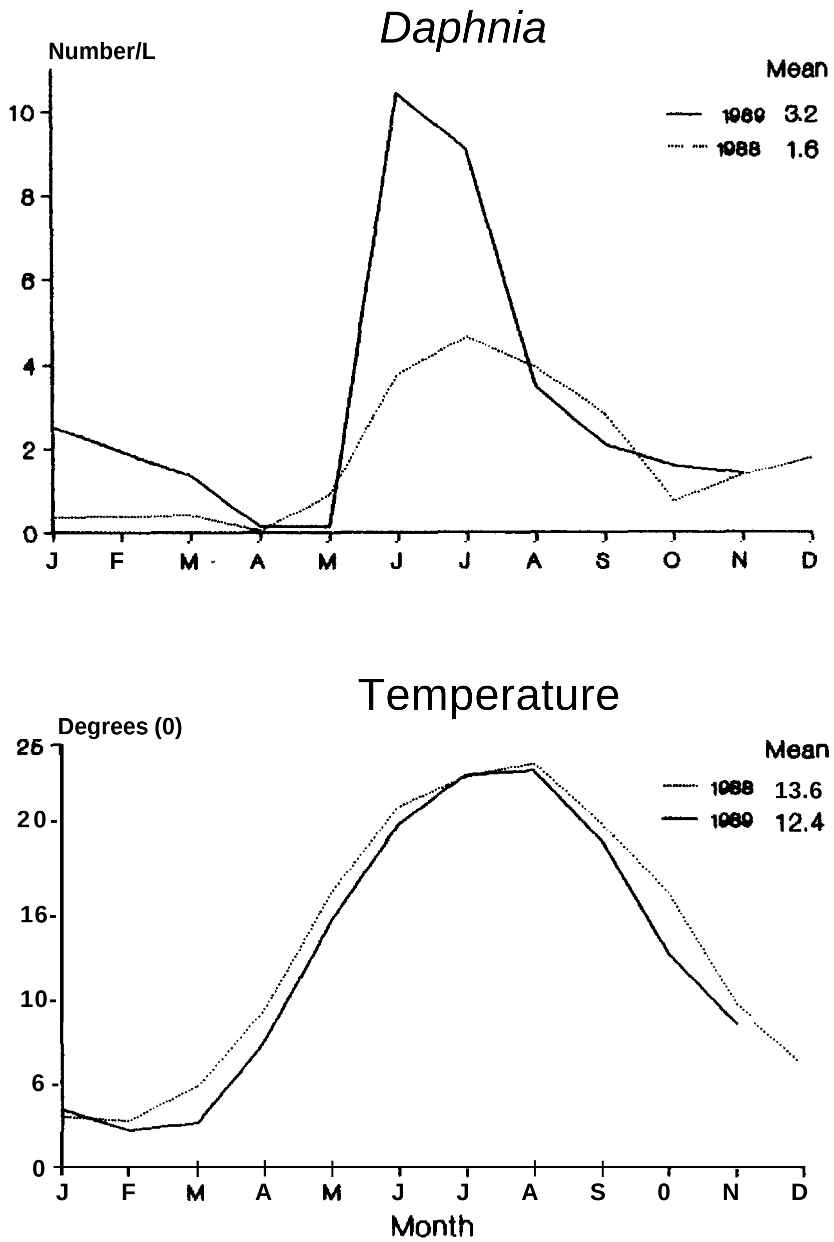


Figure 9. Daphnia densities and surface temperatures for Dworshak Reservoir in 1988 and 1989.

Food Habits

As in 1988, Daphnia and Cyclops were the most important kokanee food items; Daphnia dominated the diet though copepods were more abundant. Kokanee switched to copepods only during May when Daphnia made up less than 4% of the zooplankton present (Figure 10).

DISCUSSION

Kokanee Abundance

Kokanee abundance estimates were lower in 1989 than in 1988. Later warming and earlier sampling probably contributed to the difference. Smaller than usual kokanee fry were especially noticeable in early June when they occasionally fell through the meshes of the trawl net. Delayed recruitment to the reservoir and gear probably caused undersampling of young-of-the-year kokanee in early summer 1989. Nevertheless, the 1988 year-class may have undergone greater than normal mortality, especially considering that escapement was up three-fold in 1988.

The other major difference in 1989 abundance estimates was fewer I+ kokanee. We saw 1987 year-class kokanee throughout the 1988-89 winter in the river below the dam. Losses from the reservoir may have weakened that year-class.

Similarly, the 1985 year-class was weak in the reservoir, fishery and spawning population (Figure 3). The effect of minimal contributions of II+ fish in 1988 and III+ fish in 1989 on kokanee harvest in numbers was apparently slight. A strong 1984 year-class compensated with III+ fish in 1988. The 1986 year-class supported a similar harvest and spawning escapement with II+ fish in 1989. Loss of consecutive year-classes may have to occur before catchable size kokanee decline enough to alter harvest.

Angler Use and Harvest

The 1989 fishery started late compared to 1988. Total effort and yield were below 1988 levels (140,416 h, 4.5 kg/ha). Smaller, less catchable adult kokanee may also have produced poorer fishing in 1989. Kokanee fishing improves when densities are fairly low, growth rapid and maturity delayed (Rieman 1990). This occurs because kokanee catchability increases exponentially with size from a threshold around 170 mm for capture with conventional troll gear (Figure 11). The lack of III+ fish in the reservoir in 1989 resulted in smaller fish in the fishery. Catch rates and yield were probably lower than they would have been.

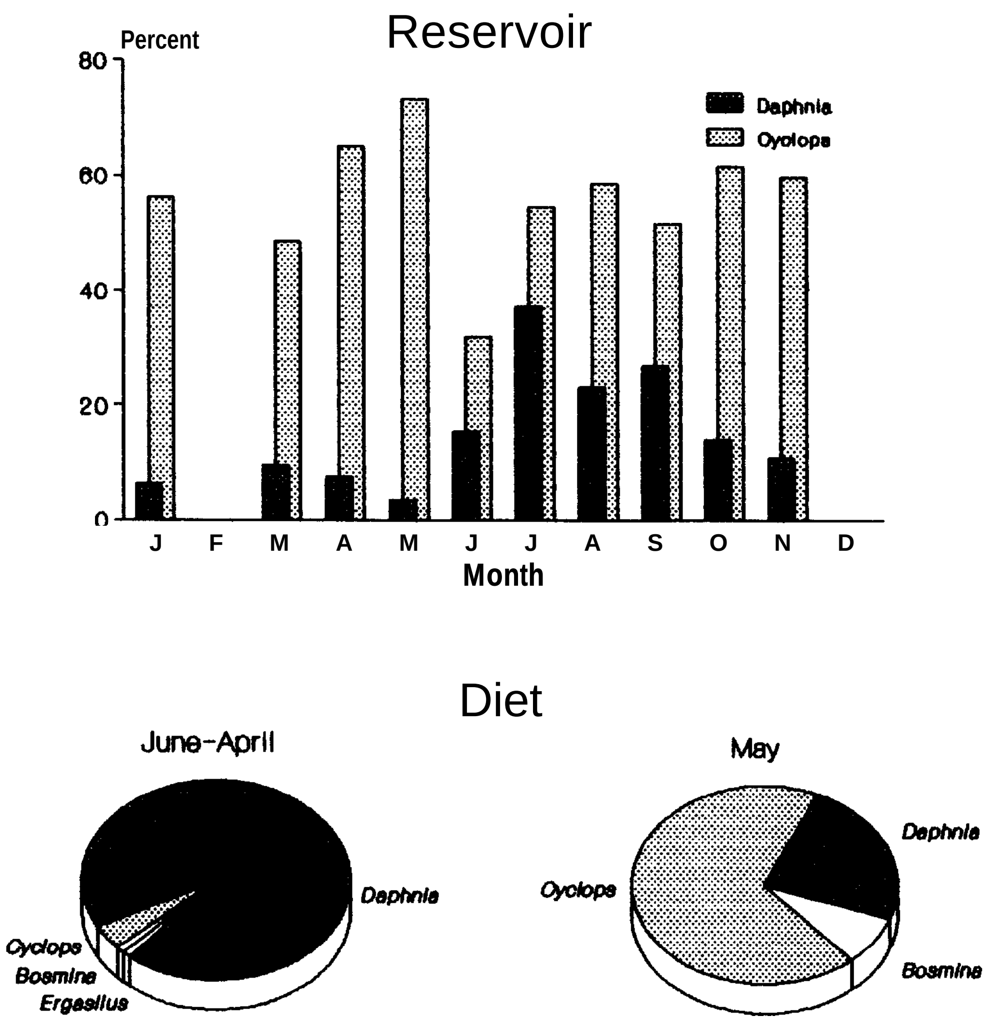
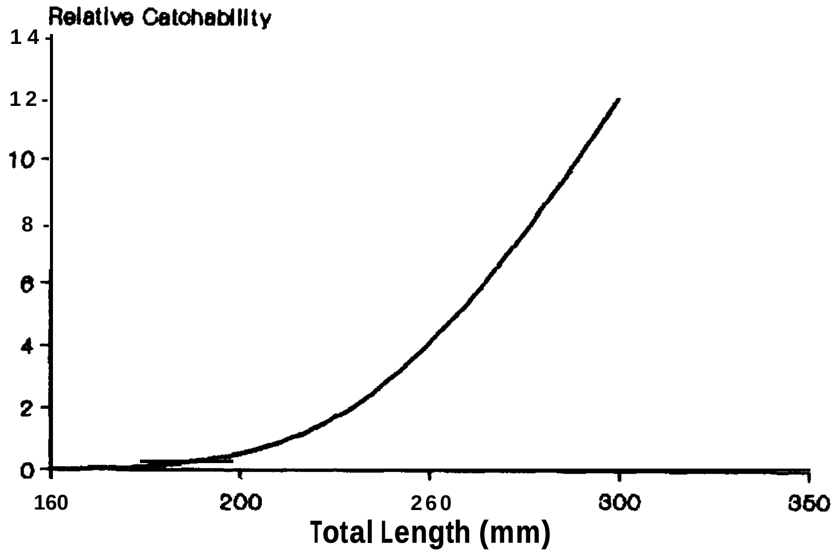


Figure 10. Seasonal composition of major food items in Dworshak Reservoir and in the kokanee diet in 1989.



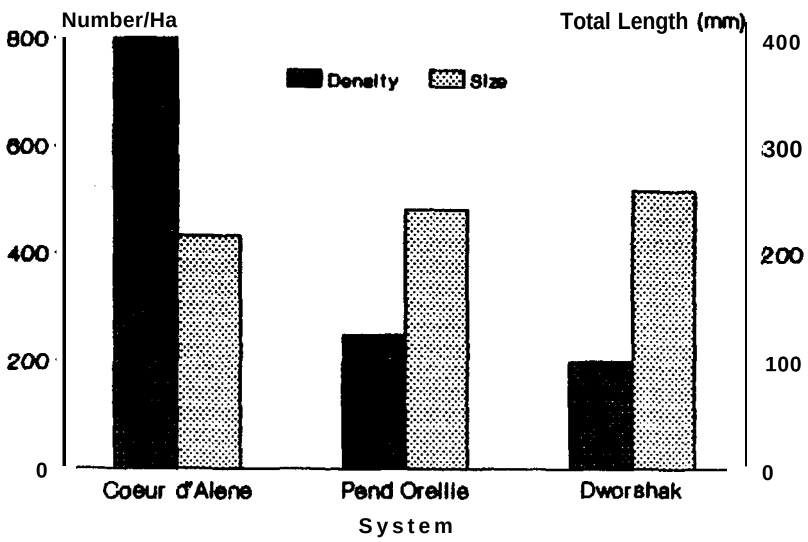


Figure 11. Kokanee vulnerability (Rieman 1990) density and size for Idaho lake systems.

If kokanee in Dworshak Reservoir decline further in size, fishery yields will decrease accordingly.

Spawning Trends

Large (35 cm) spawners predominate when three-year-old abundance is low in Dworshak tributaries (Maiolie 1988, Mauser et al. 1989). In Coeur d'Alene Lake spawner age decreased as densities increased and growth declined. This compounded the reduced catch rates and yields. Low densities tend to produce larger, more catchable kokanee in relatively unproductive waters such as Dworshak Reservoir (Figure 11).

Limnology

Phosphorous and chlorophyll levels in 1989 indicated Dworshak Reservoir is an unproductive system. However zooplankton production in 1989 was comparable to Pend Oreille, which is moderately productive (Figure 12). In 1989, nitrate nitrogen may have been unusually high at 2.4 times the 1988 value of 25 ug/L (Mauser et al. 1989). Water clarity has been consistently closer to that expected of a moderately productive body of water. Kokanee yields equal or exceed those of Idaho lakes of similar productivity (Figure 12).

Suspended sediments from leached soils exposed to drawdown probably decrease transparency of Dworshak water, but may no longer really enrich the reservoir with phosphorous. The fishery may yield more than primary productivity would indicate because kokanee densities are low to moderate. Low planktivore densities may permit relatively high standing crops of Daphnia compared to similar waters (Figure 12).

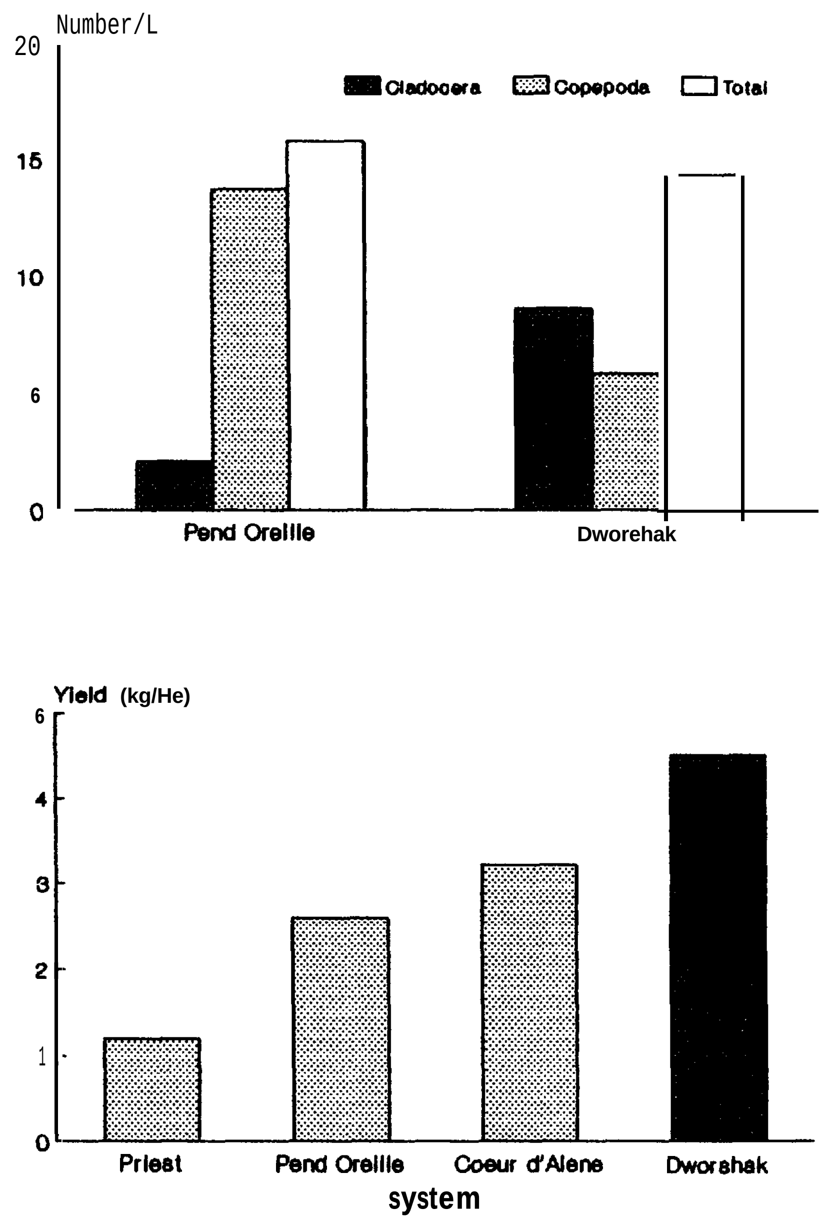


Figure 12. Zooplankton densities and kokanee yields for Idaho lake systems (Bowles et al. 1988, Rieman 1990).

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LITERATURE CITED

Ball, K. and W. Cannon. 1974. Evaluation of the limnological characteristics and fisheries of Dworshak Reservoir. Idaho Department of Fish and Game, Job Performance Report, Project DSS-29, Job 4, Boise, Idaho.

Bowles, E.C., V.L. Ellis, D. Hatch, and D. Irving. 1988. Kokanee stock status and contribution of Cabinet Gorge Hatchery - Lake Pend Oreille, Idaho. Idaho Department of Fish and Game, Annual Progress Report FY 1987, Project 85-339.

Falter, C.M., J.M. Leonard, and J.M. Skille. 1979. Early limnology of Dworshak Reservoir. U.S. Army Corps of Engineers, Contract DACW68-72-C-0142, Walla Walla, Washington.

Falter, C.M. 1982. Limnology of Dworshak Reservoir in a low flow year. U.S. Army Corps of Engineers. Walla Walla, Washington.

Horton, W.D. 1980. Dworshak Reservoir fisheries investigations Idaho Department of Fish and Game, Prepared for U.S. Army Corps of Engineers, Contract DACW68-79-C-0034, Boise, Idaho.

Horton, W.D. 1981. Dworshak Reservoir fisheries investigations. Idaho Department of Fish and Game, Prepared for U.S. Army Corps of Engineers, Contract DACW68-79-C-0034, Boise, Idaho.

Maiolie, M.A. 1988. Dworshak Dam impacts assessment and fishery investigation. Idaho Department of Fish and Game, Annual Report to Bonneville Power Administration, Contract DE-A179-87BP35167, Project 87-99, Boise, Idaho.

Malvestuto, S.P. 1983. Sampling the Recreational Fishery. Pages 397-419 in L.A. Nielsen and D.L. Johnson, editors. Fishery Techniques. American Fisheries Society, Bethesda, Maryland.

Mauser, G., D. Cannamela, and R. Downing. 1989. Dworshak dam impact assessment and fishery investigation. Idaho Department of fish and Game, Annual Report to Bonneville Power Administration, Contract DE-A179-87BP35167, Project 87-89, Boise, Idaho.

Pettit, S.W., W. Reid, and J.G. Sneva. 1975. Evaluation of the limnological characteristics and fisheries of Dworshak Reservoir. Idaho Department. of Fish and Game, Job Performance Report, Project DSS-29-5, Boise, Idaho.

Rieman, B. E. 1990. Generalized kokanee stock-recruitment model. Idaho Department of Fish and Game, Project F-73-R-12, Subproject II, Study III, Boise.

Scheaffer, R.L., W. Mendenhall, and L. Ott. 1979. Elementary survey sampling. 2nd edition. Duxbury Press, North Scituate, Massachusetts.

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APPENDIX

Appendix A. Census information for anglers seeking kokanee on Dworshak Reservoir in 1989.

	Effort (hours)				Catch rate				Harvest			
Section	I	II	III	Total	I	II	III	Total	I	II	III	Total
Month												
J	0	0	0	0	0	0	0	0	0	0	0	0
F	307	0	0	307	0	0	0	0	0	0	0	0
M	362	143	0	505	0.16	0	0	0.11	58	0	0	58
A	5,198	. 0	0	5,198	0.43	0	0	0.43	2,235	0	0	2,235
M	14,125	860	105	15,090	1.49	0.73	0.13	1.44	21,046	628	14	21,688
J	31,945	6,217	1,794	39,956	1.43	0.84	2.94	1.41	45,681	5,222	5,274	56,177
J	24,911	12,466	11,780	49,157	0.82	1.60	1.62	1.21	20,427	19,946	19,084	59,457
A	8,568	4,600	3,664	16.832	1.41	1.04	0.82	1.18	12,081	4,784	3,004	19,869
S	111	813	571	1,495	1.50	0.75	1.03	0.91	167	610	588	1,365
0	163	0	0	163	2.00	0	0	2.00	326	0	0	326
U	0	0	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	0	0	0	0	0	0	0	0
Totals	85,690	25,099	17,914	128,703	1.19	1.24	1.56	1.25	102,021	31,190	27,964	161,175

APPEUDA.89