THE FOOD HABITS AND DISTRIBUTION OF RAINBOW AND CUTTHROAT TROUT IN LAKE KOOCANUSA, MONTANA

A Master's Thesis by Steve L. McMullin
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OF

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BY

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ABSTRACT

The food habits and distribution of rainbow trout and westslope cutthroat trout in Lake Koocanusa, Montana were assessed monthly throughout 1977. Stomachs of 841 rainbow and 604 cutthroat trout were analyzed numerically, volumetrically and by frequency of occurrence. All three methods were combined into an index of relative food item importance.

Both species were concentrated in the upstream half of the reservoir during winter and early spring. Rainbow trout were evenly dispersed throughout the length of the reservoir the rest of the year. Cutthroat trout were more abundant in the downstream portion of the reservoir in summer than in the upstream portion. Both species were found mostly near the surface in limnetic areas except during mid-summer. In mid-summer, rainbow trout were most abundant at depths with temperatures in the 17-19 C range and cutthroat trout in temperatures of 15-18 C. Cutthroat trout were found close to the surface and rainbow trout at all depths in nearshore areas throughout the year. No clear pattern in the horizontal distribution of either species across the width of the reservoir was evident. The selective water withdrawal system in Libby Dam, if operated properly, can minimize the number of fish flushed downstream out of the reservoir.

Daphnia was the most important food item in the diets of both species. Both species fed almost entirely on *Daphnia* in winter. Terrestrial insects, aquatic Diptera and fish increased in importance during summer. Cutthroat trout consumed more insects than rainbow while rainbow were more piscivorous. Small rainbow and cutthroat trout derived approximately one-half of the estimated caloric energy for growth from *Daphnia*. Forage fish contributed more calories of energy than any other food item in the diets of larger fish of both species.

The advantages of using gill nets in food habits studies outweigh the disadvantages when properly used. Gill nets are relatively inexpensive, easy to use and a large sample can be secured. Regular tending of the nets will insure fresh samples. Regurgitation of stomach contents was a minor problem.

INTRODUCTION

In this report I present the findings of a study of the food habits and distribution of rainbow (Salmo gairdneri) and westslope cutthroat (Salmo clarki lewisi) trout in Lake Koocanusa, a large reservoir on the Montana-British Columbia border. I also present food habits data from collections of westslope cutthroat in Hunry Horse Reservoir, Montana. The results of seasonal zooplankton and benthic sampling are presented. Egg development was monitored in both species throughout the study. I also evaluate the use of gill nets in food habits studies.

The U.S. Army Corps of Engineers has funded several studies of Lake Koocanusa's aquatic resources. The U.S. Geological Survey has monitored the physical, chemical and biochemical attributes of Lake Koocanusa since impoundment. Woods (1979) evaluated primary productivity. Falter and Irving (University of Idaho, unpublished) are studying the population dynamics of phytoplankton and zooplankton. Bonde and Bush (1975) and the British Columbia Department of the Environment (1976) have published reports on the water quality of the Kootenai River and Lake Koocanusa.

The Corps of Engineers has also funded several studies conducted by the Montana Department of Fish, Wildlife and Parks. Some of the objectives of Montana studies included determining fish population trends, growth and condition of major fish species, distribution of fish species in the forebay area, angler use and success, and development of tributaries for trout spawning and rearing. The study of the food habits and distribution of rainbow and cutthroat reported herein is a part of Montana's overall research program.

The food habits study was initiated in an attempt to fill in some of the gaps in the existing knowledge of the life histories of rainbow and cutthroat trout in Lake Koocanusa. In spite of management efforts designed to benefit cutthroat trout (although it was assumed other species would benefit as well), rainbow trout have flourished in the reservoir since impoundment.

Most rainbow trout enter the reservoir by the start of their second summer, with some leaving the tributaries as fry (Bruce May, personal communication). A few enter the reservoir at age II. Growth is rapid after fish enter the reservoir. Rainbow trout that have spent one year in a tributary stream average approximately 60 mm (2.3 in.) total length at age I, 290 mm (11.5 in.) at age II, 390 mm (15.5 in.) at age III and 430 mm (17.0 in.) at age IV (May et al. 1979). Most rainbow mature at age III or IV. The spawning period is from late March to early May, with peak activity thought to be in mid-April.

The systematics of rainbow trout in the Kootenai drainage is an unsettled question. MacCrimmon (1971) included the Kootenai River upstream to the Idaho-Montana border in the native range of rainbow, but Allendorf et al. (1978) and Espeland and Scow (1978) provide recent evidence that rainbow trout may be native in the Montana portion of the Kootenai River below Kootenai Falls. Native Kootenai River rainbow would belong to the group of native inland rainbow trout Behnke (1979) refers to as the redband trout. Hatchery rainbow trout, derived from coastal steelhead stocks (Espeland and Scow 1978), have been planted throughout the drainage, and may be the rainbow trout presently found in the reservoir area.

Westslope cutthroat trout are native to the Kootenai drainage both above and below Kootenai Falls. Approximately 3.5 million hatchery westslope cutthroat have been planted in Lake Koocanusa and its tributaries. The hatchery fish came from the Hungry Horse Reservoir westslope cutthroat stock. Hungry Horse cutthroat are thought to be adfluvial cutthroat from Flathead Lake trapped when Hungry Horse Dam impounded the South Fork Flathead River (Joe Huston, personal communication).

Juvenile westslope cutthroat spend one to three years in tributaries before entering Lake Koocanusa. The largest number enter the lake at age II. Cutthroat average 50-75 mm growth per year in tributaries followed by rapid growth in the reservoir. Cutthroat that spend two years in a tributary stream average 325 mm (12.8 in.) after one year in the reservoir (age III) and 370 mm (14.5 in.) after two years in the reservoir (age IV). Cutthroat that spend three years in a tributary stream average 295 mm (11.6 in.) at age IV and 380 mm (15.0 in.) at age V (May et al. 1979).

Average length of spawning cutthroat in Young Creek has increased as adfluvial fish have replaced fluvial fish. Spawners that entered Young Creek in 1970 averaged less than 300 mm (11.8 in.) total length, compared to nearly 400 mm (15.7 in.) in 1977 (May and Huston 1976, 1977).

Unlike coastal cutthroat trout (*Salmo clarki clarki*), which successfully coexist with rainbow trout, and westslope cutthroat in the Salmon and Clearwater river drainages of Idaho, which have evolved with anadromous rainbow trout (steelhead), interior cutthroat have often been replaced or their ranges severely reduced after the introduction of hatchery rainbow trout (Behnke 1979). The westslope cutthroat has held up better than many subspecies of interior cutthroat but pure populations are rare and require special management (Roscoe 1974).

The Montana Department of Fish, Wildlife and Parks management program has been aimed at establishing and maintaining a westslope cutthroat fishery in Lake Koocanusa. The main thrust of cutthroat management has consisted of habitat development in tributaries. Development usually included identification of streams with spawning and rearing potential, removal of migration barriers and stocking of juvenile cutthroat that would home back to the tributaries. Some streams were chemically treated prior to stocking to reduce predation by and competition with other fish species.

A similar management strategy was employed on Hungry Horse Reservoir but to a more limited extent. Development of Hungry Horse tributaries consisted only of barrier removal. An adequate cutthroat fishery has been maintained in Hungry Horse Reservoir without hatchery supplementation.

Life history studies are being continued in Lake Koocanusa to evaluate the success of the management program. Montana Department of Fish, Wildlife and Parks personnel are investigating the spawning and early life history of rainbow and cutthroat trout. The study reported herein was set up to:

(1) assess the food habits of rainbow and cutthroat trout with respect to season, area of reservoir and size of fish, and

(2) assess the seasonal differences in distribution of rainbow and cutthroat trout within the reservoir.

DESCRIPTION OF STUDY AREA

Lake Koocanusa was created in 1972 with the completion of Libby Dam. The dam impounded the Kootenai River at RK 350.4 (RM 219), 27 km (17 mi.) upstream from Libby, Montana (Figure 1). Koocanusa is an acronym derived from Kootenai, Canada and United States of America.

The reservoir is 148 km (92 mi.) long at full pool. Slightly over half of the reservoir is within Montana. Some morphometric characteristics of the reservoir are listed in Table 1.

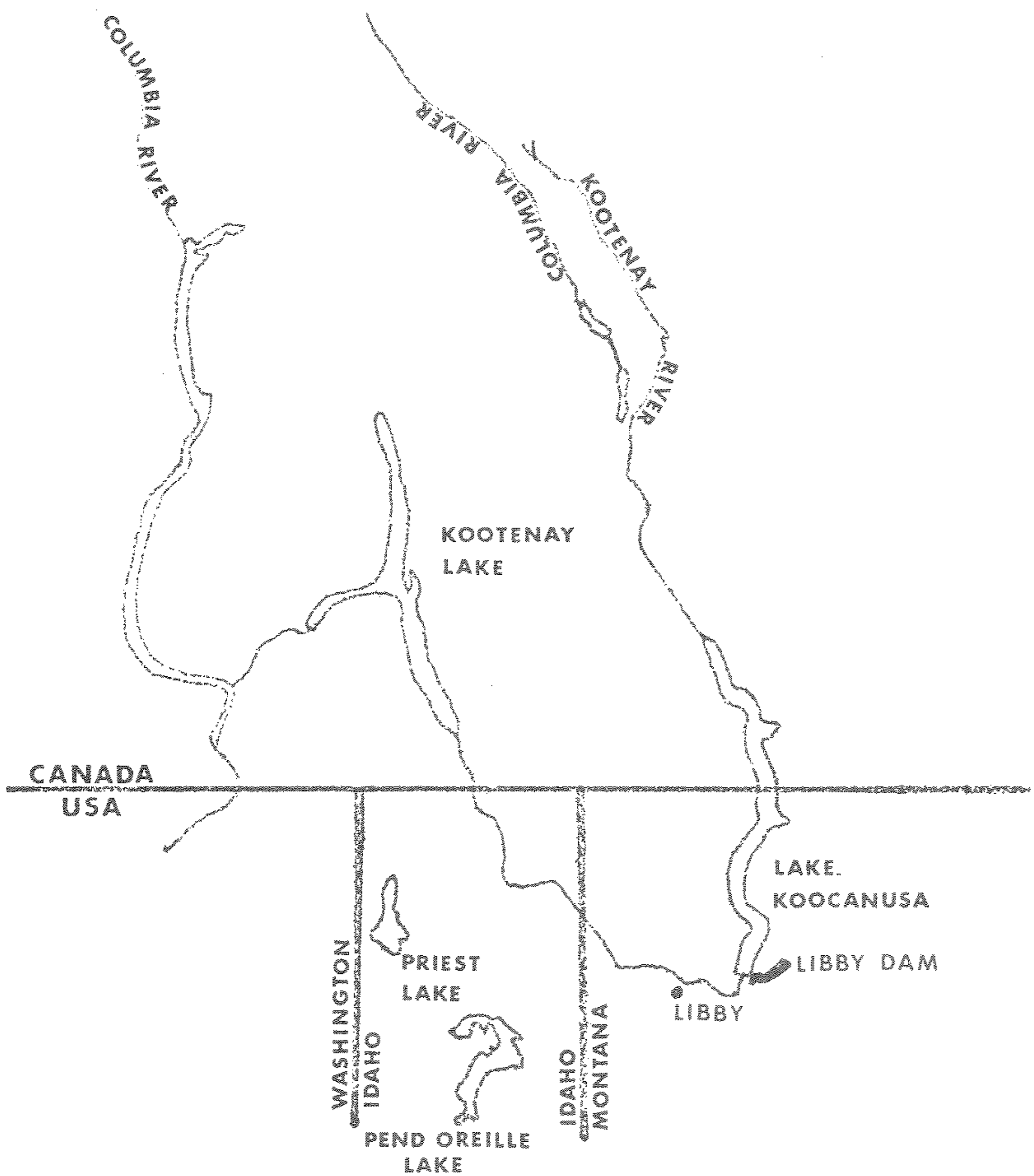


Figure 1. The Kootenai River drainage.

Table 1. Morphometric characteristics of Lake Koocanusa.

Reservoir elevation (m)	Volume (km^3)	Surface area (km^2)	Mean depth (m)	Shoreline development
749.5 (full pool)	7.16	188.2	38.1	7.41
697.1 (min. regulated pool)	1.08	59.1	18.3	--

Flood control and hydroelectric energy generation were the primary reasons for construction of Libby Dam. Recreation was also listed as a benefit of impoundment, but limited access to the reservoir has restricted recreational use.

Libby Dam was built with a selective water withdrawal system so that water released from the dam would match as closely as possible the temperature regime of the Kootenai River prior to impoundment. The system theoretically has the capacity to draw water into the turbine intakes from any depth between the surface and the penstocks (72 m below full pool elevation).

Maximum annual drawdown of 52 m (172 ft.) reduces pool volume by 85 percent. Average annual drawdown is expected to be about 37 m (120 ft.). Actual drawdowns during the period 1974-77 were 46.6 m (153 ft.), 52 m (172 ft.), 45.7 m (150 ft.) and 30.6 m (100 ft.), respectively. Discharges from the dam can fluctuate the level of the Kootenai River up to 1.8 m (6 ft.) per day when maximum electrical power production is required.

Preimpoundment studies (Bonde and Bush 1975, British Columbia Department of Environment 1976) indicated a potential for eutrophic conditions in Lake Koocanusa. High nutrient loading was cited as a reason for expecting annual blue-green algae blooms.

Although an extensive bloom occurred in 1974, a combination of factors has prevented eutrophic conditions from developing since then. Foremost among those factors was the clean up of pollution sources in Canada. Productivity has been limited by short water retention time, high turbidity in the upper half of the reservoir in spring, and the almost continuous mixing of the water column. The reservoir rarely stratifies. When stratification does occur, it is of short duration. Phytoplankton rarely occupy the entire photic zone (Paul Woods, personal communication).

Mean primary productivity from 1972 to 1975 was 28.8 $gCm^{-2}year^{-1}$ (Woods 1979), a value that ranks near the bottom end of Wetzel's (1975) oligotrophic range. Goldman (1977) classified Lake Tahoe as ultraoligotrophic with primary productivity values of 55 $g\ Cm^{-2}year^{-1}$.

Surface temperatures range from 0 C (32 F) in winter to 18-22 C (64-71 F) in summer. Winter ice cover is common as far south as Pinkham Creek (Figure 2). The reservoir south of Pinkham Creek rarely freezes.

Common game fish in Lake Koocanusa, in addition to rainbow and cutthroat trout, include mountain whitefish (Prosopium williamsoni), burbot (Lota lota), and Dolly Varden (Salvelinus malma). Behnke (1979) differentiates between coastal and interior forms of the Dolly Varden. He calls the interior form, including those found in Lake Koocanusa, bull char (Salvelinus confluentis). Other game fish known to be present include kokanee (Oncorhynchus nerka), brook trout (Salvelinus fontinalis), lake trout (Salvelinus namaycush), largemouth bass (Micropterus salmoides) and white sturgeon (Acipenser transmontanus).

Non-game species include largescale suckers (Catostomus macrocheilus), longnose suckers (Catostomus catostomus), redside shiners (Richardsonius balteatus), northern squawfish (Ptychocheilus oregonensis), peamouth (Mylocheilus caurinus) and pumpkinseed (Lepomis gibbosus).

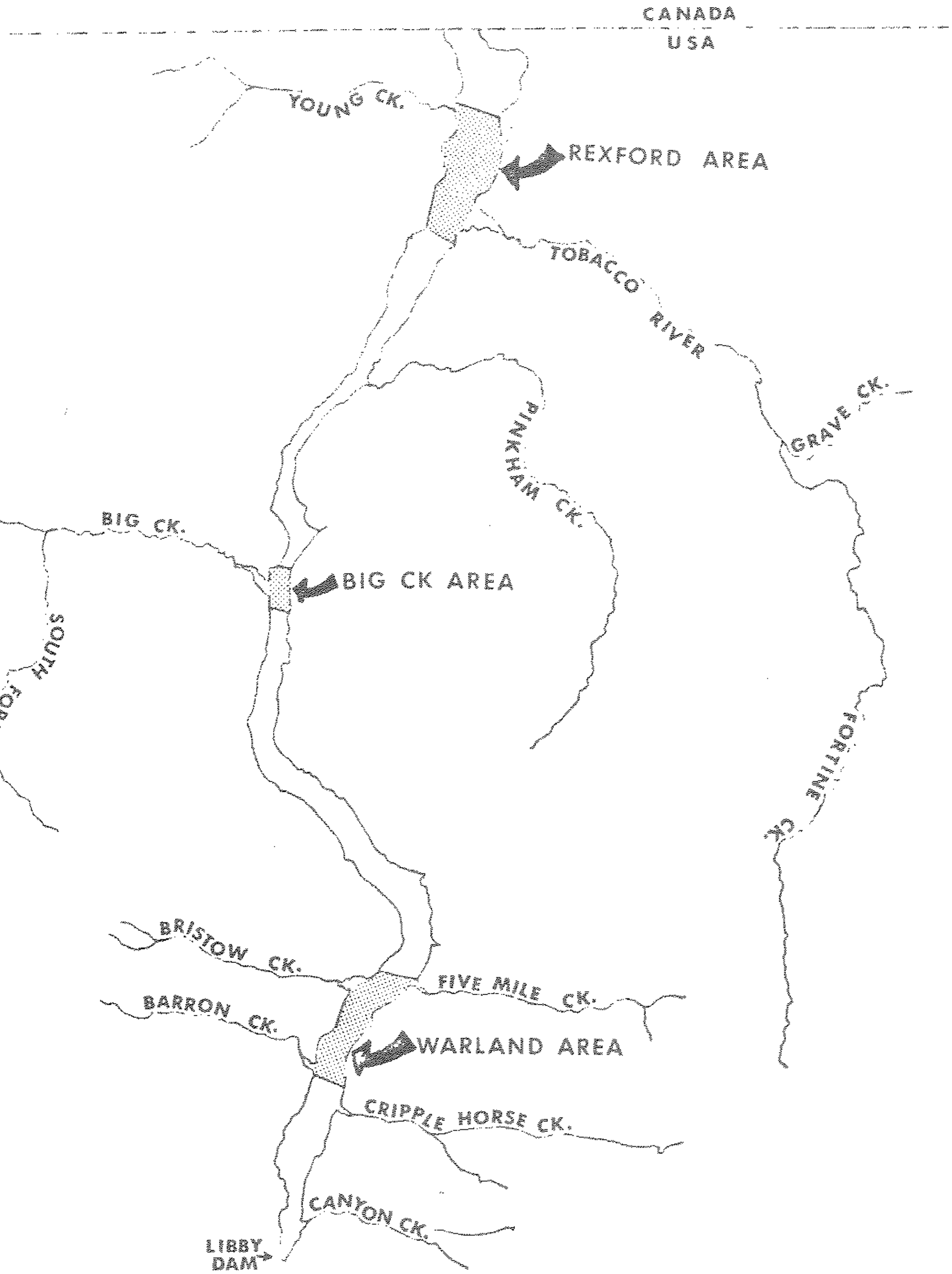


Figure 2. The Montana portion of Lake Koocanusa and its major tributaries. Shaded areas indicate sampling sites.

Hungry Horse Reservoir, a second study site, was formed when Hungry Horse Dam impounded the South Fork Flathead River in 1953. The reservoir is 55 km (34 mi.) long with a surface area of 9,600 ha (23,750 ac.). Maximum depth is 152 m (500 ft.). Fish species in Hungry Horse Reservoir include westslope and Yellowstone cutthroat (Salmo clarki bouvieri), Dolly Varden, mountain whitefish, pygmy whitefish (Prosopium coulteri), Arctic grayling (Thymallus arcticus), northern squawfish, longnose suckers and largescale suckers.

METHODS

Fish Distribution

The distribution of rainbow and cutthroat trout was assessed by using vertical gill nets, floating and sinking experimental gill nets, and by angling. Each type of gear was used to assess a particular aspect of fish distribution.

Vertical gill nets (Figure 3) were set monthly at permanent buoys in the forebay area to assess the year around vertical distribution of game fish. Montana Department of Fish, Wildlife and Parks personnel began the study in July, 1975 and it continued through December, 1977. All data were incorporated into the food habits study.

A bank of four nets were set as described by Horak and Tanner (1964). Each net was 3.7 m (12 ft.) wide by 45.7 m (150 ft.) deep. Bar mesh sizes were 19 mm (.75 in.), 25 mm (1 in.), 32 mm (1.25 in.) and 38 mm (1.5 in.). Fish captured in each 3 m (10 ft.) interval were recorded.

All experimental gill nets were set perpendicular to the shoreline shortly before dark and retrieved the following morning. Experimental nets were 38.1 m (125 ft.) long by 1.8 m (6 ft.) deep. Five panels, each 7.6 m

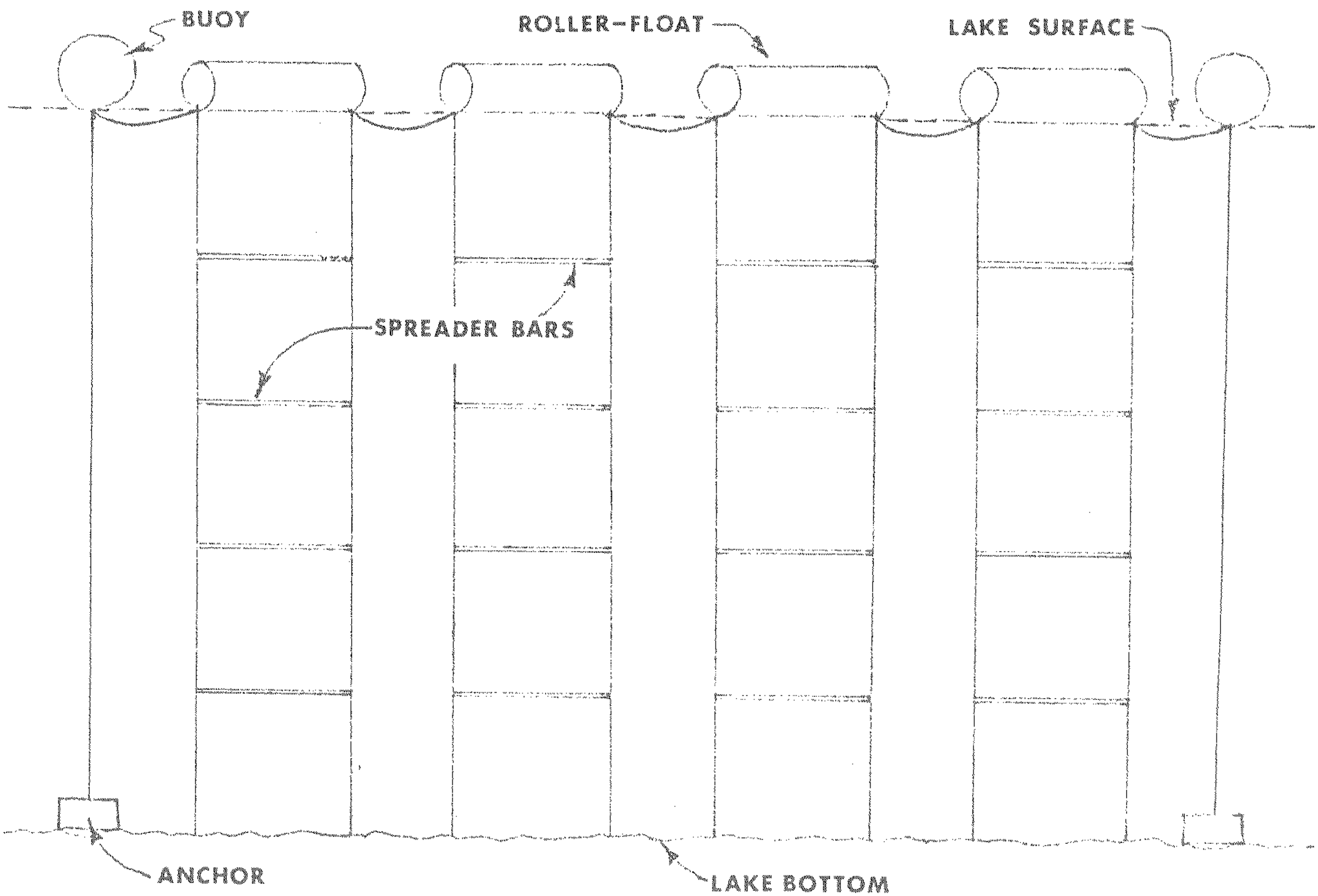


Figure 3. A schematic diagram of the vertical gill nets used during the food habits study.

(25 ft.) long consisted of 19 mm, 25 mm, 32 mm, 38 mm and 51 mm (2 in.) bar meshes. One to four single sinking nets and two to five double (tied end to end) floating nets were set monthly in the Warland and Rexford areas and quarterly in the Big Creek area (Figure 2).

A gang set of six experimental floating nets (tied end to end) was set perpendicular to the shoreline each month in the Warland and Rexford areas. Data on captured fish were recorded for each net.

Angling was used only in collecting the August, 1977 sample at Warland. We hoped to use angling to assess the daytime distribution of trout during a 24-hour diel study. The technique was abandoned because of difficulties in securing adequate samples.

The Wilcoxon rank sum test was used to analyze experimental gill net catches. The Kruskal-Wallis test used by the Montana Department of Fish, Wildlife and Parks (Gooch 1975) reduces to a Wilcoxon rank sum test in the two-sample case.

Zooplankton

Zooplankton samples were collected each month in the Warland and Rexford areas using a small Wisconsin net (12 cm mouth diameter). February and March samples were taken in mid-afternoon. All other samples were taken one to three hours after sunset.

Vertical tows of 2 m, 5 m, 10 m and 20 m and a horizontal surface tow were made in a limnetic and a near-shore area at each sampling site. Samples were preserved immediately in a mixture of methyl alcohol, formalin and acetic acid.

A subsampling technique was employed in analyzing zooplankton samples. Each sample was diluted to a point where five 1 ml subsamples contained 200-400 total organisms. Contents of the five 1 ml subsamples were counted. Subtotals were multiplied by the dilution factor to give sample totals. Sample totals were divided by the volume of water sampled. Densities of zooplankton were expressed in numbers per liter.

Zooplankters were classified to suborder (Calanoida, Cyclopoida) or genus (*Daphnia*, *Leptodora*, *Bosmina*). All juvenile copepods were identified as nauplii.

Benthos

Benthos samples were taken with either an Eckman dredge (February-April) or a Petersen dredge (May-December). Four depths in the Warland and Rexford areas were sampled each month, except when wind conditions made sampling impossible. Samples were strained through a standard sieve series consisting of the following meshes: 25.4 mm, 3.36 mm and .841 mm. Samples were picked and preserved in the field. Sorting and counting were done in the laboratory.

Food Habits

Rainbow and cutthroat trout stomachs were collected monthly in the Warland and Rexford areas during the period March-December, 1977. The Warland and Big Creek areas were sampled in February, 1977. The Rexford area of the reservoir was ice-covered in February. Additional samples were collected in the Big Creek area in May, August and November, 1977 and in the Rexford area and Hungry Horse Reservoir in July and August, 1978 (Tables 2-5).

Table 2. Fish collected, mean lengths, mean weights, number and percentage of empty stomachs taken from rainbow trout longer than 330 mm total length collected from Lake Koocanusa.

		Fish collected	Empty stomachs		Size of fish	
			number	percentage	length (mm)	weight (g)
1977						
March						
	Warland	41	7	17.1	422	733
	Rexford	19	1	5.3	400	675
April						
	Warland	35	3	8.6	410	734
	Rexford	13	3	23.1	396	616
May						
	Warland	34	1	2.9	379	575
	Big Creek	19	3	15.8	401	617
	Rexford	21	1	4.8	382	565
June						
	Warland	32	2	6.3	404	675
	Rexford	20	2	10.0	393	608
July						
	Warland	37	13	35.1	399	651
	Rexford	29	4	13.8	388	606
August						
	Warland	19	4	21.1	388	644
	Big Creek	5	1	20.0	384	579
	Rexford	4	0	0	387	551
September						
	Warland	17	1	5.9	400	720
	Rexford	13	1	7.7	384	604
October						
	Warland	21	3	14.3	390	625
	Rexford	9	0	0	392	624
November						
	Warland	23	3	13.0	392	640
	Big Creek	14	2	14.3	405	669
	Rexford	20	1	5.0	411	723

Table 2. Continued.

	Fish collected	Empty stomachs number	Empty stomachs percentage	Size of fish length (mm)	Size of fish weight (g)
December					
Warland	15	3	20.0	422	820
Rexford	14	1	7.1	405	683
1978					
July					
Rexford	33	1	3.0	381	573
August					
Rexford	22	1	4.5	368	509

Table 3. Fish collected, mean lengths, mean weights, number and percentage of empty stomachs taken from rainbow trout 330 mm or less in total length collected from Lake Koocanusa.

	Fish collected	Empty stomachs		Size of fish	
		number	percentage	length (mm)	weight (g)
1977					
March					
Warland	21	0	0	304	295
Rexford	26	2	7.7	298	290
April					
Warland	12	1	8.3	301	309
Rexford	34	4	17.4	278	221
May					
Warland	16	0	0	314	336
Big Creek	4	2	50.0	310	275
9 Rexford	17	0	0	296	283
June					
Warland	10	2	20.0	302	290
Rexford	14	3	21.4	284	263
July					
Warland	12	1	8.3	266	212
Rexford	11	1	9.1	251	204
August					
Warland	12	2	16.7	246	175
Big Creek	1	0	0		
Rexford	1	0	0		
September					
Warland	23	4	8.7	270	237
Rexford	29	0	0	271	239
October					
Warland	16	1	6.3	277	243
Rexford	34	2	5.9	267	229
November					
Warland	19	2	10.5	296	295
Big Creek	5	0	0	292	263
Rexford	20	1	5.0	288	269

Table 3. Continued.

	Fish collected	Empty stomachs number	Empty stomachs percentage	Size of fish length (mm)	Size of fish weight (g)
December					
Warland	17	0	0	308	299
Rexford	13	1	7.7	282	240
1978					
July					
Rexford	3	0	0	307	300
August					
Rexford	18	4	22.2	248	174

Table 4. Fish collected, mean lengths, mean weights, number and percentage of empty stomachs taken from cutthroat trout longer than 330 mm collected in Lake Koocanusa and Hungry Horse Reservoir.

	Fish collected	Empty stomachs		Size of fish	
		number	percentage	length (mm)	weight (g)
1977					
March					
Warland	10	1	10	395	673
Rexford	21	2	9.5	392	611
April					
Warland	30	4	13.3	416	764
Rexford	21	9	42.9	407	704
May					
Warland	39	4	10.3	394	665
Big Creek	21	4	19.0	401	686
Rexford	21	11	52.4	389	647
June					
Warland	13	0	0	371	516
Rexford	4	0	0	345	448
July					
Warland	12	0	0	361	466
Rexford	3	0	0	363	542
August					
Warland	21	9	42.9	355	477
Big Creek	1	0	0		
Rexford	1	0	0		
September					
Warland	8	0	0	361	500
Rexford	9	0	0	361	528
October					
Warland	10	0	0	369	566
Rexford	8	0	0	375	566
November					
Warland	12	4	33.3	380	570
Big Creek	8	1	12.5	370	536
Rexford	8	1	12.5	391	629

Table 4. Continued.

	Fish collected	Empty stomachs number	Empty stomachs percentage	Size of fish length (mm)	Size of fish weight (g)
December					
Warland	5	0	0	367	493
Rexford	10	0	0	375	555
1978					
July					
Rexford	6	1	16.7	357	457
Hungry Horse	2	0	0	382	443
August					
Rexford	17	12	70.6	361	466
Hungry Horse	3	0	0	367	470

Table 5. Fish collected, mean lengths, mean weights, number and percentage of empty stomachs taken from cutthroat trout less than 330 mm collected from Lake Koocanusa and Hungry Horse Reservoir.

	Fish collected	Empty stomachs		Size of fish	
		number	percentage	length (mm)	weight (g)
1977					
March					
Warland	11	0	0	291	249
Rexford	25	1	4.0	291	264
April					
Warland	15	1	6.7	287	242
Rexford	23	4	17.4	278	221
May					
Warland	12	0	0	307	310
Big Creek	4	0	0	284	270
Rexford	35	0	0	304	313
June					
Warland	14	2	14.3	306	316
Rexford	7	0	0	304	313
July					
Warland	13	2	15.4	306	322
Rexford	6	0	0	234	183
August					
Warland	20	2	10.0	256	199
Big Creek	0	0	0	0	0
Rexford	0	0	0	0	0
September					
Warland	3	0	0	295	312
Rexford	17	0	0	271	236
October					
Warland	18	0	0	294	286
Rexford	18	0	0	279	257
November					
Warland	19	2	10.5	292	276
Big Creek	8	3	37.5	286	254
Rexford	14	1	7.1	288	262

Table 5. Continued.

	Fish collected	Empty stomachs		Size of fish	
		number	percentage	length (mm)	weight (g)
December					
Warland	9	0	0	291	242
Rexford	17	0	0	300	283
1978					
July					
Rexford	9	0	0	257	203
Hungry Horse	8	0	0	276	239
August					
Rexford	17	4	23.5	244	167
Hungry Horse	11	0	0	257	191

Because the time required for 50 percent gastric evacuation of oligochaetes by rainbow trout dropped from 11.3 hr at 10 C (50 F) to 7.1 hr at 15 C (59 F) (Windell et al. 1976), all floating nets and the gang set were marked with battery-powered beacons and lifted once during the night during the warmer months of the year (May-September). All trout were removed and immediately killed. An identification number was placed in the mouth of each trout. All trout were placed on ice to slow the digestive process. During the cooler months, all nets were set at dusk and fish removed in the morning.

The following morning each stomach was placed on cheese cloth along with its identification number and rolled in the cheese cloth forming a "sausage". The sausages were tied at the ends and between stomachs and then preserved. Data collected on each fish at the time of stomach removal included species, length, weight, time of capture, sex and state of maturity.

After a sampling trip, each stomach was cut open and its contents placed in a plastic vial with the identification number and preservative. Contents of each stomach were analyzed numerically and volumetrically. Stomach contents were then pooled by species and size class before calculating frequency of occurrence.

Each analytical technique contains an inherent bias (Windell 1971, Lagler 1956). Numerical analysis is biased in favor of small food items. Volumetric analysis favors the large food items. Frequency of occurrence analysis yields no information concerning the number or bulk of food items.

Some investigators have combined analytical techniques in an effort to eliminate bias. Tester (1932) combined volume and frequency of occurrence graphically in his study of the food of smallmouth bass (<u>Micropterus dolomieu</u>). Others have used the geometric mean of volume or weight and frequency of occurrence (Bogorov 1934) or numbers and frequency of occurrence (Pirozhnikov 1955) resulting in an index of significance.

More frequently, food habits are analyzed by one analytical technique (Alexander 1975a, 1975b; Alexander and Gowing 1976; Armstrong 1971; Echo 1954; Jeppson and Platts 1958; Lackey 1969) or by more than one technique without any effort to combine the results (Barrows 1953; Bjornn 1957; Brynildson and Kempinger 1973; Hess 1974; Wales 1946; Wescoatt and Moore 1953, 1954).

I chose to combine the numeric, volumetric and frequency of occurrence analyses to form an index of relative importance (IRI). The IRI is calculated as the arithmetic mean of the number, volume and frequency of occurrence of a food item, all expressed as percentages. The IRI ranges from 0 to 100, where a value of 100 indicates exclusive use of a food item. Numbers, volumes and frequency of occurrence are also reported for comparison.

Volume was measured by displacement. Volumes less than .05 ml were arbitrarily assigned a volume of .01 ml. Stomachs containing all or nearly all zooplankton were subsampled to estimate the number of organisms present. The total stomach contents were counted when little or no zooplankton was present. The number of empty stomachs was noted for each sample but only stomachs containing food were considered in calculating frequency of occurrence.

Energy Analysis

The relative energy contribution of each food item in the diets of small and large rainbow and cutthroat trout was estimated for the period March 24 to December 15, 1977. By constructing monthly length frequencies, it was possible to monitor growth of a year class throughout the year (Table 6). Fish classified as small rainbow trout consisted primarily of the 1975 year class, with some overlap of adjacent year classes. Large rainbow trout consisted of all rainbow longer than the upper limit of the length range of small rainbow trout during any time period. Small and large cutthroat trout were classified in the same manner. More overlap of year classes occurred in small cutthroat versus rainbow because the cutthroat spent one to three years in tributaries versus mainly one year for rainbow trout.

Growth was determined from length frequencies constructed for each month's sample. Mean weights were plotted and a growth curve fitted visually. Average monthly growth, in grams, was determined from the growth curve.

Percentage composition of energy intake during a specified interval was estimated in the following manner:

1. Convert weight gain to dry weight gain using a conversion of 0.2122 (Cheng 1975).

2. Convert dry weight to calories using a conversion of 4,877 calories per gram (Cheng 1975).

3. Estimate calories ingested using a food conversion of 3.0 (G.W. Klontz, personal communication).

4. Determine percentage composition by volume (or weight) of each food item in the stomach samples.

5. Convert percentage volume (weight) to calories using conversions for relative digestive rates and caloric values (Table 7).

Table 6. Mean lengths and weights of small rainbow and cutthroat trout in Lake Koocanusa, 1977.

Date	Rainbow Trout				Cutthroat Trout			
	N	Mean length (mm)	Range	Mean weight (g)	N	Mean length (mm)	Range	Mean weight (g)
2/16	30	320	280-355	333	11	296	254-329	263
3/24	61	318	280-355	341	52	300	254-329	284
4/20	46	318	280-355	342	51	287	254-329	244
5/26	90	343	305-381	427	52	305	280-329	315
6/30	57	349	305-381	441	26	327	305-355	378
7/27	48	369	330-406	506	21	329	305-355	377
8/18	37	364	330-406	484	35	344	305-381	433
9/28	21	382	356-406	563	15	356	330-381	508
10/19	41	392	356-431	615	20	360	330-381	512
11/9	34	395	356-431	616	24	373	330-406	544
12/15	18	402	356-431	639	15	366	330-406	507

6. Sum the caloric values and determine percentage composition of energy intake.

7. Multiply total calories ingested (step 3) by percentage energy intake (step 6) for each food item to estimate the calories supplied by each food item in the diet.

Table 7. Relative digestive rates (Alexander and Gowing 1976) and caloric values (Cummins and Wuycheck 1971) of food items in the diets of rainbow and cutthroat trout in Lake Koocanusa. The relative digestive rate of fish flesh is arbitrarily set at 1.00. Caloric values (calories) are for 1 g wet weight.

Food item	Relative digestive rate	Caloric value
Daphnia	1.32	314
Leptodora	1.32	400
Calanoid copepods	1.32	550
Aquatic Diptera	0.86	656
Plecoptera	0.60	1000
Tricoptera	0.33	1000
Fish	1.00	1493
Terrestrial insects	0.15	2008
Oligochaeta	1.68	782

Female Gonad Maturation

A portion of the egg skein was taken from several rainbow and cutthroat trout each month. The eggs were wrapped in cheese cloth with the stomach of the fish from which they were taken and preserved. After a sampling trip, the diameters of a sample of 10 eggs from each fish were measured with calipers and an engineer's ruler. Diameters were measured to the nearest 0.2 mm (1/120 in.). In spring we measured diameters of eggs from green or ripe fish. In summer and fall we selected fish in the size range that would likely be spawning the following spring.

Physical Limnology

A profile of water temperatures was taken at each sampling station each month using a battery-powered resistance thermometer. Secchi disc readings were taken at the same time.

RESULTS

Fish Distribution

Distinct differences in the vertical distribution of rainbow and cutthroat trout were evident between seasons. Both species tended to occupy the uppermost portion of the water column when surface temperatures did not exceed 17-18 C (62.6-64.4 F). When surface temperatures were below 17 C, 52.6 percent of the rainbow and 77.0 percent of the cutthroat trout caught in the vertical nets from 1975 to 1978, were captured within 3 m (10 ft.) of the surface (Figure 4), and 76.3 percent of the rainbow trout and 89.2 percent of the cutthroat trout were captured within 6.1 m (20 ft.) of the surface.

During seasons with warmer surface temperatures, both species were caught most frequently at depths where cooler temperatures prevailed. Periods of thermal stratification were usually brief in Lake Koocanusa, but when stratification occurred, rainbow and cutthroat trout were concentrated in the region of the metalimnion (Figure 5).

An avoidance of temperatures exceeding 19 C (66.2 F) was displayed by rainbow trout (Figure 4). Only 4.8 percent of all rainbow trout were caught at depths where temperatures exceeded 19 C. A clear cut temperature preference was not evident but 46.5 percent of the rainbow trout captured when surface temperatures exceeded 17 C were captured at depths where temperatures ranged from 17.0-18.9 C (62.6-66.0 F), and 72.6 percent were caught at depths where

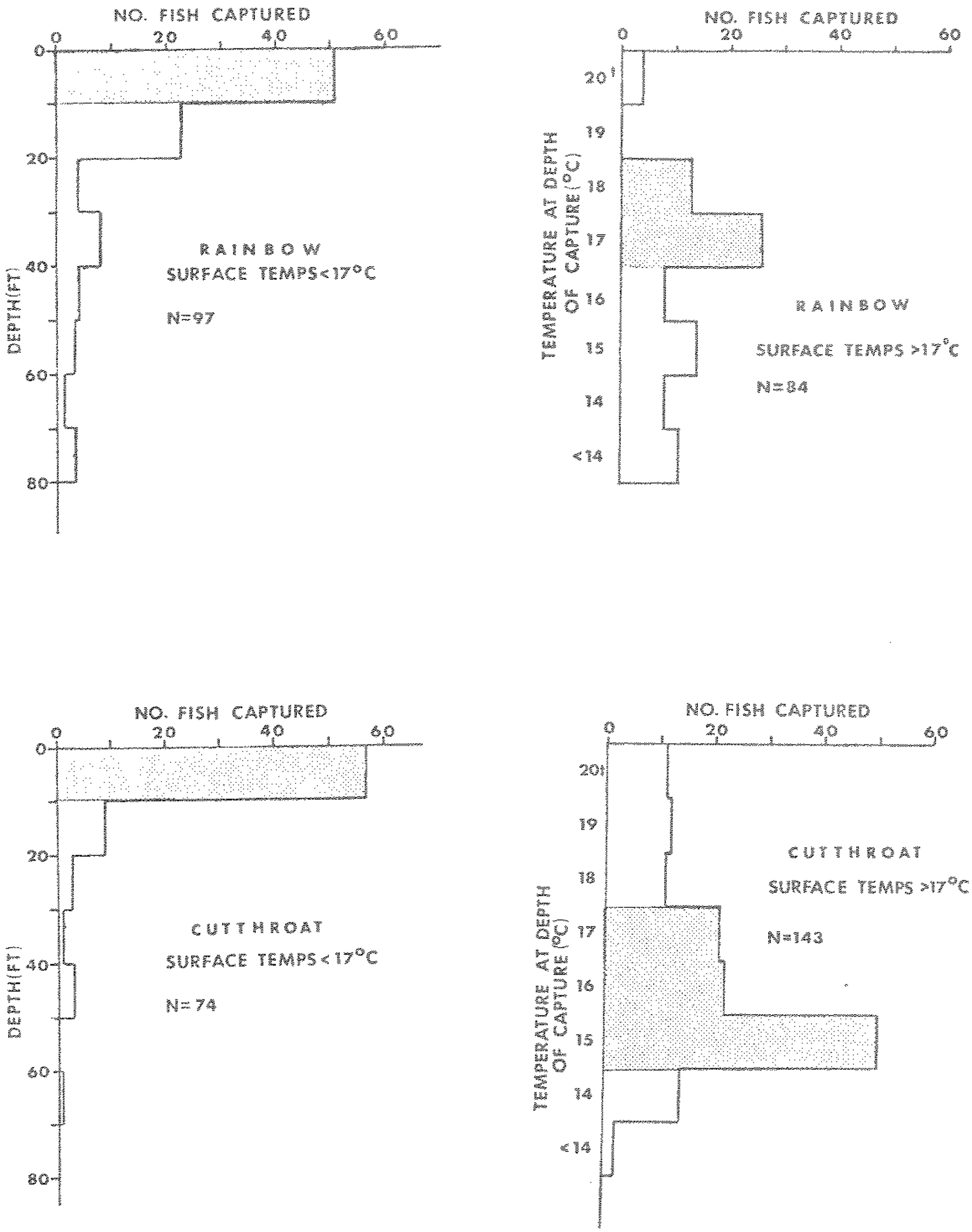


Figure 4. Vertical distribution of rainbow and cutthroat trout captured in vertical gill nets in limnetic areas of Lake Koocanusa, 1975-78.

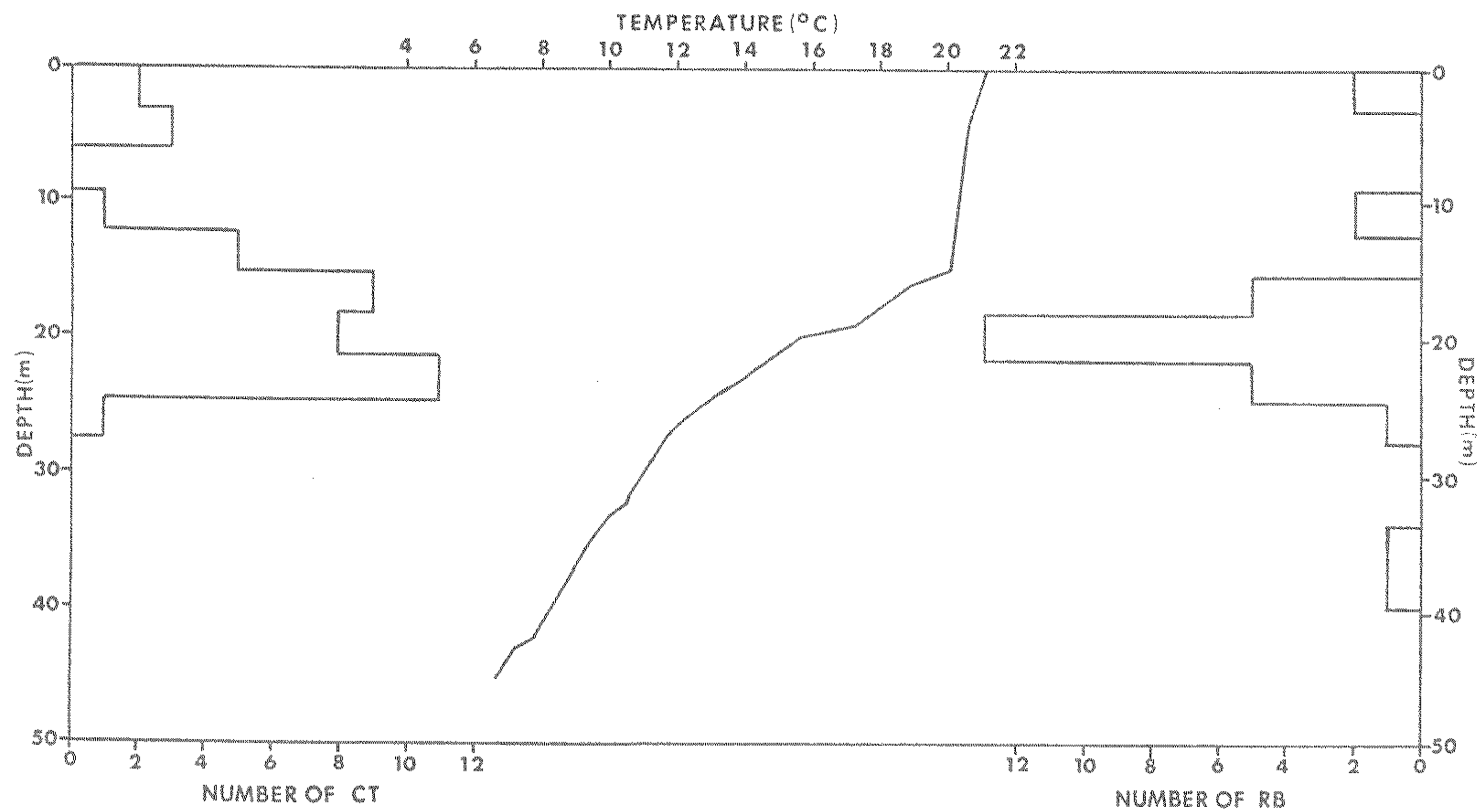


Figure 5. Temperature profile and vertical distributions of rainbow and cutthroat trout captured in vertical gill nets in the forebay area of Lake Koocanusa, August, 1977.

temperatures ranged from 15.0-18.9 C (59.0-66.0 F). Only 22.6 percent of the rainbow trout were caught at depths where temperatures were less than 15 C.

Cutthroat trout appeared to frequent water of higher temperatures than rainbow trout. Sixteen percent of the cutthroat caught when surface temperatures exceeded 17 C were caught at depths where temperatures exceeded 19 C (Figure 4). From catches of cutthroat trout, however, I suspect they prefer temperatures less than 18 C, similar to rainbow. Sixty-five percent of all cutthroat were caught at depths where temperatures ranged from 15 to 17.9 C (59.0-64.2 F). Only 11.2 percent of all cutthroat were caught at depths where temperatures were less than 15 C.

Other aspects of the distributions of rainbow and cutthroat trout were evaluated on a seasonal basis during 1977. Seasons were delineated on the basis of water temperature rather than month to minimize differences in annual weather patterns. The criteria delineating the seasons were as follows:

Winter - reservoir homothermous, temperature less than 7.5 C (45.5 F)

Spring - surface temperature 7.6-17 C (45.7-62.6 F), surface temperature rising

Summer - surface temperature above 17 C

Fall - surface temperature 7.6-17 C, surface temperature falling.

Catches in floating and sinking experimental gill nets indicated cutthroat preferred surface waters to bottom waters in shoreline areas. Rainbow were more evenly distributed. Significantly more cutthroat were caught in floating nets than sinking nets in both the Warland and Rexford areas at all times of the year (Table 8). Significantly more rainbow were caught in floating nets than sinking nets in the spring at Warland and in sinking nets in the fall at Rexford. All other comparisons between floating and sinking net catches of rainbow were nonsignificant.

Table 8. Wilcoxon rank sum test comparisons of rainbow and cutthroat trout catches in floating and sinking nets in Lake Koocanusa, 1977. Asterisk indicates a significant difference at the 5% level between catches in floating versus sinking nets.

Species	Area	Season	Number of floaters	Mean catch/set	Number of sinkers	Mean catch/set	p-value
Rainbow trout	Warland	Winter	16	4.6	22	8.3	.0559
Rainbow trout	Rexford	Winter	6	15.2	7	20.0	.3336
Rainbow trout	Warland	Spring	6	13.8	7	7.4	.0158*
Rainbow trout	Rexford	Spring	5	10.8	3	6.0	.1841
Rainbow trout	Warland	Summer	6	6.3	4	5.5	.3336
Rainbow trout	Rexford	Summer	9	7.7	1	0.0	--
Rainbow trout	Warland	Fall	9	9.1	6	15.7	.0548
Rainbow trout	Rexford	Fall	3	14.3	3	23.3	.0500*
Cutthroat trout	Warland	Winter	16	2.7	22	1.8	.0207*
Cutthroat trout	Rexford	Winter	6	28.2	7	12.3	.0256*
Cutthroat trout	Warland	Spring	6	9.7	7	0.3	.0010*
Cutthroat trout	Rexford	Spring	5	13.0	3	2.0	.0119*
Cutthroat trout	Warland	Summer	6	4.3	4	0.0	.0040*
Cutthroat trout	Rexford	Summer	9	1.4	1	0.0	--
Cutthroat trout	Warland	Fall	9	6.6	6	1.3	.0087*
Cutthroat trout	Rexford	Fall	3	8.7	3	1.3	.0228*

In the Warland area, more rainbow than cutthroat were caught close to shore in the gang set of experimental floaters. The fall, 1975 catch of cutthroat trout was evenly distributed in the four nets closest to shore (up to 150 m from shore), but one-third more fish were taken in the outermost two nets (Table 9). The catch of rainbow trout decreased in the outer nets. In subsequent samples, no consistent pattern in the distribution of either species was evident.

The distribution of fish caught in gang nets in the Rexford area in spring, 1977 was different from that in the Warland area in that more rainbow trout were caught in the outer nets than the inshore nets (Table 10). Cutthroat trout were more evenly dispersed.

Cutthroat trout were significantly more abundant in the Rexford area than at Warland in winter and more abundant in the Warland area than at Rexford in summer, based on experimental gill net catches (Table 11). Although more rainbow trout were caught in the Rexford area than at Warland in spring and fall, none of the comparisons was significant at the 5% level.

Zooplankton

Zooplankton populations in Lake Koocanusa had a spring peak in abundance in 1977. Peak population densities occurred in May and early June with substantially reduced densities the rest of the year (Figure 6).

Immature copepods were the most abundant zooplankters during the spring peak. Densities of 13.7 and 32.1 per liter in May were found in the Warland and Rexford areas, respectively. Peak densities of *Daphnia* occurred in May at Warland with 5.9 per liter and June at Rexford with 13.3 per liter in 20 m vertical tows. Cyclopoid copepods peaked at 4.6 and 20.8 per liter in May at Warland and Rexford, respectively. Calanoid copepods were found at relatively constant densities of less than 3.0 per liter. *Bosmina* and

Table 9. The seasonal catch of rainbow and cutthroat trout in the gang set of experimental floating nets, Warland area of Lake Koocanusa, 1975-1978.

		Distance from shore					
		0-76 m		76-152 m		152-228 m	
Season	Year	RB	CT	RB	CT	RB	CT
Fall	1975	30	46	20	49	11	67
	1976	15	12	8	25	5	15
	1977	25	10	22	7	16	8
Winter	1977	44	25	15	12	16	9
Spring	1976	10	21	7	11	10	8
	1977	22	18	17	14	17	10
	1978	23	4	15	8	14	7
Summer	1976	3	3	3	0	1	1
	1977	9	4	5	6	7	1

Table 10. The seasonal catch of rainbow and cutthroat trout in the gang set of experimental floating nets, Rexford area of Lake Koocanusa, 1977-78.

		Distance from shore					
		0-76 m		76-152 m		152-228 m	
Season	Year	RB	CT	RB	CT	RB	CT
Fall	1977	32	22	41	17	31	24
Winter							
Spring	1977	10	27	16	25	24	32
	1978	9	3	6	3	9	2
Summer	1977	13	5	8	2	3	1
	1978	10	4	11	5	7	1

Table 11. Wilcoxon rank sum test comparisons of rainbow and cutthroat trout catches in the Warland and Rexford areas of Lake Koocanusa, 1977-78. Asterisk indicates a significant difference at the 5% level between catches in the Warland area versus Rexford area.

Species	Season	Type of set	Sets at Warland	Mean catch/set	Sets at Rexford	Mean catch/set	p-value
Rainbow trout	Winter	Sinker	22	8.3	7	20.0	.0838
Rainbow trout	Winter	Floater	16	4.6	9	15.2	.0735
Rainbow trout	Spring	Sinker	7	7.4	3	6.0	.2843
Rainbow trout	Spring	Floater	6	13.8	5	10.8	.2061
Rainbow trout	Summer	Sinker	4	5.5	1	0.0	--
Rainbow trout	Summer	Floater	6	6.3	9	7.7	.2546
Rainbow trout	Fall	Sinker	6	15.7	3	23.3	.0968
Rainbow trout	Fall	Floater	9	9.1	3	15.7	.0934
Cutthroat trout	Winter	Sinker	22	1.8	7	12.3	.0032*
Cutthroat trout	Winter	Floater	16	2.7	9	19.7	.0017*
Cutthroat trout	Spring	Sinker	7	0.3	3	2.0	.2090
Cutthroat trout	Spring	Floater	6	9.7	5	13.0	.2912
Cutthroat trout	Summer	Sinker	4	0.0	1	0.0	--
Cutthroat trout	Summer	Floater	6	4.3	9	1.4	.0351*
Cutthroat trout	Fall	Sinker	6	1.3	3	1.3	.4443
Cutthroat trout	Fall	Floater	9	6.6	3	8.7	.3192

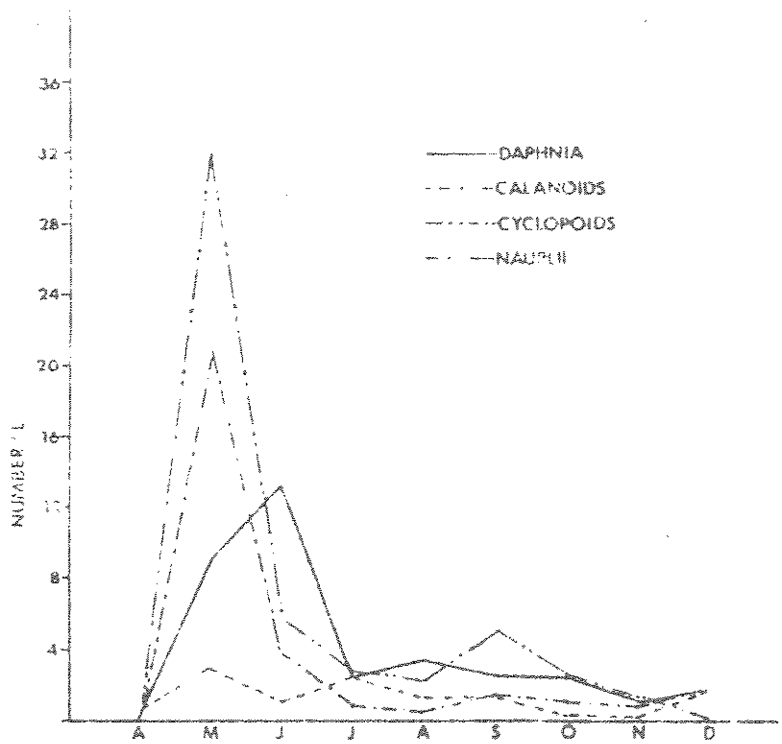


Figure 6. Monthly zooplankton densities in 20 meter vertical tows in the Rexford area of Lake Koocanusa, 1977.

Leptodora were the only other zooplankters in our samples.

Current research by Mike Falter and John Irving, from the University of Idaho, will result in a more complete picture of the population dynamics of zooplankton in Lake Koocanusa. They used the more efficient Miller high-speed sampler in their collections and found more calanoid copepods in their samples. Densities of other organisms were similar to what I found.

Benthos

Benthic organisms were not abundant in samples collected above the maximum drawdown depth (Figures 7 and 8). An average of 13.5 oligochaetes and 15.3 Diptera larvae per square meter were found in samples from substrate above the maximum drawdown level in the Warland area. Below the maximum drawdown depth, an average of 57.4 oligochaetes and 34.5 Diptera larvae were found per square meter. In the Rexford area, an average of 4.4 oligochaetes and 29.8 Diptera larvae were found per square meter above the maximum drawdown level. An average of 5,726.6 oligochaetes and 14.4 Diptera larvae per square meter were found in substrate below the maximum drawdown depth.

Two samples taken from the old river channel in the Rexford area contained large numbers of oligochaetes. The old river channel in the Warland area was never sampled because the water was too deep.

Food Habits

The zooplankter, *Daphnia schodleri*, was the most important food item in the diets of both rainbow and cutthroat trout. *Daphnia* comprised nearly the entire diet of both species during winter. Terrestrial insects, aquatic insects and fish contributed substantially to the diets the remainder of the year.

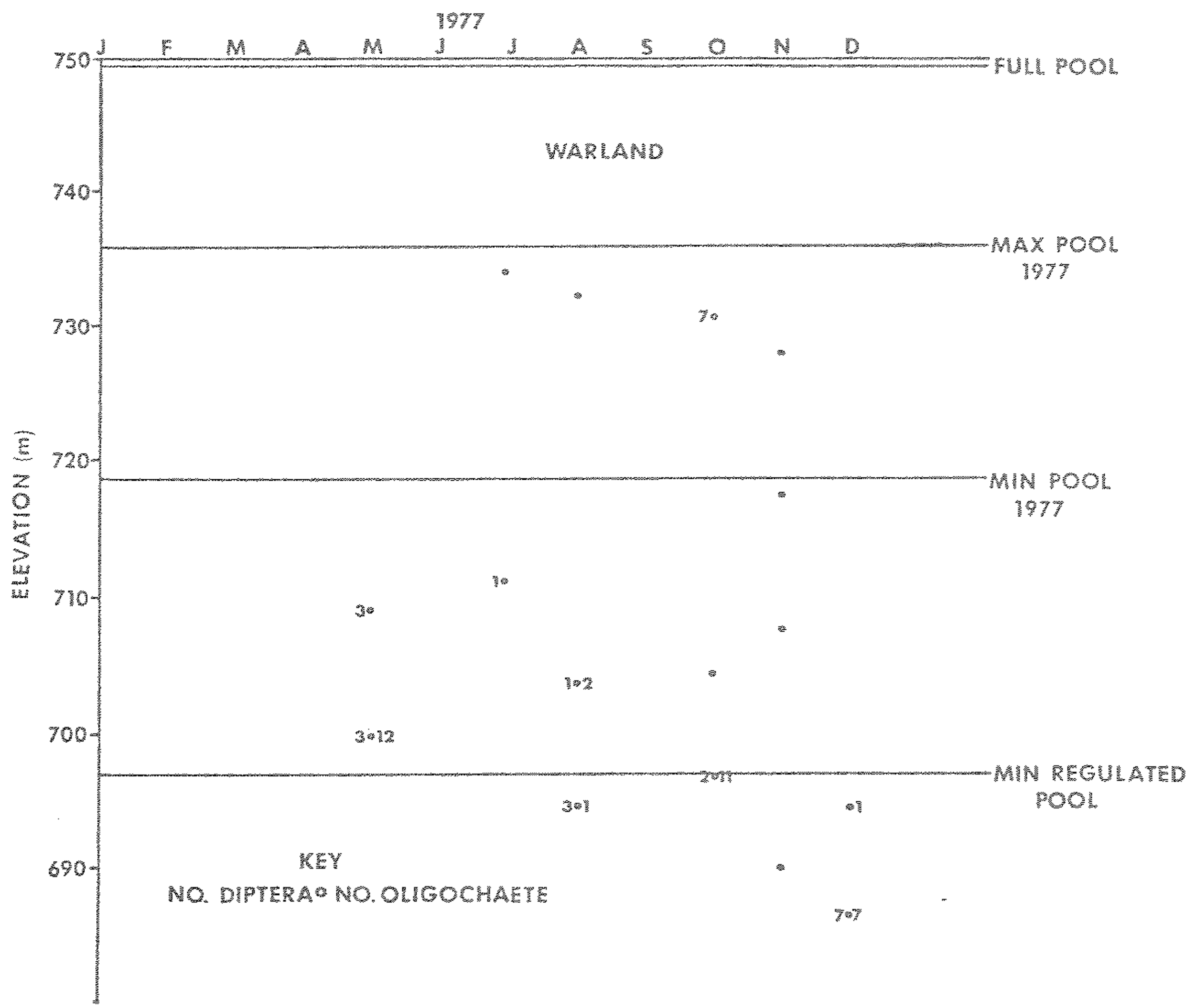


Figure 7. Benthic organisms per sample in the Warland area of Lake Koocanusa, 1977. A dot without numbers on either the right or left indicates a sample without Dipterans or Oligochaetes present.

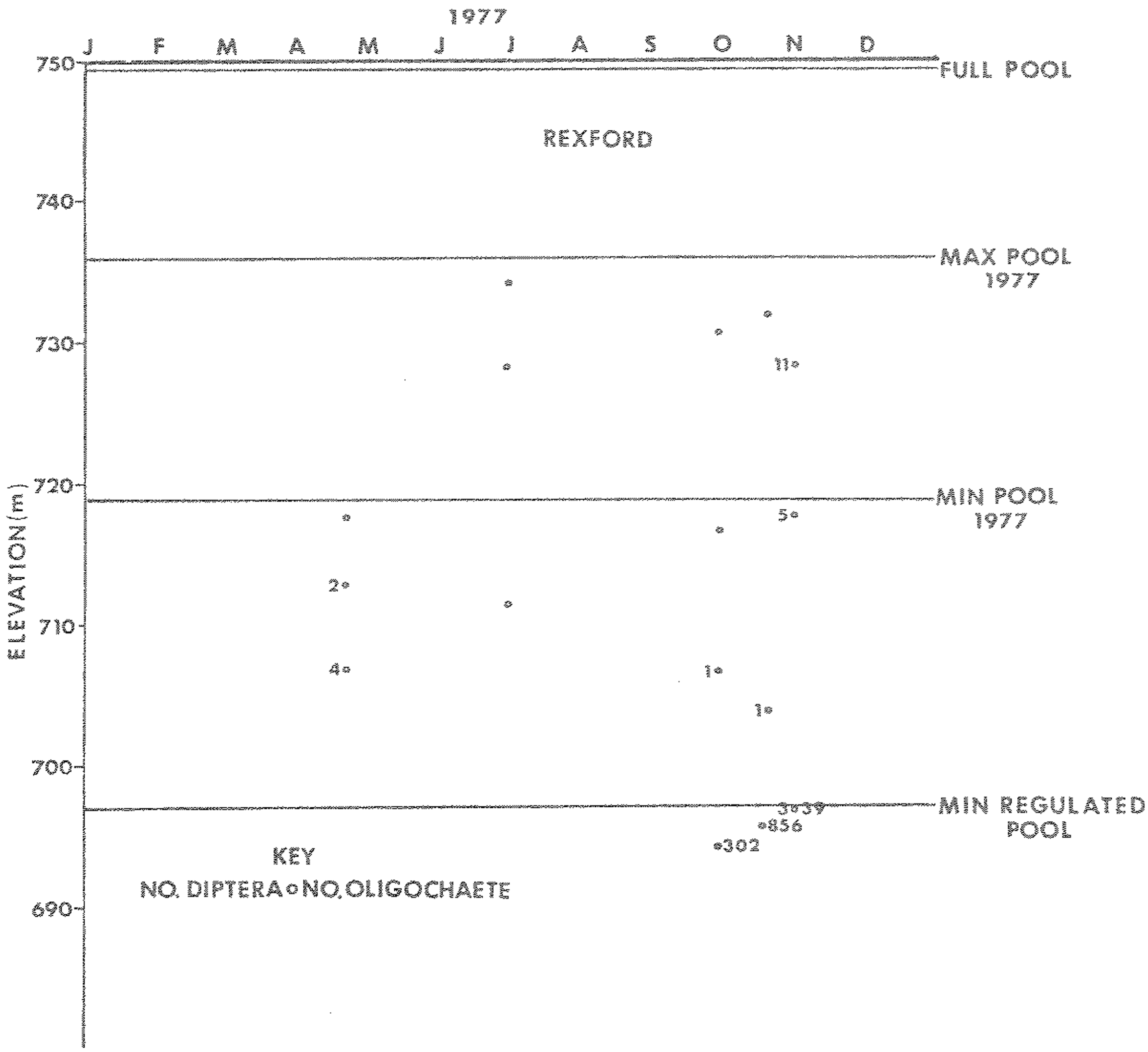


Figure 8. Benthic organisms per sample in the Rexford area of Lake Koocanusa, 1977. A dot without numbers on either the right or left indicates a sample without Dipterans or Oligochaetes present.

Rainbow Trout Longer Than 330 mm

The most important food items in the diet of large rainbow trout were *Daphnia*, fish, terrestrial insects and aquatic insects. Index of relative importance values (IRI) in 1977 were 66.1, 24,5, 15.6 and 10.8, respectively for the above mentioned items (Figure 9). Other food items included *Leptodora kindtii*, calanoid copepods and oligochaetes. Debris, including wood and stones, accounted for 5.3 percent of the total volume of large rainbow trout stomach contents in 1977.

The IRI for *Daphnia* was always higher than that of any other food item in the diet of large rainbows, with the exception of the June and July samples at Warland, when the IRI for fish was equal to that of *Daphnia* (Figure 9). *Daphnia* accounted for 97.8 percent of the total number and 24.0 percent of the total volume of food organisms eaten by large rainbow trout (Table 12).

Fish were taken throughout the year by rainbow trout but were most important in June and July. Nearly all of the fish found in the stomachs of large rainbows were redside shiners. One largescale sucker was identified. A few young-of-the-year fish of undetermined species were found.

The IRI for fish ranged from 0 in May and October to 52.9 in June at Warland and from 0 in April and October to 38.3 in June at Rexford (Figure 9). The IRI for fish were consistently higher at Warland than at Rexford during summer.

Terrestrial insects contributed to the diet of large rainbows throughout all but the winter months. IRI values were highest in August at Big Creek and Rexford with values of 60.7 and 57.0, respectively (Figure 9). The IRI for terrestrials were never above 25 at Warland in summer but reached 53.7 in October (Figure 9).

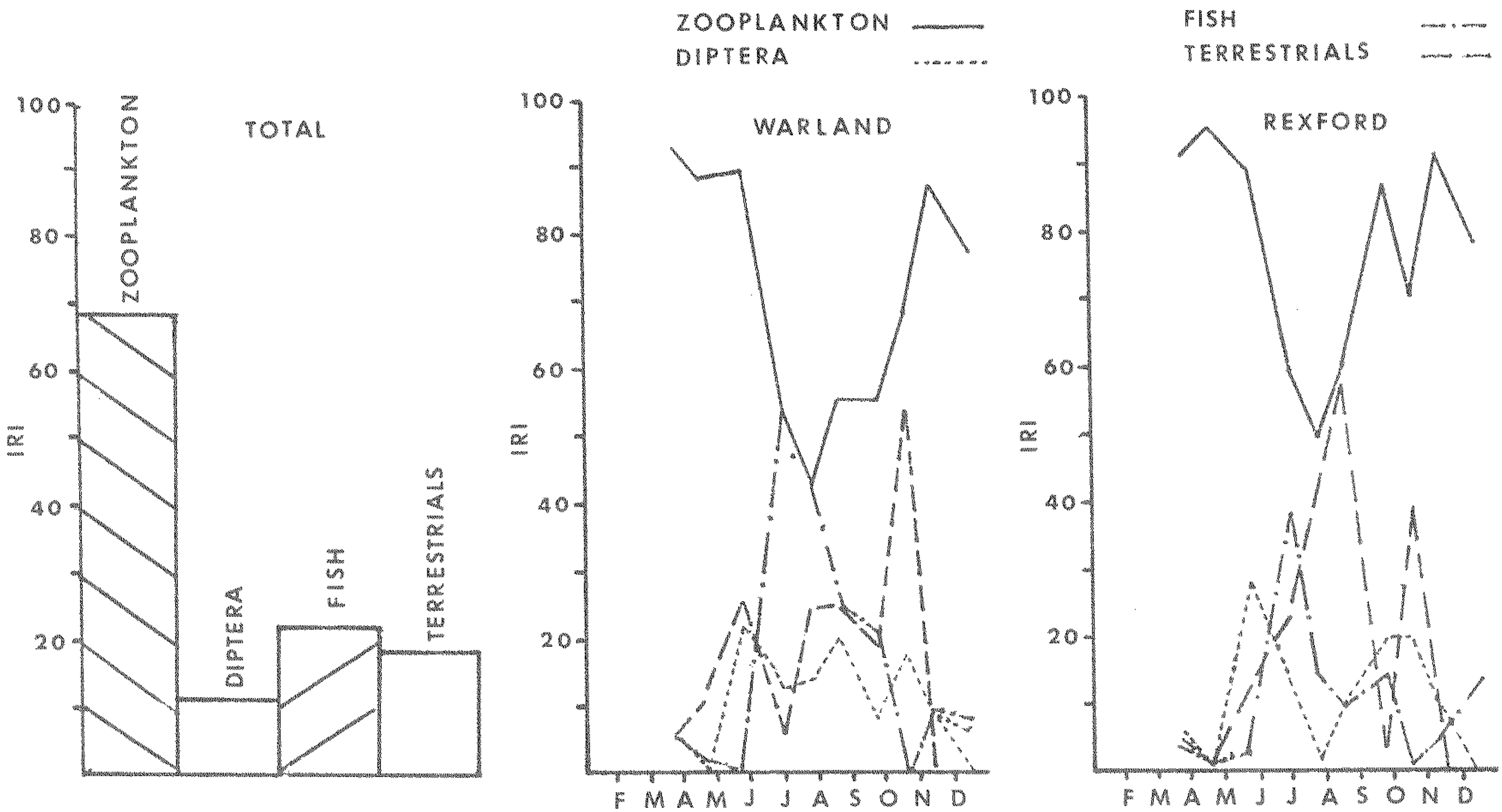


Figure 9. Total and monthly indices of relative importance (IRI) of food items in the stomachs of rainbow trout longer than 330 mm from the Warland and Rexford areas of Lake Koocanusa, March-December, 1977.

Table 12. Percentage of the number, volume and frequency of occurrence of food items in the stomachs of rainbow trout longer than 330 mm total length from Lake Koocanusa, 1977-78.

Month	Area	Zooplankton			Aquatic insects			Fish			Terrestrial insects			Debris
		No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	Vol.
1977														
March	Warland	99.94	88.74	99.18	0.01	0.02	17.65	0.01	8.74	5.88	0.04	0.07	17.65	2.26
	Rexford	99.80	91.06	83.33	0.16	0.16	11.11	0.01	3.04	11.11	0.03	0.94	16.67	3.99
April	Warland	99.89	80.02	82.90	0.02	0.02	6.25	0.01	0.72	3.13	0.10	4.71	28.13	14.50
	Rexford	100.00	87.46	100.00	--	--	--	--	--	--	--	--	--	12.54
May	Warland	99.66	73.23	93.94	0.21	0.16	63.64	--	--	--	0.14	8.72	66.67	14.51
	Big Creek	38.16	0.19	10.53	28.06	3.56	75.00	0.44	4.67	5.26	33.34	25.14	81.25	66.45
	Rexford	97.10	70.34	100.00	2.83	7.53	75.00	0.01	3.63	5.00	0.06	4.49	35.00	14.00
June	Warland	97.39	1.34	60.00	2.15	0.40	33.33	0.37	98.23	60.00	0.09	0.03	16.67	0.01
	Rexford	97.73	6.73	72.22	1.40	1.75	33.33	0.17	86.97	27.78	0.68	2.49	61.11	2.07
July	Warland	98.10	0.52	29.17	0.69	0.14	41.67	0.34	98.12	29.17	0.88	0.50	70.83	0.73
	Rexford	94.57	13.55	68.00	0.01	0.01	4.00	0.02	26.91	16.00	5.39	59.54	56.00	--
August	Warland	96.41	29.74	40.00	0.66	1.85	60.00	0.05	50.11	26.67	2.88	18.28	53.33	0.03
	Big Creek	95.94	20.59	25.00	0.06	0.27	50.00	--	--	--	4.00	78.16	100.00	0.98
	Rexford	93.66	13.39	75.00	0.23	6.70	25.00	0.08	4.46	25.00	6.04	65.03	100.00	10.42
September	Warland	99.23	14.04	52.94	0.17	5.09	23.53	0.07	49.90	11.76	0.55	2.85	56.25	28.13
	Rexford	99.88	58.32	100.00	0.11	9.69	58.33	0.01	27.51	16.67	0.01	2.33	8.33	2.14
October	Warland	96.82	29.94	77.78	0.56	2.78	50.00	--	--	--	2.64	64.12	94.44	3.17
	Rexford	97.05	23.14	88.89	0.60	2.51	55.56	--	--	--	2.35	37.23	77.78	37.09
November	Warland	99.96	67.06	95.00	0.03	0.53	20.00	0.01	17.21	10.00	--	--	--	15.20
	Big Creek	99.96	57.66	91.67	0.04	0.36	18.18	--	--	--	--	--	--	41.97
	Rexford	99.88	84.22	89.47	0.11	1.12	21.05	0.01	4.09	10.53	--	--	--	10.56
December	Warland	99.97	39.26	91.67	0.02	1.02	16.67	0.01	15.81	8.33	--	--	--	43.91
	Rexford	99.96	32.95	100.00	0.02	0.41	--	0.02	18.29	23.08	--	--	--	58.35
Means		98.87	24.56	75.60	0.51	1.07	32.13	0.02	59.35	14.01	0.60	9.76	38.65	5.26
1978														
July	Rexford	99.43	63.00	96.88	0.51	3.80	78.13	0.01	14.39	6.25	0.05	9.78	28.13	9.02
August	Rexford	99.90	80.14	100.00	0.09	0.44	23.81	0.01	18.82	14.29	--	--	--	0.60

Hymenoptera was the most important order of terrestrial insects in the diet of large rainbow. Other taxa represented in the stomachs of large rainbow, listed in decreasing order of importance, included Coleoptera, Arachnida, Hemiptera, Orthoptera, Homoptera, Lepidoptera and Neuroptera. Hymenoptera and Coleoptera were taken regularly throughout the year. Arachnids, Hemiptera and Lepidoptera were taken sporadically throughout the year. Orthoptera and Homoptera occurred mainly in stomachs taken during late summer and fall. Neuroptera was found only in stomachs taken in October.

Nearly all of the aquatic insects found in the stomachs of both rainbow and cutthroat trout were Dipterans. Diptera comprised a small but relatively constant proportion of the diet of large rainbows.

The IRI for Diptera had two peaks, one in spring made up chiefly of pupae and one in late summer or fall that included more adults. Spring peaks occurred in May with index values of 22.5 at Warland, 28.5 at Rexford (Figure 9) and 35.5 at Big Creek. The second peak occurred in August at Warland with a value of 20.8. The IRI for Diptera reached 19.6 in September and October at Rexford.

Debris was generally more prevalent in stomachs collected in winter than in those collected at other times. The amount of debris ranged from none in the stomachs of large rainbows collected in July at Warland to 66.5 percent of the total volume in the May sample from the Big Creek area.

Sixty of the 474 stomachs collected from large rainbows in 1977 were empty. The percentage of empty stomachs ranged from 0 on two occasions to 35.1 percent of the July sample at Warland.

Contents of large rainbow stomachs collected in summer, 1978 were similar to those collected in summer, 1977 (Table 12). The IRI for *Daphnia* were higher in 1978 than 1977 and terrestrial insect indices were lower in 1978. Fish and Diptera index values were about the same in both years.

Rainbow Trout Shorter Than 330 mm

Daphnia was more important and fish less important in the diet of small rainbow trout versus large rainbows (Figure 10). The most important food items in the diet of small rainbows during 1977 were Daphnia and terrestrial and aquatic insects with IRI values of 90.9, 13.7 and 12.2 respectively. Other food items included fish, calanoid copepods, Leptodora, Diplopoda and debris. Debris accounted for 2.4 percent of the total volume.

Except for small numbers of fish collected in the Big Creek area in May and August, Daphnia was the most important food item in every sample of stomachs from small rainbow trout. The IRI for Daphnia ranged from 53.6 in August to 99.4 in March at Warland and from 62.7 in July to 100 in December at Rexford (Figure 10). Daphnia made up 99.2 percent of the total number and 84.5 percent of the total volume of stomach contents in 1977 (Table 13).

Small rainbows preyed on other fish infrequently. Only 5 (1.4 percent) of the small rainbow stomachs contained fish.

Terrestrial insects were an important part of the summer diet of small rainbows but were taken in small amounts the rest of the year. The IRI for terrestrials peaked at 46.8 in August at Warland and 53.9 in July at Rexford (Figure 10). Only one small rainbow was collected in August at the Big Creek area and had fed exclusively on terrestrials.

Hymenoptera and Coleoptera were the most important orders of terrestrial insects in the diet of small rainbows. Other terrestrial taxa, listed in decreasing order of importance, were Hemiptera, Homoptera, Lepidoptera, Arachnida, Orthoptera and Neuroptera.

Aquatic Diptera were slightly more important in the diet of small rainbows than large rainbows. Peaks in the IRI for Diptera occurred in May at Rexford (35.0) and June at Warland (52.4). Indices for Diptera remained

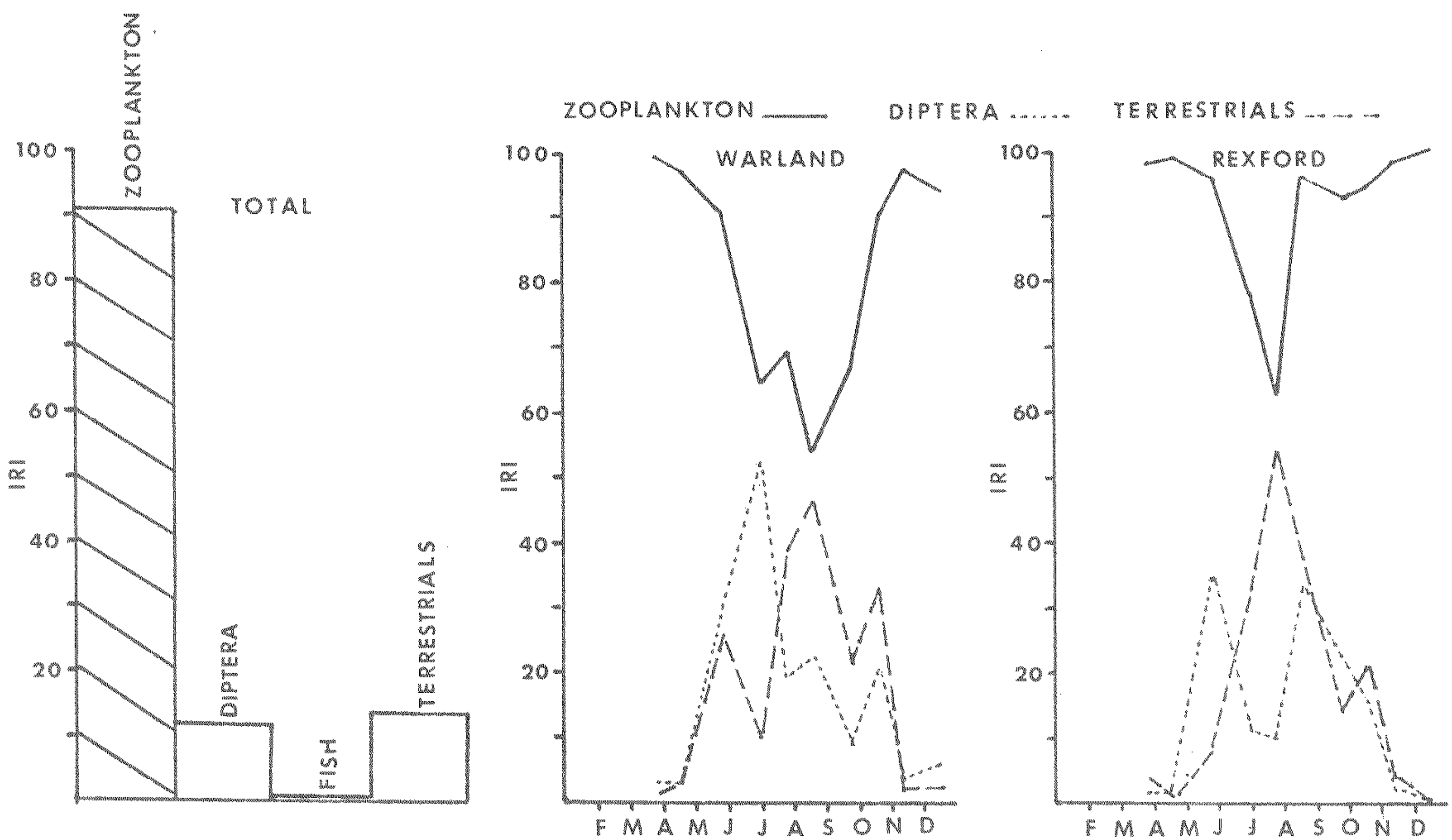


Figure 10. Total and monthly indices of relative importance (IRI) of food items in the stomachs of rainbow trout shorter than 330 mm from the Warland and Rexford areas of Lake Koocanusa, March-December, 1977.

Table 13. Percentage of the number, volume and frequency of occurence of food items in the stomachs of rainbow trout less than 330 mm total length from Lake Koocanusa. 1977-78.

Month	Area	Zooplankton No.	Zooplankton Vol.	Zooplankton Freq.	Aquatic insects No.	Aquatic insects Vol.	Aquatic insects Freq.	Fish No.	Fish Vol.	Fish Freq.	Terrestrial insects No.	Terrestrial insects Vol.	Terrestrial insects Freq.	Debris Vol.
1977														
March	Warland	99.98	98.10	100.00	0.01	0.20	9.50	--	--	--	0.01	0.10	4.76	1.70
	Rexford	99.96	94.33	100.00	0.01	0.02	4.17	0.01	0.02	4.17	0.02	0.06	12.50	5.57
April	Warland	99.98	99.51	90.90	0.01	0.12	9.09	--	--	--	0.01	0.12	9.09	0.25
	Rexford	99.98	96.92	100.00	0.01	0.06	3.30	0.01	0.06	3.30	--	--	--	2.96
May	Warland	99.45	78.42	93.75	0.33	5.29	81.25	--	--	--	0.24	10.98	68.75	5.32
	Big Creek	--	--	--	11.11	2.38	50.00	--	--	--	88.89	97.62	100.00	--
	Rexford	98.73	87.79	100.00	1.24	9.51	94.12	--	--	--	0.03	0.91	23.53	1.79
June	Warland	81.57	23.90	87.50	18.28	64.34	75.00	--	--	--	0.16	4.05	25.00	7.72
	Rexford	97.90	62.63	72.73	1.10	4.38	27.27	--	--	--	1.00	32.32	63.64	0.67
July	Warland	98.11	54.85	54.55	0.30	2.95	54.55	--	--	--	1.60	42.20	72.73	--
	Rexford	94.85	23.20	70.00	0.05	0.27	30.00	--	--	--	5.10	76.54	80.00	--
August	Warland	86.43	14.54	60.00	1.64	7.17	60.00	0.01	9.89	10.00	11.92	68.40	60.00	--
	Big Creek	--	--	--	--	--	--	--	--	--	100.00	100.00	100.00	--
	Rexford	99.12	88.40	100.00	0.88	11.60	100.00	--	--	--	--	--	--	--
September	Warland	98.24	50.38	81.25	0.60	0.90	26.32	--	--	--	1.14	20.92	42.11	27.80
	Rexford	97.65	82.85	96.55	2.28	8.55	58.62	0.01	7.03	3.45	0.05	0.98	41.38	0.15
October	Warland	99.39	85.04	86.67	0.21	2.27	60.00	--	--	--	0.40	12.20	86.67	0.49
	Rexford	99.80	93.38	90.63	0.06	1.72	43.75	0.01	0.26	3.13	0.13	3.84	53.13	0.81
November	Warland	99.98	98.76	94.12	0.01	0.07	11.76	--	--	--	0.01	0.02	5.88	1.15
	Big Creek	100.00	92.37	100.00	--	--	--	--	--	--	--	--	--	7.63
	Rexford	99.97	94.18	100.00	0.01	0.05	5.26	--	--	--	0.01	0.05	10.53	5.61
December	Warland	99.98	93.04	88.24	0.01	0.25	17.65	--	--	--	0.01	0.08	5.88	6.63
	Rexford	100.00	100.00	100.00	--	--	--	--	--	--	--	--	--	--
Means		99.22	84.59	89.09	0.51	3.35	32.74	0.01	1.35	1.47	0.26	8.32	31.86	2.39
1978														
July	Rexford	99.72	95.26	100.00	0.28	4.74	100.00	--	--	--	--	--	--	--
August	Rexford	99.66	95.99	92.86	0.31	2.39	35.71	--	--	--	0.03	0.21	14.29	1.41

near 20 through October at Warland, except for a value of 9.3 in September. The second peak in Diptera IRI in August at Rexford was based on the contents of just one stomach (Figure 10).

Debris was encountered less frequently in the stomachs of small rainbows than large rainbows. The amount of debris in small rainbow stomachs ranged from none in several samples to 27.8 percent of the September sample at Warland.

Twenty-nine of 367 (7.9 percent) stomachs collected from small rainbow trout in 1977 were empty. The percentage of empty stomachs ranged from 0 to 50 percent.

Contents of stomachs collected from small rainbows in summer, 1978 were similar to those collected in summer, 1977 (Table 13). Daphnia was slightly more important in the 1978 samples while terrestrials were less important.

Cutthroat Trout Longer Than 330 mm

Daphnia was also the most important food item in the diet of large cutthroat trout (IRI 59.5), but to a lesser extent than in the diets of small cutthroat or either size class of rainbow trout. Other important food items in the diet of large cutthroat were terrestrial insects and aquatic insects with IRI of 40.8 and 16.5, respectively (Figure 11). Other food items included fish, calanoid copepods and Diplopoda.

Daphnia was the dominant food item in the stomachs of large cutthroat collected in winter with indices of 94.1 in November at Warland and 100 in December at Rexford (Figure 11). Daphnia was least important in July at Warland (index of 9.4) and August at Rexford (index of 0). The August sample at Rexford contained only one large cutthroat. Daphnia accounted for 94.0 percent of the total number and 24.1 percent of the total volume of the

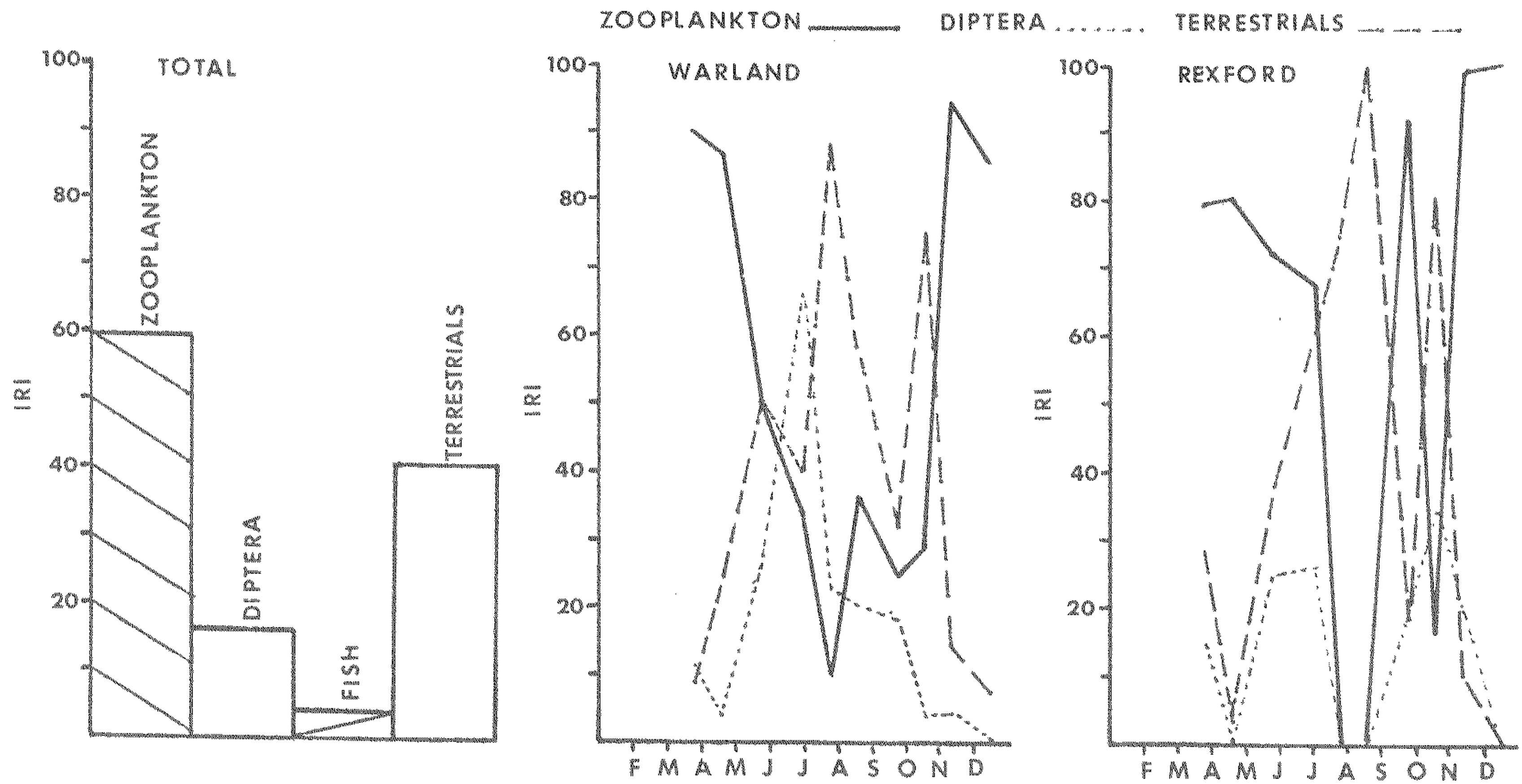


Figure 11. Total and monthly indices of relative importance (IRI) of food items in the stomachs of cutthroat trout longer than 330 mm from the Warland and Rexford areas of Lake Koocanusa, March-December, 1977.

stomach contents of large cutthroat in 1977 (Table 14).

Only 4 (1.4 percent) of the large cutthroat we collected had fish in their stomachs. The index value of 4.1 was accounted for mostly by one large redside shiner.

Terrestrial insects were the most important food item in the diet of large cutthroat in the Warland area from May through October, except for June, when aquatic Diptera were the most important food item (Figure 11). Small summer samples of cutthroat in the Rexford area made food habits determinations difficult. Hymenoptera and Coleoptera were the most important taxa of terrestrial organisms in the diet of large cutthroat, followed by Arachnida, Hemiptera, Homoptera, Lepidoptera, Orthoptera and Neuroptera.

Large cutthroat fed on aquatic Diptera more than either size class of rainbow trout, but less than small cutthroat. The IRI for Diptera peaked in May at Warland with a value of 66.5 (Figure 11). Diptera, mostly pupae, were the most important food item in the diet of large cutthroat in June at Warland then the index value dropped steadily the rest of the year.

Two peaks in the IRI for Diptera occurred at Rexford (Figure 11). The May-June peak with a value of 25.3 and 26.0, respectively, consisted mainly of pupae. The October peak, with an IRI of 35.2, consisted mainly of adults.

The incidence of debris in the stomachs of large cutthroat varied from sample to sample. No debris was present in several samples while debris accounted for 91.2 percent of the total volume in the September sample at Warland.

Fifty (16.9 percent) of the stomachs collected from large cutthroat in 1977 were empty. The percentage of empty stomachs ranged from none in many samples to 52.4 percent of the May sample at Rexford.

Table 14. Percentage of the number, volume and frequency of occurrence of food items in the stomachs of cutthroat trout longer than 330 mm total length from Lake Koocanusa. 1977-78.

Month	Area	Zooplankton No.	Zooplankton Vol.	Zooplankton Freq.	Aquatic insects No.	Aquatic insects Vol.	Aquatic insects Freq.	Fish No.	Fish Vol.	Fish Freq.	Terrestrial insects No.	Terrestrial insects Vol.	Terrestrial insects Freq.	Debris Vol.
1977														
March	Warland	99.65	82.37	88.89	0.13	0.74	33.33	0.01	5.57	11.11	0.21	2.65	22.22	8.66
	Rexford	96.57	48.06	94.74	1.01	2.44	42.11	--	--	--	2.42	20.88	63.16	28.64
April	Warland	99.39	65.53	96.20	0.05	0.18	15.38	--	--	--	0.57	14.97	53.85	18.93
	Rexford	99.86	65.22	75.00	--	--	--	--	--	--	0.14	0.66	16.67	34.11
May	Warland	93.68	22.87	31.43	2.25	6.25	68.57	--	--	--	4.06	63.44	82.86	7.44
	Big Creek	15.14	0.07	5.88	23.08	2.52	58.82	--	--	--	61.78	93.05	94.12	4.34
	Rexford	99.03	56.43	60.00	0.80	5.18	70.00	--	--	--	0.18	19.90	90.00	18.50
June	Warland	37.17	2.36	61.54	57.31	57.70	84.62	--	--	--	5.52	20.27	92.31	19.69
	Rexford	88.24	13.23	100.00	2.21	0.92	75.00	--	--	--	9.56	72.62	100.00	13.23
July	Warland	18.69	1.04	8.33	6.23	3.95	66.67	--	--	--	75.09	88.66	100.00	6.35
	Rexford	--	--	33.33	--	--	--	0.15	45.18	33.33	99.85	54.64	66.67	0.18
August	Warland	62.43	5.85	41.67	1.27	0.84	58.33	0.08	4.64	8.33	36.14	80.79	58.33	7.89
	Big Creek	--	--	--	--	--	--	--	--	--	100.00	100.00	100.00	--
	Rexford	--	--	--	--	--	--	--	--	--	100.00	100.00	100.00	--
September	Warland	84.89	1.21	37.50	2.88	1.21	50.00	--	--	--	12.24	6.37	75.00	91.21
	Rexford	99.42	75.92	100.00	0.40	4.90	55.56	--	--	--	0.19	11.01	44.44	8.16
October	Warland	64.82	2.10	20.00	3.64	2.27	70.00	--	--	--	31.53	92.98	100.00	2.66
	Rexford	10.88	0.08	37.50	14.51	3.70	87.50	0.16	27.84	12.50	74.46	67.27	100.00	1.11
November	Warland	99.94	94.88	87.50	0.03	1.71	12.50	--	--	--	0.03	1.87	33.33	1.55
	Big Creek	99.96	92.48	100.00	--	--	--	--	--	--	0.04	7.52	14.29	--
	Rexford	99.86	98.29	100.00	0.09	0.98	57.14	--	--	--	0.04	0.49	28.57	0.24
December	Warland	99.92	57.63	100.00	--	--	--	--	--	--	0.08	0.69	20.00	41.67
	Rexford	100.00	100.00	100.00	--	--	--	--	--	--	--	--	--	--
Means		94.06	24.07	60.98	1.22	3.22	45.93	0.01	10.61	1.63	4.71	53.88	64.23	8.22
1978														
July	Rexford	99.53	93.09	100.00	0.47	2.30	80.00	--	--	--	--	--	--	4.61
	Hungry Horse	--	--	--	20.39	17.36	100.00	--	--	--	79.61	82.64	50.00	--
August	Rexford	96.78	83.98	80.00	3.08	14.91	40.00	--	--	--	0.14	1.10	40.00	--
	Hungry Horse	76.04	6.58	33.33	2.76	13.82	66.67	--	--	--	21.20	79.61	100.00	--

Daphnia was more important in the diet of large cutthroat in summer, 1978 than in summer, 1977 (Table 14). Terrestrial insects were less important in summer, 1978 than in summer, 1977.

Cutthroat Trout Shorter Than 330 mm

The food habits of small cutthroat were intermediate between those of large cutthroat and small rainbows. Daphnia was more important in the diet of small cutthroat than in large cutthroat, but less important than in small rainbows (Figure 12). Terrestrial insects were less important in the diet of small cutthroat than large cutthroat, but more important than in the diet of small rainbows. Relative importance indices for Daphnia, terrestrial insects and aquatic insects were 80.4, 28.8 and 17.9, respectively in 1977. Other food items eaten by small cutthroat included calanoid copepods and fish.

Daphnia was the most important food item in the diet of small cutthroat from March through June and in November and December at Warland (Figure 12). Daphnia was the dominant food item in all months except July and August at Rexford. The IRI for Daphnia ranged from 13.8 in September to 99.2 in March at Warland and from 10.1 in July to 99.7 in December at Rexford. Daphnia accounted for 97.3 percent of the number and 62.8 percent of the volume of food items eaten by small cutthroat in 1977 (Table 15).

Small cutthroat rarely fed on fish. Only one (0.3 percent) small cutthroat had fish in its stomach.

Terrestrial insects appeared in the diet of small cutthroat almost every month. Terrestrials were the most important food item in the diet of small cutthroat from July through October at Warland but only in July at Rexford (Figure 12). No small cutthroat were caught in August at Rexford. The IRI for terrestrial insects ranged from 0 in November to 72.7 in October at Warland

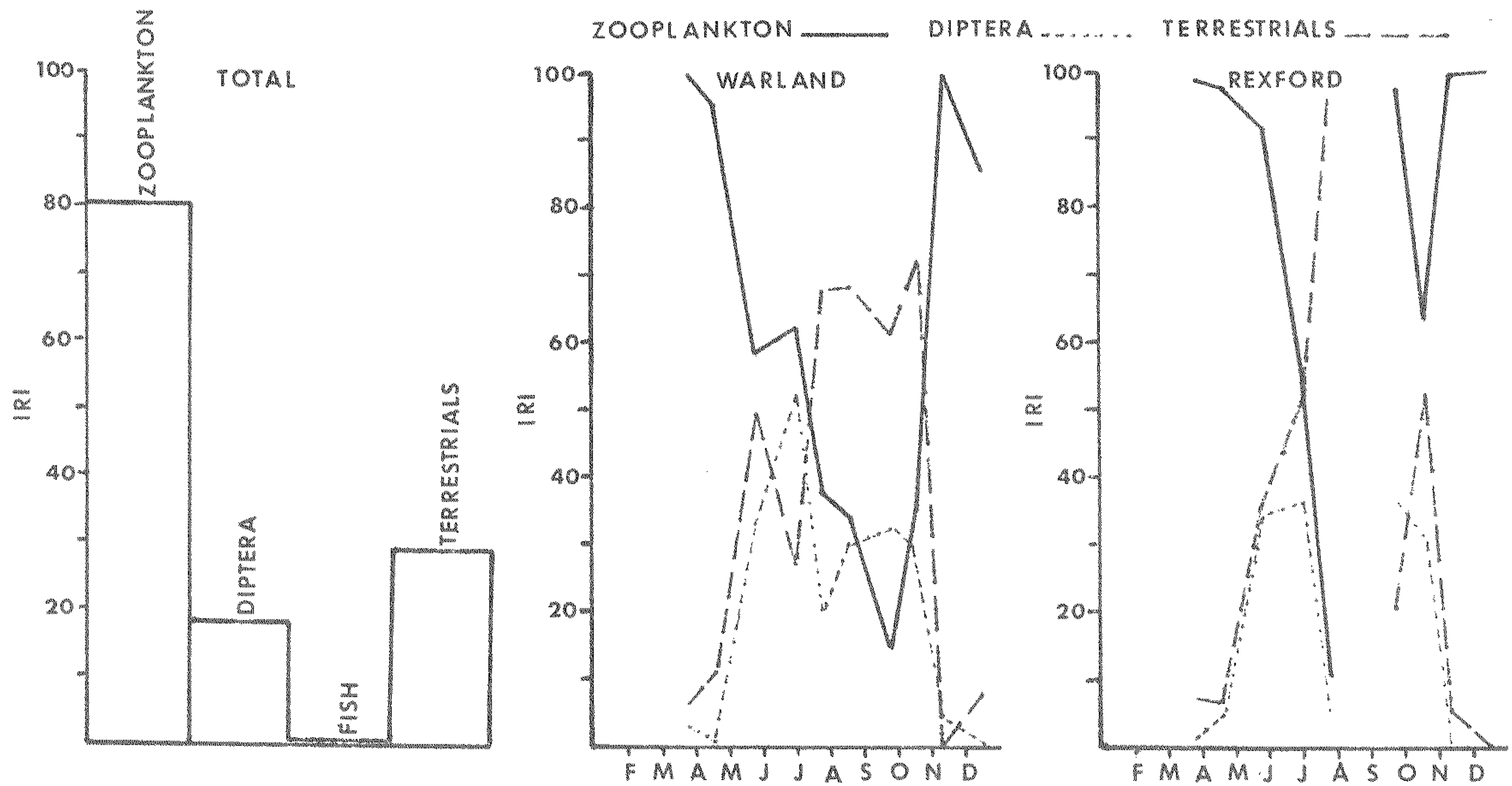


Figure 12. Total and monthly indices of relative importance (IRI) of food items in the stomachs of cutthroat trout shorter than 330 mm from the Warland and Rexford areas of Lake Koocanusa, March-December, 1977.

Table 15. Percentage of the number, volume and frequency of occurrence of food items in the stomachs of cutthroat trout less than 330 mm total length from Lake Koocanusa. 1977-78.

Month	Area	Zooplankton			Aquatic insects			Fish			Terrestrial insects			Debris
		No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	No.	Vol.	Freq.	Vol.
1977														
March	Warland	99.95	97.73	100.00	0.02	0.31	9.10	--	--	--	0.03	0.12	18.20	1.85
	Rexford	99.95	96.17	100.00	0.01	0.03	4.17	--	--	--	0.04	0.55	20.83	3.24
April	Warland	99.90	90.41	92.86	0.01	0.06	7.14	--	--	--	0.09	4.58	28.57	4.95
	Rexford	99.98	97.18	94.70	0.02	0.02	15.79	--	--	--	0.01	0.52	5.30	2.14
May	Warland	95.60	28.91	50.00	2.12	12.47	83.33	--	--	--	2.28	54.92	91.67	3.70
	Big Creek	99.29	80.97	25.00	0.33	2.02	50.00	--	--	--	0.39	17.00	75.00	--
	Rexford	98.00	77.86	97.14	1.81	7.22	94.29	0.01	0.50	2.86	0.18	13.95	91.43	0.46
June	Warland	89.10	37.84	58.33	10.23	45.74	100.00	--	--	--	0.67	11.16	66.67	5.26
	Rexford	89.86	29.66	42.86	5.53	17.07	85.71	--	--	--	4.61	51.02	100.00	2.25
July	Warland	85.09	7.45	18.18	1.20	3.48	54.55	--	--	--	13.72	88.56	100.00	0.50
	Rexford	13.05	0.48	16.67	0.05	0.24	16.67	--	--	--	86.90	99.27	100.00	--
August	Warland	52.41	3.53	44.44	4.06	7.75	83.33	--	--	--	43.53	88.74	72.22	--
	Big Creek	--	--	--	--	--	--	--	--	--	--	--	--	--
	Rexford	--	--	--	--	--	--	--	--	--	--	--	--	--
September	Warland	58.62	2.60	33.33	25.86	5.20	66.67	--	--	--	15.51	66.24	100.00	25.97
	Rexford	99.10	90.91	100.00	0.84	8.04	100.00	--	--	--	0.06	0.94	58.82	0.11
October	Warland	61.29	4.76	38.89	5.61	3.70	83.33	--	--	--	33.09	90.66	94.44	0.89
	Rexford	95.33	38.42	55.56	0.86	6.32	83.33	--	--	--	3.83	52.76	100.00	2.50
November	Warland	99.99	97.03	--	0.01	0.14	11.76	--	--	--	--	--	--	--
	Big Creek	100.00	100.00	--	--	--	--	--	--	--	--	--	--	--
	Rexford	99.99	98.79	14.29	--	--	--	--	--	--	0.01	0.63	14.29	0.57
December	Warland	99.93	55.56	11.11	--	--	--	--	--	--	0.07	13.33	11.11	31.11
	Rexford	100.00	100.00	--	--	--	--	--	--	--	--	--	--	0.80
Means		97.34	62.78	57.24	0.78	4.33	48.97	0.01	0.09	0.34	1.87	31.34	53.10	1.46
1978														
July	Rexford	99.00	70.88	88.89	0.89	16.47	55.56	--	--	--	0.12	12.45	33.33	0.20
	Hungry Horse	1.05	0.63	--	9.93	5.31	100.00	--	--	--	89.04	91.78	100.00	2.28
August	Rexford	94.80	50.48	92.31	4.79	0.26	61.54	0.01	28.62	7.69	0.38	10.01	46.15	--
	Hungry Horse	12.61	0.71	18.18	8.82	6.74	100.00	--	--	--	78.57	92.53	100.00	--

and from 0 in December to 95.4 in July at Rexford. Hymenoptera and Coleoptera were the most important taxa of terrestrial organisms in the stomachs of small cutthroat, followed by Homoptera, Hemiptera, Lepidoptera, Arachnida, Neuroptera and Orthoptera.

Aquatic Diptera were more important in the diet of small cutthroat than in large cutthroat or either size class of rainbows. The IRI for Diptera were high in spring and fall in both the Warland and Rexford areas. The spring value at Warland, consisting mostly of pupae, was 52.0 and the fall index, made up of pupae and adults, was 32.6 (Figure 12). The index values were similar at Rexford, with 36.1 in spring and 36.3 in fall.

Debris made up 1.5 percent of the volume of items found in the stomachs of small cutthroat in 1977, with ranges from 0 to 37.5 percent. Eighteen (5.8 percent) of all stomachs collected from small cutthroat in 1977 were empty. The percentage of empty stomachs was 0 in many samples but as high as 37.5 percent of those in the November sample from the Big Creek area.

Food habits of small cutthroat in summer, 1978 were similar to those of large cutthroat (Table 15). Daphnia were a more important food item for small cutthroat in summer, 1978 than summer, 1977. Terrestrial insects were less important in 1978 than in 1977.

Hungry Horse Reservoir Cutthroat Trout

Cutthroat caught in Hungry Horse Reservoir in July and August, 1978 differed substantially in their food habits from cutthroat caught in Lake Koocanusa during the same time period (Tables 14 and 15). Terrestrial insects and aquatic Diptera adults made up most of the diet. Daphnia was a minor constituent found in the stomachs of Hungry Horse fish, but an important constituent in Lake Koocanusa fish. The average size of cutthroat in Hungry Horse Reservoir is smaller than that of cutthroat in Lake Koocanusa. As a result, few large cutthroat were caught from Hungry Horse Reservoir.

Terrestrial insects were the most important food item in the diet of large cutthroat in Hungry Horse in both the July and August samples, with index values of 76.3 and 66.0, respectively. Hymenoptera was the most important taxon of terrestrial organisms, followed by Homoptera, Coleoptera and Arachnida.

Aquatic Diptera were the only other food item (index value 45.9) in the stomachs of large cutthroat in the July sample. Nearly all Diptera consumed were adults. The index value for Diptera was 27.8 in August. Daphnia were slightly more important than Diptera in August, with an index value of 38.7.

Terrestrial insects made up more of the diet of small cutthroat than large cutthroat collected from Hungry Horse Reservoir. Index values for terrestrials were 93.6 and 90.4 in July and August, respectively. Hymenoptera was the most important taxon in both samples. Other taxa in the July sample, listed in decreasing order of importance, were Coleoptera, Homoptera, Hemiptera, Arachnida, Neuroptera, Lepidoptera and Orthoptera. Other taxa in the August sample, in decreasing order of importance, were Homoptera, Hemiptera, Coleoptera, Arachnida, Neuroptera, Lepidoptera and Orthoptera.

After terrestrials, aquatic Diptera were the next most important food item in July and August (index values of 38.9 and 38.4, respectively). Nearly all Diptera consumed were adults.

Daphnia was not found in the July sample of stomachs and made up a minor portion of the August diet of small cutthroat (index value of 10.5). Other food items included one stonefly in July and one caddis fly in August.

Energy Analysis

Small Rainbow Trout

Rainbow trout weighing an average of 338 g in late March grew to an average of 630 g by mid-December, 1977 (Figure 13). An estimated 54 percent of the growth energy was supplied by *Daphnia* (Table 16). Terrestrial insects, fish and aquatic Diptera supplied an estimated 20, 18 and 8 percent, respectively. Miscellaneous food items accounted for only one percent of the growth energy.

Small Cutthroat Trout

Cutthroat trout weighing an average of 260 g in late March grew to an average of 526 g by mid-December (Figure 13). An estimated 45 percent of the growth energy was supplied by *Daphnia* (Table 17). Terrestrial insects and aquatic Diptera supplied an estimated 42 and 13 percent of the growth energy, respectively. Fish and miscellaneous food items supplied less than one percent of the growth energy.

Large Rainbow Trout

Large rainbow trout derived most of their growth energy from fish. An estimated 67 percent of the growth energy of large rainbows was supplied by fish (Table 18). *Daphnia*, terrestrials, aquatic Diptera and miscellaneous food items supplied an estimated 23, 5, 1 and 4 percent of the growth energy, respectively.

Large Cutthroat Trout

Fish supplied an important part (44 percent) of the caloric intake of large cutthroat trout (Table 19). Terrestrial insects, *Daphnia* and aquatic Diptera supplied an estimated 21, 19 and 15 percent of the growth energy, respectively.

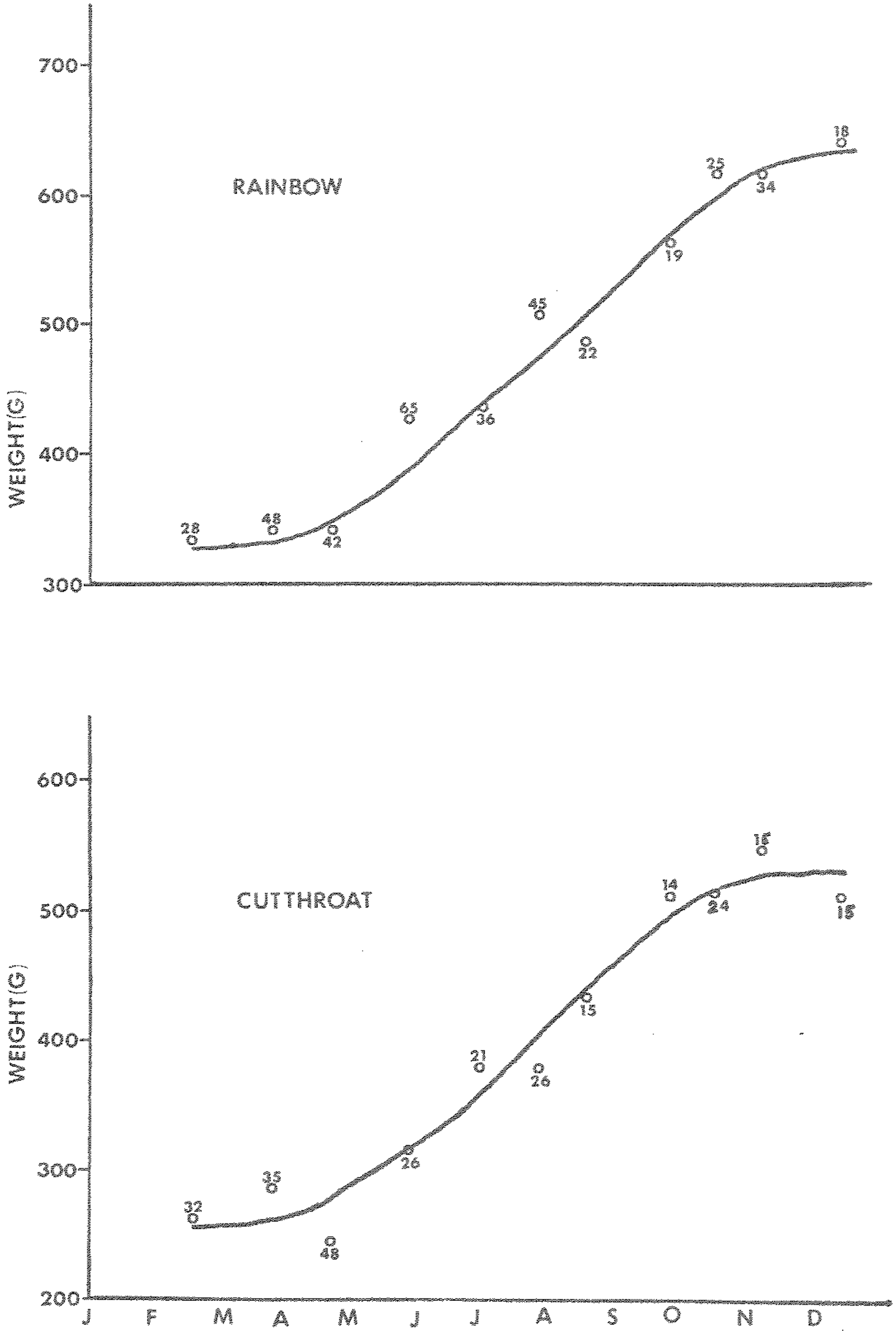


Figure 13. Growth curves of rainbow and cutthroat trout spending their first full year in Lake Koocanusa, 1977. Curves were fitted visually. Sample sizes are listed next to data points.

Table 16. Estimated growth energy (calories) supplied by food items in the diet of small rainbow trout during the period March 24-December 15, 1977, Lake Koocanusa, Montana.

Period	Fish in Sample	Estimated caloric intake	Daphnia calories	Daphnia %	Diptera calories	Diptera %	Fish calories	Fish %	Terrestrials calories	Terrestrials %	Miscellaneous calories	Miscellaneous %
3/24-4/20	90	12,420	12,168	98.0	31	0.3	190	1.5	12	0.1	19	0.1
4/20-5/26	107	173,862	154,285	88.7	8,745	5.0	1,374	0.8	9.180	5.3	278	0.2
5/26-6/30	101	152,130	93,261	61.3	29,830	19.6	15,059	9.9	13,706	9.0	274	0.2
6/30-7/27	81	121,083	39,590	32.7	19,807	16.4	16,442	13.6	40,159	33.2	5,085	4.2
7/27-8/18	67	93,141	13,152	14.1	2,440	2.6	21,609	23.2	51,982	56.8	3,958	4.3
8/18-9/28	41	192,492	77,978	40.5	4,254	2.2	68,431	35.6	41,829	21.7	--	--
9/28-10/19	44	74,514	40,093	53.8	1,632	2.2	16,760	22.5	15,992	21.5	37	0.1
10/19-11/9	59	55,884	31,127	55.7	1,090	2.0	12,468	22.3	11,171	20.0	28	0.1
11/9-12/15	52	31,047	24,273	78.2	317	1.0	6,457	20.8	--	--	--	--
Totals for season		906,573	485,927	53.6	68,146	7.5	158,790	17.5	184,031	20.3	9,679	1.0

Table 17. Estimated growth energy (calories) supplied by food items in the diet of small cutthroat trout during the period March 24-December 15, 1977, Lake Koocanusa, Montana.

Period	Fish in Sample	Estimated caloric intake	Daphnia calories	Daphnia %	Diptera calories	Diptera %	Fish calories	Fish %	Terrestrials calories	Terrestrials %	Miscellaneous calories	Miscellaneous %
3/24-4/20	67	12,420	12,168	98.0	27	0.2	--	--	215	1.7	10	0.1
4/20-5/26	83	142,815	118,565	83.0	7,298	5.1	1,100	0.8	15,738	11.0	114	0.1
5/26-6/30	74	142,815	64,867	45.4	43,544	30.5	1,085	0.8	33,290	23.3	29	0.02
6/30-7/27	47	136,608	19,344	14.2	40,408	29.6	--	--	76,856	56.3	--	--
7/27-8/18	47	105,561	1,573	1.5	1,066	1.0	--	--	102,890	97.5	32	0.0
8/18-9/28	41	186,282	90,980	48.8	9,929	5.3	--	--	84,870	45.6	503	0.3
9/28-10/19	29	55,884	26,953	48.2	4,733	8.5	--	--	24,064	43.1	134	0.2
10/19-11/9	38	18,627	10,575	56.8	691	3.7	--	--	7,361	39.5	--	--
11/9-12/15	39	24,837	24,611	99.1	62	0.2	--	--	144	0.6	20	0.1
Totals for season		825,849	369,636	44.8	107,758	13.0	2,185	0.3	345,428	41.8	842	0.1

Table 18. Estimated growth energy (calories) supplied by food items in the diet of large rainbow trout during the period March 24-December 15, 1977, Lake Koocanusa, Montana.

Period	Fish in sample	Estimated caloric intake	Daphnia		Diptera		Fish		Terrestrials		Miscellaneous	
			calories	%	calories	%	calories	%	calories	%	calories	%
3/24-4/20	91	21,733	18,017	82.9	13	0.1	3,062	14.1	641	3.0	--	--
4/20-5/26	71	298,051	230,275	77.3	6,080	2.0	38,061	12.8	23,546	7.9	89	0.0
5/26-6/30	61	260,795	40,997	15.7	2,373	0.9	211,453	81.1	5,920	2.3	52	0.0
6/30-7/27	51	208,015	291	0.1	21	0.0	207,579	99.8	62	0.0	62	0.0
7/27-8/18	28	158,340	1,140	0.7	16	0.0	156,708	99.0	428	0.3	48	0.0
8/18-9/28	14	329,098	8,425	2.6	165	0.1	279,140	84.8	2,732	0.8	38,636	11.7
9/28-10/19	9	127,293	8,427	6.6	1,298	1.0	70,686	55.5	21,614	17.0	25,268	19.9
10/19-11/9	15	96,246	37,892	39.4	4,341	4.5	28,142	29.2	25,871	26.9	--	--
11/9-12/15	20	52,780	13,570	25.7	855	1.6	38,239	72.5	--	--	116	0.2
Totals for season		1,552,351	359,034	23.1	15,162	1.0	1,033,070	66.6	80,814	5.2	64,271	4.1

Table 19. Estimated growth energy (calories) supplies by food items in the diet of large cutthroat trout during the period March 24-December 15, 1977, Lake Koocanusa, Montana.

Period	Fish in sample	Estimated caloric intake	*Daphnia*		Diptera		Fish		Terrestrials		Miscellaneous	
			calories	%	calories	%	calories	%	calories	%	calories	%
3/24-4/20	82	9,314	7,251	77.9	191	2.1	406	4.4	1,461	15.7	5	0.1
4/20-5/26	132	108,664	57,831	53.2	3,434	3.2	--	--	47,095	43.3	304	0.3
5/20-6/30	90	108,664	10,204	9.4	59,743	55.0	--	--	38,511	35.4	206	0.2
6/30-7/27	15	102,455	471	0.5	30,819	30.1	57,764	56.4	13,401	13.1	--	--
7/27-8/18	9	77,617	264	0.3	16	0.0	73,100	94.2	4,238	5.5	--	--
8/18-9/28	4	139,711	15,452	11.1	671	0.5	111,741	80.0	11,847	8.5	--	--
9/28-10/19	6	43,466	7,285	16.8	435	1.0	23,454	54.0	12,292	28.3	--	--
10/19-11/9	8	12,419	3,941	31.7	64	0.5	6,428	41.8	1,986	16.0	--	--
11/9-12/15	5	18,628	18,628	97.1	78	0.4	--	--	464	2.5	--	--
Totals for season		620,938	120,785	19.5	95,451	15.4	272,892	44.0	131,295	21.2	515	0.1

Female Gonad Maturation

Gonad development in maturing female rainbow and cutthroat trout in Lake Koocanusa begins in late summer of the year prior to spawning. Eggs from immature fish of both species averaged approximately 1.5 mm (.06 in.) throughout the summer (Figure 14). In rainbow trout I believed would spawn the following spring, egg diameters increased from a mean of 1.7 mm (.07 in.) in August to 3.0 mm (.12 in.) in September, and 4.0 mm (.16 in.) in December, 1977. The diameters of eggs in maturing cutthroat trout increased from 1.6 mm (.06 in.) to 3.5 mm (.10 in.) during the same period.

Ripe and nearly ripe eggs from rainbow trout averaged 5.7 mm (.22 in.) in April, 1977. Green cutthroat trout eggs averaged 5.1 mm (.20 in.) in April. Samples collected in May were lost, but ripe cutthroat trout eggs would probably have approached 5.5 mm (.22 in.) in diameter.

The Spearman rho nonparametric correlation coefficient described by Conover (1971) was used to determine if egg diameter was correlated with the length of ripe fish. Egg diameter was positively correlated with fish length for both rainbow (rho = 0.75) and cutthroat trout (rho = 0.73) in the April, 1977 sample (Figure 15). The largest ripe fish had eggs that were more than 1 mm larger than the smallest fish.

Physical Limnology

The drought of 1977 resulted in low water levels and higher than average temperatures in Lake Koocanusa. Minimum pool elevation for 1977 was reached in April at 718.9 m (2358.5 ft.), 21.8 m (71.5 ft.) above minimum regulated pool elevation. Maximum pool elevation was reached in July at 736.1 m (2415 ft.), 13.4 m (44 ft.) below full pool elevation.

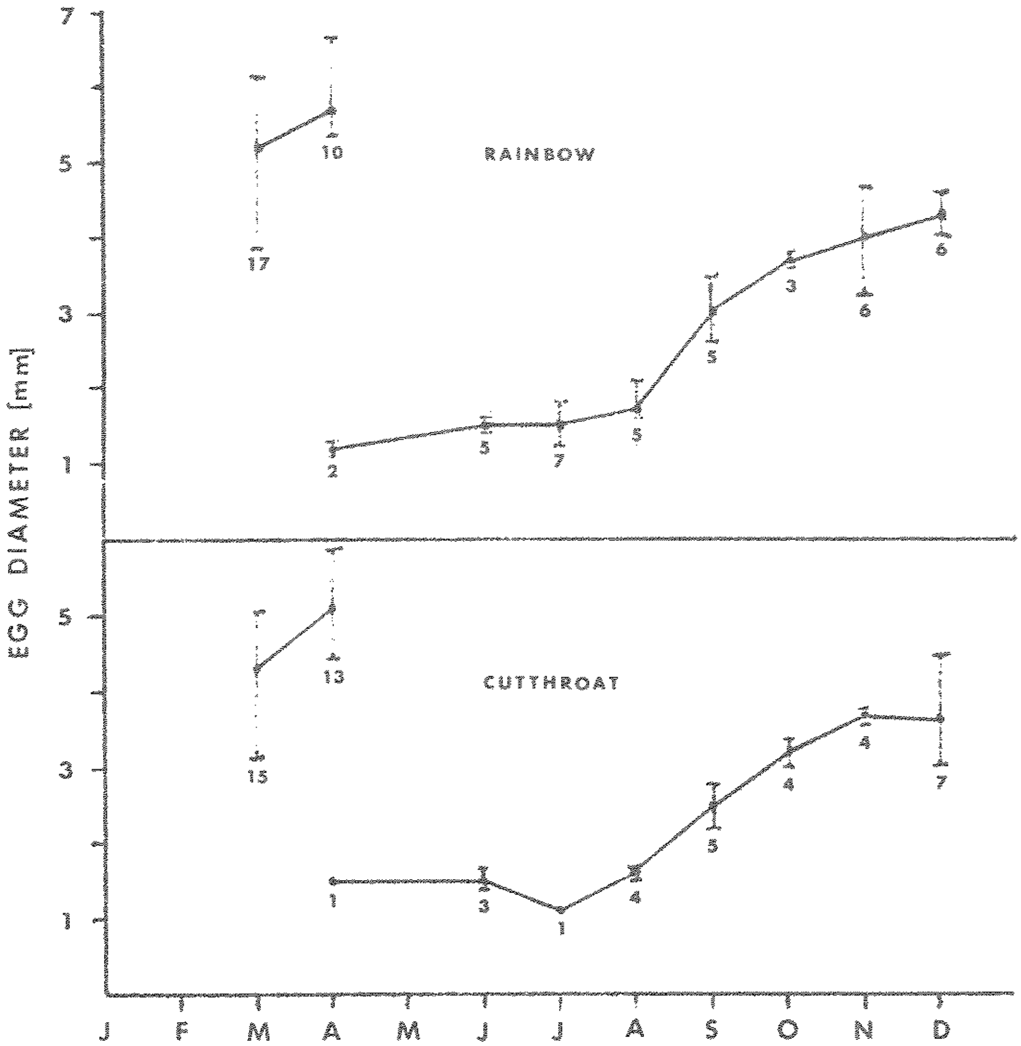


Figure 14. Monthly mean diameters of eggs from rainbow and cutthroat trout collected in Lake Koocanusa, 1977. Ranges and sample sizes are included.

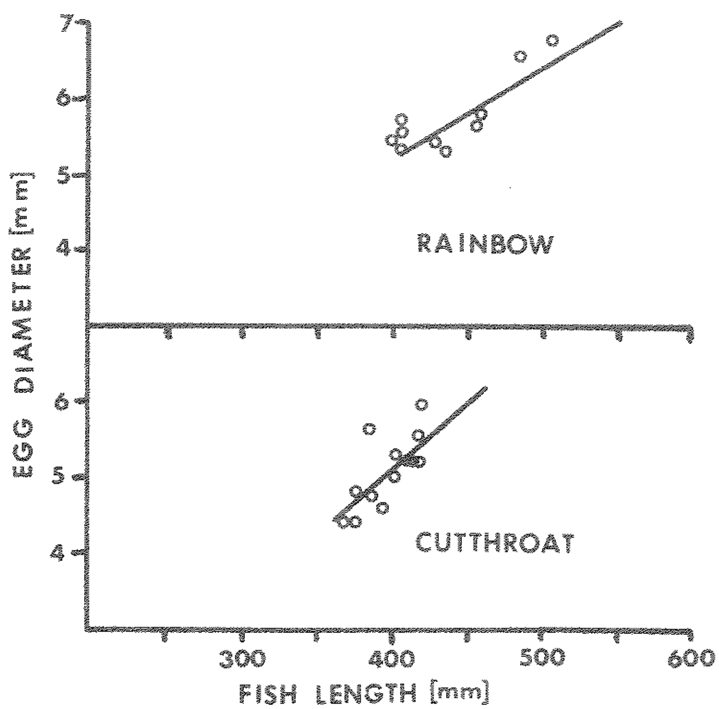


Figure 15. The relationship between fish length and egg diameter for rainbow and cutthroat collected from Lake Koocanusa, April, 1977.

Maximum recorded surface temperature was 21.1 C (70 F) in both the forebay and Rexford areas in 1977. Maximum temperatures in 1978 were 16.7 C (62 F) in the forebay and 18.9 C (66 F) at Rexford.

Secchi disc readings ranged from 3.5 to 9.0 m in the forebay and 1.0 to 7.5 m at Rexford in 1977.

DISCUSSION

Fish Distribution

Rainbow and cutthroat trout captured in the limnetic area of the reservoir were found near the surface most of the year. Only during the summer, when surface temperatures exceeded 17 C (62.6 F), did significant numbers of trout move deeper into the water column. May (1973) and Horak and Tanner (1964) noted similar seasonal depth distributions for rainbow trout.

Cutthroat trout appeared to prefer slightly cooler water than rainbow trout. Summer catches of cutthroat trout in the vertical nets were concentrated in the 15-18 C range (59-64.4 F). Although no information on the preferred temperature of cutthroat trout was found in the literature, Dwyer and Kramer (1975) found scope for activity of cutthroat trout to be largest at 15 C.

Rainbow trout appeared to prefer temperatures in the 17-19 C (62.6-66.2 F) range. A larger sample size may have resulted in an expanded range of temperature preference. Horak and Tanner (1964) and McCauley and Pond (1971) obtained similar temperature preferences for rainbow trout. Garside and Tait (1958) found a lower temperature preference. Both rainbow and cutthroat trout are polytypic species. Temperature preferences could vary significantly between subspecies.

Both rainbow and cutthroat trout avoided water warmer than 19 C. A slightly larger proportion of cutthroat versus rainbow trout were captured in water warmer than 19 C. Cutthroat fed more on terrestrial insects in summer than did rainbow trout and this may explain catches in warmer waters. Since gill net catches are a function of fish activity as well as abundance, surface catches in the vertical nets are probably biased, i.e., fish are probably more active in surface waters (during feeding periods) than they are in deeper water. In near-shore areas rainbow trout tended to be evenly distributed from top to bottom. Cutthroat trout were found mostly near the surface.

Rainbow trout were more abundant than cutthroat in both floating and sinking nets throughout the year (Table 20). Changes in the abundance of both species since 1975 may account for the lack of a consistent pattern in gang set catches. The relative abundance of rainbow has increased throughout the reservoir. Cutthroat abundance has decreased in the Warland area (May et al. 1979). Increased rainbow and decreased cutthroat catches at all distances from shore in the gang set may mask their preferred distributions.

The concentration of trout at Rexford in winter (Table 20) may be a function of temperature, food availability and spawning migrations. The Rexford area of the reservoir warms earlier than the Warland area (Figure 16) and zooplankton populations develop earlier (Figure 17). Young Creek and Gold Creek (British Columbia) support the largest known cutthroat spawning runs in Lake Koocanusa tributaries (Table 21). Both enter the reservoir from the west near the international boundary. Pinkham Creek and the Tobacco River also support cutthroat spawning runs. The Tobacco River also supports a spawning run of several thousand rainbow trout

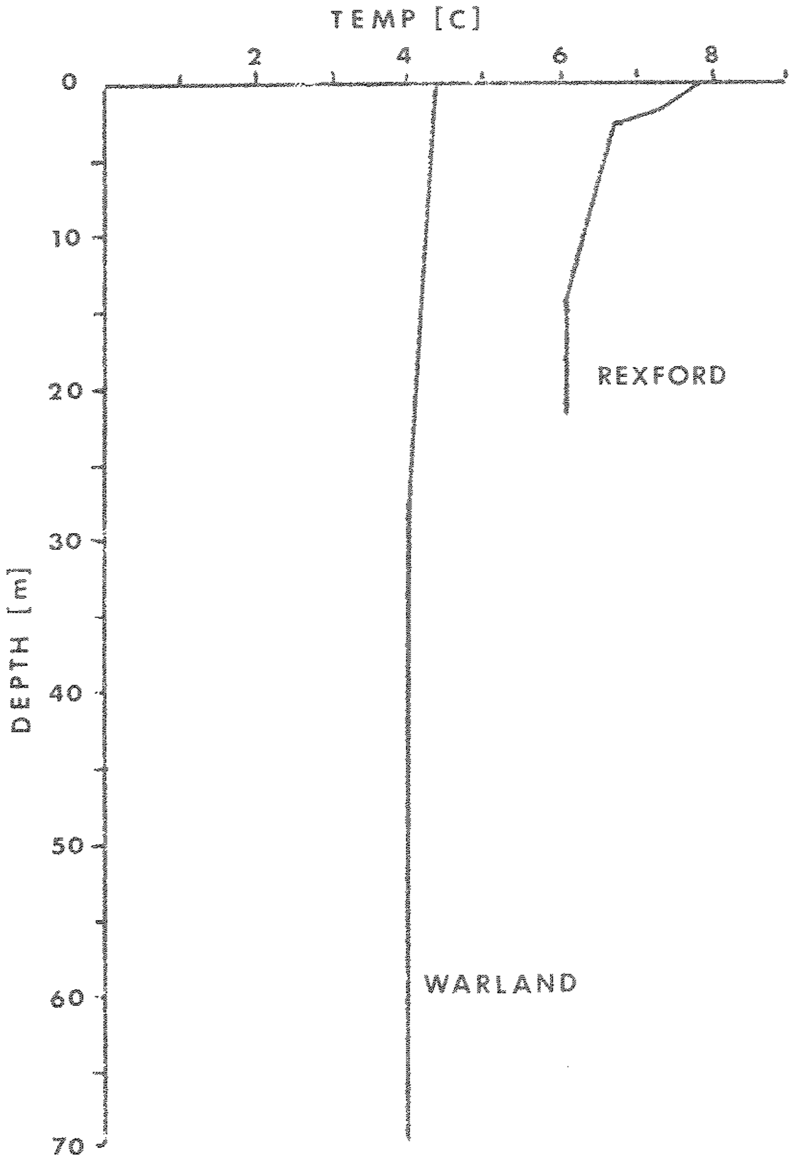


Figure 16. Temperature profiles in the Warland and Rexford areas of Lake Koocanusa, April, 1977.

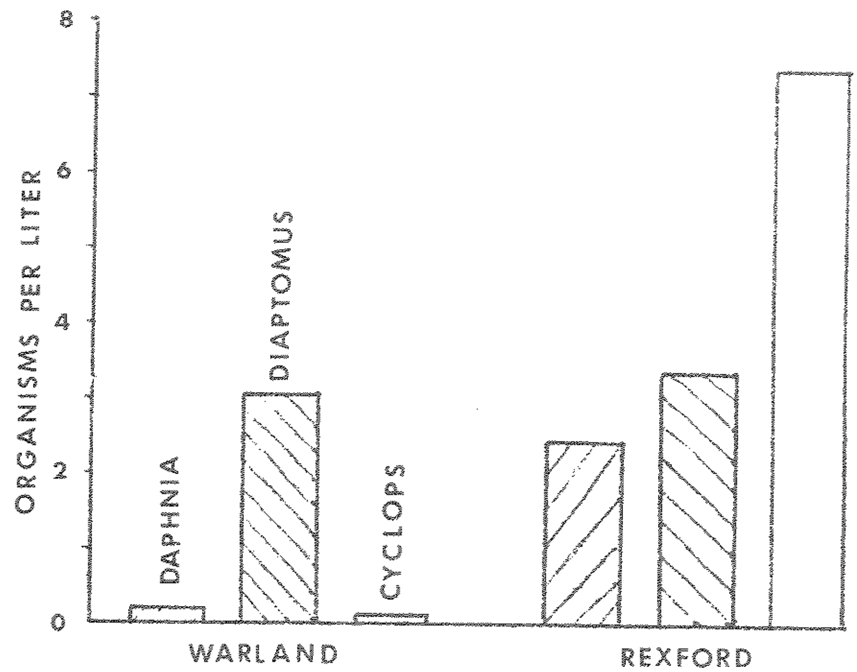


Figure 17. Zooplankton abundance in the Warland and Rexford areas of Lake Koocanusa, April, 1977.

Table 20. Wilcoxon signed-rank test comparisons of rainbow and cutthroat trout abundance in experimental gill nets, 1977. Asterisk indicates significance at the 5% level.

Season	Area	Type of set	No. of sets	Mean rainbow/set	Mean cutthroat/set	Probability of difference
Winter	Warland	Floater	16	4.6	2.7	.0041*
Winter	Rexford	Floater	9	15.2	19.7	.0156*
Spring	Warland	Floater	6	13.8	9.7	.0559
Spring	Rexford	Floater	5	10.8	13.0	.0869
Summer	Warland	Floater	6	6.3	4.3	.1020
Summer	Rexford	Floater	9	7.7	1.4	.0064*
Fall	Warland	Floater	9	9.1	6.6	.0139*
Fall	Rexford	Floater	3	15.7	8.7	.1250
Winter	Warland	Sinker	22	8.3	1.8	.0001*
Winter	Rexford	Sinker	7	20.0	12.3	.0749
Spring	Warland	Sinker	7	7.4	0.3	.0107*
Spring	Rexford	Sinker	3	6.0	2.0	.2061
Summer	Warland	Sinker	4	5.5	0.0	.0329*
Summer	Rexford	Sinker	1	0.0	0.0	--
Fall	Warland	Sinker	6	15.7	1.3	.0132*
Fall	Rexford	Sinker	3	23.3	1.3	.0516

Table 21. Estimated 1977 westslope cutthroat spawning runs in tributaries of Lake Koocanusa (May et al. 1979).

Area	Tributary	Spawners
Warland	Canyon Creek	7
	Cripple Horse Creek	44
	Five Mile Creek	221
	Bristow Creek	144
		416
Rexford	Pinkham Creek	308
	Young Creek	750
	Gold Creek	476
		1,534

(Bruce May, personal communication). In contrast, the Warland area of the reservoir has smaller tributaries with smaller spawning runs of cutthroat.

Rainbow trout were fairly evenly distributed between the Warland and Rexford areas throughout the year. Cutthroat trout, however, apparently move upreservoir in winter and downreservoir in summer. Thirty-eight percent of the 1974 tag returns and 46 percent of the 1975 tag returns from cutthroat tagged during their spawning migration in Young Creek came from the Kootenai River downstream from Libby Dam (May et al. 1979). More cutthroat were caught in the Warland area in summer, 1977 than the Rexford area, another indicator of downreservoir movement in summer. The comparatively shallow Rexford area contains less water of suitable temperature in summer than the Warland area but downreservoir movements of cutthroat have been noted in years when water temperatures in the Rexford and Warland areas were nearly ideal.

Using the rainbow and cutthroat trout distribution data, the selective withdrawal system could be operated to minimize downstream losses of fish. A modification of the original operating plan for the selective withdrawal system has already been put into effect. Under the modified operating plan, water is never drawn from within 15.2 m (50 ft.) of the reservoir surface and water warmer than 14 C is not withdrawn.

Food Habits

The food habits of rainbow and cutthroat trout in Lake Koocanusa are notable more for their similarities than for their differences. Both species depended on *Daphnia* for food in winter. *Daphnia* was the most important food item in the diets of smaller fish of both species. Food habits of the two species diverged as size increased. Large rainbow trout were more piscivorous than cutthroat. Cutthroat trout were more insectivorous than rainbow.

On a calorie basis, fish provided more energy than any other food item in the diets of both large rainbow and cutthroat. Daphnia, aquatic Diptera and terrestrial insects contributed approximately equal shares of the balance of the intake of large cutthroat. Daphnia contributed most of the balance of the energy intake of large rainbow.

The importance of fish in the diet of cutthroat trout is probably overemphasized by the caloric intake analysis. Few cutthroat in the reservoir attain the size necessary to utilize forage fish regularly as a food source. Less than two percent of the cutthroat trout longer than 330 mm sampled during this study had fish in their stomachs. All of the cutthroat that ate fish were among the largest cutthroat captured.

Large rainbow trout (larger than 1000 g) were not uncommon in Lake Koocanusa in 1977 and 1978 and is probably a reflection of their piscivorous feeding habits. Rainbows in their third or fourth year of life fed more on redside shiners. Seventy-six percent of the rainbow trout stomachs containing fish were from rainbows longer than 390 mm (15.4 in.) total length. Cutthroat trout heavier than 1000 g were rare. The largest rainbow captured during this study was 625 mm (24.6 in.) in total length and weighed 2500 g (5.5 lb.). The largest cutthroat captured was 467 mm (18.4 in.) and weighed 1025 g (2.26 lb.).

Some biologists have suggested that the evolutionary relationship between westslope cutthroat and two predators, northern squawfish and Dolly Varden (bull char), resulted in the westslope cutthroat being less predacious than most other subspecies of cutthroat trout (Behnke, unpublished, Roscoe 1974). Cutthroat in Lake Koocanusa do not eat fish regularly, with the possible exception of the largest cutthroat in the population. Echo (1954) investigated the food habits of cutthroat trout and yellow perch (*Perca flavescens*) in Thompson Lakes, Montana and found that 40 percent of the cutthroat stomachs contained perch fry. Although Thompson Lakes now contain westslope cutthroat, it is suspected that hatchery Yellowstone cutthroat may have been common in the lakes at the time of Echo's study (Joe Huston, personal communication). Bjornn (1957) found no fish in the stomachs of westslope cutthroat he collected from Priest Lake, Idaho.

Rainbow trout commonly utilize forage fish for food in lacustrine habitats (Alexander and Gowing 1976, Brynildson and Kempinger 1973, Hess 1974, Jeppson and Platts 1958, Leonard and Leonard 1946, Percival and Burnet 1963, Rawstron 1973). Redside shiners made up nearly all of the fish fed upon by rainbow trout in Paul Lake, British Columbia (Crossman and Larkin 1958, Larkin and Smith 1953). The period of heaviest utilization of redside shiners by rainbow in Lake Koocanusa coincided with the shiner spawning period when shiners were concentrated in shoreline areas.

The importance of terrestrial insects in the diets of both species, but especially in cutthroat, is similar to the findings of Norlin (1967). Terrestrial insects made up 48 percent of the drifting fauna in several Swedish lakes. Fish selectively fed on terrestrials. Norlin believed the contribution of drifting organisms to the lakes' energy budgets was important because of the easy availability to fish predators and because the energy was introduced at a high trophic level, i.e., directly to the consumers. Terrestrial organisms were most important as food items in lakes with fluctuating water levels.

The coefficient of condition (K) of both cutthroat and rainbow trout rose from a winter low to a pre-spawning peak in spring, declined as spent fish reentered the reservoir and then increased to a maximum in the fall

(Figure 18). Cutthroat condition factors ranged from a low of 0.91 (C = 32.8) in February to 1.12 (C = 40.4) in October. Rainbow condition factors ranged from 0.99 (C = 35.7) in February to a post-spawning low of 0.97 (C = 35.0) in July to a high of 1.09 (C = 39.3) in September. Surprisingly, smaller, mostly immature fish had the same early summer drop in condition as larger fish.

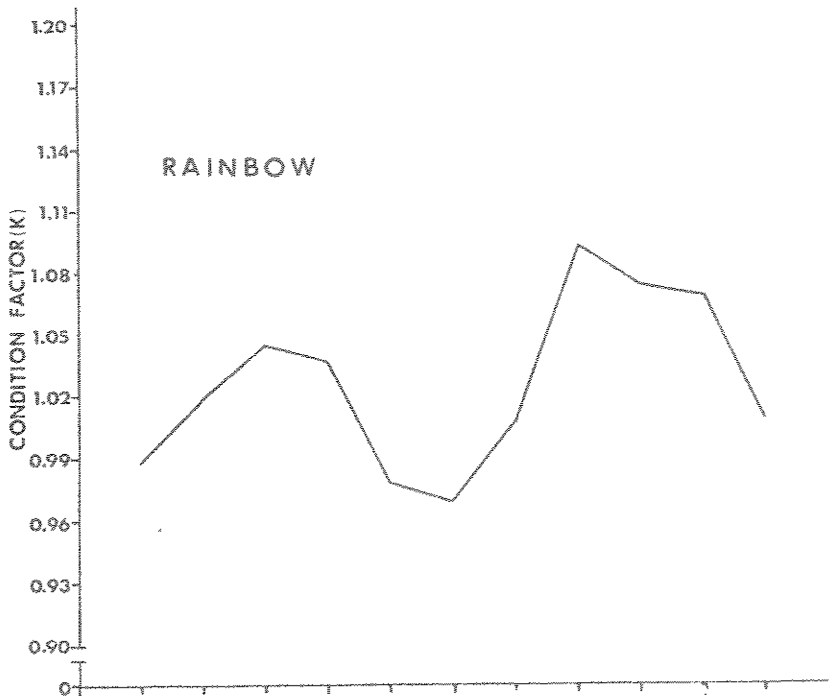
The spring peak in condition factor coincided with the period of maximum Daphnia abundance. Flying ants and Diptera pupae were also abundant in late spring and early summer. High condition factors in fall were probably a result of the summer-long ingestion of large quantities of insects and forage fish.

Benthos and Zooplankton

Diversity of benthic organisms is severely limited by winter drawdown in Lake Koocanusa. Oligochaetes and Diptera larvae were the only organisms found in benthic samples. Snails, although abundant in the Kootenai River, were absent in the reservoir. A complete lack of aquatic macrophytes in the reservoir limited benthic production.

Oligochaetes were found only near or below the maximum drawdown level. Freezing of exposed substrate above the maximum drawdown level probably prevents colonization by oligochaetes. Paterson and Fernando (1969) found no oligochaetes survived more than approximately two months of freezing exposure in an Ontario reservoir. Chironomidae were more tolerant.

The limited area of oligochaete production is of little significance to trout in Lake Koocanusa. No aquatic oligochaetes were found in the stomachs of rainbow or cutthroat trout. Increased production of aquatic Diptera would benefit trout, as both species used Dipterans as a food source.



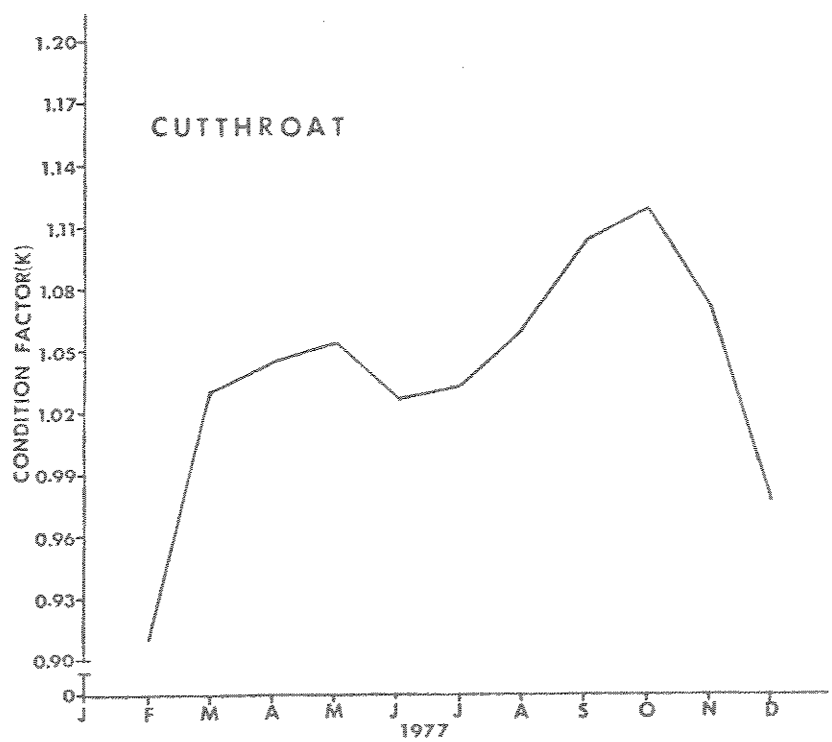


Figure 18. Condition factors (K) of rainbow and cutthroat trout in Lake Koocanusa, 1977.

Diptera pupae appear to be the favored developmental stage.

Zooplankton densities are sufficient at the present time to support a large trout population. If, as happens in most impoundments, productivity of the reservoir declines with age, a corresponding decline in zooplankton densities could be detrimental to trout production.

Reduced zooplankton densities would probably have little effect on trout in the spring and summer when a variety of other foods are available. The critical period may be in the winter when both rainbow and cutthroat trout (and presumably other species) feed almost entirely on _Daphnia_.

Overlap in the food habits of two species is generally regarded as a healthy situation, i.e., the resources are sufficiently abundant that both species can utilize them (Larkin 1956). Overlap in the winter diets of rainbow and cutthroat trout in Lake Koocanusa, however, is a result of the limited variety of foods available at that time of year. The nearly complete overlap in winter food habits of rainbow and cutthroat trout might lead to serious competition if _Daphnia_ declined in abundance.

Selective feeding on _Daphnia_ by both trout species could hasten the advent of competition for food by altering the zooplankton population. Galbraith (1967) noted drastic changes in the zooplankton communities of two Michigan lakes. He attributed the changes to selective predation on large _Daphnia_ by rainbow trout and yellow perch.

Gill Nets as a Food Habits Sampling Tool

Gill nets are a poor tool for collecting fish in food habits studies, according to often repeated dogma. The problems cited include length of time between capture of a fish and removal of its stomach, and the tendency of gill net-caught fish to regurgitate their stomach contents.

In this study, we attempted to minimize the first problem by tending the nets as often as manpower would allow. Digestive rates were sufficiently slow in winter so that we could leave the fish in the nets overnight. During warmer periods, we checked the nets and removed the trout once during the night. A second check would have been desirable in summer.

Regurgitation of stomach contents was investigated on two occasions. In November, 1977, 105 rainbow trout and 68 cutthroat trout were inspected for evidence of regurgitation. Fifteen (14 percent) rainbow and 10 (15 percent) cutthroat trout had food in their buccal cavity, which we interpreted as evidence of having regurgitated some of their stomach contents. Another sample of 36 rainbow and 15 cutthroat, inspected in July, 1978, contained 12 (33 percent) rainbow and 2 (13 percent) cutthroat trout that might have regurgitated some food.

The proportions of food items remaining in the stomachs of fish that regurgitated a portion of their stomach contents were virtually identical to the proportions in fish that had no evidence of regurgitation. In all cases, the regurgitated food items were almost entirely Daphnia, but both species were feeding almost entirely on Daphnia. When a greater variety of food items is being eaten, selective regurgitation could affect the conclusions drawn from a food habits study.

When properly used, advantages of using gill nets outweigh the disadvantages. Gill nets are relatively inexpensive, easy to use and a large sample can be secured in a short time period. One shortcoming, in addition to those already mentioned, is that we were limited to sampling at night. Few trout were caught in daylight sets of multifilament nylon gill nets. Monofilament nets might have been more effective in daylight sampling.

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