MONTANA DEPARTMENT OF FISH AND GAME

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FISHERIES DIVISION
Completion Report
January 1, 1969 to September 30, 1978

LAKE KOOCANUSA POST-IMPOUNDMENT FISHERIES STUDY

Libby, Montana

By

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Reservoir Investigations Project
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Project No. 3151

Project Title: Lake Koocanusa Post-Impoundment Fisheries Study

Period Covered: January 1, 1969 through September 30, 1978

ABSTRACT

Data collected during pre-impoundment and post-impoundment time periods are presented. Peamouth, northern squawfish and redside shiner populations have increased markedly since impoundment of the river in 1971. Burbot, rainbow trout and cutthroat trout populations have also increased since impoundment. The largescale suckers, longnose suckers, mountain whitefish and Dolly Varden populations have increased but their relative numbers have changed little. Nongame fish populations present in the river expanded rapidly and it only took three years for them to fill the available habitat in the new reservoir.

Spawning runs of westslope cutthroat and rainbow trout have developed in most suitable tributaries and natural reproduction of both species has been higher than anticipated.

Growth rates of rainbow and cutthroat trout in the reservoir have been faster than pre-impoundment rates but slowed down slightly in 1978. Mountain whitefish growth rates in the reservoir were faster to age three than river fish, but by age five and six, the pre-impoundment growth had exceeded post-impoundment growth.

Catch rates by anglers dropped somewhat from 1975 to 1978 but are still good for an essentially wild trout reservoir fishery. Fishing pressure has been comparatively light.

Game fish in the forebay area are concentrated in the upper 20 feet of the water column year round except when surface water temperatures exceed 62-65°F. Operation of the selective withdrawal system has reduced the loss of game fish downstream out of the reservoir.

Daphnia were the most important food item for rainbow and cutthroat trout. Fish were the next most important component in the diet of large rainbow trout (>13 inches), whereas terrestrial insects were second in importance for small rainbow and all cutthroat. These diets could be considered typical for large deep, fluctuating reservoirs prior to accumulation of benthic sediments.

BACKGROUND

Lake Koocanusa is the reservoir created by Libby Dam impounding the Kootenai River approximately 17 miles upstream from Libby, Montana. A small pool extended about 10 miles upstream of the dam from 1971 until 1972 when the river was first impounded. Full pool elevation was not reached until 1974 because of a 230 foot drawdown for construction activity in the 1972-73 winter. Full pool elevation at 2459 MSL creates a reservoir 90 miles long, (48 miles in Montana and 42 miles in British Columbia), with a surface area of 46,500 acres and a gross storage capacity of 5,809,000 acre feet, (Table 1). Average depth at full pool is 125.8 feet as compared to 69.2 feet at low pool. Predicted average annual drawdown of 120 feet reduces the reservoir volume 69 percent and the maximum drawdown of 172 feet reduces the volume 85 percent. Forebay elevations are shown in Figure 1.

Water level fluctuations have a considerable influence on the aquatic communities inhabiting the reservoir. The biota of the reservoir is also greatly influenced by the elevation of the discharge outlet. A selective withdrawal system has been constructed for each of the eight penstocks with the capability of drafting water from elevations 2287 to 2459 MSL. Depth selection for selective withdrawal has been studied to determine the level which will minimize escapement of game fish from the reservoir, yet release water downstream which approximates the natural seasonal temperature regime of the Kootenai River prior to impoundment.

Table 1. Morphometric data on Lake Koocanusa.

Area (acres)	46,500
Drainage (sq. miles)	9,070
Average annual discharge (acre feet)	8,658,000
Shoreline (miles)	224
Maximum length (miles)	90
Shoreline development	7.41
Maximum breadth (miles)	2.4
Maximum depth (feet)	370
Mean depth (feet)	126
Storage capacity (acre feet)	5,808,680
Usable storage (acre feet)	4,933,500
Water rentention (years)	.66
Elevation at full pool	2459 MSL
Elevation at minimum operating pool	2287 MSL

Game fish species present in the reservoir and species abbreviations used in this report include: rainbow trout (Salmo gairdneri) (Rb), westslope cutthroat trout (Salmo clarki Subsp.) (Wct), Dolly Varden (Salvelinus malma) (DV), kokanee (Oncorhynchus nerka) (Kok), brook trout (Salvelinus fontinalis) (Eb), ling (Lota lota) (ling) and mountain whitefish (Prosopium williamsoni) (Mwf). Nongame species include largescale suckers (Catostomus macrocheilus) (Csu), longnose sucker (C. catostomus) (FSu), redside shiner (Richardsonius balteatus) (RsS), northern squawfish (Ptychocheilus oregonensis) (NSq), and peamouth (Mylocheilus caurinus) (CRC).

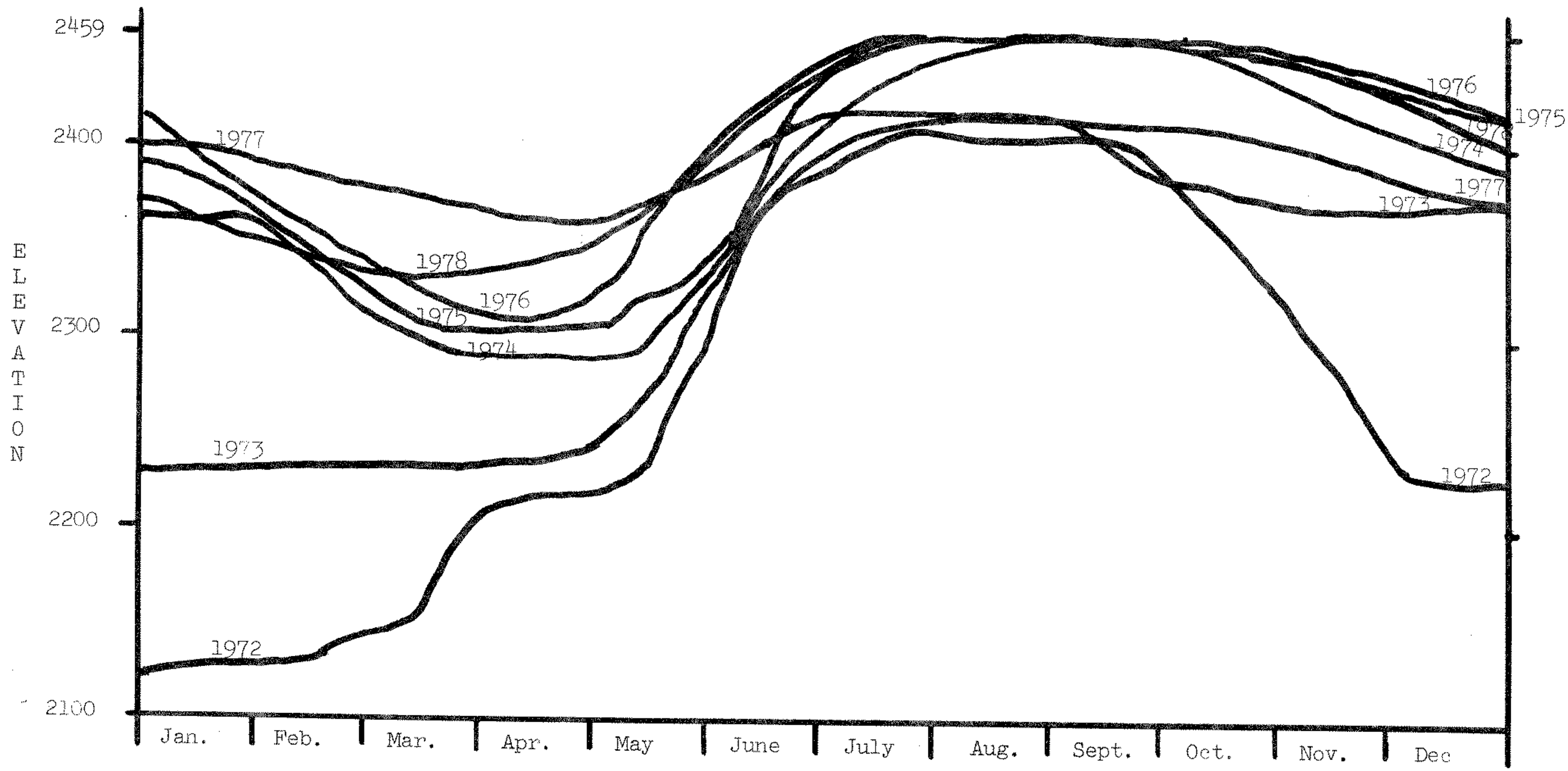

Figure 1. Lake Koocanusa forebay elevations, 1972 through 1978.

The initial reservoir management plan was to establish spawning runs of adfluvial westslope cutthroat and other game fish in suitable tributary streams. Adfluvial cutthroat are fish that live in large lakes or reservoirs, migrate into tributary streams for spawning, and young fish rear in the stream for one to three years before returning to the lake. Westslope cutthroat trout inhabiting Hungry Horse Reservoir were selected as most suitable for the deep fluctuating reservoir environment of Lake Koocanusa. This cutthroat strain has adapted well to a similar environment in Hungry Horse Reservoir and has provided a good fishery without stocking for over 20 years. Approximately 500,000 young-of-the-year cutthroat have been imprint planted in tributary streams of Lake Koocanusa. Approximately 3,000,000 young-of-the-year and yearling cutthroat were planted directly in the reservoir from 1970-76. The reservoir population of cutthroat was adversely affected by the escapement of fish out of the reservoir when it was drafted 230 feet below full pool for construction in the winter of 1972-73 and when spillways released water from near the surface in 1974 from July through December.

New reservoirs generally provide excellent sport fishing for the first few years because of minimal competition and an abundance of food and space which result in excellent growth and survival of fish. As the reservoir ages, the maintenance of a satisfactory sports fishery becomes increasingly difficult. Some of the factors affecting reservoir game fish populations are: 1) inadequate annual recruitment of game fish from natural reproduction, 2) increased numbers of rough fish and increased competition for food and space between all species, 3) increased predation, 4) decline in nutrients and fish food production and 5) downstream escapement of game fish. Reservoir operations can impact game fish by altering any one of the variables. The annual stocking of large numbers of hatchery fish can help maintain a sports fishery if the reservoir provides a suitable environment for their survival and growth. Thus, reservoir operation is critical to provide environment which is satisfactory for game fish.

Lake Koocanusa is in the first stage of its evolution and is providing a good sport fishery for cutthroat trout, rainbow trout and Dolly Varden. Rainbow and Dolly Varden trout populations derive from natural or hatchery escapement reproduction, whereas the cutthroat population has been maintained by large plants of hatchery fish and natural reproduction. The reservoir was last planted with cutthroat in October, 1976.

OBJECTIVES

The objectives of this project were to: 1) determine the seasonal vertical and horizontal distribution of major fish species in the forebay area, 2) monitor population trends of major fish species, 3) collect data on angler harvest and movement of game fish, 4) determine growth rates and condition factors of major game species and 5) determine food habits of rainbow and cutthroat trout.

PROCEDURES

Fish Population Trend Sampling

Standard experimental surface and bottom gill nets were used to determine fish population trends. Catch by species was analyzed using the Kruskal-Wallis non-parametric ranking rest advocated by Gooch (1975). Montana's standard nylon gill net is 125 feet long and comprised of equal sections of 3/4-inch, 1-inch, 1 1/4-inch, 1 1/2-inch, and 2-inch mesh bar measure.

Bottom gill nets were used to determine trends in abundance of benthic-oriented species. Target species in the Rexford area during the spring included mountain whitefish, Dolly Varden, ling, largescale and longnose suckers. The sampling criteria were: 1) reservoir elevation between 2450 to 2375 MSL, 2) surface water temperatures of approximately 55°F, and 3) secchi disc readings around 3.0 feet.

Surface gill nets were used to determine relative abundance of species inhabiting surface waters during the fall season. Target species for this sampling included rainbow trout, cutthroat trout, northern squawfish, peamouth, and redside shiners. The sampling was conducted in the fall when reservoir elevation was within five feet of full pool and surface water temperatures were near 60°F. The location of the Bailey Bridge, Rexford and Cripple Horse netting areas are shown in Figure 2.

Trend data on spawning cutthroat were collected by trapping and counting adults entering Young Creek and by making redd counts in selected tributaries. Rainbow trout spawners were collected by Fyke traps and standard box traps near the mouths of the Tobacco River and Pinkham Creek in the spring of 1978. Fish were placed upstream after being anesthetized, measured, weighed, tagged and scale sampled.

Scale impressions were made on plastic strips and the images read with the aid of a Bausch and Lomb microprojector. The length at each annulus was determined using a nomograph which assumed a linear relationship between body-scale growth.

Determination of Vertical and Horizontal Fish Distribution

Sampling to determine vertical and horizontal fish distribution has been limited to the forebay (Figure 2) and Cripple Horse areas. Sampling frequency was monthly or when noticeable water temperature changes occurred. Acoustical gear was used to determine overall vertical and horizontal fish distribution throughout a 24-hour period, whereas gill nets were used to determine species distributions in overnight sets. Net catches during daylight hours were too low to provide meaningful data.

Angler Success and Pressure

Beginning in 1975, creel data were based on complete trips obtained at a compulsory checking station located at Canoe Gulch Ranger Station. This census contacted anglers mostly from the lower 25 to 30 miles of the reservoir. Total fishing pressure estimated for the reservoir was obtained from a statewide postal census.

Food Habits

Fish were collected at monthly intervals in the Cripple Horse and Rexford areas and quarterly in the Big Creek area. Standard procedure was to set three gangs of two each surface nets, a gang set of six surface nets and two single bottom nets.

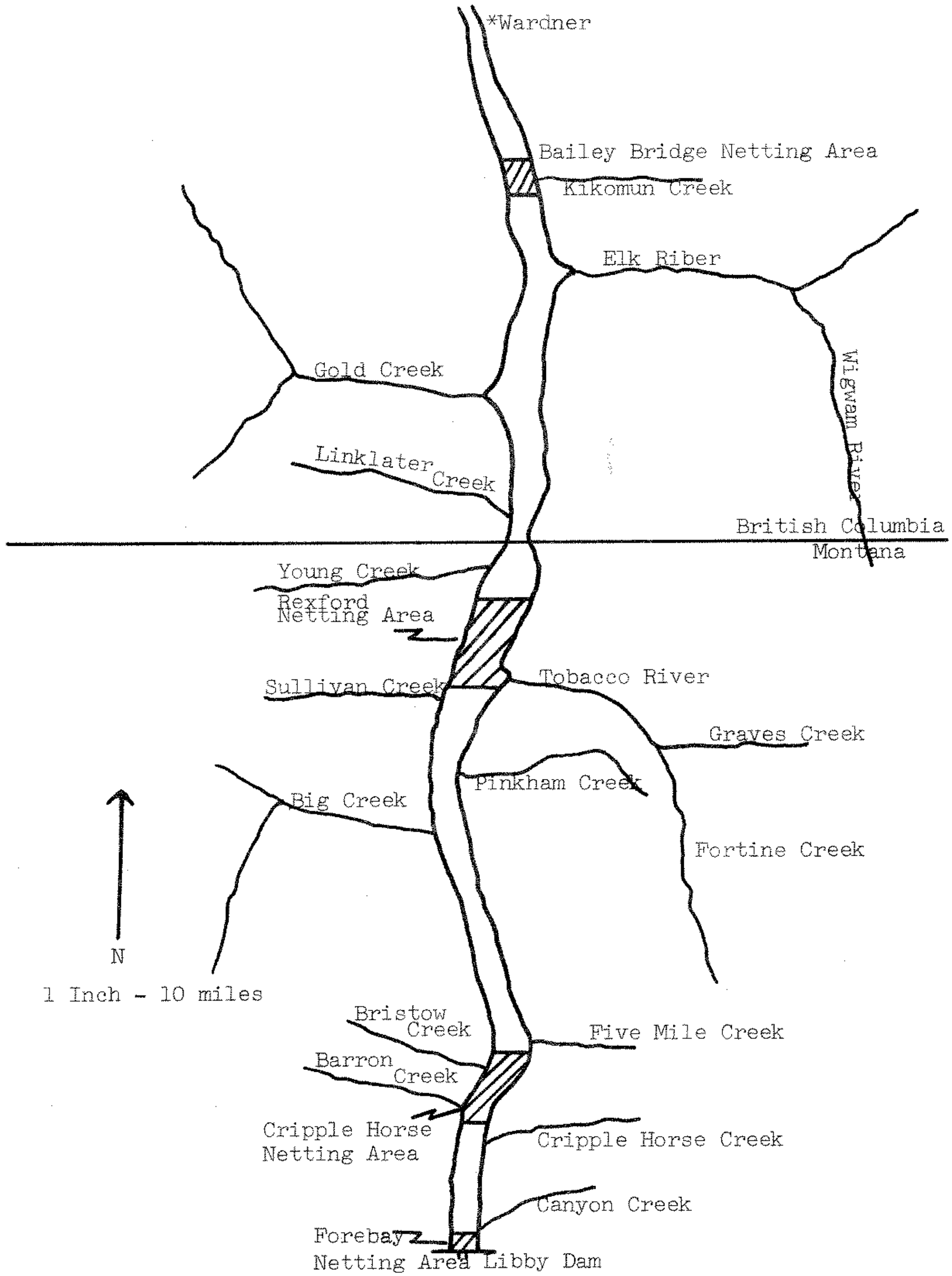

Figure 2. Map of Lake Koocanusa showing major tributaries and netting areas.

Nets were set at dusk and lifted at dawn. Based on information from Windell, et al. (1976), nets were checked during the middle of the night and trout removed when surface temperatures exceeded 54°F. Trout removed at night were killed immediately, an identification number placed in the mouth and placed on ice. Stomachs were removed the following morning.

Stomachs were placed individually in cheesecloth bags with the identification number and preserved in a mixture of methyl alcohol, formaldehyde and acetic acid. Information obtained on each fish at the time of stomach removal included: total length, weight, sex, state of sexual maturity, location by net or depth of capture and time of capture. Later, the stomachs were removed from the cheesecloth and the contents of each emptied into a plastic vial with preservative.

Analysis of stomach contents was done using three methods - numerical, volumetric and frequency of occurrence. All results will be expressed in percentages.

Plankton

Monthly plankton samples were taken to evaluate the nocturnal distribution of zooplankton in the Cripple Horse and Rexford areas. Vertical and horizontal plankton tows were taken at each site with a standard Wisconsin net.

For analysis, each sample was diluted depending on the density of zooplankton. Originally ten 1.0 ml. aliquots were removed from each diluted sample with a Hensen-Stempel pipette and counted in a Sedgewick-Rafter cell. Chi-square analysis on the March and April samples showed no measurable difference between the results of counting five aliquots and counting ten aliquots; therefore, only five aliquots were counted for all samples after April.

Benthos

Four benthos samples were taken monthly at each site. Samples were taken at various depths depending upon drawdown including one taken near the point of maximum drawdown. The February - April samples were taken with a one-half square foot Eckman dredge. Subsequent samples were obtained with a 1.0 square foot Peterson dredge.

FINDINGS

Spawning Population Trends

The number of spawning cutthroat trout ascending Young Creek was monitored (Table 2) and redd counts were conducted on nine tributaries (Table 3) including Young Creek. Redd counts were made at the end of the spawning season during the first part of June.

The number of cutthroat spawners in Young Creek increased from about 50 fish in 1970 (May & Huston, 1970) to approximately 750 fish in 1976 and 1977. The 1978 cutthroat redd count indicated that spawning intensity was higher in Big Creek and Canyon Creek than in previous years, about the same in Bristow

Creek, and considerable less in Pinkham, Young Creek, and Five Mile Creek than in 1977. The number of redds located in Young Creek was 441 in 1977 as compared to only 21 in 1978. These data indicate a large decline in numbers of spawners between the two years, although the difference is probably not as large as it appears. Redds were much easier to locate in 1977 than in 1978 due to the record low flows. In addition, the flows in 1978 were sufficiently high to obliterate redds dug in the smaller gravels in the meadow area where about 230 redds were observed in 1977. The apparently reduced run in 1978 was at least in part due to a hundred-year flood in January, 1974 (May & Huston, 1975) which caused extensive mortalities of fish in Young Creek. An Amish community of about 60 to 100 people is now residing along the banks of Young Creek and have greatly increased cattle and horse use in the riparian zone. This change in land use has had an adverse effect on bank stability and sediment loads.

Table 2. Summary of data from cutthroat trout spawning in Young Creek, 1974-1977.

Parameter	Year 1974	1975	1976	1977
Number trapped	229	281	692	679
Estimated number of spawners	305	290	750	750
Sex ratio (male:female)	1.0:1.6	1.0:2.7	1.0:4.8	1.0:3.3
Average length (male in inches)	13.7	14.7	15.4	15.6
Average length (female in inches)	14.2	14.7	15.3	15.6
Estimated fecundity in (thousands)	--	220	870	810

Table 3. Summary of cutthroat trout redd surveys in Lake Koocanusa tributaries, 1976-1978.

Stream	Location	Number Redds 1976	1977	1978
Pinkham	Lower six miles	N/A	231	135
Young	Lower seven miles	N/A	441	21
Canyon	Lower one mile	31	5 1/	48
Five Mile	Lower two miles	47	166	35
Bristow	Lower two miles	75	108	70
Cripple Horse	Lower three miles	33	33	N/A
Big	Drop Creek to West Fork	N/A	38	107
Fortine	Davis Creek to Sec. 29	0	10	N/A
Sullivan	Three miles	0	0	--

1/ Flows insufficient for fish passage

A summary of the spawning run monitoring conducted in British Columbia by British Columbia Fish and Wildlife Branch is presented in Table 4. Significant runs of westslope cutthroat were found in the Linklater, Kokomun and Gold Creek drainages. The actual number of spawners entering these streams is higher than indicated because traps were not 100 percent efficient. The Wigwam River was found to be a major spawning and nursery tributary for Dolly Varden with 434 being trapped in 1978. The data collected from tributaries in the Montana and British Columbia parts of Lake Koocanusa indicate spawning runs of westslope cutthroat have developed in most tributaries.

Table 4. Summary of fish trapping conducted on tributaries to Lake Koocanusa in British Columbia, Canada, 1975-1978.

Species	Life Stage	Linklater Creek	Plumlob Creek
	1975		
Westslope cutthroat	Spawners	145	3
Westslope cutthroat	Fry	1250	--
Westslope cutthroat	Smolts	48	--
Rainbow	Spawners	9	--
	1976		
		Kokomun Creek	Caven Creek (Gold Creek Trib)
Westslope cutthroat	Spawners	124	24
Westslope cutthroat	Smolts	8	63
Rainbow	Spawners	9	--
	1977		
		Gold Creek	
Westslope cutthroat	Spawners	476	
Westslope cutthroat	Smolts	7585	
Rainbow	Spawners	11	
Dolly Varden	Spawners	24	
	1978		
		Wigwam River	
Dolly Varden	Spawners	434	
Dolly Varden	Smolts	597	

Fish traps were operated in the mouth of the Tobacco River, Pinkham Creek and Young Creek during April of 1978 to monitor the spawning runs of rainbow trout. The catch in all traps was low. Rainbow trout were not caught in Pinkham Creek, only one was collected in Young Creek and 25 were taken in the Tobacco River. High flows in Tobacco River and Pinkham Creek precluded efficient sampling of the run.

Rainbow trout in the reservoir are produced almost entirely by natural reproduction or escapement from a British Columbia fish hatchery and have increased rapidly since 1975. An intensive survey should be conducted to determine the important streams utilized by rainbow as spawning and nursery areas in both Montana and British Columbia.

In-Reservoir Population Trends

Species composition data from Kootenai River collected by electrofishing and netting data collected in 1973, 1974, 1975, 1976 and 1978 are presented in Tables 5 through 9 and Appendix 1. These data show relative abundance of the species in different areas of the river and reservoir.

Peamouth catch rates were low in 1973 and 1974 and this correlated with electrofishing data from the river prior to impoundment which showed peamouth were quite rare. Electrofishing data also indicated that squawfish populations were comparatively low in the free-flowing river, yet the catch rate of squawfish was 6.1 fish per net in 1973. Squawfish were producing strong year classes in 1971 and 1972 in the area impounded from Libby Dam upstream approximately 10 miles. Redside shiners exhibited a population evolution similar to peamouth and squawfish, being relatively rare in the river, but increasing rapidly soon after the river was impounded. Only 1.3 shiners were caught per net in 1973 as compared to almost six per net in 1974 in the Cripple Horse and Rexford areas. Fall net catches in 1974 indicated that rainbow trout were more numerous in the lower part of the river than cutthroat trout with the reverse situation occurring in the river in Canada. These findings were in accord with electrofishing and creel census data collected prior to impoundment.

The spring bottom net series conducted in 1973 indicated that largescale suckers were the most abundant fish followed by mountain whitefish with Dolly Varden being present in fair numbers. The same relative abundance was indicated in electrofishing samples prior to impoundment.

Reservoir conditions during the fall netting series were quite similar among the areas from year to year (Table 7). The reservoir elevations were within five feet of full pool and surface water temperatures varied from 59° to 63°. Water transparencies as indicated by secchi disc readings were the most variable parameter, although the values were comparable within the reservoir for given years.

The fall rainbow trout catch rates increased markedly in all three areas from 1975-1978 (Figure 3) and (Table 8) with the increased from 1976 to 1978 being highly significant. The catch rate in 1978 at Cripple Horse (5.9 fish per net) was comparable to the Rexford catch rate (6.4 per net) but the Bailey Bridge catch rate of 3.5 fish per net was markedly lower than the other two areas. The data show that the population of rainbow trout has increased significantly throughout the reservoir with the lower 2/3 of the reservoir having the highest populations in the fall. The rainbow population is produced entirely by natural reproduction, except for the loss of an unknown number of fish annually from a hatchery on the Bull River in Canada.

The fall catch rates for cutthroat trout remained comparatively stable in the Rexford and Baily Bridge area. The catch rates in the Cripple Horse have

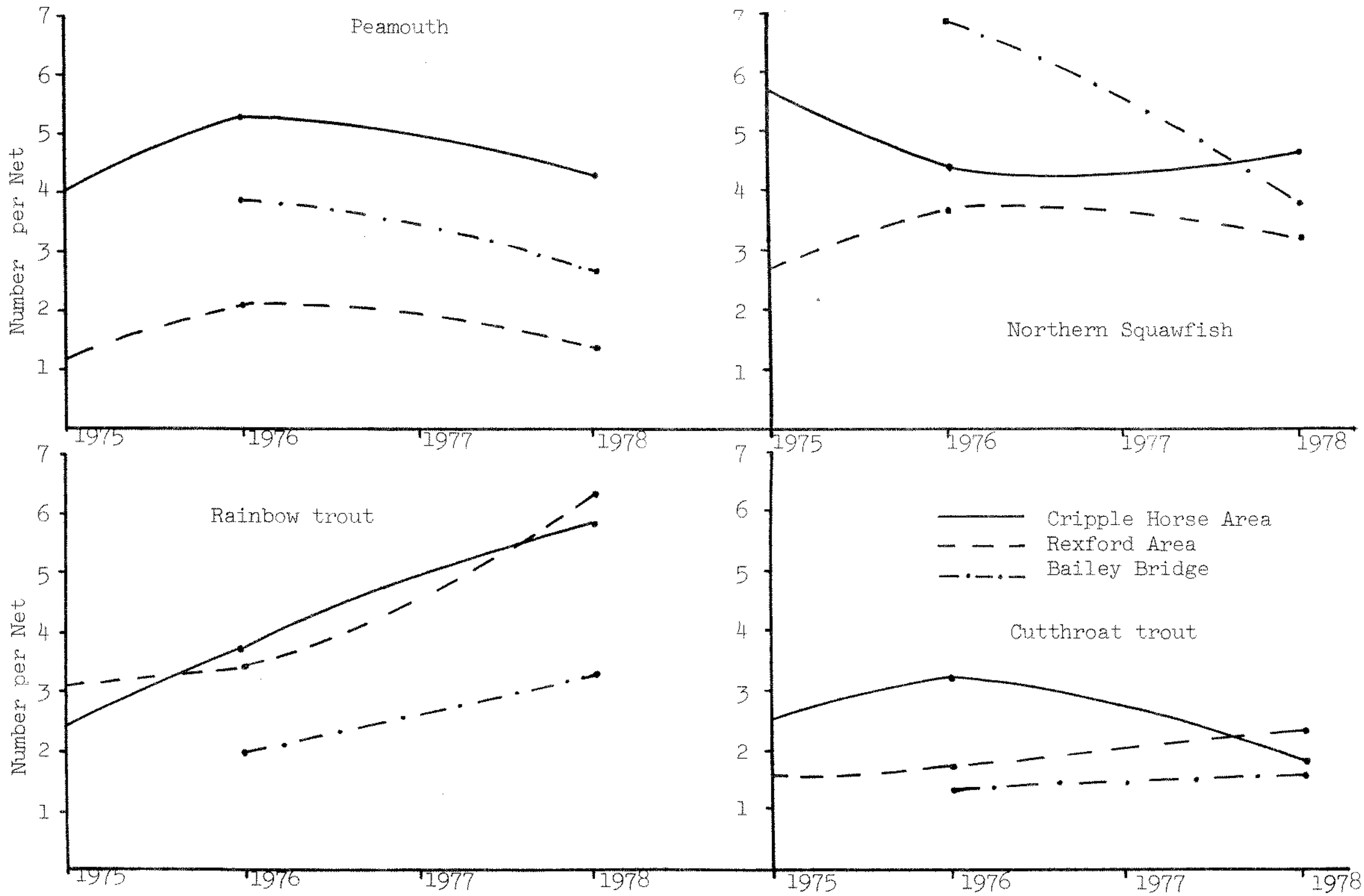

Figure 3. Average catch per net of rainbow and cutthroat trout, peamouth and squawfish, Cripple Horse, Rexford and Bailey Bridge sampling areas, 1975-1978.

Table 5. Number of fish by species collected by electrofishing from Kootenai River in 1969, 1970 and 1971 prior to impoundment.

Area	Number of Fish					
	Rb	Ct	DV	Mwf	Csu 1/	FSu
Cripple Horse	15	11	1	1,212	323	7
Rexford	1	7	4	361	96	23

1/ All suckers were not collected

Table 6. Summary of experimental gill net catches from Lake Koocanusa, 1973 and 1974.

Floating Nets

Area	Date	Number Nets	Mean catch per net					Water Elevation	Surface H_2O Temperature
			Ct	Rb	Sq	CRC	RsS		
All	10/ 4/73	16	4.3	3.3	6.1	--	1.3	2380	60
Cripple Horse	9/26/74	10	2.1	5.3	3.5	0.5	5.9	2458	62
Rexford	10/10/74	9	2.4	6.4	10.0	1.0	5.7	2446	57
Bailey Bridge	10/23/74	16	3.4	2.1	1.8	1.5	3.1	2434	57

Sinking Nets

Area	Date	Number Nets	DV	Mwf	Csu	FSu	Ling	Water Elevation	Surface H_2O Temperature
Cripple Horse	5/ 9/73	16	2.9	15.3	42.7	3.2	--	2258	47
Cripple Horse	9/26/74	12	0.6	4.1	44.3	0.2	--	2458	62
Rexford	10/10/74	12	3.2	5.4	12.0	3.3	--	2446	57

varied from 2.6 in 1975 to 3.2 in 1976 to a low of 1.8 in 1978. The catch rates for all three areas were quite similar in 1978 and were lower than the catch of rainbow trout. Overall the populations of cutthroat trout appear to have remained at the same level in the upper two areas of the reservoir and dropped in the Cripple Horse Area since 1976. Scale analysis from 1976 collections indicated that about 30-50 percent of the cutthroat were of hatchery origin.

Catch rates of cutthroat and rainbow varied from season to season in 1977 (Figure 4). Cutthroat densities appeared to be highest in Rexford in the winter and lowest in Rexford in the summer. Catch rates were comparable in the spring and summer between Rexford and Cripple Horse areas. Rainbow catch rates were not significantly different between these two areas during the year, although the winter catch rate appeared to be higher in Rexford than in Cripple Horse. It is surmised that trout are concentrated in the Rexford area in the winter because of the movement of fish from the upper reservoir areas during drawdown and possibly higher plankton density than the Cripple Horse area.

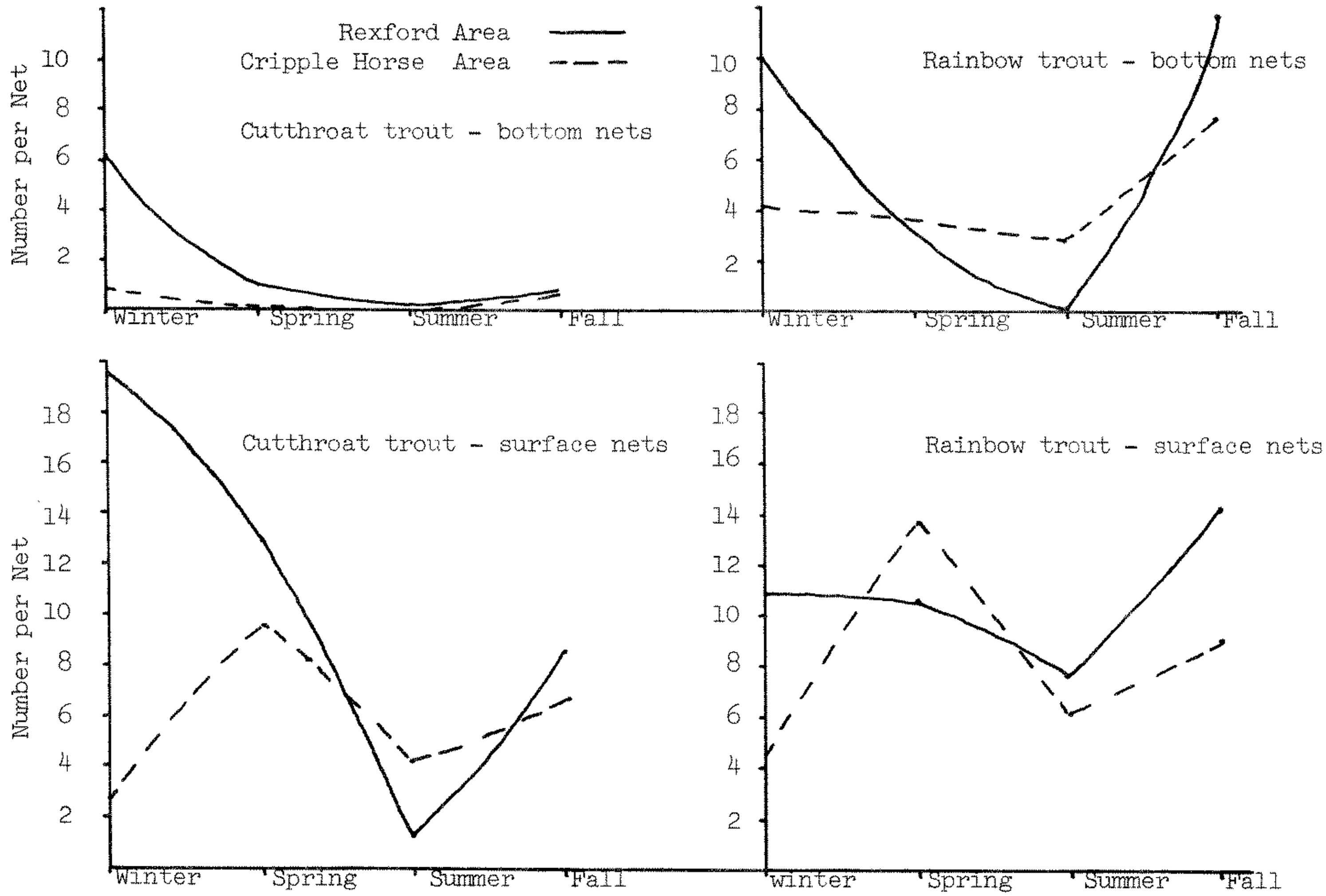

Figure 4. Average catch per net of rainbow and cutthroat trout from 250 foot long surface and bottom gill nets, Cripple Horse and Rexford sampling areas, 1977.

Table 7. Reservoir elevations, water temperatures and secchi disc readings during netting series in Lake Koocanusa.

Area	Date	Reservoir Elevation MSL	Secchi Disc in Feet	Water Temperature in F° 5	25 Feet	50 Feet
			Spring Series			
Rexford	6/ 8/75	2358	1.7	55	51	50
Rexford	5/18/76	2370	--	54	50	48
Rexford	5/17/78	2370	3.3	52	51	50
			Fall Series			
Bailey Bridge	9/28/76	2457	29.7	63	61	54
Bailey Bridge	9/26/78	2456	20.8	61	58	54
Rexford	9/24/75	2454	16.4	60	59	59
Rexford	9/23/76	2458	23.1	62	61	60
Rexford	9/21/78	2457	18.8	60	60	60
Cripple Horse	9/30/75	2454	19.1	61	60	60
Cripple Horse	9/22/76	2458	23.1	63	62	61
Cripple Horse	9/19/78	2458	24.8	59	59	57

Table 8. Kruskal-Wallis Ranking Test of surface gill net catches from Lake Koocanusa in fall 1975, 1976 and 1978.

Species	Mean Net Catch 1975	1976	1978	Chi^2 Value 1975 vs 1976	Chi^2 Value 1976 vs 1978
Rainbow trout	2.46	3.74	5.88	7.69**	12.30**
Cutthroat trout	2.46	3.19	1.80	4.10*	14.55**
Peamouth	4.03	5.32	4.32	0.62	1.44
Squawfish	5.79	4.45	4.68	5.91*	0.06
		REXFORD AREA			
Rainbow trout	3.03	3.45	6.40	0.76	19.71**
Cutthroat trout	1.63	1.77	2.40	0.01	2.74
Peamouth	1.26	2.14	1.43	0.36	0.26
Squawfish	2.74	3.70	3.22	2.25	0.29
		BAILEY BRIDGE AREA			
Rainbow trout		2.00	3.35		8.37**
Cutthroat trout		1.51	1.65		0.88
Peamouth		3.96	2.70		2.80
Squawfish		6.94	3.80		5.26*

* Significant difference at the 95 percent level
** Significant difference at the 99 percent level

The length-frequency distribution of rainbow and cutthroat trout, peamouth and squawfish are shown in Figures 5, 6 and 7, while condition factors are listed in Table 9. Rainbow trout lengths have remained relatively constant from year to year from the three sampling areas. Fish in the 14.0-16.9 inch range have comprised the majority of the catch. The average length and condition factors have varied little from year to year. Cutthroat trout length-frequency distribution from the Cripple Horse and Bailey Bridge areas indicated that a greater proportion of the population was smaller than 11 inches in 1978 than in previous years. These fish would all be wild stock since survivors of the last plant in 1976 would all be larger than 11 inches. Evidently, recruitment of wild cutthroat trout has been comparatively good since planting ceased. Condition factors did not change significantly from year to year.

Peamouth catch rates (Figure 3) have varied little in the Cripple Horse and Rexford areas from 1975 to 1978. Catch rates increased from 1975-76 but then decreased in 1978 to about the same rate as recorded in 1975. The Bailey Bridge area showed a significant drop in catch rate from 1976-1978. Catch rates were highest in the Cripple Horse area, lowest in the Rexford area and intermediate in the Bailey Bridge area. A marked change occurred in the size distribution of the catch from 1975 to 1978 in the Cripple Horse area. Approximately 15 percent of the catch in 1978 was over 10 inches as compared to none in 1975. Peamouth were rare in the Kootenai River prior to impoundment and the older and larger year classes were not present in 1975. Peamouth appear to have had several strong year classes when the river was first impounded and apparently reached the carrying capacity of the available habitat as populations have remained stable since 1975. Heaton (1961) found that the fish populations in the section of the Missouri impounded by Canyon Ferry Dam in 1953 had expanded to fill the new environment by 1955. Patriarche and Campbell (1957) concluded that the populations of small fish in Clearwater Reservoir were established within the first three years after impoundment and the population of larger fish had apparently reached the carrying capacity of the reservoir within five years.

Northern squawfish catch rates were comparatively stable in the Rexford area ranging from 2.7 fish per net in 1975 to high of 3.7 in 1976 and down to 3.2 fish in 1978. Catch from Cripple Horse was 5.8 fish in 1975, declining to 4.5 fish per net in 1976 and 4.7 in 1978. The catch of 6.9 fish per net in 1976 in the Bailey Bridge area was the highest recorded for all areas, but the catch dropped significantly in 1978 to 3.8 fish per net. The population of squawfish in the Cripple Horse and Rexford areas appear to have been comparatively stable from 1975-78, but have dropped markedly in the Bailey Bridge area from 1976 to 1978. The low water elevations throughout 1977 dewatered considerable area in the British Columbia portion of the reservoir and may have had a depressing affect on the squawfish populations. Fish under ten inches in length comprised markedly less proportion of the catch in 1978 than in previous years in the Bailey Bridge and Rexford areas. A similar pattern existed for fish under eight inches in length in the Cripple Horse area. These changes in population structure suggest that reproduction and recruitment of squawfish have been comparatively low since 1976. Squawfish numbers, initially low in the river, expanded rapidly in the uncrowded reservoir environment and appeared to have approached the carrying capacity of 1975. Condition factors have changed little from year to year although the average size increased markedly in the Rexford and Bailey Bridge areas, indicating that the population was of older fish in 1978 than 1974 or 1975.

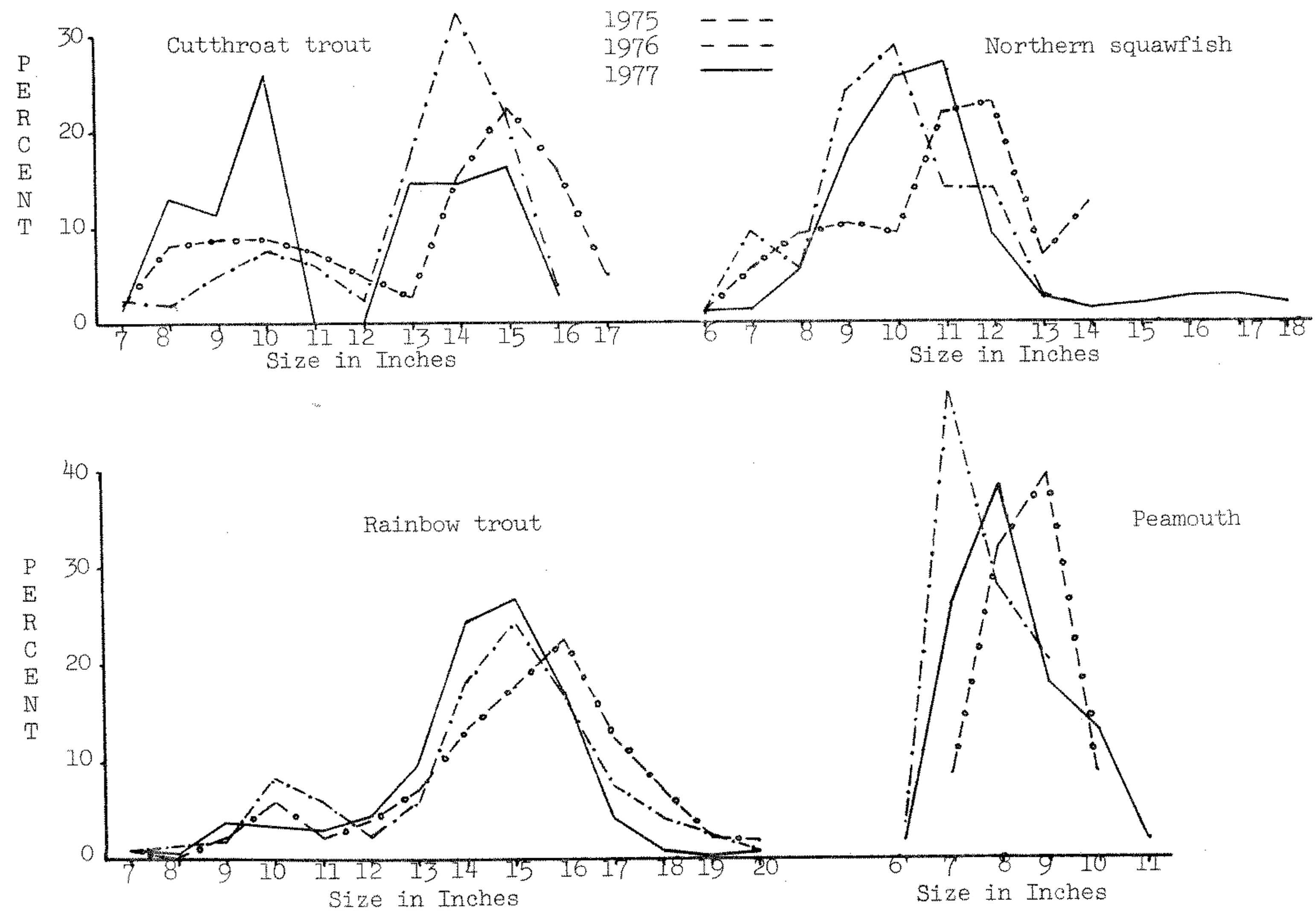

Figure 5. Length frequency distribution of cutthroat and rainbow trout, northern squawfish and peamouth caught by surface gill nets from Cripple Horse area, Lake Koocanusa, 1975 through 1978.

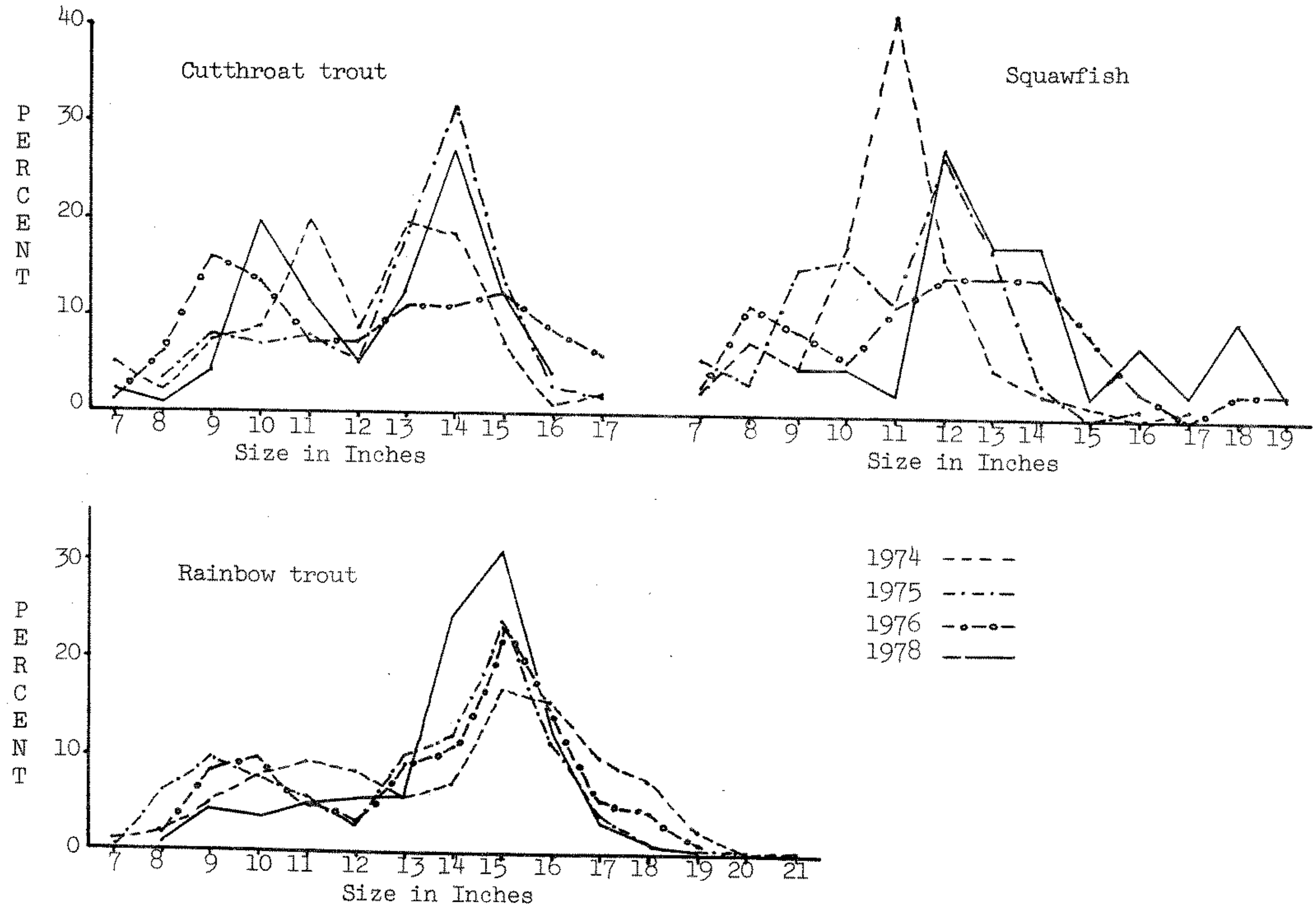

Figure 6. Length frequency distribution of cutthroat and rainbow trout and northern squawfish caught by surface gill nets from Rexford area, Lake Koocanusa, 1974 through 1978.

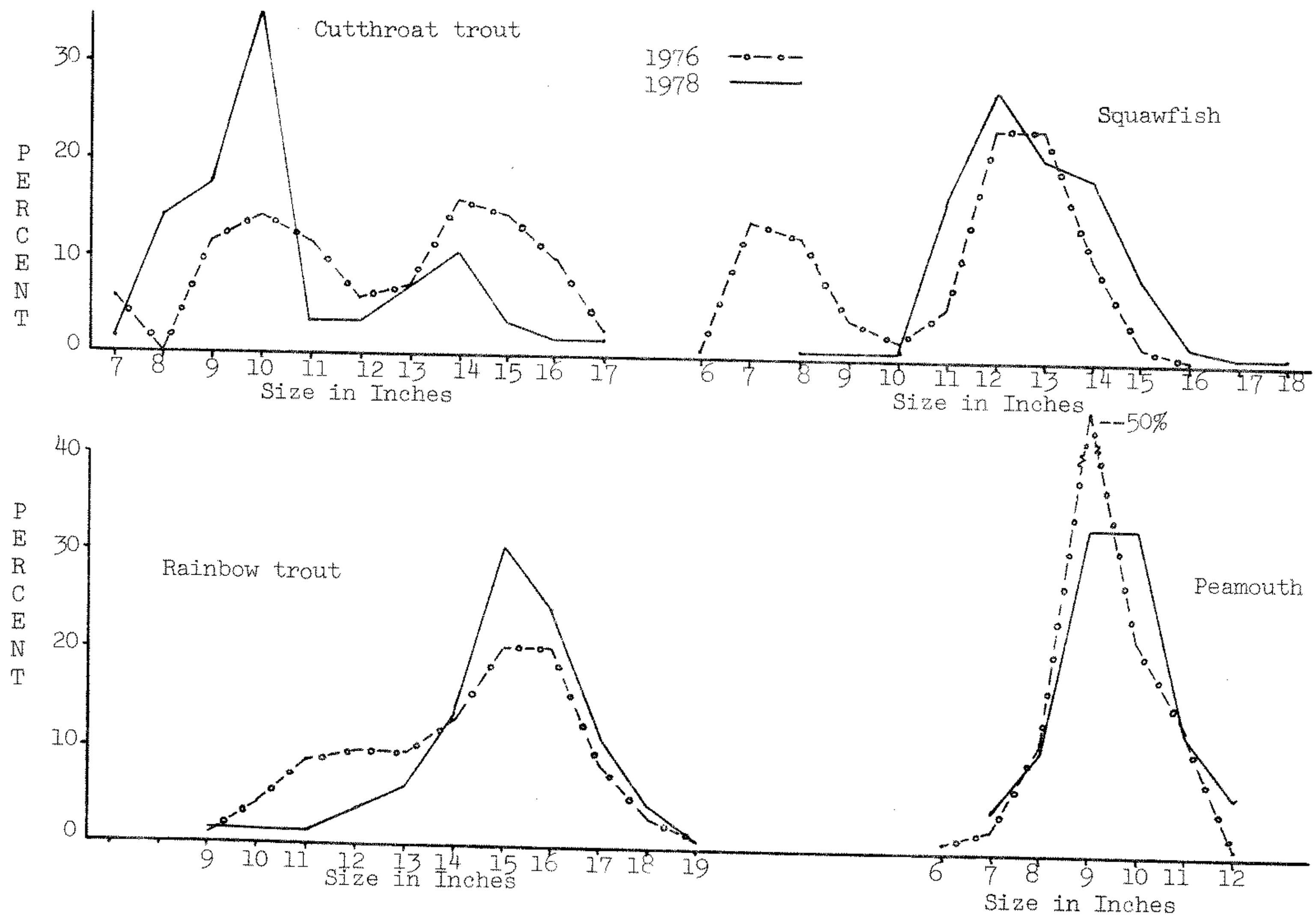

Figure 7. Length frequency distribution of cutthroat and rainbow trout, northern squawfish and peamouth caught by surface gill nets from Bailey Bridge area, Lake Koocanusa, 1976 and 1978.

Table 9. Lengths (inches), weights (pounds) and condition factors of cutthroat and rainbow trout, squawfish and peamouth, fall netting, Lake Koocanusa, 1974-1978.

Year	Species	Number	Average Length	Average Weight	Range in Length	Condition Factor
			Cripple Horse Area			
1975	Ct	159	13.5	1.02	6.0-16.8	38.4
1976	Ct	150	13.4	1.03	7.5-17.4	38.0
1978	Ct	62	12.1	0.75	7.5-16.6	37.7
1975	Rb	168	14.8	1.28	7.5-20.4	37.3
1976	Rb	178	15.4	1.43	7.5-20.2	37.2
1978	Rb	100	14.6	1.16	7.6-22.2	36.2
1975	CRC	82	8.2	.18	6.8- 9.5	32.6
1976	CRC	91	8.9	.23	7.1-10.9	31.5
1978	CRC	114	8.6	.22	6.7-11.1	32.3
1975	Sq	103	10.3	.39	7.0-14.3	32.6
1976	Sq	88	11.4	.54	6.2-16.3	32.7
1978	Sq	146	11.4	.58	7.7-19.2	33.7
			Rexford Area			
1974	Ct	179	12.4	.80	6.0-18.8	38.1
1975	Ct	114	13.3	.97	8.1-17.4	38.7
1976	Ct	82	12.6	.84	7.5-17.7	37.2
1978	Ct	96	12.9	.89	7.6-16.9	38.3
1974	Rb	237	14.2	1.24	6.5-21.1	38.1
1975	Rb	213	13.6	1.04	7.6-20.2	37.7
1976	Rb	153	14.2	1.16	8.5-23.1	36.9
1978	Rb	257	14.6	1.17	8.6-19.4	36.6
1974	Sq	80	11.3	.55	7.4-17.9	35.3
1975	Sq	87	11.4	.54	6.9-16.7	33.4
1976	Sq	35	12.5	.79	7.1-19.8	33.3
1978	Sq	40	14.0	1.06	9.9-19.5	34.8
			Bailey Bridge Area			
1977	Ct	70	12.6	.85	6.7-17.2	37.1
1978	Ct	66	11.1	.61	7.9-17.0	39.8
1977	Rb	93	14.7	1.24	9.4-19.5	37.0
1978	Rb	134	15.5	1.42	9.5-19.2	37.3
1977	Sq	143	11.5	.60	6.8-16.1	34.8
1978	Sq	152	13.3	.85	8.5-20.0	34.6
1977	CRC	87	9.7	.31	6.7-12.7	32.8
1978	CRC	108	10.1	.35	7.7-12.4	33.0

Redside shiners catch rates (Figure 8) increased markedly from 1975 to 1976 in the Cripple Horse area, then leveled off. In contrast, shiner catches dropped steadily in the Bailey Bridge area from 1974 (3.1 fish per net) to 1978 (1.8 fish per net). The catch rates in the Rexford area were more variable, but showed a decrease from 1974 (5.9 fish per net) to 1978 (3.1 fish per net). It appears that shiners also filled the available habitat in the reservoir by 1975. The extended drawdown in 1977 probably had an adverse affect on shiner populations and accounts for their reduced catch rate in 1978. Shiners are most generally found in shallow shoreline habitat which was greatly reduced by the drawdown.

The catch rates for largescale and longnose suckers, mountain whitefish and Dolly Varden from the spring sampling in the Rexford area are summarized in Figure 9 and Table 10. Dolly Varden and whitefish were common in the Kootenai River prior to impoundment and have shown a slightly increasing trend from 1975 through 1978 in the reservoir. Differences from year to year were not statistically significant. Dolly Varden and mountain whitefish catch rates increased by 33 and 10 percent (respectively) during this period. The catch rate of ling increased by over 500 percent from 1975-1978 but catch rates are still too low to compare statistically.

Table 10. Kruskal-Wallis Ranking Test of bottom gill net catches from Lake Koocanusa in spring 1975, 1976 and 1978.

Species	Mean Net Catch 1975	Mean Net Catch 1976	Mean Net Catch 1978	Chi^2 Value 1975 vs 1976	Chi^2 Value 1976 vs 1978
Dolly Varden	1.44	1.91	2.18	0.91	2.34
Mountain whitefish	6.56	6.35	7.18	0.47	2.15
Largescale suckers	37.32	26.05	23.46	8.23**	0.02
Longnose suckers	7.86	11.14	9.13	16.37**	4.20*

* Significant difference at the 95 percent level
** Significant difference at the 99 percent level

The size distribution of the mountain whitefish catch was dominated by fish in the 10-12.9 class in 1975 with few fish under 9.9 inches (Figure 10). The 1978 catch was comprised primarily of 7.0-9.9 and 12.0-13.9 inch fish with comparatively few 10.0-11.9 fish. The Dolly Varden size distribution has shown a tendency towards more fish over 17.0 inches and less under 9.9 from 1975 to 1978. The paucity of smaller Dolly Varden in the 1978 catch is probably related to small spawning runs prior to 1978. Dolly Varden usually do not spawn until they are at least 5-6 years old.

The average size of Dolly Varden has increased from 12.6 inches in 1975 to 15.1 inches in 1978 (Table 11). Condition factors have remained relatively stable. The largest fish netted was 28.0 inches in length and weighed 8.80 pounds.

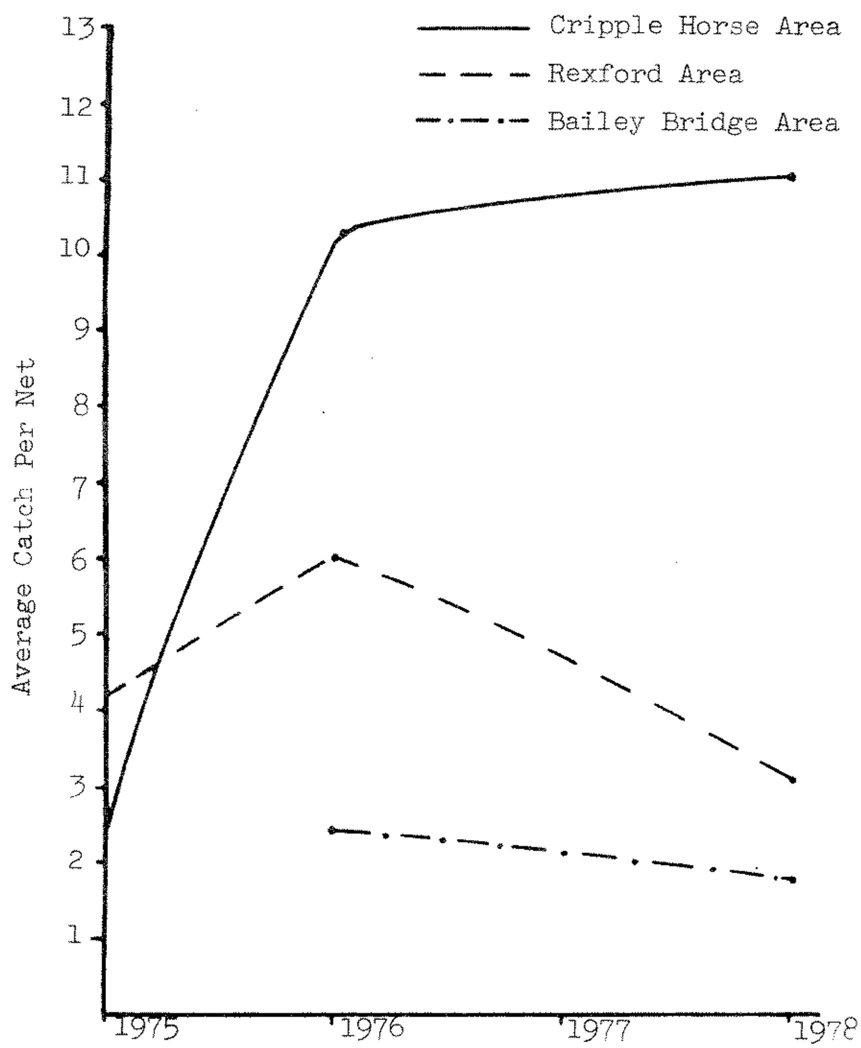

Figure 8. Catch per surface net of redside shiners, Lake Koocanusa, 1975 through 1978.

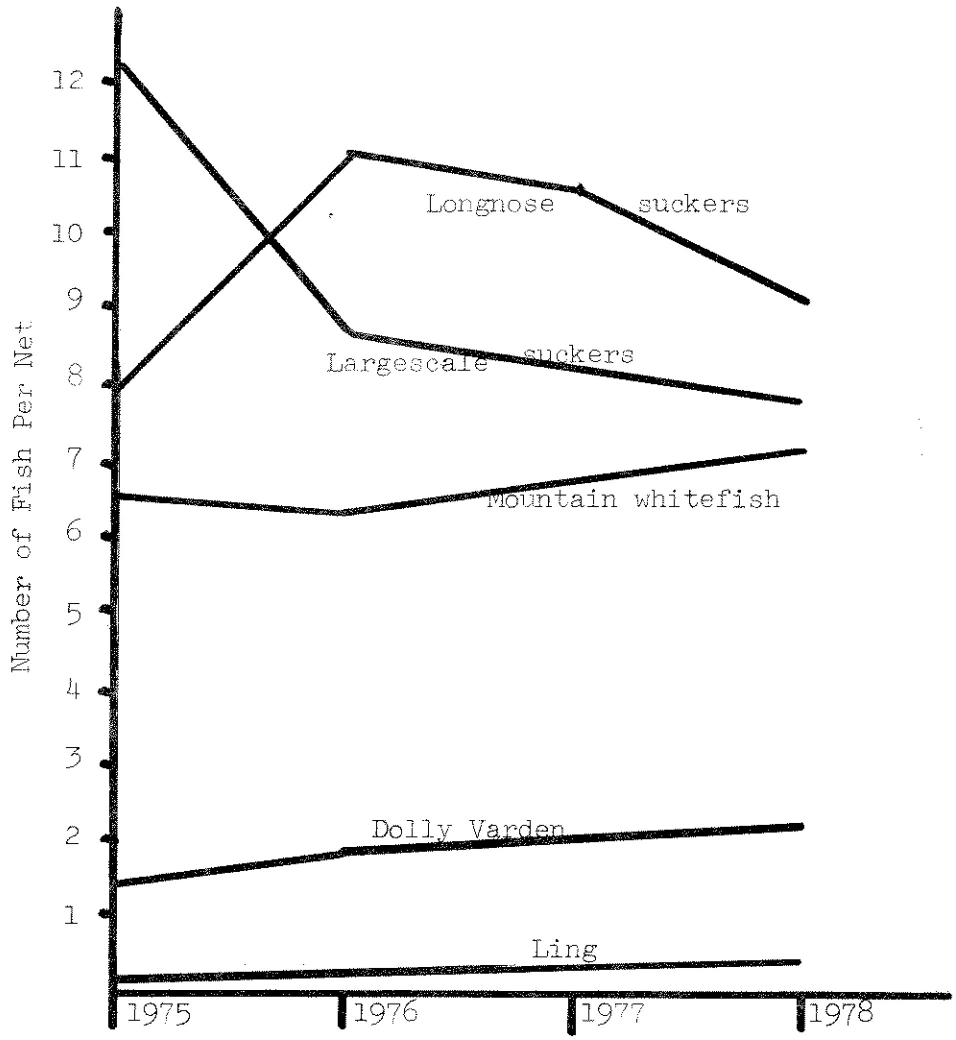

Figure 9. Average catch per bottom gill net of ling, Dolly Varden, mountain whitefish, largescale and longnose suckers, spring sampling at Rexford area, Lake Koocanusa, 1975 through 1978.

Table 11. Lengths (inches), weight (pounds) and condition factors of Dolly Varden, mountain whitefish, largescale and longnose suckers, Rexford area of Lake Koocanusa, 1975-1978.

Year	Species	Number	Average Length	Average Weight	Range in Length	Condition Factor
1975	DV	152	12.6	.74	6.5-19.5	31.3
1976	DV	82	13.6	.94	9.1-28.0	21.4
1978	DV	83	15.1	1.43	10.4-21.8	33.3
1975	MWf	338	11.4	.47	8.0-15.7	30.6
1976	MWf	229	11.6	.50	7.1-14.9	32.0
1978	MWf	174	10.8	.43	6.8-14.7	30.7
1975	CSu	270	10.0	.46	5.9-22.3	37.9
1976	CSu	180	11.1	.61	6.1-22.1	36.8
1978	CSu	273	12.2	.72	7.3-21.6	35.8
1975	FSu	102	11.1	.56	6.5-15.9	37.3
1976	FSu	103	12.5	.84	6.7-15.1	40.6
1978	FSu	70	12.5	1.03	7.5-15.8	41.1

The catch rates of largescale suckers have exhibited a steadily decreasing trend from a high of 37.3 fish per net in 1975 to low of 23.5 fish in 1978. The difference in catch rates from 1975 to 1976 was highly significant. The size distribution has also changed from 1975-1978 (Figure 10). Fish in the 6-8 inch class dropped from about 36 percent in 1975 to 2 percent in 1978. Largescale suckers were abundant in the river prior to impoundment and produced strong year classes the first years after impoundment. The average size of the catch has increased from 10.0 inches in 1975 to 12.2 in 1978, indicating a shift towards older and larger fish.

The catch rates of longnose suckers have also varied considerably from year to year ranging from 7.9 fish per net in 1975 to 11.1 in 1976 and 9.1 in 1978. The catch rates were significantly different all three years. The size distribution of the catch has shifted towards larger fish over 13 inches in total length (Figure 10). Fish in the 13.0-15.9 inch length group comprised 77 percent of the catch in 1978 as compared to only about 15 percent in 1975.

Age and Growth

Growth data for rainbow trout from Kootenai River and Lake Koocanusa are presented in Table 12. Growth rates of fish in the impoundment has been much faster than that of rainbow in the river prior to impoundment. Low aquatic insect production caused by Canadian-source pollution (Bonde, 1972) may have limited growth rates of fish in Kootenai River. The growth data also suggests that rainbow trout spawned in tributary streams rear in those streams for up to two years before smolting downstream into the reservoir. The growth data presented in Table 12 is

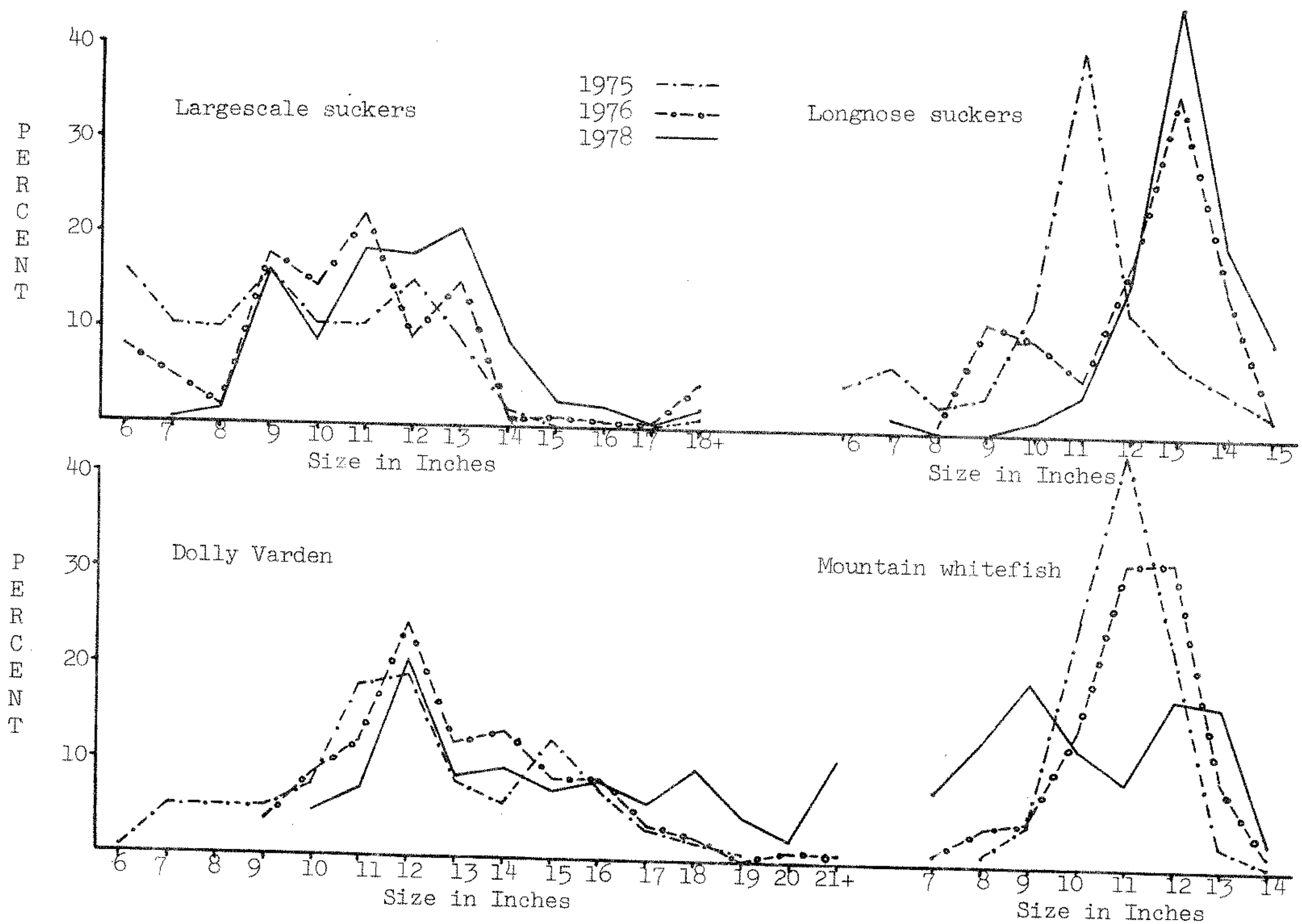

Figure 10. Length frequency distribution of largescale and longnose suckers, Dolly Varden and mountain whitefish caught in bottom gill nets, Rexford area of Lake Koocanusa in 1975, 1976 and 1978.

divided into fish thought to have emigrated to the reservoir after one year (migration Class X_1) and after two years (migration Class X_2) of rearing in the stream.

Table 12. Growth of rainbow trout from Kootenai River and Lake Koocanusa by migration-class and year-class.

Year Class	Length in Inches at Age 1	2	3	4	5
	Kootenai River-Migration Class Unknown				
Combined	3.3(15)*	7.4(10)	11.0(8)	14.9(4)	--
	Lake Koocanusa Migration Class X_2				
1971	2.6(27)	11.1(27)	14.6(27)	16.8(1)	--
1972	2.8(43)	11.3(44)	15.8(11)	15.9(1)	--
1973	3.0(72)	11.2(70)	15.6(22)	18.8(2)	--
1974	2.8(35)	10.7(46)	14.4(14)	16.9(6)	--
1975	2.4(26)	10.9(34)	14.6(29)	--	--
1976	2.4(40)	11.4(102)	--	--	--
Combined	2.7(293)	11.2(323)	14.9(103)	17.2(10)	--
	Lake Koocanusa Migration Class X_2				
1972	2.0(8)	4.5(19)	12.2(16)	--	--
1973	2.0(8)	4.3(26)	13.7(3)	16.5(3)	19.0(1)
1974	2.1(12)	4.7(12)	11.9(12)	14.7(6)	--
1975	2.0(44)	4.7(44)	11.8(23)	--	--
1976	2.0(18)	4.8(18)	--	--	--
Combined	2.0(90)	4.6(119)	12.0(54)	15.3(9)	19.0(1)

* Number in parenthesis is sample size

Growth rates of rainbow trout in Lake Koocanusa have been good with fish reaching an acceptable size for angler harvest after spending one year in the impoundment. Rainbow trout from Canyon Ferry Reservoir (Heaton, 1961)averaged about 2 inches larger at a comparable age, while rainbow trout from Snake River impoundments (Irving and Culpin, 1956) averaged smaller.

Growth rates calculated from adult cutthroat trout spawning in Young Creek are thought to be representative of cutthroat inhabiting the entire reservoir. These growth data are presented in Table 13 and include fish from the Kootenai River prior to impoundment and fish from the impoundment. Studies on the life cycle of cutthroat trout spawning and rearing in Young Creek have demonstrated that cutthroat rear from one to three years in the stream before emigrating into the reservoir. Growth data for cutthroat collected in Young Creek prior to impoundment is presented by spawning run year while growth of fish from the reservoir is presented by year class and migration class.

Table 13. Growth of adult cutthroat trout collected from Young Creek before and after impoundment of Kootenai River.

Spawning Year	Length in Inches at Age					
	1	2	3	4	5	6
			Pre-Impoundment			
1971	2.2(39)*	5.1(39)	9.5(39)	12.7(35)	14.8(2)	--
1972	2.1(52)	5.1(52)	10.3(52)	12.9(37)	14.9(12)	--
Year Class			Post-Impoundment Migration Class X_1			
1970	2.0(10)	7.2(3)	12.4(5)	13.2(4)	--	--
1971	2.2(83)	8.4(6)	12.7(6)	15.3(6)	17.1(1)	--
1972	2.3(37)	10.6(11)	14.3(11)	16.2(1)	16.2(1)	17.0(1)
1973	2.2(57)	11.3(12)	14.4(12)	15.8(1)	--	--
Combined	2.2(187)	10.1(32)	13.8(34)	13.7(12)	16.7(2)	17.0(1)
			Migration Class X_2			
1970	2.1(124)	4.6(124)	11.2(75)	14.0(75)	14.3(9)	--
1971	2.1(123)	4.4(123)	12.4(80)	15.0(80)	16.4(8)	--
1972	2.2(134)	4.5(134)	12.6(56)	14.9(56)	17.2(18)	--
1973	2.5(44)	4.5(44)	12.8(66)	15.1(66)	--	--
Combined	2.2(425)	4.5(425)	12.2(277)	14.8(277)	16.4(35)	--
			Migration Class X_3			
1970	2.1(3)	3.8(82)	6.1(82)	12.4(38)	14.9(38)	16.2(10)
1971	1.9(87)	3.9(87)	6.2(87)	13.4(22)	15.5(22)	17.5(13)
1972	2.5(58)	4.5(58)	6.7(58)	13.2(65)	15.3(65)	--
1973	--	--	6.6(20)	12.4(20)	--	--
Combined	2.1(148)	4.0(227)	6.3(247)	12.9(145)	15.2(125)	16.9(23)

* Number in parenthesis is size of sample

Growth rates of cutthroat trout after impoundment were considerably faster than before impoundment. It was presumed that most of the fish collected prior to impoundment were from migration class X_2 (X is total age while 2 is smolting age) and would be most comparable to post-impoundment migration class X_2. Data in Table 13 shows that cutthroat trout growth rates after impoundment are almost a year ahead of similar aged fish from pre-impoundment times. Growth of cutthroat trout in Lake Koocanusa was faster than that recorded by Huston (1969) for cutthroat in Hungry Horse Reservoir and by Averett and MacPhee (1971) in Coeur d'Alene Lake.

Growth of Dolly Varden prior to impoundment of the Kootenai River was not determined. Growth data presented in Table 14 indicates that age class 3_2 (total age of 3 years and smolting age of 2 years) growth during their first year in the reservoir has increased from 1974 through 1978. The small sample size precludes determining other changes in growth rates of Dolly Varden.

Table 14. Growth of Dolly Varden from Lake Koocanusa.

Year Class	Total Length in Inches at Age						
	1	2	3	4	5	6	7
			Migration Class X_2				
1971	2.8(10)*	5.2(10)	9.4(10)	13.6(2)	--	--	--
1972	2.7(32)	5.1(32)	9.1(27)	13.0(24)	17.1(3)	20.0(3)	--
1973	2.7(18)	5.2(18)	10.1(18)	13.6(5)	16.3(5)	--	--
1974	2.8(9)	5.5(9)	10.2(9)	14.4(9)	--	--	--
1975	2.9(14)	5.5(14)	10.7(14)	--	--	--	--
Combined	2.8(83)	5.2(83)	9.8(78)	13.4(40)	16.6(8)	20.0(3)	--
			Migration Class X_3				
1971	2.6(30)	4.6(30)	6.8(30)	11.1(12)	14.3(8)	17.8(1)	20.4(1)
1972	2.4(19)	4.5(19)	6.8(19)	11.1(17)	15.7(7)	18.7(7)	--
1973	2.5(17)	4.4(17)	7.1(17)	11.9(14)	15.1(14)	--	--
1974	2.6(13)	4.5(13)	6.8(13)	11.3(13)	--	--	--
Combined	2.5(79)	4.5(79)	6.9(79)	11.3(56)	15.0(29)	18.6(8)	20.4(1)

* Number in parenthesis is size of sample

Growth of mountain whitefish during the first three years of life in the reservoir was faster than prior to impoundment (Table 15). River residents growth caught up to reservoir growth at age four and five and at age six, river fish averaged longer than reservoir fish. Several factors account for these differences in growth rates. Large zooplankton populations in the reservoir enabled the whitefish to initially grow more rapidly than river fish, but large aquatic insects which older river fish fed on almost exclusively (May and Huston, 1975) were absent from the reservoir and thus older-aged whitefish growth slowed because they had to feed primarily on zooplankton.

Angler Harvest and Movement Patterns of Westslope Cutthroat Trout

Return of tags by anglers from cutthroat trout tagged at Young Creek has provided information on exploitation (Table 16) and movements (Figure 11). Exploitation has ranged from 3.9 percent for fish tagged in 1977 to 11.8 percent of fish tagged in 1974. The higher harvest rate of 1974 tagged fish was due in part to the movement of large numbers of cutthroat downstream out of the reservoir in the summer and fall of 1974. Fourteen of the 37 tag returns of fish tagged in 1974 were caught in Kootenai River below Libby Dam. It is expected that the rate of return for fish tagged in 1977 will increase with time as data shown in Table 16 indicate tagged fish are available for angler capture at least four years after tagging. Overall angler harvest of tugged cutthroat trout from Young Creek was low regardless of where they were caught.

Angler returns indicated that cutthroat trout leaving Young Creek tended to migrate downstream towards the dam rather than upstream. The annual drawdown

Table 15. Growth of mountain whitefish before and after impoundment of Kootenai River.

Year Class	Total Length in Inches at Age 1	2	3	4	5	6
1964[1/]	3.5(17)*	5.9(17)	8.4(17)	10.4(17)	12.1(17)	15.0(11)
1965[1/]	3.9(25)	6.8(25)	9.1(25)	11.1(25)	13.3(21)	14.9(7)
1966[1/]	3.7(24)	7.2(24)	9.5(24)	11.5(15)	12.8(10)	--
1967[1/]	4.2(26)	7.4(26)	9.8(20)	12.1(11)	--	--
Combined	3.9(92)	6.9(92)	9.2(86)	11.2(68)	12.8(48)	15.0(18)
1971[2/]	3.7(23)	7.9(23)	10.2(23)	11.2(31)	--	--
1972[2/]	4.2(30)	8.8(30)	10.1(45)	12.5(22)	13.1(3)	14.3(3)
1973[2/]	4.3(9)	8.5(15)	11.3(36)	12.1(16)	13.2(16)	--
1974[2/]	3.8(15)	8.7(27)	11.0(22)	12.5(22)	--	--
1975[2/]	3.7(17)	8.5(22)	10.7(22)	--	--	--
1976[2/]	3.6(40)	8.7(40)	--	--	--	--
Combined	3.8(134)	8.6(157)	10.6(148)	12.0(91)	13.2(19)	14.3(3)

* Number in parenthesis is size of sample

1/ Pre-impoundment year class

2/ Post-impoundment year class

Table 16. Angler harvest of westslope cutthroat trout tagged at Young Creek Fish Trap, 1973-77.

Year Tagged	Number Tagged	Number of Tags Returned Each Year 1973	1974	1975	1976	1977	1978	Total	Percent Exploitation
				Angler Harvest					
1973	237	2	10	--	--	1	--	13	5.5
1974	313	--	6	16	12	2	1	37	11.8
1975	578	--	--	12	12	22	3	59	8.7
1977	663	--	--	--	--	21	5	26	3.9

has a great influence on cutthroat movements as it tends to concentrate fish in the lower half of the reservoir due to dewatering in British Columbia. The minimum pool elevation of 2287 exposes the reservoir except for the river channel from about Rexford upstream. The upper half of the reservoir is severely dewatered in most years from December into June. Surface water temperatures above 62° in hot summers appear to trigger movement of cutthroat into the deeper and cooler waters in the lower part of the reservoir. The number of cutthroat caught below Libby Dam has dropped markedly since 1975. The selective withdrawal system was utilized in 1977 and 1978 to select water from depths where game fish species were not concentrated.

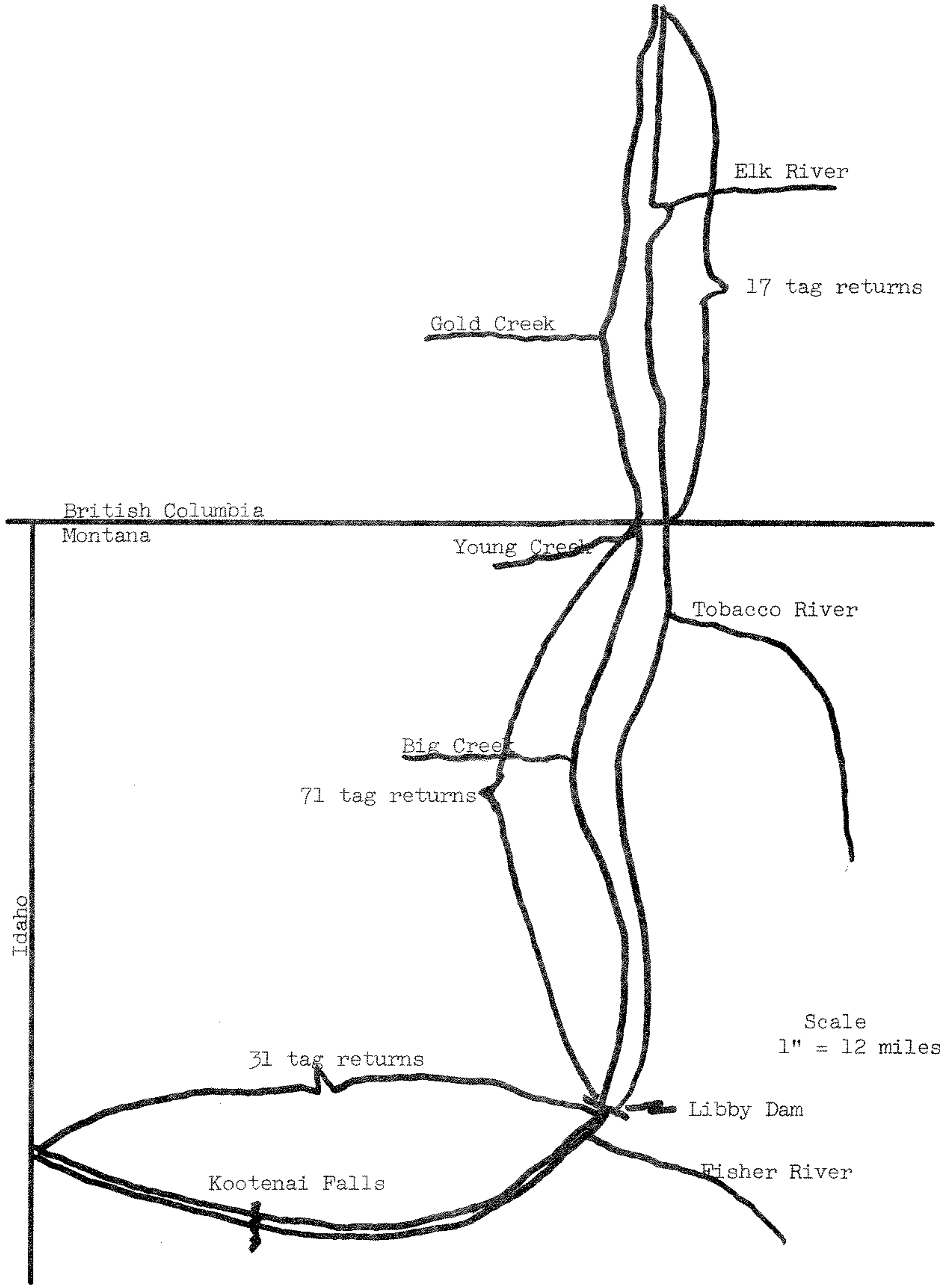

Figure 11. Location of angler harvest of cutthroat trout tagged in Young Creek in 1973-1977.

The 1976-76 statewide angler pressure survey estimated an angler use of 18,567 man-days for the Montana part of Lake Koocanusa. Sixty-nine percent of this pressure occurred during spring-summer and 31 percent during fall-winter. Factors contributing to the limited use of the reservoir by anglers include: 1) access problems created by the drawdown, 2) the relative isolation of the reservoir from major population centers and 3) an abundance of natural lakes and streams in the area which provide quality angling in aesthetically-pleasing environments.

The catch rate of trout in the reservoir has ranged from a high of .53 fish per hour in the fall of 1975 to .28 fish per hour in the summer of 1977 (Table 17). The catch rates in the spring and summer of 1976 (.43 and .39) were higher than in the same periods in 1977, but the 1978 catch rates for the spring and summer were slightly higher than in 1977. Lower catch rate in the summer of 1977 (.28 fish per hour) was probably influenced by the warm surface water temperatures. Fish inhabiting deeper water are relatively more difficult to catch. Overall, the average catch rate in the spring and summer has changed little from 1976 to 1978.

Normal variations in water temperatures, water elevations and weather conditions can cause differences in catch rates from year to year.

The catch rates in Lake Koocanusa are comparable to those recorded in three Snake River impoundments by Irving and Cuplin (1956) for a rainbow trout fishery. Catch rates are also comparable to those recorded by Vincent (1975) for Hebgen Reservoir on the Madison River. The fishery in Lake Koocanusa, however, was based primarily on wild rainbow and wild and hatchery cutthroat trout, whereas the fisheries in the Madison River and Snake River impoundments were based primarily on hatchery-raised rainbow trout.

Species composition of the catch has varied considerably from year to year. Cutthroat comprised 63 percent of the catch in 1976 as compared to only 43 percent in 1978. In contrast, rainbow comprised 30 percent of the catch in 1976, increasing to 56 percent in 1978. The increase in the rainbow catch in 1978 is in accord with species changes in the fall netting series in the lower part of the reservoir.

Vertical and Horizontal Fish Distribution

The catch of vertical gill nets in relation to water depth and temperature from the forebay area is summarized in Figures 12, 13 and Appendix 2 and 3. Purpose of this sampling was to determine best operation pattern for the selective withdrawal system to eliminate movement of fish out of the reservoir yet provide acceptable downstream temperatures.

Nighttime concentrations of cutthroat and rainbow trout were found in the upper 20 feet of the water column when surface water temperatures were below 62°. Approximately 74 percent of the rainbow and 93 percent of the cutthroat were taken in this strata. Ten percent of the rainbow netted and 0 cutthroat were taken below 60 feet. Mountain whitefish were found at greater depths than cutthroat or rainbow. Whitefish taken in the upper 20 feet of the water column were 24 percent and 31 percent were taken below 60 feet.

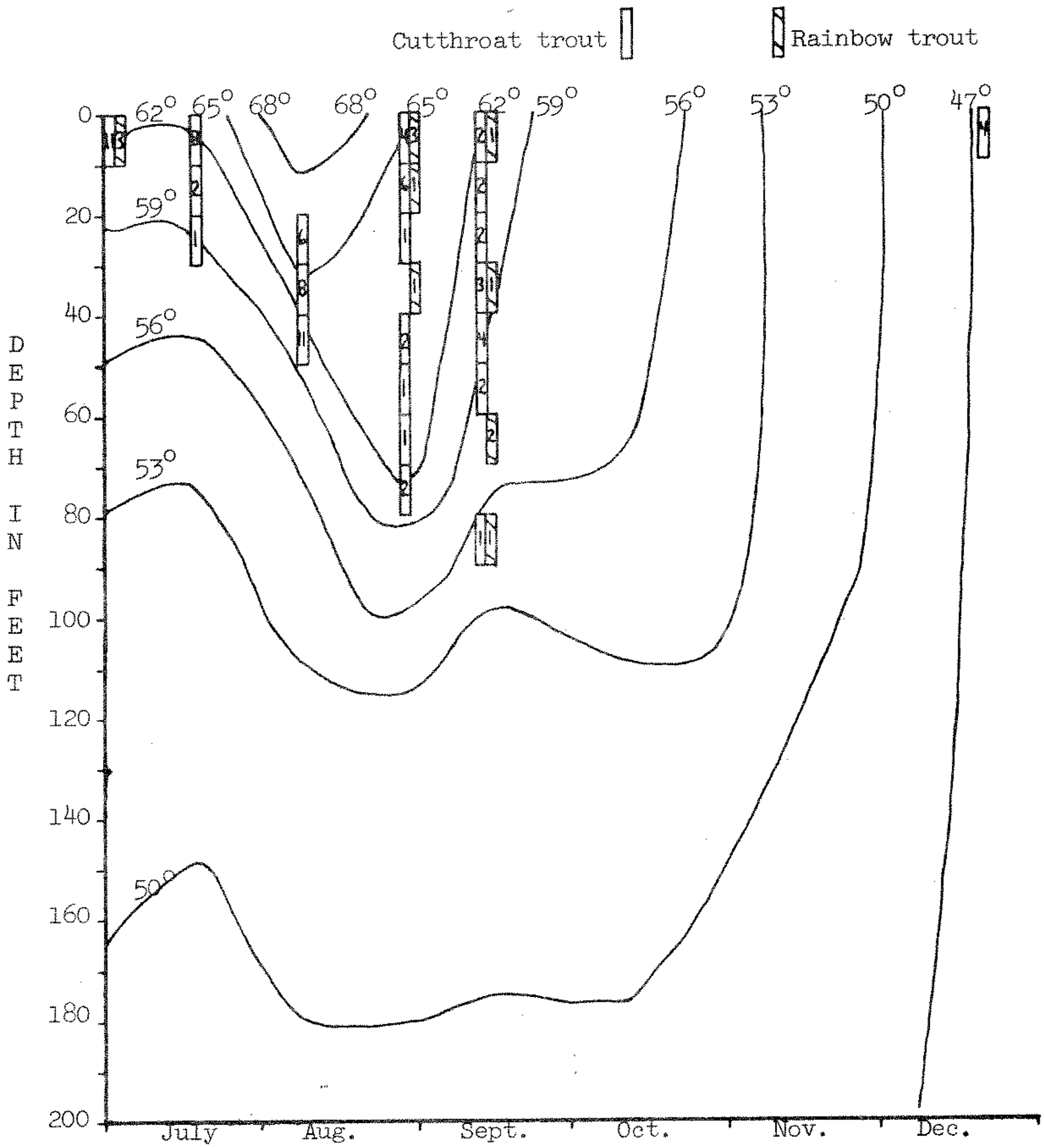

Figure 12. Temperature isotherms (Fahrenheit) and depth distribution of rainbow and cutthroat trout, Lake Koocanusa forebay, 1975.

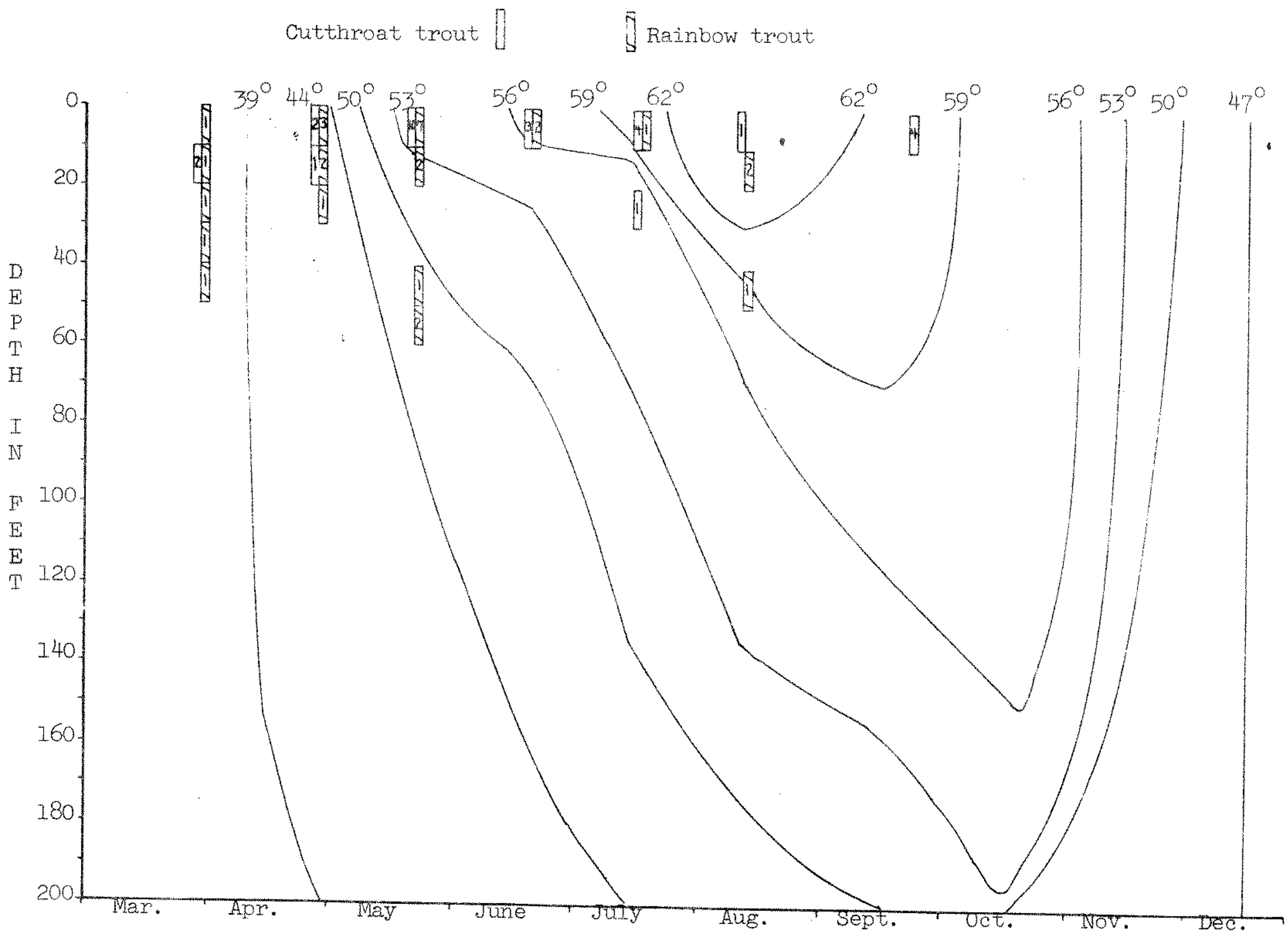

Figure 13. Temperature isotherms (Fahrenheit) and depth distribution of rainbow and cutthroat trout, Lake Koocanusa forebay, 1976.

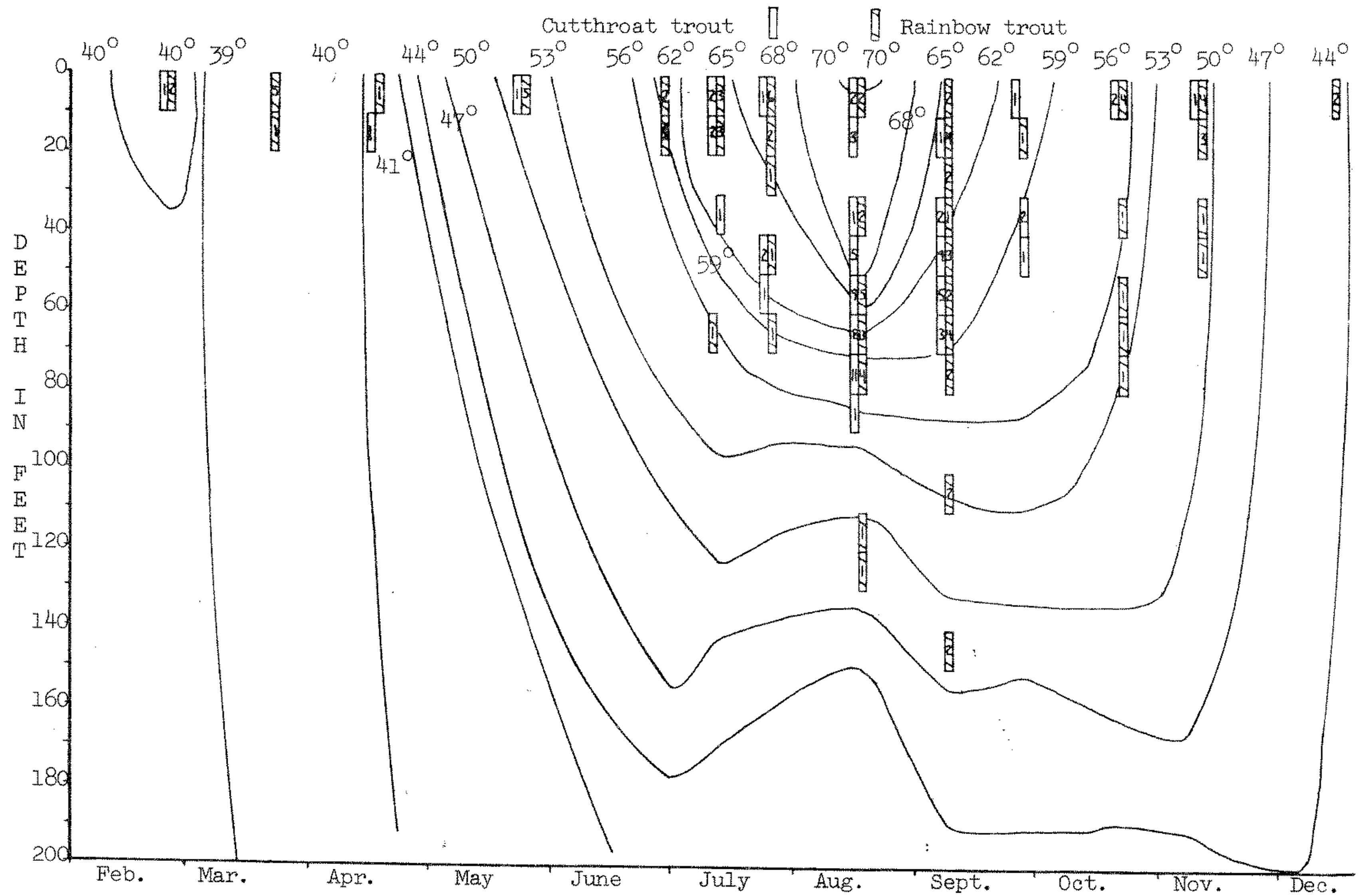

Figure 14. Temperature isotherms (Fahrenheit) and depth distribution of rainbow and cutthroat trout, Lake Koocanusa forebay, 1977.

Table 17. Angler harvest of rainbow and cutthroat trout and Dolly Varden from lower 30 miles of Lake Koocanusa, 1975-1978.

Period	Number Anglers	Percent Successful Anglers	CPMH	Number Caught Rb	WCt	DV
Fall, 1975	84	79	0.53	85(53)*	75(46)	2(1)
Spring, 1976	264	71	0.43	158(30)	319(62)	40(8)
Summer, 1976	77	58	0.39	24(19)	100(79)	2(2)
Fall, 1976	50	70	0.40	41(43)	50(52)	5(5)
Year - 1976	391	68	0.42	223(30)	469(63)	47(7)
		Average length in inches		14.6	14.8	14.1
Spring, 1977	379	60	.31	280(51)	260(47)	9(2)
Summer, 1977	145	52	.28	92(47)	105(53)	0(0)
Fall, 1977	74	64	.42	51(44)	65(56)	0(0)
Year - 1977	598	59	.31	423(49)	430(50)	9(1)
		Average length in inches		14.1	14.0	17.5
Spring, 1978	349	62	0.34	329(59)	216(39)	15(2)
Summer, 1978	80	61	0.33	47(37)	71(56)	5(7)
Year - 1978	429	62	0.34	356(56)	287(43)	20(1)
		Average length in inches		13.8	13.5	12.6

* Percent of total harvest in parenthesis

The nighttime depth distribution of cutthroat and rainbow changed markedly when surface waters were above 62°F. When the temperature was about 62°F, 17 percent of the cutthroat and 22 percent of the rainbow were caught in the upper waters, while nearly 70 percent of the cutthroat and 63 percent of the rainbow were taken in the temperature isotherms of between 59-65°F. Mountain whitefish also were located in the temperature zones of below 65°, although their distribution included a wider range of temperatures and depths. Pronounced differences occurred in the temperature patterns during the summer from year to year. The summers of 1975 and 1977 were comparatively hot and surface waters warmed sufficiently to force the rainbow, cutthroat and mountain whitefish to seek preferred temperature strata. In contrast, the summers of 1976 and 1978 were comparatively cool and the fish remained concentrated in the upper 20 feet of the water column throughout the year.

The catch of cutthroat and rainbow trout in 750 foot long surface gill nets set perpendicular to the shoreline is summarized in Figure 15. Overall, rainbow trout appeared to be concentrated closer to the shore than cutthroat trout. Forty-seven percent of the rainbow were taken in the first 250 feet of

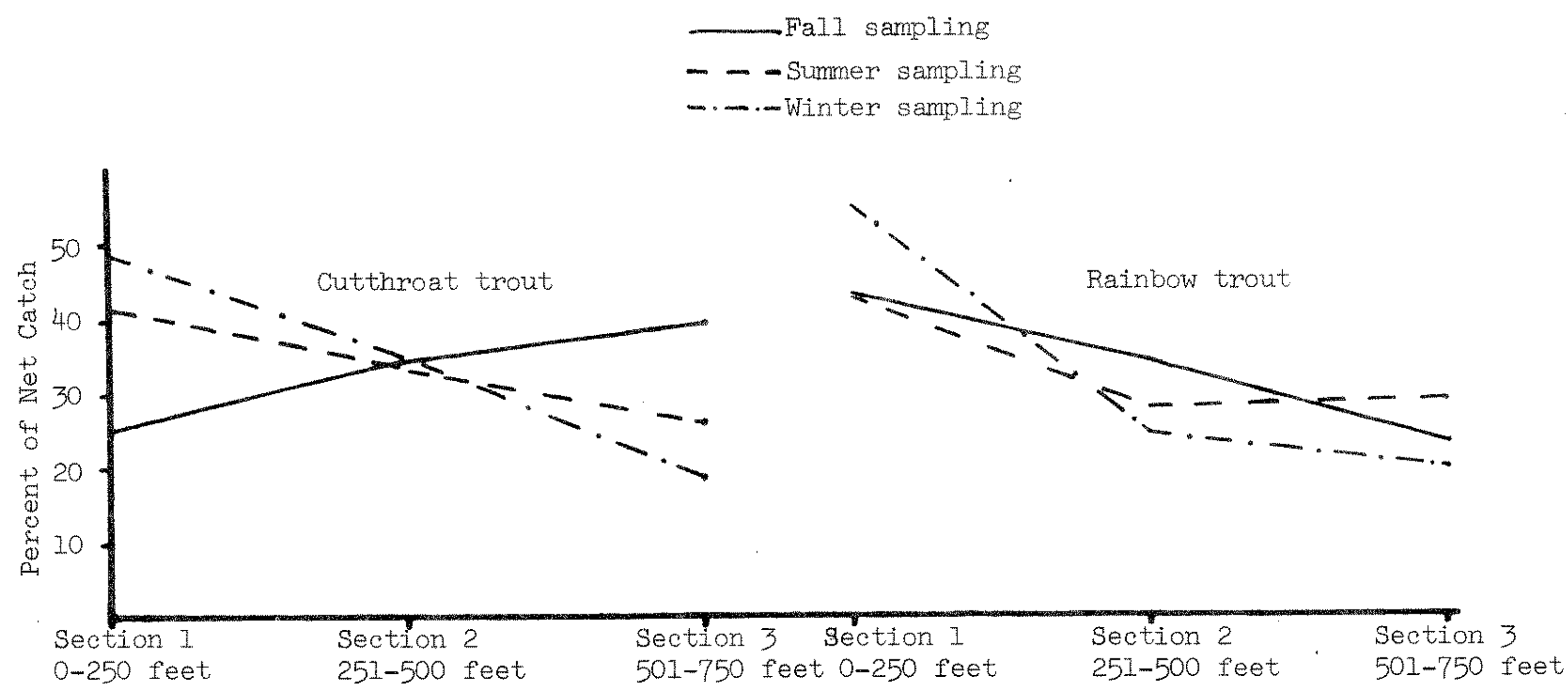

Figure 15. Catch of rainbow and cutthroat trout by 250 foot long sections of 750 foot long surface gill nets set perpendicular to shoreline in fall, summer and winter, Cripple Horse and forebay areas, Lake Koocanusa, 1975-1978.

net as compared to 36 percent of the cutthroat. A higher percentage of cutthroat were caught in the 500-750 section of net in the fall than any other time of the year. Rainbow and cutthroat were more closely associated with the shoreline in the winter and spring than in the summer and fall.

Rainbow comprised 89 percent of the trout catch and cutthroat 11 percent in the sinking nets in conjunction with the surface gang sets.

Data gathered by acoustical gear showed a marked diurnal difference in the vertical and horizontal distribution of fish during the summer. During the daylight hours, fish were concentrated immediately above the thermocline at depths of between 40-60 feet below the surface (Figure 16). There appeared to be a denser concentration of fish near the shoreline than in the pelagic area of the lake. Net catches indicated that fish along the shoreline were primarily largescale suckers, redside shiners, Dolly Varden, mountain whitefish and rainbow trout, whereas fish in the pelagic area were most likely largescale suckers, cutthroat trout, mountain whitefish and rainbow trout. Most fish at night were concentrated in the upper 10-20 feet of the water column and they were more dispersed towards the center of the lake than in the daytime. Comparatively few fish were found in the 40-60 foot depths at night and most of these were probably trout and whitefish. In the winter when surface temperatures were around 40°F, the fish were concentrated within 100-200 feet of the shoreline in the upper 20 feet of the water column both day and night.

In summary, the vertical and horizontal distribution of rainbow, cutthroat and mountain whitefish in the forebay area appears to be influenced primarily by water temperature, light intensity and food preference. Cutthroat and rainbow perfer temperatures below 62-65° and most fish tend to reside deeper in the water column during the day than at night. Although cutthroat and rainbow prefer temperatures below 62-65°F, they use the warmer surface waters at night during the summer to feed.

Application of the vertical distribution data to operation of the selective withdrawal system resulted in the following criteria:

1. When reservoir is isothermal in late fall, winter and early spring, no stop logs would be placed in selective withdrawal system.

2. When water temperatures are rising or falling, stop logs will be raised or lowered so that maximum temperature of water selected does not exceed 58°F.

3. At no time will stop logs reach closer than 50 feet below the surface.

4. Selective withdrawal operation criteria will be subject to periodic review.

Food Habits

Daphnia was the most important food item in the diet of both rainbow and cutthroat trout. Fish were the next most important component in the diet of large (>13 inches) rainbow. Terrestrial insects were second in importance in the diets of small rainbow and all cutthroat.

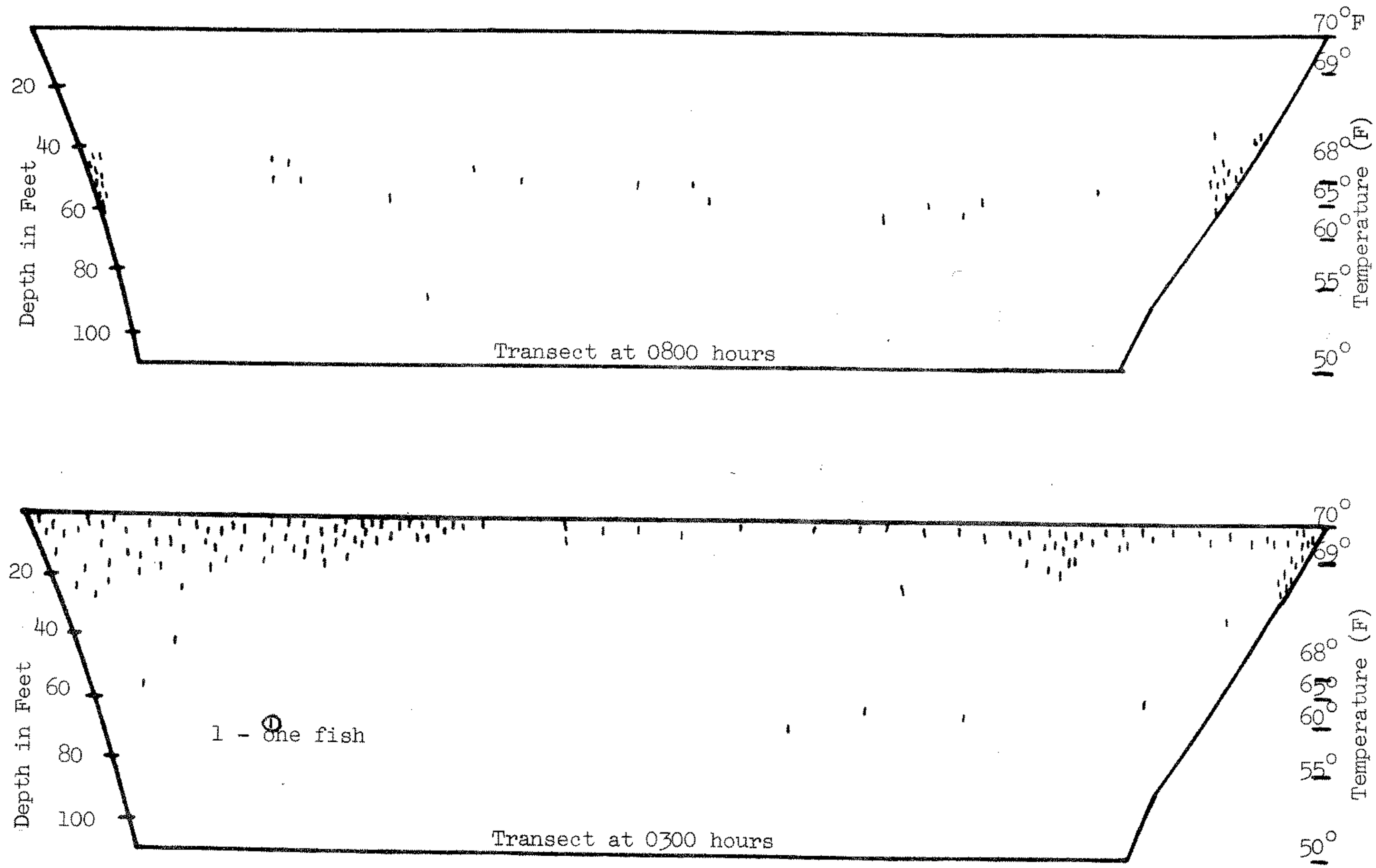

Figure 16. Depth distribution of fish in forebay area as determined by acoustical sounding, August 16, 1977. Transect length 4,300 feet.

Tables 18 through 21 list the percentages by number and volume for each type of food item in each sample. Warland area used for food habits in the same as the Cripple Horse area. Figures 17 and 18 illustrate the index of relative importance (IRI) of food items for each species and size class in the Warland and Rexford areas, respectively. The IRI is calculated as the mean of the total number, total volume and frequency of occurrence of a food item, all expressed as percentages. Values of the IRI range from 0 to 100.

Nearly all of the diet of both species during the winter was composed of Daphnia. Terrestrial insects and aquatic Dipterans became important in late spring, summer and early fall. Redside shiners were heavily preyed upon by large rainbow trout during June and July. Although fish were present in a few large rainbow stomachs throughout the year, only during June and July did the IRI of fish approach that of Daphnia. Large congregations of redside shiners in near-shore areas probably make them more susceptible to predation during June and July. The only other positively identified species of fish in a rainbow trout stomach was a largescale sucker.

Daphnia continues to be the dominant food item of small rainbow trout in the summer months. Terrestrial insects and aquatic Dipterans compose the balance of the diet.

Terrestrial insects, especially flying ants, dominate the summer diet of large cutthroat trout. Terrestrials were generally the most important dietary item from June through October. Aquatic Dipterans were very important for a brief period in the spring. Small cutthroat trout also fed heavily on terrestrial insects in summer. The diet of small cutthroat paralleled the diet of large cutthroats.

There was little difference in food habits of trout in the Warland and Rexford areas.

Samples from the summer of 1978 were distinctly different from the summer of 1977. Fewer terrestrial insects were available, and as a result, Daphnia was more important in the summer 1978 diets than in summer 1977.

RECOMMENDATIONS

1. Continue monitoring reservoir fish population trends.

Data presented in this report indicate a changing reservoir fish population with highest numbers of nongame fish occurring in about 1975 and game fish increasing through 1978. Annual trends data should be collected yearly through at least 1985 to determine the general health of the total fish population and as an aid to determine the benefits derived from planting large numbers of cutthroat trout into the reservoir from Murray Springs hatchery.

2. Continue monitoring cutthroat trout spawning runs in selected reservoir tributaries.

Size of spawning runs are a direct measure of the health of the reservoir fish population. It is recommended that the Young Creek upstream trap be operated in spring 1979 to count adult cutthroat trout moving into Young Creek for

Table 18. Stomach contents of rainbow trout less than 330 mm total length.

	Area	N	% empty	Mean TL(mm)	Mean Wt(gm)	Zooplankton % No	Zooplankton % Vol	Aquatic Insects % No	Aquatic Insects % Vol	Fish % No	Fish % Vol	Terrestrial Insects % No	Terrestrial Insects % Vol	Debris % Vol
1977														
March	Warland	21	0.0	304	295	99.98	98.10	0.01	0.20	--	--	0.01	0.10	1.70
	Rexford	26	7.7	298	290	99.96	94.33	0.01	0.02	0.01	0.02	0.02	0.06	5.57
April	Warland	12	8.3	301	309	99.98	99.51	0.01	0.12	--	--	0.01	0.12	0.25
	Rexford	34	11.8	294	269	99.98	96.92	0.01	0.06	0.01	0.06	--	--	2.96
May	Warland	16	0.0	314	336	99.45	78.42	0.33	5.29	--	--	0.24	10.98	5.32
	Big Creek	4	50.0	310	275	--	--	11.11	2.38	--	--	88.89	97.62	--
	Rexford	17	0.0	296	283	98.73	87.79	1.24	9.51	--	--	0.03	0.91	1.79
June	Warland	10	20.0	302	290	81.57	23.90	18.28	64.34	--	--	0.16	4.05	7.72
	Rexford	14	21.4	284	263	97.90	62.63	1.10	4.38	--	--	1.00	32.32	0.67
July	Warland	12	8.3	266	212	98.11	54.85	0.30	2.95	--	--	1.60	42.20	--
	Rexford	11	9.1	251	204	94.85	23.20	0.05	0.27	--	--	5.10	76.54	--
Aug.	Warland	12	16.7	246	175	86.43	14.54	1.64	7.17	0.01	9.89	11.92	68.40	--
	Big Creek	1	0.0	218	110	--	--	--	--	--	--	100.00	100.00	--
	Rexford	1	0.0	280	270	99.12	88.40	0.88	11.60	--	--	--	--	--
Sept.	Warland	23	8.7	270	237	98.24	50.38	0.60	0.90	--	--	1.14	20.92	27.80
	Rexford	29	0.0	271	239	97.65	82.85	2.28	8.55	0.01	7.03	0.05	0.98	0.15
Oct.	Warland	16	6.3	277	243	99.39	85.04	0.21	2.27	--	--	0.40	12.20	0.49
	Rexford	34	5.9	267	229	99.80	93.38	0.06	1.72	0.01	0.26	0.13	3.84	0.81
Nov.	Warland	19	10.5	296	295	99.98	98.76	0.01	0.07	--	--	0.01	0.02	1.15
	Big Creek	5	0.0	292	263	100.00	92.37	--	--	--	--	--	--	7.63
	Rexford	20	5.0	288	269	99.97	94.18	0.01	0.05	--	--	0.01	0.05	5.61
Dec.	Warland	17	0.0	308	299	99.98	93.04	0.01	0.25	--	--	0.01	0.08	6.63
	Rexford	13	7.7	282	240	100.00	100.00	--	--	--	--	--	--	--
Total Means		367	7.6	285	262	99.22	84.59	0.51	3.35	0.01	1.35	0.26	8.32	2.39
1978														
July	Rexford	3	0.0	307	300	99.72	95.26	0.28	4.74	--	--	--	--	--
Aug.	Rexford	18	22.2	248	174	99.66	95.99	0.31	2.39	--	--	0.03	0.21	1.41

Table 19. Stomach contents of rainbow trout longer than 330 mm total length.

	Area	N	% empty	Mean TL(mm)	Mean Wt(gm)	Zooplankton % No	Zooplankton % Vol	Aquatic Insects % No	Aquatic Insects % Vol	Fish % No	Fish % Vol	Terrestrial Insects % No	Terrestrial Insects % Vol	Debris % Vol
1977														
Mar.	Warland	41	17.1	422	773	99.94	88.74	0.01	0.02	0.01	8.74	0.04	0.07	2.26
	Rexford	19	5.3	400	675	99.80	91.06	0.16	0.16	0.01	3.04	0.03	0.94	3.99
Apr.	Warland	35	8.6	410	734	99.89	80.02	0.02	0.02	0.01	0.72	0.10	4.71	14.50
	Rexford	13	23.1	396	616	100.00	87.46	--	--	--	--	--	--	12.54
May	Warland	34	2.9	379	575	99.66	73.23	0.21	0.16	--	--	0.14	8.72	14.51
	Big Creek	19	15.8	401	617	38.16	0.19	28.06	3.56	0.44	4.67	33.34	25.14	66.45
	Rexford	21	4.8	382	565	97.10	70.34	2.83	7.53	0.01	3.63	0.06	4.49	14.00
June	Warland	32	6.3	404	675	97.39	1.34	2.15	0.40	0.37	98.23	0.09	0.03	0.01
	Rexford	20	10.0	393	608	97.73	6.73	1.40	1.75	0.17	86.97	0.68	2.49	2.07
July	Warland	37	35.1	399	651	98.10	0.52	0.69	0.14	0.34	98.12	0.88	0.50	0.73
	Rexford	29	13.8	388	606	94.57	13.55	0.01	0.01	0.02	26.91	5.39	59.54	--
Aug.	Warland	19	21.1	388	644	96.41	29.74	0.66	1.85	0.05	50.11	2.88	18.28	0.03
	Big Creek	5	20.0	384	579	95.94	20.59	0.06	0.27	--	--	4.00	78.16	0.98
	Rexford	4	0.0	387	551	93.66	13.39	0.23	6.70	0.08	4.46	6.04	65.03	10.42
Sept.	Warland	17	5.9	400	720	99.23	14.04	0.17	5.09	0.07	49.90	0.55	2.85	28.13
	Rexford	13	7.7	384	604	99.88	58.32	0.11	9.69	0.01	27.51	0.01	2.33	2.14
Oct.	Warland	21	14.3	390	625	96.82	29.94	0.56	2.78	--	--	2.64	64.12	3.17
	Rexford	9	0.0	392	624	97.05	23.14	0.60	2.51	--	--	2.35	37.23	37.09
Nov.	Warland	23	13.0	392	640	99.96	67.06	0.03	0.53	0.01	17.21	--	--	15.20
	Big Creek	14	14.3	405	669	99.96	57.66	0.04	0.36	--	--	--	--	41.97
	Rexford	20	5.0	411	723	99.88	84.22	0.11	1.12	0.01	4.09	--	--	10.56
Dec.	Warland	15	20.0	422	820	99.97	39.26	0.02	1.02	0.01	15.81	--	--	43.91
	Rexford	14	7.1	405	683	99.96	32.95	0.02	0.41	0.02	18.29	--	--	48.35
Total		474												
Means			12.7	391	661	98.87	24.56	0.51	1.07	0.02	59.35	0.60	9.76	5.26
1978														
July	Rexford	33	3.0	381	573	99.43	63.00	0.51	3.80	0.01	14.39	0.05	9.78	9.02
Aug.	Rexford	22	4.5	368	509	99.90	80.14	0.09	0.44	0.01	18.82	--	--	0.60

Table 20. Stomach contents of cutthroat trout less than 330 mm total length.

	Area	N	% empty	Mean TL(mm)	Mean Wt(gm)	Zooplankton % No	Zooplankton % Vol	Aquatic Insects % No	Aquatic Insects % Vol	Fish % No	Fish % Vol	Terrestrial Insects % No	Terrestrial Insects % Vol	Debris % Vol
1977														
March	Warland	11	0.0	291	249	99.95	97.73	0.02	0.31	--	--	0.03	0.12	1.85
	Rexford	25	4.0	291	264	99.95	96.17	0.01	0.03	--	--	0.04	0.55	3.24
April	Warland	15	6.7	287	242	99.90	90.41	0.01	0.06	--	--	0.09	4.58	4.95
	Rexford	23	17.4	278	221	99.98	97.18	0.02	0.02	--	--	0.01	0.52	2.14
May	Warland	12	0.0	307	310	95.60	28.91	2.12	12.47	--	--	2.28	54.92	3.70
	Big Creek	4	0.0	284	270	99.29	80.97	0.33	2.02	--	--	0.39	17.00	--
	Rexford	35	0.0	302	312	98.00	77.86	1.81	7.22	0.01	0.50	0.18	13.95	0.46
June	Warland	14	14.3	306	316	89.10	37.84	10.23	45.74	--	--	0.67	11.16	5.26
	Rexford	7	0.0	304	313	89.86	29.66	5.53	17.07	--	--	4.61	51.02	2.25
July	Warland	13	15.4	306	322	85.09	7.45	1.20	3.48	--	--	13.72	88.56	0.50
	Rexford	6	0.0	234	183	13.05	0.48	0.05	0.24	--	--	86.90	99.27	--
Aug.	Warland	20	10.0	256	199	52.41	3.53	4.06	7.75	--	--	43.53	88.74	--
	Big Creek	0	0.0	--	--	--	--	--	--	--	--	--	--	--
	Rexford	0	0.0	--	--	--	--	--	--	--	--	--	--	--
Sept.	Warland	3	0.0	295	312	58.62	2.60	25.86	5.20	--	--	15.51	66.24	25.97
	Rexford	17	0.0	271	236	99.10	90.91	0.84	8.04	--	--	0.06	0.94	0.11
Oct.	Warland	18	0.0	294	286	61.29	4.76	5.61	3.70	--	--	33.09	90.66	0.89
	Rexford	18	0.0	279	257	95.33	38.42	0.86	6.32	--	--	3.83	52.76	2.50
Nov.	Warland	19	10.5	292	276	99.99	97.03	0.01	0.14	--	--	--	--	--
	Big Creek	8	37.5	286	254	100.00	100.00	--	--	--	--	--	--	--
	Rexford	14	7.1	288	262	99.99	98.79	--	--	--	--	0.01	0.63	0.57
Dec.	Warland	9	0.0	291	242	99.93	55.56	--	--	--	--	0.07	13.33	31.11
	Rexford	17	0.0	300	283	100.00	100.0	--	--	--	--	--	--	0.80
Total Means		308	5.8	289	278	97.34	62.78	0.78	4.33	0.01	0.09	1.87	31.34	1.46
1978														
July	Rexford	9	0.0	257	203	99.00	70.88	0.89	16.47	--	--	0.12	12.45	0.20
	Hungry Horse Reservoir	8	0.0	276	239	1.05	0.63	9.93	5.31	--	--	89.04	91.78	2.28
Aug.	Rexford	17	23.5	244	167	94.80	50.48	4.79	0.26	0.01	28.62	0.38	10.01	--
	Hungry Horse Reservoir	11	0.0	257	191	12.61	0.71	8.82	6.74	--	--	78.57	92.53	--

Table 21. Stomach contents of cutthroat trout longer than 330 mm total length.

	Area	N	% empty	Mean TL(mm)	Mean Wt(gm)	Zooplankton % No	Zooplankton % Vol	Aquatic Insects % No	Aquatic Insects % Vol	Fish % No	Fish % Vol	Terrestrial Insects % No	Terrestrial Insects % Vol	Debris % Vol
1977														
March	Warland	10	10.0	395	673	99.65	82.37	0.13	0.74	0.01	5.57	0.21	2.65	8.66
	Rexford	21	9.5	392	611	96.57	48.06	1.01	2.44	--	--	2.42	20.88	28.64
April	Warland	30	13.3	416	764	99.39	65.53	0.05	0.18	--	--	0.57	14.97	18.93
	Rexford	21	42.9	407	704	99.86	65.22	--	--	--	--	0.14	0.66	34.11
May	Warland	39	10.3	394	665	93.68	22.87	2.25	6.25	--	--	4.06	63.44	7.44
	Big Creek	21	19.0	401	686	15.14	0.07	23.08	2.52	--	--	61.78	93.05	4.34
	Rexford	21	52.4	389	647	99.03	56.43	0.80	5.18	--	--	0.18	19.90	18.50
June	Warland	13	0.0	371	516	37.17	2.36	57.31	57.70	--	--	5.52	20.27	19.69
	Rexford	4	0.0	345	448	88.24	13.23	2.21	0.92	--	--	9.56	72.62	13.23
July	Warland	12	0.0	361	466	18.69	1.04	6.23	3.95	--	--	75.09	88.66	6.35
	Rexford	3	0.0	363	542	--	--	--	--	0.15	45.18	99.85	54.64	0.18
Aug.	Warland	21	42.9	355	477	62.43	5.85	1.27	0.84	0.08	4.64	36.14	80.79	7.89
	Big Creek	1	0.0	335	445	--	--	--	--	--	--	100.00	100.00	--
	Rexford	1	0.0	354	410	--	--	--	--	--	--	100.00	100.00	--
Sept.	Warland	8	0.0	361	500	84.89	1.21	2.88	1.21	--	--	12.24	6.37	91.21
	Rexford	9	0.0	361	528	99.42	75.92	0.40	4.90	--	--	0.19	11.01	8.16
Oct.	Warland	10	0.0	369	566	64.82	2.10	3.64	2.27	--	--	31.53	92.98	2.66
	Rexford	8	0.0	375	566	10.88	0.08	14.51	3.70	0.16	27.84	74.46	67.27	1.11
Nov.	Warland	12	33.3	380	570	99.94	94.88	0.03	1.71	--	--	0.03	1.87	1.55
	Big Creek	8	12.5	370	536	99.96	92.48	--	--	--	--	0.04	7.52	--
	Rexford	8	12.5	391	629	99.86	98.29	0.09	0.98	--	--	0.04	0.49	0.24
Dec.	Warland	5	0.0	367	493	99.92	57.63	--	--	--	--	0.08	0.69	41.67
	Rexford	10	0.0	375	555	100.00	100.00	--	--	--	--	--	--	--
Total Means		296	16.9	385	611	94.06	24.07	1.22	3.22	0.01	10.61	4.71	53.88	8.22
1978														
July	Rexford	6	16.7	357	457	99.53	93.09	0.47	2.30	--	--	--	--	4.61
	Hungry Horse	2	0.0	382	443	--	--	20.39	17.36	--	--	79.61	82.64	--
Aug.	Rexford	17	70.6	361	466	96.78	83.98	3.08	14.91	--	--	0.14	1.10	--
	Hungry Horse	3	0.0	367	470	76.04	6.58	2.76	13.82	--	--	21.20	79.61	--

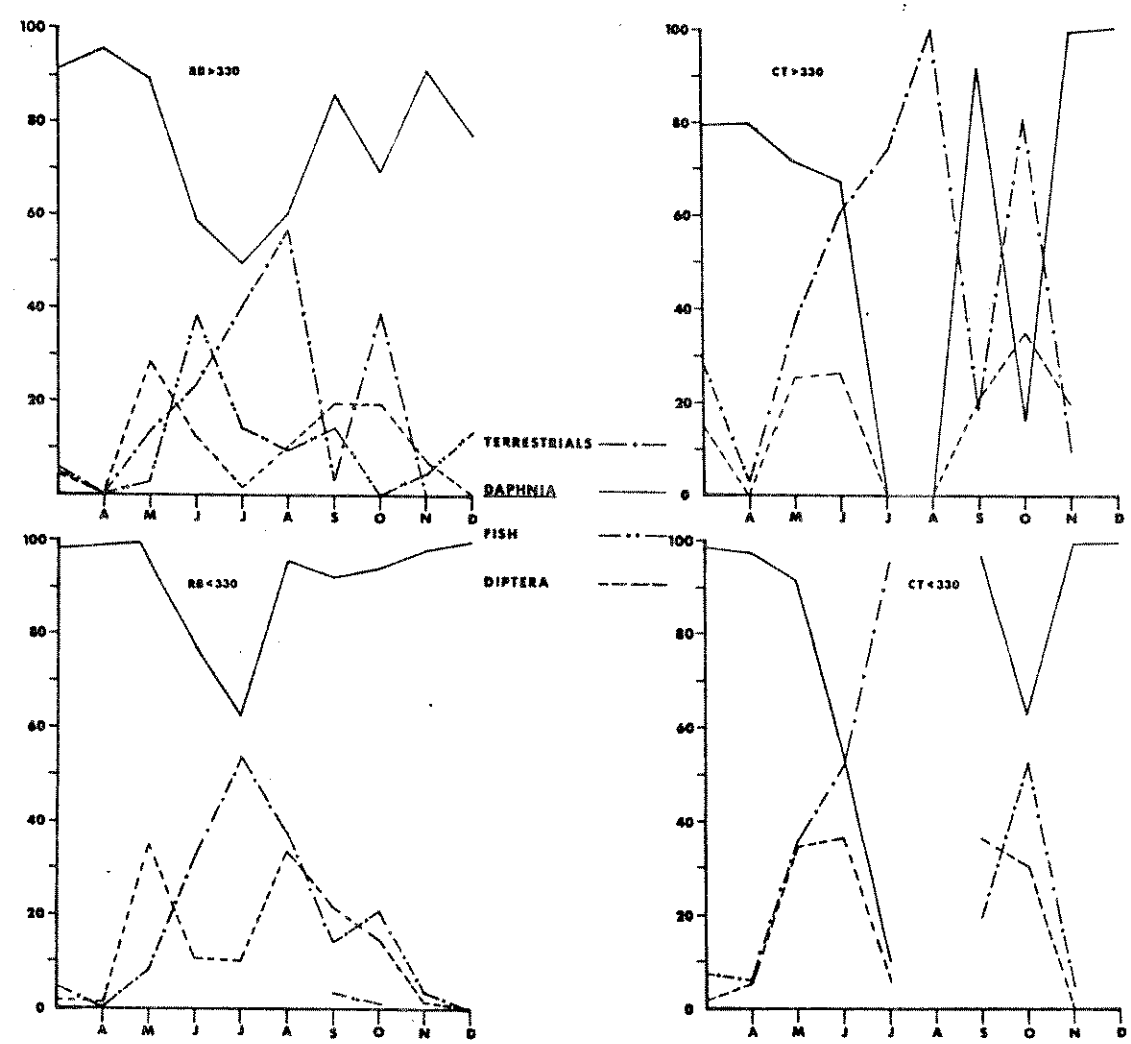

Figure 17. Monthly indices of relative importance (IRI) of food items in the stomachs of trout caught in the Rexford area.

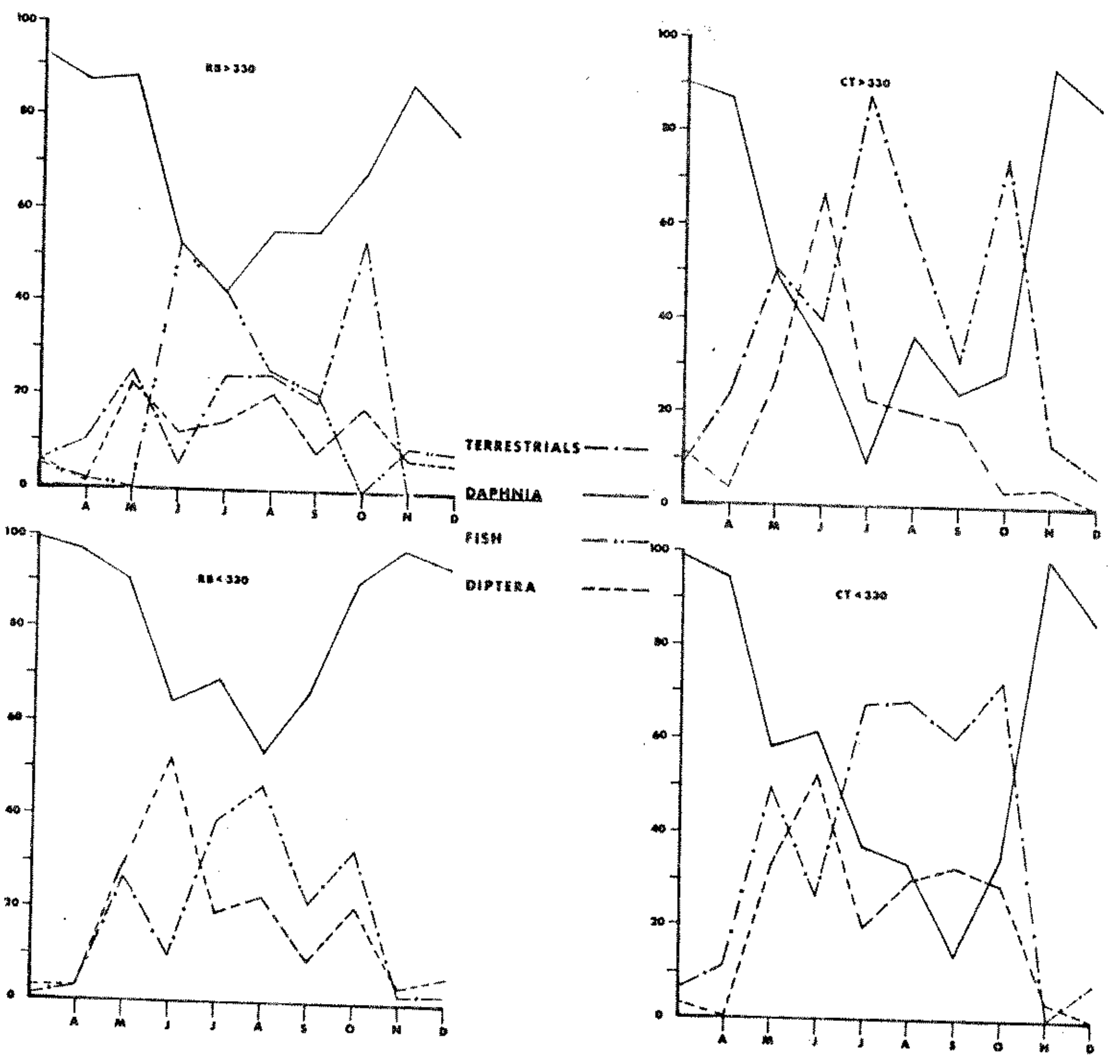

Figure 18. Monthly indices of relative importance (IRI) of food items in the stomachs of trout caught in the Warland area.

spawning and that the Young Creek upstream-downstream trap be operated in spring-summer 1980 to count adults moving upstream to spawn and smolts moving downstream into the reservoir. The Young Creek upstream trap should be operated about once every two years thereafter until at least 1986 to help determine contribution of hatchery planted cutthroat trout to spawning runs.

Spawning run information should be collected from other tributaries as time permits to determine spawning run strengths. Information can be collected by making redd counts and comparing to previous years' redd counts. Streams that should be sampled include Five Mile Creek, Big Creek and at least one major British Columbia tributary such as Gold Creek.

3. Determine those streams being used for spawning by rainbow trout, determine spawning time, density and recruitment.

Data presented in this report show that rainbow trout have increased markedly in the reservoir. Very little is known where these fish reproduce or whether a major contributor is a British Columbia Fish and Wildlife Branch fish hatchery located on Bull River. Investigation into the sources of rainbow trout in Lake Koocanusa should be a major effort in future investigational work. This work will necessarily include both Montana Department of Fish and Game and British Columbia Fish and Wildlife Branch efforts.

Extensive survey should be done on all reservoir tributaries including main-stem Kootenai River in British Columbia using suitable techniques. Techniques to be used include visual observation, electrofishing, trapping and netting and marking large numbers of rainbow trout in the reservoir and obtaining angler recapture data. It is estimated that the effort required to determine those streams used by rainbow trout for spawning will consume at least three years.

Unofficial but reliable sources have indicated that escapement of rainbow trout from the Bull River hatchery may be a major source of rainbow trout in Lake Koocanusa. Determining extent of the contribution of fish to the reservoir from this source will require cooperation from British Columbia Fish and Wildlife Branch fishery biologists. Electrophoretic comparisons of reservoir rainbow trout populations against British Columbia's rainbow trout hatchery brood and Montana's brood source may prove valuable.

4. Determine the relationships between nongame fish reproduction and reservoir operation.

Study of rainbow trout food habits in Lake Koocanusa has shown that rainbow trout consume large numbers of redside shiners. Studies on other lakes and reservoirs have shown that Dolly Varden and ling consume large quantities of fish including redside shiners, suckers, peamouth and mountain whitefish. Continued maintenance of good numbers or expanding numbers of large rainbow trout, Dolly Varden and ling may be dependent upon sufficient forage fish numbers.

Mountain whitefish are tributary spawners and spawning success is not directly affected by reservoir operation. Suckers and peamouth may spawn successfully both in tributary stream and within the reservoir proper. Redside shiners spawn only in the reservoir during late spring and summer and may be directly affected by reservoir operation. It is proposed that year-class strength of redside shiners and in-reservoir spawning suckers and peamouth be determined by necessary sampling techniques. This sampling will have to be done annually for several years so that year-class abundance can be compared to different reservoir operation patterns.

5. Determine angler harvest of cutthroat trout planted in Lake Koocanusa from Murray Springs fish hatchery.

Murray Springs fish hatchery represents the major money outlay for mitigation of fishery losses associated with Libby Dam construction. Optimizing the benefits to be derived from this hatchery will require extensive knowledge about all phases of the biology of Lake Koocanusa. Investigations to determine methods to best utilize this hatchery product for the long-term are not considered within these recommendations since methods can change rapidly as changes occur within Lake Koocanusa.

It is recommended that reservoir-wide creel census data and total angler pressure information be collected during calendar year 1981 and calendar year 1983. The 1981 census would measure angler harvest before the hatchery product enters the fisherman's creel, while the 1983 census will determine angler harvest after fish from Murray Springs hatchery reach a harvestable size.

Other data to be collected during these reservoir-wide angler censuses include estimated use by all types of water-based recreation activities.

VALUE OF LAKE KOOCANUSA INVESTIGATIONS

State of Montana and Corps of Engineers have spent considerable time and money on biological studies of Kootenai River and Lake Koocanusa formed by impounding Kootenai River. Reports written by biologists primarily for other biologists and fishery managers often times leaves engineers and most other non-biological trained people with questions such as: "What does it all mean?", "How does this work relate to providing fishing?" and "What did the Corps of Engineers and the U.S. taxpayer get for the money spent?".

This section of this report addresses such questions AND STRIVES TO answer them for the non-biologist. At the start, we must make it clear that few biological questions can be answered with engineering precision. The results of good engineering is usually a visible structure which all people can easily see. Good biology is oftentimes the avoidance of ecological blunders which if made, may or may not be easily seen or understood by laymen. Good biology can also be the selection of the best course of action which will provide quality recreational benefits for the greatest length of time at the least cost.

Comparisons between impoundment projects will be made to illustrate some of the ecological errors made on other impoundments but which were avoided on the Libby project. Construction at all four impoundments (Libby, Hungry Horse, Noxon Rapids and Cabinet Gorge Reservoirs) was similar in their biological impacts: changing downstream flows and changing river into fluctuating lakes.

Hungry Horse Dam was constructed on the South Fork Flathead River by the Bureau of Reclamation being completed in 1952. No project funding was made available for either pre- or post-impoundment fishery studies by Bureau of Reclamation and Montana Department of Fish and Game had only one biologist to serve northwestern Montana during the preconstruction and construction era. Consequently, there were practically no fisheries data upon which to recommend mitigation measures to reduce damage to the fishery.

Unobstructed upstream movement of game fish into tributaries for spawning is a major concern in impoundment fisheries management. Roads constructed on both sides of Hungry Horse Reservoir crossed 28 streams suitable for game fish (cutthroat trout, Dolly Varden and mountain whitefish) spawning. Poor placement of culverts blocked access into 16 of these 28 streams. As a result of these culverts, fish reproduction was severely restricted. Starting in 1963 and continuing to the present time, the Department and U.S. Forest Service have had a continual program to alleviate fish passage problems at these road crossings. To date, permanent access (replacement of culverts with bridges) or temporary access (construction of gabion sills below culverts eliminating culvert outfalls) has provided complete or partial upstream fish passage at 14 of the original 16 blocked streams.

Loss to the fishery resource of Hungry Horse Reservoir and its tributaries through reduced spawning habitat has been great. Cost to the angler public and general taxpayer has been excessive. These fish passage problems would not have occurred if stream crossing had been designed by engineers and biologists working together when these roads were first constructed.

On the Libby project, pre-impoundment surveys done by biologists delineated potential spawning streams. Biologists working with Corps of Engineers designed stream crossings that would provide adequate passage for spawning fish. As a result, Lake Koocanusa game fish have access into all suitable spawning tributaries and potential for maximum natural reproduction is a reality. Spawning stream surveys in the Lake Koocanusa drainage has shown that game fish are using almost all the spawning habitat made available and has resulted in increasing game fish populations and angler use of the resource.

Libby project provided the Department with funding to clear potential spawning streams of natural barriers such as log jams. This made more spawning and rearing habitat available for use by spawning fish from Lake Koocanusa.

Hungry Horse Dam had no fishery oriented criteria for flow releases. Flows below this dam have varied from a minimum of 160 cfs to about 10,000 cfs several times a day. The six miles of South Fork Flathead River below Hungry Horse Dam to the confluence with main-stem Flathead River is truly a biological desert. Outflows from Libby Reservoir have fluctuated severely since impoundment but the minimum flow of 2,000 cfs is rarely reached. The larger minimum flows passed through Libby Dam has supported an excellent sports fishery downstream, while the sport fishery in the South Fork below Hungry Horse is essentially nonexistent.

Flows from Cabinet Gorge Reservoir have fluctuated the Clark Fork River in Idaho as much as 14 feet ranging from a few hundred cfs up to about 35,000 cfs. Impact of this wide range of flows on the Clark Fork River and Lake Pend Oreille severely affect the sport fishery. For the past several years, Washington Water Power Company has set a voluntary minimum flow of 3,000 cfs for the benefit of the fishery resource. No minimum flows are in effect for Noxon Rapids Reservoir since its tailwater is the headwater of Cabinet Gorge Reservoir.

Fluctuations in main-stem Flathead River from operation of Hungry Horse Reservoir have reduced spawning success of kokanee and whitefish. Fluctuations occurring at any time of the year also severely affect sport fishing opportunity. Fluctuations in Kootenai River caused by Libby Dam do affect game fish reproduction but not to the extent that Hungry Horse does in the Flathead River system. River fluctuations below Libby Dam affect fishing opportunity but again, not to the extent of Hungry Horse Reservoir operations. Corps of Engineers is trying to operate Libby Dam in a manner more compatible to angler opportunity, while Bureau of Reclamation has made little effort to alter their operations to benefit the angling public.

Fisheries management at Noxon Rapids and Cabinet Gorge Reservoir has had limited success due to rapid movement of most game fish out of the reservoirs into downstream waters. Wise operation of Libby Dam with a selective water release system has largely eliminated downstream escapement of game fish. The operational criteria for selective withdrawal outlets was developed by engineers and biologists working together. Downstream escapement out of Hungry Horse Reservoir is not a problem due to the very low level turbine intakes.

Temperature of water released from Hungry Horse Reservoir will range from 39°F to 42°F year-around. These low temperatures have greatly reduced aquatic insect biomass and species diversity in South Fork below the dam. The low temperatures and wildly fluctuating flow releases have affected fish movement, fish spawning and aquatic insect production in main-stem Flathead River downstream from the mouth of the South Fork to Flathead Lake, a distance of 46 miles. Turbine intakes for both Noxon Rapids and Cabinet Gorge Dams are high enough that warm water is released. Mid-summer water temperatures immediately below Noxon Rapids but in Cabinet Gorge Reservoir will oftentimes be isothermal in the mid-70°F temperature range at depths of 100 feet. Brown trout in Clark Fork River below Cabinet Gorge Reservoir have been observed spawning in mid-March compared to a normal spawning time of late October and November. This delayed spawning is thought to be the result of temperature changes brought about by Noxon Rapids and Cabinet Gorge Reservoirs.

Water released from Libby Dam is being regulated by operation of the selective withdrawal system to provide the best temperature pattern possible for Kootenai River without affecting the biota of Lake Koocanusa. Temperature control is expected to increase total biomass carrying capacity, particularly aquatic insects and fish, in Kootenai River downstream from Libby Dam. Increased biomass will result in more fish being available for anglers.

Corps of Engineers has been funding biological studies to determine best operation of Libby Dam with respect to factors such as the fishery and has always been concerned with most aspects of the environment. Washington Water Power Company has funded extensive pre- and post-impoundment studies on their Montana Reservoirs and has shown concern for water-based recreational activities. Bureau of Reclamation has recently started to fund fishery studies on the effects of Hungry Horse Reservoir operation on downstream waters.

In summary then, as a result of actions recommended by biological studies, fishermen have had excellent sport angling in Lake Koocanusa and Kootenai River since impoundment. Anglers fishing the other reservoirs and outflow waters have been shortchanged due to lack of ecological consideration.

There are other benefits to the fisheries and angling public utilizing this resource as a result of biological studies. These are listed and described below and will be limited to Lake Koocanusa and its tributary streams.

1. A report titled "Revision of 1965 Fishery Analysis, Libby Dam Project, Kootenai River, Montana" prepared by Montana Department of Fish and Game in April, 1974 stated that estimated annual fisherman-day-use of Lake Koocanusa without any mitigation would average 10,000 days over a 100-year period. Completion of all mitigation except the hatchery would increase angler use 6,000 man-days per year for a total use of 16,000 fisherman-day-use per year.

The 1975-76 angler pressure estimate listed angler use on Lake Koocanusa at about 18,500 man-days for a 12-month period. This angler-use was supported by some planted fish, but mostly by naturally reproduced rainbow and cutthroat trout. Population data collected since 1972 indicate that the present Lake Koocanusa game fish densities would support a fishery at least double that of 1975-1976. The present game fish densities are all from natural reproduction. Planting of the reservoir with cutthroat trout from the Murray Springs hatchery may increase the potential angler pressure several more times without damage to the resource.

2. The revision of 1965 fishery analysis report also stated that streams tributary to the reservoir would support 11,000 man-days of angler use without the project and that with the project, the same angler-use could be supported if all mitigation measures except the hatchery were done. Almost all stream mitigation measures have been finished on tributary streams. The Department does not have a current fishing pressure estimate on the tributaries but limited creel census and contact with anglers indicate that tributary fishing pressure is heavier now than prior to impoundment. Anglers appear to be very satisfied with the quality and quantity of fish caught from reservoir tributaries. Anglers have excellent chances of catching much larger fish (spawning fish from the reservoir) now than prior to creation of Lake Koocanusa. Examples of the above include Big, Barron, Bristow, Jackson, Canyon, Cripple Horse and Five Mile Creeks. Prior to impoundment, these streams were populated by resident rainbow or brook trout with few fish exceeding 8 inches in length. Fishermen are now catching spawning rainbow or cutthroat trout having average lengths of about 15 inches.

Much of the spawning run development and angler use of these fish can be attributed to the aggressive tributary development done in the early 1970's.

3. Quality of and quantity of spawning streams with good reproductive potential can easily be affected by land-use patterns. Spawning stream inventory of Lake Koocanusa tributaries on a continuing basis will provide current data for the Department and other agencies to maintain the integrity of these streams in the face of ever-increasing land use. Continued vigilance is required to insure maximum natural reproduction for Lake Koocanusa.

4. Page 9 of the 1974 revision of the 1965 fishery analysis states that westslope cutthroat trout were at one time considered an endangered fish species by the U. S. Fish and Wildlife Service. This species is no longer considered

endangered but is still a "species of special concern" by the State of Montana. This report also states that the Libby project would destroy considerable fluvial westslope cutthroat trout habitat but that Lake Koocanusa would provide an excellent opportunity to expand the range of adfluvial westslope cutthroat trout. Fish population data collected from tributary streams and Libby Reservoir indicate that adfluvial westslope cutthroat trout are thriving in the reservoir and that their range has been extended.

5. Data presented in this report show that rainbow trout populations have markedly increased in recent years. This can be attributed to natural reproduction or escapement from a fish hatchery in British Columbia. Study of the food habits of rainbow trout show that the larger fish switch to a fish diet during the summer months and that the principal prey species is redside shiners. The Departments' experience with redside shiners in other fluctuating impoundments has been that high populations occur for the first few years of impoundment followed by drastic declines in numbers. Redside shiners are shoreline spawners and reservoir fluctuations appear to limit spawning success. A decline in numbers of redside shiners in Lake Koocanusa would likely have marked effects on rainbow trout populations. We would expect reduced numbers of all sizes of rainbow trout since the larger fish feeding on shiners are also the spawning fish.

6. Study of the food habits of cutthroat trout showed that these fish were feeding almost entirely on plankton and terrestrial insects and, therefore, should be less susceptible to water level fluctuations than rainbow trout. Cutthroat trout in Hungry Horse Reservoir feed heavily on Diptera pupae found along the bottom. Populations of bottom-living aquatic insects should increase in time in Lake Koocanusa having potential as another major food source for cutthroat and rainbow trout.

7. Lake Koocanusa is one of the most productive reservoirs in the Northwest. To a large extent, this initial productivity is a result of Canadian-source phosphate pollution. Clean-up of this pollution should result in lower fish-food production in the reservoir and consequently lower numbers of fish. Greatest impact of lowered basic productivity will be felt by fish species highest on the food chain; i.e., game fish such as rainbow trout, Dolly Varden and burbot. It may be possible to increase basic productivity if that drastic a step is ever required.

8. Lake Koocanusa is rapidly gaining a regional reputation as an excellent fishing lake. Dissemination of information on horizontal and vertical distribution of game fish can improve fishing success. We know that anglers fishing near shoreline areas catch mostly rainbow trout, while fishing away from the shoreline yields mostly cutthroat trout. Burbot angling has been excellent in the spring and early summer at localized areas using special fishing tactics. Dolly Varden catch rates will vary with time of year, location fished and type of fishing method used. Summer angling on most large lakes and reservoirs is the least productive compared to other seasons. Vertical distribution of game fish is regulated by their preferred water temperature range. Some years anglers may have to fish at depths up to 80 feet before they are within range of the fish. Very few anglers fish Lake Koocanusa at night, but fish distribution shows that night angling may be more productive than daylight angling. Nighttime angling during the hotter summer months may be more productive when fishing surface waters than would be found fishing deeper waters during the daylight hours.

Appendix 1. Summary of gill net catches from Lake Koocanusa and Kruskal-Wallis Ranking Test, 1975 through 1978.

Species	Number of Nets			Mean Catch Per Net			X^2 Value	P	X^2 Value	P
	1975	1976	1978	1975	1976	1978	1975 vs 1976		1976 vs 1978	
CRIPPLE HORSE FLOATING NETS										
Rb	61	47	40	2.46	3.74	5.88	7.69	.006**	12.30	<.001**
Ct	61	47	40	2.46	3.19	1.80	4.10	.04*	14.55	<.001**
CRC	61	47	40	4.03	5.32	4.32	.62	.80	1.44	.70
Sq	61	47	40	5.79	4.45	4.68	5.91	.02*	.06	.80
RSS	61	47	40	2.4	10.4	11.0	--	--	--	--
REXFORD FLOATING NETS										
Rb	68	44	40	3.03	3.45	6.40	.76	.35	19.71	<.001**
Ct	68	44	40	1.63	1.77	2.40	.01	.90	2.74	.10
CRC	68	44	40	1.26	2.14	1.43	.36	.50	.26	.85
Sq	68	44	40	2.74	3.70	3.22	2.25	.10	.29	.85
RSS	68	44	40	4.2	6.0	3.1	--	--	--	--
BAILEY BRIDGE FLOATING NETS										
Rb	--	47	40	--	2.00	3.35	--	--	8.37	.004**
Ct	--	47	40	--	1.51	1.65	--	--	.88	.30
CRC	--	47	40	--	3.96	2.70	--	--	2.80	.09
Sq	--	47	40	--	6.94	3.80	--	--	5.26	.03*
RSS	--	47	40	--	2.4	1.8	--	--	--	--
REXFORD SINKING NETS										
DV	111	43	39	1.44	1.91	2.18	0.91	.30	2.34	.10
MWf	111	43	39	6.56	6.35	7.18	0.47	.45	2.15	.10
CSu	111	43	39	37.32	26.05	23.46	8.23	.004**	0.02	.85
FSu	111	43	39	7.86	11.14	9.13	16.37	<.001**	4.20	.04*
Ling	111	43	39	0.05	0.16	0.33	--	--	--	--

** 99 percent significance level
* 95 percent significance level

Appendix 2. Mountain whitefish, rainbow trout and cutthroat trout distribution in forebay in relation to temperature, when surface temperatures were above 62°F, 1975 through 1978.

Temperature Range	Species		
	Ct	Rb	MWf
70-68	11(7.8)*	4(5.1)	20(8.5)
68-65	13(9.4)	14(17.7)	13(5.5)
65-62	49(35.5)	30(40.0)	67(28.4)
62-59	47(34.1)	18(22.8)	33(14.0)
59-56	16(11.6)	6(7.6)	32(13.5)
56-53	2(1.5)	1(1.3)	39(16.5)
53-50	--	2(2.5)	24(10.2)
50-47	--	4(5.1)	8(3.4)
Totals	138	79	236

* Percent of total catch by species is in parenthesis

Appendix 3. Distribution by depth of mountain whitefish, rainbow trout and cutthroat trout from forebay, when surface temperatures were less than 62°F, 1975 through 1977.

Depth in Feet	Species		
	Ct	Rb	MWf
0-9	56(58.9)*	45(75.0)	17(9.6)
10-19	15(15.8)	11(18.3)	25(14.1)
20-29	4(4.2)	2(3.3)	20(11.3)
30-39	4(4.2)	--	26(14.7)
40-49	3(3.2)	1(1.7)	18(10.2)
50-59	3(3.2)	1(1.7)	17(9.6)
60-140	10(10.5)	--	54(30.5)
Totals	95	60	177

* Percent of catch by species is in parenthesis

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