Montana Department of Fish, Wildlife and Parks
Helena, Montana 59901

In Cooperation With

Seattle District, U.S. Army Corps of Engineers

LAKE KOOCANUSA INVESTIGATIONS FINAL REPORT

1972-1983

By

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ABSTRACT

Lake Koocanusa was created in 1972 by impounding the Kootenai River at a point 28 km upstream from the town of Libby, Montana. This reservoir is 145 km long of which 78 km are in Montana and 67 km in British Columbia, Canada. At maximum pool elevation of 741.5 m the surface area is 188 km^2. Lake Koocanusa has been classified as oligotrophic, but with the potential to be very productive. Weak thermal stratification results in low primary productivity due to phytoplankton being circulated out of the euphotic zone. High turbidities during spring and early summer also limit primary productivity.

Species of fish common to the Kootenai River prior to impoundment included mountain whitefish (Prosopium williamsoni), westslope cutthroat trout (Salmo clarki lewisi), rainbow trout (Salmo gairdneri), bull trout (Salvelinus confluentus), brook trout (Salvelinus fontinalis), ling (Lota lota), largemouth bass (Micropterus salmoides), longnose sucker (Catostomus catostomus), largescale sucker (C. macrocheilus), northern squawfish (Ptychocheilus oregonensis), peamouth (Mylocheilus caurinus) and redside shiner (Richardsonius balteatus). Fish species common to the river but not found in Lake Koocanusa included torrent sculpin (Cottus rhotheus), slimy sculpin (Cottus cognatus) and longnose dace (Rhinichthys cataractae). Fish common to the reservoir but not found in the river included kokanee (Oncorhynchus nerka), yellow perch (Perca flavescens) and lake trout (Salvelinus namaycush). Five white sturgeon (Acipenser transmontanus) were captured from Kootenai River below Kootenai Falls and transplanted into Lake Koocanusa.

Pre-impoundment surveys indicated that largescale suckers and mountain whitefish were the most abundant species in the Kootenai River. Cutthroat trout was the most abundant trout in the upper two-thirds of the impoundment area, while rainbow trout was most abundant in the lower one-third. Bull trout and burbot were occasionally found throughout the impoundment area. Dace, sculpins and redside shiners were abundant throughout the impoundment area. Longnose suckers, largemouth bass, brook trout, squawfish and peamouth were rarely found prior to impoundment and were limited to river oxbows, sloughs and springs.

Post-impoundment surveys have shown changes in species composition. Largescale suckers were very abundant in the reservoir as they were in the river. Longnose suckers, squawfish and peamouth, rare in the river, were very abundant in the reservoir. Brook trout and largemouth bass were rarely caught in the reservoir and then mostly from very select habitat types. Abundance of burbot and bull trout has increased in the reservoir while numbers of mountain whitefish have declined significantly.

Abundance of rainbow and cutthroat trout has increased in the reservoir in response to management efforts including spawning enhancement and planting of hatchery-reared fish. Lake trout, not found in the river, were rare in the reservoir and were probably escapees from a fish hatchery in British Columbia. Yellow perch were rarely caught in the reservoir and

were probably from lakes in the Tobacco River drainage. White sturgeon probably do not exist in the reservoir as three of the five fish planted by Montana have been reported caught. Small numbers of mature kokanee were first caught in the reservoir in 1979 while large numbers of one-year old fish were found in 1981. These fish were most likely escapees from a fish hatchery in British Columbia.

Montana selected westslope cutthroat trout as the management species for Lake Koocanusa. Tributaries to Lake Koocanusa within Montana were few in number and of poor quality so spawning enhancement was undertaken. Six drainages were treated by removing barriers, reducing resident fish stocks and imprint planting young-of-the-year westslope cutthroat trout. Spawning enhancement benefitted other stream spawning species as well as cutthroat trout. Significant spawning runs of rainbow and cutthroat trout developed in most reservoir tributaries. Mountain whitefish fry were planted in several Montana tributaries but no spawning runs were established.

Lake Koocanusa was planted with westslope cutthroat trout fingerlings to take advantage of the initial productivity of the reservoir and provide a good sports fishery. Approximately 3.1 million cutthroat were planted from 1972-1976. These fish had good survival and growth and contributed to the sport fishery. The reservoir was not planted again until 1981 and 1982 when approximately 635,000 cutthroat fingerlings were put in Lake Koocanusa. These fish appear to have comprised about 40 percent of cutthroat population in Lake Koocanusa by the fall of 1982.

The depth distribution of major game species was investigated in the forebay area of Lake Koocanusa from 1975-1978. Rainbow and cutthroat trout were found in the upper 5-6 meters of the water column when surface water temperatures were below 17°C. During the summer, when surface temperatures were above 19°C, rainbow and cutthroat trout were concentrated in the thermocline at temperatures of 15 to 18°C and 17 to 19°C, respectively. Cutthroat trout appeared to be more surface oriented than rainbow trout which were more evenly distributed in surface and bottom areas along the shoreline.

Trout were numerous during the winter and spring in the Rexford area of the reservoir as a result of reservoir drawdown, food availability, warmer temperatures and proximity of major spawning tributaries.

The food habits of rainbow and cutthroat trout varied seasonally and with the size of individual fish. Both species of all sizes relied heavily on *Daphnia* during the winter. *Daphnia* was the most important year-round food item for fish of both species under 330 mm in total length. Rainbow over 330 mm derived most of their energy from fish which comprised 67 percent of their caloric intake. In contrast, terrestrial insects and aquatic dipteran were the most important food items eaten by large cutthroat trout. The importance of *Daphnia* in the diet of all fish, especially in the winter, indicates that large populations of kokanee may result in competition for this important food resource in the future.

The growth of gamefish was above average when compared to other large lakes and reservoirs in the area. Rainbow trout averaged 408 mm in length at age IV, but growth of larger fish declined from 1978-1982 due to a decline in the redside shiner population. Age IV cutthroat trout which resided two years in a tributary stream had a mean length of 347 mm. Kokanee from the 1980 year class, which matured at age II+ in the fall of 1983, averaged 432 mm in length. The growth of burbot and mountain whitefish was also above average.

Cutthroat and rainbow trout tagged on their spawning runs into Young Creek, Big Creek and Tobacco River dispersed throughout the reservoir after spawning. Most fish were caught near major fisherman access points. The tag return of approximately 10 percent indicated that angler harvest of trout in Lake Koocanusa was a moderate mortality factor.

Fishing pressure and angler harvest has increased since impoundment. Cutthroat comprised 62 percent of the catch in 1976 as compared to only 28 percent in 1981. In contrast, the rainbow composition of the catch increased from 30 percent in 1976 to 55 percent in 1981. The decline in the trout catch was offset by the appearance of large numbers of kokanee in the creel in 1981 and 1982.

There was a marked change in the number of non-resident anglers contacted from 1976 to 1981. Anglers from Lincoln County comprised 86-95 percent of the fishermen contacted from 1976-1978. However, in 1981 only 31 percent of the anglers were from Lincoln County as compared to 28 percent out-of-county and 41 percent out-of-state. The excellent kokanee fishery which developed in 1981 and 1982 attracted many anglers from Idaho and Washington.

ACKNOWLEDGEMENTS

Many people have worked on this project through the years and contributed to the success of the study. Fisheries fieldmen Bill Bothman and Jim Steffes spent many long hours in the field tending fish traps and sampling fish populations under adverse weather conditions throughout the year. Other Department personnel who assisted in the project include Gary Anderson, Charlotte Schultz, Ben White, Pam DeAngelo, Laurie Martens, Joe DosSantos and Brad Shepard.

Personnel from the Kootenai National Forest helped picked nets, process fish and count redds. Special thanks go to Gary Altman and Don Godtel for the assistance that they and their field crews rendered.

We are especially grateful to Delano Hanzel and Bob McFarland for their advice and help in the statistical analysis of the data. Tom Bonde, biologist for the U.S. Army Corps of Engineers, provided water quality data and constructive criticism and advice throughout the study. Bob Ayers and Jack Thompson, biologists for the Corps of Engineers, also provided guidance and advice in the early years of the studies. Cathy Turley-Addington typed the report.

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INTRODUCTION

Construction of Libby Dam on the Kootenai River (spelled Kootenay in Canada), approximately 28 kilometers (17 miles) upstream from Libby, Montana created Lake Koocanusa. This multipurpose (flood control, power production and recreation) impoundment was made possible by a treaty between the United States and Canada for cooperative development of water resources of the Columbia River Basin.

The Kootenai River, the principal tributary to Lake Koocanusa, is the second largest tributary of the Columbia River. The river arises in Kootenai National Park, British Columbia, flows south into Montana, then northwest through Montana and Idaho, re-enters Canada and flows into Kootenay Lake; it then flows southwest out of Kootenay Lake and enters the Columbia River at Castlegar, British Columbia (Figure 1). The Kootenai River is approximately 780 kilometers (485 miles) in length and drains an area of about 50,000 square kilometers (19,300 square miles).

Construction was begun on Libby Dam in 1966 with completion occurring in March of 1972. Lake Koocanusa is a relatively large, long and narrow impoundment. Full pool elevation of 741.5 meters (2,459 feet) msl was first reached in 1974 creating a reservoir 145 kilometers (90 miles) long of which 78 kilometers (48 miles) lie in Montana and 67 kilometers (42 miles) lie in British Columbia. Lake Koocanusa has a total surface area of 188 square kilometers (46,500 acres) and a gross storage capacity of 7.24 cubic kilometers (5,869,400 acre-feet). Average depth of the reservoir at full pool is 38.5 meters (126.4 feet) as compared to 21 meters (69.2 feet) at the low pool elevation of 697.1 meters (2,287 feet) msl. Maximum depth at full pool of 107 meters (350 feet) occurs in the forebay area of the reservoir. Predicted average annual drawdown of 38.4 meters (126 feet) reduces the reservoir volume 69 percent and the maximum drawdown of 52 meters (172 feet) reduces the volume 85 percent.

Libby Dam is operated for power production and flood control with sufficient lake drawdown by May 1st to provide protection from a 200-year flood for a critical area near Bonners Ferry, Idaho and to reduce flooding in the lower Columbia River (Storm et al. 1982). Refilling of the reservoir generally occurs during the period of May through mid-July. The maximum flood control storage space for the reservoir is based upon runoff forecasts. Factors affecting reservoir drawdown include power, flood control, and recreation requirement. The summer high elevations are normally held through Labor Day to increase recreation potential. The reservoir is then gradually drawn down during September and October for power production. Further drawdown may be required through March, depending upon runoff forecasts and power requirements.

Water level fluctuations have 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 which has the capacity of drafting water from elevations 693 (2,287 feet) to 745 meters (2,459 feet) msl has been operational since 1977. A temperature rule curve for the selective withdrawal was determined

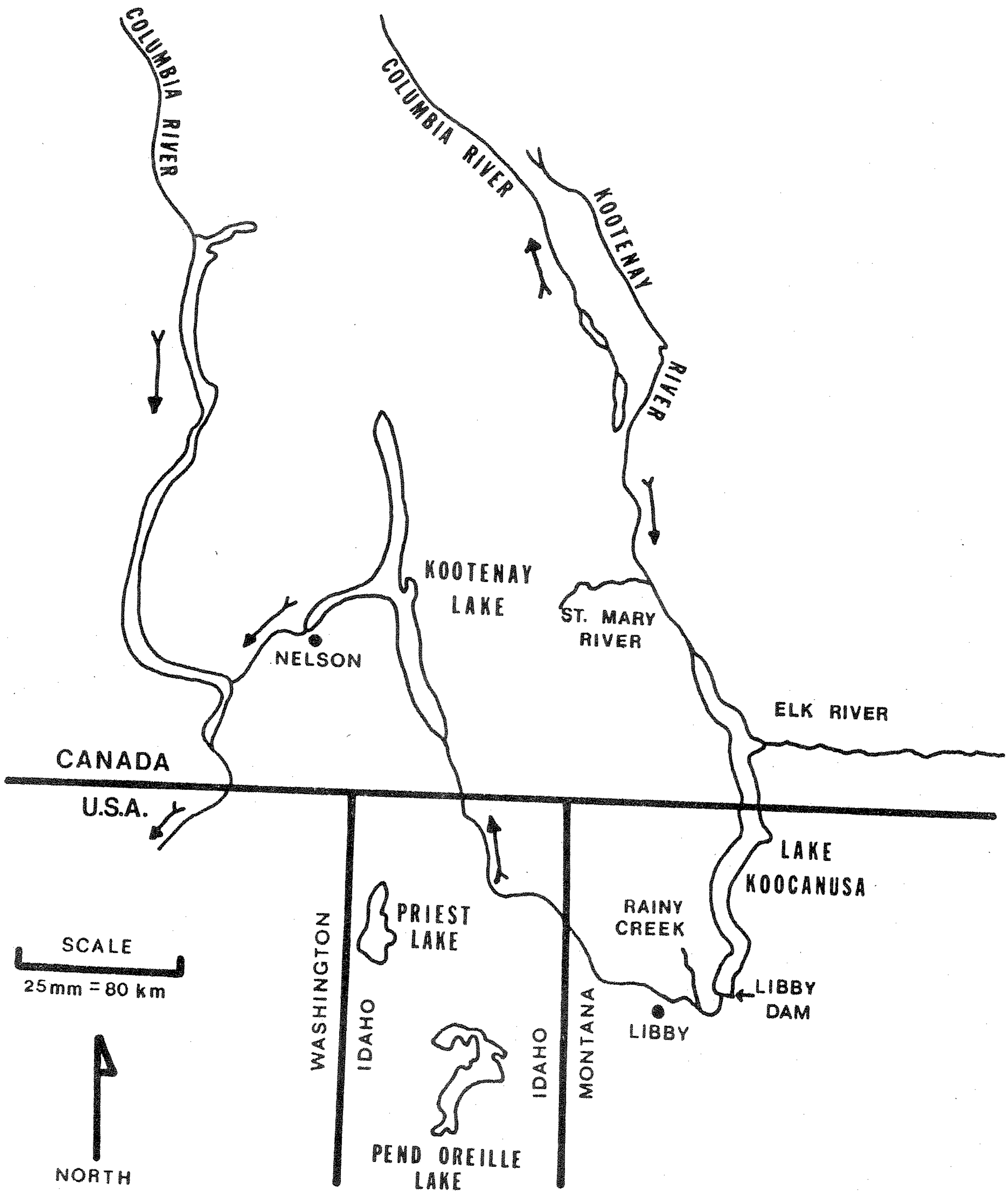


Figure 1. Kootenai River drainage.

to minimize escapement of gamefish from the reservoir, and also release water downstream to provide good temperature and provide near optimum temperatures for aquatic insect and rainbow trout production.

The fishery in the upper Kootenai River prior to Libby Dam consisted primarily of cutthroat trout, rainbow trout, mountain whitefish and burbot. The initial management plan for Lake Koocanusa was to establish spawning runs of adfluvial westslope cutthroat trout and other gamefish in suitable tributary streams. Westslope cutthroat trout inhabiting Hungry Horse Reservoir were selected as most suitable for the deep fluctuating reservoir environment of Lake Koocanusa. Approximately 1.4 million young-of-the-year cutthroat have been imprint planted in tributary streams of Lake Koocanusa. Approximately 3.7 million young-of-the-year yearling and adult cutthroat were planted directly into the reservoir from 1972-1982. The stocking plan for Lake Koocanusa has been 300,000 yearling cutthroat trout in the spring and 500,000 young-of-the-year each fall.

New reservoirs generally provide excellent sport fishing for the first few years due to low competition and an abundance of food and space resulting in excellent growth and survival of fish. As the reservoir ages, the maintenance of a satisfactory sports fishery becomes increasingly more difficult. Some of the factors affecting reservoir gamefish populations are: 1) inadequate annual recruitment of gamefish 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 gamefish. Reservoir operations can impact gamefish by altering any one of these 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 the environment which is satisfactory for gamefish.

Lake Koocanusa, now 10 years old, has provided a good sport fishery for cutthroat trout, rainbow trout and bull trout. Burbot populations have increased and are presently providing a fishery during the winter and spring months. The rainbow trout population is from natural reproduction and limited hatchery plantings, burbot and bull trout are recruited from natural reproduction, whereas the cutthroat population has been maintained by large plants of hatchery fish and natural reproduction. Kokanee salmon provided an excellent fishery during 1981 and 1982. These kokanee probably resulted from inadvertent introduction, but neither Montana or British Columbia has any record of such stocking.

In 1972, Corps of Engineers funded a comprehensive biological study of the newly formed reservoir, Lake Koocanusa. This report summarizes the data collected between 1972 and 1982 and some pre-impoundment information. The objectives of this study were to determine the changes in the fish population in Lake Koocanusa after impoundment of the Kootenai River, enhance spawning runs of gamefish and collect data necessary for the management of the sport fishery. The specific job objectives were:

1. Enhance spawning runs of cutthroat trout in suitable tributaries.
2. Evaluate effectiveness of spawning enhancement program.
3. Monitor relative abundance of important fish species in the reservoir.
4. Determine seasonal vertical and horizontal distribution of major gamefish.
5. Determine migration patterns of rainbow and cutthroat trout.
6. Determine angler catch rates and species composition of the harvest.
7. Determine food habits of rainbow and cutthroat trout.
8. Determine growth rates of major game species.
9. Determine origin of rainbow trout in Lake Koocanusa.

METHODS

WATER QUALITY DATA

Water quality and primary productivity data was provided by the U.S. Geological Survey and by Seattle District Corps of Engineers.

FISH POPULATION TREND SAMPLING

Standard gill net sampling techniques and methods for measuring relative abundance and determining fish population trends in Lake Koocanusa were developed by the Department's biological and statistical staff in 1974. These methods were:

1. Sampling in spring at the Rexford sampling area (Figure 2) to determine trends of bottom-oriented fish. Fish caught in each standard experimental bottom gill net set overnight were counted by species. A standard experimental gill net contains 7.6 meter-long sections of 1.9 centimeters, 2.5 centimeters, 3.2 centimeters, 3.8 centimeters and 5.1 centimeter bar measure mesh 1.8 meter deep. The catch-per-night of suckers, mountain whitefish, bull trout and ling was analyzed using the Kruskall-Wallis non-parametric ranking test (Gooch 1975).

   Sampling was to be done when: a) the reservoir was between elevation 716.3 and 723.9 meters msl during spring refill, b) surface water temperatures were 11^{o}C $\pm$ 2 degrees, and c) secchi disc readings were 1 meter or less. Since 1975, these netting criteria have been met in 1975, 1976, 1978, 1980 and 1982. Netting times have varied from May 6 in 1980 to June 7-8 in 1975.

2. Sampling in the fall at the Rexford and Cripple Horse netting areas (Figure 2) to determine trends in surface-oriented fish species. Nets were fished overnight for two nights at each netting area. Number of fish by species were counted by net and catch of rainbow and cutthroat trout, redside shiners, northern squawfish and peamouth chub analyzed using the Kruskall-Wallis non-parametric ranking test. Sampling was to be conducted when: a) Lake Koocanusa was within 3.0 meters of full pool elevation of 749.5 meters msl, b) surface water temperatures were 15.5^{o}C $\pm$ two degrees, and c) secchi disc readings 6.1 meters or greater. Since 1975, these netting criteria have been met in all years except 1977 and 1981. Calendar time of netting was the last week of September or the first week of October.

3. The Bailey Bridge area in British Columbia was net sampled in fall 1976, 1978 and 1980 using methods similar to those in Item 2 above. Sampling in British Columbia was limited by personnel available and British Columbia Fish and Wildlife Branch.

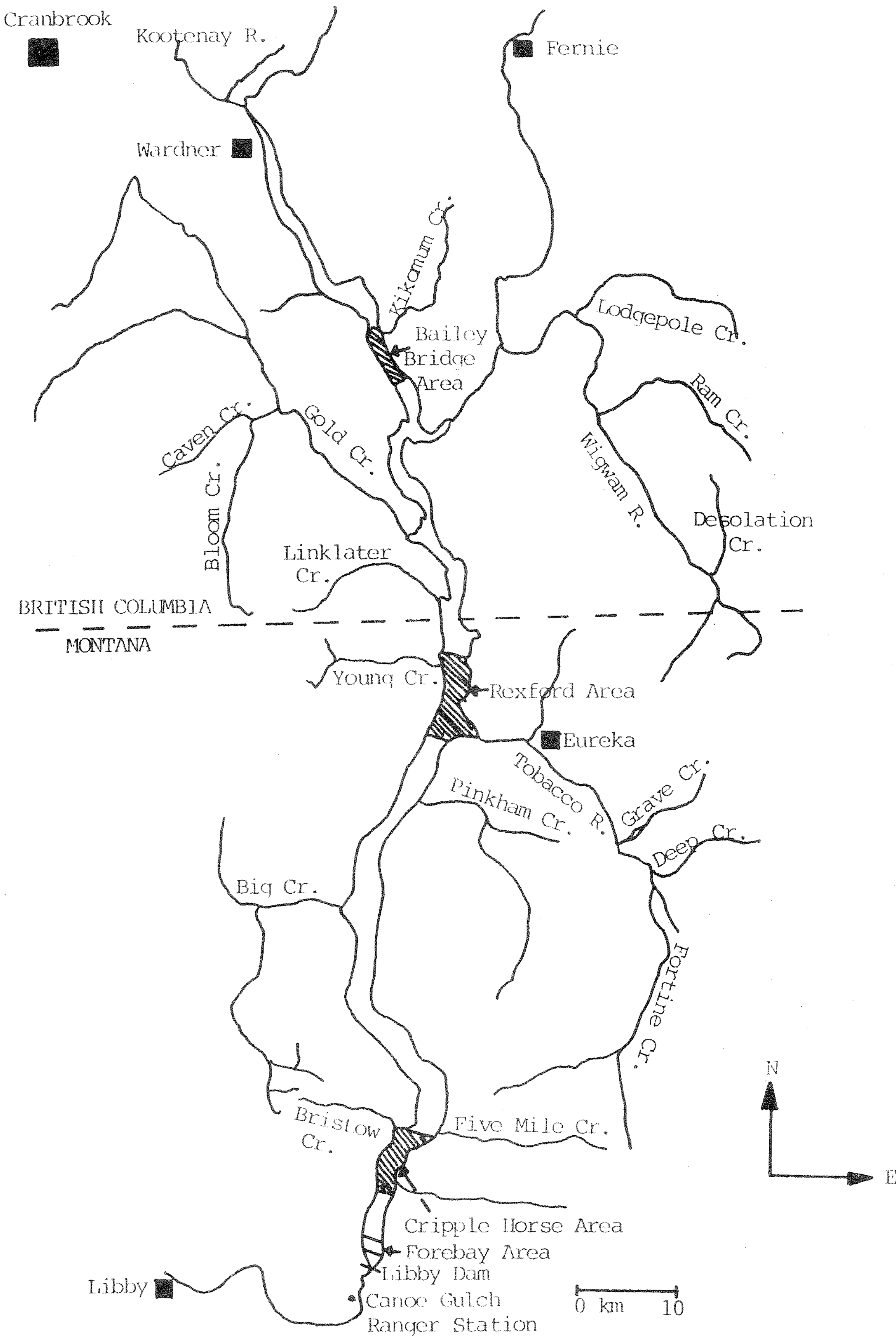


Figure 2. Lake Koocanusa sampling areas.

SPAWNING RUN TRENDS AND ESTIMATES

Spawning runs and smolt emigration of cutthroat trout were monitored at the Young Creek fish trap. Cutthroat trout collected in the upstream trap from 1970-1980 were measured, weighed, sexed, tagged, a scale sample removed, and released upstream. Jaw tags were used from 1970 through 1975 to mark individual adult fish; anchor tags were used in 1977, 1979 and 1980, and no adults were tagged in 1976 and 1978.

Spent spawners captured in the downstream trap were recorded by tag number, sex, length and released downstream.

Juvenile cutthroat trout (smolts) collected in the downstream trap from 1970 to 1973 were measured, weighed, marked by fin removal and released downstream. The same procedure was followed in 1974 and 1975, except the fish were cold branded following techniques outlined by Mighell (1969). Smolts over 17.8 cm in length were jaw tagged from 1970-1975.

Two sections of Young Creek were sampled annually to determine the survival and growth of imprint plants. Methods outlined by Vincent (1971) were used and population parameters were calculated from the field data by the use of a computer program (Holton 1975). The Tooley Lake section (350 meters long) was located in the lower five kilometers of Young Creek which was not chemically treated. Prior to development, this section contained cutthroat and brook trout. Section 3 (457 meters long) was located in the middle of the area which was treated to reduce resident fish populations. Prior to treatment, this section contained resident brook trout and fluvial cutthroat in about equal proportions. This section received annual imprint plants of about 1,350 adfluvial sub-fingerling cutthroat per 330 meters of stream length from 1970-1975.

Scales were collected from an area on the caudal peduncle immediately above the lateral line below the adipose fin insertion and were magnified 67 times to determine annual growth. The scales were collected from the caudal peduncle to avoid the problems of missing annuli associated with scales collected from just above the lateral line below the insertion of the dorsal fin (Brown and Bailey 1952 and Averett and MacPhee 1971).

Estimates were made of cutthroat and rainbow trout runs into the Tobacco River drainage in 1979 and the Big Creek drainage in 1980. Spawners caught with electrofishing gear and fyke nets near the mouth were marked and released upstream. Fish were caught and examined for marks throughout the drainage using fyke nets and box traps. Eleven traps were fished in the Tobacco River system in 1979 and six traps were fished in Big Creek in 1980.

AGE AND GROWTH DETERMINATION

Scale samples for determination of age structures and growth rates were collected from about 25 fish per each 25 mm group during netting and trapping operations. Samples were taken from cutthroat trout, rainbow trout, bull trout and mountain whitefish. Scales were collected from a small area below the origin of the dorsal fin and one scale row above the lateral line with the exception of cutthroat trout described previously.

Cellulose acetate impressions of the scales were read with the aid of a Bausch and Laumb microprojector. Measurements (mm) were made from the center of the focus to each annulus and to the anterior edge of the scale. Otoliths were taken from kokanee salmon and burbot and annular measurements were determined using a Bausch and Laumb dissecting microscope.

The Fire I computer program (Hesse 1977) was used to calculate the body-scale relationship. The relationship was most accurately described by the Monastrysky logrithmic method which is based on log-log plot of fish length versus scale radius. Body-scale relationships for mountain whitefish, rainbow trout, cutthroat trout and bull trout were calculated from pooled data (1975-1982) from Lake Koocanusa netting samples. Back-calculated lengths were determined using the Monastrysky relationship and Age Mat program, developed by Delano Hanzel and Bob McFarland of Montana Department of Fish, Wildlife and Parks. Growth data from the Rexford and Cripple Horse area were combined, because there was little difference in the growth of fish between the two areas.

The age at which juvenile rainbow, cutthroat and bull trout emigrated from their natal stream into Lake Koocanusa varied from young-of-the-year to three years old. Fish that emigrated as fry from the natal stream were classified as X_0. Fish that lived in the natal stream up to one year were classified X_1 and those that lived two and three years in the natal streams as X_2 and X_3, respectively. In this classification, 4_2 is a fish with total age of four years which emigrated after rearing in the natal stream for two years.

DETERMINATION OF VERTICAL AND HORIZONTAL FISH DISTRIBUTION

Sampling to determine vertical and horizontal fish distribution was limited to the forebay area (Figure 2). Sampling was conducted 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 vertical gill nets were used to determine species distributions in overnight sets. Net catches during daylight hours were too low to provide meaningful data.

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 surface nets, one gang of six surface nets and two single bottom nets.

Nets were set at dusk and lifted at dawn. Based on information from Windell, et al. (1976), nets were checked during the night and trout removed and placed on ice when surface temperatures exceeded 12°C. 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. Stomachs were preserved in a mixture of methyl alcohol, formaldehyde and acetic acid. In the laboratory stomach contents were analyzed using three methods; numerical, volumetric and frequency of occurrence.

TAG RETURNS

Rainbow trout, cutthroat trout and rainbow-cutthroat trout hybrids longer than 250 mm total length captured during spawning migration from Lake Koocanusa were tagged with a numbered anchor tag and released. Tagging was done in Young Creek, Big Creek and the Tobacco River drainage. Return of tags by anglers provided useful information on movements of individual fish and on angler harvest. Fishermen were requested to return tags from fish they had caught and provide information as to location, date and size of the tagged fish they caught. Through newspaper articles and radio programs anglers were asked to return tags and information to either Department personnel or local sporting goods stores.

CREEL CENSUS

Creel census data based on complete trips was collected from anglers at a compulsory checking station located at the Canoe Gulch Ranger Station from 1975-1978 (Figure 2). Anglers contacted in this census were primarily from the lower 40 to 50 kilometers of the reservoir. Creel census information was collected in the fall of 1975, spring, summer and fall of 1976 and 1977, and spring-summer of 1978. A total fishing pressure estimate for the reservoir was obtained from a statewide postal census for the 1975-1976 year.

A contact creel census was conducted on the lower 78 kilometers (U.S. portion) of the reservoir from April through October in 1981. Three major developed access sites on the eastside of the reservoir; Rexford bench, Peck Gulch and Cripple Horse were used to contact anglers as they returned to boat ramps. Shore anglers were also contacted at these sites. This creel census was conducted on two weekdays (Friday and Monday) and the two weekend days during May through July and only weekend days through October. Census schedules were adjusted so that the three sites were sampled equally.

Data collected from each angler included hours of fishing effort, time of day fished, number of fish caught by species and length and weight of fish caught. Gear type was recorded and included use of natural bait, artificial lures, flies or a combination. Residency of each angler was classified as resident of Lincoln County, other State of Montana residents, or non-residents.

Recreation Survey

A recreation survey was conducted at three developed campground and boat launch sites. The three sites, Cripple Horse, Peck Gulch and Rexford are located on the eastside of Lake Koocanusa approximately 8, 45 and 70 kilometers north of Libby Dam, respectively. Counts were made on vehicles, vehicle campers, tents and boats at each site in conjunction with creel census efforts. Boat numbers reflect all boats seen whether on the lake, docked, or on trailers. Counts were made on two weekdays (Monday and Friday) and the two weekend days from May through July. Only weekend days were counted in August through October as the creel census period was reduced. Additional information was obtained from Forest Service records for Peck Gulch and Rexford facilities.

FINDINGS AND DISCUSSION

MORPHOMETRIC CHARACTERISTICS

The lower 65 km of Lake Koocanusa is a narrow deep reservoir confined to a restricted floodplain between steep mountains. The upper part of the reservoir from about the mouth of the Tobacco River to the head of the pool near Wardner, British Columbia extends through a broad shallow valley.

Reservoir drawdown for flood control and power generation during the fall and winter substantially reduces the volume of Lake Koocanusa and causes a number of changes in the reservoir morphometry (Table 1). The surface elevation at full pool is 749.5 m above msl as compared to 697.1 m at minimum pool. At full pool the reservoir has a length of 145 km, a volume of 7.24 km^3 and a surface area of 188.0 km^2. The drawdown to minimum pool reduces the length to 68 km, the volume to 1.10 km^3 and the area to 58.6 km^2. The drawdown from 1974-1982 has ranged from 52.2 m to 28.5 m (Table 2).

Retention time is the average time required to replace the contents of a reservoir at a given rate of flow. A mean retention time of 0.67 years was calculated for Lake Koocanusa, based on mean annual volume and annual flow (Bush and Bonde 1977). Woods and Falter (1982) calculated retention times for each month because of the reservoir's wide range of volumes and flows. They also calculated flushing time for each month. Flushing time was defined as the average time required to remove the reservoir's contents at a given flow. They found that flushing and retention times varied widely in Lake Koocanusa. In each of the four years examined, retention times in the spring were less than 0.1 years as large volumes of spring runoff entered the reservoir. Flushing times were also short during reservoir filling and drawdown. Mean annual retention times ranged from 0.20 to 0.68 years. These short retention and flushing times contributed to weak thermal structure in the reservoir.

PRE-IMPOUNDMENT WATER QUALITY

Little data were collected on the water quality and fishery of the Kootenai River prior to 1970. Bonde and Bush (1975) reported that in the 1950's water quality deteriorated in the Kootenai River, resulting in increased algae growth, silt and sediment becoming more noticeable. Sediment loads during the spring appeared larger and more persistent and on occasion the river developed an odd color. A decline in cutthroat trout and burbot populations and an increase in rainbow trout and mountain whitefish was associated with changes in water quality. Major sources of pollution were a pulp mill on Skookumchuck Creek, smelter and fertilizer plants on the St. Mary River,and coal mines in the Elk River drainage all in British Columbia.

Pollution in the St. Mary River resulted from effluents from a lead-zinc mine, a concentrator, a fertilizer plant and city sewage plant (Malick 1978). The mine began operation in 1900, the fertilizer plant in 1953 and the iron and steel plants operated from 1961 to 1972. Water quality in the

Table 1. Summary of Lake Koocanusa morphometric characteristics.

Area	
Maximum pool	188.0 sq km (46,456 acres)
Minimum pool	58.6 sq km (14,487 acres)
Volume	
Maximum pool	7.24 km^3 (5,869,400 acre ft)
Minimum pool	1.10 km^3 (890,000 acre ft)
Depth	
Mean	38.5 m (126.4 ft)
Maximum	107 m (350 ft)
Length	
Maximum	145 km (90 miles)
Minimum	67.6 km (42 miles)
Breadth	
Maximum	4 km (2.5 miles)
Shoreline	
Length	362 km (224 miles)
Development	7.4
Elevation	
Maximum pool	749.5 m (2,459 ft)
Minimum pool	697.1 m (2,287 ft)
Drawdown	
Maximum	52.4 m (172 ft)
Average	38.4 mm (126 ft)
Storage ratio	0.67 year
Drainage area	23,271 km^2 (8,985 m^2)
Drainage area:Surface area	124:1

Table 2. Maximum and minimum pool elevations in Lake Koocanusa, 1972-1982.

Calendar year	Minimum elevation in meters	Maximum elevation in meters	Drawdown in meters
1972	----	733.4	----
1973	679.2	736.6	70.3
1974	703.1	749.5	46.4
1975	697.3	749.5	52.2
1976	703.7	749.5	45.8
1977	719.3	736.6	30.2
1978	710.5	749.5	39.0
1979	721.0	747.7	28.5
1980	717.7	749.5	31.8
1981	716.6	749.5	32.9
1982	714.3	749.5	35.2

Kootenai River improved in 1968 following implementation of the first step of pollution control at the industrial complex on the St. Mary River. The improvement in water quality resulted in a marked increase in aquatic insect populations in the Kootenai River. The standing crop of aquatic insects increased from 1968 to 1971 by 273 percent above Libby Dam site and by 392 percent downstream from Libby Dam (Bonde and Bush 1975).

Additional improvements in water quality of the St. Mary River and Kootenai River were made in 1975 and 1977, largely by recycling effluents (Malick, ibid.). The concentrations of dissolved phosphorous, iron, zinc, lead and fluorides were reduced and the pH increased. Rapid recovery of the stream biota occurred in conjunction with the reductions in levels of heavy metals, suspended solids and phosphorous discharged into the St. Mary River. Cutthroat trout populations have increased and a good fishery now exists for this species in the St. Mary River (Jerry Oliver, personal communication).

In summary, water quality problems in the Kootenai River prior to impoundment were limiting aquatic insect populations and appeared to have caused a shift in species from a population dominated by cutthroat trout and burbot to one dominated by rainbow trout and mountain whitefish.

POST-IMPOUNDMENT WATER QUALITY

An intense water quality sampling program was conducted on Lake Koocanusa. This program was prompted by concern over the water quality of Lake Koocanusa and led to a cooperative study by the Seattle District, Corps of Engineers and British Columbia Waste Management Branch. Eight sampling stations were established on Lake Koocanusa, four in the United States portion and four in the Canadian portion. The U.S. Geological Survey (USGS) collected the water quality samples and did the field and laboratory analysis under contract with the Seattle District Corps of Engineers. The results of this study are summarized in the report "Limnological Investigations Lake Koocanusa, Montana" by P.C. Storm et al. (1982) and in the annual USGS Water-Date Reports for the Columbia River basin in Montana. A brief discussion of some of the more important water quality parameters affecting primary production and fish distribution and production follows.

<u>Alkalinity and pH</u>

The average total alkalinities in Lake Koocanusa have ranged from 83 to 100 mg/l since impoundment of the Kootenai River (Table 3). The average pH values during the same period have ranged from 8.0 to 8.6. These values classify Lake Koocanusa as a medium-water lake. There has been little change since impoundment in the alkalinity and pH values in Lake Koocanusa. There was little difference in the concentrations of these constituents in the upper and lower part of the reservoir.

It is generally recognized that the best waters for the support of diversified aquatic life are those with pH values between 7 and 8, having a total alkalinity of approximately 100-120 mg/l or more (McKee and Wolf 1963). This alkalinity serves as a buffer to help prevent any sudden

Table 3. The average annual pH, total alkalinity, specific conductance, total phosphorous and dissolved orthophosphate from Lake Koocanusa, 1972-1981. The measurements were taken in the upper ten feet of the water column.

Year	pH		Total alkalinity		Specific conductance		Total phosphorous		Total orthophosphate	
	TM 1/	IB 2/	TM	IB	TM	IB	TM	IB	TM	IB
1972	8.3	8.3	83	86	192	199	---	---	.022	.028
1973	8.1	8.0	100	98	230	227	---	---	.035	.020
1974	8.3	8.3	98	88	204	172	.037	.045	.018	.007
1975	8.3	8.2	96	88	229	201	.045	.038	.022	.018
1976	8.4	8.5	93	90	207	196	.023	.019	.006	.016
1977	8.6	8.6	99	95	227	223	.008	.010	.006	.006
1978	8.5	8.5	95	90	226	219	.004	.004	.001	.000
1979	8.6	8.5	96	95	238	227	.005	.004	.003	.000
1980	8.4	8.4	92	93	220	224	.007	.007	.003	.002
1981	8.5	8.4	96	92	240	229	.012	.006	.001	.001

1/ Ten mile station (27 kilometers upstream from Libby Dam).
2/ International border station (82 kilometers upstream from Libby Dam).

change in pH value, which might cause death to fish or other aquatic life. Using these criteria, it appears that Lake Koocanusa has the potential to be quite biologically productive.

Specific Conductance

The specific conductance in Lake Koocanusa from 1972 to 1981 ranged from 172 umhos to 238 umhos (Table 3). Specific conductance was generally slightly higher at the Ten Mile Station than at the International Border Station. The conductance varied from year to year with no apparent trend upward or downward.

Conductance has often been used as a gross indicator of potential productivity of aquatic systems. Studies by Ellis et al. (1946) indicated that the specific conductance of inland fresh waters supporting a good mixed fish population lay, in general, between 150-500 umhos. This data indicates that Lake Koocanusa has the potential to support a diverse and productive fish fauna.

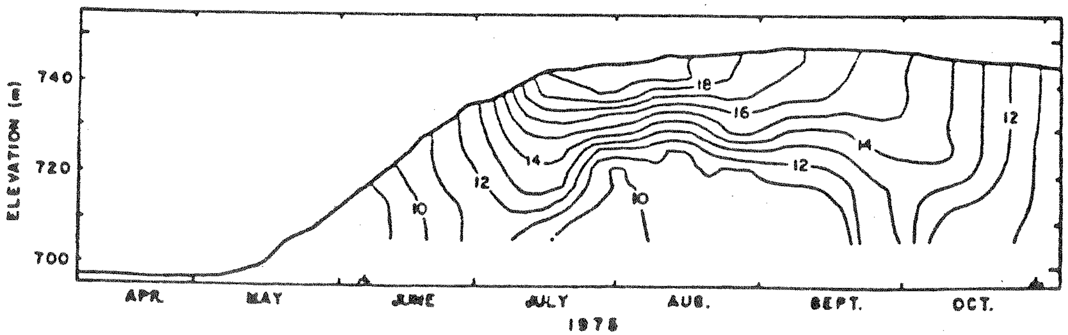
Nutrient

Total phosphorous and dissolved orthophosphate were high in Lake Koocanusa from 1972-1975 (Table 3). Concentrations of both forms of phosphate declined in 1976 and again in 1978 when loadings from the fertilizer plant on the St. Mary River were reduced. The range of mean epilimnetic total phosphorous concentrations from 1972-1975 rank Lake Koocanusa as eutrophic, as do the lakewide concentrations of total phosphorous (Woods and Falter 1982). Concentrations of soluble phosphorous of greater than .01 mg/l at the start of the growing season often result in nuisance blooms of algae (Sauger 1947). Concentrations of soluble phosphate in Lake Koocanusa after 1978 were generally below the level that triggers algae blooms.

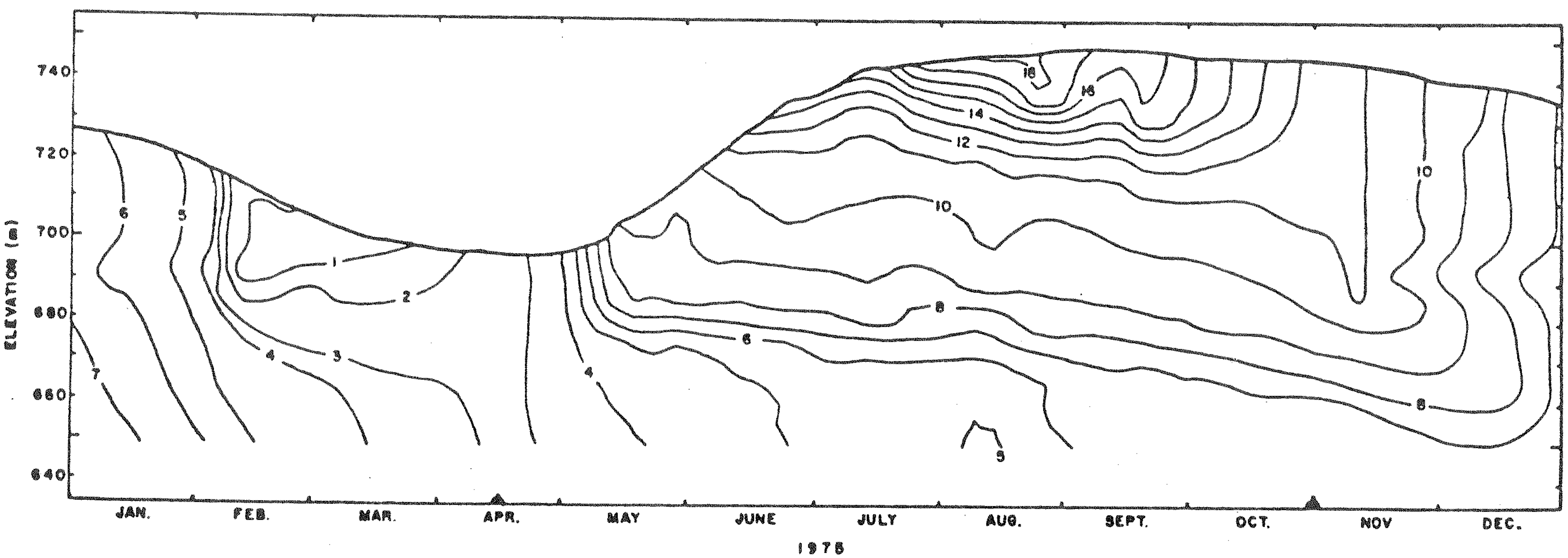
Water Temperature

Water temperature in Lake Koocanusa have ranged from 0.0 to 23°C with the maximum surface temperatures occurring from late July to early August (Figures 3 and 4). Water temperatures in the upper part of the reservoir at the Boundary Station generally warmed up faster in the earlier summer and cooled faster in the fall than in the lower part of the reservoir at the Forebay and Ten Mile stations. Consequently, isotherming occurred earlier at the Boundary Station than at the Ten Mile and Forebay stations.

The wide spacing of the isotherms in Lake Koocanusa indicates a predominantly weak thermal structure (Woods and Falter 1982). They pointed out that the weak thermal structure of Lake Koocanusa was largely attributable to the complexity of water movements within the reservoir. Water movements in reservoirs result from the interactions of currents, thermal stratification, basin morphology, climate and reservoir operations. When flows are large relative to reservoir volume, retention and flushing times are reduced. Retention and flushing times vary widely in Lake Koocanusa, depending to a large degree upon the magnitude of the annual spring flood and reservoir operation. In general, short retention and flushing times are associated with weak thermal structure.



a. Boundary station.



d. Forebay station.

Figure 3. Isopleths of water temperature (°C) in 1975.

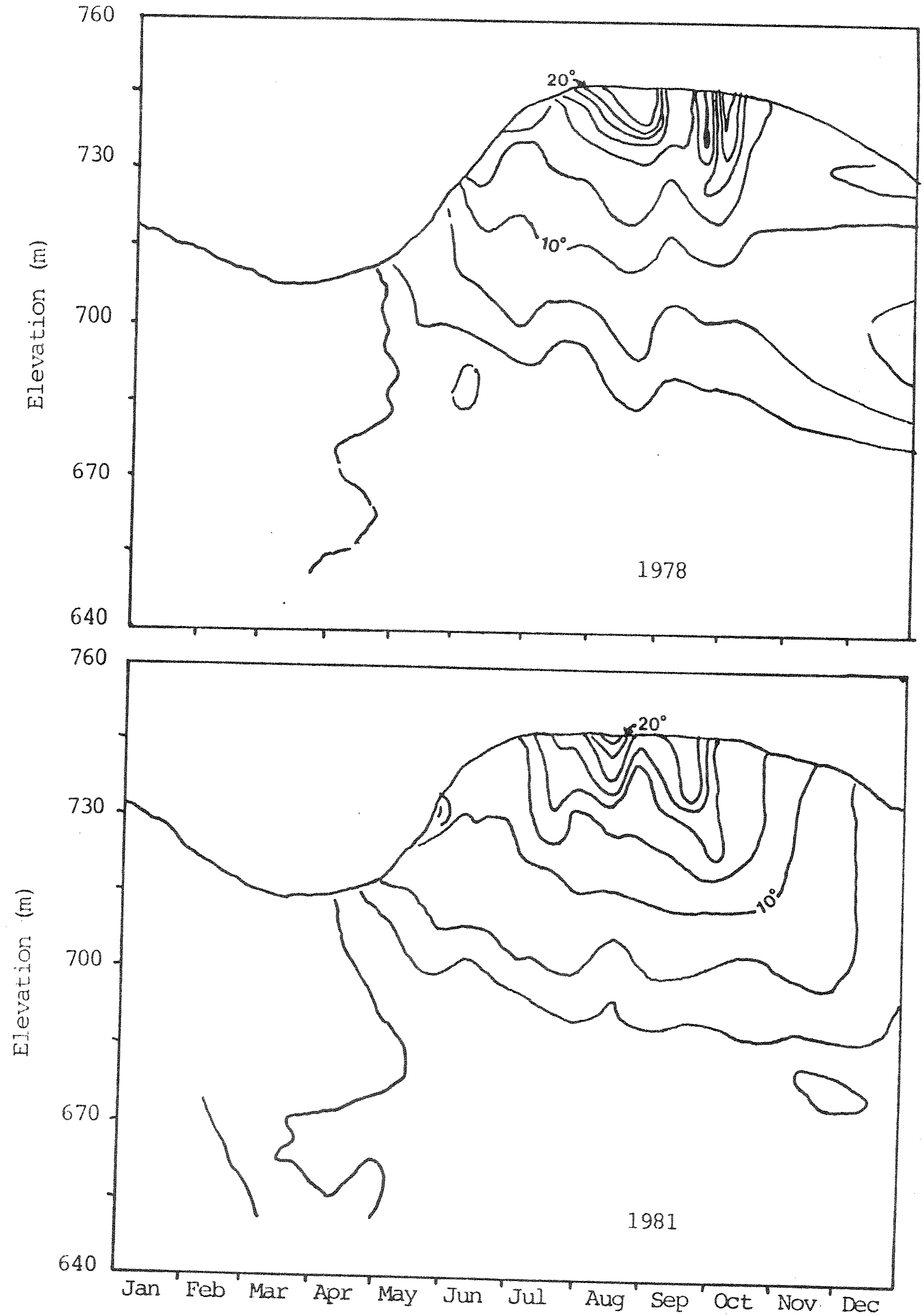


Figure 4. Temperature isopleths (2°C) in forebay area of Lake Koocanusa, 1978 and 1981.

The growing season for rainbow trout and cutthroat trout was longer in Lake Koocanusa than in the river prior to impoundment. Water temperatures in the Kootenai River prior to impoundment were above 10°C an average of 111 days a year from June 15 to October 4 (Table 4). Following impoundment, the water temperatures in the upper ten feet of the water column in the reservoir were above 10°C from approximately May 20 to November 15, or a total of about 180 days. In addition, the water temperatures in the reservoir are warmer during the winter than the Kootenai River was prior to impoundment.

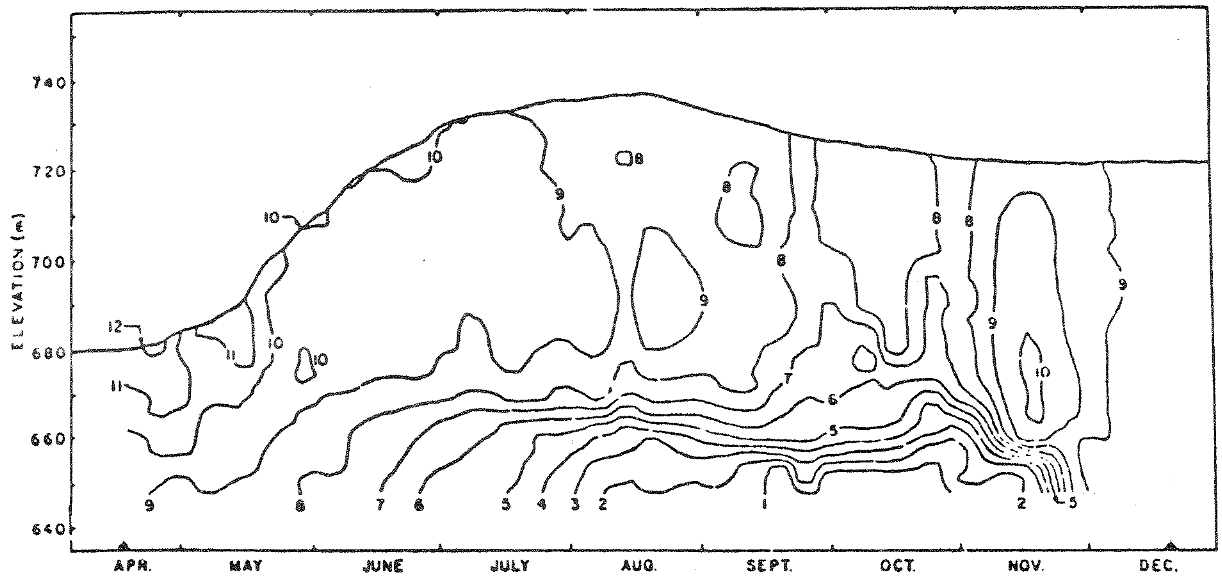
Table 4. The number of days in which the water temperatures in the Kootenai River and in the upper ten feet of Lake Koocanusa were above 10°C. The Lake Koocanusa data was based on temperature profiles taken at the Forebay and Ten Mile Stations.

Calendar year	Period temperature above 10°C	Number of days temperature above 10°C
Pre-impoundment 1962-1971	6/15-10/4	111
Post-impoundment 1972-1981	5/20-11/15	180

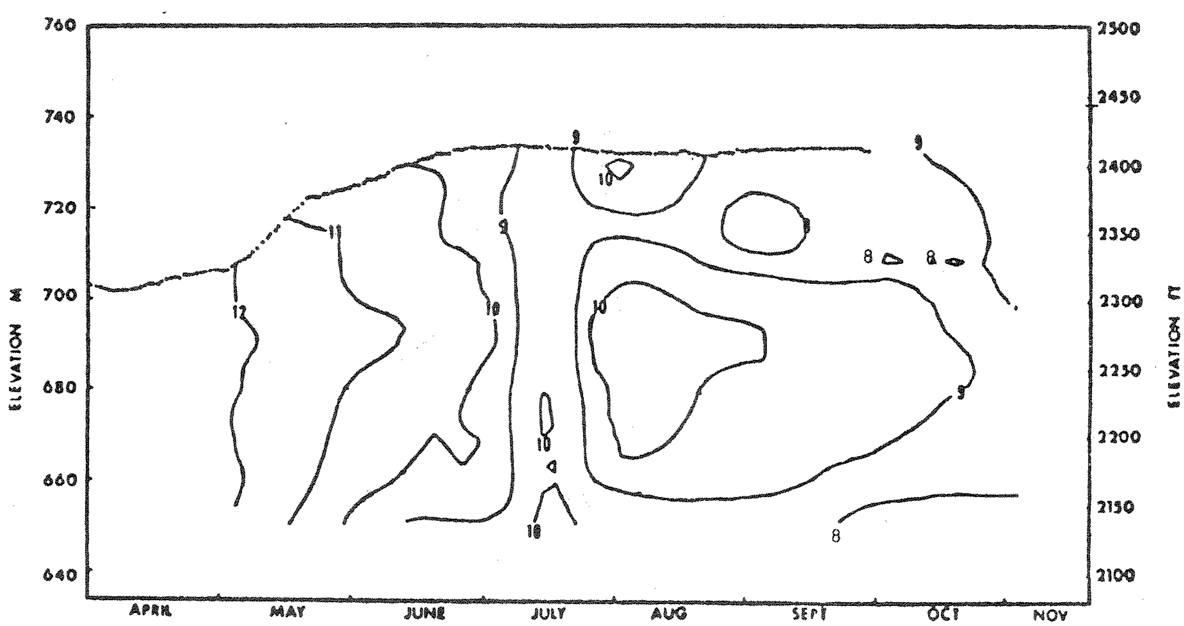
Temperature preferences vary from species to species. Studies by Atherton and Aiken (1970) and McCauley et al. (1977) found that rainbow trout over one year old preferred temperatures of about 10-12°C and grew best at a temperature of about 11.7°C. Hokanson et al. (1977) noted that the maximum specific growth rate of juvenile rainbow trout fed excess rations occurred at a temperature of 17.2°C. Little work has been done on temperature preferences of cutthroat trout, but it appears that they prefer slightly cooler temperatures than rainbow trout McMullin (1979). Kokanee are a pelagic fish and prefer temperatures close to 10°C (Seeley and McCammon 1966). Temperatures above 60°F can lead to severe mortalities among young fish.

Dissolved Oxygen

Dissolved oxygen concentrations in the upper 30 m of the water column in Lake Koocanusa have generally ranged from 8 to 10 mg/l (Figure 5). These concentrations are adequate to sustain healthy aquatic life and are above the minimum required to support fish life. The Montana State Department of Health and Environmental Sciences standard for B-Dl waters, which include Lake Koocanusa, is a dissolved oxygen concentration of above 7.0 mg/l. The quality of this water is suitable for growth and propagation of salmonid fishes and associated aquatic life.



1973.



1977.

Figure 5. Isopleths of dissolved oxygen (mg/l) in forebay area of Lake Koocanusa.

Selective Withdrawal System

A selective withdrawal system became operational at Libby Dam in June 1977. Under current operational plans, the selective withdrawal system is typically placed in operation in April with installation of the bulkheads. All bulkheads are removed in the late fall when the reservoir becomes isothermal. A temperature rule curve was instituted to regulate temperatures of discharge to benefit fish growth in Kootenai River without causing fish loss out of the reservoir. Winter discharges are hypolimnional at the penstock inverts where the temperatures are generally near 4°C. As the reservoir fills in the spring, the selective withdrawal is operated to follow the temperature rule curve with the constraint that water be withdrawn no closer than 50 feet from the pool surface to reduce escapement of fish from the reservoir. The operation of the system provides temperatures which are warmer than the natural regime in the Kootenai River from October to March and cooler from April through September (May and Huston 1983).

The operation of the selective withdrawal system has resulted in a discharge from the epilimnion and thermocline rather than the hypolimnion during the period from April through October. The overall affects of this change in water withdrawal strategy is not known, but it has likely had a significant effect upon the limnology of the reservoir. Outlet depth influences water temperatures, nutrient concentrations and primary productivity in reservoirs. It also affects the magnitude of downstream loss of plankton and fish.

Outlet depth appears to influence fish production in reservoirs. Jenkins (1968) concluded that outlet depth greatly influenced the standing crops of fishes in reservoirs. An increase in outlet depth was correlated with decreased standing crops of fishes in hydroelectric impoundments.

Primary Productivity

The average annual primary productivity in $mg/c/m^2/day$ in Lake Koocanusa is given in Table 5. The annual average for the reservoir ranged from 114 to 166 $mg/C/m^2/day$ with an average for the ten years of record of 136. Average productivity was higher from 1977-1981 (147) than from 1972-1976 (125). This may have been in response to more stable water levels from 1977-1981 and/or operation of the selective withdrawal system. There was little overall difference in productivity among the three areas of the reservoir. These primary productivity values indicate that Lake Koocanusa was oligotrophic in nature even though the reservoir has a potential for eutrophy due to large nutrient loadings. Short retention time, large volumes of stratified interflow or underflow and high levels of abiogenetic turbidity limited primary productivity.

The complex reservoir hydrodynamics caused by the operational schedule resulted in weak thermal structure in the reservoir resulting in circulation of phytoplankton out of the euphotic zone. The decrease in phytoplankton photosynthesis caused by low light conditions beneath the euphotic zone was an important factor in the suppression of primary productivity to oligotrophic levels. Circulation effects on photosynthesis was further compounded by the highly turbid spring inflows. The euphotic zone depths

Table 5. The average annual primary productivity in Lake Koocanusa from 1972-1981. Primary productivity was measured in terms of mg/C/m^2/day in the euphotic zone.

Year	Forebay	Ten Mile	International border	Annual average
1972	113	180	152	148
1973	125	155	99	130
1974	128	106	120	118
1975	114	111	117	114
1976	130	115	98	116
1977	146	139	132	140
1978	152	157	134	150
1979	155	136	138	144
1980	164	148	193	166
1981	129	130	161	137
Average	135	137	134	136

were reduced by the turbid inflows and this coupled with the weak thermal structure resulted in the phytoplankton community being below the euphotic zone much of the time during reservoir filling.

Weak thermal structure has been correlated with low fish production in reservoirs (Jenkins 1970). He noted that reservoirs with a thermocline typically have higher total standing crops than those without. It is logical that a reduction in phytoplankton productivity would result in low fish production because the primary productivity in large reservoirs is based on phytoplankton. Low production of phytoplankton results in less food organisms for fish and consequently a low standing crop of our finny friends.

PRE-IMPOUNDMENT FISH POPULATIONS

Very little data were collected from the Kootenai River drainage fishery prior to construction of Libby Dam. Game wardens collected some creel census information in 1949, 1951, 1952 and 1965 through 1968. Department biologists electrofished Kootenai River at the Cripple Horse and Rexford areas from 1969 through 1971, and made spawning habitat analysis of most river tributaries from 1966 through 1971. A summary of the creel census information is shown in Table 6.

Cutthroat dominated the catch during the summer season comprising 46.2 percent of the fish creeled followed by mountain whitefish (38.7%), burbot (7.6%), rainbow trout (6.5%) and bull trout (1.0%). The average length of cutthroat and rainbow trout creeled was 284 mm and 304 mm, respectively. The catch rate of all gamefish was .97 fish per hour of effort, whereas the catch rate of trout only was 0.52 fish per hour of effort. Mountain whitefish comprised 90 percent of the harvest during the winter and these fish averaged 282 mm in length. The creel data indicates that the Kootenai River supported a good fishery for cutthroat trout prior to impoundment even though water quality problems were limiting aquatic insect populations.

Electrofishing data collected from the Cripple Horse area from 1969-1971 indicated that mountain whitefish was the most abundant gamefish followed by cutthroat trout, rainbow trout and bull trout (Table 7). In the Rexford area, mountain whitefish comprised 96.7 percent of the catch with the remainder of the sample consisting of 2.2 percent cutthroat, 0.8 percent bull trout and 0.3 percent rainbow trout.

Stream surveys to determine those streams with significant potential for spawning and rearing of gamefish from the new reservoir were conducted on most Kootenai River tributaries from the dam site to the British Columbia border. Twenty-two streams tributary to the Kootenai River were surveyed of which three streams had falls immediately above or below reservoir full pool which blocked access by reservoir fish. Thirteen streams were considered to have little potential as spawning streams. Reasons for rejection included one or more of the following factors: small size, high gradients, stair-step beaver dams, heavy brook trout populations, barriers to upstream fish passage other than falls (such as culverts) or active beaver colonies.

Table 6. A summary of angler catch by season from creel census conducted by game wardens in the Kootenai River for 1949, 1951, 1952, 1954-1964.

Number of anglers	Catch per man hour of effort		Percent species composition of the catch and average total length in mm in parenthesis				
	Trout	Gamefish	RB[1/]	CT	DV	MWF	LING
Summer, May 1 - Oct. 31							
315	.52	.97	6.5(307)	46.2(284)	1.0(323)	38.7(259)	7.6(434)
Winter, Nov. 1 - Apr. 30							
1,834	.06	1.53	0.2(290)	3.0(279)	0.6(290)	94.0(282)	2.2(470)

1/ Abbreviations are: RB = rainbow trout, CT = cutthroat trout, DV = bull trout, MWF = mountain whitefish, LING = ling.

Table 7. Species composition of gamefish from electrofishing catches in the Rexford and Cripple Horse areas of the Kootenai River, 1969-1971. Number of fish caught is in parenthesis.

Date	Species			
	Cutthroat	Rainbow	Bull trout	Mountain whitefish
Rexford Area				
1969-1970	2.2 (8)	0.3 (1)	0.8 (3)	96.7 (348)
Cripple Horse Area				
1969-1971	2.8 (18)	2.3 (15)	0.3 (2)	94.6 (611)

Six streams tributary to Kootenai River were considered worthy of special consideration and included Young Creek, Sullivan Creek, Big Creek, Tobacco River and its tributaries, Pinkham Creek and Five-Mile Creek (Figure 6). Results of tributary development and establishment of spawning runs will be discussed later. Spawning runs of gamefish from Kootenai River did enter some of the six tributary streams prior to impoundment. These were: Young Creek - cutthroat trout, Tobacco River - cutthroat, rainbow and bull trout and mountain whitefish, and Pinkham Creek - rainbow trout.

POST-IMPOUNDMENT FISHERIES INVESTIGATIONS

Nineteen species of fish have been documented to have been present in Kootenai River and Lake Koocanusa. A species list for Kootenai River and Lake Koocanusa is presented in Table 8. Three species, kokanee, yellow perch and lake trout now present in Lake Koocanusa were not found in Kootenai River. Lake trout and kokanee originated from a British Columbia Fish and Wildlife fish hatchery located on the Bull River immediately upstream from Lake Koocanusa. Yellow perch were probably from Murphy Lake which lies in the Tobacco River drainage about 29 km above the reservoir. White sturgeon, although planted in Lake Koocanusa, probably are no longer present in the reservoir. Three of the five individuals transplanted into the reservoir from Kootenai River below Kootenai Falls have been reported caught by anglers. A fourth fish was caught in the Kootenai River upstream from Lake Koocanusa by British Columbia Fish and Wildlife Branch personnel.

Longnose dace, torrent sculpin and slimy sculpin were present in Kootenai River but have never been captured in Lake Koocanusa. It is likely that these species are still present in the reservoir but confined to stream mouths. Their numbers are surely reduced from pre-impoundment levels. Largemouth bass and brook trout were occasionally caught prior to impoundment; the bass in backwater sloughs and brook trout in creek mouths and sloughs. Both species were rarely caught in the impoundment.

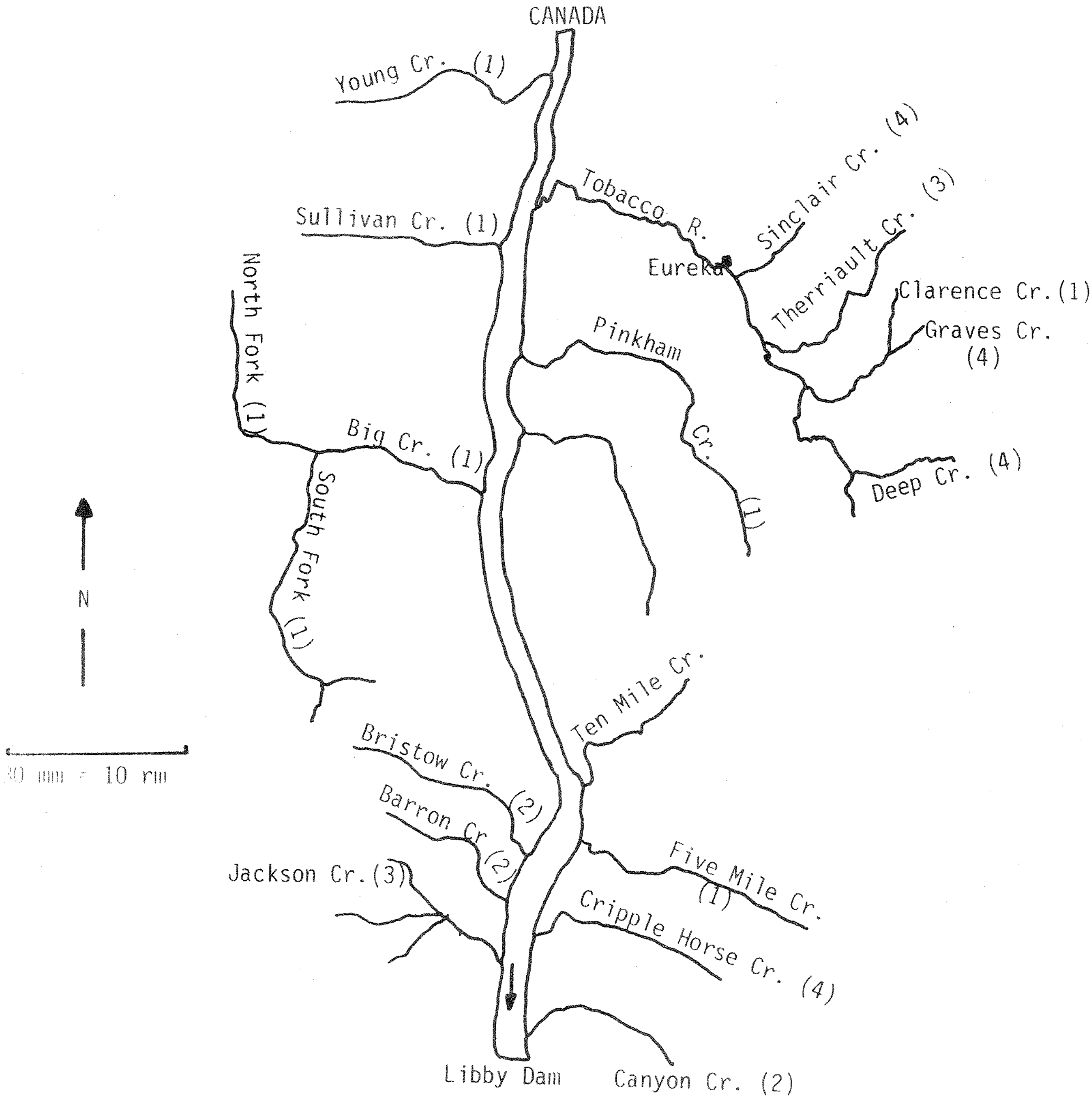


Figure 6. Map of Lake Koocanusa showing enhancement work done on tributaries. (1) - barrier removal, suppression of resident fish and imprint plants of westslope cutthroat; (2) = barrier removal and imprint plants of westslope cutthroat or mountain whitefish; (3) barrier removal only; (4) only imprint plants of westslope cutthroat or mountain whitefish.

Table 8. Species list and relative abundance of fish in the Kootenai River upstream from Libby Dam and from Lake Koocanusa.

Common name	Scientific name	Abbreviation	Relative abundance	
			Pre-impoundment	Post-impoundment
Westslope cutthroat trout	*Salmo clarki lewisi*	WCT	C[1]	A
Rainbow trout	*Salmo gairdneri*	RB	C	A
Bull trout	*Salvelinus confluentus*	DV	C	C
Brook trout	*Salvelinus fontinalis*	EB	R	R
Lake trout	*Salvelinus namaycush*	LT	X	R
Mountain whitefish	*Prosopium williamsoni*	MWF	A	C
Ling (Burbot)	*Lota lota*	LING	U	U
Kokanee salmon	*Oncorhynchus nerka*	KOK	X	C
Largemouth bass	*Micropterus salmoides*	LMB	R	R
White sturgeon	*Acipenser transmontanus*	---	X	N
Yellow perch	*Perca flavescens*	YP	X	R
Torrent sculpin	*Cottus rhotheus*	COT	A	N
Slimy sculpin	*Cottus cognatus*	COT	U	N
Longnose sucker	*Catostomus catostomus*	FSU	U	A
Largescale sucker	*Catoostomus macrocheilus*	CSU	A	A
Northern squawfish	*Ptychocheilus oregonensis*	SQ	R	A
Peamouth chub	*Mylocheilus caurinus*	CRC	R	A
Redside shiner	*Richardsonius balteatus*	RSS	C	C
Longnose dace	*Rhinichthys cataractae*	---	C	N

1/ A = abundant, C = common, U = uncommon, R = rare, N = not collected, X = absent.

Peamouth, longnose sucker and squawfish were rarely caught in Kootenai River, but all three species are abundant in the reservoir. Relative abundance of bull trout and largescale suckers has not changed from the riverine to lake environment, while abundance of mountain whitefish has decreased. Abundance of rainbow trout and cutthroat trout has increased at least partially due to management efforts including planting of hatchery fish and tributary spawning development.

Evaluation of Tributary Development

Corps of Engineers and Montana Department of Fish, Wildlife and Parks selected pure strain westslope cutthroat trout as the management species for Lake Koocanusa and this species has been the principle salmonid planted from hatchery sources. The exceptions were planting of mountain whitefish fry in Lake Koocanusa tributaries in an attempt to establish spawning populations, and transplanting five white sturgeon into the reservoir from Kootenai River below Kootenai Falls.

Native stocks of westslope cutthroat trout collected from Hungry Horse Creek, a tributary of Hungry Horse Reservoir, were planted in Lake Koocanusa and its tributary streams. This fish stock has sustained itself in Hungry Horse Reservoir and has a life cycle suited to bodies of water with considerable competition from other fish species, but with adequate tributary streams.

Adult cutthroat spawn in tributary streams in mid- to late spring. Most adults are four to six years old and are seldom more than 457 mm long. The eggs hatch and the young rear in the tributary (natal stream) for a period of one to three years before smolting downstream into the lake or reservoir. These juvenile fish spend one to three years in the lake or reservoir before reaching maturity and returning to the natal stream to spawn, completing the life cycle. Juvenile fish smolting at an age of one to three years are large enough to avoid severe competition and predation from other fishes. The number of juvenile fish smolting into a particular body of water is regulated by the amount of suitable spawning and rearing tributaries.

Non-salmonid fish were expected to severely restrict salmonid populations, particularly westslope cutthroat trout, due to competition and predation. Corps of Engineers constructed Murray Springs cutthroat trout hatchery as partial mitigation of fish losses expected from impounding Kootenai River and to mitigate lack of spawning streams.

Development of streams to maximize gamefish recruitment was deemed a viable management option to help mitigate fishery losses from inundation of Kootenai River. Development work was done on about 150 km of streams within the Big Creek, Tobacco River, Pinkham, Five-Mile, Sullivan and Young Creek drainages. Development work included removal of barriers inhibiting upstream movement of fish, chemical suppression of resident fish populations, and imprint plantings of westslope cutthroat trout or mountain whitefish. Any one or a combination of steps were carried out on each stream treated (Figure 6). Development work and results are presented by drainage below.

Young Creek

Young Creek was selected as a test stream to determine the feasibility of establishing spawning runs of westslope cutthroat trout in Lake Koocanusa tributaries. Young Creek rises on the east slopes of the Purcell Mountains and has a drainage area of 120 square km. The creek flows 17 km to its confluence with Lake Koocanusa, 5 km south of the Montana-British Columbia border (Figure 7). Median annual high flows are about 100 cubic feet per second (cfs) and low flows are about 5 cfs. Water temperatures ranged from 0-18°C, while summer and fall alkalinities were about 130 mg/l and standard conductance was about 200 micromhos.

Prior to impoundment, Young Creek supported a small spawning run of cutthroat trout from the Kootenai River. Resident cutthroat trout and brook trout inhabited the stream with brook trout concentrated in the meadow area. The development work was done in 1970 and Young Creek received annual imprint plants from 1970-1975 of approximately 1,350 cutthroat per 300 m of stream.

Corps of Engineers constructed a concrete upstream-downstream fish trap on Young Creek located about 300 feet above the full pool elevation of Lake Koocanusa in 1969. Department personnel removed barriers to upstream fish movement in Young Creek in 1970 and 1971. Barriers inhibiting upstream movement included a road culvert, numerous abandoned beaver dams and a waste pile left from an abandoned saw mill. Young Creek channel ran through the waste pile for about 50 m. Part of the waste was burned, some removed by hand and some new stream channel constructed. The upper 11 km of Young Creek, starting at the junction of Young and South Fork Young Creek, was chemically treated with rotenone to eliminate the existing brook and cutthroat trout resident population. The rotenone was detoxified with potassium permangenate at the point Young Creek entered private land about 6 km above the Lake Koocanusa full pool elevation. Chemical treatment was done in August 1970 and took 18 hours to complete.

The fish population of Young Creek prior to chemical treatment included a small spawning population of fluvial cutthroat trout from Kootenai River, small numbers of rainbow trout and large numbers of resident cutthroat and brook trout. Fish from Kootenai River spawned in the lower 5 km of Young Creek. Juvenile fish reared in the creek one to three years before smolting into Kootenai River. The upper section of Young Creek which was treated contained about equal numbers of resident brook trout and cutthroat trout. The lower area of Young Creek not chemically treated contained cutthroat trout, brook trout and some rainbow trout.

In September, 1970 and annually thereafter through 1975, the treated section of Young Creek was planted with about 1,350 young-of-the-year westslope cutthroat trout per 300 m of creek. Stream sampling was conducted annually in 1971 through 1973 to determine survival rates of the planted fish and reinvasion of the treated area by brook trout.

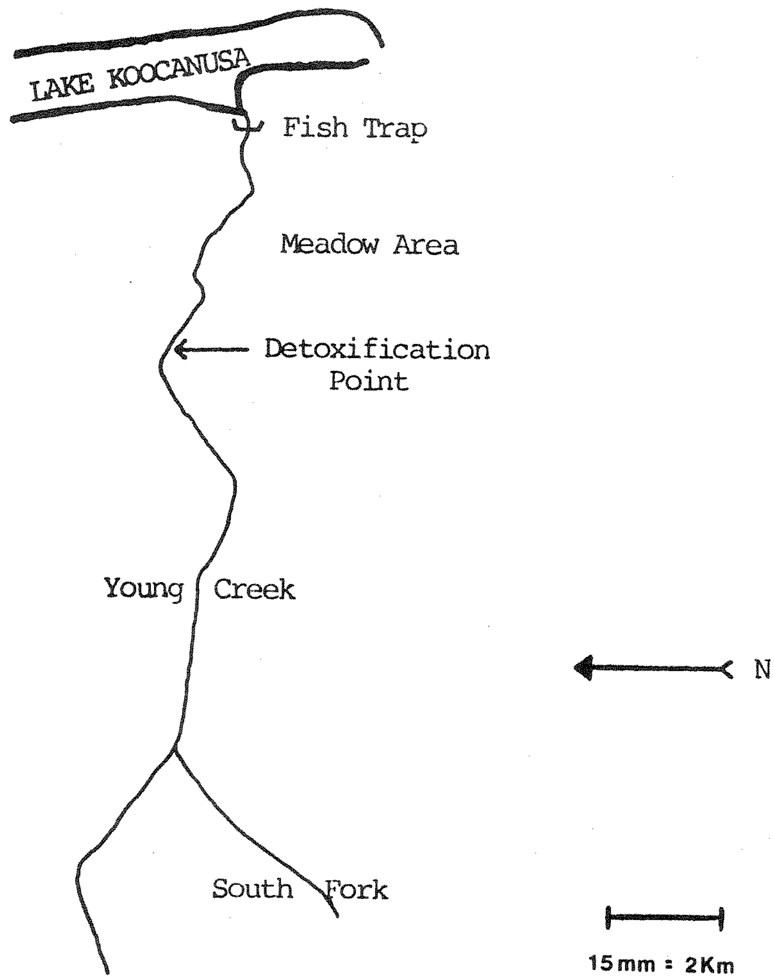


Figure 7. Map of Young Creek showing fish trap and detoxification point.

Survival of the young-of-the-year cutthroat planted in fall 1970 to fall 1971 was determined to be 29 percent. Survival of fish planted in fall 1972 to fall 1973 was 42 percent. Lower survival rate of fish planted in 1970 was likely related to depressing effects of the chemical treatment upon aquatic insects. Standing crop of cutthroat in 1971 when only one year class was present was 28.8 kilograms per hectare of creek. Standing crop in 1973 when three age classes were present was 77.5 kilograms per hectare. Reinvasion of the treated area by brook trout was minimal by 1973; four percent of the electrofishing catch was brook trout and 96 percent cutthroat trout.

The untreated area of Young Creek was not planted with westslope cutthroat trout. The pre-development fish population included brook, cutthroat and rainbow trout. Sampling in 1973 indicated that rainbow trout were absent, brook trout made up about three percent of the catch and cutthroat trout 97 percent. Ninety-nine percent of the cutthroat were three years or younger, indicating that many of these fish were juvenile adfluvial cutthroat moving downstream.

Smolting of westslope cutthroat trout from their natal streams into another body of water is thought to be regulated by a combination of genetics, growth rates and population density in the stream. Number of smolts estimated moving out of Young Creek in 1970 through 1972 was about 500 fish (Table 9). These smolts were from Kootenai River cutthroat spawning in Young Creek and mostly two year old fish. Number of smolts captured in 1973 through 1975 averaged 1,435 per year ranging from 1,341 to 1,558. The estimated number based upon downstream trap efficiency was 3,000 per year. Ages of these fish were seven percent one-year old, 46 percent two-year olds and 47 percent three-year old fish. Catch of smolts in 1980 was 1,850 and the total estimated run was 4,000 fish. Age structure of the 1980 catch was 10 percent one year old fish, 63 percent two year old and 27 percent three year old fish.

Research on westslope cutthroat trout in Hungry Horse Reservoir has established that ages of juvenile fish smolting into the reservoir averages about 20 percent one year old fish, 70 percent two year old and 10 percent three year old fish (Huston 1984). The high numbers of three year old smolts in Young Creek from 1973 through 1975 was from slow growth rates, low densities in kg/m, not high numbers of fish. The age structure of the 1980 smolts was approaching that which occurred in Hungry Horse Reservoir creeks indicating Young Creek was approaching carrying capacity. It was estimated that maximum smolt production from Young Creek should be about 7,000 to 10,000 fish per year. This production level may never be met because of declining numbers of spawning adults entering Young Creek after 1977 and presence of some numbers of brook trout and resident cutthroat trout.

Fish moving out of Kootenai River or Lake Koocanusa to spawn in Young Creek were captured in 1970 through 1977, 1979 and 1980 and in 1983. Number of adults entering Young Creek to spawn are shown in Table 10 and are estimated total spawning run derived from trap efficiencies. Upstream trap efficiencies varied from a low of 72 percent in 1975 to a high of 96 percent in 1980. Trap efficiencies were calculated by comparing the number

Table 9. Number of juvenile westslope cutthroat captured smolting from Young Creek by year, total estimated juveniles and age composition.

Year	Period of trapping	Number caught	Estimated total	Ages (percent) I	II	III
1970	4/19-7/29	498	500	--	--	--
1971	4/17-7/30	161	500	10	73	17
1972	3/17-11/13	352	500	35	49	16
1973	4/6-7/20	1,408	3,000	14	48	38
1974	4/1-9/30	1,558	3,000	5	54	41
1975	4/16-7/31	1,341	3,000	3	36	61
1980	4/18-8/16	1,850	4,000	10	63	27

of unmarked fish to marked fish caught in the downstream trap after they had completed spawning. Fish were marked as they passed through the upstream trap.

Fish caught in 1970, 1971 and 1972 were considered to have been all fluvial cutthroat from Kootenai River. The marked increase in numbers caught between 1970 and 1971-1972 was related to removal of a road culvert near the mouth of Young Creek in fall, 1970 and to clearing of most creek-side vegetation in the area to be inundated prior to reservoir filling which started in late 1971. Cutthroat also spawned in Young Creek from the trap downstream to the Kootenai River, a distance of about 1.5 km. Total spawning run of Kootenai River fish was not known. Kootenai River fish were not allowed above the fish trap after 1970, being forced to spawn below the trap or taken for artificial propagation. Adults entering Young Creek from 1973 afterwards can then be considered adfluvial cutthroat trout resulting from reservoir planting or imprint planting of Young Creek.

Numbers of adult westslope cutthroat trout spawning in Young Creek steadily increased from 115 fish in 1973 to 750 in 1976 and 1977. Spawning runs in 1979, 1980 and 1983 were much reduced from 1976-77 levels. Reasons for the declining spawning population are not fully understood but may include all of the following:

1. Increased angler harvest of adult fish before they reach the trap site. Fishing pressure has increased markedly in Lake Koocanusa since the mid-1970's and in Young Creek below the fish trap. Improved boat access, i.e. low water boat ramps, had increased angler use of the reservoir in the spring when fish are concentrated around tributary mouths. Creek angling season starts each year the third Saturday of May which falls during the middle of the Young Creek spawning run most years.

2. Increased harvest of adult fish during spawning and increased harvest of juvenile fish.

   Human population of the Young Creek area has increased several-fold in the last ten years which in turn may mean increased harvest of both adult and juvenile cutthroat from Young Creek.

3. Deterioration of habitat quality in Young Creek. Increased human habitation of Young Creek area has also increased agricultural and timber harvest in the drainage. Whether the more intense use of the land has affected the quality of the habitat in Young Creek is not known at this time, but often stream habitat suffers from agricultural or timber management practices.

4. Ceasation of imprint planting of Young Creek and planting in Lake Koocanusa. The last imprint plant of young-of-the-year cutthroat trout in Young Creek was made in summer 1975, while Lake Koocanusa had no cutthroat planted in 1977 through 1980. Juvenile fish leaving Young Creek were marked and examination of spawning adults for these marks indicated that less than ten percent of the 1973

Table 10. Estimated westslope cutthroat trout spawning runs, Young Creek, 1970-1977, 1979, 1980 and 1983.

Year	Total run	Sex ratio Male:Female	Average length (mm) Male	Average length (mm) Female	Egg potential (1000's)
1970	21				
1971	54				
1972	86	1:1.3	325	369	52.9
1973	115	1:1.0	320	335	43.7
1974	305	1:1.6	348	361	150.1
1975	390	1:2.7	373	373	220.1
1976	750	1:4.8	391	389	850.3
1977	750	1:3.3	396	396	810.0
1979	345	1:3.6	371	386	351.0
1980	380	1:3.4	376	386	371.9
1983	260	1:3.4	386	388	260.0

and 1974 spawning run were from Young Creek juvenile fish. About 75 percent of the adults entering Young Creek in 1977 had been marked as smolts leaving Young Creek in previous years. These data show that spawning runs using Young Creek were a mix of fish reared in the creek, fish planted in the reservoir and fish straying from other streams. Angler return of tagged fish indicated few fish stray from their natal stream for spawning, so this factor is considered of minimum impact. Ceasation of reservoir planting may have had a considerable impact on the Young Creek spawning population.

5. Decreased survival of Young Creek cutthroat in Lake Koocanusa. An estimated 534 adult cutthroat spawning in Young Creek in 1977 were the result of planting 116,000 young-of-the-year fish and natural spawning of 96,600 eggs. An estimated 220 adult cutthroat spawning in 1980 were the result of planting 59,000 fish and natural spawning of 1,070,400 eggs. The apparent low survival of the eggs and fish making up the 1980 adult spawners probably occurred in Lake Koocanusa after smolting from Young Creek. Reasons for this apparent lower survival may be related to normal aging of the reservoir, effects of reservoir operation, increased competition with other fish for food and space and increased predation by other fish.

Huston (1972) reported that a dramatic decline in numbers of cutthroat trout spawning in Hungry Horse Creek, tributary to Hungry Horse Reservoir, was attributable to reservoir operation affecting reservoir survival rates of both adult and juvenile fish. Drafting of Hungry Horse Reservoir for provisional (additional) power was thought to be the causative factor of decreased survival rates.

Other significant general information collected from operation of the Young Creek trap included: (some of these data are compared to Hungry Horse Creek, Huston 1984.

1. Spawning runs usually commence about the first of May and fish move upstream for about a month. The timing of the run is about three weeks earlier than cutthroat trout entering Hungry Horse Creek and about two weeks later than cutthroat in Coeur d'Alene Lake (Averett and MacPhee 1971). Cutthroat started entering Young Creek with spring-time daily minimum temperatures being 4°C and reservoir surface temperatures about 10°C. Spawning fish usually start congregating around the trap each day about 3:00 p.m. and enter the trap from 3:00 p.m. to 8:00 p.m. Fish entering the Hungry Horse Creek trap generally entered the trap between the hours of 2:00 through 7:00 p.m. Fish going upstream moved with the daily rise of stream temperature and stopped when temperature dropped.

2. The average length of time individual fish spend to complete spawning ranges from two to four weeks. Hungry Horse Creek fish spent three to five weeks.

3. Spawning mortality ranged from 27 percent in 1975 to 60 percent in 1973. Mortality rates were higher for males than females. Mortalities were slightly higher in Hungry Horse Creek, while Ball and Cope (1961) reported mortality of 48 percent for Yellowstone cutthroat trout spawning in Yellowstone Lake tributaries.

4. Sex ratios of adults were highly skewed to females and ranged from a low of 1 male:1 female in 1973 to a high of 1 male:4.8 female in 1976. Sex ratios in Hungry Horse Creek ranged from a low of 1 male:1.8 female to a high of 1 male:6.2 females. Sex ratios of juvenile fish smolting out of Young Creek was determined to be 1 male:1.9 females, while sex ratios were 1 male:1.8 females in gill net catch in Lake Koocanusa.

5. Migration class 2 fish with a total age of four and five years were the most numerous wild fish in the spawning runs. The next most abundant were of migration class 3 with a total age of four and five years. Least abundant were fish that migrated from rearing streams at one year of age. Most of these fish were three years old when they spawned.

6. Spent adults returning to the reservoir were most frequently caught during the hours of 10:00 p.m. to 2:00 a.m.

7. Most juvenile fish moving downstream were caught during the hours of midnight to daybreak. Time of year of most smolting is from immediately after high water (late May to early June) to mid-July. Juvenile fish moving out of Hungry Horse Creek is heaviest in July through mid-August.

8. Survival rates were determined for juveniles marked by cold branding and with plastic jaw tags in 1975 when they smolted through return as spawners in 1977. Annual survival rate for branded fish was 49 percent compared to 38 percent for jaw-tagged fish The survival rate for branded fish was significantly higher (.005 level).

Work done on Young Creek for the years of 1969 through 1975 was under the Young Creek Development project funded by Corps of Engineers. Work done after 1975 was under the Lake Koocanusa fishery investigation contract.

Tobacco River

Tobacco River is the largest tributary system of Lake Koocanusa within Montana draining an area of 1,140 km^2 with 462 km of perennial streams. Tobacco River proper, 18 km in length, originates at the confluence of Grave and Fortine creeks. The headwaters of Grave Creek are on the west slopes of the Whitefish Mountain Range and it flows west about 26 miles, while Fortine Creek arises on the east slopes of the Salish Mountains and flows north about 43 km to its junction with Grave Creek. About 70 percent of the drainage is within the boundaries of Kootenai National Forest, while much of the remaining land is used for cattle operations. Tobacco River is a moderately productive stream with an average pH of 8.3 and total alkalinity of 128 mg/l during the summer. Maximum summer water temperatures reached about 22°, while average summer temperatures were 14°C. Median peak flows are about 1,000 cfs in the spring, while median summer flows are about 120 cfs.

Spawning development work done in Tobacco River drainage included barrier removal in Grave Creek and Clarence Creek, suppression of fish stocks in Clarence Creek and imprint planting westslope cutthroat trout in Grave and Clarence creeks. Development work done in Fortine Creek and one tributary, Deep Creek, was limited to imprint planting cutthroat trout. Limited barrier removal work was done in Therriault Creek, while barrier removal and imprint planting was done in Sinclair Creek. A total of 567,215 young-of-the-year westslope cutthroat trout were planted in the Tobacco River drainage from 1972 through 1980.

Investigation of cutthroat and rainbow trout spawning in Tobacco River drainage was done to determine where trout were spawning and to determine an estimate of total spawning population. Spawning trout were captured, marked and released in Tobacco River bay using gill nets and electrofishing gear and in Tobacco River near its mouth in three fyke nets. Box traps or fyke nets were fished in Sinclair, Therriault, Grave, Fortine, Meadow and Deep creeks. Location of fyke and box traps are shown on Figure 8. In addition, a box trap and fyke net were fished in Grave Creek about 5 km above the Glen Lake Irrigation diversion dam (Figure 8) to determine effectiveness of fish passage repair work done by Soil Conservation Service, Kootenai National Forest, Glen Lake Irrigation District, and Department of Fish, Wildlife and Parks.

Catch at the three fyke nets, installed April 4, 1979 in Tobacco River near its mouth, was six cutthroat and 65 rainbow trout. All these fish were marked and released upstream. The first rainbow trout was captured April 11 when minimum and maximum water temperatures were 2.7°C and 6.1°C and flow was 232 cfs. The last rainbow trout was captured June 1 when water temperatures ranged from 7.3°C to 11.5°C and flow was 624 cfs. The first cutthroat trout was captured May 12 when water temperatures ranged from 5.0 to 9.9°C and flow was 627 cfs. Cutthroat trout were still entering Tobacco River when the traps were removed so no ending of the spawning run was determined. These data indicated that about a months' time existed between start of spawning runs of rainbow trout and cutthroat trout. The minimum water temperature measured for Tobacco River at the initiation of the cutthroat spawning migration was similar to that found in other westslope cutthroat spawning streams.

Fifteen nights of gill netting and electrofishing effort was required to capture, mark and release 59 cutthroat and 129 rainbow trout in Tobacco River bay. Almost all of these fish were caught between the hours of 8:00 p.m. and midnight. Sampling after midnight was generally unsuccessful, indicating that spawning fish had either moved into Tobacco River or back out into the reservoir. Observations on Hungry Horse Reservoir tributaries indicated cutthroat trout congregated around creek mouths in late afternoon-early evening and entered the creeks during the night.

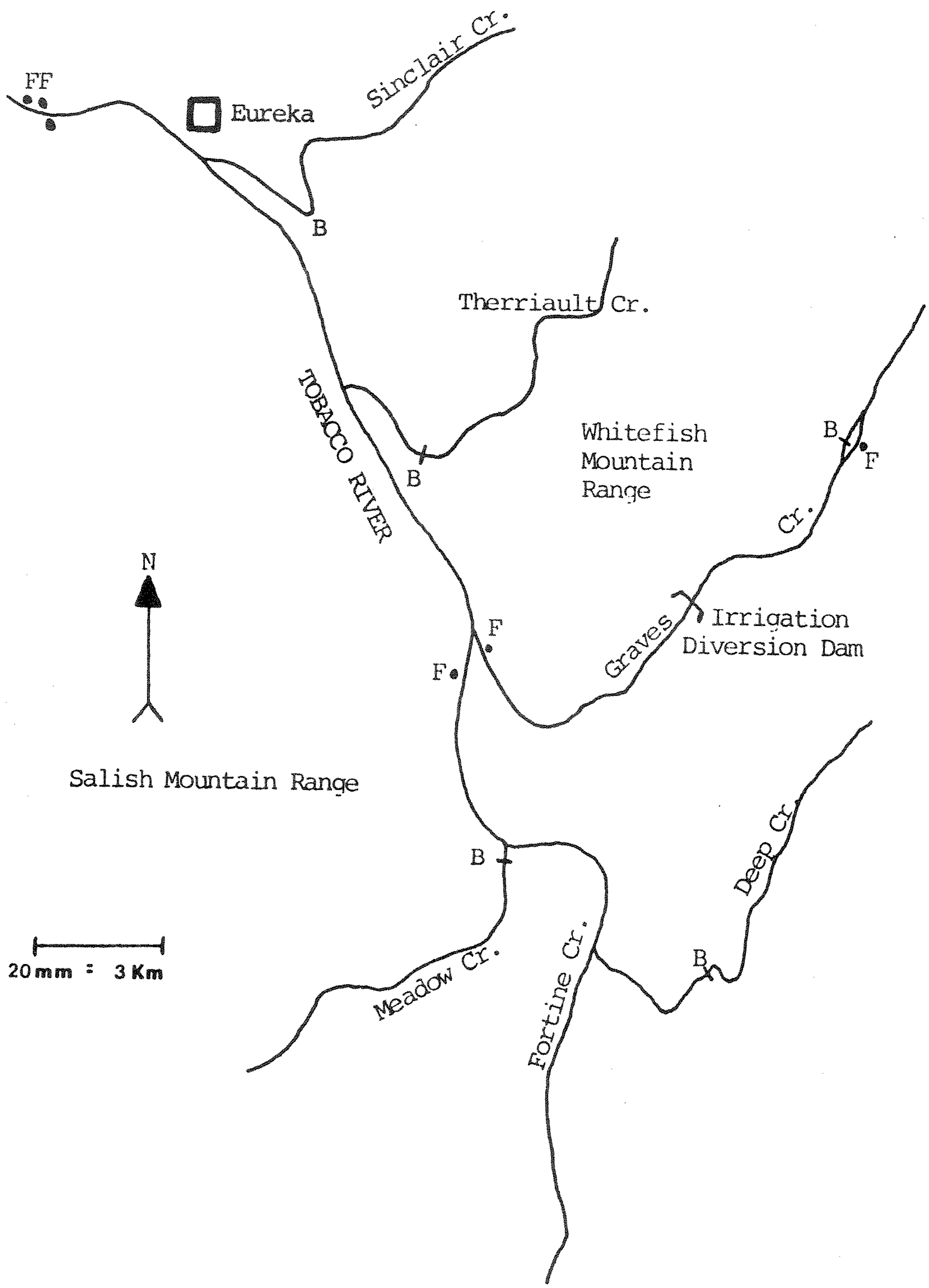


Figure 8. Map of Tobacco River drainage showing trap sites in 1979. F = fyke net and B = box trap.

Before releasing rainbow trout adults upstream in Tobacco River bay April 11, 1979, about 150 spawning rainbow were caught by netting and electrofishing and held in Murray Springs Hatchery. Eggs were taken from some of these fish and shipped to Idaho Fish and Game Department. Poachers broke into the holding cages and stole an estimated 50-60 fish.

Catches in tributaries are listed in Table 11. Box traps having leads extending from bank to bank are generally much more effective than fyke nets. Fyke nets used here were conical in shape with mouths of one meter and 1.3 meters wide and 3 meters long. They were constructed of EMT conduit covered with 13 mm mesh hardware cloth. Fyke nets had no leads. Typically they are fished on a stream curve between the outside bank and the thalweg in depths sufficient to cover the net with at least 0.3 m of water. Floating debris did not render a fyke net inoperable as happened frequently with a box trap with bank to bank leads.

Table 11. Catch of rainbow and cutthroat trout in tributaries to Tobacco River, spring 1979.

Stream	Period of trapping	Number caught		Date 1st fish caught	
		RB	WCT	RB	WCT
Sinclair	4/12-6/4	36	47	4/30	5/15
Therriault	4/13-6/4	50	5	4/15	5/20
Grave-near mouth	5/8-6/4	57	21	5/9	5/18
Grave-above mouth	5/17-6/11	1	4	5/19	5/19
Fortine	5/6-6/4	14	1	5/6	
Meadow	5/7-6/3	14	0	5/8	
Deep	4/12-6/3	3	5		

Trap catches shown in Table 11 do not represent total spawning runs into any of the streams, but rather are an indication of where and when fish spawn in the drainage. Time that the first fish was caught indicates that rainbow trout entered spawning streams much earlier than cutthroat trout. Few cutthroat trout were caught in Therriault, Fortine and Meadow creeks, while more cutthroat than rainbow trout were caught in Sinclair, Upper Grave and Deep creeks. It appears that cutthroat trout were spawning in streams flowing out of the Whitefish Mountain Range, while rainbow were predominant in streams arising in the Salish Mountains. An exception to this general rule was Therriault Creek.

Spring run-off patterns between streams flowing out of the Salish and Whitefish Mountain ranges are considerably different. Salish streams peak about three to four weeks earlier than Whitefish streams and probably temperature patterns are warmer in Purcell streams. These different flow and temperature patterns may determine species composition of spawning runs into the various streams. Therriault Creek is a Whitefish Mountain Range creek but has mostly rainbow trout. This creek's flow and temperature pattern is heavily influenced by springs and is similar to Salish streams.

An estimate of total numbers of spawning rainbow trout was obtained from marking fish in lower Tobacco River and bay and recapturing them upstream in traps. The point estimate was 5,937 ±40 percent fish. No estimate could be made of cutthroat trout since few fish were marked and trapping did not extend throughout the entire spawning run.

Average length of female rainbow trout was 414 mm and 406 mm for males. Sex ratio was 1 male:1.2 females. Scales from 426 rainbow were aged to determine migration age and total age of the spawning fish. These data are shown in Table 12. These data shown that most of the fish emigrated from spawning stream(s) into the reservoir at or near the age of one year and returned to spawn at a total age of three or four years.

Table 12. Age composition of rainbow trout spawning run into the Tobacco River in spring, 1979. Sample size is given in parenthesis.

Migration class	Percent in age group				
	2	3	4	5	6
One	4.7(16)	58.2(199)	35.4(121)	---	1.7(6)
Two	---	22.6(19)	36.9(31)	19.0(16)	21.5(18)
Combined	3.8(16)	51.2(218)	35.7(152)	3.8(16)	5.5(24)

Other gamefish species spawning in the Tobacco River system include bull trout and mountain whitefish. Prior to impoundment, whitefish moved upstream as far as the Glen Lake Irrigation District diversion dam in Grave Creek and to near the north portal of the Flathead tunnel in Fortine Creek. Limited observations since impoundment indicates whitefish spawning was limited to Tobacco River downstream from the town of Eureka. Bull trout spawning was likely limited to the Grave Creek drainage.

Big Creek

Big Creek rises on the east slopes of the Purcell Mountains and flows approximately 29 km to its confluence with Lake Koocanusa (Figure 9). The drainage area of 360 km^2 is entirely within Kootenai National Forest and has approximately 115 km of perennial streams. Timber production is the primary land use in the drainage. Big Creek is a soft-water stream with a pH of 7.5 and total alkalinity of only 26 in the summer. Median peak flows in the spring are 738 cfs, while median flows in the summer are 22 cfs.

A spawning development program was conducted on Big Creek in 1973. The program included barrier removal, suppression of resident fish stock and imprint plants of 166,540 westslope cutthroat trout juveniles.

The spawning run of rainbow, cutthroat and cutthroat-rainbow trout hybrids ascending Big Creek was monitored from April 24 to July 13, 1980. The fish trap locations are shown in Figure 9. A downstream trap was fished from June 3 to June 27 to capture spent spawners returning to the reservoir. A total of 754 cutthroat trout, 111 rainbow trout and 235 cutthroat-rainbow hybrids were caught and released during the survey (Table 13).

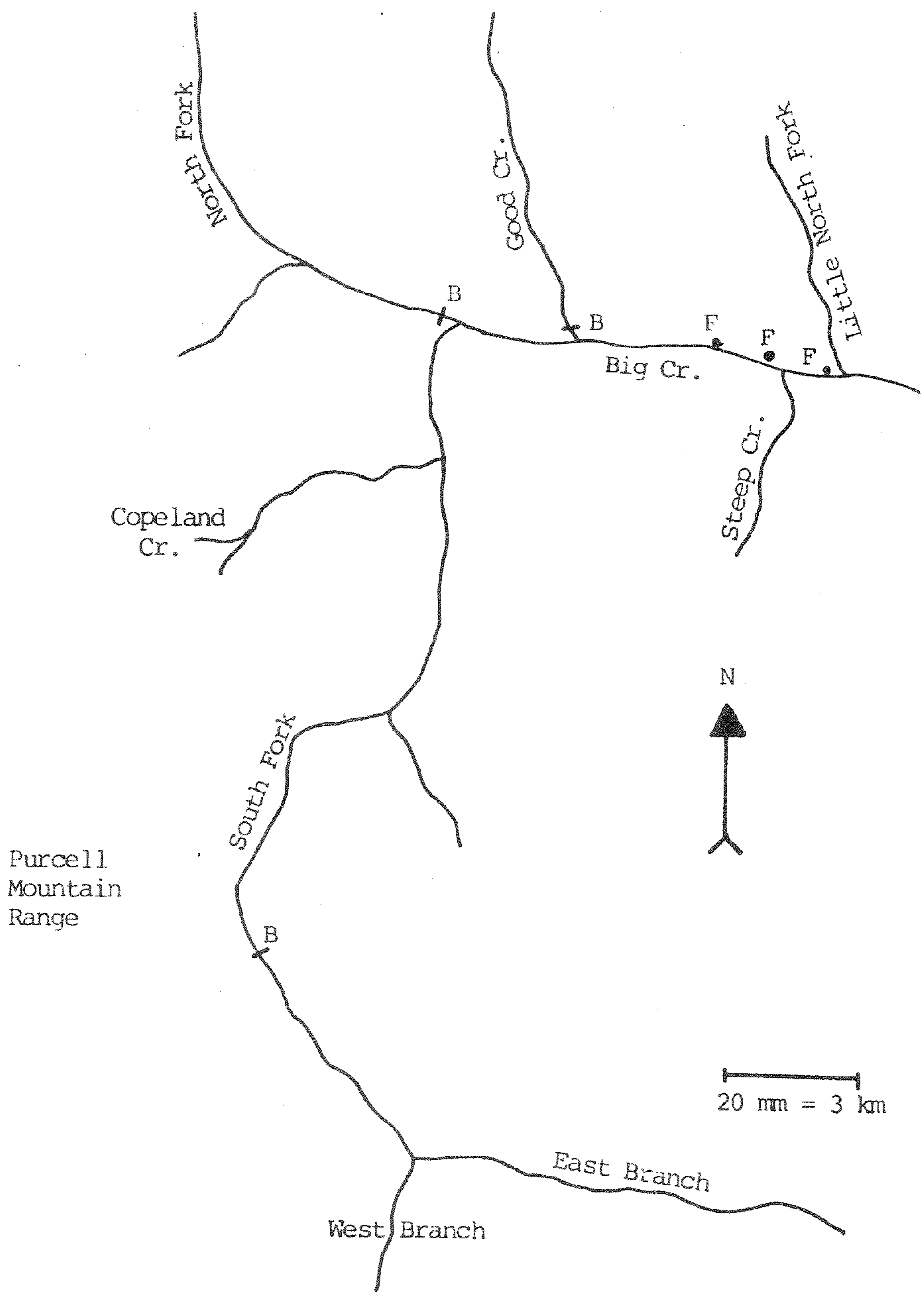


Figure 9. Map of Big Creek Drainage showing trap sites in 1980. Abbreviations used are F = fyke net and B = box trap.

Table 13. Catch of rainbow trout, cutthroat trout, and rainbow x cutthroat hybrids ascending Big Creek in spring, 1980. Abbreviations for capture method are: N = gill nets; EF = electrofishing gear; B = box traps and F = fyke nets.

Location and capture method	Species			Period trap operated
	Ct	Rb	CtxRb	
Big Creek Bay (EF and N)	3	19	1	4/21-5/8
Big Creek (F)	93	36	29	4/24-6/3
North Fork Big Creek (B)	133	12	35	5/13-6/10
Good Creek (B)	11	4	5	5/13-6/9
South Fork Big Creek (B)	164	10	74	5/20-6/13
Total trapped in upstream run	404(20)*	81(1)	144(6)	
Downstream trap in Big Creek (B)	350(58)**	30(5)	91(17)	6/3-6/27

* Number of parenthesis is number of fish marked in Big Creek Bay (EF and N) and Big Creek (F) recaptured at other trap sites.

** Number in parenthesis is number of marked fish recaptured.

Three fyke nets were fished in the mainstem of Big Creek from April 24 to June 3. Rainbow and cutthroat trout were first captured on May 9 when average water temperatures varied between 2.2 and 5.0^{o}C and the flow had increased to 667 cfs (Table 14). Most of the spawners were collected from May 9 to May 25. A total of 157 trout were caught in three fyke nets. Although this was a large catch for fyke nets, the nets caught only about five percent of the run. The timing of the Big Creek run was unusual in that rainbow and cutthroat trout migrated during the same period when minimum water temperatures were below 5.0^{o}C for most of the run.

A box trap fished in Good Creek near the mouth caught 11 cutthroat, four rainbow and five hybrids from May 13 to June 9. The trap efficiency was high and the total run probably did not exceed 30 fish (Table 13). The spawning run ascending the North Fork of Big Creek was monitored with a box trap which was installed on May 13 and removed on June 10. The peak of the cutthroat run occurred from May 20 to June 5. The catch in the trap included 133 cutthroat, 35 hybrids and 12 rainbow. The total run was probably between 200-300 fish.

A box trap was fished in South Fork Big Creek from May 20 to June 13. Cutthroat, rainbow and hybrids were first collected on May 23. Most of the cutthroat were caught from May 25 to June 12. A total of 164 cutthroat, 74 hybrids and 10 rainbow were caught and released upstream. The total run entering the South Fork was much higher than indicated by the catch, due to the leads being forced down by high water on several days during the peak of the run and the early part of the run not being sampled.

Two point estimates were calculated for the spawning run from 1) mark and recapture data from upstream traps with the fyke nets being used for marking fish and the box traps for recapturing fish, and 2) mark data from all upstream traps with the downstream trap used for recapturing fish (Table 15). The estimated runs of 2,824 and 3,508 fish are comparable and indicate that the estimates are valid indices of the magnitude of the spawning runs. Cutthroat trout comprised the majority of the run followed by hybrid trout and rainbow trout. The large number of trout in the run indicates that the spawning development program was quite successful.

A sample of 11 fish identified in the field as rainbow X cutthroat trout hybrids were analyzed by the University of Montana's Population Genetics Laboratory. All fish were first generation crosses between rainbow and westslope cutthroat trout. Hybridization between the two trout species appears to be occurring frequently in the Lake Koocanusa system. Both species enter Big Creek at the same time for spawning, therefore hybridization should be common in this drainage. In other drainages like Tobacco River it is likely that interbreeding is limited to male cutthroat crossing with female rainbow trout. Male cutthroat enter spawning streams as ripe fish capable of spawning with what is available while female cutthroat are generally very green and not capable of spawning until they have been in the spawning area for some days.

Table 14. Average maximum and minimum temperatures (°C) and flows (cfs) for five day periods and number of rainbow, cutthroat and hybrid rainbow x cutthroat spawners caught in fyke nets near mouth of Big Creek, 1980.

Date	Temperature		Flow	Number of spawners		
	Maximum	Minimum	(cfs)	RB	WCT	RbxCT
4/26-4/30	3.3	0.6	307	0	0	0
5/1-5/5	4.4	1.1	547	0	0	0
5/6-5/10	5.0	2.2	667	7	19	0
5/11-5/15	8.3	2.2	638	15	23	5
5/16-5/20	---	---	762	8	30	16
5/21-5/25	8.9	5.0	725	2	13	4
5/26-5/31	7.7	4.4	525	2	8	2
6/1-6/5	7.7	3.9	227	2	0	2

Table 15. Summary of data from spawning run of rainbow trout, cutthroat trout and hybrid rainbow x cutthroat ascending Big Creek in spring 1980. The 80 percent confidence limit for the point estimate of the run is given in parenthesis.

Parameter	Species			Total
	CT	RB	CTxRB	
Point estimate				
Upstream trap	1,803	370	651	2,824 (±1.1%)
Downstream trap	2,389	368	751	3,508 (±0.6%)
Sex ratio male:female	1.0:4.1	1.0:4.3	1:62.3	
Mean length male(mm)	386	389	371	
Mean weight male (g)	568	586	563	
Mean length female(mm)	381	401	419	
Mean weight female (g)	577	663	154	
Estimated egg potential in thousands	2,140.0	437.1	1,062.5	3,639.6

Other Streams

An evaluation of the spawning development program was made on six other streams (Table 16) by counting the number of spawning beds or redds. Generally, one female cutthroat or rainbow trout will deposit her eggs in one redd. The highest number of redds was found in Pinkham Creek followed by Bristow Creek, Five Mile, Cripple Horse and Canyon creeks. No redds were found in Sullivan Creek, but local anglers have reported catching large cutthroat from this creek in the spring. The number of redds counted varied considerably from year to year. The counts were influenced by the flows during and after the spawning period. Many redds were unrecognizable after flows had moved the gravel in high water years.

Table 16. Redd surveys of cutthroat or rainbow trout in Lake Koocanusa tributaries.

Stream	Location	Number of redds		
		1976	1977	1978
Canyon	Lower 2 km	31	5 1/	48
Cripple Horse	lower 5 km	33	33	--
Bristow	lower 3 km	75	108	70
Five Mile	lower 3 km	47	166	35
Pinkham	lower 10 km	--	231	135
Sullivan	lower 5 km	0	0	--

1/ Flows insufficient for fish passage through Highway 37 culvert.

The data collected on the use of tributary streams by cutthroat for spawning indicates that the development program was successful. Information from Young, Five Mile and Pinkham creeks, however, suggest that some of the runs may be declining. The magnitude of the spawning runs should be determined periodically in order to assess the long-term trends. Additional work may be needed in some of the tributaries in the future.

Large numbers of mountain whitefish swim-up fry were collected from Hungry Horse Reservoir spawning populations and planted in five Lake Koocanusa tributaries in the Mid-1970's. Big Creek was planted three years with 386,000 fry, Sutton Creek two years with 193,000, Cripple Horse Creek two years with 275,000, Fivemile Creek two years with 154,000 and Bristow Creek for one year with 70,000 fry. No spawning runs of mountain whitefish were established. The only known mountain whitefish spawning areas are Tobacco River in Montana, Elk River and Kootenai River in British Columbia.

British Columbia Spawning Runs

Surveys were conducted on spawning activity in six tributaries of Lake Koocanusa in British Columbia by British Columbia Fish and Wildlife Branch (Ringstad and Phillips 1978, Ringstad and Oliver 1979 and Oliver 1981). The results of these surveys are summarized in Table 17 and the locations of the tributaries are shown in Figure 2. Good spawning populations of

Table 17. Summary of fish trapping conducted on tributaries to Lake Koocanusa in British Columbia, Canada 1975-1978 and electrofishing sampling in mainstem Kootenai in 1980 in British Columbia.

Species	Life stage	Stream	
		Linklater	Plumbob
	1975		
Westslope cutthroat	Spawners	145	3
Westslope cutthroat	Fry	1,250	---
Westslope cutthroat	Smolts	48	---
Rainbow	Spawners	9	---
	1976		
		Kikomum	Gold Cr. Trib.
Westslope cutthroat	Spawners	124	24
Westslope cutthroat	Smolts	8	63
Rainbow	Spawners	9	---
	1977		
		Gold	
Westslope cutthroat	Spawners	476	
Westslope cutthroat	Smolts	7,585	
Rainbow	Spawners	11	
Bull trout	Spawners	24	
	1978		
		Wigwam	
Bull trout	Spawners	434	
Bull trout	Smolts	597	
	1980		
		Kootenai River	
Westslope cutthroat	Spawners	20	
Rainbow	Spawners	93	
Bull trout	Spawners	22	
Burbot	Adult	20	
White sturgeon	Adult	1	

cutthroat trout were found in Linklater, Kikomum and Gold creeks. The spawning runs of cutthroat ranged from 124 to 476 fish with the maximum number of rainbow caught being 11. These are minimum estimates of spawners, because the traps were not 100 percent efficient.

The proportion of rainbow trout in the spawning runs appeared to have increased through time. An electrofishing survey conducted in the spring of 1980 in the mainstem of the Kootenai River indicated that rainbow trout spawners were more numerous than cutthroat spawners (Table 17).

A major bull trout spawning run was documented ascending the Wigwam River in 1978. A total of 434 bull trout were captured in the trap fished near the mouth of Wigwam. It appears that the Wigwam River has the largest spawning run of bull trout of any tributary to Lake Koocanusa.

Kokanee Spawning

A strong year class of kokanee appeared in the anglers catch in 1981 and 1982 and in the fall gill nets set in 1982. The origin of these fish is from leakage of kokanee fry from the Kootenay Trout Hatchery on Norbury Creek, British Columbia and natural reproduction of these fish when they matured.

A survey of potential spawning streams was conducted in October of 1982 to locate areas utilized by kokanee for spawning. The Tobacco River was the only tributary in the Montana part of the reservoir which had a run of kokanee. Approximately 500 fish were counted in the stream and the estimated run was about 1,000 kokanee (Table 18).

Kikomum and Norbury creeks in British Columbia were surveyed by airplane and the number of kokanee utilizing these streams were estimated at 15,000 and 7,000 fish, respectively. Most of the flow in these two streams comes from springs. Norbury Creek is the outlet for the Kootenay Trout Hatchery and a small run of about 200 kokanee had been observed in it from 1979-1981. Additional spawners were observed in the St. Mary River and mainstem of the Kootenai near Skookumchuck Creek. The total estimated run was approximately 26,000 fish with only about 1,000 of the fish utilizing a U.S. tributary.

Table 18. Estimated numbers of kokanee spawning in Lake Koocanusa tributaries in fall 1982.

Tributary	Distances in km upstream from Libby Dam	Estimated number of kokanee spawners
Tobacco River	67	1,000
Kikomum Cr.	114	15,000
Norbury Cr.	146	7,000
St. Marys River	174	1,000
Skookumchuck Cr.	226	2,000
TOTAL		26,000

RESERVOIR POPULATION TRENDS

Fish population trends were determined by gill net sampling the Rexford area with sinking gill nets in the spring and the Rexford and Cripple Horse areas with floating gill nets in the fall. Limited sampling was also done in the fall using floating gill nets at the Bailey Bridge area in British Columbia. These sampling areas are shown on Figure 2. Netting methods and sampling criteria are described in the Methods section of this report. Physical sampling conditions are shown in Appendix a.

Large numbers of net sets were made in spring and fall 1975 to determine the number of sets needed for the Kruskall Wallis ranking test. It was determined that 35 to 40 net sets per sampling area were needed to validate the Kruskall Wallis test.

Spring Sampling

Target species for the spring sampling included those with benthic habits and those that were fall spawners. These included largescale and longnose suckers, ling, bull trout and mountain whitefish. The Kruskall Wallis ranking test was done on all of these species except ling to determine significant changes in gill net catches. Catches of squawfish, peamouth and redside shiners were considered valid trends although these species are generally more surface oriented than bottom-dwelling. Catches of rainbow and cutthroat trout were not considered valid measurements of population trends since sampling was done while these fish were moving into or out of tributaries for spawning. Catches by species are shown in Table 19.

Total catches from 1975 through 1982 were similar although there was considerable variation between the yearly catches of some species. Largescale suckers were the most numerous fish except in 1982 even though the catch varied from 37.3 fish in 1975 to 23.5 in 1978 and back up to 36.3 in 1980. Catches of mountain whitefish were similar from 1975 through 1978 but declined in 1980. Peamouth catches were similar from 1975 through 1978, increased ten-fold in 1980 and tripled again in 1982 to replace largescale suckers as the most numerous fish in the catch. Catch of individual species is discussed below.

Largescale Sucker

Largescale suckers were one of the most abundant fish in Kootenai River prior to impoundment. The average catch per net of largescale suckers following impoundment varied considerably from year to year ranging from 37.3 fish in 1975 to 18.6 in 1982. Annual catch declined from 1975 through 1982, except for a marked increase in 1980. Suckers caught in 1975 averaged 254 mm total length ranging from 150 to 566 mm total length (Table 20). Only three of the 279 suckers measured were longer than 380 mm. Average size of suckers increased to 310 mm in 1978 and 307 mm in 1982. Maximum size declined from 566 mm in 1975 to 432 mm in 1982, while minimum size increased from 150 mm in 1975 to 198 mm in 1982.

Table 19. Average catch per net during spring sampling at Rexford area, 1975, 1976, 1978, 1980, and 1982.

Parameter	Year 1975	1976	1978	1980	1982
Surface temperature (°C)	12.8	12.2	11.1	11.1	11.7
Number of nets	111	41	41	38	36
Fish caught[1/]					
RB	0.8	0.3	1.4	0.7	1.4
CT	0.2	0.4	0.4	0.2	0.4
RBxCT	0.0	0.0	0.0	0.0	<.1
MWF	6.6	6.4	7.2	1.0	2.0
CRC	0.3	1.0	0.7	7.2	24.3
SQ	2.3	1.2	5.8	2.8	4.3
RSS	--[2/]	1.4	2.8	0.7	1.9
DV	1.4	1.9	2.2	0.8	1.5
LING	<.1	0.2	0.3	0.6	0.5
CSU	37.3	26.1	23.5	36.3	18.6
FSU	7.9	11.1	9.1	5.8	10.9
YP	0.0	0.0	0.0	0.0	0.2
TOTAL	56.8	50.0	53.4	56.1	66.0

1/ Fish species abbreviations are shown in Table 8.
2/ Numbers of redside shiners were not recorded in 1975 except that several hundred were caught.

Table 20. Average lengths (mm), weights (grams) and condition factors of bull trout (DV), mountain whitefish (MSF), largescale (CSu) and longnose suckers (LNSu), Rexford area of Lake Koocanusa, spring netting series, 1975-1982.

Year	Species	Number measured	Average length	Range in length	Average weight	Condition factor
1975	CSu	279	254	150-566	209	1.05
1976	CSu	180	282	155-561	277	1.02
1978	CSu	273	310	185-549	327	0.99
1980	CSu	224	302	163-488	281	0.91
1982	CSU	160	307	198-432	304	0.93
1975	FSu	102	282	165-404	254	1.03
1976	FSu	103	318	170-383	381	1.12
1978	FSu	70	343	191-401	468	1.14
1980	FSu	105	328	173-417	377	1.01
1982	FSu	107	348	295-414	472	1.10
1975	MWF	338	290	203-399	213	0.85
1976	MWF	229	295	180-378	227	0.89
1978	MWF	174	274	173-373	195	0.85
1980	MWF	36	262	168-406	168	0.86
1982	MWF	71	277	160-384	277	0.93
1975	DV	152	320	165-495	336	0.87
1976	DV	82	345	231-711	427	0.87
1978	DV	83	384	264-554	649	0.92
1980	DV	32	345	191-505	413	0.86
1982	DV	54	391	208-627	622	0.88
1976-1982	LING	73	472	277-635	752	---

Length frequency distributions shown in Figure 10 show a population in 1975 of small fish shifting to larger fish in 1978 and 1982. The large number of small fish in 1975 was probably a reflection of high reproductive success following impoundment in 1972. Smaller catches in succeeding years reflected increased competition and increased mortality rates within the reservoir. Condition factors listed in Table 20 show a decline from a high of 1.05 in 1975 to 0.91 in 1980 and 0.93 in 1982.

The catch in 1980 of 36.3 fish per net, comparable to 1975 and higher than previous and succeeding years, was thought to be related to two factors: 1) larger numbers of small fish were caught than in other years except 1975 showing good survival in previous years; and 2) large numbers of spawning suckers were caught indicating that sampling coincided with shoreline spawning activities more in 1980 than in other years.

Kruskall Wallis ranking tests done on gill net catches in 1975, 1978 and 1982 indicated a declining catch rate of suckers although significant at the 99 percent level only between 1975 to 1978 (Table 21). If 1980 net catch data were included in this statistic then a significant increase would have been noted from 1978 to 1980 followed by a significant decline from 1980 to 1982.

Table 21. Comparisons of sinking gill net catches, Rexford sampling area, spring 1978 vs spring 1975 and spring 1982 vs spring 1980.

	Year		
Species	1975	1978	1982
DV	1.4	2.2*	1.5*
MWF	6.6	7.2	2.0*
CSU	37.3	23.5*	18.6
FSU	8.0	9.1	10.6

* Significant at 99 percent confidence level.

Catch of largescale suckers in fall sampling done at Rexford and Cripple Horse sampling areas (Table 22) indicated a decline in population numbers from 1975 through 1982.

Longnose Sucker

Longnose suckers were considered uncommon in the Kootenai River prior to impoundment. Following impoundment, longnose suckers were caught only during spring bottom gill net samplings and catch varied considerably between the years sampled with no apparent pattern. No longnose suckers

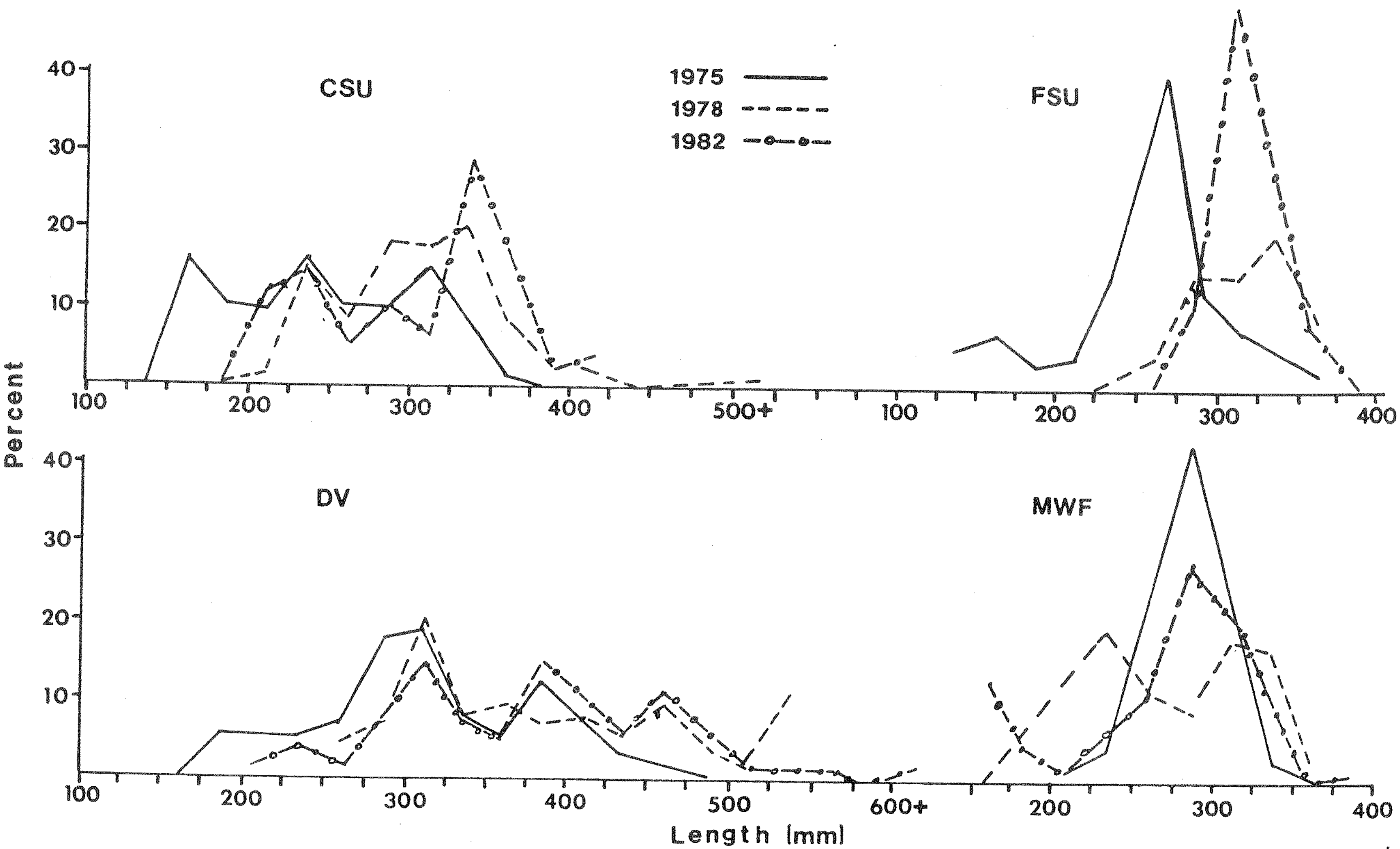


Figure 10. Length frequency distribution of largescale suckers (CSU), longnose suckers (FSU), bull trout (DV) and mountain whitefish (MWF) from Rexford area of Lake Koocanusa, 1975, 1978 and 1982.

were caught in floating gill nets during fall samplings. Huston (1984) noted that longnose suckers were common in bottom gill nets in Hungry Horse Reservoir in the spring, but very rare in bottom gill nets in the fall. Scott and Crossman (1973) noted that this species of sucker is common only in deep lakes in the southern portion of its range.

Many of the longnose suckers caught by gill net sampling in Lake Koocanusa in the spring were spawning adults. Timing of gill net sampling to spawning is thought to have had the most influence on numbers caught. The average length of fish netted ranged from 282 mm in 1975 to 348 mm in 1982 while condition factors ranged from 1.01 in 1980 to 1.14 in 1978 (Table 20). Condition factors were the lowest (1.03 in 1975 and 1.01 in 1980) when average catch per net was low. Condition factors were highest in 1976, 1978 and 1982 when average catch was high. Condition factors of spawning fish are generally higher than non-spawning fish of the same species due to their gravid condition.

Numbers caught each year were not considered a reliable measure of abundance. Kruskall Wallis ranking of gill net catches showed no significant differences between any years (Table 21).

Length frequency data (Figure 10) show a definite shift to larger fish from 1975 to 1982 coupled with a notable lack of fish smaller than 300 mm in 1982. It is thought that the 1975 catch was comprised of mostly non-spawning fish while the 1982 sample was almost entirely spawning fish.

<u>Mountain Whitefish</u>

Mountain whitefish and largescale suckers were the most numerous fish in Kootenai River prior to creation of Lake Koocanusa. Following impoundment, catch of mountain whitefish in the Rexford area (Table 19) remained about the same from 1975 through 1978, but declined noticably in 1980 and 1982. The average catch of 2.0 fish per net in 1982 was significantly less than the 1978 catch of 7.2 whitefish (Table 21). Average size and range of size of whitefish was generally larger in 1975-1978 than in 1980 and 1982, while condition factors showed little change between all years sampled (Table 20). Length frequencies in Figure 10 show marked similarities between 1975 and 1982, except that the 1982 sample contained more smaller fish than 1975.

Net catches of mountain whitefish in floating gill nets set in the fall (Table 22) follow the same trend as spring gill net sampling. Catches in 1975-1976 were noticeably higher than catches in fall 1978 and later years.

Prior to impoundment, whitefish spawned extensively in the Kootenai River and in Tobacco River in Montana. In the Tobacco River system numerous fish, probably in the thousands, ascended Tobacco River for spawning, moving as far upstream as Glen Lake irrigation diversion structure in Graves Creek and almost to the Flathead Railroad Tunnel in Fortine Creek (Figure 2). Spawning movements generally started in early September.

Surveys done following impoundment showed that whitefish spawning still occurs in Tobacco River but at a much reduced level. Few whitefish move as far upstream as the town of Eureka with most spawning occurring within two to three miles of the reservoir. Spawning fish generally do not start moving into Tobacco River until mid-October.

Numbers of mountain whitefish in Lake Koocanusa were substantially lower in 1982 than in 1975-78 and it is anticipated that whitefish will not increase much in future years. Lack of suitable spawning is probably the single-most limiting factor controlling population levels.

A weak mountain whitefish population may have implications for bull trout populations in Lake Koocanusa. Analysis of bull trout stomachs collected from Hungry Horse Reservoir (Huston, 1984) and from Flathead Lake (Leathe and Graham, 1982), indicates that mountain whitefish were the single-most important food item eaten by bull trout of all sizes. Whitefish were the most important even when other species of forage fishes such as suckers, peamouth, squawfish, kokanee and other salmonid species were available.

Bull trout

Bull trout were less than common in Kootenai River prior to impoundment but contributed to angler opportunity by providing a few large fish each year. Bull trout were not a major component of the gill net catches. Catch per net was 1.4 fish in 1975, changing to 2.2 fish in 1978, and 1.5 fish in 1982 (Table 19). Catch rates in 1978 and 1982 were significantly different (Table 21) from the preceding year. Average size and range of size of fish increased from 1975 to 1978, dropped in 1980, and increased again in 1982 (Table 20). Condition factors increased with increased size of fish. Length frequency data presented in Figure 11 show a shift to more larger (and older) fish from 1975 to 1978 and 1982.

Trend data presented in Tables 19, 20, and 21, and Figure 10 are thought to present viable population trend data, but more so, viable trend data in relationship to a slow-growing, long lived, slow maturing fish species. Bull trout in Montana waters generally grow about 75 mm per year reaching maturity and spawning for the first time at an age of five to six years. Bull trout often live 10 years or more. Most of the bull trout spawning occurs in British Columbia tributaries and juvenile fish rear in tributary streams two to three years before smolting downstream into Lake Koocanusa.

Increasing gill net catches from 1975 through 1978 were thought to represent increased survival of juvenile bull trout smolting into the reservoir following impoundment. The decreased catch in 1980 is thought to represent movement of these juveniles out of the reservoir as mature spawning fish, while the increased catch in 1982 would reflect increased natural recruitment somewhat offset by increased mortality rates due to increased competition within the reservoir.

Catch of bull trout increased and decreased with catch of mountain whitefish (Table 19). Whether this similarity is a cause and effect relationship cannot be determined at this time. Additional research will be needed to determine whether the bull trout population reacts to changes in the mountain whitefish population.

Ling

Kootenai River was reported to contain an excellent population of burbot (ling) prior to the 1950's, but this species declined thereafter (Bonde and Bush 1975). Ling were considered uncommon immediately prior to impoundment. Gill net catch of ling steadily increased from 1975 through 1982 (Table 19). Ling caught have varied from 277 to 635 mm total length averaging 472 mm long (Table 20). Average size of ling increased throughout the years, while range in size also increased indicating an increased average age, but at the same time more age groups in the population. In 1982, anglers reported catching ling from several inches long to about 30 inches long including one ling that had several young 2-3 inch ling in its stomach.

The small number of ling living in Kootenai River spawned shortly before or after impoundment and their progeny survived in good numbers in the new reservoir resulting in increased numbers of individual fish. Burbot, like bull trout, are considered slow growing, long lived, old maturing fish. It is predicted that their numbers will slowly increase in Lake Koocanusa in coming years.

Ling, like longnose suckers, were never caught in surface gill nets set in the fall at the Cripple Horse and Rexford sampling areas.

Yellow perch

Yellow perch were first caught in Lake Koocanusa in 1982. It is probable that this species moved into the reservoir from Murphy Lake in the Tobacco River drainage. The future of this species is unknown at this time since Lake Koocanusa is generally rapidly refilling during the perch's spawning period. Perch prefer debris and vegetation for their spawning activity and little debris or vegetation is available.

Fall Sampling

Target species for the fall netting included spring spawning, rainbow and cutthroat trout, and surface or mid-water dwellers, such as peamouth, squawfish and redside shiners. Kruskall Wallis ranking tests were done on gill net catches of these species to determine significant changes between sampling years.

Fall sampling was done during the time bull trout were spawning in tributary streams so catches would not be representative of population trends. Mountain whitefish net catches would be representative of population trends since this species generally entered spawning stream after the netting was completed. Catch of largescale suckers appeared to be repre-

Table 22. Average catch per net, fall sampling at Cripple Horse and Rexford sampling areas, 1975, 1976, 1978, 1979, 1980 and 1982.

Parameter	Year					
	1975	1976	1978	1979	1980	1982
Surface temperature[1/] (°C)	16.1	17.2	15.6	16.7	15.6	16.7
Number of nets	129	91	78	73	79	70
Fish caught[2/]						
RB	2.8	3.6	6.3	4.9	4.8	2.4
CT	2.0	2.5	2.0	1.4	1.2	1.2
RBxCT	0.0	0.0	0.1	<.1	<.1	<.1
MWF	2.0	2.3	1.2	1.4	0.6	1.0
CRC	4.0	4.2	3.0	6.5	8.8	15.1
SQ	4.2	4.7	4.2	2.1	1.9	3.5
RSS	3.3	7.9	7.3	2.0	0.5	0.2
DV	<.1	<.1	<.1	0.1	0.2	<.1
CSU	1.9	2.4	0.9	1.1	1.2	1.2
KOK	0.0	0.0	0.0	0.2	0.0	7.1
TOTAL	20.2	27.6	25.0	19.7	19.2	31.7

1/ Temperature shown is the highest of the two sampling areas.
2/ Fish species abbreviations are shown in Table 8.

sentative of population trends although this species is bottom oriented.

Kokanee catch rates were considered to be valid indicators of population trends although almost all fish caught were adults seeking spawning areas. This species was introduced into Lake Koocanusa accidentally from a fish hatchery on Bull River, British Columbia. Gill net catches are shown in Table 22.

Average catch per net for target species by individual sampling station, Cripple Horse and Rexford, is listed in Appendix B. Length, weight and condition factors by sampling area are listed in Appendix C.

Total catch per net was more or less stable from 1975 through 1980 but increased markedly in 1982. There were variations in catch of individual species in the 1975-1980 period. The marked increase in numbers of fish caught in 1982 resulted from increased numbers of kokanee and peamouth. Catch of individual species is discussed below.

Rainbow Trout

Rainbow trout was considered a common salmonid in Kootenai River prior to impoundment. Gill net catches in Lake Koocanusa ranged from 2.8 fish per net in 1975 to 6.3 fish per net in 1978 and back to 2.4 fish in 1982. Rainbow trout increased rapidly in the reservoir from 1975 to 1978, declined slightly in 1979 and 1980 followed by a marked decline in 1982. Kruskall Wallis ranking tests showed a significant increase in gill net catches from 1975 to 1978 and a significant decrease from 1978 to 1982 (Table 23).

Table 23. Kruskall-Wallis ranking test of fall gill net catches from Lake Koocanusa, 1975x1978 and 1978x1982.

	Year		
Species	1975	1978	1982
RB	2.8	6.1*	2.4*
CT	2.0	2.0	1.2*
PM	1.9	2.9	15.1*
NSQ	4.2	4.0	3.4
RSS	3.3	7.0*	0.2

* Significantly different at 99% confidence level.

Length frequencies for rainbow trout shown in Figure 11 for the years 1975, 1978 and 1982 are similar except that the 1975 catch included a large number of fish smaller than 300 mm. Average lengths of rainbow trout (Table 24) have varied only 19 mm in all years sampled, but size range of rainbows caught changed over the years. Minimum size for the years 1975 through 1979 were similar but declined considerably in 1980 and 1982.

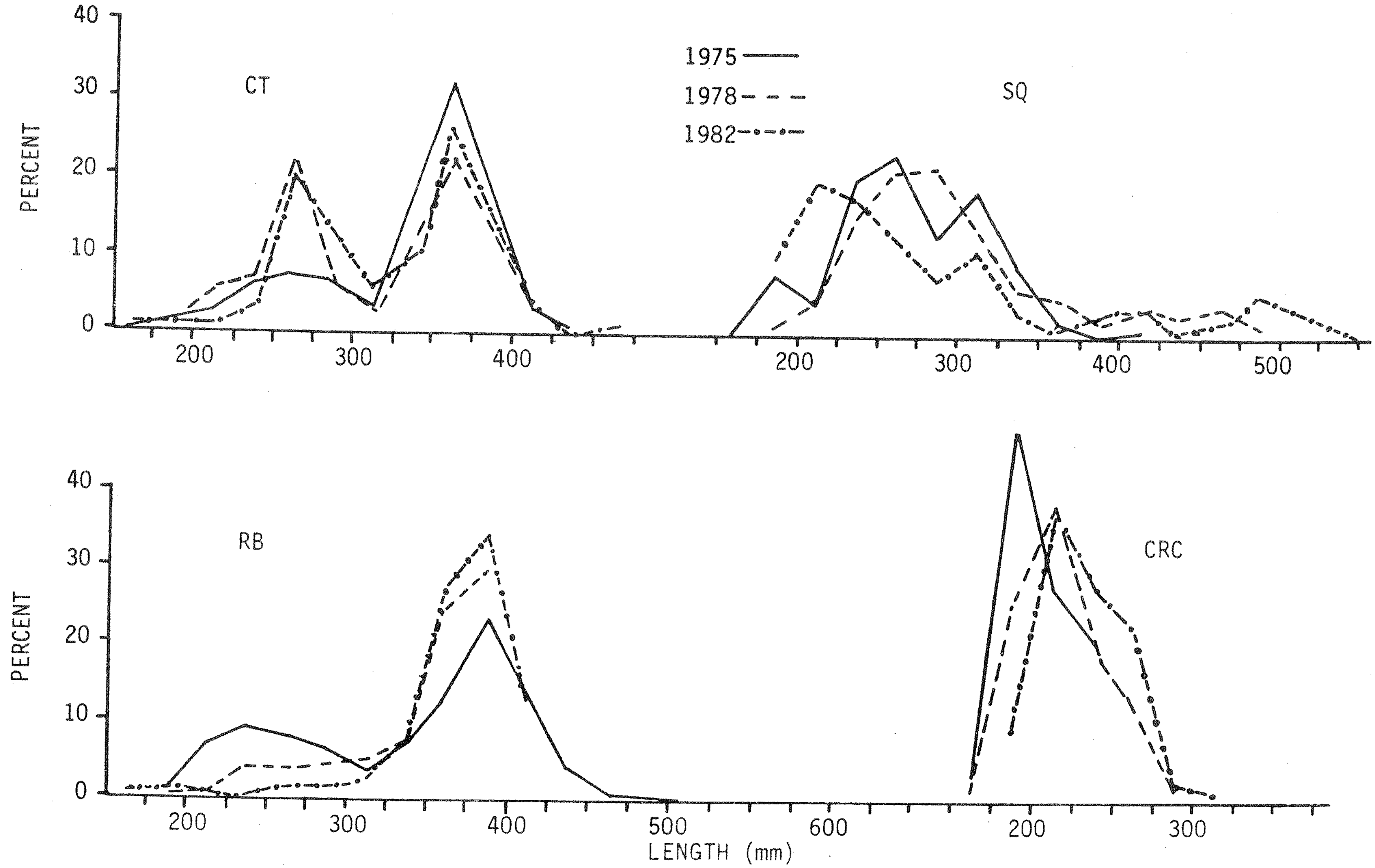


Figure 11. The length frequency distributions of cutthroat trout (CT), rainbow trout (RB), northern squawfish (SQ) and peamouth chub (CRC) from Lake Koocanusa, 1975, 1978, and 1982.

Table 24. Average length, range in lengths, average weight and condition factors of rainbow trout, cutthroat trout, kokanee, peamouth and squawfish collected from Lake Koocanusa, 1975-1982.

Year	Species	Number measured	Average length	Range in length	Average weight	Condition factor
1975	RB	381	359	191-518	520	1.04
1976	RB	331	377	191-587	592	1.03
1978	RB	357	371	193-564	529	1.01
1979	RB	326	364	198-483	494	0.96
1980	RB	361	358	170-483	454	0.95
1982	RB	170	375	155-460	510	0.94
1975	WCT	273	341	152-442	451	1.06
1976	WCT	232	327	191-450	437	1.04
1978	WCT	158	320	193-429	379	1.05
1979	WCT	102	329	203-432	385	1.01
1980	WCT	91	332	170-475	395	1.00
1982	WCT	86	329	165-462	379	1.00
1982	KOK	500	440	302-500	815	0.98
1975	CRC	82	208	173-241	82	0.90
1976	CRC	91	226	180-277	104	0.87
1978	CRC	114	218	170-282	100	0.89
1979	CRC	238	220	165-300	106	0.97
1980	CRC	356	218	165-317	99	0.89
1982	CRC	222	233	185-312	114	0.85
1975	SQ	190	275	175-424	208	0.91
1976	SQ	123	298	157-503	277	0.91
1978	SQ	186	304	196-495	310	0.94
1979	SQ	132	322	173-528	355	0.93
1980	SQ	67	395	213-513	472	0.93
1982	SQ	154	292	185-546	304	0.84

Smaller minimum size of fish netted in 1980 and 1982 suggests slower growth rates but growth rates (presented later in this report) did not decline for age I and II fish throughout the years sampled.

Maximum size of fish increased from 518 mm in 1975 to 587 mm and 564 mm in 1976 and 1978. Maximum size declined sharply in 1979 through 1982, again suggesting reduced growth rates for older fish or decreased longevity. Rainbow trout in Lake Koocanusa seldom lived more than four years; no fish in the 1975 sample were aged older than four years, while only two fish from the 1980 sampled were five years old. Growth rates of three-year-old and four-year-old fish did decline.

Condition factors of rainbow trout (Table 24) declined steadily throughout the years sampled falling from 1.04 in 1975 to 0.94 in 1982. Most rainbow trout in Lake Koocanusa two years old or older were 330 mm long when captured in the fall gill net sampling. McMullin (1979) found that redside shiners were an important component of the diet of rainbow trout over 330 mm long. His study was done in 1977 and 1978 when redside shiners were abundant (Table 22) and condition factors above 1.00.

Beginning in 1979, numbers of redside shiners declined significantly in net catches. It can be assumed that redside shiners were not an important part of the diet of rainbow trout after 1978 resulting in lowered condition factors and probably increased mortality rates.

In general, netting data shows a decline in the number of rainbow trout in Lake Koocanusa at all age classes. This decline apparently started in 1979 and continued through 1982. Reasons for this decline would include reduced annual recruitment, increased mortality rates of all ages of fish in the reservoir, declining numbers of redside shiners for forage and eliminated escapement of rainbow trout from the Kootenay Trout Hatchery in British Columbia.

Conversations between the author and the hatchery manager resulted in the admittance that hatchery rainbow trout were being released into Bull River, a tributary of Lake Koocanusa. Numbers of fish released were unknown but estimates of up to 100,000 yearly in the 1970's have been "rumored". Reduction or elimination of these releases in the 1980's may have had a direct impact on numbers of rainbow trout present in the reservoir.

Age composition of the catch of rainbow trout from fall sampling is shown in Table 25. These data were derived from analysis of scale samples from almost all rainbow trout collected each year. Data from the 1981 fall sampling is also included in this table. Sampling done in 1981 took place when reservoir surface temperatures were 12^{o}C, some three degrees lower than minimum netting criteria and these data have not been included in other tables.

Table 25. Percent age composition of rainbow trout from gill net catches, Lake Koocanusa, fall 1975 through 1982.

Sampling year	AGE GROUP I Number	I Percent	II Number	II Percent	III Number	III Percent	IV and older Number	IV and older Percent
1975	63	17	206	56	94	25	8	2
1976	53	16	135	41	118	36	25	7
1978	48	10	297	60	121	24	30	6
1979	52	15	148	42	105	29	50	14
1980	76	21	159	44	91	26	34	9
1981	31	14	107	49	68	31	12	6
1982	4	2	97	56	57	33	16	9

Age composition of the gill net catch for all years is within the range of normal expectations with the exception of age IV and older fish in 1975 and age I fish in 1982. Four-year-old fish in the 1975 sample year would have been spawned in spring 1971, before Lake Koocanusa was created. These fish would represent remnants of the Kootenai River rainbow population and would be expected to occur in low numbers.

Occurrence of low numbers of age I fish in the 1982 sample was caused by a much more complex set of circumstances, most of which were not or cannot be evaluated. Possible reasons for the marked decline of one-year-old fish in the 1982 reservoir gill net sample included:

1. Sampling error. Continued sampling in 1983 by fisheries personnel funded by Bonneville Power Administration indicates that net catch of rainbow trout has not increased over that experienced in 1982.

2. Low numbers of fish spawning in 1981 which would have produced one year old rainbow trout in the reservoir in 1982. The best measure of the strength of the 1981 spawning population would be the fall 1980 gill net catch (Table 22) and age composition of this catch (Table 25). Rainbow trout spawning in 1981 would have been the 2, 3 and 4 year old fish in the 1980 sample and net catch of 1980 indicates spawning populations should have been sufficient to produce numerous offspring. An unknown factor would be overwinter mortality rates between fall 1980 and spring 1981. Catch of rainbow trout in the 1981 fall sampling was intermediate between the 1980 and 1982 catch, but since this sampling was done at a much cooler reservoir temperature, catch would probably have been reduced from the temperature factor alone.

3. Poor survival of eggs and fry may have occurred in tributary streams. Whether or not this occurred is unknown.

4. Low survival of smolts after they enter the reservoir. Rainbow trout emigrate from tributary streams into Lake Koocanusa at two distinct ages; fish one year old or less (migration class 1) and fish two years old or older (migration class 2). Age composition listed in Table 25 shows a marked decline in age group I (migration class 1) in 1982 compared to previous years indicating increased mortality rates.

   Coincident with the decreased numbers of age I fish in the 1982 sample was a marked increase in numbers of peamouth most apparent in 1982 but starting after 1978 (Tables 19 and 22). Habitat preferences and food habits of peamouth and small rainbow trout should overlap since both are plankton feeders inhabiting shoreline areas of the reservoir.

   Migration class 2 rainbow trout may not have been affected by competition with peamouth to the degree that migration class 1 rainbow trout. Migration class 1 rainbow enter the reservoir at a length of 100 mm or less while migration class 2 rainbow are generally 140 mm long or longer.

5. Escapement of hatchery rainbow trout was minimize in 1981 which would have reduced number of age I fish in the 1982 gill net catch.

<u>Westslope Cutthroat Trout</u>

Cutthroat trout were a common species in the Kootenai River prior to impoundment and were given special consideration in the development of the management plan for Lake Koocanusa. Planting of hatchery-reared fish was started in tributary streams (Young Creek) in 1970 and in the reservoir in 1972 (Table 26). Between 1970 and 1982, over 5.1 million cutthroat were planted with 3.7 million or 72 percent being planted in the reservoir. Hatchery fish planted in the reservoir prior to 1981 were released at various times of the year from late spring to early fall and at sizes varying from 25 to 125 mm long. Plants in tributary streams were made in mid-summer and these young-of-the-year fish were generally about 50 mm long. Starting in 1981, planting of cutthroat into the reservoir was limited to two times of the year. Yearling fish 100 to 125 mm long were to be planted in late April or early May when lake surface temperature was near 10°C. Young-of-the-year fish 50 to 75 mm long were to be planted in late September or early October when lake surface temperature was near 16°C. In 1981, 200,000 yearlings were planted in mid-May, but no fish were planted in September-October. In 1982, 200,000 yearlings were planted in early May and 235,000 young-of-the-year were planted in late September.

Differentiation of cutthroat planted directly into the reservoir from those planted in tributary streams or from natural reproduction was extremely difficult. Westslope cutthroat trout generally rear in their natal streams at least two years before smolting and hatchery reared young-of-the-year cutthroat planted in Young Creek also generally reared one to two years before smolting out of Young Creek. Hatchery fish planted into the reservoir would generally lay down a planting mark on their scales,

Table 26. Number of westslope cutthroat trout and waters planted in Lake Koocanusa area, 1970-1982. Number of fish are in 1,000's and rounded to nearest 1,000.

Water name	Year										
	1970	1971	1972	1973	1974	1975	1976	1979	1980	1981	1982
Lake Koocanusa	--	--	204	1,000	540	758	612	--	--	200	435
Big Creek	--	--	--	70	77	77	--	--	55	--	--
Clarence Creek	--	--	--	15	24	20	11	--	23	--	--
Deep Creek	--	--	--	15	14	7	--	--	40	--	--
Five Mile Creek	--	--	15	11	9	--	--	--	20	--	--
Fortine Creek	--	--	--	40	32	30	42	--	73	--	--
Grave Creek	--	--	72	--	--	--	--	20	73	--	--
Pinkham Creek	--	--	--	10	24	22	--	--	40	--	--
Sullivan Creek	--	--	--	24	10	10	--	--	25	--	--
Young Creek	51	50	54	62	45	60	--	--	--	--	--
St. Clair Creek	--	--	--	--	--	--	17	--	25	--	--
Bristow Creek	--	--	--	--	--	--	--	--	15	--	--

which in the case of fish planted in the spring, was similar to and was considered an annulus mark. Fish planted in the summer or fall would lay down a planting mark followed by an annulus mark the following spring creating some confusion as to whether it was a hatchery fish or a two-year-old smolt from a tributary stream. Upon entering the reservoir, both hatchery fish or smolts from tributary streams would at least double their length within the first full growing season. As examples, cutthroat planted in the reservoir in the spring at 100 mm (one year old fish) would reach a size of 275 mm by late September when most netting was done and 300 mm the following spring (two year old fish). Cutthroat smolting from Young Creek in summer at 125 mm (two year old fish) would be 275 mm long during fall sampling and 300 mm the next spring as a three year old fish.

Cutthroat trout planted in the reservoir were separated from those planted in tributary streams or from natural reproduction by scale annulus marks and growth patterns. Those showing one annulus mark followed by rapid growth were classified to be from lake plants while those with two or more annulus marks followed by rapid growth were classified as being from tributary plants or from natural reproduction. This method was not "foolproof" since it was known that some fish smolted out of tributary streams as one year old fish and that some fish planted into the reservoir in summer and fall laid down planting marks indistinguishable from annulus marks.

Cutthroat trout planted into Lake Koocanusa in spring 1981 were marked using an external fluorescent dye and fed tetracycline which marks the bones internally. These marks were located using a "black light". Fish planted in 1982 were identifiable as hatchery fish from an unusually high incidence of fin erosion.

Average catch per gill net of cutthroat trout in Lake Koocanusa (Table 22) increased from 2.0 fish per net in 1975 to a high of 2.5 fish in 1976. Catch after 1976 declined to a low of 1.2 fish per net in 1982. Kruskall Wallis ranking test (Table 23) showed that the decline from 1978 of 2.0 fish per net to 1.2 fish in 1982 was significant. Between the years of 1972 and 1976, a total of 3.1 million cutthroat were planted into Lake Koocanusa. No fish were planted into the reservoir from 1977 through 1980. It is likely that cessation of planting in 1976 was the single largest factor in the marked decline of cutthroat in 1979 and succeeding years.

Cutthroat trout caught by gill nets were assigned as either hatchery fish planted into the reservoir or "wild" fish by scale characteristics for years of 1975 through 1980. In 1981 and 1982, scale characteristics, presence of dye or tetracycline marks or eroded fins were used to assign individual fish as either hatchery fish or wild fish. Composition of the gill net catch of cutthroat trout as either hatchery or wild fish is shown in Table 27. Data from 1974 are included in this table although fish caught in 1974 were from summer samplings.

Table 27. Number and percent of hatchery and wild cutthroat trout in gill net catches, Lake Koocanusa, 1975-1982.

Netting year	Wild Fish Number	Wild Fish Percent	Hatchery Fish Number	Hatchery Fish Percent
1974	63	44	79	56
1975	108	40	162	60
1976	101	44	130	56
1977	51	57	38	43
1978	110	71	45	29
1979	74	73	28	27
1980	79	100	0	0
1981	65	75	21	25
1982	49	56	39	44

Data presented in Table 27 show that cutthroat planted directly into the reservoir made up the majority of fish caught from 1974 through 1976. Reservoir planting was terminated from 1977 through 1980 and catch of hatchery fish declined rapidly starting in 1977 and disappeared completely in 1980. Planting of cutthroat trout into the reservoir was resumed in spring 1981 and these fish made up 25 percent of the total cutthroat trout catch in fall 1981. In 1982, almost half of the cutthroat caught were from hatchery fish planted in spring 1981 and spring 1982.

Numbers of wild fish caught in 1975 through 1978 were relatively stable. It should be noted that sampling in 1977 was not a population trend effort and netting intensity was about half that of other years. Catch of naturally reproduced cutthroat trout in the years of 1975 through 1978 was undoubtedly lower than indicated in Table 27. Intensive planting of tributary streams with young-of-the-year cutthroat in 1973 through 1975 (Table 26) should have contributed considerable numbers of "wild" fish to the cutthroat population in 1975 through 1978.

Numbers of wild fish caught during 1979 through 1981 were fairly uniform but lower than in previous years. This decline in numbers of wild fish is thought related to cessation of all tributary planting in 1976. The number of wild fish caught in 1982 may be an excellent measure of Lake Koocanusa's tributary system capability to produce fish by natural reproduction.

Aging of cutthroat trout showed that few fish lived more than three years in the reservoir (Table 28). In general, fish planted in the fall at a size of 25-75 mm disappeared after 36 months, while those planted in the spring at 100-125 mm disappeared after 29 months. Juveniles smolting out of the tributaries in the summer as two and three-year old fish seldom lived for more than three years in the reservoir.

Information on longevity of westslope cutthroat trout is scant in the fishery literature. Studies on Hungry Horse Reservoir (Huston 1984) showed that good numbers of westslope cutthroat lived four years in the reservoir after smolting, a few five years, and one fish seven years. Leathe (1982) aged some cutthroat in Flathead Lake as six to eight-year old fish that had smolted into the lake at two years of age.

The apparent short-lived nature of cutthroat in Lake Koocanusa may be related to the hatchery reared origin of this fish or to its rapid growth rate. Almost all cutthroat in Lake Koocanusa were of hatchery origin; either from planted fish or descendents of planted fish. Selecting fast growing brood fish within the hatchery system may also be an inadvertent selection toward a shorter-lived fish.

Westslope cutthroat in Hungry Horse Reservoir and Flathead Lake occasionally achieve total lengths of 450 mm or greater and this size of fish is usually six years old or olders. Very few of the cutthroat caught in Lake Koocanusa were 450 mm or longer and most of these fish had been planted directly into the reservoir.

Table 28. Number of cutthroat caught in fall sampling by months of reservoir residence from time of planting or smolting. Catch for years or 1974 through 1982 are combined.

Type Cutthroat	Time of smolting or planting	Number caught 1st Fall	2nd Fall	3rd Fall	4th Fall
Wild	May-June	194 (4 mo)	149 (16 mo)	85 (28 mo)	4 (40 mo)
Hatchery	April-May	18 (5 mo)	21 (17 mo)	18 (29 mo)	1 (41 mo)
Hatchery	August-September	64 (12 mo)	99 (24 mo)	39 (36 mo)	2 (48 mo)

The average length of cutthroat trout caught varied only 21 mm during all the years sampled (Table 24). Changing minimum and maximum sizes of fish caught between years was probably one of the vagaries of gill net sampling. Condition factors of cutthroat did show a steady decline most noticeable between 1978 and 1979. Reasons for this noticeable decline are now known but change in condition factor did occur when net catch declined from 2.0 fish in 1978 to 1.4 fish in 1979.

Length frequencies for fish caught in 1975, 1978 and 1982 do show considerable differences between 1975 compared to 1978 and 1972 (Figure 11). Percentagewise, less fish in 1975 were 200 to 300 mm long than in either 1978 or 1982. Average size of cutthroat in 1975 was also about 20 mm longer than in any other year. The difference between 1975 and 1978-82 was thought to be a function of planting fish into the reservoir in 1973. In 1973, about one million cutthroat 25-50 mm long were planted in the months of July through September. These fish would have entered the gill net catch of 1975 at a length ranging from 325 to 400 mm.

Cutthroat captured by gill netting in 1981 and in 1982 were examined for fluorescent dye or tetracycline marks. In 1981, only fish less than 350 mm long were examined since the marked fish had been planted in May, 1981 at a length of 125 mm. In 1982, all fish were examined although growth rates indicated that marked fish would generally be 300 mm long or longer. Also, fish released from the hatchery in May 1982 had an unusually high incidence of fin deformity and fish in the gill net catch with deformed fins were most likely from this May 1982 planting. Number of marked or deformed fined fish is shown in Table 29. Anglers contributed another 69 cutthroat of all sizes for tetracycline testing in 1981 and results of this testing are also shown.

Numbers of fish found to have either tetracycline or fluorescent dye marks should be considered a minimum figure and not the true contribution of the 1981 plant to the total catch. Neither the fluorescent dye or tetracycline appeared to adequately mark the fish. Fluorescent dye marked fish were characterized by having only one or two specks imbedded on the head or gill covers. Jim Peterson, Montana's fish health biologist, examined all fish for tetracycline marks and reported as many probable marks as definitive marks. His opinion was that the tetracycline did not lay a good mark probably due to poor feeding efficiency. In addition, only 140,000 of the 200,000 fish planted in spring 1981 were fed tetracycline.

The data in Table 29 for marked fish does indicate that hatchery fish planted in 1981 made up a substantial part of the total gill net catch in October 1981 and that a considerable number were still present in September, 1982. Cutthroat trout with deformed fins were rarely observed in either the gill net catch or angler catch prior to 1982 and it can be assumed these fish were from the 1982 spring plant. Catch of marked and deformed fish in the 1982 fall sampling would indicate at least 40 percent of the net catch was hatchery fish.

Kokanee

Kokanee were first caught by nets in the fall of 1979 (Table 22) and these few fish averaged about 500 mm long. Aging of these fish showed they were two years old and from the 1977 year-class. Kokanee had never been "officially" planted in Lake Koocanusa and origin of these few fish was thought to be either of two potential sources: 1) Glen Lake in the Tobacco River drainage, or 2) British Columbia's Kootenay Trout Hatchery on Bull River.

Glen Lake is an off-channel irrigation reservoir receiving its water from Graves Creek through an irrigation system with no known connection to Lake Koocanusa and the outlet stream, Lick Creek, which enters Tobacco River. Lick Creek is very small and does not contain much water most of the year. Glen Lake has been planted with kokanee from the Flathead lake stock on a regular basis since 1951. Kokanee fry could have drifted out of Glen Lake, down Lick Creek and Tobacco River into Lake Koocanusa.

Table 29. Total catch of cutthroat trout in fall samplings of 1981 and 1982 and number with fluorescent dye or tetracycline marks or deformed fins.

Date fish collected	Total number		Number of fish with						Percent of total catch marked
			Fluorescent dye		Tetracycline		Deformed fins		
	<300 mm	>300 mm	<300 mm	>300 mm	<300 mm	>300 mm	<300 mm	>300 mm	
Oct 8-13, 1981	37	49	10	2	Not checked				14
Aug 22-Oct 14, 1981	69 total fish angler catch		Not checked		15 fish				22
Sep 24-28, 1982	35	53	Not checked		0	7	17	12	41

British Columbia's Kootenay Trout Hatchery hatched kokanee eggs collected in fall 1976 and reared fry for planting in 1977. Most hatcheries do leak fish out their drain system, and this hatchery drains into Bull River, Kootenai River and Lake Koocanusa. This hatchery is considered the most likely source of kokanee in Lake Koocanusa since a few hundred kokanee entered the Bull river system for spawning in 1979. Kokanee return to their natal stream for spawning with considerable consistency.

Later knowledge that kokanee were in Lake Koocanusa was gained in February 1981 when several hundred were found stranded on the banks of the Kootenai River below Libby Dam following a rapid decrease in outflow from 20,000 cfs to 4,000 cfs. These kokanee averaged 150 mm long ranging from 125 mm to 175 mm. Scale analysis indicated all these fish were one year old and thus were from the 1980 year class or 1979 spawning year.

This year class of kokanee first entered the angler catch in late summer 1981 and averaged about 280 mm long. Angler harvest of kokanee in 1982 was significant and these fish ranged from 280 mm to 500 mm long. Gill net catch of kokanee in fall 1982 averaged 7.1 fish per net (Table 22. All fish caught were adults in spawning condition. Males averaged 442 mm long compared to 427 mm for females. Males varied from 302 mm to 500 mm total length while females ranged from 343 mm to 490 mm total length.

All adult kokanee caught in fall 1982 netting were two year old fish from the 1980 year class or 1979 spawning season. It was known that some kokanee spawned in Bull River drainage in 1979 but spawn from the few hundred fish observed would not account for the large numbers of kokanee caught in Lake Koocanusa in 1981 and 1982 and the estimated spawning population of 26,000 fish in fall 1982. Source of most of the 1980 year class of kokanee in Lake Koocanusa was from an accidental release of at least 250,000 fry from the Kootenay Trout Hatchery in 1980.

The impact of kokanee on other species of fish in Lake Koocanusa is not known at this time. However, addition of this species to the reservoir could have a detrimental impact on other plankton-eating fish species such as rainbow and cutthroat trout. Competition would likely be most intense during periods of ice-cover when plankton is the major component of the diet of rainbow and cutthroat trout.

It is hypothesized that numbers of kokanee will be low in future years if the only recruitment source is natural reproduction. Successful kokanee reproduction appears to be regulated by water temperature during incubation of the eggs; i.e. temperatures below 5°C during egg deposition and below 2°C during eye-up cause severe egg mortalities. These temperature criteria eliminate most tributaries of Lake Koocanusa except two which have springs as their major water source. The two, Kikomum Creek and Norbury Creek in British Columbia, have very limited amounts of spawning area due to the small size of Norbury Creek and a barrier culvert in Kikomum Creek.

Kokanee have also been reported to successfully reproduce by broadcast spawning over rubble substrate such as rip-rap along roads in Coeur d'Alene

Lake, Idaho (Reiman 1983) and in Banks Lake, Washington (Stober et al. 1979). Areas suitable for broadcast spawning are abundant in Lake Koocanusa along the two roads encircling the reservoir, but it is expected that spawning in these areas would not be successful. Reservoir drawdown dewaters most of these areas in late fall and winter which would kill most eggs deposited.

Rainbow-Cutthroat Trout Hybrids

Hybridization between rainbow and cutthroat trout has occurred in Lake Koocanusa and hybrids are more abundant in the population than indicated by this report (Table 22). Individual fish were classified as either rainbow trout or cutthroat trout whenever possible using morphological characteristics such as lateral line scale counts, absence or presence of hyoid teeth, and general body coloration and spotting patterns.

Leary et al. (1983) determined that morphological characteristics were generally worthless in trying to differentiate between cutthroat, rainbow trout and their hybrids. Electrophoretic analysis of 12 selected trout from Lake Koocanusa collected in fall 1982 showed that 11 were hybrids and one a pure rainbow trout. Field identification of these fish as either rainbow, cutthroat or hybrids by the authors of this report resulted in a score of four right and eight wrong by Joe Huston and Bruce May and 11 right and one wrong by Paul Hamlin. Mr. May called most of the hybrids rainbow trout, while Mr. Huston identified the hybrids as cutthroat trout. Mr. May has been project biologist on all Lake Koocanusa work since its inception and has done almost all fish identification.

It is estimated that as much as 20-25 percent of the Salmo population in Lake Koocanusa at the present time are hybrids. It is suspected that more hybrids were classified rainbow trout than cutthroat trout during this investigation. Extensive electrophoretic examination of large numbers of fish will be required to determine the extent of Salmo hybridization in the reservoir.

Hybrid Salmo were first suspected to be more than a rare occurrence during the spawning run into Big Creek in 1980. Eleven suspect spawning fish were sent to University of Montana Population Genetics Laboratory for electrophoretic analysis. All 11 fish were first generation crosses between rainbow and cutthroat trout. These adult fish were likely four and five year old fish showing that hybridization between the two species had occurred as early as 1975 or 1976. These adult hybrids were fairly easy to identify by the silvery olive green coloration with little spotting and no brilliant cutthroat slash common to cutthroat trout and no red lateral line band typical of spawning rainbow trout. Coloration and spotting was very similar to the coloration of adult tench (Tinca tinca). Hybrids made up 21 to 23 percent of the total Salmo spawning run into Big Creek in 1980 (Table 15).

It is thought that spawning between cutthroat and rainbow trout occurs in most tributaries of the reservoir. Except for Big Creek, rainbow trout enter the spawning tributary several weeks earlier in the spring than cutthroat trout, but the tail end of the rainbow trout spawning run overlaps with the start of the cutthroat spawning run. Female cutthroat trout almost always enter the stream as very green fish but male cutthroat are generally ripe. Spawning crosses between the two species probably occur between female rainbow trout and male cutthroat trout. In Big Creek the two species entered the stream at the same time so crosses may occur between both sexes. Sex ratios shown in Table 15 would indicate female hybrids mating (recrossing) with males of either rainbow or cutthroat trout.

Long-term effects of severe hybridization between rainbow and cutthroat trout are not known at this time. One fact is apparent; hybrid vigor has not occurred since growth rates and population numbers of Salmo have declined.

Redside Shiners

Redside shiners were common to Kootenai River but were fairly well restricted to sloughs, backwaters and low velocity pools. Following impoundment, numbers of shiners increased from 3.3 fish per net in 1975 to 7.9 and 7.3 fish in 1976 and 1978 (Table 22). Catch in 1979 dropped to 2.0 fish followed by further declines in 1980 and 1982 to 0.2 fish per net. Kruskall-Wallis ranking tests (Table 23) showed a significant increase from 1975 to 1978 and a significant decrease from 1978 to 1982.

Brown (1971) reported that redside shiners spawning habitat is flooded vegetation and organic matter in shallow, shoreline areas. Annual fluctuation of Lake Koocanusa has destroyed most areas suitable for redside shiner spawning and is thought to be the major reason for the population decline. Decreased numbers of redside shiners have had impacts on other fish species, notably rainbow trout, since they were the major prey species for predatory species.

Squawfish

Squawfish were rarely found in Kootenai River prior to impoundment but increased in abundance markedly after impoundment to become one of the most numerous fish species in the gill net catch. Catch per gill net was similar from 1975 through 1978 ranging from 4.2 to 4.7 fish. Catch in 1979 and 1980 was 2.1 and 1.9 fish, respectively, increasing to 3.5 fish per net in 1982 (Table 22). Kruskall-Wallis ranking tests showed no changes between the years tested (Table 23).

Catch per net of squawfish was similar in size for all years sampled except 1979 and 1980. Average lengths and weights of squawfish listed by year in Table 24 show that the average size of squawfish was considerably larger in 1979 and 1980 than the other years indicating a population of older larger fish. Average length and weight of squawfish declined from 1980 to 1982 indicating a shift back to smaller, younger fish. Range in length increased from 1980 to 1982 indicating more year classes of fish in the 1982 net catch.

Length frequencies of squawfish (Figure 11) show two major changes between 1982 and 1975-1978. The 1975 and 1978 curves are very similar except that some squawfish were longer in 1978. The 1982 length frequency curve shows that fish less than 225 mm were more abundant in 1982 than in either 1975 or 1978 and that more fish were longer than in prior years. The abundance of smaller squawfish in 1982 indicates good survival of one or two year classes spawned prior to 1982 while increased lengths of fish indicate increased numbers of older larger fish. The 1982 length frequency may indicate a blossoming of squawfish in the near future.

Condition factors of squawfish (Table 24) were constant from 197 through 1980 but dropped significantly in 1982. An explanation for the drop in 1982 may be the large numbers of fish less than 225 mm and larger than 450 mm in 1982 compared to previous years.

Peamouth Chub

Peamouth were considered rare in Kootenai River prior to impoundment but increased after impoundment to be one of the most abundant fish in the reservoir. Average catch per gill net was stable from 1975 through 1978 and increased dramatically from 1979 through 1982 (Tables 19 and 22). Kruskall-Wallis ranking tests showed no increase in catch from 1975 versus 1978, but a significant increase from 1978 to 1982 (Table 23).

Average length and range in lengths of peamouth (Table 24) indicate that size of peamouth increased each sampling year. Carlander (1969) reported that peamouth reach maturity at an age of four years and a length of 211 mm. Length frequency data shown in Figure 11 show that much of the gill net catch in 1975 was less than 200 mm long and not of spawning size. Size of fish increased in 1978 and 1982.

It would appear that reproductive success of peamouth was very high immediately following impoundment in 1972 and that many of these fish had not reached sexual maturity by 1975. Reproductive success remained high after 1975 as indicated by increased catch rates starting in 1979 and continuing through 1982. Whether catch of peamouth will increase in future years is not known although catch per net in 1983 (Shepard, personal communication) was as high as 1982.

The delayed marked increase in numbers of peamouth in Lake Koocanusa was similar to peamouth dynamics in Noxon Rapids Reservoir (Huston 1984). Immediately prior to impoundment of the Clark Fork River (Noxon Rapids Reservoir) in 1958, the river was chemically treated and large numbers of peamouth killed. Peamouth were not caught in gill nets until 1962 and they increased to be the most numerous fish caught by 1968.

Bailey Bridge Sampling

Gill net sampling done at the Bailey Bridge area in British Columbia was limited to the fall of 1976, 1978 and 1980. Average catch per net night is shown in Table 30.

Table 30. Average catch per net night, fall sampling at Bailey Bridge area, 1976, 1978 and 1980.

Parameter	Year 1976	1978	1980
Surface temperature	16.7	16.1	16.1
Number of nets	47	40	39
Fish caught			
RB	2.0	3.4	3.5
CT	1.5	1.7	0.7
MWF	0.8	0.4	0.2
CRC	4.0	2.7	2.3
SQ	6.9	3.8	3.0
RSS	2.3	2.7	0.2
DV	0.0	<.1	0.2
CSU	7.8	18.0	3.8
KOK	0.0	0.0	0.3
TOTAL	25.3	32.7	14.2

Comparison of catch by species between Table 30 and Table 22 indicate population trends similar in the Montana and British Columbia parts of Lake Koocanusa. Rainbow trout catches increased from 1976 to 1978 and were stable in 1980, while cutthroat trout catches were stable from 1976 to 1978 but decreased in 1980. Mountain whitefish catches steadily declined from 1976 through 1980. Bull trout catches increased slightly, while kokanee were caught only in 1980. Catch of squawfish and peamouth were higher in 1976 than either 1978 or 1980, while catch of redside shiners increased from 1976 to 1978 but declined markedly in 1980.

Catch of largescale suckers in British Columbia did not conform to trends of catch in Montana. Numbers caught were much higher in the Bailey Bridge area and increased in 1978 when catch in Montana decreased. Bailey Bridge catch in 1980 was much lower than in 1978, while catch in Montana increased slightly from 1978 to 1980.

AGE AND GROWTH RATES AND SMOLTING

Monastrysky fish length-scale radius relationships were developed for rainbow, cutthroat and bull trout and mountain whitefish from Lake Koocanusa and Kootenai River. The equations describing these relationships are shown in Table 31 and the correlation coefficients show the regression equations accurately describe the body length-scale radius relationships for all four species.

Table 31. Equations describing the relationship between total body length (mm) and scale radius (mm) at 67X magnification for rainbow trout, cutthroat trout, bull trout and mountain whitefish from Lake Koocanusa.

Species	Equation	Correlation coefficient (r)	Sample size
Rainbow	log TL=.742 log SR+.946	0.92	1,279
Cutthroat	log TL=.811 log SR+.907	0.90	1,510
Bull trout	log TL=1.062 log SR+.680	0.94	389
Mountain whitefish	log TL=.765 log SR+.680	0.96	558

Age of smolting was determined by visual examination of the scale and counting annulus marks of creek growth before the fish emigrated to the river or reservoir. River or reservoir growth was much more rapid than creek growth.

Rainbow Trout

Data on growth rates of rainbow trout from Kootenai River and from Lake Koocanusa is shown in Table 32. Growth information is presented by smolting age, fry, one year and two year old fish, and for time periods corresponding to shifts in Lake Koocanusa fish population. The period of 1972-1978 was characterized by an expanding rainbow trout and redside shiner population, while post-1978 was characterized by a declining population of both rainbow trout and redside shiners. Growth rates by individual year class are presented in Appendix D.

Growth of rainbow trout from Lake Koocanusa was about the same as Kootenai River except for the first year in the reservoir following smolting. One year and two year old smolts averaged 145 mm and 88 mm growth, respectively, the first year after smolting from tributaries into the Kootenai River. The same age smolts averaged 217-230 mm and 172-182 mm growth, respectively, the first year after smolting from tributaries into Lake Koocanusa (Table 32). McMullin (1979) showed that rainbow trout smaller than 330 mm fed almost exclusively on plankton in Lake Koocanusa.

Table 32. Average annual growth of fry, one year old and two year old smolting rainbow trout to age four from Kootenai River (1966-1971) and Lake Koocanusa for growth years of 1972-1978 (high numbers of redside shiners) and 1979-1982 (low numbers of redside shiners). A growth year was from May through April of the following year.

Smolting age	Time period	Yearly Increment and Length at Annulus in Millimeters							
		Increment	Annulus I	Increment	Annulus II	Increment	Annulus III	Increment	Annulus IV
Fry	1972-78	112	112(255)*	205	317(149)	78	395(37)	56	451(7)
	1979-82	110	110(59)	199	309(47)	73	372(25)	7	379(2)
One year old	pre-1972	88	88(22)	145	233(8)	72	305(6)	41	346(4)
	1972-78	82	82(490)	217	299(324)	86	385(117)	39	424(18)
	1979-82	79	79(178)	230	309(198)	66	375(68)	27	402(10)
Two year	pre-1972	67	67(22)	52	119(22)	88	207(8)	57	264(5)
	1972-78	80	80(217)	67	147(217)	172	319(94)	57	376(26)
	1979-82	74	74(86)	63	137(86)	182	319(73)	52	371(15)

* Number in parentheses is size of sample.

It was likely that rainbow trout in Kootenai River were feeding almost entirely on insects.

Growth rates of rainbow trout after their first year in the reservoir slowed in succeeding years. McMullin (ibid) showed that rainbow trout derived most of their calorie input from redside shiners after they reached a size of 330 mm during their second year in the reservoir. Table 33 shows the length at annulus formation and at time of capture for rainbow trout aged four and five years old. These data show an expanding gap between sizes of four and five year old fish at both annulus formation and time of capture. Rainbow trout after 1979 were not growing as fast as those caught between 1972 and 1978.

Growth rates of pre-smolt fish in tributary streams was similar throughout all three time periods except for pre-impoundment two year old smolts. The smaller average size of two year old smolts was probably related to the small sample size and "Rosa Lee's phenomenon" (Ricker 1958).

Composition of rainbow trout caught in Kootenai River and Lake Koocanusa by age at smolting is shown in Table 34. No fry smolts were caught prior to impoundment. Complete absence of this age of smolt was probably related to the small sample size or low survival of this size of smolt in Kootenai River.

Table 34. Migration composition of rainbow trout captured in Kootenai River (pre-1972) and Lake Koocanusa.

	Percent by time period		
Smolting age	Pre-1972	1972-1978	1979-1982
Fry	0	26.5	18.3
One year old	50.0	50.9	55.1
Two year old	50.0	22.6	26.6
Total Fish	44	962	323

During the years 1972 through 1978, fry smolts contributed about one-fourth of the fish caught indicating good survival of these small fish in the reservoir. Contribution of fry smolts declined in 1979-1982 indicating decreased survival. Decreased survival of rainbow fry may be related to the dramatic increase in numbers of peamouth in Lake Koocanusa.

In summary, growth rates of rainbow trout in Lake Koocanusa were slower in 1979-1982 than in 1972-1978, but only after the fish had spent one year in the reservoir. The slower growth rate was thought related to decreasing numbers of redside shiners that provided a major food item for rainbow trout larger than 330 mm long. Survival of fry smolts in the reservoir declined after 1978 probably as a result of increased numbers of peamouth chub.

Table 33. Length at annulus and time of capture of one and two year old smolting rainbow trout at four and five years total age from Lake Koocanusa for periods of 1972-1978 and 1979-1982.

		Length in Millimeters at			
Smolting age	Time period	Annulus IV	Time of capture IV+	Annulus V	Time of capture V+
One year old	1972-1978	424(18)*	470	498(3)	528
	1979-1982	402(10)	436	429(4)	462
Two year old	1972-1978	376(26)	427	450(4)	483
	1979-1982	371(15)	406	389(3)	414

* Number in parentheses is size of sample.

Westslope Cutthroat Trout

Growth information for wild westslope cutthroat trout is shown in Table 35 by age at smolting and time periods corresponding to major shifts in the Lake Koocanusa fish population as described for rainbow trout. Growth of wild cutthroat by year class is given in Appendix E.

The small number of cutthroat trout collected from Kootenai River prior to impoundment precludes any valid comparison between river and reservoir growth rates. However, the limited data would appear to indicate that pre-smolt cutthroat growth was similar before and after impoundment and that growth rate of cutthroat the first year in the river was considerably less than first year growth in the reservoir.

Growth rates of juvenile cutthroat (pre-smolts) after impoundment was similar during the two post-impoundment periods. It does appear that three year old smolts grew slower than two year old smolts and that two year old smolts grew slower than one year old smolts while in the creek environment. This phenomenon where older aged smolts grow at a slower pace than younger smolts has been recognized in Flathead Lake and Hungry Horse Reservoir. No explanation can be given except it has been speculated that genetics and environment may be involved. Three year old smolts may be hatched and reared in headwater areas where growth factors such as temperature and food availability may be less favorable for good growth.

Growth of cutthroat their first year in Lake Koocanusa was very rapid. Most fish at least doubled their total length within the first year in the reservoir. Most smolting occurs in June and July and annulus formation is thought to occur the following April; therefore, the first year is in fact generally 10 months or less. Second year reservoir growth rate declined considerably. Factors affecting second year growth include accelerated weight gains instead of length and, most important, energy going into sex products rather than length or weight gains. Most cutthroat were sexually mature, spawning adults after two years in the reservoir with maturity reached during the second year.

Two major differences were noted between the Hungry Horse Reservoir and Lake Koocanusa adult cutthroat. Very few of the Lake Koocanusa adult cutthroat spawned more than one time, while at least 25 percent of the Hungry Horse Reservoir cutthroat spawned at least two or more times. Hungry Horse fish showed considerable alternate year spawning. Reason(s) for lack of repeat spawning by Lake Koocanusa cutthroat are unknown at this time, but it is suspected that short longevity may be a prime reason. Almost all cutthroat in Lake Koocanusa, even those considered wild, were of hatchery origin.

Composition of cutthroat trout caught in Lake Koocanusa and Kootenai River by age at smolting is shown in Table 36. One year old smolts were absent prior to impoundment and this was probably related to the small sample size. Most preimpoundment cutthroat smolted into Kootenai River at an age of three year.

Table 35. Average annual growth of one year, two year and three year old smolting cutthroat trout from Kootenai River and Lake Koocanusa for growth years of 1967-1971 (preimpoundment), 1972-1978 and 1979-1982 (post-impoundment). A growth year was from May through April of the following year.

Smolting age	Time period	Yearly Increment (Inc) and Length at Annulus in Millimeters									
		Inc	Annulus I	Inc	Annulus II	Inc	Annulus III	Inc	Annulus IV	Inc	Annulus V
One year old	1972-78	76	76(28)*	139	215(17)	93	308(6)	---	---	---	---
	1979-82	72	72(12)	164	236(12)	90	326(7)	---	---	---	---
Two year old	1967-71	58	58(5)	65	123(5)	100	223(5)	39	262(1)	73	335(1)
	1972-78	61	61(247)	59	120(247)	166	286(116)	62	348(37)	36	384(2)
	1979-82	61	61(35)	64	125(35)	174	299(35)	44	343(18)	---	---
Three year old	1967-71	51	51(9)	52	103(9)	50	153(9)	159	312(1)	---	---
	1972-78	53	53(79)	47	100(79)	54	154(79)	144	298(50)	57	355(14)
	1979-82	56	56(12)	47	103(12)	53	156(12)	148	305(12)	69	374(6)

* Number in parentheses is size of sample.

Table 36. Smolting age of cutthroat trout captured in Kootenai River (pre-1972) and Lake Koocanusa.

Smolting age	Percent by time period Pre-1972	1972-1978	1979-1982
One year old	0	5	20
Two year old	36	72	60
Three year old	64	23	20
Total Fish	14	343	59

Most cutthroat migrated into the reservoir at an age of two and three years during the time several reservoir tributaries were being planted with young-of-the-year cutthroat (1972-1978). During the 1979-1982 period, more cutthroat were emigrating out of the streams as yearling fish. This apparent shift in emigration age to a younger fish may have been related to cessation of planting resulting in decreased fish densities in tributary streams. It may also relate to increased survival of one year old smolts in the reservoir.

In resume, growth rates of cutthroat trout in Lake Koocanusa have remained similar throughout the two periods after impoundment. Slight changes may have occurred in smolting age of juveniles entering the reservoir. Decreased rate of growth after fish had been in the reservoir were related to reaching sexual maturity, not change in food habits. Cutthroat fed extensively in plankton and insects throughout their life span in the reservoir.

Growth rates of cutthroat planted directly into Lake Koocanusa are shown in Table 37. These data are separated into those fish planted each year during the spring, summer and fall. Fish planted in the spring average 100 to 125 mm total length when planted and the first annulus and planting times were considered the same. Fish planted in the summer or fall ranged from 25 to 75 mm total length First year's growth was a combination of length when planted and growth from time of planting to the first annulus the following spring.

Cutthroat trout planted in the summer as 25 to 50 mm long fish were almost the same size at annulus I as fish planted in the spring. Fish planted in the fall at 50-75 mm were about 25 mm shorter than fish planted in the spring. Growth was rapid for hatchery fish their first full year in the reservoir. Fish planted in the spring averaged 177 mm growth (1972 plant omitted) during their first year, while fish planted in summer-fall averaged 186 mm increase in length. Growth during the first year for hatchery cutthroat was greater than the average for wild fish of 156 mm increase in length. It should be remembered that the first year in the reservoir for wild fish was less than 12 months and depended upon time of smolting.

Table 37. Average annual growth of westslope cutthroat planted directly into Lake Koocanusa by spring and summer-fall plantings.

Time of planting	Year planted	Yearly Increment and Length at Annulus in Millimeters							
		Increment	Annulus I	Increment	Annulus II	Increment	Annulus III	Increment	Annulus IV
Spring	1972	97	97(3)*	161	258(3)	75	333(3)	---	---
(late April,	1973	112	112(13)	176	288(13)	69	357(5)	37	394(1)
May, early	1974	117	117(42)	181	298(24)	82	380(11)	---	---
June)	1981	116	116(25)	175	291(25)	---	---	---	---
Summer	1972	111	111(37)	169	280(37)	109	389(2)	---	---
(July,	1973	106	106(32)	199	305(12)	96	401(2)	---	---
August)	1974	107	107(21)	197	304(21)	49	353(5)	---	---
Fall	1975	92	92(48)	179	271(34)	78	357(18)	39	396(2)
(September,	1976	96	96(53)	186	282(36)	45	327(14)	---	---
October)									

The growth increment between annulus II and III was noticeably less than between annulus I and II. This increment for hatchery fish averaged 75 mm for all years. Comparable growth for wild fish was 70 mm. As with wild cutthroat, growth of hatchery fish, expressed as length increase, declined due to their reaching sexual maturity and spawning during the third spring.

Growth data from fish planted in spring 1972 were not included because most of these fish were lost out of Lake Koocanusa into Kootenai River during the winter 1972-73 draft down to penstock invert depth. It did not appear that this drawdown caused many of the summer 1972 planted fish to pass out of the reservoir, but the deep drawdown may have depressed their growth rate during part of 1973.

Very few planted cutthroat lived more than three years in the reservoir suggesting a short longevity for these hatchery fish.

Relative survival of cutthroat planted in spring and summer 1974, fall 1975, and fall 1976 was calculated using average catch per gill net night versus number of fish planted. These data show relative survival to annual fall gill net sampling and total accumulative survival to gill net sampling. The survival information is presented in Table 38.

Table 38. Relative survival of planted westslope cutthroat trout in annual fall gill net samplings.

Time planted	Number planted	Percent (10^{-6}) survival to fall sampling in 1974	1975	1976	1977	1978	1979	Total
Spring 1974	136,000	.03	2.79	.88	--	--	--	3.70
Summer 1974	404,000	--	.92	.62	.44	--	--	1.98
Fall 1975	758,000	--	--	.64	.53	.30	.05	1.52
Fall 1976	612,000	--	--	--	.69	.52	.34	1.55

The gross estimates of survival shown in Table 38 indicate that fish planted in the spring survived at about twice the rate of summer planted fish and 2.5 times the rate of fall planted fish. Even through summer and fall planted fish had lower survival rates, more were available to the net catch since more were planted. Spring planted fish were present in "good" numbers during two samplings, while "good" numbers of summer and fall planted fish were available during three samplings.

Cutthroat planted in 1974 through 1976 were released from hatchery trucks directly into the reservoir at three to four planting sites. It is likely that this type of planting of 25-75 mm long fish in the summer and fall resulted in high mortality rates due to predation. Small cutthroat planted in fall 1983 were planted by boat away from the shoreline and scattered over several miles of reservoir. This method of planting should materially reduce first year mortality rates.

Bull Trout

Juvenile bull trout, like cutthroat trout, rear in tributaries for two or three years before smolting into Lake Koocanusa. The smolts spend two to four years in the reservoir before returning to the tributaries to spawn. Few adult bull trout were caught since most of these larger fish were unavailable for capture during netting times and places. Growth data presented here include instream residence prior to smolting and reservoir growth to age six. Growth data for preimpoundment, 1972-1978 and 1979-1982 are given in Table 39 for two and three year old smolts. Composition of the catch by smolting age is presented in Table 40. Growth rates of individual year classes are shown in Appendix F.

Growth rates of pre-smolt bull trout in tributary streams was similar throughout all time periods sampled. Three year old smolts appeared to grow at a slower rate than two year old smolts while they were in tributary streams. Length at annulus II for two year old smolts ranged from 123-126 mm compared to 102 to 109 mm at annulus II for three year old smolts.

Annual increment for two year old smolts their first year in the reservoir was considerably larger than the increment for two year old smolts their first year in the river. Reservoir growth increments for the period of 1979-1982 were generally slightly larger than the increments for 1972-1978 for both two and three year old smolts. It would appear that growth rates of bull trout have increased with time. In Flathead Lake and Hungry Horse Reservoir, bull trout feed almost exclusively on fish regardless of their size, and whitefish was the most important food item. It can be assumed that the decline in numbers of mountain whitefish that occurred in Lake Koocanusa did not reduce growth rates of bull trout.

Smolting age of bull trout collected from Kootenai River and Lake Koocanusa is shown in Table 40. These data show that more two year old smolts entered Lake Koocanusa than entered Kootenai River. Reasons for this shift in migration age may include an increased spawning population resulting in higher densities of juveniles in tributaries or higher survival rate of the smaller younger fish in the reservoir than river.

Table 40. Smolting age of bull trout from Kootenai River (pre-1972) and Lake Koocanusa (1972-1978 and 1979-1982).

	Percent by Time Period		
Smolting age	Pre-1972	1972-1978	1979-1982
Two year old	44	63	57
Three year old	56	37	43
Total Fish	89	189	44

Table 39. Average annual growth of two and three year old smolting bull trout from Kootenai River and Lake Koocanusa for growth years of 1969-1971 (pre-impoundment), 1972-1978 and 1979-1982 (post-impoundment). A growth year was from April through May of the following year.

		Yearly Increment (Inc) and Length at Annulus in Millimeters											
Smolt age	Time period	Inc	Annulus I	Inc	Annulus II	Inc	Annulus III	Inc	Annulus IV	Inc	Annulus V	Inc	Annulus VI
Two years	1969-71	59	59(39)*	64	123(39)	84	207(7)	93	300(7)	---	---	---	---
	1972-78	60	60(120)	66	126(120)	114	240(120)	95	335(55)	82	417(12)	84	501(4)
	1979-82	59	59(25)	67	126(25)	126	252(56)	95	347(31)	91	438(18)	96	534(3)
Three years	1969-71	53	53(50)	49	102(50)	59	161(50)	---	---	---	---	---	---
	1972-78	53	53(69)	51	104(69)	58	162(69)	110	272(97)	101	373(40)	85	458(9)
	1979-82	53	53(19)	56	109(19)	73	182(19)	104	286(25)	102	388(16)	109	497(3)

* Number in parentheses is size of sample.

Mountain Whitefish

Mountain whitefish fry do not rear in tributary streams but drift into Lake Koocanusa shortly after hatching. Average annual growth rates for mountain whitefish from Kootenai River and Lake Koocanusa are given in Table 41. The annual increment indicates that growth rates the first year of life were similar for whitefish in all time periods. Incremental growth the second year of life appeared to be slightly greater for whitefish in Lake Koocanusa than Kootenai River. Annual growth rates thereafter appeared to be greater for river fish than reservoir fish. Slower growth rates of the older whitefish in the reservoir is probably a result of a plankton diet compared to an insect diet of the river-living whitefish.

Growth rates by year class are listed in Appendix G.

Ling

Forty-seven ling captured during spring gill net sampling in 1980, 1981 and 1982 were aged using the otolith bone. Time of capture in May was considered to coincide with annulus formation so total length at capture was considered length at the last annulus. These data are presented in Table 42. Ling in Lake Koocanusa had a rapid growth rate when compared to other Montana waters where they averaged 356 mm at age IV (Brown 1971).

Table 42. Average length at capture of 1975-1980 ling year classes collected from Lake Koocanusa in May 1980-82. Number of fish aged is given in parentheses.

Age class	Average length in mm at age group				
	II	III	IV	V	VI
1975	---	---	---	516(12)	569(1)
1976	---	---	500(11)	541(8)	564(4)
1977	---	---	500(4)	503(5)	---
1978	---	354(1)	406(3)	---	---
1979	---	345(3)	---	---	---
1980	294(2)	---	---	---	---
Combined	294(2)	348(4)	485(18)	521(18)	566(5)

Kokanee

Growth rates of kokanee collected in fall 1982 during spawning are shown in Table 43. All these fish were from the 1980 year class accidentally released into the reservoir from the Kootenay Trout Hatchery in British Columbia. Kokanee cease growth when sexual maturity is reached and die after spawning; therefore, length shown at annulus II+ was maximum attained. Growth rates of kokanee are thought to be governed by fish densities and length of kokanee at spawning in fall 1982 varied from 200 mm in Ashley and Tally lakes, Montana to 432 mm in Lake Koocanusa. Growth

Table 41. Average annual growth of mountain whitefish from Kootenai River and Lake Koocanusa for growth years of 1965-1971 (pre-impoundment), 1972-1978 and 1979-1981 (post-impoundment). A growth year was from April through May of the following year.

Time period	Yearly Increment (Inc) and Length at Annulus in Millimeters											
	Inc	Annulus I	Inc	Annulus II	Inc	Annulus III	Inc	Annulus IV	Inc	Annulus V	Inc	Annulus VI
1965-71	122	122(186)*	91	213(93)	54	267(41)	34	301(17)	67	368(2)	13	381(2)
1972-78	124	124(310)	105	229(339)	42	271(282)	31	302(164)	25	327(50)	22	349(5)
1979-82	120	120(34)	105	225(94)	48	273(103)	29	302(50)	21	323(27)	30	353(5)

* Number in parentheses is size of sample.

rates of kokanee in Lake Koocanusa should decline when fish densities increase.

Table 43. Growth of 1980 kokanee year class in Lake Koocanusa.

Year class	Sex	Average length in mm at annulus I	II	III
1980	Male	--	355(51)	447(51)
1980	Female	--	342(66)	423(66)
1980	Male & Female	--	346(117)	432(117)

RAINBOW AND CUTTHROAT TROUT VERTICAL AND LONGITUDINAL DISTRIBUTION AND FOOD HABITS

Distribution and food habits of rainbow and cutthroat trout in Lake Koocanusa were the subject of a special project in 1975 through 1978. A Master's of Science degree thesis entitled "The Food Habits and Distribution of Rainbow and Cutthroat Trout in Lake Koocanusa, Montana", University of Idaho, Moscow, Idaho, December 1979 by Steve L. McMullin discusses the findings of these studies in detail. The abstract of this Master's Thesis is given here as a brief resume of findings. Interested readers may obtain a copy of McMullin's thesis by writing College of Forestry, wildlife and Range Sciences, University of Idaho, Moscow, Idaho 83843.

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

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

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

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

ANGLER HARVEST AND MOVEMENT OF TAGGED ADULT FISH

Cutthroat trout, rainbow trout and their hybrids were tagged with numbered tags as they entered or left Young Creek in 1977, 1979 and 1980, Tobacco River in 1979 and Big Creek in 1980. Angler return of tags from fish they caught provided some information on harvest rates of adult fish, location and time of harvest. Data given in Table 44 list catch by area and total number of tags returned. Total return should be considered a minimum estimate of total harvest since it must be assumed that an unknown portion of anglers did not return tags.

Total tag return was highest for hybrids from Big Creek and most were caught from Lake Koocanusa. Total return of rainbow and cutthroat from Big Creek, where most fish were tagged prior to spawning, was similar between the two species. Rainbow and cutthroat trout entered Big Creek at the same time for spawning, and catch when the fish were in the creek was similar; 3.3 percent total tag return for rainbow and 3.8 percent for cutthroat trout. Catch of cutthroat and rainbow trout after they left Big Creek was also similar; 6.6 percent for rainbow trout and 6.8 percent for cutthroat trout. One cutthroat tagged in Big Creek was caught from Kootenai River below Libby Dam.

Catch of cutthroat trout was greater than rainbow trout tagged in Tobacco River with the difference occurring in Tobacco River and not the reservoir. Greater harvest of cutthroat in Tobacco River was due to opening of stream angling season about the time cutthroat trout started entering the drainage for spawning. Rainbow trout entered the drainage for spawning about five weeks before angling was legal and spent fish were starting to return to the reservoir when stream angling was allowed. One rainbow trout tagged in Tobacco River April 30, 1979 at a length of 439 mm was caught by an angler near Balfor, British Columbia in July 1980. This fish had moved out of Lake Koocanusa, down the Kootenai River and almost through Kootenay Lake, British Columbia, a distance of about 350 km.

Angler harvest of cutthroat trout from Young Creek was greatest in 1977 when fish were tagged entering the creek for spawning. Of the total return of 62 tags, 32 were from fish caught during spawning. Peak of upstream spawning movement in Young Creek generally occurs within days of opening of Montana's stream fishing season, the third Saturday of May. Angler harvest of cutthroat from Lake Koocanusa and other areas (including

Table 44. Angler return of tags from adult fish tagged in Big Creek, Young Creek and Tobacco River as they entered stream for spawning or returned to Lake Koocanusa after spawning.

Stream and species	Year tagged	Spawn stage	Number tagged	Number Returned by Area				Total	
				From stream	Lake Koocanusa	Below Libby Dam	Unknown	No.	Percent
Tobacco River	1979								
Rainbow trout		Pre	469	17	24	1	7	49	10.4
Cutthroat trout		Pre	148	23	4	0	1	28	18.9
Big Creek	1980								
Rainbow trout		Pre	91	3	6	0	0	9	9.9
Cutthroat trout		Pre	601	23	37	1	3	64	10.6
Hybrids		Pre	78	5	19	0	0	24	30.8
Young Creek									
Cutthroat trout	1977	Pre	663	32	22	6	2	62	9.4
	1979	Post	225		17	0	3	20	8.9
	1980	Post	234		18	0	2	20	8.5

unknown) appeared to be greater in 1979 and 1980 than in 1977. Percent of angler harvest of total fish tagged in 1979 and 1980 from Lake Koocanusa and other areas was 8.7 percent compared to only 4.6 percent in 1977. Six adult cutthroat tagged in Young Creek in 1977 were caught from Kootenai River below Libby Dam, while no fish in 1979 or 1980 were caught below Libby Dam.

Return of tags indicated that adult cutthroat trout are harvested about equally from their spawning stream and from Lake Koocanusa. Rainbow trout and hybrids are more frequently caught in the reservoir. Catch of spawning cutthroat may be a detriment to maximizing tributary smolt production and population levels in Lake Koocanusa proper. It appears there are different harvest rates between species and streams. Hybrid rainbow-cutthroat trout were caught at a markedly higher rate than either cutthroat or rainbow. Childers and Bennett (1967) reported that hybrids are often more aggressive and easier to catch than their parent species. Cutthroat trout were caught more frequently than rainbow trout but the different catch rate occurred in the spawning stream. Catch of rainbow and cutthroat trout from Tobacco River was slightly higher than either Big or Young Creek. Fishing pressure in Tobacco River and around its mouth is probably greater than either Big Creek or Young Creek.

The month in which rainbow and cutthroat trout tagged in Big Creek and tobacco River were caught is shown in Table 45. Angler harvest of fish in the months of May and June was mostly from the stream, while catch in other months was from the reservoir. These data show that slightly more cutthroat were caught than rainbow trout both in the reservoir and in tributary streams. Fifty-seven percent of the tagged fish were cutthroat, while 63 percent of the tag returns were from cutthroat. Cutthroat were caught in 11 months of the year, while rainbow were caught only nine months during the year.

Location of angler harvest of tagged fish from Tobacco River, Big and Young Creek in Lake Koocanusa is shown in Figure 12. Cutthroat tagged in Young Creek showed a definite tendency to move downstream as only 18 tagged fish were caught in the reservoir north of Young Creek, while 96 were caught south of Young Creek. Another 32 cutthroat from Young Creek were caught in Kootenai River below Libby Dam. Most of this escapement out of Lake Koocanusa occurred prior to operation of the selective withdrawal system. Some Young Creek cutthroat did stray into other reservoir tributaries for spawning as seven tagged adults were caught in Elk River and one in Gold Creek.

Only five cutthroat tagged in Tobacco River were caught in Lake Koocanusa. Four of these returns were from south of Tobacco River, while one was from the British Columbia portion of the reservoir. No Tobacco River cutthroat were returned from other reservoir tributaries. Cutthroat tagged in Big Creek appeared to move downstream in the reservoir as 30 were caught south of Big Creek and seven north of Big Creek. Four of these seven fish were caught in the British Columbia portion of the reservoir. One cutthroat from Big Creek was caught in Kootenai River below Libby Dam and none were caught from other reservoir tributaries.

Table 45. Month in which rainbow and cutthroat trout tagged in Tobacco River in 1979 and Big Creek in 1980 were caught by anglers.

Species	Number tagged	Percent	Number of Fish Caught by Month												Total	
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	No	%
Rainbow trout	560	43	0	0	1	1	7	18	13	4	4	4	1	0	53	37
Cutthroat trout	749	57	2	5	3	1	21	24	14	5	10	5	1	0	91	63

* Total tags here do not agree with totals in Table 44 since not all fishermen recorded date fish caught.

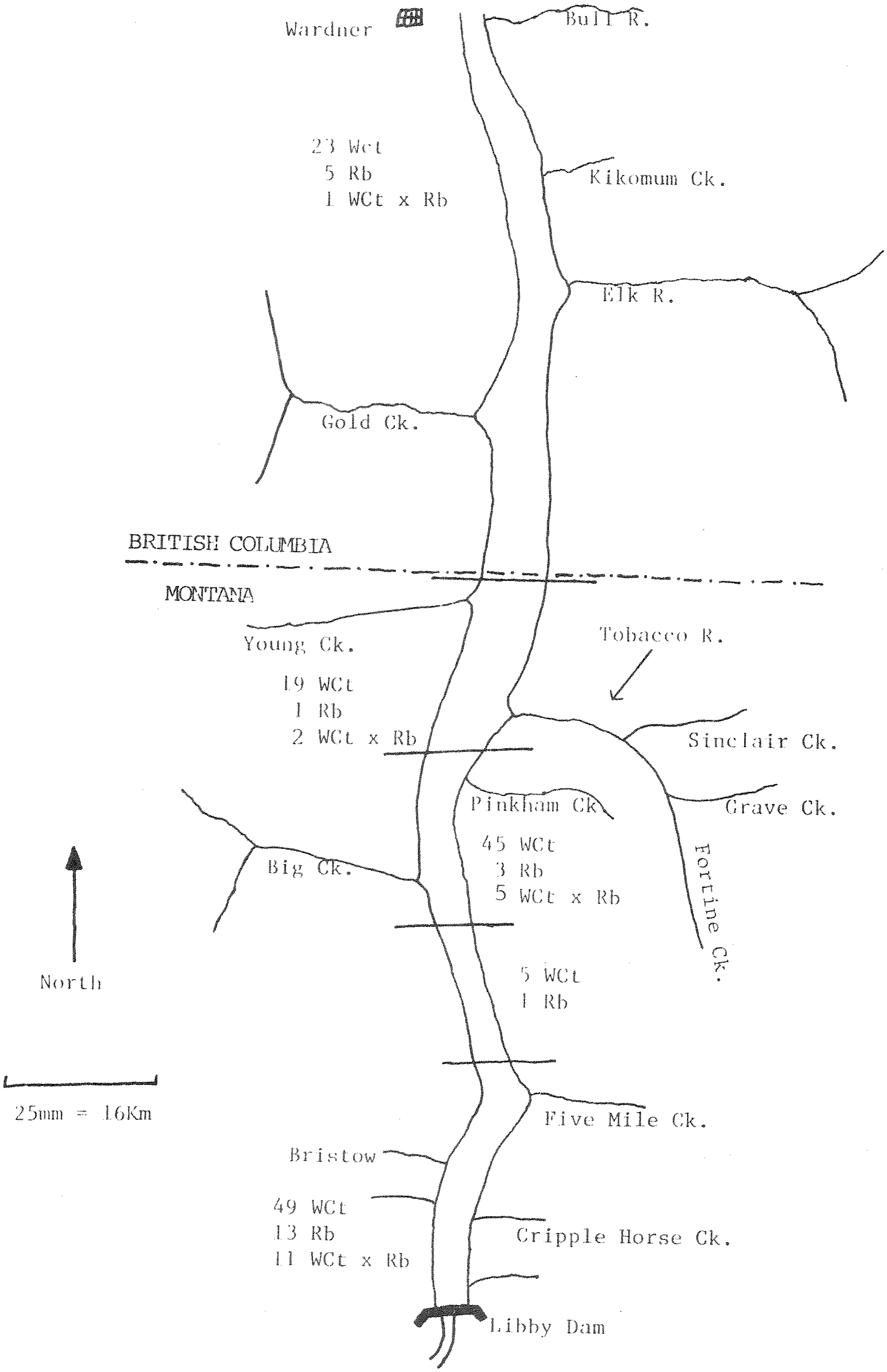


Figure 12. Location of tag returns in Lake Koocanusa of fish tagged in Young and Big creeks and Tobacco River.

Six rainbow trout tagged in Tobacco River were caught north of Tobacco River including 5 from the British Columbia portion of the reservoir. Two tagged rainbow from Tobacco River were also caught in Elk River during the following spawning season indicating some straying of spawning fish. Sixteen rainbow trout tagged in Tobacco River were caught south of Tobacco River in the reservoir but no fish were caught in other tributaries. One rainbow tagged in Tobacco River was caught in Kootenay Lake, British Columbia, about 350 km downstream from where it was tagged. Rainbow cutthroat hybrids tagged in Big Creek also had a tendency to move downstream in the reservoir. Sixteen tags were returned from fish caught south of Big Creek while only three were caught north of Big Creek. One of these three fish was caught in the British Columbia portion of the reservoir.

Angler return of tagged fish was thought to represent fish movements more than angler concentrations. The area between the Montana British Columbia border down to Pinkham Creek is one of the most heavily fished areas of Lake Koocanusa while the next two areas downstream from Pinkham Creek are probably the least fished areas of the Montana portion of the reservoir. The area from above Five Mile Creek to Libby Dam may be the most heavily fished area of the entire reservoir.

CREEL CENSUS

Estimated angler use of the Montana portion of Lake Koocanusa increased from 18,567 man-days in May 1, 1975 through April 30, 1976 to 45,379 man-days in May 1, 1982 through April 30, 1983. Reasons for this marked increase in angling pressure include improved and expanded recreational facilities around the reservoir, four boat ramps useable to about 100 feet of drawdown, good possibilities of catching rainbow and cutthroat trout and availability of fair numbers of large kokanee.

Creel census data from the fall of 1975, spring and summer of 1978 and spring, summer, and fall of 1976, 1977 and 1981 are shown in Table 46 and 47. A total of 84 anglers were contacted in the fall of 1975, 391 in 1976, 598 in 1977, 429 in 1978, and 1,680 anglers were contacted in the 1981 creel census.

The catch rates of trout in Lake Koocanusa have ranged from a high of .53 fish per hour in the fall of 1975 to .25 fish per hour during the spring and summer periods of 1981 (Table 46). Spring catch rates show a gradual decline from a high of .43 fish per hour in 1976 to .25 in 1981. Gill net catch data shows an increase in cutthroat and rainbow trout per net until 1978. Catch rates were higher during periods of drawdown. This would be expected as higher drawdowns concentrate fish in a smaller volume of water.

Catch rates in the spring and summer of 1976 (.43 and .39) were higher than in the same periods in 1977-1981. Catch rates were lowest in the summer period and have ranged from a high of .39 fish per hour in 1976 to a low of .25 fish per hour in 1981. These lowered summer catch rates were probably influenced by warm surface water temperatures in late summer. Fish inhabiting deeper water are relatively more difficult to catch. Catch rates increased slightly in the fall over summer rates in all years probab-

Table 46. Angler catch of rainbow trout (RB), westslope cutthroat trout (WCT), bull trout (DV) and kokanee (KOK) from the lower 30 miles of Lake Koocanusa, 1975-1978, and lower 48 miles (US portion) in 1981.

Period	anglers	Percent successful anglers	CPMH Trout	CPMH Salmon	Number caught RB	Number caught WCT	Number caught DV	Number caught KOK
1975								
Fall	84	79	0.53	--	85(53)	75(46)	2(1)	---
1976								
Spring	264	71	0.43	--	158(30)	319(62)	40(8)	---
Summer	77	58	0.39	--	24(19)	100(79)	2(2)	---
Fall	50	70	0.40	--	41(43)	50(52)	5(5)	---
Year-1976	391	68	0.42	--	223(30)	469(63)	47(7)	
1977								
Spring	379	60	0.31	--	280(51)	260(47)	9(2)	---
Summer	145	52	0.28	--	92(47)	105(53)	0(0)	---
Fall	74	64	0.42	--	51(44)	65(56)	0(0)	---
Year-1977	598	59	0.31	--	423(49)	430(50)	9(1)	---
1978								
Spring	349	62	0.34	--	329(59)	216(39)	15(2)	---
Summer	80	61	0.33	--	47(37)	71(56)	5(7)	---
Year-1978	429	62	0.34	--	356(56)	287(43)	20(1)	
1981								
Spring	699	54	0.25	<.01	591(67)	238(27)	45(5)	4(1)
Summer	771	49	0.25	.03	469(58)	248(31)	3(<1)	87(11)
Fall	210	81	0.29	.18	210(34)	168(27)	1(<1)	245(14)
Year-1981	1,680	56	0.26	.04	1,270(55)	654(28)	63(3)	336(14)

ly due to cooling of the surface water. The highest fall trout catch rate was recorded in 1975 at .53 fish per hour, whereas the low of .26 occurred in 1981.

Overall, catch rates in Lake Koocanusa have declined slightly from 1976 to 1981. Catch rates for the 1981 creel census were influenced by the appearance of kokanee in Lake Koocanusa (Table 47). A strong 1980 year class of salmon entered the catch in the summer of 1981 and catch rates increased in the fall to a high of .18 salmon per hour resulting in a total catch rate for the reservoir of .47 fish per hour.

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 similar to those recorded by Vincent (1975) for Hebgen Reservoir on the Madison River but slightly lower than those reported by Stone and Eiserman (1979) for Flaming Gorge Reservoir on the Green River. The fishery in Lake Koocanusa, however, is based primarily on wild rainbow and wild and hatchery cutthroat trout, whereas the fishery in Flaming Gorge, Hebgen and the Snake River reservoirs were based primarily on hatchery-reared rainbow trout.

The percent of successful anglers from 1975 to 1981 is shown in Table 46. With the exception of the fall of 1981, percent successful anglers has changed little between the three seasons within each year. Success drops slightly in the summer season as do catch rates. The high value of 81 percent in the fall of 1981 can be attributed to the entrance of kokanee salmon in the catch. Overall, percent success has declined from a high of 68 percent in 1976 to 56 percent in 1981.

The species composition of the angler catch has varied considerably from 1976-1981. Cutthroat trout comprised 63 percent of the catch in 1976, while making up only 28 percent of the catch in 1981. In contrast, rainbow trout made up 30 percent of the catch in 1975, compared to 56 percent in 1978 and 55 percent in 1981. These changes in species composition of fish in the anglers creel were in accord with changes in species composition of the fall netting data. Rainbow trout comprised 59 percent of the trout net catch in 1976 with cutthroat trout making up the remaining 41 percent. In 1980, rainbow trout made up 81 percent of the trout net catch while cutthroat trout comprised only 19 percent. Kokanee salmon entered the catch in the 1981 creel census and made up 11 percent of the summer catch. Salmon recorded the highest catch of all species in the fall with 39 percent and made up 14 percent of the total catch for the year. Kokanee also appeared in the fall netting series comprising four percent of the gamefish catch per net in 1981 and increased to 66 percent of the gamefish catch per net in the 1982 netting series.

Bull trout are caught incidentally while fishing for cutthroat and rainbow trout. Catches of bull trout have remained low throughout the years of creel census (Table 46). The highest catch was recorded in 1976 with seven percent of the catch declining to one percent in 1977 and 1978. Sixty-three bull trout were checked in 1981 making up three percent of the catch. Bull trout net catches in the spring netting series have also remained low varying between 0.8 and 2.2 fish per net.

Table 47. Summary of contact creel census conducted on Lake Koocanusa from April 10, 1981 through October 11, 1981.

Month	Number anglers	Percent successful	Hours fishing	CPMH[1/]		Number caught (percent) and average length (mm)							
						RB		WCT		DV		KOK	
				Trout	Salmon	No.	$\bar{x}$	No.	$\bar{x}$	No.	$\bar{x}$	No.	$\bar{x}$
Apr	337	50	1,679.25	0.28	--	346(74)	351	115(24)	356	7(2)	378	2(.5)	269
May	362	58	1,847.50	0.22	--	245(60)	353	123(30)	335	38(9)	366	2(1)	---
Jun	231	46	939.75	0.27	--	169(67)	348	70(28)	340	14(5)	384	1(.5)	---
Jul	389	53	1,394.00	0.27	0.04	233(53)	361	142(33)	351	3(1)	376	57(13)	269
Aug	151	42	574.25	0.18	0.05	67(51)	353	36(27)	297	---	---	29(22)	279
Sep	197	80	1,114.50	0.27	0.17	186(37)	302	119(24)	307	---	---	195(39)	287
Oct	46	85	210.50	0.35	0.24	24(19)	345	49(40)	343	1(7)	---	50(40)	287
Total	1713	56	7,759.75	0.26	0.04	1270(55)	351	654(28)	335	63(3)	373	336(14)	282

1/ CPMH is the abbreviation for catch per man hour of effort.

Rainbow-cutthroat hybrids were also detected in the 1981 creel census. Due to inconsistencies between creel clerks in identifying hybrids, hybrids were classified as either rainbow or cutthroat trout based upon dominance of morphological characteristics. Hybrids encountered in Lake Koocanusa typically show more rainbow than cutthroat trout characteristics. Other game species occasionally creeled include burbot and mountain whitefish. Burbot are caught primarily in the northern portion of the reservoir during the winter and spring periods. Angling for burbot occurs primarily from shore during the night.

The average size of rainbow trout, cutthroat trout, bull trout and kokanee salmon caught from 1976-1978 and 1981 are shown in Table 48. The average size of rainbow trout caught in 1976 was 371 mm in total length as compared to 351 mm in 1978 and 1981. Average weight for rainbow has ranged from 490 grams in 1977 to 440 grams in 1981. The longest rainbow checked during creel census was 508 mm in 1976. Cutthroat trout also showed a decrease in average size from 376 mm in 1976 to 343 mm in 1978 and 335 mm in 1981. The average weight for cutthroat in 1976 was 531 grams as compared to 440 grams in 1981. A cutthroat 465 mm in total length was caught by an angler in 1977. Average size for bull trout has varied due in part to a small sample size. Bull trout averaged 445 mm in 1977 with a low average length of 320 mm in 1978. A 630 mm bull trout weighing 2.2 kilograms was caught in the spring of 1981. Kokanee checked in the 1981 creel census averaged 282 mm in length and weighed an average of 263 grams. The same year class of kokanee caught in the fall netting series in 1982 averaged 434 mm and weighed 815 grams.

Table 48. Average length (mm) and weight (grams) of rainbow trout (RB), westslope cutthroat trout (WCT), bull trout (DV) and kokanee salmon (KOK) harvested by anglers from Lake Koocanusa, 1976-78 and 1981.

	RB		WCT		DV		KOK	
Year	Length	Weight	Length	Weight	Length	Weight	Length	Weight
1976	371	---	376	---	358	---	---	---
1977	358	490	356	531	445	---	---	---
1978	351	485	343	395	320	222	---	---
1981	351	440	335	440	373	535	282	263

Fishing methods used by anglers varied from season to season. Lure fishing predominated during the three seasons with 57 to 96 percent of anglers using lures (Tables 49 and 50). Percent of anglers using lures increased in the fall of 1977 and 1981. Natural bait was the second most popular method with 1 to 30 percent of the anglers using bait. Bait fishing was highest in spring and summer months. The highest use of bait was recorded during the spring and summer of 1978, with 23 and 30 percent, respectively. The lowest use of natural bait occurred both in the fall of 1977 with eight percent and the fall of 1981 with only one percent use.

Table 49. Fishing method and residency of anglers contacted during the creel survey conducted on Lake Koocanusa in 1976, 1977, 1978 and 1981.

Season	Year	Percent anglers fishing with				% anglers fishing from		Percent of anglers		
		Natural	Lures	Flies	Combination	Shore	Boat	Local resident	Non-local resident	Non-resident
Spring	1976	--	--	--	--	41	59	96	1	3
Summer	1976	--	--	--	--	64	36	85	5	10
Fall	1976	--	--	--	--	32	68	100	0	0
Total	1976	--	--	--	--	44	56	94	2	4
Spring	1977	21	69	1	9	33	67	88	7	5
Summer	1977	21	68	0	11	27	73	90	6	4
Fall	1977	8	92	0	0	72	28	65	4	31
Total	1977	19	72	<1	9	36	64	86	6	8
Spring	1978	23	74	2	1	34	66	84	2	14
Summer	1978	30	57	4	9	32	68	95	0	5
Total	1978	24	70	3	3	33	67	86	2	12
Spring	1981	18	69	0	13	25	75	40	36	24
Summer	1981	6	88	<1	6	10	90	25	24	51
Fall	1981	1	96	0	3	2	98	27	19	54
Total	1981	11	81	<1	8	15	85	31	28	41

Table 50. Fishing method and residency of anglers contacted during the creel survey conducted on Lake Koocanusa, April 10 through October 11, 1981.

Month	Percent anglers fishing with				% anglers fishing from		Percent of anglers		
	Natural	Lures	Flies	Combination	Shore	Boat	Local resident	Non-local resident	Non-resident
Apr	91(27)	179(53)	---	67(20)	136(40)	201(60)	172(51)	106(31)	59(31)
May	36(10)	305(84)	---	21(6)	40(11)	322(89)	105(29)	145(40)	112(11)
Jun	3(1)	219(95)	---	9(4)	8(3)	233(97)	70(30)	28(12)	133(58)
Jul	43(11)	314(81)	1(<1)	31(8)	66(17)	323(83)	71(18)	112(29)	206(53)
Aug	2(1)	142(94)	---	7(5)	6(4)	145(96)	52(34)	42(28)	57(38)
Sep	1(1)	189(96)	---	7(4)	4(2)	193(98)	43(22)	36(18)	118(60)
Oct	2(4)	44(96)	---	---	2(4)	44(96)	22(48)	10(22)	14(30)
Total	178(11)	1392(81)	1(<1)	142(8)	262(15)	1451(85)	535(31)	479(28)	699(41)

Combination and flies followed in importance varying from 0 to 13 percent and 0 to four percent use, respectively. On an annual basis, the fishing methods followed closely that of season use. In order of importance in all three years were lures, natural bait, combination and flies.

Most anglers fished from boats in all seasons with the exception of the summer of 1976 and the fall of 1977 when angling from shore recorded the highest use. Overall, boat angling was the dominate method in all four years ranging from 56 percent in 1976 to 85 percent in 1981. Shore angling was highest in 1976 with 44 percent and lowest in 1981 with only 15 percent use. The creel census conducted in 1981 was biased toward boats as angler contacts were made primarily at three boat ramps.

Residency of anglers fishing Lake Koocanusa has changed considerably since the 1978 creel census (Table 49). From 1976 to 1978, local residents made up 95 to 86 percent of the anglers. In the same period, non-local residents comprised two to six percent, while non-residents varied from four to 12 percent. In 1981, local residents declined to 31 percent of the anglers while non-local residents and non-residents increased to 28 and 41 percent, respectively. Possible factors affecting this increase in non-local and non-resident use were good consistent catch rates, low density of anglers, appearance of kokanee salmon, completion of campground facilities and improvement of boat launch sites.

RECREATIONAL SURVEY

The average number of vehicles, vehicle campers, tents and boats counted by month for Cripple Horse, Peck Gulch and Rexford facilities are given in Table 51. Cripple Horse area received slightly higher use in all four categories with the Rexford area receiving the second most use. The Cripple Horse recreation area (approximately 37 km from the town of Libby), includes the only commercial marina on Lake Koocanusa. Peck Gulch near Big Creek, the site located farthest from any population center, received the lowest use.

As would be expected, weekend use was higher than weekday use. The months of June, July and August recorded higher use for each area with the exception of Peck Gulch as it was closed during a portion of those months.

The U.S. Forest Service estimated a total of 5,500 RVD's (Recreation Visitor Day) for the Peck Gulch boat ramp for the period of May 15 to October 15,1981. Separate estimates were made at the Rexford facilities with the boat ramp receiving 5,800 RVD's, beach receiving 1,600, day use area receiving 200 and the campground receiving 11,200 RVD's. No estimates of RVD's were made for the Cripple Horse and McGillvery recreation areas.

ORIGIN OF RAINBOW STOCKS

The origin of rainbow stocks in Lake Koocanusa has been the source of speculation by fisheries workers in British Columbia, Montana and Idaho. Electrophoresis tests have been conducted on rainbow trout netted from Lake Koocanusa in June 1979 (Phelps 1980), five rainbow trout stocks taken from the Kootenay Trout Hatchery at Wardner, B.C. in March, 1980 (Phelps and

Table 51. Average daily use by month at Cripple Horse, Peck Gulch and Rexford campgrounds and boat ramps, Lake Koocanusa, May through October, 1981.

Month	Average number of							
	Vehicle		Vehicle campers		Tents		Boats	
	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday
	Cripple Horse							
May	7.0(2)	2.5(2)	10.3(4)	3.8(5)	2.7(4)	1.0(5)	2.7(3)	1.3(4)
Jun	16.2(6)	8.9(8)	15.5(6)	12.0(8)	0.2(6)	0.0(8)	10.2(6)	8.6(8)
Jul	19.2(6)	11.0(9)	21.2(6)	17.1(9)	3.7(6)	2.4(9)	20.3(6)	16.4(9)
Aug	15.3(6)	---	15.3(6)	---	2.5(6)	---	15.5(6)	---
Sep	11.6(5)	---	14.8(5)	---	0.6(5)	---	13.0(5)	---
Oct	2.0(2)	---	3.5(2)	---	0.0(2)	---	1.5(2)	---
YEAR	14.1(27)	9.2(19)	13.9(29)	11.7(22)	1.8(29)	1.2(22)	12.6(28)	10.6(21)
	Peck Gulch							
May	7.5(2)	5.0(2)	9.3(8)	4.3(8)	1.5(2)	0.0(2)	5.7(6)	1.5(6)
Jun	2.0(2)	1.5(2)	1.5(2)	1.5(2)	0.0(2)	0.0(2)	2.0(2)	1.5(2)
Jul	0.5(2)	1.0(3)	4.5(2)	1.3(3)	0.0(2)	0.0(3)	2.0(2)	0.7(3)
Aug	8.7(7)	---	8.4(7)	---	0.3(7)	---	2.4(7)	---
Sep	4.8(6)	---	13.0(6)	---	0.0(6)	---	5.2(6)	---
Oct	4.0(2)	---	1.5(2)	---	0.0(2)	---	4.5(2)	---
YEAR	5.6(2)	2.3(7)	8.4(27)	3.2(13)	0.2(21)	0.0(7)	4.0(25)	1.3(11)
	Rexford							
May	20.0(2)	11.0(2)	12.8(5)	6.2(6)	0.4(5)	0.2(6)	2.7(3)	4.7(3)
Jun	9.3(7)	5.8(6)	12.4(7)	8.2(6)	0.9(7)	0.5(6)	3.4(7)	1.8(6)
Jul	24.5(8)	6.7(7)	15.3(8)	9.0(7)	1.5(8)	0.7(7)	5.6(8)	3.6(7)
Aug	14.4(5)	---	14.6(5)	---	1.0(5)	---	3.2(5)	---
Sep	7.0(6)	---	7.3(6)	---	1.0(6)	---	1.5(6)	---
Oct	0.0(2)	---	4.5(2)	---	0.0(2)	---	3.5(2)	---
YEAR	13.8(30)	6.9(15)	12.1(33)	7.8(19)	0.9(33)	0.5(19)	3.5(31)	3.1(16)

Allendorf 1980b), rainbow trout from the Tobacco River spawning run in spring, 1980, and rainbow trout from headwaters of Big Creek (Phelps and Allendorf 1981). The spawning run of rainbow into the Tobacco River came from Lake Koocanusa.

The results of the electrophoresis tests show that the rainbow trout collected from Lake Koocanusa were of coastal origin, but different from the present Jocko River Hatchery stock at six of eleven variable loci. The five stocks of rainbow from the Kootenay Trout Hatchery were very similar to each other in allelic composition and gene frequencies at variable loci. These stocks are an inland rainbow strain and quite different from the Lake Koocanusa and Jocko River stocks. The coastal strain of rainbow in L-ke Koocanusa is different from the inland strain in the Kootenay Trout Hatchery and coastal strain in Jocko River Hatchery. This indicates that the natural reproduction of progeny of a hatchery planted coastal type rainbow trout is the source of the current rainbow stock in Lake Koocanusa.

The rainbow trout spawning run into the Tobacco River was found to be most closely related to Lake Koocanusa stock, although it was different at three loci. The differences between Lake Koocanusa and Tobacco River fish may indicate the presence of multiple rainbow trout stocks in Lake Koocanusa which are genetically isolated spatially, temporally, or both. However, the overall similarity of the Tobacco River and Lake Koocanusa fish support the theory that natural reproduction of previous hatchery plantings of a coastal stock is the source of the rainbow trout population in Lake Koocanusa.

The rainbow trout from the West Branch of the South Fork of Big Creek were monomorphic at all loci examined except one. This lack of variation is extreme for a population of rainbow trout and was the least variable of any population examined. This low amount of genetic variation is indicative of rapid genetic drift. It was difficult to tell if this population was derived from a hatchery or a native population. By losing so much genetic variation, it has lost all characteristics of either the coastal (hatchery) or inland (native) variety of rainbow trout. The low genetic variation is much less than found in native populations of rainbow trout and this lack of genetic variation is most likely due to a recent founding event of this population from an introduced hatchery stock. A founding event is caused by a small number of parents starting the original population.

LAKE KOOCANUSA MANAGEMENT OBJECTIVES

Lake Koocanusa is currently producing a good fishery for rainbow trout, cutthroat trout and kokanee. A popular fishery for burbot also exists in the Rexford area during the winter-spring. Maintenance and, where feasible, improvement of these fisheries should be the long-term management objectives.

The rainbow trout population is maintained by natural reproduction in tributary streams and natural reproduction accounts for a large proportion of the cutthroat trout population. The spawning and rearing habitat for these species is a critical requirement which needs to be protected and enhanced. The Kootenai National Forest (KNF) is the primary landowner in the watersheds of tributaries to Lake Koocanusa. Close cooperation needs to be maintained between the Montana Department of Fish, Wildlife and Parks (MDFWP) and KNF to ensure that the protection of water quality, channel stability and fish habitat remains a high priority in the Forest Plan. Upstream fish passage should be maintained and enhanced, where possible, on the streams tributary to Lake Koocanusa.

The protection of water quality and channel stability on private lands is currently the responsibility of the Lincoln County Conservation District with assistance from MDFWP. Rigorous enforcement of the Natural Streambed and Land Preservation Act by these agencies is vital to protect critical spawning and nursery habitat in stream sections on private land.

Requests for water rights on important spawning and nursery streams have increased due to development of irrigated farm land and subdivisions. Establishment of instream flow reservations needs to be accomplished in order to protect the valuable spawning and nursery habitat in streams which have significant spawning runs of salmonids. The Kootenai National Forest funded a study in 1982 which collected data necessary to file for instream flows on Young Creek, Pinkham Creek, Tobacco River and Fortine Creek. An instream flow right has been requested for Young Creek by the MDFWP. The KNF is in the process of filing for instream flows on the other streams.

The decline in the rainbow and cutthroat trout populations from 1978 to 1982 indicates reduced recruitment from tributary streams and hatchery plants and/or reduced survival in the reservoir. Reduced survival of gamefish is common in reservoirs after the first few years after impoundment due to increased competition for food and space between gamefish and large populations of non-game fish. The spawning run data indicates that runs have declined in many streams. Additional spawning enhancement work may be necessary in these streams. Angler mortality may be an important factor in reducing cutthroat runs. The opening of the fishing season on the third Saturday in May usually occurs during the peak of the cutthroat run and latter part of the rainbow trout. Cutthroat trout are especially vulnerable to anglers during this period and tag return data indicates that the harvest of spawners can be substantial.

A change in the opening day of the stream fishing season to mid-June or later could be used to reduce the harvest of cutthroat and rainbow spawners. By this time, nearly all the spawning activity of rainbow and cutthroat would be completed. Effective 1 May 1984, bag limits in streams tributary to Lake Koocanusa was reduced from 10 fish to 5 fish.

Supplementing natural reproduction with annual plants of westslope cutthroat from Murray Springs Fish Hatchery should help maintain and increase levels of cutthroat trout in Lake Koocanusa. However, the current broodstock at Murray Springs has lost much of its genetic diversity, resulting in poor egg production, incubation success, disease problems and grossly deformed fins. The MDFWP is in the process of replacing the current broodstock with wild fish. Once this is achieved, wild fish should be introduced into the broodstock periodically to ensure that genetic diversity of the brood remains high.

The appearance of large numbers of kokanee in Lake Koocanusa in 1981 raised concerns over the potential for competition between this species and rainbow and cutthroat trout. Daphnia is the primary food of all trout in the winter in Lake Koocanusa and is utilized heavily year-round by fish under 330 mm in total length. Growth increments of rainbow and cutthroat trout in 1981 and 1982 did not show a decline from previous years, indicating that competition for food is not severe at present densities of kokanee. However, large increases in kokanee densities above present levels would probably result in intense competition for certain food resources in Lake Koocanusa between trout and salmon resulting in a decline in growth for the three species. Therefore, we recommend a management goal for kokanee of comparatively large size and low densities in Lake Koocanusa. The rapid growth and large size attained by the 1980 kokanee year class is what made the fishery so unique. There are plenty of lakes in the northwest that have kokanee populations, but few lakes where the fish average 432 mm after only three growing seasons. An average size of 400-450 mm in total length at maturity should be the management goal for kokanee in Lake Koocanusa.

The achievement of the above management goal will entail control over escapement of kokanee in their important spawning streams in the Montana and British Columbia portions of Lake Koocanusa. Presently, the two major streams are Kikomun and Norbury creeks in British Columbia. These are spring fed streams in which escapement could be easily controlled through the use of inexpensive fish traps. Management of the kokanee reproduction in these streams would require an agreement on management goals for kokanee in Lake Koocanusa between the fishery agencies of British Columbia and Montana, and a cooperative project to achieve these goals.

The failure to limit reproduction of kokanee may result in high densities but small size of this species and reduced growth and survival of cutthroat and rainbow trout. If this occurs, the introduction of a large predator such as gerard stock of rainbow trout, or some Pacific salmon, should be considered.

Reservoir operation has a large influence on the limnology of Lake Koocanusa and eventually fish survival and growth. Large annual drawdown plays an important role in limiting primary productivity of the reservoir by reducing the area of the photic zone and releasing warm water which increases the tendency towards weak thermal stratification. Corps of Engineers should maintain Lake Koocanusa as near full pool as possible at all times of the year.

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Appendix A. Reservoir elevations, water temperatures and secchi disc readings for Lake Koocanusa trend gill net sampling.

Area	Date	Reservoir elevation (m)	Secchi disc (m)	Water temperature (°C) Surface	7.6m	15.3m
		Spring Netting				
Rexford	6/8/75	719.2	0.5	12.8	10.6	10.0
	5/18/76	722.8	---	12.2	10.0	8.9
	5/17/78	722.8	1.0	11.1	10.6	10.0
	5/6/80	729.6	0.8	11.1	10.0	8.3
	5/25/82	720.4	0.7	12.2	11.7	9.4
		Fall Netting				
Cripple Horse	9/30/75	748.5	5.8	16.1	15.6	15.6
	9/22/76	749.7	7.0	17.2	16.7	16.1
	9/19/78	749.7	7.6	15.0	15.0	13.9
	10/5/79	745.7	7.8	16.1	16.1	15.6
	9/30/80	749.1	8.7	15.6	14.8	14.1
	9/27/82	749.1	5.5	16.1	15.6	15.6
Rexford	9/24/75	748.5	5.0	15.6	15.0	15.0
	9/23/76	749.7	7.0	16.7	16.1	15.6
	9/21/78	749.4	5.7	15.6	15.6	15.6
	10/4/79	746.0	6.2	16.7	16.7	16.1
	10/2/80	748.8	7.2	15.1	15.0	14.9
	9/23/82	749.1	4.9	16.7	16.1	16.1
Bailey Bridge	9/28/76	749.4	9.1	16.7	16.1	12.2
	9/26/78	749.1	6.3	16.1	14.4	12.2
	10/2/79	746.3	7.0	16.7	16.1	15.6
	9/22/80	749.4	5.0	16.1	---	---

Appendix B. Average catch per floating net in Cripple Horse, Rexford and Bailey Bridge areas of Lake Koocanusa, 1975-1982. An asterisk indicates that the catch for that year was significantly different at .01 level of significance from the previous year.

Parameter	Year 1975	1976	1978	1979	1980	1982
Cripple Horse Area						
Number of nets	61	47	38	37	40	35
Fish caught						
RB	2.5	3.7*	6.2*	4.2*	3.7	2.5
CT	2.5	3.2	1.6*	1.4	1.2	2.0
RBxCT	0.0	0.0	<.1	<.1	<.1	<.1
CRC	7.0	6.1	4.6	6.6	7.9	15.3
SQ	5.8	5.6	5.2	2.1	1.6	3.0
RSS	4.3	9.7*	11.8	1.4*	0.4	0.1
KOK	0.0	0.0	0.0	0.1	0.0	4.4*
Rexford Area						
Number of nets	68	44	40	36	39	35
Fish caught						
RB	3.0	3.5	6.4*	5.5	6.0	2.4*
CT	1.6	1.8	2.4	1.4	1.2	0.5
RBxCT	0.0	0.0	<.1	<.1	<.1	<.1
CRC	1.3	2.1	1.4	6.3*	9.9	14.9
SQ	2.7	3.7	3.1	2.3	2.0	4.0
RSS	2.4	6.0	3.0	2.3	0.6	0.3
KOK	0.0	0.0	0.0	0.2	0.0	9.7*
Bailey Bridge Area						
Number of nets	--	47	40	--	39	--
Fish caught						
RB		2.0	3.2*		3.6	
CT		1.5	1.7		0.8	
CRC		4.0	2.7		2.1	
SQ		6.9	4.0		3.0	
RSS		2.3	1.6		0.2	
KOK		0.0	0.0		0.3	

Appendix C. Average lengths (mm), weights (grams) and condition factors of rainbow trout (RB), westslope cutthroat (WCT), kokanee (KOK), peamouth chub (PM), and northern squawfish (NSQ) from the Cripple Horse, Rexford and Bailey Bridge areas of Lake Koocanusa fall netting series, 1975-1982.

Year	Species	Number	Average length	Average weight	Range in length	Condition factor
			Cripple Horse Area			
1975	WCT	159	343	463	152-427	1.06
1976		150	340	467	191-442	1.05
1978		62	307	340	191-422	1.04
1979		52	325	376	203-432	1.01
1980		48	331	395	173-455	0.99
1982		67	323	363	165-462	1.01
1975	RB	168	376	581	191-518	1.03
1976		178	391	649	191-513	1.03
1978		100	371	526	193-564	1.00
1979		154	368	508	198-483	0.96
1980		141	361	454	185-483	0.93
1982		84	384	535	180-460	0.94
1982	KOK	77	447	875	391-500	
1982		67	424	758	343-485	
1975	PM	82	208	82	173-241	0.90
1976		91	226	104	180-277	0.87
1978		114	218	100	170-282	0.89
1979		154	218	104	165-300	0.94
1980		195	211	91	173-310	0.89
1982		96	226	104	188-307	0.87
1975	NSQ	103	262	177	178-363	0.90
1976		88	290	245	157-414	0.91
1978		146	290	263	196-488	0.93
1979		68	292	249	173-445	0.93
1980		35	335	440	216-513	0.93
1982		64	272	254	185-523	0.85
			Rexford Area			
1975	WCT	114	338	440	206-442	1.07
1976		82	320	381	191-450	1.03
1978		96	328	404	193-429	1.06
1979		50	333	395	224-414	1.00
1980		43	333	395	170-475	1.01
1982		19	351	435	259-406	0.98

Appendix C. (Continued).

Year	Species	Number	Average length	Average weight	Range in length	Condition factor
			Rexford Area			
1975	RB	213	345	472	193-513	1.04
1976		153	361	526	216-587	1.02
1978		257	371	531	218-493	1.01
1979		172	361	481	208-483	0.95
1980		220	356	454	170-475	0.97
1982		86	366	485	155-437	0.94
1982	KOK-M	188	442	853	302-500	0.98
1982	F	168	427	767	348-490	0.97
1979	PM	84	224	109	165-300	1.03
1980		161	226	109	165-317	0.90
1982		126	239	122	185-312	0.83
1975	NSQ	87	290	245	175-424	0.93
1976		35	317	358	180-503	0.92
1978		40	356	481	251-495	0.96
1979		64	353	467	211-528	0.92
1980		32	356	508	213-503	0.93
1982		90	307	340	196-546	0.83
			Bailey Bridge Area			
1976	WCT	70	320	386	170-437	1.03
1978		66	282	277	201-432	1.10
1980		28	320	363	224-434	1.02
1976	RB	93	373	562	239-495	1.02
1978		134	394	644	241-488	1.03
1980		137	363	481	203-480	0.98
1976	PM	87	246	141	170-323	0.91
1978		108	257	159	196-315	0.91
1980		86	236	127	180-323	0.88
1976	NSQ	143	292	272	173-409	0.96
1978		152	338	386	216-508	0.96
1980		111	335	376	183-483	0.92

Appendix D. Growth of 1966-1980 rainbow trout year classes from Lake Koocanusa. Number of fish aged is in parentheses.

Year class	I	II	III	IV	V
		Migration Class X_0			
1971	115(5)	308(5)	379(5)	---	---
1972	116(21)	318(19)	468(2)	480(1)	---
1973	123(33)	334(7)	405(3)	---	---
1974	107(20)	302(18)	399(8)	457(4)	---
1975	113(23)	313(20)	397(10)	425(2)	---
1976	107(53)	320(38)	377(9)	379(2)	---
1977	116(62)	320(42)	377(16)	---	---
1978	102(38)	316(25)	328(3)	---	---
1979	109(49)	304(18)	380(6)	---	---
1980	112(10)	293(4)	---	---	---
		Migration Class X_1			
1966-69	85(8)	233(8)	305(6)	346(4)	498(3)
1971	90(14)	298(14)	382(14)	422(1)	---
1972	98(17)	323(17)	397(11)	436(2)	---
1973	91(84)	307(68)	408(20)	480(2)	---
1974	79(41)	278(39)	365(10)	405(2)	462(1)
1975	82(52)	296(39)	399(30)	415(11)	417(3)
1976	80(128)	295(90)	362(32)	393(7)	---
1977	82(74)	308(57)	373(28)	---	---
1978	77(94)	306(71)	368(21)	423(3)	---
1979	79(100)	312(68)	386(19)	---	---
1980	80(78)	310(59)	---	---	---
		Migration Class X_2			
1966-69	59(15)	105(15)	207(8)	264(5)	437(3)
1971	85(7)	149(7)	331(7)	---	---
1972	84(16)	154(16)	295(7)	372(1)	---
1973	83(25)	143(25)	330(7)	417(2)	483(1)
1974	84(18)	159(18)	319(14)	382(8)	396(1)
1975	81(62)	150(62)	314(41)	368(15)	385(2)
1976	78(45)	142(45)	333(18)	---	---
1977	78(51)	143(51)	328(26)	365(7)	---
1978	76(51)	139(51)	308(30)	377(8)	---
1979	71(35)	134(35)	323(17)	---	---

Appendix E. Growth by year class of wild westslope cutthroat trout, Lake Koocanusa and Kootenai River.

Year class	Length in mm at annulus				
	I	II	III	IV	V
			X_1 Migration Class		
1971	58(1)	185(1)	307(1)	---	---
1972	79(1)	198(1)	---	---	---
1973	76(1)	---	---	---	---
1974	---	---	---	---	---
1975	71(10)	196(6)	302(4)	---	---
1976	76(2)	185(2)	335(1)	---	---
1977	81(13)	246(7)	335(5)	---	---
1978	69(7)	274(3)	---	---	---
1979	76(5)	178(2)	305(2)	---	---
			X_2 Migration Class		
1969	46(1)	99(1)	178(1)	262(1)	325(1)
1970	61(4)	129(4)	234(4)	323(4)	---
1971	66(21)	129(21)	290(21)	353(5)	---
1972	66(23)	134(23)	317(8)	374(3)	---
1973	62(16)	122(16)	294(9)	333(2)	399(1)
1974	58(27)	119(27)	291(19)	359(7)	389(1)
1975	60(52)	118(52)	284(38)	346(16)	401(1)
1976	61(61)	117(61)	273(17)	343(12)	---
1977	57(43)	114(43)	303(24)	---	---
1978	60(22)	121(22)	278(6)	343(6)	---
1979	63(5)	127(5)	308(5)	---	---
1980	64(8)	134(8)	---	---	---
			X_3 Migration Class		
1969	58(1)	117(1)	173(1)	312(1)	358(1)
1970	50(8)	101(8)	150(8)	282(8)	368(1)
1971	58(18)	106(18)	161(18)	319(9)	401(1)
1972	53(9)	100(9)	152(9)	283(8)	347(4)
1973	51(13)	100(13)	161(13)	301(11)	358(4)
1974	52(15)	97(15)	143(15)	295(6)	342(3)
1975	53(16)	97(16)	150(16)	305(8)	382(3)
1976	51(8)	97(8)	158(8)	302(7)	---
1977	54(8)	102(8)	155(8)	290(3)	366(3)
1978	63(3)	109(3)	163(3)	328(3)	---
1979	48(1)	89(1)	147(1)	---	---

Appendix F. Growth of 1969-79 bull trout year classes from Lake Koocanusa. Number of fish aged is in parentheses.

Year class	Back-calculated length in mm at annulus I	II	III	IV	V	VI
	Migration Class X_2					
1969	54(7)	111(7)	202(7)	300(7)	---	---
1970	60(23)	128(23)	238(23)	339(2)	428(2)	---
1971	59(9)	118(9)	235(9)	332(9)	---	---
1972	56(37)	118(37)	223(37)	326(24)	422(4)	501(4)
1973	60(20)	124(20)	253(20)	334(6)	409(6)	---
1974	60(9)	127(9)	251(9)	362(9)	---	---
1975	68(18)	138(18)	266(18)	335(5)	436(5)	534(3)
1976	59(5)	123(5)	243(5)	340(5)	435(3)	---
1977	62(31)	132(31)	256(31)	350(20)	440(10)	---
1978	60(16)	129(16)	246(16)	342(6)	---	---
1979	56(9)	121(9)	248(9)	---	---	---
	Migration Class X_3					
1969	56(19)	104(19)	161(19)	253(19)	305(1)	420(1)
1970	52(10)	101(10)	153(10)	266(9)	357(9)	437(1)
1971	52(21)	100(21)	164(21)	271(21)	377(14)	467(7)
1972	51(25)	104(25)	159(25)	261(13)	---	---
1973	54(14)	105(14)	174(14)	294(14)	381(14)	---
1974	58(15)	109(15)	168(15)	288(15)	386(2)	472(2)
1975	50(7)	92(7)	146(7)	281(6)	369(6)	547(1)
1976	55(8)	104(8)	154(8)	269(8)	364(2)	---
1977	52(10)	113(10)	184(10)	304(10)	409(8)	---
1978	54(9)	105(9)	181(9)	281(7)	---	---

Appendix G. Growth of 1965-80 mountain whitefish year classes from Lake Koocanusa. Number of fish aged is given in parentheses.

Year class	Average length in mm at annulus					
	I	II	III	IV	V	VI
1965	103(13)	197(13)	261(13)	303(13)	---	---
1966	109(12)	226(12)	272(12)	---	---	---
1967	99(6)	208(6)	302(2)	333(2)	368(2)	381(2)
1968	123(6)	174(2)	218(2)	252(2)	279(2)	---
1969	122(12)	218(12)	271(12)	294(12)	318(6)	315(1)
1970	126(48)	215(48)	263(48)	287(35)	323(12)	---
1971	125(89)	225(89)	264(74)	294(44)	325(9)	---
1972	129(48)	234(48)	281(41)	314(27)	335(4)	358(4)
1973	123(45)	234(45)	269(44)	314(17)	336(17)	---
1974	128(27)	237(27)	288(24)	317(24)	---	---
1975	125(26)	228(26)	274(26)	314(5)	335(5)	353(5)
1976	119(65)	226(65)	270(25)	297(5)	319(17)	---
1977	125(39)	226(39)	269(35)	299(22)	327(5)	---
1978	121(60)	225(60)	275(49)	307(23)	---	---
1979	119(27)	225(27)	273(19)	---	---	---
1980	122(7)	221(7)	---	---	---	---