MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

IN COOPERATION WITH U.S. ARMY CORPS OF ENGINEERS

CONTRACT NO. DACW 67-79-C-0077

FISHERIES DIVISION

Annual Progress Report

April 16, 1979 to September 30, 1980

LAKE KOOCANUSA POST-IMPOUNDMENT FISHERY STUDY

Libby, Montana

By

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Reservoir Investigations Project

August 1, 1980

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Project Title: Lake Koocanusa Post-Impoundment Fisheries Study

Period Covered: April 6, 1979 through September 30, 1980

ABSTRACT

Spawning runs of rainbow and cutthroat trout ascending Tobacco River, Big Creek and Young Creek drainages were monitored. Estimates from mark and recapture data indicated that approximately 6,000 rainbow and 500 cutthroat spawned in the Tobacco River as compared to 2,000 cutthroat and 1,100 rainbow and rainbow x cutthroat hybrids in Big Creek. The cutthroat trout run ascending Young Creek (387 fish) was about 50 percent less than in 1977 and 1978. Factors influencing this run are presented. Rainbow trout were documented migrating up the Kootenai River as far upstream as Skookumchuck, which is 90 miles upstream from the British Columbia border.

Data from the 1979 fall and 1980 spring gill net series are presented. Net catches of rainbow and cutthroat trout in 1979 dropped from the previous year in all three areas samples. The differences were significant only in the Cripple Horse area for rainbow and for cutthroat in the Rexford area. Northern squawfish catch rates dropped in all three areas from the previous year. The bull trout and mountain whitefish catch rates from the spring series dropped markedly from previous years. It appeared that factors other than abundance were responsible for the reduced catch rates in 1980. The catch rate of ling increased markedly from the previous year, and a popular winter and spring fishery developed for this species in the Rexford area in 1980.

Movement patterns of cutthroat and rainbow trout were determined from return of tagged fish by anglers. Rainbow trout spawners tagged in the Tobacco River System dispersed throughout the reservoir area. Most cutthroat trout tagged in Young Creek were caught in the upper 50 miles of the reservoir, whereas nearly all cutthroat tagged in the Tobacco River were caught in the Tobacco River.

Information on the origin of rainbow stocks in Lake Koocanusa is presented. Origin of rainbow trout populations in the reservoir has not been determined and will be subject to additional testing. Information is also presented on depth distribution of game species in the forebay area, and initial results of mercury analysis of tissue from bull, rainbow and cutthroat trout.

BACKGROUND

Lake Koocanusa is the reservoir created by Libby Dam impounding the Kootenai River approximately 17 miles upstream from Libby, Montana in spring, 1972. Full pool elevation of 2459 feet MSL was not reached until 1974. May and et al. (1979) presented a detailed description of reservoir operation and morphometric data on Lake Koocanusa. Full pool elevation at 2459 feet MSL creates a reservoir 90 miles long (48 in Montana and 42 in British Columbia) with a surface area of 46,500 acres and a gross storage capacity of 5,809,000 acre feet. Predicted average annual drawdown of 120 vertical feet reduces the reservoir volume by 69 percent.

A selective withdrawal system which has the capability of drafting water from elevations 2287 to 2459 feet MSL has been operational since 1977. A temperature rule curve was developed by the Corps of Engineers and Montana Department of Fish, Wildlife and Parks to provide adequate temperatures for trout growth in the river below Libby Dam and minimize escapement of game fish from the reservoir.

New reservoirs generally provide excellent sport fishing for the first few years due to minimal competition and an abundance of food and space. Lake Koocanusa is still in this stage and is providing a good sport fishery for cutthroat trout, rainbow trout and bull trout. A good fishery for ling has also developed in the winter and spring the last two years according to anglers. The rainbow trout population is derived from natural reproduction and hatchery escapement; the ling and bull trout are derived from natural reproduction, whereas the cutthroat population has been maintained by large plants of hatchery fish from 1970-76 and natural reproduction.

OBJECTIVES

The specific objectives for the report period were to: 1) monitor spawning runs of cutthroat and rainbow trout into the Tobacco River System, Big and Young Creeks, 2) monitor population trends in Lake Koocanusa with fall and spring gill net series, 3) conduct depth distribution study of game fish in forebay area, 4) determine growth rates of game fish species, 5) determine origin of rainbow stocks in Lake Koocanusa, and 6) cooperate with Kootenai National Forest in maintaining fish habitat, water quality and fish passage in important spawning and nursery tributaries.

PROCEDURES

Fish Population Trend Sampling

Montana Standard experimental surface and bottom gill nets were used to determine fish population trends. These nets are 125 feet long and comprised of equal sections of 3/4-inch, 1-inch, 1 1/4-inch, 1 1/2-inch and 2-inch mesh bar measure. Catch was analyzed by species using the Kruskal-Wallis non-parametric ranking test advocated by Gooch (1975). Bottom gill nets were used to determine trends in abundance of benthic-oriented species. Target species in the Rexford area during the spring included mountain whitefish, bull trout, ling, largescale and longnose suckers. Sampling criteria were: 1) reservoir elevation between 2350 and 2375 feet MSL, 2) surface water temperatures of approximately 55°F, and 3) secchi disc readings 3.0 feet.

Surface gill nets were used to determine relative abundance of species inhabiting surface waters during the fall season. Target species for this sampling included rainbow trout, cutthroat trout, northern squawfish, peamouth, and redside shiners. The sampling was conducted in the fall when reservoir elevation was within five feet of full pool and surface water temperatures were near 60°F. The location of the Bailey Bridge, Rexford and Cripple Horse netting areas are shown in Figure 1.

Spawning runs of cutthroat trout and smolt emigration were monitored at the Young Creek fish trap. 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 standard box traps. Eleven traps were fished in the Tobacco River System in 1979 and six traps were fished in Big Creek in 1980.

Scale impressions were made on plastic strips and the images read with the aid of a Bausch and Lomb microprojector. A computer program (Hesse, 1977) was utilized to process age and growth data.

Determination of Vertical and Horizontal Fish Distribution

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

FINDINGS

Tributary Stream Surveys

Data collected from Big Creek for a trout habitat suitability

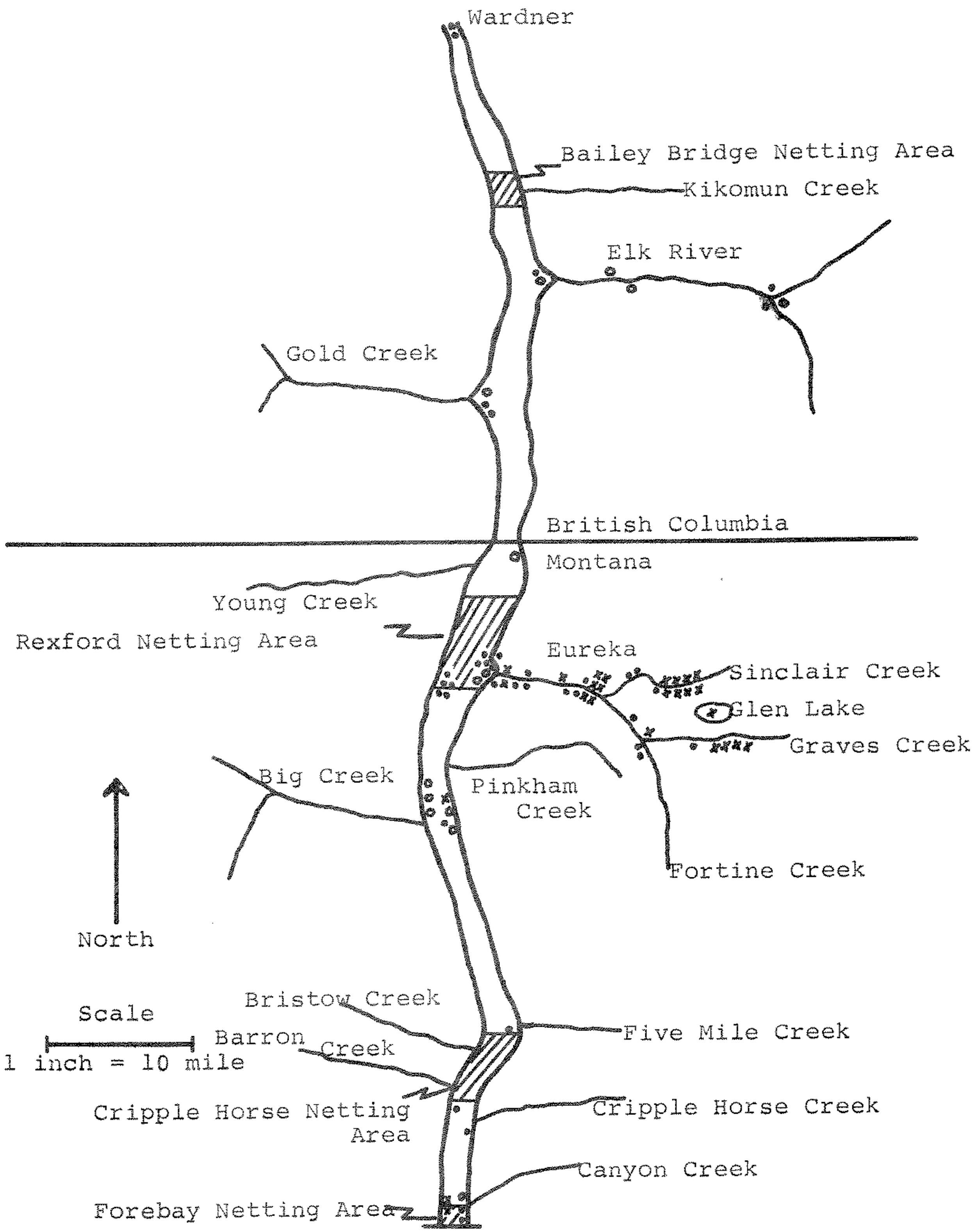

Figure 1. Angler tag return locations of cutthroat trout tagged in Young Creek (o) and Tobacco River system (x) and rainbow trout from Tobacco River system (.). These fish were tagged in 1979 and returned in 1979. Netting areas are also depicted.

study, funded by the Kootenai National Forest, are presented in Table 1. Classification of small trout was difficult and it appeared that hybridization between rainbow and cutthroat trout was common. The trout in Big Creek were tentatively classified as a rainbow x cutthroat complex.

The rubble, boulder substrate found in much of Big Creek is good habitat for the rearing of juvenile trout. The population estimates in the mainstem of Big Creek (677 trout per surface acre) and in the South Fork Big Creek (1,749 trout per surface acre) were quite high. It appears that Big Creek is capable of producing large numbers of juvenile smolts for Lake Koocanusa. This is in accord with a large spawning run of rainbow, cutthroat, and rainbow x cutthroat hybrids ascending Big Creek in 1980.

Table 1. Population estimates by length groups and approximate age classes for trout from Big Creek, August, 1979. The 80 percent confidence limits are given in parenthesis as percent of point estimate.

Length group	Assigned age	Average length in inches	Average weight in pounds	Estimates per surface acre: Number	Estimates per surface acre: Weight
Rainbow x Cutthroat Complex - Big Creek - T35N R30W S25					
3.0-4.4	1	3.8	.02	450	9.0
4.5-6.9	2	5.3	.06	208	12.5
7.0-8.7	3	7.7	.18	19	3.4
				677(±24.5)	24.9
Rainbow x Cutthroat Complex - South Fork Big Creek - T33N R30W S8					
2.4-4.1	1	3.1	.02	1,484	29.4
4.2-6.6	2&3	4.8	.04	265	10.5
Total				1,749(±18.7)	39.9

Spawning Runs

Spawning runs of rainbow and cutthroat trout ascending the Tobacco River System were monitored from April 4 to June 11, 1979 (Table 2). This period covered the entire rainbow run and part of the cutthroat run. Rainbow were first caught in the fyke nets near the mouth of the Tobacco River on April 11, when diurnal water temperatures varied between 35-41^{o}F. Cutthroat were initially caught in the fyke traps on April 24 when minimum water temperatures were above 41^{o}F. The fyke traps were fished in the thalweg on the outside of meander bends and trap only a small part of the run. The locations of the various traps are given in Figure 2.

Table 2. Summary of trap operation during rainbow and cutthroat trout spawnig runs into the Tobacco River Drainage, spring, 1979. Abbreviations for capture method are: 1. N = gill nets, 2. EF = electrofishing gear, 3. B = box traps, and 4. F = fyke nets.

Location and capture method	Species Ct	Rb	Period trap operated
Tobacco River (mouth) (N & EF)	59	129	4/11-5/14
Tobacco River (near mouth) (F)	6	65	4/ 4-6/ 4
Fortine Creek (near mouth) (F)	1	14	5/ 5-6/ 4
Sinclair Creek (1 mile from mouth) (B)	47	36	4/12-6/ 4
Therriault Creek (1 miles from mouth) (B)	5	50	4/13-6/ 4
Meadow Creek (near mouth) (B)	--	14	5/ 7-6/ 3
Deep Creek (2 miles from mouth) (B)	5	3	4/12-6/ 3
Graves Creek (near mouth) (F)	21	57	5/ 8-6/ 4
Graves Creek (6 miles from mouth) (B & F)	4	1	5/17-6/11
Tobacco River Bay (spent fish) (EF)		98	5/17-6/ 1
Total	148	467	

A box trap was fished in Sinclair Creek approximately one mile from the mouth, from April 12 to June 4. Rainbow were first collected on April 30 (minimum water temperature 41^{o}F), while cutthroat were first caught on May 4, when the water temperature ranged from 41-50^{o}F. The rainbow run was most intense from May 1 to May 17, whereas the cutthroat run peaked from May 15 to May 31. The latter part of the cutthroat run was not sampled as the trap was pulled on June 4.

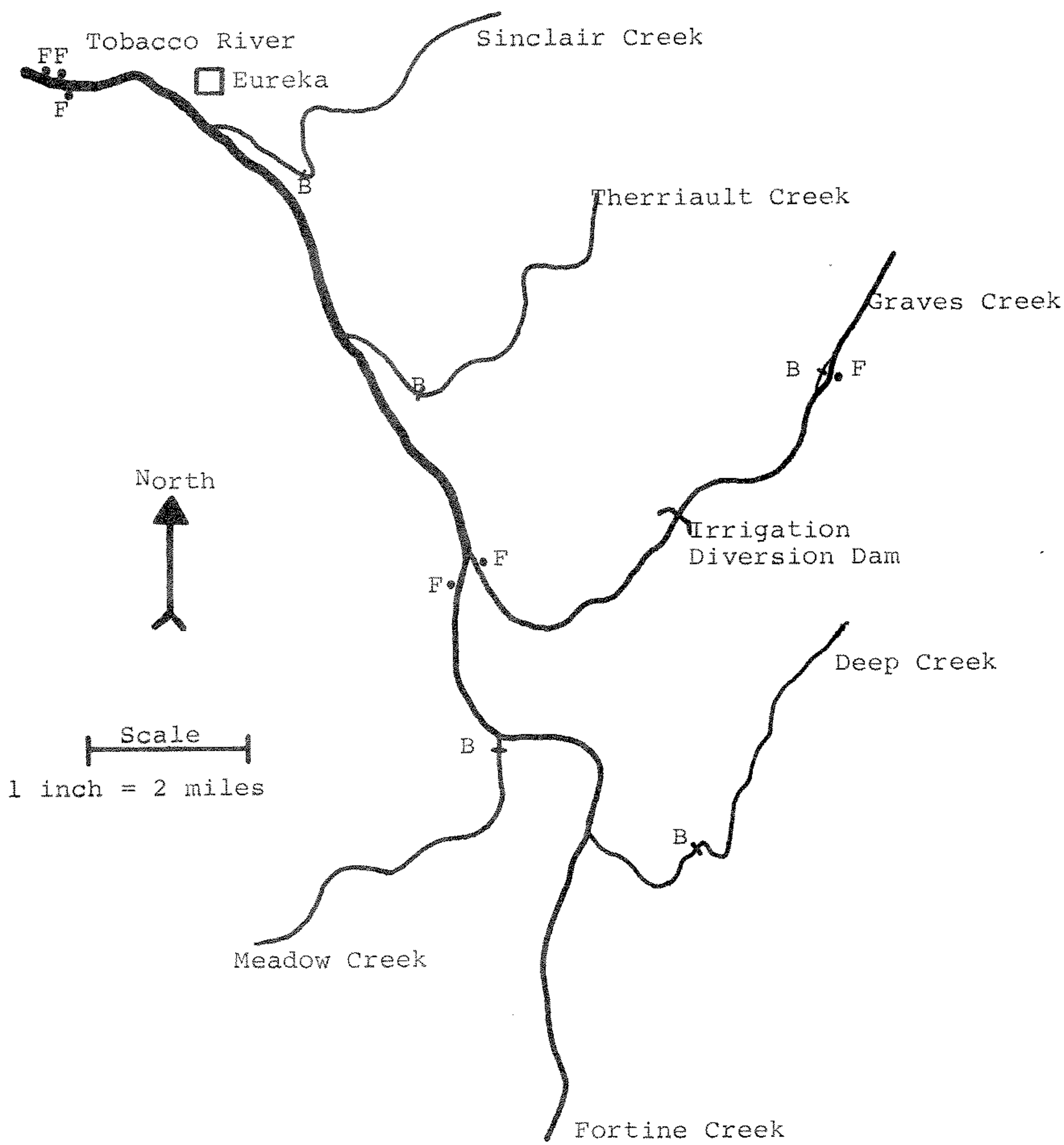

Figure 2. Map of Tobacco River Drainage showing trap sites in 1980. Abbreviations used are F = fyke net and B = box trap.

The run ascending Sinclair Creek was much higher than the trap catch, as the trap leads were forced down on 12 days by high water and associated debris. Some spawning also occurred in the stream section downstream from the trap. The total run into Sinclair Creek may exceed 200 fish.

A municipal water supply dam, 5 miles upstream from the mouth of Sinclair Creek, is blocking access into about 6 miles of spawning and nursery habitat. The dam is owned by the City of Eureka, but is no longer operational. Providing fish passage at this dam site has been suggested as a project to the Eureka Rod and Gun Club.

Rainbow trout were first collected in the box trap in Therriault Creek on April 15 and the peak of the run occurred from May 5 to May 25. The trap efficiency at this site was quite high, but some spawning occurred in the stream section downstream from the trap. The total run of rainbow in Therriault was probably about one hundred fish. Only five cutthroat were caught in the trap.

Meadow Creek is a small stream which enters Fortine Creek about 2 miles downstream from Fortine. A total of 14 rainbow trout were collected in a box trap from May 8 to 23. The trap efficiency was close to 100 percent as the flows were only about one cubic feet per second. The total run, however, was probably about 20-30 fish as the trap was installed after the run had begun. Two rainbow were caught the first day the trap was installed.

A fyke trap was fished near the mouth of Fortine Creek from May 5 to June 4. A total of 14 rainbow trout and only one cutthroat trout were caught. Most rainbow were caught from May 5 to May 24.

The efficiency of capture of the fyke net was low and only a small part of the run was sampled. An estimate of the total run into Fortine Creek cannot be made with such limited data.

Rainbow and cutthroat spawners ascending Graves Creek were sampled with a fyke net near the mouth and with a fyke net and box trap about six miles upstream from the mouth. The box trap was located in a side channel.

A total of 21 cutthroat and 57 rainbow were caught in the fyke trap near the mouth of Graves Creek. The rainbow run peaked from May 9 to May 24, whereas most cutthroat were caught from May 18 to June 2. Minimum water temperature ranged from 40°F on May 12 to 42°F on May 31. The large number of trout caught in the fyke trap indicates that Graves Creek supports a substantial run of cutthroat and rainbow.

The catch of four cutthroat and one rainbow in the traps located six miles upstream indicated that spawners are able to negotiate the irrigation diversion located about three miles upstream from the mouth. Improvement of fish passage at the diversion has resulted from a cooperative program among the Soil Conservation Service, Kootenai National Forest, and the Montana Department of Fish, Wildlife and Parks.

A box trap was fished in Deep Creek from April 12 to June 3, but only five cutthroat and three rainbow were caught. High water forced the leads down on 15 days during the peak of the run, resulting in low trap efficiency. The run of spawners into this stream was much higher than indicated by the trap catch. Log and trash jams in the lower two miles retard upstream fish movement and need to be removed.

A total of 467 rainbow and 148 cutthroat were collected during the survey. The point estimate from mark and recapture data for rainbow and cutthroat were 5,937 and 516, respectively (Table 3). The large confidence limits (35-40 percent) indicates that the actual number of fish in the runs could vary considerably from the point estimates. Regardless, the data does indicate that the Tobacco River System supports good spawning populations of rainbow and cutthroat trout.

Table 3. Summary of data from rainbow and cutthroat trout run ascending Tobacco River Drainage, spring, 1979. The 80 percent confidence limit for point estimate of run is given in parenthesis.

Parameter	Species	
	Ct	Rb
Point estimate	516(±35%)	5,937(±40%)
Sex ratio male: female	1.0:1.2	1.0:1.2
Average length male in inches	14.5	16.0
Average weight male in pounds	1.21	1.54
Average length female in inches	15.2	16.3
Average weight female in pounds	1.24	1.58

The average lengths of rainbow in the Tobacco River spawning run were similar to that recorded for the Big Creek run. Cutthroat trout males averaging 14.5 inches were 0.4 and 0.8 inches less than the average lengths of males in the Young Creek and Big Creek runs, respectively. The average length of cutthroat females (15.2 inches) in the Tobacco River was similar to that recorded for Big Creek and Young Creek.

Maintenance and improvement of fish passage, water quality, and fish habitat in the drainage are essential to maintaining or increasing these important spawning runs. The value of the Tobacco River and its tributary system as spawning and nursery areas is now recognized by the Kootenai National Forest and more consideration is being given to protecting the fisheries habitat and water quality.

The spawning run of rainbow, cutthroat, and cutthroat x rainbow trout hybrids ascending Big Creek was monitored from April 24 to June 13 (Table 4). The trap locations are shown in Figure 3. 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, 110 rainbow trout, and 235 cutthroat x rainbow hybrids were caught and released during the survey.

Three fyke nets were fished in the mainstem of Big Creek from April 24 to June 3. Rainbow and cutthroat were first caught on May 9, when minimum water temperature was 36°F and the maximum 40°F. Most of the rainbow, cutthroat, and hybrid trout were collected from May 5 to May 27. The temperatures on May 27 were still low with minimum and maximum being 39°F and 44°F, respectively. The Big Creek run was unusual in that rainbow and cutthroat ascend during the same period when minimum water temperatures were below 40°F.

A total of 157 trout were caught in the three fyke nets. Although this is a large catch for fyke nets, the nets caught only about 5 percent of the estimated run.

A box trap fished near the mouth of Good Creek caught 11 cutthroat, 4 rainbow and 5 hybrids. The trap efficiency was high and the total run into this stream probably did not exceed 25-30 fish.

The spawning run ascending the North Fork of Big Creek was monitored with a box trap, which was installed on May 13 and removed June 10. The peak of the cutthroat run occurred from May 20 to June 5. Minimum water temperatures during this period ranged between 36°-42°F. The catch in the trap included 133 cutthroat, 12 rainbow and 35 hybrids. The total run probably was between 200-300 fish.

A box trap was fished in the 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. The minimum water temperature was 38°F at the start of the run and 42°F at the end of the run. A total of 164 cutthroat, 10 rainbow and 74 hybrids were caught and released upstream. The total run entering the South Fork was much higher than indicated by the catch as the trap leads were forced down on several days during the peak of the run and the early part of the run was not sampled.

Table 4. Catch of rainbow trout, cutthroat trout, and rainbow x cutthroat hybrids ascending Big Creek, spring, 1980. Abbreviations for capture method are: 1. N = gill nets, 2. EF = electrofishing gear, 3. B = box traps, and 4. F = fyke nets. The number of recaptures is given in parenthesis.

Location and capture method	Species			Period fish collected
	Ct	Rb	CtxRb	
Big Creek Bay (EF and N)	3	19	1	4/21-5/ 8
Big Creek (F)	93	35	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)	80(1)	144(6)	
Downstream trap in Big Creek (B)	350(58)	30(5)	91(17)	6/ 3-6/27

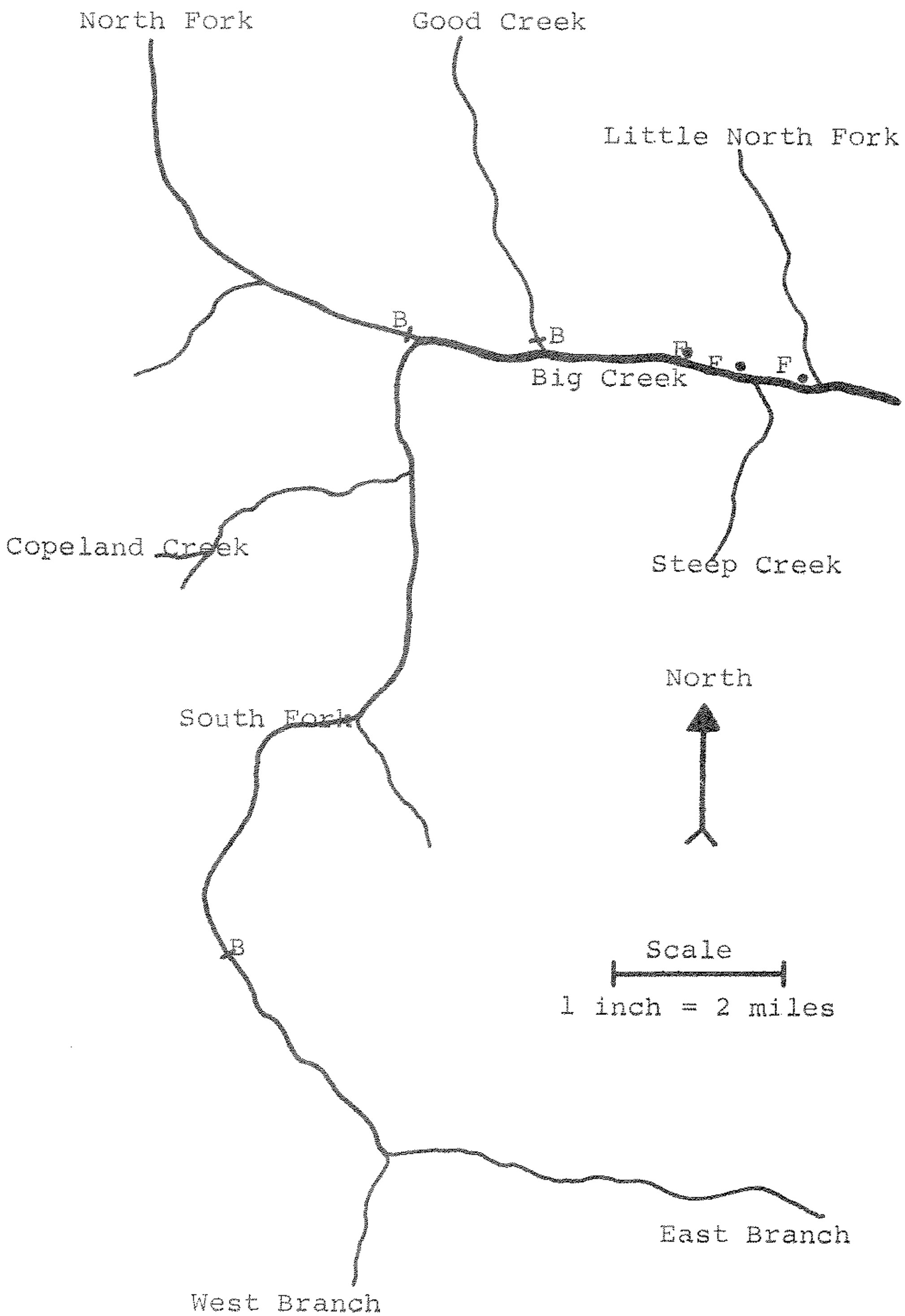

Figure 3. Map of Big Creek Drainage showing trap sites in 1980.
Abbreviations used are F = fyke net and B = box trap.

Several potential barriers to upstream fish movement were noted in the East and West Branch of the South Fork during a redd survey. Removal of these barriers by the Kootenai National Forest will provide access into about five more miles of spawning and nursery habitat.

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 re-capturing fish, and 2) mark data from all upstream traps with the downstream trap used for recapturing fish (Table 5). The estimated runs of 2,824 fish and 3,508 fish are fairly close, indicating that the estimates are valid indices of the magnitude of the spawning runs. Big Creek supports a large run of cutthroat trout and fair runs of rainbow and cutthroat x rainbow hybrids.

Table 5. Summary of data from rainbow trout, cutthroat trout and hybrid rainbow x cutthroat run ascending Big Creek, spring, 1980. The 80 percent confidence limit for the point estimate of run is given in parenthesis.

	Species			
Parameter	Ct	Rb	CtxRb	Total
Point estimate				
Upstream traps	1,803	370	651	2,824(±1.1%)
Downstream traps	2,389	368	751	3,508(±0.6%)
Sex ratio male:female	1.0:4.1	1.0:4.3	1:62.3	
Average length male*	15.2	15.3	14.6	
Average weight male**	1.25	1.29	1.24	
Average length female*	15.0	15.8	16.5	
Average weight female**	1.27	1.46	1.54	

*Length in inches

**Weight in pounds

The number of cutthroat in the run was more than expected (1,803-2,389), whereas the number of rainbow (368-370) was less than anticipated. Part of the early rainbow run may not have been sampled adequately. The sex ratio of the cutthroat run was similar to the Young Creek run, but the rainbow run had a much higher preponderance of females than the Tobacco River run.

The large number of hybrids (651-751) was expected as electrofishing data from Big Creek in 1979 indicated that considerable hybridization had occurred between rainbow and cutthroat trout. Ten hybrids were saved for electrophoretic tests to determine the degree of hybridization.

A total of 367 westslope cutthroat trout spawners were captured and released upstream at the Young Creek fish trap (Table 6). The run was larger than the 1979 run (315 fish), but markedly less than the 1977 run (679 fish). The marked declines in the 1979 and 1980 cutthroat runs were at first thought to be due to habitat problems in the drainage from agricultural and housing development, and excessive exploitation of adults and juveniles in Young Creek by anglers.

While these factors may be adversely influencing the number of adults, data from the 1980 smolt emigration indicates that other factors are involved. More smolts (1,410) were collected in the downstream trap by the end of June than in any previous year. The highest number of smolts caught was 1,558 in 1974, and this number should be easily exceeded in 1980. The 1980 smolts are comprised primarily of the 1977 and 1978 year classes, indicating that escapement was adequate in these years and juvenile survival was at least average from 1977-80.

Table 6. Summary of data from cutthroat trout spawning in Young Creek, 1977-1980.

Parameter	Year		
	1977	1979	1980
Number trapped	679	315	367
Estimated number of spawners	750	350	390
Sex ratio (male:female)	1.0:4.8	1.0:3.6	1.0:3.4
Average length of males in inches	15.4	14.6	14.9
Average length of females in inches	15.3	15.2	15.4

The weak 1979 and 1980 spawning runs must be primarily a result of factors other than habitat degradation and overfishing in Young Creek. Floods in the drainage in January, 1974 and December, 1975 reduced the strengths of the 1973, 1974, 1975 and 1976 year classes and this would have been reflected in reduced spawning runs in 1979 and 1980. The cessation of cutthroat plants in the reservoir beginning in 1976 has resulted in reduced cutthroat populations and a decline in non-imprinted fish seeking streams in which to spawn.

The average sizes of males (14.9) and females (15.4) in the run were slightly larger than in 1979 and comparable to 1977, indicating that growth in the reservoir is still good.

The movement of adult cutthroat and rainbow trout into the Kootenai River in British Columbia was monitored in spring, 1980 (personal communication from Gerry Oliver). A total of 91 rainbow and 20 cutthroat were captured during this electrofishing survey. Rainbow began their spawning run in mid-April and continued into mid-May. Spent fish were first collected in late May. The survey showed that rainbow migrated as far upstream as Skookumchuck (90 miles upstream from the Canadian Border) and appeared to spawn in the mainstem river. Spent fish were first collected in late May. Nearly all of the cutthroat were collected in the vicinity of Elk River and there did not appear to be a significant migration above Wardner (Figure 1). It appeared that most cutthroat were spawning in tributary streams entering the reservoir pool area.

A white sturgeon which was planted in the reservoir near Cripple Horse (Figure 1) on May 8, 1975 was collected in the Kootenai River near Wardner on May 21, 1980. This fish was 42.1 inches long when caught compared to 36.5 inches when planted. This is the first verified return of any of the five sturgeon planted in the reservoir.

In-Reservoir Population Trends for Fall Netting Series

The average catch rates for the fall netting series from 1975 to 1979 are summarized in Figure 4 and netting areas are shown in Figure 4. Reservoir elevations (2,445-2,447 MSL) during the 1979 series were about 12 feet below the previous year's levels and may have been a factor influencing catch rates. Surface water temperatures (61-62^{o}F) and water transparencies as indicated by secchi disc readings (20.4-25.6 feet) were comparable to previous years.

The rainbow trout catch rates in 1979 dropped in all three sections from the previous year but the difference was significant only in the Cripple Horse Area. The catch rate in 1979 was 4.1 fish per net as compared to 5.9 fish per net in 1978. The highest catch rate in 1979 was recorded in the Rexford area (5.7 fish per net), whereas the lowest catch rate occurred in the Bailey Bridge area (2.9 fish per net). The Bailey Bridge area has consistently recorded the lowest catch rates.

The cutthroat trout catch rates were lower in 1979 than in 1978 in all three netting areas. The difference was significant only in the Rexford area where the catch rate dropped from 2.4 fish per net in 1978 to 1.4 fish per net in 1979. The cessation of cutthroat plants into the reservoir and tributary streams in 1976 appears to have had its largest impact on populations in the lower part of the reservoir. Cutthroat catch rates in the

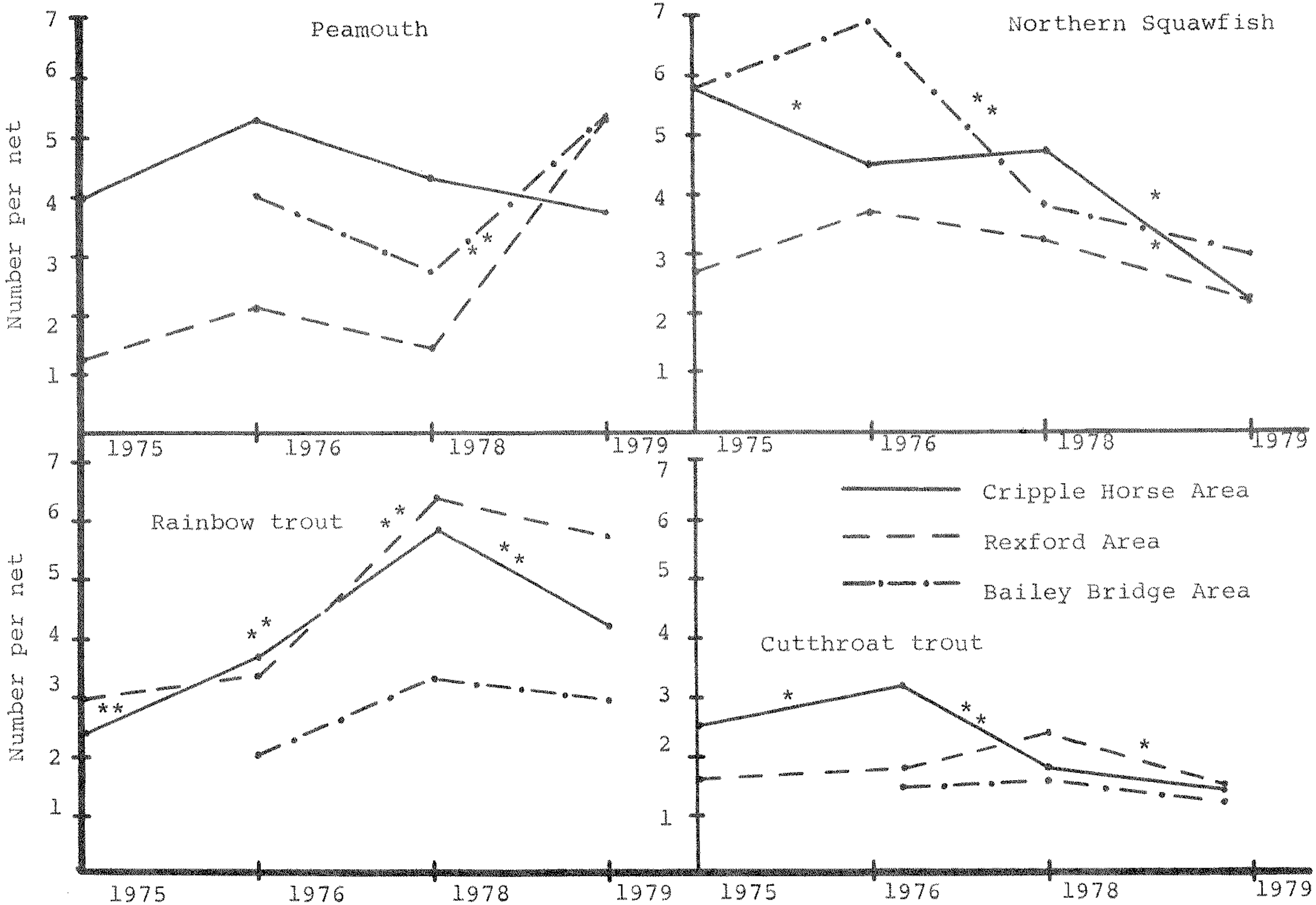

Figure 4. Average catch per net of rainbow trout, cutthroat trout, peamouth and northern squawfish in the Cripple Horse, Rexford and Bailey Bridge areas, 1975-1979. One asterisk indicates significant difference in catch rates between years at .05 level. Two asterisks differentiate .01 and greater level. KW tests were not run on 1977 Bailey Bridge data due to small sample size (14 nets).

Cripple Horse area have declined from 3.2 fish per net in 1976 to 1.4 fish per net in 1979. Catch rates in both the Rexford area and Bailey Bridge area were only 0.4 fish per net less in 1979 than in 1976. The location of major cutthroat spawning tributaries in the upper part of the reservoir may be an important factor in the maintenance of current population levels without additional hatchery plants. Cutthroat catch rates ranged from 1.5 fish per net to 4.3 fish per net lower than rainbow rates in the three netting areas.

The catch rates in the Bailey Bridge area were lower than the other areas from 1976-78. The low catch rates of cutthroat and rainbow trout in this part of the reservoir was likely due to the effects of dewatering. The area is almost totally dewatered in most years from November through May and has warmer water temperatures than downstream areas.

The catch rates of peamouth chubs increased from 1978 to 1979 in the Bailey Bridge and Rexford areas, but dropped in the Cripple Horse area. The difference was highly significant in the Rexford area where the rates changed from 1.4 to 5.3 fish per net from 1978 to 1979, respectively. The higher catch rates in the Rexford and Bailey Bridge areas may be related to the comparatively small drawdown in the 1978-79 winter of only 96 feet, which left the upper end of the pool extending about 12 miles into British Columbia.

The catch of northern squawfish dropped in all three areas from 1978 to 1979. The differences were significant in the Cripple Horse and Bailey Bridge areas. The trend in squawfish catch rates has been downward since 1976. The reasons for the decline in squawfish catch rates are unknown.

In-Reservoir Population Trends for Spring Netting Series

The catch rates for the spring netting series from 1975 to 1980 are summarized in Figure 5. Surface water temperatures (52°F) and transparencies as indicated by secchi disc readings (2.6 feet) were comparable in 1980 to previous years, but the reservoir elevation was about 20 feet higher in 1980 than previous years. The higher elevation in 1980 may have biased the catch for some species.

The catch of longnose suckers declined from 1978 (9.1/net) to 1980 (5.8/net), whereas the catch for largescale suckers increased from 1978 (23.4/net) to 1980 (36.3/net). The differences in the catch between 1978 and 1980 for both species were highly significant. The catch of these species has been quite variable from year to year. It is possible that the changes in catch are not indicative of significant changes in population, but rather due to sampling error. Suckers are slow growing, long-lived fish, whose populations should not change significantly every year.

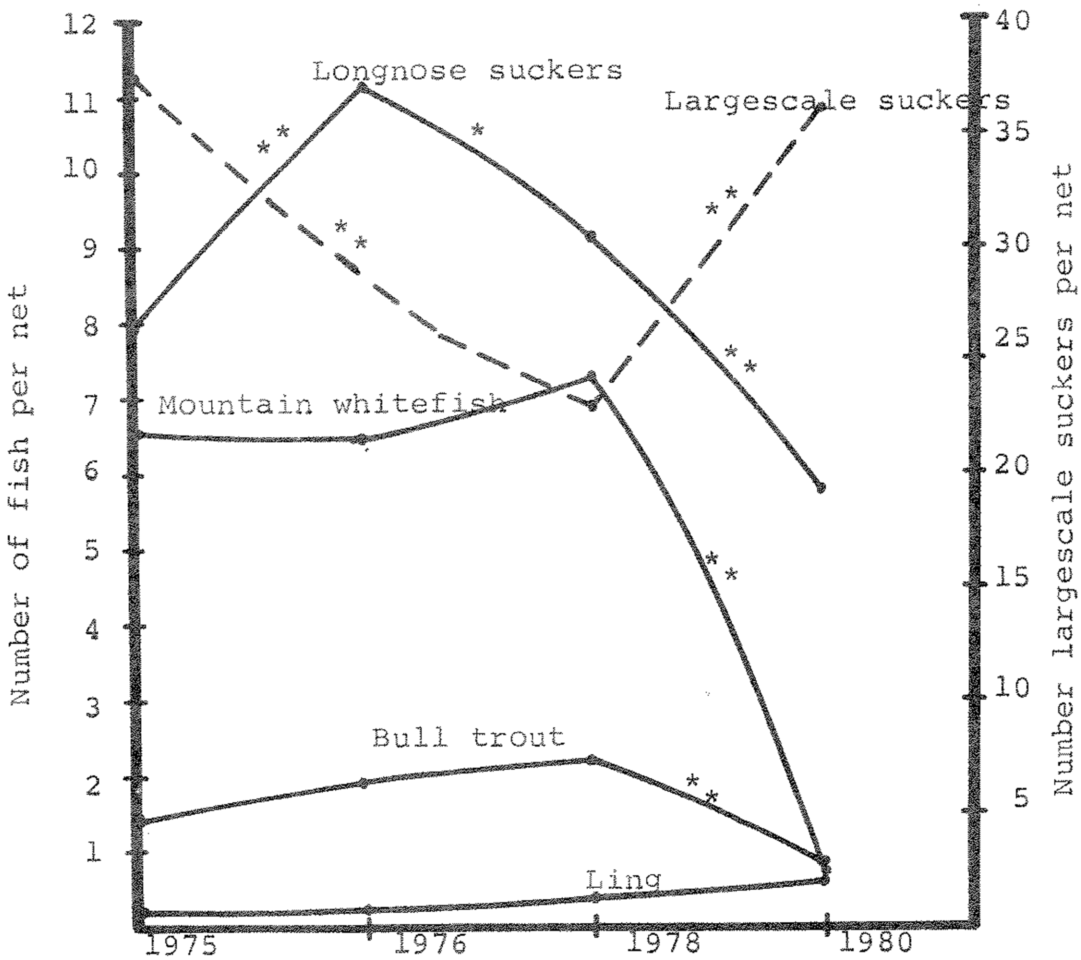

Figure 5. Average catch per bottom gill net of bull trout, mountain whitefish, ling, largescale and longnose suckers in the spring sampling at Rexford area, Lake Koocanusa, 1975 through 1980.

The catch of bull trout and mountain whitefish declined significantly from 1978 to 1980. The catch of bull trout dropped from 2.2 fish/net in 1978 to 0.8 fish/net in 1980, whereas the catch of mountain whitefish declined from 7.2 fish/net in 1978 to 0.6 fish/net in 1980.

Prior to 1980, the catch of both species had increased gradually from 1975 to 1978. The large decline in catch in 1980 from previous years was most likely due to unknown sampling errors rather than actual abundance changes in the fish populations.

The catch rate of ling almost doubled from 1978-1980 and has increased steadily since 1975. A popular winter and spring fishery now exists for this species in the Rexford areas of the reservoir. Control of pollution from the industrial complex on the St. Mary's River in B.C. appears to be an important factor in the resurgence of the ling population. Ling populations declined dramatically in the Kootenai in the late 1950's when effluent from a fertilizer plant on the St. Mary's River was introduced into the drainage. Bonde & Bush (1975) found toxic concentrations of heavy metals, fluorides and ammonia in the Kootenai River from the complex on the St. Mary's. Treatment facilities have reduced pollutants by about 90-95% since 1968.

Migration and Angler Harvest

The locations of fish tagged in 1979 and caught by anglers in 1979 are given in Figure 1. A total of 842 trout were tagged in 1979 and 82 tags (9.7 percent) were returned by anglers. The tag return rates varied between the species and tagging locations. Only 6.2 percent of the cutthroat tagged in Young Creek were returned by anglers, as compared to a 16.8 percent return from cutthroat tagged in the Tobacco River drainage, and an 8.6 percent return on rainbow from the Tobacco River.

Major differences occurred in the tag return patterns of cutthroat tagged in the Tobacco River and Young Creek drainages. Twenty-three of 26 tag returns from cutthroat tagged ascending Tobacco River were from the Tobacco River and its tributaries.

Cutthroat appear to be more vulnerable to exploitation than rainbow. Eight of these tags were from Sinclair Creek and five from Graves Creek. A tag return from Glen Lake indicated that spent fish returning downstream from Graves Creek entered the irrigation canal at the diversion site. No fish tagged in the Tobacco River were returned from the Canadian part of the reservoir. In contrast, 5 of 13 tag returns from Young Creek fish were from Canada and five were returned from the Big Creek area. No tags were returned from Young Creek, even though it receives intense fishing pressure. The paucity of fish tags from Young Creek is undoubtedly due to failure to return tags, rather than a lack of harvest. No cutthroat trout tags were returned from the Kootenai

River below Libby Dam, indicating that the operational plan to reduce fish escapement from the reservoir worked quite well in 1979.

Rainbow trout tags were returned from the Tobacco River (13), the Canadian part of the reservoir (7), U.S. part (17) and no location (5). Fish were caught near Libby Dam to the head of the reservoir at Wardner, indicating that the Tobacco River spawning run includes fish from all areas of the reservoir. No tags were returned from the Kootenai River downstream from Libby Dam.

Depth Distribution

The vertical distribution of rainbow and cutthroat trout in the forebay area was examined in June, July and August 1979. Results were similar to previous years when surface temperatures ranged between 66-70°F. Both species were concentrated in the thermocline area (20-60 feet deep) where water temperatures ranged between 55-63°F. Cutthroat exhibited a preference for a little cooler temperatures than rainbow. Operation of the selective withdrawal system and a low inflow resulted in few trout escaping from the reservoir in 1979.

Age and Growth

Fish scales were aged and nomographed from rainbow, cutthroat, bull trout and mountain whitefish collected in 1979. Growth data were processed by a new computer program and will be summarized in a future report.

Heavy Metals Tests

Rumors concerning mercury contamination of fish in the reservoir prompted an investigation into the validity of these rumors. An initial sample of seven salmonids collected in January 1980 were sent to Montana State University for mercury analysis. Two bull trout (2.03 and 9.3 pounds) averaged 0.45 ppm mercury while 3 rainbow and 2 cutthroat trout averaging 1.1 pounds averaged 0.22 ppm mercury in the flesh. The federal standard for human consumption was 0.5 ppm at that time.

The rather high levels of mercury found in some fish, especially bull trout, warranted a more thorough study. Additional samples were taken from the reservoir in May. If these fish samples contained high mercury levels, a joint program with the British Columbia Fish and Wildlife Branch was to begin in fall 1980 to pinpoint the source of the mercury pollution,

Fish samples collected in May from the Rexford area for mercury analysis included 12 rainbow trout, 3 cutthroat trout, 11 mountain whitefish, 9 bull trout, and 11 ling. Muscle samples were collected from each specimen. Some people like to eat ling liver (for its reputed aphrodisiac powers) and since heavy metals tend to concentrate in liver tissue, samples from 11 ling livers were also collected. Table 7 lists the mercury analysis by specimen.

Data listed in Table 7 indicate that mercury levels are well below the federal standards of 0.5 ppm. These standards are expected to be raised to 1.0 ppm before 1981. As expected, bull trout and ling appeared to have higher concentrations of mercury than the other fish species tested. These two species have diets mostly of other fish, while whitefish, cutthroat and rainbow trout feed mostly on plankton and aquatic insects.

Table 7. Mercury concentrations found in muscle and liver samples of ling and muscle samples of rainbow and cutthroat trout, bull trout and mountain whitefish, Lake Koocanusa, 1980.

Tissue type	Species[1]	Length inches	Weight pounds	Mercury ppm[2]
Muscle	Rb	14.7	1.33	0.103
Muscle	Rb	15.0	1.26	0.090
Muscle	Rb	15.0	1.15	0.068
Muscle	Rb	15.1	1.20	0.097
Muscle	Rb	15.3	1.18	0.176
Muscle	Rb	16.0	1.34	0.075
Muscle	Rb	16.1	1.44	0.102
Muscle	Rb	16.4	1.44	0.143
Muscle	Rb	17.0	1.84	0.175
Muscle	Rb	17.1	1.04	0.085
Muscle	Rb	17.5	1.41	0.109
Muscle	Rb	18.2	1.74	0.080
Muscle	Ct	13.1	0.90	0.099
Muscle	Ct	13.6	0.84	0.083
Muscle	Ct	15.4	1.32	0.112
Muscle	DV	11.2	0.44	0.122
Muscle	DV	11.5	0.46	0.245
Muscle	DV	12.0	0.56	0.137
Muscle	DV	12.3	0.60	0.134
Muscle	DV	14.5	0.93	0.215
Muscle	DV	14.5	0.94	0.279
Muscle	DV	16.5	1.46	0.258
Muscle	DV	17.4	1.52	0.262
Muscle	DV	19.3	2.43	0.340
Muscle	Mwf	9.0	0.28	0.080
Muscle	Mwf	9.3	0.26	0.059

Table 7. Continued

Tissue type	Species[1]	Length inches	Weight pounds	Mercury ppm[2]
Muscle	Mwf	9.5	0.28	0.042
Muscle	Mwf	10.0	0.40	0.093
Muscle	Mwf	10.5	0.40	0.068
Muscle	Mwf	10.6	0.45	0.092
Muscle	Mwf	11.0	0.44	0.084
Muscle	Mwf	11.8	0.52	0.116
Muscle	Mwf	12.0	0.52	0.096
Muscle	Mwf	13.0	0.74	0.192
Muscle	Mwf	13.7	0.84	0.123
Muscle	Ling	16.2	1.10	0.053
Liver	Ling			0.268
Muscle	Ling	16.4	1.14	0.239
Liver	Ling			0.268
Muscle	Ling	17.2	1.26	0.204
Liver	Ling			0.154
Muscle	Ling	18.3	1.14	0.107
Liver	Ling			0.148
Muscle	Ling	19.8	1.98	0.058
Liver	Ling			0.123
Muscle	Ling	20.8	1.92	0.347
Liver	Ling			0.377
Muscle	Ling	20.9	2.26	0.346
Liver	Ling			0.201
Muscle	Ling	21.2	2.44	0.230
Liver	Ling			0.245
Muscle	Ling	21.9	2.35	0.215
Liver	Ling			0.294
Muscle	Ling	22.3	2.94	0.104
Liver	Ling			0.148
Muscle	Ling	23.9	3.62	0.170
Liver	Ling			0.234

[1]Rb - rainbow trout, Ct - cutthroat trout, Mwf - mountain whitefish, DV - bull trout, Ling - ling or burbot.

[2]Ppm is abbreviation for parts per million.

Origin of Kootenai River Rainbow Trout Stocks

The origin of the rainbow trout stocks in Kootenai River drainage has been the source of some speculation by area residents, sportsmen and biological personnel of Montana, Idaho and British Columbia. Research by University of Montana personnel has provided a "partial" answer to rainbow trout origins. Four reports by these University of Montana researchers are attached to this report and include description of their work on rainbow trout in Kootenai River drainage below Kootenai Falls, rainbow trout spawning in Bobtail and Pipe Creeks between Libby Dam and Kootenai Falls, rainbow trout spawning in Tobacco River system (Lake Koocanusa) and rainbow trout being reared at the Bull River trout hatchery in British Columbia.

These reports indicate that some rainbow found in the Kootenai River drainage below Kootenai Falls are of the inland (native) strain while others are of the coastal (non-native) strain. Rainbow trout currently in the British Columbia hatchery at Bull River are of the inland-native strain. Rainbow trout found in the reservoir and Pipe-Bobtail Creeks were of an undetermined strain most closely resembling the coastal-non-native strain but yet different from Montana's rainbow brood stock.

Additional rainbow trout collections will be made from Big Creek, tributary to Lake Koocanusa, and from selected spawning tributaries of the reservoir to help determine the true origin of rainbow trout in the reservoir. The research into rainbow trout origins has been and will continue to be funded in part by this contract with Corps of Engineers, by State of Montana and by British Columbia Fish and Wildlife Branch.

Value of Studies

The documentation of spawning runs of cutthroat and rainbow trout into the Tobacco River and Big Creek drainages has clearly demonstrated to land management agencies the value of these streams to the area fishery. These agencies will recognize these values in their land-use and resource-use programs. Knowing the quality and quantity of tributaries used for reproduction by reservoir fish will affect long-term Lake Koocanusa fisheries management plans.

Kootenai National Forest has expressed a desire to increase the length of South Fork Big Creek available to reservoir spawners by removal of barriers preventing upstream movement of adult fish. The area to be cleaned of barriers by the Forest Service is the same that the Forest Service requested the Department to leave untouched during the original stream development project in 1972-1974.

Removal of a small defunct City of Eureka water works dam on Sinclair Creek will be investigated by a new Eureka rod and gun club. The City of Eureka turned down a Department request for removal or modification of this structure in 1975. Capture of spawning rainbow and cutthroat trout above the Glen Lake irrigation diversion structure on Graves Creek has shown that repair work done by the Forest Service was successful in providing passage for spring spawning fish.

Sufficient data were collected about mercury contamination of fish in Lake Koocanusa to belie any questions asked by interested sportsmen. Although this facet of study was not included in the contracted work plans, both the Corps of Engineers and Department were enough concerned that the necessary tests were obtained.

RECOMMENDATIONS

Recommendations for the continuation of these Lake Koocanusa investigations remain largely within the scope of the basic proposal for Contract for the period of January 1, 1979 through December 31, 1983. Fiscal-year 1981 activities will include collection of creel census data and recreational-use information for calendar-year 1981; qualifying and quantifying spawning populations of cutthroat and rainbow trout into Young Creek and other selected tributary streams; and determining in-reservoir population trends.

Primary purpose of the creel census during calendar-year 1981 is to collect data on harvest rates and species composition of the angler catch before hatchery-reared fish enter the catch. Lake Koocanusa has not been planted since 1976 and the small cutthroat planted in tributary streams in 1980 should not reach a catchable size until late 1982. The 1981 creel census will be repeated in 1983 at which time hatchery-reared fish will have reached a size large enough to contribute to the angler harvest. Changes in harvest rates and species composition between 1981 and 1983 will be a measure of the contribution of fish planted in the reservoir from the Murray Springs hatchery.

Estimating total catch from Lake Koocanusa was a part of the original creel census proposal. This total catch estimate would have been obtained from applying creel census data collected to a fishing pressure estimate derived from a statewide pressure estimate. The Department will not be obtaining total pressure estimates from any state water because of budget restrictions and program problems. Final form for the Lake Koocanusa 1981 creel census has not been decided at this time but consultations will be held with appropriate statisticians to develop the best appropriate methodology.

Spawning runs of cutthroat trout and rainbow trout have been quantified in most major tributaries. Work planned for Fiscal-year 1981 will be limited to measuring spawning runs of cutthroat and rainbow trout into several smaller tributaries such as Pinkham, Sullivan, Five-Mile, Barron and Bristow Creeks. Enumeration of numbers of spawning fish entering each creek may not be obtained but spawning areas in each creek will be located. The Young Creek upstream-downstream trap will be operated throughout the time fish are immigrating and emigrating.

In-reservoir fish population trends will be determined using methodology similar to past years' trend sampling. Spring net sampling will be done to determine trends for benthic species and fall net sampling for pelagic species. Some mid-reservoir netting will also be done to determine species of fish utilizing this area of the reservoir.

State of Montana will cost-share continuing investigation into some aspects of the biology of the Lake Koocanusa fishery. These include:

1. Studies to determine origin of rainbow trout in Lake Koocanusa.

2. Studies to determine spawning success and survival rates of rainbow trout-cutthroat trout hybrids.

3. Collection of data necessary to file for flow reservations in the Tobacco River drainage.

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June 1979

BIOCHEMICAL GENETIC EVIDENCE FOR NATIVE RAINBOW TROUT IN MONTANA: O'BRIEN CREEK POPULATION.

Report to: Montana Department of Fish and Game
Helena, Montana

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Abstract

Rainbow trout (Salmo gairdneri) from O'Brien Creek (T 31N R 34W) in the Kootenai River drainage of Northwestern Montana were examined electrophoretically to detect the presence of an extant native population. Allele frequencies intermediate to those of coastal and inland populations of rainbow trout were found. There was a significant decrease in the number of heterozygotes at the LDH-4 locus compared to those expected from the Hardy-Weinberg proportion. This could indicate the presence of non-random mating within this population. The O'Brien Creek population may represent a combination of planted coastal and native inland forms.

Introduction

Two major taxonomic groups of rainbow trout, coastal and inland, have been described in the western North America on the basis of biochemical genetic information (Allendorf and Utter, 1979; Utter and Allendorf 1978). The geographical division of these two groups corresponds with the crest of the Cascade Mountain Range. Hatchery stocks of rainbow trout throughout the United States were derived from coastal populations. Therefore, rainbow trout populations in the Kootenai River Drainage with a similar gene frequencies to that of the inland group, likely represent native rainbow trout populations. Using this reasoning, Allendorf et al. (1979) reported the existance of native rainbow trout in the Kootenai drainage.

Background

A previous study done by Espeland and Scow (1978) did not find any rainbow trout present in O'Brien Creek. Bruce May, Montana Department of Fish and Game, (personal communication) indicated to the contrary that rainbow trout were found in O'Brien Creek and provided the samples for this study. This study is a continuation of the initial study of Allendorf et al. (1979).

Methods

Fifteen rainbow trout were collected from O'Brien Creek in May 1979. Electrophoretic analysis followed the methods of Utter et al. (1974). The enzymes and their loci designations were described in Allendorf et al. (1977).

Results

The results reported here are from only two of the polymorphic loci (LDH-4 and SOD) which have been previously found to be most useful in descriminating the coastal and inland forms of rainbow trout (Allendorf and Utter 1979). The allele frequencies at both loci are compared to the results found during the initial study (Table 1). The allele frequency at the SOD locus in the O'Brien Creek population is typical of an inland rainbow trout population. The LDH-4 allele frequency on the otherhand, is intermediate of coastal and inland frequencies. This is similar to what was found for the Yaak River population (Allendorf et al. 1979).

A F statistic developed by Nei (1965) was used to examine the LDH-4 genotype frequencies for departures from proportions expected under Hardy-Weinberg equilibrium.

$$F = 1 - \frac{H_o}{H_e}$$

where H_o is the observed and H_e is the expected proportion of heterozygotes. F will assume positive values for a deficiency of observed heterozygotes at a locus, negative values for an excess and 0 for the exact number of observed heterozygotes as predicted from the Hardy-Weinberg proportions. To test the significance of the F value a X^2 test can be used

$$X^2 = F^2 N$$

where N equals the number of individuals sampled (Workman 1969). The observed deficiency at the LDH-4 heterozygote genotype resulted in $F = .5833$, $X^2 = 5.104$ ($P < .025$) 1 df.

Forces which may cause an increase in F are inbreeding, positive assortive mating and population subdivision. The significant departure from random mating likely indicates the presence of both planted hatchery rainbow trout and native rainbow trout in O'Brien Creek.

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TABLE 1

Stock Composition and Allele Frequencies at the LDH-4 and SOD Loci of Rainbow Trout Populations in the Kootenai Drainage

Stock Composition	Sample Area	Genes Sampled	LDH-4 (100)	SOD (100)
1 Native Rainbow Trout	1) Callahan Creek, MT	80	.539	.988
	2) Callahan Creek, ID	80	.488	1.000
2 Mixed Native and Hatchery Rainbow Trout	3) O'Brien Creek, MT	30	.800	.970
	4) Yaak River, MT	80	.700	.912
3 Planted Hatchery (Coastal Rainbow Trout)	5) Arbo Creek, MT	60	.883	.700
	6) Raymond Creek, MT	36	1.000	.944
	7) Star Creek, ID	100	1.000	.740
4 Jocko Hatchery	Arlee, MT	458	.954	.827

Identification of the source of rainbow trout in Lake Koocanusa

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February 14, 1980

INTRODUCTION

The Kootenai River was impounded by Libby Dam in 1972 forming a large cold-water reservoir called Lake Koocanusa. Efforts were undertaken to maintain a population of the native trout of this area, the west-slope cutthroat trout, *Salmo clarki lewisi*, by developing spawning runs in tributary streams and hatchery plantings. This effort was initially successful but rainbow trout (*S. gairdneri*) have been markedly increasing in numbers since 1976 and are currently the most abundant trout in the reservoir (Bruce May personal communication).

The present rainbow trout population in Lake Koocanusa is suspected to have three possible origins; a native inland rainbow stock, the Jocko River State Trout Hatchery stock, or a stock from a Canadian hatchery, which operates on the Bull River upstream from Lake Koocanusa. The intent of this study is to determine which of these three stocks or combinations of these stocks is most likely the ancestrial source of the current rainbow trout population.

METHODS

Seventy-three rainbow trout were collected by gill nets from Lake Koocanusa in June 1979. Horizontal starch gel electrophoresis was conducted according to the methods of Utter, Hodgins, and Allendorf (1974). The buffer systems and staining methods used in this study are described by Allendorf et al. (1977). The nomenclature used to describe the gene loci and the allele variants encoding the enzymes surveyed follows the system proposed by Allendorf and Utter (1979).

Muscle, liver and eye tissue samples were used for the analysis. Twenty enzymes (38 loci) were chosen on the basis of adequate resolution enzyme activity and genetic variation. The tissue and buffer system combinations with the best activity and resolution generally agree with Allendorf et al. (1977).

RESULTS AND DISCUSSION

Native Rainbow Trout

Two major taxonomic groups of rainbow trout, coastal and inland, exist in western North America (Allendorf and Utter 1979, Behnke, 1979). Two loci, LDH-4 and SOD, have previously been found to be the most useful in biochemically discriminating between the coastal and inland forms (Utter and Allendorf 1978). Hatchery stocks of rainbow trout were derived from coastal populations (MacCrimmon, 1971). Therefore, rainbow trout populations in the Kootenai River drainage with gene frequencies similar to that of the inland group, likely represent native rainbow trout. Using this assumption, Allendorf et al. (1980) reported the existence of native rainbow trout in the Kootenai drainage downstream from Troy, Montana.

The gene frequencies at the LDH-4 and SOD loci from Lake Koocanusa are statistically different from inland trout populations and are similar to coastal populations (Table 1). Therefore, I conclude that the present Koocanusa rainbow trout populations did not originate from native fish. It is likely that the Kootenai Falls acted as an impassible barrier to upstream migration of fish and prevented the establishment of native rainbow trout populations in the area which is now Lake Koocanusa.

Jocko River State Trout Hatchery

Rainbow trout from the Jocko River Hatchery were heavily planted in the Kootenai River and its tributaries from the early 1950's until 1960. Since that time, the Montana Department of Fish, Wildlife, and Parks have only planted westslope cutthroat trout in this area. Gene frequency data from the Jocko River State Trout Hatchery has been compiled since 1972, long after the area which is now Lake Koocanusa was planted with rainbow trout from this hatchery. However, the current stock at the Jocko River Hatchery can be used for comparison by assuming that the gene frequencies have not changed significantly in the brood stock in the past years prior to 1972. This assumption is supported by (1) the gene frequencies at individual gene loci in a population are stable attributes of that population and tend to persist from generation to generation (Allendorf and Utter 1979); (2) there has been no introduction of rainbow trout from outside of the hatchery into this brood stock, which would cause marked changes in the gene frequencies of the present brood stock which has been at the Jocko River Hatchery since 1952 (Emmett Colley, personal communication).

The Lake Koocanusa rainbow trout population is statistically different from the present Jocko River Hatchery stock at six of eleven variable loci (Table 2). Three of the five loci that are not statistically different had a very low frequency (.01) of the variant allele in both populations. There are also four alleles, MDH-1,2 (22); MDH-3,4 (122, 81); ME-2 (93) which do not occur in the hatchery stock and one allele, CK-1 (65), which does not occur in Lake Koocanusa. The four unique alleles found in Lake Koocanusa are not the result of a sampling bias due to the detection of a few rare alleles in very large samples. Over eight times as many fish have been examined from the Jocko River Hatchery so one would expect the bias to be in the opposite direction.

Canadian Hatchery

The Canadian Hatchery presently contributes an unknown amount of rainbow trout to this drainage. It is suspected that these fish move downstream into the reservoir and may be the cause of the current increase in rainbow trout population. However, the amount and type of genetic variation present at the Canadian Hatchery is unknown (Bruce May, personal communication).

CONCLUSION

The results indicate that the present rainbow trout population in Lake Koocanusa are not derived from a native stock. The Jocko River Hatchery stock also does not appear to have been the major source of fish in the present population. This indicates that the Canadian Hatchery apparently represents the major source of the rainbow trout in Lake Koocanusa. The Canadian Hatchery stock must be examined before a quantitative estimate of the relative contribution of this stock to the total fishery can be determined.

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Table 1. Comparison and χ^2 test of significance of Lake Koocanusa rainbow trout to coastal and inland populations at LDH-4 and SOD.

Coastal Populations	Genes Sampled	Allele Frequency LDH-4 (100)	Allele Frequency SOD (100)	Reference*
Arbo Creek, MT	60	.883	.700	a
Raymond Creek, MT	36	1.000	.944	a
Star Creek, MT	100	1.000	.740	a
Morse Lake, WA	112	.955	.572	b
Chambers Creek Hatchery, WA	86	1.000	.442	b
Entiat Hatchery, WA	90	1.000	.656	c
Quinault River, WA	80	.975	.575	b
Washougal River, WA	360	.841	.720	b
Jocko Hatchery, MT	764	.950	.805	a,d
Inland Populations				
North Fork Callahan Creek, MT	80	.488	1.000	a
Callahan Creek, MT	80	.539	.988	a
Deschutes River, OR	80	.400	.962	b
Pahsimeroi River, ID	80	.388	.938	b

	Combined Coastal Populations	χ^2_{1df}	Lake Koocanusa	χ^2_{1df}	Combined Inland Populations
LDH-4	.957	0.79	.972	114.36	.453
SOD	.751	2.23	.808	36.71	.972

*a. Allendorf et al. 1980; b. Allendorf 1975; c. Utter and Hodgins 1972; d. unpublished data.

Variable alleles at individual gene loci, allelic frequencies and χ^2 values between the Lake Koocanusa rainbow trout population and the Jocko River State Hatchery rainbow trout brood stock.

Loci	Lake Koocanusa Alleles	Hatchery Jocko River Alleles	χ^2 1df
AGP-2	100, 140 (.99 .01)	100, 140 (.99 .01)	.68
CK-1, 2	100 (1.00)	100, 65 (.96 .04)	6.11 +
IDH-3, 4	100, 42, 70, 121 (.55 .16 .27 .02)	100, 43, 70, 121 (.44 .42 .06 .08)	*79.72 ++
LDH-4	100, 73 (.97 .03)	100, 73 (.95 .05)	1.01
MDH-1, 2	100, 22 (.97 .03)	100 (1.00)	16.4 ++
MDH-3, 4	100, 70, 122, 81 (.90 .08 .02 .003)	100, 70 (.84 .16)	12.72 ++
ME-1	100, 88 (.99 .01)	100, 88 (.99 .01)	0.02
ME-2	100, 93 (.92 .08)	100 (1.00)	55.98 ++
PGM-2	100, 84 (.88 .22)	100, 84 (.95 .05)	7.17 ++
SDH	100, 50 (.99 .01)	100, 50 (.99 .01)	0.01
SOD	100, 145 (.81 .19)	100, 145 (.80 .20)	0.01

* 3 df

\+ significance > .95

++ significance > .99

Identification of the source of rainbow trout in Lake Koocanusa: Examination of five Canadian hatchery stocks

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INTRODUCTION

The Kootenai River was impounded by Libby Dam in 1972 forming a large cold-water reservoir called Lake Koocanusa. The fisheries management policy for this lake is to maintain a population of westslope cutthroat trout, *Salmo clarki lewisi*, the native trout of this area. To achieve this goal, the Murray Springs Trout Hatchery was constructed, large hatchery plantings of westslope cutthroat trout commenced, and efforts were under taken to develop spawning runs in tributary streams. This management plan was initially successful, but rainbow trout, *S. gairdneri*, have been markedly increasing in numbers since 1976 and are currently the most abundant trout in the reservoir (Bruce May, personal communication).

The present rainbow trout population in Lake Koocanusa is suspected to have three possible origins: a native inland rainbow stock, the Jocko River State Trout Hatchery stock, or a stock from the Kootenay Trout Hatchery, which operates on the Bull River upstream from Lake Koocanusa. The intent of this study is to determine which of these three stocks, or combinations of these stocks, is most likely the ancestrial source of the current rainbow trout population. The results of the first part of this study (Phelps, 1980) indicated that the present rainbow trout population in Lake Koocanusa was derived from a coastal type rainbow trout. It was also reported that the Jocko River Hatchery stock was significantly different from the current rainbow trout population in Lake Koocanusa. Since this initial study indicated that native or Jocko River Hatchery rainbow trout are not likely the source of rainbow trout in Lake Koocanusa, the Canadian hatchery appeared to be the source and cause of the current increase of the rainbow trout population in Lake Koocanusa. This report presents the results of samples taken from the Canadian hatchery.

METHODS

Five separate stocks of rainbow trout are currently maintained at the Kootenay Trout Hatchery at Wardner, B.C., although some of the stocks have had introductions from the same source (See Appendix 1 for stock composition histories). Samples from each stock were collected in March 1980. Stock name and corresponding sample sizes are: Badger Lake-33; Beaver Lake-54; Duncan-33; Premier Lake-37; Spahomin-45.

Horizontal starch gel electrophoresis was conducted according to the methods of Utter, Hodgins, and Allendorf (1974). The buffer systems and staining methods used in this study are described by Allendorf et al. (1977). The nomenclature used to describe the gene loci and the allele variants encoding the enzymes surveyed follows the system proposed by Allendorf and Utter (1979).

Muscle, liver and eye tissue samples were used for the analysis. Twenty enzymes (38 loci) were chosen on the basis of adequate resolution, enzyme activity and genetic variation. The tissue and buffer system combinations with the best activity and resolution generally agree with Allendorf et al. (1977).

RESULTS AND DISCUSSION

The five stocks of rainbow trout from the Kootenay Trout Hatchery are all very similar to each other in allelic composition and gene frequencies at variable loci (Table 1). The Badger Lake stock and Premier Lake stock have more polymorphic loci and are closer genetically to each other than to the other three stocks. All of these stocks have allele frequencies at Ldh-4 and Sod which are typical of the inland type of rainbow trout (Table 2).

Introuctions of coastal type rainbow trout stocks apparently contributed little if any genes to the present stocks.

Since the five Kootenay rainbow trout stocks are genetically similar to each other, we combined the gene frequency data of all five stocks to compare the Kootenay hatchery rainbow trout to those from Lake Koocanusa. A locus by locus comparison of the Kootenay Hatchery to that of Lake Koocanusa fish indicate significant differences at 5 of the 9 loci compared (Table 3). There are also five alleles present in Lake Koocanusa rainbow trout which are absent from the Kootenay Hatchery stocks and two alleles present in the Kootenay Hatchery which do not occur in the Lake Koocanusa sample (Table 1). These results indicate that the Canadian Hatchery is <u>not</u> the source of the rainbow trout in Lake Koocanusa.

The findings of this study are somewhat perplexing since the three likely origins of the rainbow trout population now present in Lake Koocanusa that were originally proposed have all been discredited. How can these findings be explained? The single sample taken from Lake Koocanusa may not be representative of the entire rainbow trout population; that is, there may be more than one rainbow trout stock present in the reservoir. We recommend that additional samples be taken in various parts of the reservoir. Information from these samples will give us a better idea of the population structure of the rainbow trout in the lake.

Another possible explanation is that the present rainbow trout population in Lake Koocanusa developed from hatchery rainbow trout plantings during the 1950's and 1960's in the Kootenai River Drainage. Survivors from these early plantings, or migrants from plantings downstream from the dam location, may have maintained low population numbers in the river environment.

Then, when the reservoir was created, the rainbow trout population rapidly expanded into this unoccupied niche. This would account for why the westslope cutthroat trout enhancement appeared initially successful. Samples from tributary streams may indicate the major reproductive areas for the reservoir.

CONCLUSION

The data collected so far on the Lake Koocanusa rainbow trout population indicate that these fish are a coastal type of rainbow trout. This eliminates the native inland rainbow trout and the Canadian hatchery as possible sources of the current population. The Jocko River Hatchery contains coastal type rainbow trout but the present population at the hatchery is significantly different from the sample of rainbow trout from Lake Koocanusa. This indicates that natural reproduction of progeny of a hatchery planted coastal type rainbow trout is the source of the current increase in numbers in the rainbow trout fishery.

Table 1.

The number of copies and frequency of each allele at variable gene loci in the five hatchery from the Kootenay Trout Hatchery, B.C. Canada, Lake Koocanusa, and the Jocko River State Trout Hatchery, Montana.

Locus (i) Alleles		Agp-1 100,140	Ck-1,2 100,76	Idh-2 100,140	Idh-3 100,70,42,121	Ldh-4 100,76	Mdh-1 100,40
Badger Lake Stock	# of genes	66 ,0	66 ,0	63 ,3	No Data	26 ,40	66 ,0
	Freq.	1.00,0	1.00,0	0.95,0.05		0.39, 0.61	1.00,0
Beaver Lake Stock	# of genes	104 ,0	104 ,0	104 ,0	No Data	28 ,78	104 ,0
	freq.	1.00,0	1.00,0	1.00,0		0.26, 0.74	1.00,0
Duncan Stock	# of genes	66 ,0	66 ,0	66 ,0	0, 24, 3, 0	0 ,66	66 ,0
	freq.	1.00,0	100 ,0	1.00,0	0,0.89,0.11, 0	0 , 1.00	1.00,0
Premier Lake Stock	# of genes	74 ,0	74 ,0	65 ,9	0, 21, 9, 0	22 ,52	74 ,0
	freq.	1.00,0	1.00,0	0.88,0.12	0,0.70,0.30, 0	0.30, 0.70	1.00,0
Spahomin Stock	# of genes	90 ,0	90 ,0	90 ,0	0, 52, 0, 0	37 ,53	87 ,3
	freq.	1.00,0	1.00,0	1.00,0	0,1.00, 0, 0	0.41, 0.59	0.97,0.03
Lake Koocanusa	# of genes	145 ,1	146 ,0	No Data	67, 33, 20, 3	141 , 4	142 ,4
	freq.	0.99,0.01	1.00,0		0.55,0.27,0.16,0.02	0.97, 0.03	0.97,0.03
Jocko River Hatchery	# of genes						
	freq.	0.99,0.01	0.96,0.04	0.81, 0.19	0.44,0.06,0.42,0.08	0.95,0.05	1.00,0

Table 1 continued

Locus (i)		Mdh-3,4	Me-1	Pgm-1	Pgm-2	Sdh	Sod	Pgm-1 (liver)
Alleles		100, 67, 125	100, 57, 110	100, 123	100, 90, 115	100, 42	100, 152	freq of enzyme activity
Badger Lake Stock	# of genes	105, 5, 22	64, 0, 2	58, 8	64, 0, 2	64, 2	66, 0	
	freq.	0.79,0.04,0.17	0.97, 0,0.03	0.88,0.12	0.97, 0,0.03	0.97,0.03	1.00, 0	0
Beaver Lake Stock	# of genes	152, 4, 52	104, 0, 0	104, 0	104, 0, 0	104, 0	104, 0	
	freq.	0.73,0.02,0.25	1.00, 0, 0	1.00, 0	1.00, 0, 0	1.00, 0	1.00, 0	0
Duncan Stock	# of genes	126, 0, 2	66, 0, 0	66, 0	66, 0, 0	66, 0	66, 0	
	freq.	0.98, 0,0.02	1.00, 0, 0	1.00, 0	1.00, 0, 0	1.00, 0	1.00, 0	0
Premier Lake Stock	# of genes	133, 7, 8	71, 0, 3	70, 4	72, 0, 2	72, 2	74, 0	
	freq.	0.90,0.05,0.05	0.96, 0,0.04	0.95,0.05	0.97, 0,0.03	0.97,0.03	1.00, 0	0
Spahomin Stock	# of genes	103, 14, 23	90, 0, 0	90, 0	90, 0, 0	90, 0	90, 0	
	freq.	0.79,0.08,0.13	1.00, 0, 0	1.00, 0	1.00, 0, 0	1.00, 0	1.00, 0	0
Lake Koocanusa	# of genes	264, 22, 5	144, 2, 0	No Data	129, 17, 0	144, 2	118, 28	No Data
	freq.	0.90,0.08,0.02	0.99,0.01, 0		0.88,0.22, 0	0.99,0.01	0.81,0.19	
Jocko River Hatchery	# of genes							
	freq.	0.84,0.16, 0	0.99,0.01, 0	1.00, 0	0.95,0.05, 0	0.99,0.01	0.80,0.20	0.07

Table 2. Allele frequencies at Ldh-4(100) and Sod(100) in the coastal type and inland type rainbow trout.

Coastal Populations	Genes Sampled	Allele Frequency Ldh-4 (100)	Sod (100)	Reference*
Arbo Creek, MT	60	.883	.700	a
Raymond Creek, MT	36	1.000	.944	a
Star Creek, MT	100	1.000	.740	a
Morse Lake, WA	112	.955	.572	b
Chambers Creek Hatchery, WA	86	1.000	.442	b
Entiat Hatchery, WA	90	1.000	.656	c
Quinault River, WA	80	.975	.575	b
Washougal River, WA	360	.841	.720	b
Jocko Hatchery, MT	764	.950	.805	a,d
Lake Koocanusa, MT	146	.966	.808	e
Inland Populations				
North Fork Callahan Creek, MT	80	.488	1.000	a
Callahan Creek, MT	80	.539	.988	a
Deschutes River, OR	80	.400	.962	b
Pahsimeroi River, ID	80	.388	.938	b
Kootenay Hatchery, Canada				
Badger Lake Stock	66	.394	1.000	f
Beaver Lake Stock	106	.264	1.000	f
Duncan Stock	66	.000	1.000	f
Premier Lake Stock	74	.297	1.000	f
Spahomin Stock	90	.411	1.000	f

*a. Allendorf et al. 1980; b. Allendorf 1975; c. Utter and Hodgins 1972; d. unpublished data; e. Phelps 1980; f. this paper.

Table 3. Variable alleles at individual gene loci, allele frequencies, and χ^2 values between the Lake Koocanusa rainbow trout population and the combined Canadian hatchery stocks.

Loci	Lake Koocanusa	Combined Kootenay Hatchery stocks	χ^2	P
Agp-2	100, 140 (.99, .01)	100 (1.00)	2.74_{1df}	not significant
Idh-3	100, 70, 42, 121 (.55, .27, .16, .02)	70, 42 (.89, .11)	134.53_{3df}	<.001
Ldh-4	100, 76 (.97, .03)	100, 76 (.28, .72)	204.75_{1df}	<.001
Mdh-1,2	100, 40 (.97, .03)	100, 40 (.99, .01)	3.34_{1df}	not significant
Mdh-3,4	100, 67, 125 (.90, .08, .02)	100, 67, 125 (.82, .04, .14)	37.97_{2df}	<.001
Me-1	100, 57 (.99, .01)	100, 110 (.99, .01)	$3.43_{2\ df}$	not significant
Pgm-2	100, 90 (.88, .22)	100, 115 (.99, .01)	49.33_{2df}	<.001
Sdh	100, 42 (.99, .01)	100, 42 (.99, .01)	0.14_{1df}	not significant
Sod	100, 152 (.81, .19)	100 (1.00)	80.84_{1df}	<.001

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Appendix 1.

The stock histories of the 5 "genetic" groups of rainbow trout presently being reared at the Kootenay Trout Hatchery at Wardner, B.C.

1. Duncan: Parent Stock - Duncan River (Gerrard) natural stock.
2. Spahomin (Pennask outlet spawners): Parent Stock Pennask Lake natural stock.
3. Badger Lake: Parent Stock (mid 1970's) - Tunkwa, Pinantan, Beaver, Premier Lakes.
4. Premier Lake: Parent Stock (1957 - 58) - Premier, Knouff, Beaver, Pennask, Loon and domestic Rainbow from Washington.
5. Beaver Lake: (Prior to 1900) Parent Stock - Domestic Rainbow from Washington and California, Paul, Pinantan, Lejeune, Beaver, Oyama, Lardeau, Knouff, Spahomin, Pennask.

Native rainbow trout in Montana: Pipe and Bobtail Creeks

Genetics Report 80/4

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20 June 1980

INTRODUCTION

Rainbow trout (Salmo gairdneri) are now considered native to the Kootenai drainage of Montana and are a "species of special concern" (Holton 1980). Indigenous populations were identified in Callahan Creek and a mixture of native and hatchery fish occur in the Yaak River and O'Brien Creek (Allendorf et al. 1980, Phelps 1979). There appears to be some reproductive isolation between these two groups in O'Brien Creek. All of these areas in which native rainbow trout have been found are downstream from Kootenai Falls which is suspected to have acted as an upstream barrier to the movement and colinization of native rainbow trout.

Pipe and Bobtail Creeks are tributaries of the Kootenai River upstream from Kootenai Falls (upper Kootenai River). These two creeks presently have large spawning runs of rainbow trout from the Kootenai River each spring. Fertilized eggs from these creeks are being transplanted into O'Brien Creek to try to develop a spawning run of rainbow trout from the lower Kootenai River into this tributary stream (Bruce May, personal communication). Since O'Brien Creek contains native rainbow trout, the impact of these plantings upon the small native population needed to be assessed. To accomplish this, the origin of the rainbow trout (i.e., hatchery or native) from Pipe and Bobtail Creek first has to be known.

Native rainbow trout populations in Montana can be discriminated from hatchery planted rainbow trout by gene frequency differences at two diagnostic gene loci, Ldh-4 and Sod. These two loci have previously been found to be the most useful in biochemically discriminating between the coastal and inland forms of rainbow trout (Allendorf 1975, Utter and Allendorf 1978). These are the two major taxonomic groups of rainbow trout in western North America (Allendorf and Utter 1979, Behnke 1979).

Hatchery stocks of rainbow trout were derived from the coastal type populations (MacCrimmon 1971). Therefore, rainbow trout populations in the Kootenai River drainage with gene frequencies at Ldh-4 and Sod similar to that of the inland group, represent indigenous native rainbow trout.

MATERIALS AND METHODS

Forty-four and 52 rainbow trout were collected from Pipe and Bobtail Creek respectively in August 1979 by MDFWP personnel.

Horizontal starch gel electrophoresis was conducted according to the methods of Utter, Hodgins, and Allendorf (1974). The buffer systems and staining methods used in this study are described by Allendorf et al. (1977). The nomenclature used to describe the gene loci and the allele variants encoding the enzymes surveyed follows the system proposed by Allendorf and Utter (1979).

Muscle, liver and eye tissue samples were used for the analysis. Twenty enzymes (38 loci) were chosen on the basis of adequate resolution enzyme activity and genetic variation. The tissue and buffer system combinations with the best activity and resolution generally agree with Allendorf et al. (1977).

RESULTS AND DISCUSSION

Rainbow trout from Pipe and Bobtail creeks appear to contain genes from hatchery as well as native rainbow trout. The Ldh-4(100) and Sod (100) allele frequencies are intermediate between the coastal type and the inland type of rainbow trout (Table 1). This is similar to what was found in the Yaak River and O'Brien Creek.

We have used the measure proposed by Nei (1972) to estimate the degree of genetic identity between populations of rainbow trout in the Kootenai drainage and the Jocko River State trout hatchery (Table 2). The magnitude of the genetic identity estimates should not be compared with other studies because of the selected sample of only two loci. The identity relationships among these populations are demonstrated through the use of numerical taxonomy technique shown in Figure 1. Pipe Creek clusters with the other intermediate populations of O'Brien Creek and the Yaak River. Bobtail Creek, however, clusters more closely with the coastal type populations.

Significant χ^2, $p<.05$, (2x2 contingency tables of allele frequencies) values at Idh-2 and Ldh-4 between these two creeks indicate that there is some reproductive isolation between these two creeks (Table 3). Variation occurs at Mdh-1,2 only in Pipe Creek and a Me-1(120) allele occurs solely in Bobtail Creek. Although these variant alleles occur at low frequency, they further support the lack of gene flow between these two creeks.

A deficit of heterozygotes at a locus from the expected Hardy-Weinberg genotypic proportions ($p^2 + 2pq + q^2 = 1$, where p and q are the allele frequencies) is an indication of non-random mating within a population. When the gene frequency at a locus sufficiently differs between two populations, a sample containing both populations will also show a deficit of heterozygotes (the Walhund effect). The gene frequency differences are maintianed by reproductive isolation (i.e., no gene flow). Since these creeks show evidence of both coastal and inland rainbow trout, any assortative mating between these two groups could result in a deficit of heterozygotes at the two diagnostic loci which differ in gene frequency.

This prediction is exactly what was found. Significant deficits of heterozygotes occur at Sod in Pipe Creek ($\chi^2_{1df} = 6.31$, $p<.025$) and at Ldh-4 in Bobtail Creek ($\chi^2 = 6.96$, $p<.01$) (Table 3). This evidence for assortative mating between the two types of rainbow trout is the same as what was found in O'Brien Creek.

Another measure of non-random mating is linkage disequilibrium. Assortative mating within rainbow trout of like origin (coastal or inland) will generate nonrandom associations between the alleles at different loci when gene frequency differences occur at these loci. These associations will persist even after several generations of random mating and are therefore more useful than comparing observed genotypes from those expected under Hardy-Weinberg equilibrium, since one generation of random mating will erase any of these differences. In the case of unlinked loci, (loci which occur on different chromosomes) the coefficient of linkage disequilibrium ($\underline{D}$) will decrease by one-half each generation. Linkage between the two loci will delay the approach to random association: ($\underline{D}' = (1-\underline{r})\underline{D}$, where $\underline{r}$ is the rate or recombination and $\underline{D}'$ is the coefficient of linkage disequilibrium in the next generation. Linkage disequilibrium occurs in Bobtail Creek between Idh-2 and Sod ($\chi^2_{1df} = 6.42$, P .025); Ldh-4 and Pgm-2 ($\chi^2_{1df} = 4.41$, P .05). These results further support the evidence for the co-existence and reproductive isolation between the inland and coastal forms of rainbow trout in this creek. (See Appendix 1 for $\underline{D}$ values).

Where did these native (inland) type rainbow trout in Pipe and Bobtail Creek come from? There appears to be two possibilities at the present time. They could have originated from below Kootenai Falls or they could have come from the Canadian rainbow trout hatchery at Wardner, B.C. Both these areas have been identified as having inland type rainbow trout populations (Phelps 1980; Allendorf et al. 1980).

It is not likely that rainbow trout could have gotten above Kootenai Falls naturally (Bruce May, personal communication). Also, inland populations of cutthroat trout S. clarki occur naturally only in areas in which rainbow trout were historically excluded (Behnke 1979). Montana Department of Fish, Wildlife, and parks (MDFWP) records indicate the westslope cutthroat trout was native to this area. There are no MDFWP records of rainbow trout being planted from below Kootenai Falls into this area (Emmit Colley, personal communication). The possibility of unrecorded plantings from below the falls into the upper Kootenai River, however, cannot be ruled out.

The Canadian hatchery (Kootenay trout hatchery) also cannot be ruled out as a source for the inland rainbow in Pipe and Bobtail Creeks. Inland type rainbow trout from the Upper Columbia drainage were transported to this hatchery and stocked in lakes and rivers in the Kootenai drainage. Rainbow trout would have had to move downstream over 100 miles to occupy the area of Pipe and Bobtail Creek. Since the construction of Libby Dam this journey would be more difficult. There is also no evidence of inland type rainbow trout in Lake Koocanusa, however, only one sample of rainbow trout has been analyzed from the reservoir (Phelps and Allendorf 1980).

CONCLUSION

Spawning runs of rainbow trout into Pipe and Bobtail Creeks consist of a combination of inland and coastal type rainbow trout. This is essentially the same composition of rainbow trout that is already present in O'Brien Creek. Therefore, the plantings of rainbow trout eggs from Pipe and Bobtail Creeks should not cause a swamping effect by the hatchery type rainbow trout and subsequent loss of native rainbow trout from O'Brien Creek.

The possible breakdown of what appears to be some degree of reproductive isolation between the coastal and inland form of rainbow trout that occur in

O'Brien Creek can only be answered by subsequent samples of the progeny of these planted eggs. We may expect that this isolation to continue since the introduced stocks also show some degree of non-random mating. This depends, however, upon what factors are causing the reproductive isolation to occur. A study which would identify possible isolating mechanisms, both environmental and genetic, would be a big step in predicting what will happen when these two types of rainbow trout occur sympatrically. This would provide information on the vulnerability of these remaining native populations to genetic mixing and the resulting loss of these native salmonid populations from Montana.

Table 1. Stock composition and allele frequencies at the Ldh-4 and Sod loci of rainbow trout populations in the Kootenai drainage, the Jocko River State trout hatchery and the Kootenay trout hatchery, Wardner, British Columbia.

Stock composition	Sample number	Sample area	Genes Sampled	Ldh-4 (100)	Sod (100)
1 Native Rainbow Trout	1	Callahan Creek, MT	80	.539	.988
	2	South Callahan Creek, MT	80	.488	1.000
		Kootenay hatchery, BC			
	3	Badger Lake Stock	66	.394	1.000
	4	Beaver Lake Stock	106	.264	1.000
	5	Duncan Stock	66	.000	1.000
	6	Premier Lake Stock	74	.297	1.000
	7	Spahomin Stock	145	.411	1.000
2 Mixed Native and Hatchery Rainbow Trout	8	O'Brien Creek, MT	30	.800	.970
	9	Yaak River, MT	80	.700	.912
	10	Bobtail Creek	104	.837	.716
	11	Pipe Creek	88	.693	.774
	12	Arbo Creek, MT	60	.883	.700
3 Planted Hatchery (Coastal Rainbow Trout)	13	Raymond Creek, MT	36	1.000	.944
	14	Star Creek, ID	100	1.000	.740
	15	Jocko River State Trout Hatchery, MT	760	.954	.805

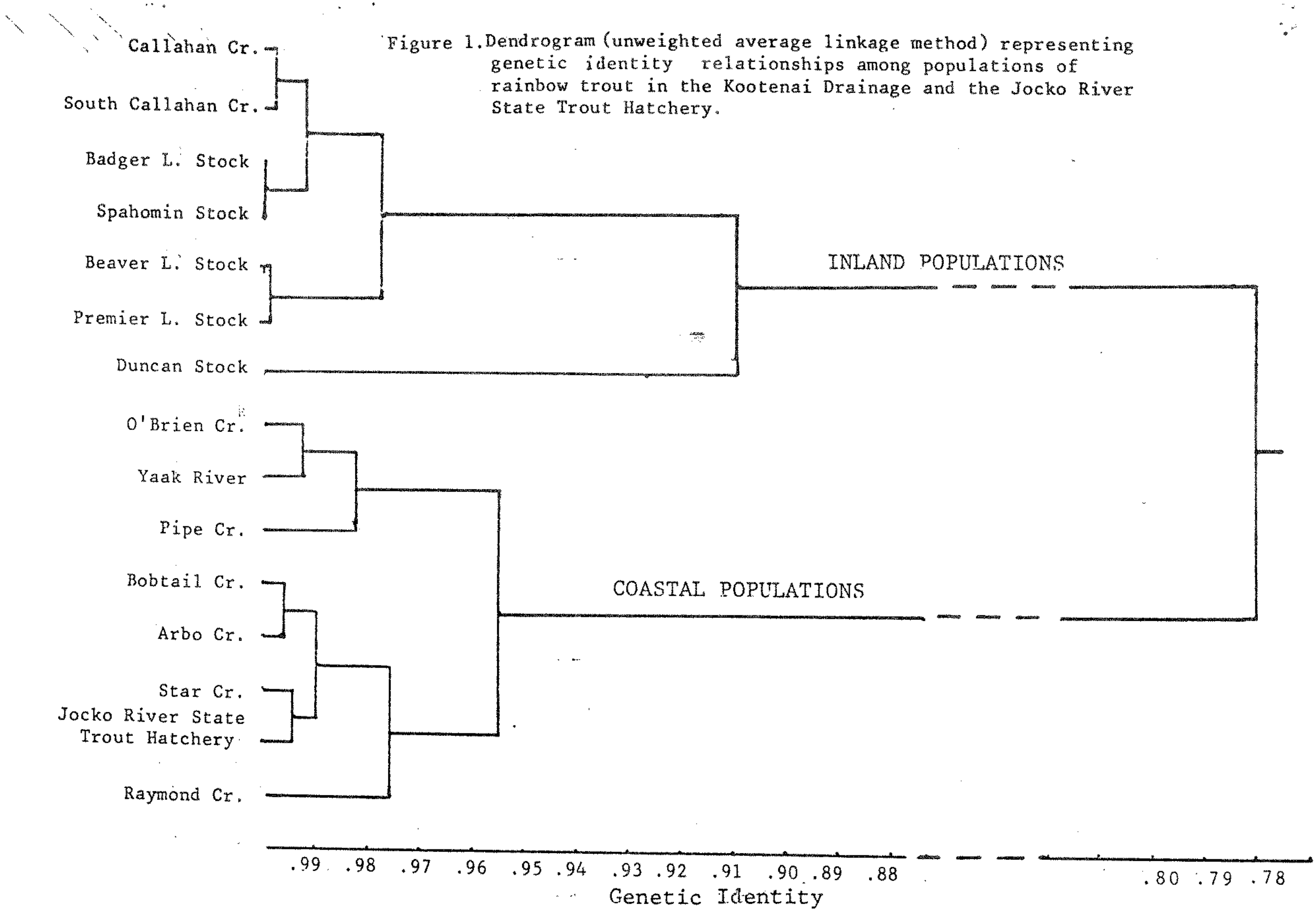
Table 2. Genetic identity matrix after Nei (1972) between populations of rainbow trout in the Kootenai River drainage and the Jocko River State Trout Hatchery. (see Table 1 for sample names)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	CAT														
2	CAI	0.969													
3	PAC	0.922	0.953												
4	SPA	0.930	0.961	0.992											
5	REL	0.856	0.838	0.935	0.927										
6	PRY	0.873	0.965	0.951	0.943	0.994									
7	OBW	0.861	0.829	0.782	0.791	0.717	0.734								
8	YAA	0.881	0.859	0.803	0.811	0.729	0.755	0.921							
9	PIP	0.816	0.799	0.737	0.740	0.672	0.669	0.8[illegible]	0.928						
10	RCS	0.715	0.684	0.637	0.645	0.572	0.589	0.855	0.834	0.899					
11	ARP	0.684	0.653	0.606	0.614	0.541	0.557	0.823	0.803	0.863	0.969				
12	STM	0.646	0.614	0.567	0.576	0.502	0.519	0.785	0.764	0.830	0.906	0.922			
13	JOJ	0.701	0.670	0.623	0.631	0.558	0.574	0.841	0.820	0.854	0.897	0.912	0.944		
14	PAV	0.748	0.716	0.669	0.678	0.604	0.621	0.887	0.834	0.762	0.804	0.820	0.898	0.903	
15	DUR	0.725	0.756	0.803	0.795	0.863	0.852	0.585	0.606	0.541	0.440	0.409	0.370	0.425	0.472

Table 3. Observed and expected genotypes, frequency of the 100 allele and χ^2 tests of significance for gene frequency differences between Pipe and Bobtail Creek and differences from expected Hardy-Weinbert proportions in each creek at selected loci.

Locus	Creek	AA	AA'	A'A'	χ^2_{HW}	freq. of A allele	χ^2 between creeks
Idh-2	Pipe	37	15	0	1.50	0.856	
		(38.1)	(12.8)	(1.1)			4.47
	Bobtail	22	19	2	0.72	0.733	
		(23.1)	(16.8)	(3.1)			
Ldh-4	Pipe	39	9	4			
		(36.4)	(14.2)	1.4)	6.96	0.837	
	Bobtail	21	19	4			5.55
		(21.1)	(18.7)	(4.2)	0.11	0.693	
Pgm-2	Pipe	40	12	0	0.94	0.885	
		(40.7)	(10.6)	0.7)			0.08
	Bobtail	36	7	1	0.76	0.898	
		(35.5)	(8.1)	(0.5)			
Sod	Pipe	26	21	4	0.01	0.716	0.81
		(26.2)	(20.7)	(4.1)			
	Bobtail	28	9	5	6.31	0.774	
		(25.2)	(14.7)	(2.2)			

Figure 1. Dendrogram (unweighted average linkage method) representing genetic identity relationships among populations of rainbow trout in the Kootenai Drainage and the Jocko River State Trout Hatchery.



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Appendix 1. Linkage disequilibrium coefficients estimated in trout collected from Mill Creek. Values were estimated using the method of Hill (1974). Values of D are listed above the diagonal and values of D' = (D/D_{max}) are listed below the diagonal.

Pipe Creek	Idh-2	Ldh-4	Mdh-B	Pgm-2	Sod
Idh-2	-----	0.012	-0.008	0.015	0.031
Ldh-4	0.062	-----	-0.020	0.019	0.001
Mdh-B	0.131	0.277	-----	-0.015	-0.026
Pgm-2	0.168	0.233	0.570	-----	0.029
Sod	0.196	0.009	0.508	0.305	-----

Bobtail Creek					
Idh-2	-----	0.115	-0.004	0.017	-0.040
Ldh-4	0.095	-----	0.006	0.033	-0.005
Mdh-B	0.249	0.061	-----	-0.016	-0.013
Pgm-2	0.162	0.311	0.999	-----	0.011
Sod	1.000	0.110	0.398	0.117	-----