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A FISHERIES INVENTORY OF BEAR CREEK PRIOR TO PROPOSED MINERAL MINING AT JARDINE, MONTANA

Prepared For
Homestake Mining Co., Golden, Colorado

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ABSTRACT

A fisheries inventory was initiated on Bear Creek to provide baseline fisheries data prior to proposed mineral mining in the Jardine vicinity. Bear Creek was found to support a relatively substantial spawning migration of Yellowstone River cutthroat trout. Captured fish were implanted with numbered Floy tags to provide future information on the movements of these fish. The spawning migration appeared to be confined to the lower portions of Bear Creek and peaked between July 9 and July 22, 1981. Attempts to document use of the stream by migrating Yellowstone River brown trout and mountain whitefish by electrofishing were unsuccessful, although spawning whitefish were visually observed in the extreme lower portions of the stream in November. Resident trout populations were investigated in three 1,000 foot sections of the stream. The dominant gamefish in Bear Creek is the rainbow X cutthroat hybrid trout. Numbers of these hybrids ranged between 65 and 151 fish per 1,000 feet in the three study sections. Hybrids were followed in abundance by Yellowstone cutthroat trout. Cutthroat trout were collected in all three study sections but were most abundant in the upstream trail section at 42 fish per 1,000 feet. Rainbow trout were collected in low numbers in all three study sections while low numbers of brown trout and mountain whitefish were collected in the Powerhouse section near the mouth of the stream. The most productive fishery was found in the LePage section immediately downstream from Jardine.

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INTRODUCTION

Placer gold was first discovered in Bear Creek in 1866 by "Uncle" Joe Brown who separated gold from streambed gravels with a sluicing operation (Lyden 1948). Brown's sluice was succeeded by hydraulic giants in the working of the streambed but this process was abandoned in 1885 due to poor production. Since that time, gold mining in the Bear Creek drainage has continued intermittently and has largely been confined to underground workings.

Modern methods of mining and separating gold from native ores combined with high gold prices have resulted in a renewed interest in historic gold producing areas throughout Montana. The Bear Creek drainage is no exception to this trend and the Homestake Mining Company of Golden, Colorado, has proposed plans for an expanded gold mining operation near the town of Jardine, Montana. The proposed mining activities call for an underground load operation centered in the vicinity of Mineral Hill and old tailings above the town of Jardine. Plans also call for the construction of an on-site concentration mill which would use a flotation process to concentrate the ore. The ore would then be shipped out of the area for smelting.

Prior to this study, little was known of the Bear Creek fishery or of impacts of past or potential mining and logging operations on that fishery. Bear Creek has been known to support an abundant population of cutthroat trout (Hanzel 1961) and a recreational fishery estimated in 1975-1976 at 171 fisherman days per year (MDFWP 1976). Berg (1975) mentioned timber harvest and proposed mineral mining as potential threats to the Bear Creek fishery but did not include the stream in his study of Yellowstone River tributaries. Mineral mining and processing operations have been found to have adverse impacts on stream fisheries in some cases. These potential impacts include the production of increased suspended solids and bedload sediments, altered pH levels, the discharge of heavy metals into the stream and alterations in stream channel and stream flow (AFS 1980). In the interest of gaining baseline information on the composition and magnitude of the Bear Creek fishery and the use of the stream by migrating Yellowstone River fish as a spawning site, this study was initiated by the MDFWP and funded by the Homestake Mining Company in June of 1981.

STUDY AREA

Bear Creek originates on the northwest end of the Absaroka Range and flows approximately 12 miles to its confluence with the Yellowstone River about 1.75 miles west of Gardiner, Montana, at the Yellowstone National Park boundary (Figure 1). Headwater tributaries of the mainstem stream arise at elevations of 8,800 to 9,400 feet and tributaries of the North Fork of Bear Creek originate at 9,600 to 10,000 feet above sea level. The stream drops rapidly through coniferous forests and steep sided canyons to an elevation of approximately 5,200 feet at its mouth. The estimated gradient of the

stream averages about 333 feet per mile and ranges between about 267 feet per mile for the 7.5 mile reach between Darroch Creek and the mouth to about 533 feet per mile for the canyon area near the mouth. Bear Creek drains an area of about 43.5 square miles. Major tributaries include Darroch, the North Fork, Pine, Pole and Palmer Creeks.

Bear Creek flows through the town of Jardine, Montana, at approximately stream mile 3.5. Jardine has been the center of gold mining activities and an arsenic plant in the past. Old tailings piles can be observed immediately above the town to the east. The proposed mining operations are also to be located east of town in the vicinity of Mineral Hill and the ore is to be concentrated in Jardine.

Bear Creek is a low conductance soft water stream characterized by an alkaline pH, low turbidity, high concentrations of dissolved oxygen, and low concentrations of dissolved ionic constituents (Westech 1981). Despite its past mining history, preliminary measurements of heavy metals in Bear Creek indicate that concentrations are generally below levels known to be detrimental to fish. The only possible exception was found in copper concentrations which in combination with the soft water of the stream could represent a potential threat to trout populations (Dr. G. Pagenkopf, personal communication). Stream discharge was measured at 125.1 cfs at the Jardine Bridge on July 8, 1981, and at 33.1 cfs on August 11, 1981, at the same station (Westech 1981).

The substrate of Bear Creek is composed mainly of large rubble, rocks and boulders due to the high gradient of the stream. Most fish cover is provided instream as pools and depressions behind rocks and boulders. Streambank cover appeared to be incidental, especially at low summer flows, due to the widely scoured nature of the channel from high spring runoff flows. Instream vegetation was largely composed of microscopic periphyton; however, large skeins of filamentous algae were observed in the LePage section at Jardine during the month of August. This bloom of filamentous algae may have been due to unidentified nutrient releases in the Jardine vicinity.

METHODS

The fisheries inventory of Bear Creek was initiated in June of 1981 to gain base-line data on the use of the stream as a spawning site for migratory Yellowstone River gamefish and to determine the species composition and magnitude of resident gamefish populations.

The sampling effort was concentrated in three 1,000 foot sections known as the Powerhouse, LePage, and Trail sections (Figure 1, Table 1). Single sampling runs were made in two other 1,000 foot sections, the Upper Powerhouse and Darroch sections, in search of migratory Yellowstone cutthroat trout.

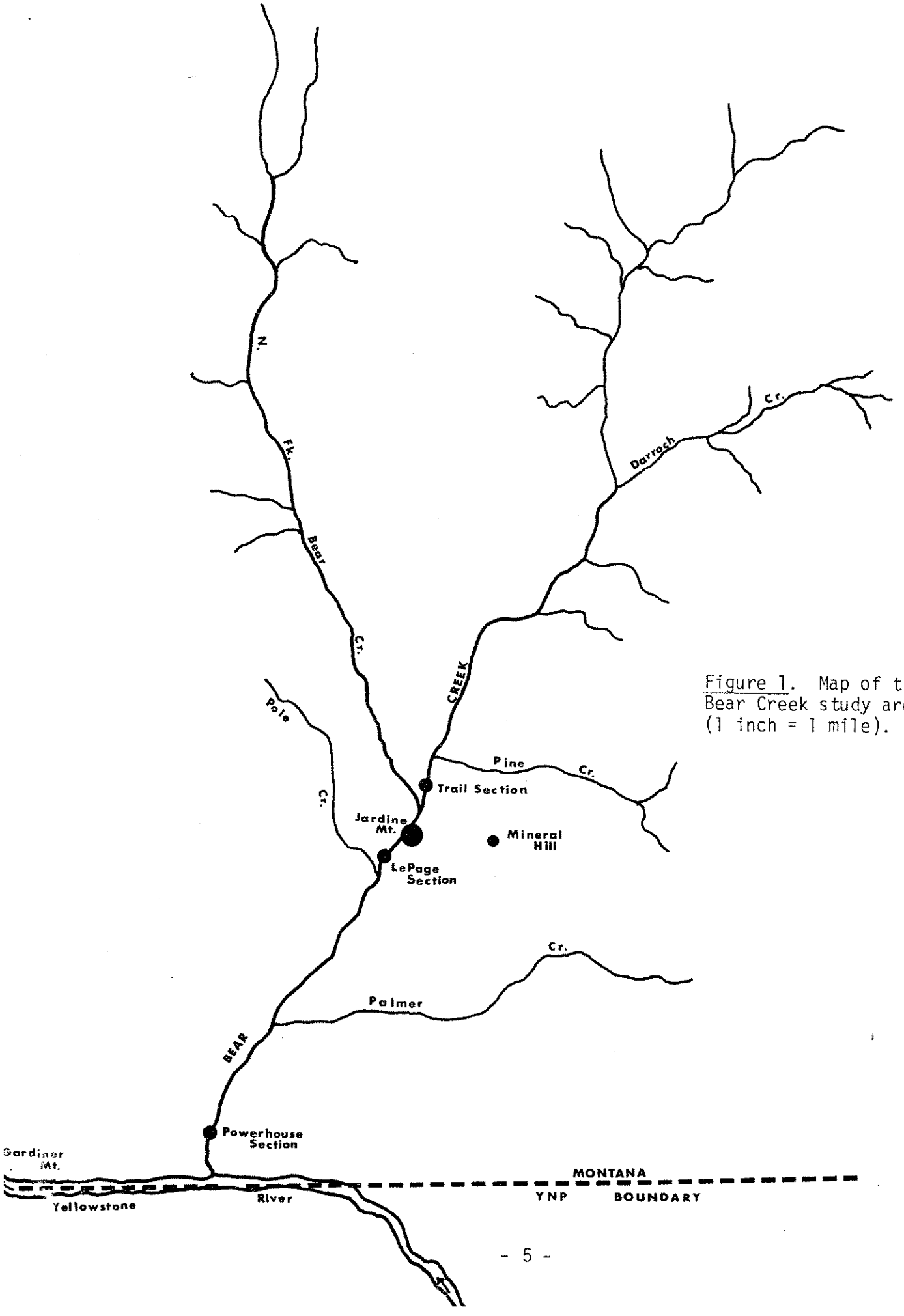

Figure 1. Map of the Bear Creek study area (1 inch = 1 mile).

Table 1. The locations of 1,000 foot electrofishing sections sampled on Bear Creek during the 1981 sampling season.

Section	Legal Description	Stream Mile
Powerhouse	T9S, R9E, Sec 19D	0.50
Upper Powerhouse	T9S, R9E, Sec 19D	0.70
LePage	T9S, R9E, Sec 8A	3.25
Trail	T9S, R9E, Sec 4C	4.25
Darroch	T8S, R9E, Sec 27D	7.50

Fish migrations and populations were sampled by using a bank electrofishing unit consisting of a 110 volt Honda generator, a Fisher shocker box, a 500 foot electric cord, a stationary negative electrode and a mobile positive electrode. Direct current was used to draw fish to the positive electrode where they were netted and held in a live car.

During the phase of the study concerned with the documentation of spawning migrations, captured fish were anesthetized, measured, weighed, marked with individually numbered red Floy tags and a complete adipose fin clip and released. Scale samples were also collected from each fish for age determination. One run was made through a particular sample section on each sample date. Most of the sampling effort was concentrated in the Powerhouse section during July for migrating cutthroat trout and during October and November for migrating brown trout and mountain whitefish (Table 2).

Table 2. Sampling schedule implemented at Bear Creek during the 1981 sampling season.

Section	Sample Date	Purpose
Powerhouse	6/29	Cutthroat trout migration
Powerhouse	7/6	Cutthroat trout migration
Powerhouse	7/9	Cutthroat trout migration
Powerhouse	7/14	Cutthroat trout migration
LePage	7/16	Cutthroat trout migration
Darroch	7/16	Cutthroat trout migration
Powerhouse	7/22	Cutthroat trout migration
Upper Powerhouse	7/23	Cutthroat trout migration
Powerhouse	8/5	Population estimate-mark
LePage	8/6	Population estimate-mark
Trail	8/6	Population estimate-mark
Powerhouse	8/19	Population estimate-recap
LePage	8/20	Population estimate-recap
Trail	8/20	Population estimate-recap
Powerhouse	10/16	Brown Trout-whitefish migration
Powerhouse	11/5	Brown Trout-whitefish migration

To sample resident gamefish populations, two electrofishing runs were made through the Powerhouse, LePage and Trail sections during the month of August (Table 2). During the first run, captured fish were anesthetized, measured, weighed, marked with a partial fin clip on the anal pr pelvic fins, and released. Scale samples were again collected from each fish for aging. After a time period of two weeks, a recapture run was made through each study section. During the second run, lengths, weights and scale samples were collected from each unmarked fish and lengths were measured on marked fish which were noted as recaptures.

Standing crop estimates of numbers of fish per 1,000 feet were calculated by using a modification of the basic formula:

$$P = \frac{MC}{R}$$

where: P = estimated number of fish
M = number of fish initially marked
C = total number of fish collected in recapture run
R = number of marked fish collected in recapture run

Standing crops were estimated by ½ inch group, length group (size groups of similar recapture efficiency), age group, and biomass by using a computer program developed by the MDFWP. The program also calculates average condition factors of fish and average weight by length group. Electrofishing and estimate methods used during this study are discussed by Vincent (1971 and 1974).

RESULTS

Migratory Cutthroat Trout

A relatively substantial spawning migration of Yellowstone River cutthroat trout was documented in Bear Creek during the month of July. A total of 16 migratory cutthroat were captured and tagged between July 9 and July 22, 1981 (Table 3). Three more migratory fish were captured during the August population estimates. These fish were considered to be migrants that had not yet reutrned to the river at the time of capture. Fish were considered to be migrants on the basis of color pattern (normal Yellowstone cutthroat spawning color), large size relative to resident fish, accelerated growth rates relative to resident fish, and breeding condition (sexually ripe or recently spent). An arbitrary minimum length of ten inches was accepted as a conservative point of separation between migrant and resident fish. This resulted in the elimination of four tagged cutthroat between 8.4 and 9.8 from the migrant tally although these fish were in breeding condition. Berg (1975) included some fish between nine and ten inches in his migrant tally of spawning cutthroat in other Yellowstone tributaries.

Table 3. Numbers, length ranges, and sex ratios of migratory Yellowstone River cutthroat trout captured in Bear Creek during the 1981 spawning migration.

Date	Number Captured	Length Range (inches)	Sex Ratio M/F
6/29	-	-	-
7/6	-	-	-
7/9	9	10.5 - 15.8	5/4
7/14	5	10.3 - 16.2	4/1
7/22	2	14.6 - 15.3	1/1
7/23*	-	-	-
8/5**	2	10.8 - 11.0	2/0
8/19**	1	13.4	0/1

*Sample in Upper Powerhouse section; all other samples in Powerhouse section.

**Migratory cutthroat remaining in Bear Creek after the spawning season and captured during the population estimate.

All of the migrating cutthroat collected during the study were captured in the Powerhouse section. Electrofishing runs in upstream sections revealed no migrants so the distance that fish move upstream could not be accurately fixed during this study. Spawning activity appeared to take place between July 9 and July 22, 1981, since all cutthroat captured prior to July 22 were in ripe breeding condition while fish captured after July 22 were spent. Spot temperatures recorded on each sample date ranged between 46 and 54°F during this time period while stream discharge was measured at 125 cfs on July 8 at the Jardine Bridge.

The 19 migrant cutthroat captured during the study were composed of 12 males and 7 females which calculates to a sex ratio of 1.7 males per female. Males averaged 12.5 inches in length (range 10.3 to 15.8 inches) and .74 lb in weight. Females were slightly larger averaging 14.0 inches (range 11.6 to 16.2 inches) and weighing an average of 1.09 lb.

The migrants were composed of age III, age IV, and older fish (Table 4). The majority of the fish were age III or IV and nearly half of the fish collected were age III. The sex ratio for age IV and older fish was even at 1.0 males per female. In the age III group, however, males outnumbered females seven to two for a sex ratio of 3.5 males per female.

Table 4. Numbers and lengths (inches), by age group and sex, of migratory Yellowstone River cutthroat trout captured in Bear Creek during the 1981 spawning migration.

Age Group		Males	Females	All Fish
III	Number	7	2	9
	Length Range	10.3 - 12.7	11.6 - 12.8	10.3 - 12.8
	Average Length	11.0	12.2	11.3
IV	Number	3	3	6
	Length Range	13.7 - 14.0	13.4 - 14.6	13.4 - 14.6
	Average Length	13.9	14.1	14.0
IV+	Number	2	2	4
	Length Range	15.3 - 15.8	15.2 - 16.2	15.2 - 16.2
	Average Length	15.6	15.7	15.6

The rate of recapture of migrant cutthroat tagged in the Powerhouse section was quite low. Of the 16 migrants tagged during the month of July, only one fish, a 10.8 inch male tagged on July 9 and recaptured on July 22, was handled twice. One fish, a 9.6 inch male tagged on July 9, was recaptured on August 5, October 16 and November 5 and subsequently removed from the migrant tally as a probable resident fish. At the time of this report, January of 1982, none of the tags implanted in the migrant cutthroat have been reported by fishermen or MDFWP personnel, therefore no data on the dispersal of these fish in the Yellowstone River is available.

Brown Trout and Mountain Whitefish

Attempts were made to capture migratory brown trout and mountain whitefish during October and November of 1981. The two sampling runs resulted in one 8.6 inch brown trout and no mountain whitefish captured. The single brown trout appeared to be a resident fish, thus no spawning migrations of brown trout or mountain whitefish were documented in the Powerhouse section in 1981. Concentrations of whitefish were visually observed, however, at the footbridge at the mouth of Bear Creek on November 9, 1981. These fish were only observed in the immediate vicinity of the mouth of Bear Creek and appeared to be in the process of spawning because large numbers of eggs were collected in macroinvertebrate kick samples at this time (M. Fillinger, Personal communication).

Low numbers of brown trout and whitefish were collected in the Powerhouse section throughout the course of the 1981 study. Totals of seven brown trout and four whitefish were captured, tagged and released within the section. One brown trout and one whitefish were recaptured in

the section after they had been tagged. No brown trout or mountain whitefish were captured or observed in any of the other sample sections. Brown trout that were captured averaged 10.7 inches in length and were composed of age III or older fish while whitefish averaged 12.2 inches and were also age III or older fish (Table 5).

Table 5. Lengths, weights and numbers of brown trout and mountain whitefish captured in the Powerhouse section between June 29 and November 5, 1981.

Species		Length (in)	Weight (lb)	Number
Brown Trout	Range	8.6 - 12.7	0.25 - 0.81	7
	Average	10.7	0.50	
Mountain Whitefish	Range	11.5 - 13.6	0.41 - 0.91	4
	Average	12.2	0.62	

Resident Populations

Resident gamefish populations were estimated in the Powerhouse, LePage and Trail sections by using a mark-recapture method during the month of August. Electrofishing data for the three sections are summarized in Tables 6, 7, and 8.

Table 6. Summary of electrofishing survey data for the 1,000 foot Powerhouse section (T9S, R9E, Sec 19D) of Bear Creek on August 5 and August 19, 1981.

Species	Number Captured	Length Range (inches)
Rainbow X Cutthroat Hybrid	86	3.0 - 10.2
Cutthroat Trout	21	5.1 - 13.4
Rainbow Trout	7	6.2 - 9.9
Brown Trout	1	10.4
Mountain Whitefish	2	11.9 - 13.6

Table 7. Summary of electrofishing survey data for the 1,000 foot LePage section (T9S, R9E, Sec 8A) of Bear Creek on August 6 and August 20, 1981.

Species	Number Captured	Length Range (inches)
Rainbow X Cutthroat Hybrid	109	2.8 - 12.6
Cutthroat Trout	4	5.3 - 10.8
Rainbow Trout	4	5.5 - 13.0

Table 8. Summary of electrofishing survey data for the 1,000 foot Trail section (T9S, R9E, Sec 4C) of Bear Creek on August 6 and August 20, 1981.

Species	Number Captured	Length Range (inches)
Rainbow X Cutthroat Hybrid	44	3.1 - 10.8
Cutthroat Trout	30	2.7 - 10.6
Rainbow Trout	1	9.1

The dominant gamefish collected in all three sections was the rainbow X cutthroat hybrid trout (Salmo gairdneri X S. clarki). Hybrids were most clearly dominant in the LePage section where they composed 93 percent of the caputred fish. Hybrids were followed in dominance by cutthroat trout (Salmo clarki) which were most abundant in the Trail section (40 percent of captured fish). A limited number of cutthroat from the Trail and Powerhouse sections were collected and preserved for meristic determination of cutthroat strain. All meristic characteristics examined indicated that these fish were of the pure strain of Yellowstone cutthroat trout (J. Roscoe, personal communication). The rainbow trout (Salmo gairdneri) was the only other gamefish common to all three sections and was present in very low numbers. Brown trout (Salmo trutta) and mountain whitefish (Prosopium williamsoni) were collected only in the Powerhouse section which exhibited the highest gamefish diversity of the three sections. Non-game species were not collected or observed in any of the three sections during the course of the study.

Estimates of standing crop (numbers and biomass) were calculated for the resident trout populations of the Powerhouse, LePage and Trail sections where sufficient numbers of a species were captured to insure statistical reliability of the estimate (Tables 9, 10 and 11). Estimates were calculated

for standing crops of rainbow X cutthroat hybrid trout in all three study sections and cutthroat trout in the Trail section. In order to gain a more complete estimate of the gamefish population of each section, estimates based on the combined totals of the rainbow, cutthroat and rainbow X cutthroat hybrid trout were calculated for each section. These combined estimates were also calculated because of the difficulty of on-site separation of pure cutthroat or rainbow trout from the numerous hybrids that were present.

Table 9. Estimated standing crop of trout in the 1,000 foot Powerhouse section (T9S, R9E, Sec 19D) of Bear Creek on August 5, 1981. Eighty percent confidence intervals are in parentheses.

Species*	Length Group (inches)	Per 1,000 ft. Number	Pounds
Rb X Ct	4.0 - 6.9	92	
	7.0 - 10.2	35	
		127(±35)	16(±4)
Rb X Ct; Rb; Ct Combined	4.0 - 6.9	121	
	7.0 - 13.4	67	
		188(±47)	29(±7)

*Rb X Ct = rainbow X cutthroat hybrid; Rb = rainbow trout; Ct = cutthroat trout

Table 10. Estimated standing crop of trout in the 1,000 foot LePage section (T9S, R9E, Sec 8A) of Bear Creek on August 6, 1981. Eighty percent confidence intervals are in parentheses.

Species*	Length Group (inches)	Per 1,000 ft. Number	Pounds
Rb X Ct	4.0 - 6.9	95	
	7.0 - 12.6	56	
		151(±34)	27(±5)
Rb X Ct; Rb; Ct Combined	4.0 - 6.9	111	
	7.0 - 13.0	61	
		172(±39)	31(±5)

*Rb X Ct = rainbow X cutthroat hybrid; Rb = rainbow trout; Ct = cutthroat trout

Table 11. Estimated standing crop of trout in the 1,000 foot Trail section (T9S, R9E, Sec 4C) of Bear Creek on August 6, 1981. Eighty percent confidence intervals are in parentheses.

Species*	Length Group (inches)	Per 1,000 ft. Number	Pounds
Rb X Ct	4.0 - 6.9	50	
	7.0 - 10.8	15	
		65(±19)	8(±2)
Ct	4.0 - 10.6	42	
		42(±13)	9(±3)
Rb X Ct; Rb; Ct Combined	4.0 - 6.9	76	
	7.0 - 10.8	39	
		115(±27)	18(±5)

*Rb X Ct = rainbow X cutthroat hybrid; Rb = rainbow trout; Ct = cutthroat trout

The largest numerical standing crop in terms of combined trout species was estimated in the Powerhouse section at 188 fish per 1,000 feet. The highest trout biomass, however, was found in the LePage section at 31 pounds per 1,000 feet. The lowest standing crops were found in the Trail section where the numerical and biomass estimates were 61 and 58 percent of the observed highs for the Powerhouse and LePage sections. Standing crops of the dominant gamefish, the rainbow X cutthroat hybrid, were highest in both numbers and biomass in the LePage section. While numbers of hybrids in the Powerhouse section approached those estimated in the LePage section, biomass amounted to only 59 percent of the LePage estimate. Hybrid numbers and biomass in the Trail section were far below those estimated for the other two sections. Cutthroat trout were estimated at 42 fish per 1,000 feet in the Trail section. Although the cutthroat trout were exceeded in numbers by rainbow X cutthroat hybrids, cutthroat biomass slightly exceeded that of the hybrids in the Trail section.

Estimates of catchable fish (six inches and larger) within the populations of the three sections were calculated and can be compared on a percent basis. The data showed that catchable fish composed 58 percent of the Powerhouse population, 53 percent of the LePage population and 46 percent of the Trail population for the combined trout estimates. Catchable rainbow X cutthroat hybrids amounted to 45 percent of the Powerhouse population, 55 percent of the LePage population and 30 percent of the Trail population. Seventy-three percent of the Trail section cutthroat population was composed of catchable fish.

Population estimates by age group are given in Table 12. The majority of the rainbow X cutthroat hybrid trout (72 to 79 percent of the sectional populations) were age I and age II fish. Age III hybrids composed between 15 and 19 percent of the population of each section while age IV and older fish were estimated at only four fish per 1,000 feet in the Powerhouse and Trail sections. In the LePage section, however, age IV and older fish were estimated at 16 per 1,000 feet and comprised 11 percent of the hybrid population. The age structure of the Trail section cutthroat population shows that the vast majority of the fish persent were age II and age III fish.

Table 12. Numbers of trout within different age groups from populations estimated in the Powerhouse, LePage and Trail sections on August 5 and August 6, 1981.

Section and Species	Age Group I	II	III	IV+	Total
Powerhouse Rb X Ct	59	40	24	4	127
LePage Rb X Ct	65	44	26	16	151
Trail Rb X Ct	35	17	10	4	66
Trail Ct	6	15	20	2	43

A relative indix of trout growth can be derived through a comparison of the mean lengths of fish within each age group (Table 13). The increment of growth between age I and age II and between age II and age III fish is nearly equal among the three study sections. Mean length at age, however, is slightly higher for each age group in the LePage section when compared with the other sections. This suggests an accelerated growth rate for the LePage section hybrids during their first year of life which is reflected as a greater mean length at age in later years.

Table 13. Mean rainbow X cutthroat hybrid trout length (inches) at different ages from populations estimated in the Powerhouse, LePage and Trail sections on August 5 and August 6, 1981.

Section	Age Group I	II	III	IV+
Powerhouse	4.8	6.2	8.6	10.0
LePage	5.2	6.4	8.8	10.9
Trail	4.9	6.0	8.6	10.6

Another index of trout growth is the condition factor which is based on a weight to length relationship and describes the "heft" or "fatness" of a fish. Rainbow X cutthroat hybrid trout condition factors are given for each section for fish five inches long and larger in Table 14. Mean condition factors dropped markedly as length increased in all three study sections. Hybrid condition was lowest in the Trail section, intermediate in the Powerhouse section and highest in the LePage section.

Table 14. Mean rainbow X cutthroat hybird trout condition factors from populations estimated in the Powerhouse, LePage and Trail sections on August 5 and August 6, 1981.

Section	Length Group (inches)	Condition Factor
Powerhouse	5.0 - 6.9	47.03
	7.0 - 10.2	40.95
	Total	44.30
LePage	5.0 - 6.9	50.09
	7.0 - 12.6	44.33
	Total	46.98
Trail	5.0 - 6.9	43.18
	7.0 - 10.8	41.57
	Total	42.57

DISCUSSION

Migratory Cutthroat Trout

The use of tributary streams by cutthroat trout for spawning and rearing of young has been well documented. Upstream migrations of adult spawners and downstream migrations of juvenile fish have been described for adfluvial Yellowstone (Brown and Bailey 1952, Laakso and Cope 1956) and westslope (Johnson 1953, Bjornn 1957, Averett and MacPhee 1971) cutthroat trout. Much less work has been done on the migrations of fluvial cutthroat from rivers into tributary streams. Thurow and Bjornn (1978) investigated migrations of fluvial westslope cutthroat from the St. Joe River in Idaho and Fraley et al. (1981) documented the use of Flathead River tributaries by migrant fluvial westslope cutthroat in Montana. The use of Yellowstone River tributaries by migratory fluvial cutthroat was studied by Berg (1975) who documented spawning migrations in nine streams. Bear Creek was not included among the streams investigated by Berg.

The nineteen migratory cutthroat trout captured in Bear Creek in 1981 indicate that the stream is utilized as a spawning tributary for Yellowstone River fish. No quantitative estimate of the scope of the 1981 migration can be derived from the data because of the nature of the sampling effort. Single passes were made through a 1,000 foot reach of the stream on selected days thus limiting the sampling effort in time and distance. In addition to this, high water prevented a thorough electrofishing of sample reaches and probably resulted in a low capture efficiency. The magnitude of the Bear Creek migration can, however, be compared on a relative basis with similar surveys on other Yellowstone River tributaries. Berg (1975) documented cutthroat spawning migrations in nine of 16 tributaries that were monitored over a three year period. The largest numbers of migratory cutthroat were captured in Cedar Creek where the average capture was 20 fish per year over the three year period. After Cedar Creek, the next highest numbers of cutthroat trout captured by Berg were nine fish in Nelson Spring Creek in 1975 and six fish in Mol Heron Creek in 1973. Numbers of fish captured in the other six tributaries were substantially lower. In the light of these comparisons with Berg's data, Bear Creek appears to support a relatively substantial cutthroat spawning migration in relation to other Yellowstone tributaries.

The peak of the cutthroat migration in Bear Creek appeared to take place between July 9 and July 14, 1981. Spot temperatures measured at about mid-day on these dates were 50 and 54°F. Berg (1975) noted three different peak migration dates spanning the period between July 2 and July 24 in three years of study on Cedar Creek. He correlated the dates of the spawning peaks with average maximum daily water temperatures of 54 to 56°F. The Bear Creek spawning migration appeared to be confined to the lower portions of the stream. Similar observations were noted by Berg (1975) and Thurow and Bjornn (1978) for migratory fluvial cutthroat trout.

The Bear Creek migration was composed of age III, age IV and older fish. Bjornn (1957) found that spawning migrations of adfluvial cutthroat trout were dominated by age III and age IV fish. The sex ratio of the Bear Creek migrants was 1.7 males per female. The ratio in age IV and older fish was 1:1 but the age III fish exhibited a sex ratio of 3.5 males per female. This suggests that male Yellowstone cutthroat reach sexual maturity earlier than females. Similar observations were made by Thurow and Bjornn (1978) for westslope cutthroat trout. Berg (1975) found an overall sex ratio of 2.00 males per female in Cedar Creek but noted that the ratio more nearly approached 1:1 at the peak of the migration.

No attempt was made to ascertain the spawning success of the migrant cutthroat in Bear Creek. Cutthroat fry emerged from the gravels from mid to late August in Cedar Creek (Berg 1975) and as late as early September in some tributaries of Yellowstone Lake (Laakso and Cope 1956). Many small cutthroat (4 to 6 inches long) were captured throughout the sample season in the Powerhouse section. These immature fish could not be differentiated as resident or migrant progeny, however, examination of specimens of these fish revealed that they were pure strain Yellowstone cutthroat trout (J. Roscoe, personal

communication). Several studies have noted the presence of two separate races (i.e. resident and migrant) of cutthroat trout in tributary streams and found that migrant progeny may remain in spawning tributaries, especially the lower reaches, from one to three years before returning to the river or lake (Johnson 1963, Bjornn 1957, Averett and MacPhee 1971, Thurow and Bjornn 1978). Upon return to the parent river or lake, growth of the migrant progeny accelerates and the fish generally grow to much larger sizes than the residents (Bjornn 1957, Averett and MacPhee 1971, McMullin and Graham 1981). Patterns of accelerated growth, usually in the second or third growing season were evident in scale sample collected from the Bear Creek migrant cutthroat indicating that at least some of the fish probably remained in the tributary for a one or two year rearing period.

Tags implanted in the Bear Creek migrants should provide valuable information on the movements and homing tendency of the fish. Tag returns from fishermen and electrofishing surveys have provided valuable information on the movements of migratory cutthroat trout (Thurow and Bjornn 1978, Fraley et al. 1981). Berg (1975) found that Yellowstone River cutthroat trout that migrated up Cedar Creek came from distances at lease as far as 12 to 14 miles down river and demonstrated a remarkable homing tendency to the parent stream.

Brown trout and Mountain Whitefish

No migratory brown trout or mountain whitefish were collected during electrofishing runs through the Powerhouse section during October and November. Streamflow was very low at this time and the high gradient and large boulders present in the reach may have constituted a barrier or severe hindrance to upstream migration in 1981. The observation of concentrations of spawning whitefish in Bear Creek near the mouth on November 9, 1981 (M. Fillinger personal communication); while no whitefish were collected in the Powerhouse section on November 5, 1981, indicates that Bear Creek is used as a spawning tributary by the species but the upstream distance of the migration may be limited by streamflow. Further study would be required to determine the upstream progression of whitefish migrations and to determine if the stream is used by brown trout in high water years.

Brown trout were collected sporadically in the Powerhouse section throughout the entire 1981 sample season. Growth rates from scale analysis suggested that these fish were Bear Creek residents rather than Yellowstone River fish. Berg (1975) concluded that migratory Yellowstone River brown trout utilized low gradient spring creeks for spawning and were not found in high gradient mountain streams.

Four mountain whitefish were collected and tagged in July and August in the Powerhouse section. Growth, as observed from scale analysis, indicated that these specimens could be Yellowstone River fish but no conclusions could be drawn due to small sample size. Whitefish were observed to prefer high gradient mountain tributaries of the Yellowstone River for spawning migrations (Berg 1975).

Resident Species Composition

The resident fishery of Bear Creek was clearly dominated by rainbow X cutthroat hybrid trout. This hybrid is common throughout Yellowstone tributaries (Berg 1975) and generally results when rainbow trout are introduced into native cutthroat popualtions (Hanzel 1961, Behnke and Zarn 1976). Bear Creek was stocked with 2,050 catchable (7 inches and larger) rainbow trout in 1958 (MDFWP stocking records). The Bear Creek hybrids may have originated from this plant, from unrecorded plants of rainbow trout prior to 1958, from migration of rainbow trout or hybrids from the Yellowstone River, or from a combination of these events. Unlike many other hybrids, the rainbow X cutthroat is fertile and readily reproduces in suitable streams (Behnke and Benson 1980). Berg (1975) found that if rainbow X cutthroat hybrids were present in a Yellowstone tributary, they were usually distributed throughout the entire drainage. Hybrids were captured as far upstream as the Darroch Creek section in Bear Creek but were present in very low numbers in that section.

Cutthroat trout were found throughout the Bear Creek drainage but were most common upstream in the Trail section. Meristic examination of specimens of these fish revealed them to be of the pure Yellowstone strain of cutthroat trout (J. Roscoe, personal communication). Berg (1975) collected cutthroat trout in 13 of 21 Yellowstone River tributaries studied and found them to be most common in headwater portions of occupied streams. Cutthroat trout were fairly abundant in the Powerhouse section but were rarely captured in the LePage section at Jardine. The data suggest that the cutthroat trout of the Trail section were probably resident fish while an inderterminate portion of the Powerhouse cutthroat were probably migrant river fish that had not yet returned to the Yellowstone. The low numbers of cutthroat captured in the LePage section may be reflective of a spatial difference between the upstream stronghold of the resident cutthroat and the downstream habitat of migrant Yellowstone River fish. The scarcity of cutthroat trout in the LePage section may also be due to habitat changes effected by past mining practices in the Jardine area. Hanzel (1961), in his work on the distribution of cutthroat trout in Montana, classified Bear Creek as a stream in which cutthroat trout were more abundant than any other gamefish. The present data clearly indicates that the dominant position formerly held by the cutthroat is now occupied by the rainbow X cutthroat hybrid in Bear Creek. It is not specifically known what factor or factors led to the decrease of the Bear Creek cutthroat, however, it is well documented that cutthroat trout are very intolerant of environmental disturbances and habitat changes, are poor competitors with introduced species, readily hybridize with rainbow trout, and are highly susceptible to fishing pressure (Hanzel 1961, Behnke and Zarn 1976, Behnke and Benson 1980).

Rainbow trout were collected infrequently in all three study sections but were most common in the Powerhouse section. Berg (1975) collected rainbow trout in 12 of 21 Yellowstone River tributaries studied and found them

to be limited to the mainstems of occupied streams. Brown trout and mountain whitefish were infrequently collected in the Powerhouse section of Bear Creek. Berg (1975) collected brown trout in 12 Yellowstone tributaries but found them to be most abundant in spring creeks and present in low numbers in the lower reaches of mountain streams such as Bear Creek. Mountain whitefish were collected in six of 21 Yellowstone tributaries and were confined to the lower reaches of streams which had wide riffle and run habitats (Berg 1975). This habitat type was virtually absent in the lower reaches of Bear Creek.

Resident Populations

Estimated standing crops of total trout numbers (rainbow, cutthroat and rainbow X cutthroat hybrid trout) ranged between 115 and 188 fish per 1,000 feet in the three Bear Creek study sections while trout biomass ranged between 18 and 31 pounds per 1,000 feet. The average standing crop for the three sections was 158 fish per 1,000 feet. In an investigation of seven study sections on five Yellowstone River tributaries, Berg (1975) estimated total trout numbers to average 359 fish per 1,000 feet and biomass to range between 11 and 64 pounds per 1,0-0 feet. Some of these streams, however, contained large populations of brook or brown trout and are not truly comparable to Bear Creek. Berg's inventory also found that numbers of trout seven inches long and larger ranged between 30 and 108 fish per 1,000 feet within the estimated tributary populations. Numbers of these larger fish ranged between 39 and 67 fish per 1,000 feet in the three Bear Creek study sections. In addition to the five streams for which population estimates were calculated, Berg (1975) investigated 16 other Yellowstone River tributaries and presented data on the numbers and sizes of fish captured. Comparisons of the three Bear Creek study sections with these 16 tributaries reveal that Bear Creek supports above average trout populations for a mountain stream in the Yellowstone River drainage.

Populations of the dominant gamefish, the rainbow X cutthroat hybrid trout ranged between 151 per 1,000 feet in the LePage section and 65 per 1,000 feet in the Trail section while biomass ranged between 27 and 8 pounds per 1,000 feet. Estimatable hybrid populations in three other Yellowstone River tributaries ranged between 89 and 317 per 1,000 feet and represented biomass totals of 11 to 22 pounds per 1,000 feet (Berg 1975). Catchable sized hybrids composed between 30 and 55 percent of their respective Bear Creek populations in 1981. On a relative basis, the rainbow X cutthroat populations of Bear Creek appear to be substantial and capable of providing a good mountain stream sport fishery.

The only estimatable cutthroat trout population was found in the Trail section. This population was estimated at 42 fish per 1,000 feet and represented a total biomass of nine pounds per 1,000 feet. Berg (1975) found only one estimatable cutthroat population in his survey of Yellowstone tributaries. This population was estimated at 25 fish and five pounds per 1,000 feet. The resident cutthroat of Bear Creek were determined to be of the Yellowstone strain of the species, a species of special concern in

Montana (Deacon et al. 1979). The cutthroat trout population of Bear Creek can provide fishermen with a unique opportunity to catch native cutthroat trout in a mountain stream setting; an opportunity that has become increasingly restricted in the recent past.

Among the three Bear Creek study sections, total numbers of fish increased in a downstream direction from the Trail to the Powerhouse section. This may be due to an interaction of several factors including a change in climatic conditions associated with a loss in elevation, increased production associated with increased chemical nutrient levels, habitat differences associated with individual species habitat preferences and recruitment of fish from the Yellowstone River in the lower reaches of the stream. Although the numerical trout estimate for the Powerhouse section was slightly higher than that of the LePage section, trout biomass was much higher in the LePage section. This was probably indicative of a higher fish production rate in the LePage section which may be due to nutrient releases in the Jardine vicinity as suggested by the heavy filamentous algal growth observed in the section in August. The high biomass of the LePage section may also be partially reflective of a more limited fishing pressure associated with private land ownership in the Jardine vicinity. Rainbow X cutthroat hybrid populations were estimated at 127 per 1,000 feet in the Powerhouse section and 151 per 1,000 feet in the LePage section but only totaled 65 per 1,000 feet in the Trail section. The marked decrease in hybrid numbers between the LePage section immediately below Jardine and the Trail section immediately above Jardine is probably due to habitat differences that favor cutthroat trout upstream from the town. These habitat differences may be due to past mining activities or current effects of human habitation in the Jardine vicinity. Behnke and Zarn (1976) state that cutthroat trout are extremely intolerant of environmental change and generally fare well in undisturbed headwater portions of streams.

Age Structure

Most of the rainbow X cutthroat hybrid trout captured in the three study sections were age I and age II fish while age IV and older fish were present in low numbers. This is indicative of good recruitment into the population and a relatively high mortality associated with harsh conditions prevalent in mountain streams. The highest numbers of age IV and older fish were found in the LePage section and may result from habitat conditions highly favorable to the hybrid trout or from reduced fishing pressure associated with private land ownership in Jardine.

The cutthroat trout of the Trail section were most abundant in the age II and age III classes. A similar observation was made for a resident cutthroat population in Willow Creek, Montana (Oswald 1981) where it was suggested that better cutthroat trout habitat, and hence, the stronghold of the cutthroat population was located upstream of the study section. A similar situation may occur in Bear Creek and the Trail section may have been located near the periphery of the best cutthroat spawning and rearing habitat. Low numbers of age I fish, however, may also indicate poor spawning success and

and a poor year class from the 1980 spawning season.

Some difficulty was encountered in aging the Bear Creek fish, both resident and migrant. This was due to the apparent failure of many of the fish to form an annulus in their first year of life. This is common among spring or summer spawning fish in mountain streams and has been particularly well documented for cutthroat trout (Brown and Bailey 1952, Fraley et al. 1981, McMullin and Graham 1981).

Length and Condition

Resident trout collected in Bear Creek generally ranged between about four and ten inches in length with low numbers of fish exceeding ten inches. This size range is typical of the harsh growing and survival conditions found in mountainous tributary streams (Purkett 1950, Behnke and Benson 1980, Oswald 1981). The highest numbers of larger fish (catchable fish and fish longer than ten inches) were found in the LePage section. Furthermore, rainbow X cutthroat hybrid trout attained a slightly greater average length at age in the LePage section than in the other two sections. The similarity of average length at age between the Powerhouse and Trail sections indicates that this difference is not due to elevational differences among the sections but is probably due to a higher production rate in the LePage section.

Rainbow X cutthroat hybrid trout in Bear Creek were quite heavy in relation to their length. Average condition factors for Bear Creek hybrids were much higher than those measured in other Yellowstone River tributaries (Berg 1975) or in upper reaches of the Gallatin River (Purkett 1950). Hybrid condition factors were lowest in the Trail section, intermediate in the Powerhouse section and highest in the LePage section. The high values observed for the LePage section again suggest increased fish production for that reach while the lower condition factors of the Trail section are probably reflective of a less productive headwater environment. Purkett (1950) found no differences in trout condition among three different elevational study sections on the Gallatin River although different growth rates in length were obvious.

CONCLUSIONS

1. Bear Creek is utilized by migrating Yellowstone River cutthroat trout as a spawning tributary. Spawning tributaries like Bear Creek provide a vital link in the life cycle of these migrant fish and must contain habitat suitable for reproduction and the rearing of juvenile fish. Care must be taken to protect this resource from any adverse impacts of mineral mining that could alter the habitat and render it unacceptable as a spawning site for this species of special concern.

2. Bear Creek supports a relatively diverse and abundant sport fishery. The bulk of this fishery is sustained by rainbow X cutthroat hybrid trout which provide a unique opportunity to catch pan-sized wild trout in a mountain stream setting. Despite past mining activities centered in the Jardine vicinity, the most productive hybrid fishery was found immediately downstream from the town. Development of future mining activities should be implemented with care to maintain this fishery.

3. Bear Creek was found to support resident populations of pure Yellowstone strain cutthroat trout, a species of special concern in Montana. While these cutthroat were collected in all three study sections, they were most abundant and composed the greatest percentage of the fish population in the Trail section above the town of Jardine. Although this area is upstream from the reaches that could potentially be impacted by the proposed mining activities, care should be taken to prevent adverse impacts from any future development e.g., mining, logging, road construction etc. which could reduce or eliminate the existing cutthroat population. Because lower reaches of Bear Creek below Jardine are utilized by both resident and migrant cutthroat, mining developments at Jardine should be implemented with care to protect the remaining cutthroat trout habitat in Bear Creek.

4. Mineral mining can adversely impact stream fisheries through the production of suspended and bedload sediments, altered pH levels, heavy metal discharges, and alterations in stream channel and streamflow (AFS 1980). Mining activities in the Bear Creek drainage should be carefully planned and closely monitored to prevent the occurrence of such impacts and protect the intrinsic fisheries values of the stream.

5. Timber harvest also has the potential to adversely impact stream fisheries. Logging activities can be harmful to fisheries through increased sedimentation, streamflow alteration, increased water temperature, decreased oxygen levels, chemical additions and logging debris (Platts 1980). Any future logging development in the upper Bear Creek drainage should be carefully planned to protect the remaining cutthroat trout habitat in the upper reaches of the stream.

6. Data presented in this report can be used as a base-line from which future changes in the fishery of Bear Creek can be compared.

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