MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
FISHERIES DIVISION

JOB COMPLETION REPORT

76
#5

State Montana

Project No. F-20-R-27 Title South Central Montana Fisheries Investigations

Job No. IV-a Title Bighorn Lake and Bighorn River Post-Impoundment Study

Period Covered April 1, 1982 through March 31, 1983

ABSTRACT

Ten gill nets set in Bighorn Lake during April and May 1982 captured 58 fish, representing 11 species of which over half were walleye. Creel census of 565 anglers fishing Bighorn Lake indicated walleye comprised 69% of the anglers' catch. Approximately 1,130 fisherman days were expended in catching about 988 walleye by anglers fishing Bighorn Lake. This includes only those anglers whose trips originated from the Ok-A-Beh Access near the dam.

Creel census of 1,647 anglers who fished Yellowtail Afterbay revealed a catch rate of 0.37 rainbow trout per hour with peak catch rates in September through December, and heaviest fishing pressure during September and October. Expansion of creel census data produced a minimum pressure estimate of 3,345 fisherman days expended in catching 5,313 rainbow trout.

A river-mile index of the Bighorn River from the Afterbay Dam to Arapooish Fishing Access is presented. An index was also constructed of the upper 16 miles of the Bighorn River from the Afterbay Dam downstream, referencing 24 major side-channel areas and identifying 67 subchannels which were active at a flow of 4,000 cfs. At 2,500 cfs, flow was depleted from 17 of the 67 subchannels. Impacts associated with drawing the Bighorn River down to 400 cfs were documented. Monitoring of water temperatures was continued at two sites.

The life history of brown trout in the upper Bighorn River was documented. Peak spawning occurred during the first week of December. Hatching occurred during late March through early April with fry emerging from the gravel throughout April. Four brown trout population estimates were conducted in the upper electrofishing section. Estimated population of Age 1 and older brown trout ranged from 2,384 to 5,488 fish per mile. Annual

mortality rates were not excessive. Biomass of brown trout in the upper Bighorn River has remained relatively constant, ranging from 3,209 to 4,375 pounds per mile of river.

One population estimate was conducted on the lower electrofishing section 18 river miles downstream from the Afterbay Dam. The estimated population of Age 1 and older brown trout was 1,316 per mile. Length frequencies of brown trout in the upper electrofishing section are analyzed by age group based on scale sample analysis. Condition factors of brown trout in the Bighorn River are exceptionally low for fish larger than 18 inches.

Population numbers of rainbow trout appear to be strongly related to the stocking of hatchery fish. Estimated population of rainbow trout 9 inches and longer in the upper electrofishing section ranged from 417 to 1,097 fish per mile during three estimates. Biomass was 589 to 1,631 pounds per mile. The peak size group in length frequencies of fish taken during electrofishing has paralleled the observed growth of 40,000 6-inch rainbow stocked in the river during August 1981. Those fish grew an average of nearly 10 inches from August 1981 to December 1982. Condition factors of rainbow trout were generally excellent.

BACKGROUND

From 1975 through August 19, 1981, the 44 miles of the Bighorn River on the Crow Indian Reservation was closed to fishing by nontribal members. During most of that period, the Department did not do any work on the Bighorn River within the reservation boundary. Prior to 1975 work was mainly limited to a creel census conducted during 1972 and 1973 (Stevenson 1975) and some occasional run-of-the-river electrofishing surveys. Comparisons with that data indicate that the brown trout population has expanded considerably through natural reproduction since the early 1970's.

On March 24, 1981, the U. S. Supreme Court ruled that the bed of the Bighorn River belonged to the State of Montana, and not the Crow Indian Tribe. The Department of Fish, Wildlife and Parks (DFWP) was faced with managing a very valuable high-use fishery with an almost total absence of biological information. The regulations adopted on the upper 12 miles of the Bighorn for the opening season which began August 20, 1981 consisted of a three-fish slot limit which allowed anglers to keep one trout over 22 inches and two under 18 inches. For the succeeding two seasons which ran from May 1, 1982 through April 30, 1984, this was relaxed to a limit of three trout, only one of which could exceed 18 inches in length. Fishing pressure has been heavy since the river reopened to the public in 1981. An intensive creel census was recently completed on the Bighorn River with results to follow in a later report.

Major management problems on the Bighorn River at present include the low reproductive rates of rainbow trout and poor

condition factor of large brown trout. Gas bubble disease affects trout in the upper river seasonally as a result of a nitrogen supersaturation problem associated with the Afterbay Dam. An annual fall drawdown to inspect the seepage flow around the main Yellowtail Dam reduces flow in the river to 400 cfs and causes major fish stranding and fish kill problems. Future research efforts will focus on these areas of concern.

Bighorn Lake was created by Yellowtail Dam in 1965. Subsequent introductions of rainbow trout, lake trout and kokanee have failed to produce a salmonid fishery for these species. Walleye introductions have been much more successful to the point that walleye have become the major game fish species sought by anglers in Bighorn Lake. The lake in Montana is mostly confined to a rugged canyon with precipitous banks, and as a result is largely inaccessible except by boat. Management efforts in the past have focused on water-level manipulation to enhance forage fish production. Greater emphasis needs to be placed here in the future.

The Yellowtail Afterbay is basically a reregulating reservoir. Daily water-level fluctuations somewhat limit the fishery potential. The Afterbay has been a consistently good put-and-take rainbow trout fishery, with fish planted as fingerlings in the spring demonstrating excellent growth rates. Management options are limited and escapement of planted trout downstream into the Bighorn River will continue to be a problem.

OBJECTIVES AND DEGREE OF ATTAINMENT

Job Objectives:

1. Bighorn Lake

a) To estimate the abundance, spawning time and growth of walleye.

b) To determine the fisherman harvest of fish species in cooperation with the Wyoming Game and Fish Commission. Fish species of concern are walleye, yellow perch, black crappie, brown and rainbow trout, burbot and channel catfish.

2. Bighorn River

a) To determine the distribution, composition and relative abundance of game fish species present in the river.

b) To monitor water temperatures on a daily basis at Fort Smith and Two Leggins Fishing Access.

c) To determine relative abundance of natural reproduction of brown and rainbow trout from the Afterbay Dam downstream.

d) To determine angling pressure and catch rates of rainbow and brown trout from Afterbay Dam to Two Leggins Access.

Degree of Attainment: All objectives were accomplished. Data are presented in this report with major emphasis on objectives 1b, 2a and 2c.

DESCRIPTION OF STUDY AREA AND METHODS

The location of the study area electrofishing sections, thermograph sites and fishing access sites is presented (Fig. 1). A map of Bighorn Lake has been included in all previous progress reports. More detailed maps of the upper and lower electrofishing sections were included in the latest progress report on this study (Swedberg 1983).

Gill nets set in Bighorn Lake were standard 6 x 125 feet sinking nets (exception, one floating net) with five equal length panels of 1.5, 2, 2.5, 3 and 4-inch mesh. Nets were set in the evening and fished overnight.

Creel census data for Bighorn Lake and Yellowtail Afterbay were collected at the Bighorn creel census station located along Highway 313 about 12 miles downstream from the Afterbay Dam. Anglers were required to stop at the station. The rate of compliance was unknown, but is believed to have been high. For the period April 1982 through October 1982, the station was operated the last 10 daylight hours of every other day on the average. During November 1982 through March 1983, the station was in operation 10 hours per day on about every fourth day with the actual schedule randomly determined. Information was coded and keypunched with statistical summaries prepared by computer.

Procedures used to compile river mile and side-channel indices are described in appropriate portions of this report. Water temperatures were monitored with continuous-recording, Taylor 30-day thermographs located at the Afterbay Dam and Two Leggins Access (Fig. 1).

Procedures used to establish brown trout life history parameters and certain other biological comparison information are presented within the text. Population and biomass estimates were conducted using boom-equipped electrofishing boats powered by outboard jet engines. The standard Petersen-type mark-and-recapture methods accepted statewide were used (Vincent et al. 1981). As many as 10 marking runs were used followed by a 2-week waiting period and recapture runs of approximately equal effort. Computations to determine population, biomass and condition factors were performed by computer. Scale samples were taken from 10 fish per 1/2-inch class, and plastic impressions were analyzed to determine age-class relationships for brown trout.

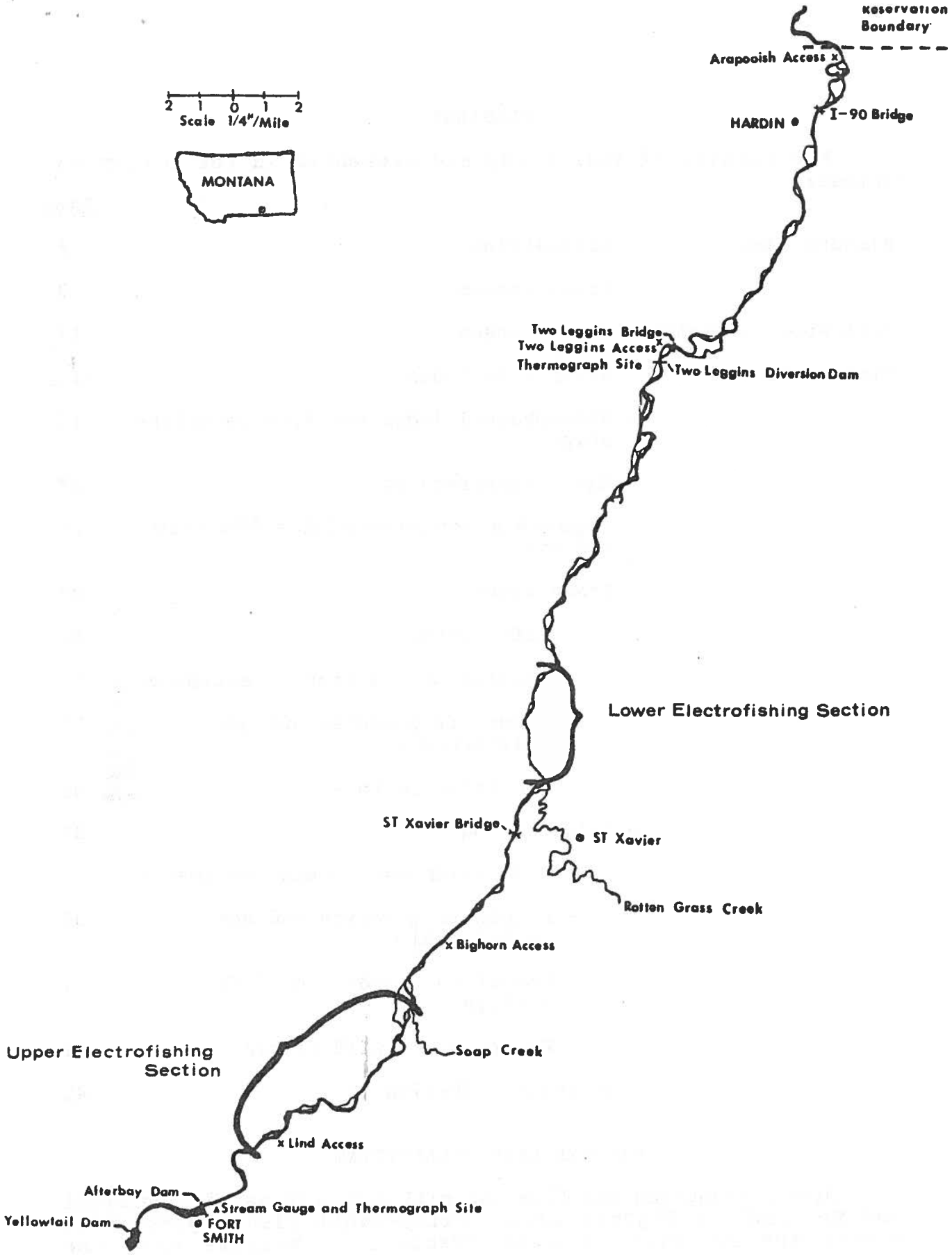

Fig. 1. Map of the Bighorn River from Yellowtail Dam to the Crow Reservation boundary showing locations of upper and lower electrofishing sections.

FINDINGS

The results of this study are presented in the following format:

BIGHORN LAKE GILLNETTING

Nine sinking and one floating gill net were set during April and May 1982 in Bighorn Lake. Fifty-eight fish representing eleven species were captured (Table 1). Walleye were the dominant species, comprising over half the catch.

Table 1. Species composition of fish captured in gill nets from Bighorn Lake during 1982.

Net No.	Date Set	Area of Lake	Species[1]										
			We	Saug	YP	ChCat	Ling	Rb	LL	Carp	ShRH	LNSu	WSu
1	4/22/82	Devils Canyon	17	1						1	2	1	
2	4/22/82	Devils Canyon	1	1							3		
3	4/22/82	Devils Canyon	4		1	2						1	1
4	4/22/82	Devils Canyon								2			
*5	4/22/82	Devils Canyon	4					2	3	1			1
6	5/25/82	Black Canyon	1									1	
7	5/25/82	Bull Elk	1										
8	5/25/82	Bull Elk	1				1					1	
9	5/25/82	Bull Elk	1							1		1	
10	5/25/82	Bull Elk	No fish										
Total fish			30	2	1	2	1	2	3	5	5	5	2

[1]We = walleye, Saug = sauger, YP = yellow perch, ChCat = channel catfish, Ling = burbot, LL = brown trout, Carp = carp, ShRH = shorthead redhorse, LNSu = longnose sucker and WSu = white sucker.

*Floating net.

The 30 walleye captured ranged in length from 12.1 to 19.8 inches. Nineteen of the 30 fish (63%) were males. All 15 of the males captured on April 22 were mature ripe fish. Of four males captured on May 25, one was immature, one was ripe and two were spent (i.e., done spawning).

Eleven females were captured in the Devils Canyon area of the lake on April 22, 1982. Of these fish, five were 15.0-15.9 inches long and were immature (i.e., no gonadal development). One fish 19.0 inches long was also immature. Five of the 11 females were mature fish. Two of these fish were not yet ripe; two were ripe, releasing eggs when pressure was applied; and one was a spawned-out female. The five mature females were 16.5-19.8 inches in length. It would appear from these limited observations that the peak of walleye spawning in Bighorn Lake during 1982 was somewhere around the end of April.

BIGHORN LAKE CREEL CENSUS

Results from the Bighorn River creel census station for anglers fishing Bighorn Lake are presented (Table 2). Of 717 fish caught by anglers, 68.9% were walleye, 13.1% were brown trout, 11.0% were rainbow trout, 6.1% were yellow perch, 0.7% were sauger and 0.1% were black crappie.

Walleye were the dominant species in the sport fishery. Catch rates (Table 2) were highest for this species during June (0.28 fish per hour), July (0.24 fish per hour) and August (0.20 fish per hour). Catch rates did not exceed 0.1 walleye per hour during any other month. The largest of 148 walleye that were measured and weighed at the check station from April 1, 1982 through March 31, 1983 was 30.1 inches long and weighed 11.75 pounds. A length frequency of 126 walleye measured at the check station during June-August 1982 is presented (Figure 2). The average length was 14.5 inches.

The average party size for anglers fishing Yellowtail was 2.5 anglers per party with parties of two and three anglers comprising over two-thirds of the total. Residency of the 565 anglers interviewed was 8% local (Hardin, Ft. Smith area), 68% Billings area, 15% from other areas of Montana and 8% from out of state.

Almost 70% of the anglers were licensed men followed by 18% licensed women, 10% unlicensed juveniles and 2% people over 62 with a pioneer fishing license. Only one of the 565 anglers interviewed was a member of the Crow Indian Tribe. Ninety-six percent of the anglers fished from boats.

Lures were the most popular type of terminal tackle, used by 49% of the 565 anglers surveyed. Twenty-four percent of the anglers used some combination of bait, lures or flies during the day. Twenty-one percent of the anglers used bait by itself, and only 6% used flies exclusively.

Table 2. Hours fished and summary of fish caught by month by 565 anglers who fished Bighorn Lake during April 1982 through March 1983.

Month	Anglers Interviewed	Hours Fished	Walleye Caught	Walleye Caught Per Hour	Brown Trout Caught	Rainbow Caught	Yellow Perch Caught	Sauger Caught	Crappie Caught
April 1982	29	178.5	10	0.06	2	1	0	0	0
May 1982	106	618.25	25	0.04	22	19	0	3	0
June 1982	123	666.0	187	0.28	32	30	9	0	1
July 1982	113	560.25	134	0.24	14	9	11	0	0
Aug. 1982	95	517.5	101	0.20	4	11	3	1	0
Sept. 1982	50	262.0	21	0.08	9	7	20	0	0
Oct. 1982	20	149.0	11	0.07	6	2	1	1	0
Nov. 1982	3	12.0	0	0	1	0	0	0	0
Feb. 1983	8	55.0	0	0	2	0	0	0	0
March 1983	18	99.0	5	0.05	2	0	0	0	0
Total	565	3,111.5	494	0.16	94	79	44	5	1

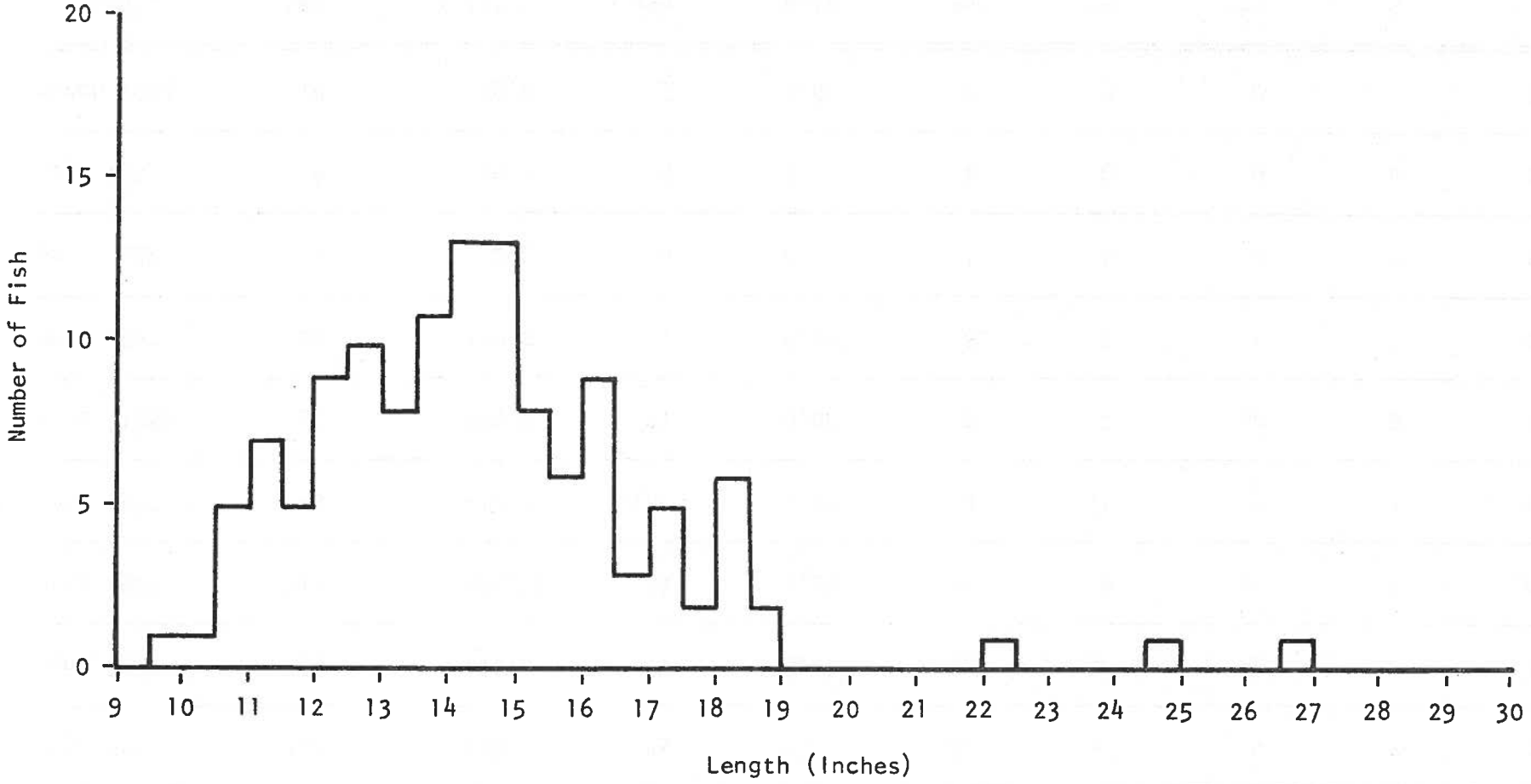

Fig. 2. Length frequency of 126 walleye caught from Bighorn Lake by anglers during June 1982 through August 1982.

Anglers kept 83% of the walleye that they caught. The proportion of the catch kept for other species was brown trout 91%, rainbow trout 85%, yellow perch 89%, sauger 80% and crappie 100% (only one caught).

Since about half the days were censused during the period, a rough estimate of the fishing pressure and harvest by anglers on Bighorn Lake who used the Ok-A-Beh access point can be formulated by doubling the figures presented in this report. This provides a minimum estimate, since an unknown number of anglers avoided the creel census station by either failing to stop or taking alternate routes that did not pass the census station. As a rough minimum estimate, 1,130 anglers fished 6,223 hours and caught about 988 walleye (0.87 fish/angler; 0.16 fish/angler hour) during the April 1, 1982 through March 30, 1983 census period.

YELLOWTAIL AFTERBAY CREEL CENSUS

A total of 1,647 anglers who fished the Yellowtail Afterbay were interviewed between April 1, 1982 and March 30, 1983 (Table 3). They fished a total of 7,387.25 hours for an average of 4.5 hours per angler. Over 60% of the anglers interviewed fished during the months of July through October with approximately equal numbers of anglers during these 4 peak months.

The anglers surveyed caught 2,704 rainbow trout which made up over 97% of the total catch of game fish. Other species caught were 76 brown trout and 1 walleye. Catch rates for trout were much higher during September through December than during the other 8 months (Table 3), averaging 0.67 trout per hour during that fall period. A likely reason for this increased fall catch rate is that the 40,000 5-inch rainbow trout planted on June 6-10, 1982 began to enter the fishery at a length of about 8 inches during August. During the August through December period, these fish comprised the bulk of the catch. Growth response of the rainbow planted in 1982 is illustrated in Table 4.

Anglers kept 86% of the rainbow trout they caught. The largest rainbow trout checked was 22.3 inches long.

The average party size was 2.5 anglers per party. Parties of two and three anglers were 36 and 27% of the total anglers, respectively. Of the 1,647 anglers interviewed, 17% were local residents (Hardin, Ft. Smith area), 61% were from the Billings area, 16% were from elsewhere in Montana and 6% were non-residents.

About 54% of the anglers were licensed men, 20% licensed women, 13% unlicensed juveniles and 13% people over age 62 who held a pioneer fishing license. Only three of the anglers interviewed were Crow tribal members. About 63% of the anglers fished from shore and 37% used boats.

Table 3. Hours fished and summary of fish caught by month by 1,647 anglers who fished Yellowtail Afterbay during April 1982 through March 1983.

Month	Anglers Interviewed	Hours Fished	Rainbow Caught	Rainbow Caught Per Hour	Brown Trout Caught	Walleye Caught
April 1982	74	277.25	36	0.13	1	0
May 1982	157	613.0	124	0.20	5	0
June 1982	173	889.5	137	0.15	48	1
July 1982	251	1,114.0	105	0.09	7	0
August 1982	207	987.0	290	0.29	8	0
September 1982	249	1,259.5	768	0.61	4	0
October 1982	286	1,341.5	989	0.74	2	0
November 1982	41	187.0	122	0.65	0	0
December 1982	23	112.0	52	0.46	0	0
January 1983	66	259.0	45	0.17	1	0
February 1983	56	153.5	18	0.12	0	0
March 1983	64	194.0	18	0.09	0	0
Total	1,647	7,387.25	2,704	0.37	76	1

Table 4. Average length of angler-caught rainbow trout stocked as 5-inch fish on June 9-10, 1982 and measured during the subsequent 9-month period at the Bighorn creel census station.

Month	No. of Fish Measured	Average Length (in)
June 1982	Sample at stocking	5
July 1982	0	-
August 1982	88	8.9
September 1982	452	9.9
October 1982	806	10.5
November 1982	116	11.3
December 1982	47	11.4
January 1983	39	11.9
February 1983	15	12.0
March 1983	6	12.4

Bait fishing was the most popular method used, with nearly two-thirds of the anglers (64%) using bait exclusively. Another 17% of the anglers used some combination of bait and lures or flies, 12% used artificial lures only and 6% fished with flies exclusively.

Expansion of check station data to account for days not censused (with stratification of weekend days and week days) allows an absolute minimum estimate of fishing pressure and harvest on the Yellowtail Afterbay during the period. The estimate would be somewhat higher if expansion factors were introduced to account for anglers not stopping, anglers coming through during noncensus hours on census days, and anglers residing in Ft. Smith or other areas who either did not pass by the census station, or passed out of the study area by a different route. The expanded estimates are presented in Table 5.

About 55% of the total estimated pressure occurred on weekends. An estimated total of 3,345 fisherman days occurred on the Afterbay between April 1, 1982 and March 30, 1983. Anglers caught an estimated total of 5,313 rainbow trout. This indicates a minimum of at least 13.3% return on annual plants of 40,000 rainbow trout.

RIVER MILE INDEX

A 3-page "river mile index" map is included in this report for the purpose of establishing reference points for future work and discussion on the Bighorn River (Fig. 3, 4 and 5). These maps were made by tracing from a set of aerial photos taken by the USDA on September 26, 1980 and October 3, 1980, and currently on file at the DFWP regional office in Billings. The tracing was photoreduced to the present scale. Original aerial photography was on a scale of 1:40,000. The flow in the Bighorn River was 3,990 cfs at the time the photos were taken.

The river mile index divides the upper 43 miles of the Bighorn River downstream from Yellowtail Afterbay Dam into 1-mile sections. These mileages were determined by marking off known points listed in the "River Mile Index of the Yellowstone River" (Montana DNRC 1976). Interpolation between known points was made on standard 7.5 topographic maps using a map measuring device. Mile boundaries were then transferred to the river mile index presented here (Fig. 3, 4 and 5). All distances were measured in downstream order from the Afterbay Dam.

SIDE-CHANNEL INDEX AND FLOW RELATIONSHIPS

Maps were made of the upper 16 miles of the Bighorn River by tracing from 1980 aerial photos shot at 3,990 cfs (Fig. 6 and 7). Ground-proofing, at a flow of about 4,000 cfs during 1983, was used to accurately identify side-channels present in this section of river. Twenty-four side-channels were numbered in downstream order from the dam to St. Xavier bridge. Side-channel complexes,

Table 5. Estimated number of anglers, hours fished and rainbow trout caught from Yellowtail Afterbay during April 1982 through March 1983.

Month	Estimated Total No. of Anglers	Estimated Total Hours Fished	Estimated Total No. of Rainbow Caught
April 1982	148	554.5	72
May 1982	306	1,194.8	242
June 1982	359	1,845.8	284
July 1982	455	2,019.4	190
August 1982	387	1,845.3	542
September 1982	442	2,235.7	1,363
October 1982	521	2,443.8	1,802
November 1982	147	670.5	437
December 1982	65	316.5	147
January 1983	207	812.3	141
February 1983	151	413.9	49
March 1983	157	475.9	44
Total	3,345	14,828.4	5,313

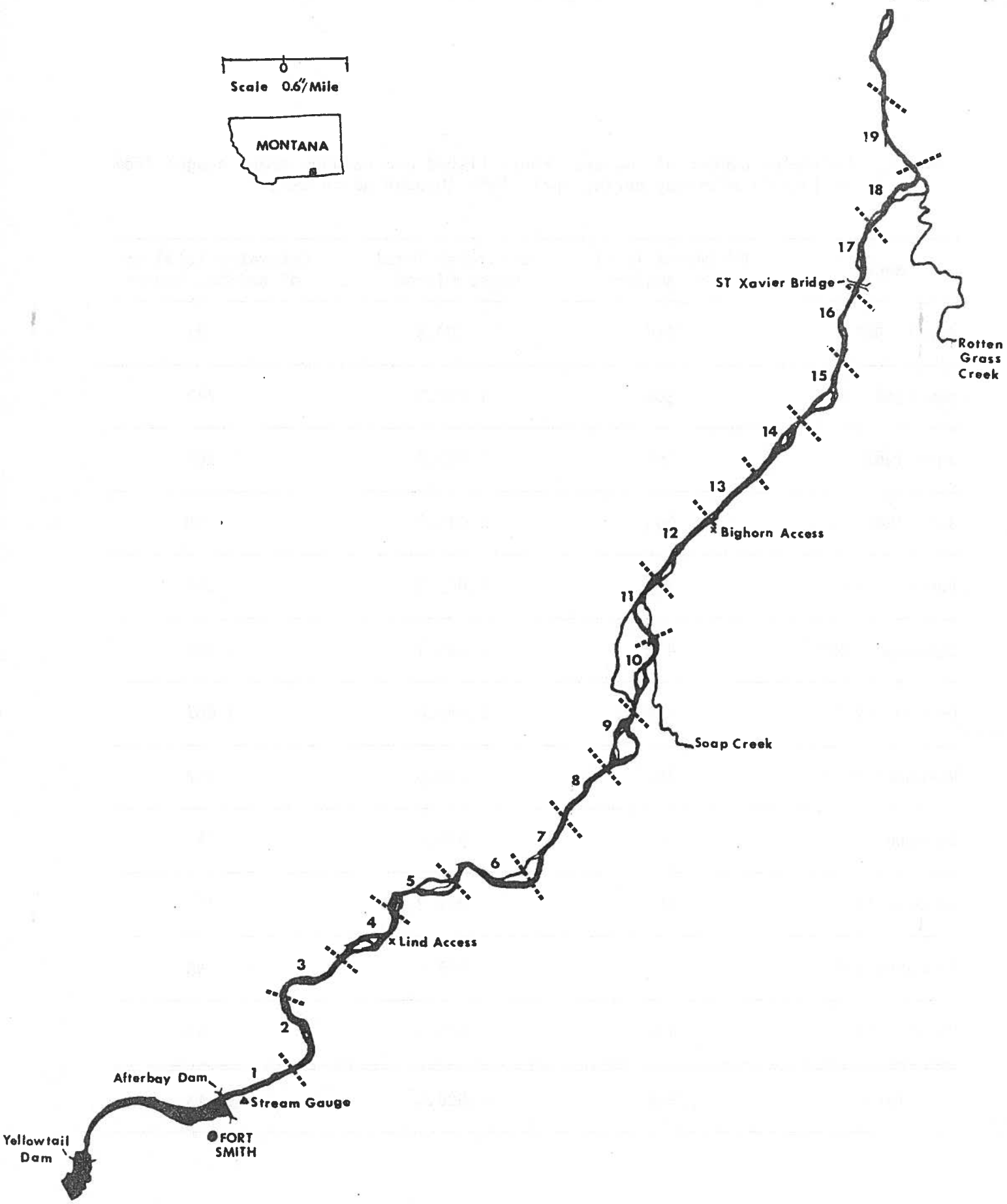

Fig. 3. River mile index of the Bighorn River - Sheet 1 (miles 1-18), Afterbay Dam to Rotten Grass Creek.

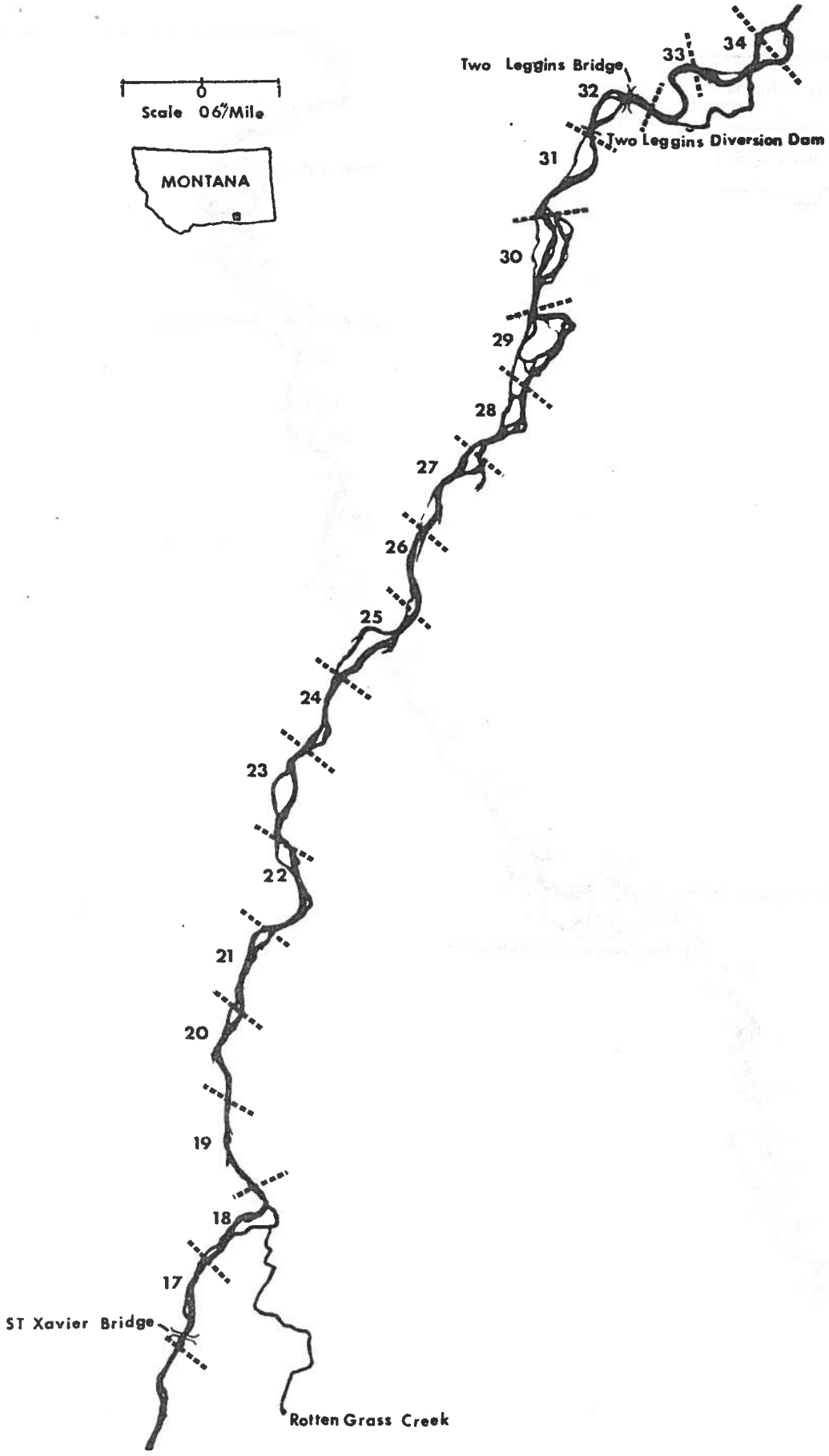

Fig. 4. River mile index of the Bighorn River - Sheet 2 (miles 19-32), Rotten Grass Creek to Two Leggins.

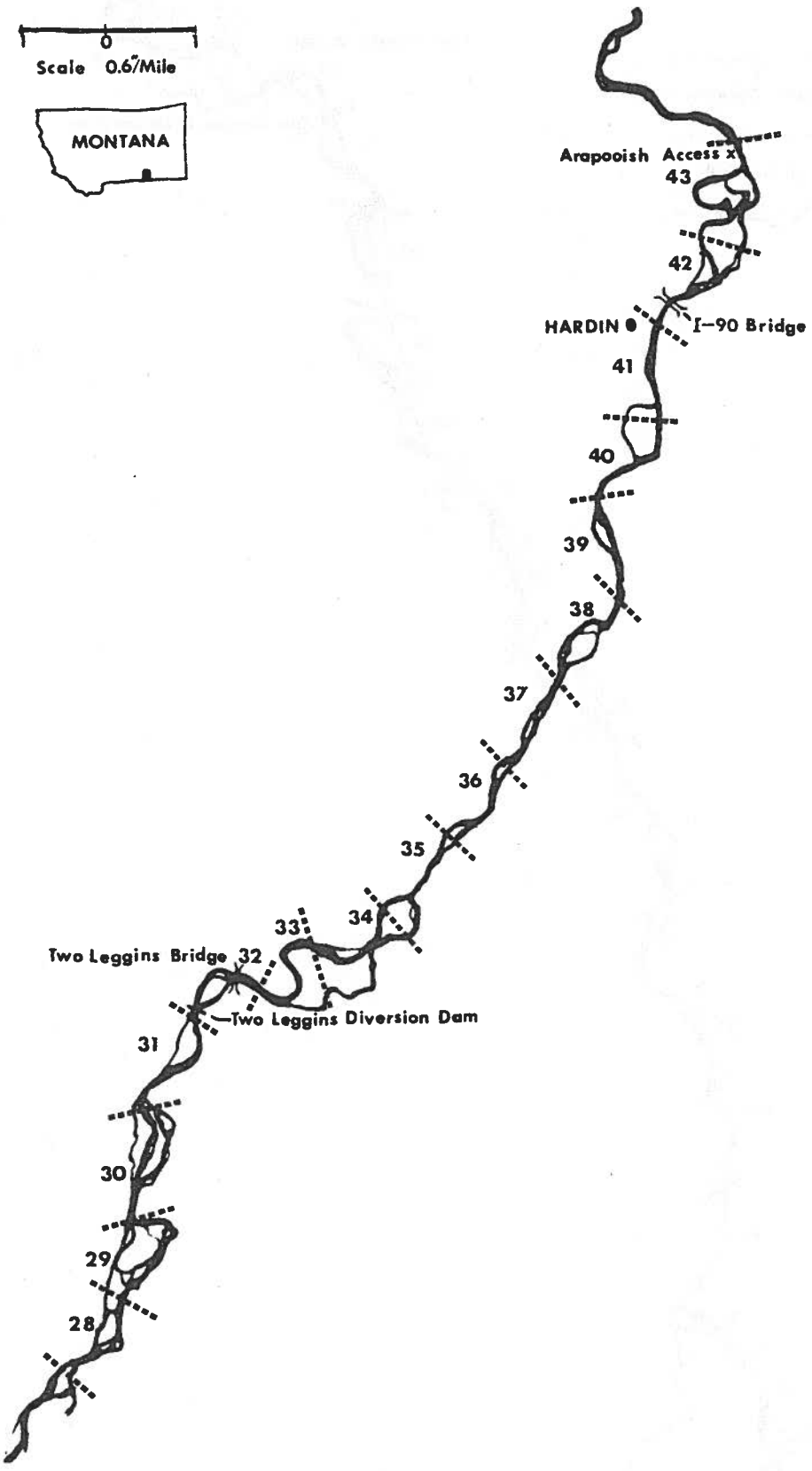

Fig. 5. River mile index of the Bighorn River - Sheet 3 (miles 33-43), Two Leggins to Arapooish Fishing Access.

where more than one major subdivision occurred, were further divided by a lettering system, again in downstream order (Fig. 6 and 7).

At 4,000 cfs, 24 major side-channels and/or complexes with a total of 67 identifiable subchannels were delineated in the upper 16 miles of the Bighorn River. These were ground-verified on February 15-17, 1983 by visual observation.

On April 19-20, 1983, the river was surveyed at a flow of 2,500 cfs. Side-channels 4, 8A, 12H, 13, 13B and 15C were not flowing at that time (Fig. 6 and 7). Particularly significant was the lack of flow in SC13 which was over 1 mile long. Very marginal flows were observed in SC6E, 7B, 7D, 8B, 10, 12C, 13A, 15D, 21G, 21H and 24. At a flow of 2,500 cfs, only 50 of the 67 side-channels identified at 4,000 cfs maintain sufficient flow to provide fish habitat.

A survey conducted on April 19-20, 1983, at a flow of 2,500 cfs, found catchable trout over 8 inches and as long as 20 inches were stranded in pools in SC8A (one fish), SC10 (about 25 fish) and SC13 (about 30 fish). Long-term survival of these fish without a flow increase was doubtful; however, no dead fish were encountered.

Further documentation of side-channel flow relationships at various flows is needed.

WATER TEMPERATURES

During April-October 1982, mean monthly maximum water temperatures were 2-10° F warmer at the Two Leggins thermograph than at the upstream station at the Afterbay Dam at Ft. Smith (Table 6). Mean monthly minimum temperatures showed more variation with the Two Leggins Station averaging 2-3° F cooler during 3 of the 7 months when records were kept.

Absolute maximum water temperatures were 65° F on September 3 and September 7-9 at the Afterbay Dam; 69° on August 25, September 3 and September 5-9 at Two Leggins. Absolute minimum temperatures were recorded at both stations during the first week of April 1982, 35° F at the Afterbay and 32° F at Two Leggins.

IMPACTS ASSOCIATED WITH A 90% FLOW REDUCTION

On October 15, 1982, flows in the Bighorn River were reduced from 4,000 to 400 cfs for a period of 6 hours (7:00 a.m. to 1:00 p.m.) in order to conduct an annual seepage test around the base of the main Yellowtail Dam. At 400 cfs the Bighorn River was largely confined to a single channel with most of the 67 side-channels that were identified at 4,000 cfs totally depleted of all flow. Further documentation of side-channel flow relationships will be gathered during a scheduled 1983 test.

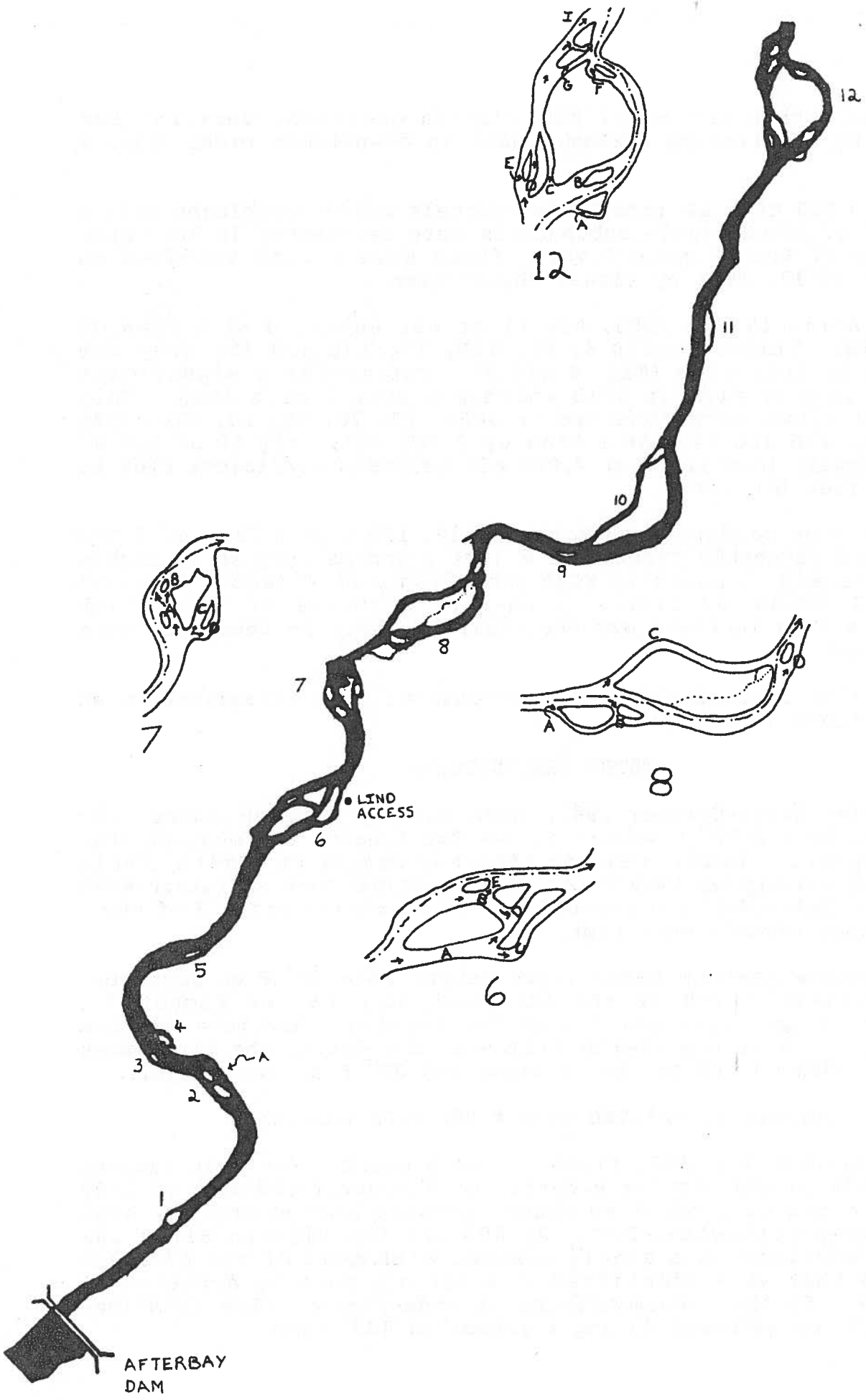

Fig. 6. Side-channel index map of the Bighorn River (Afterbay Dam to River Mile 9)

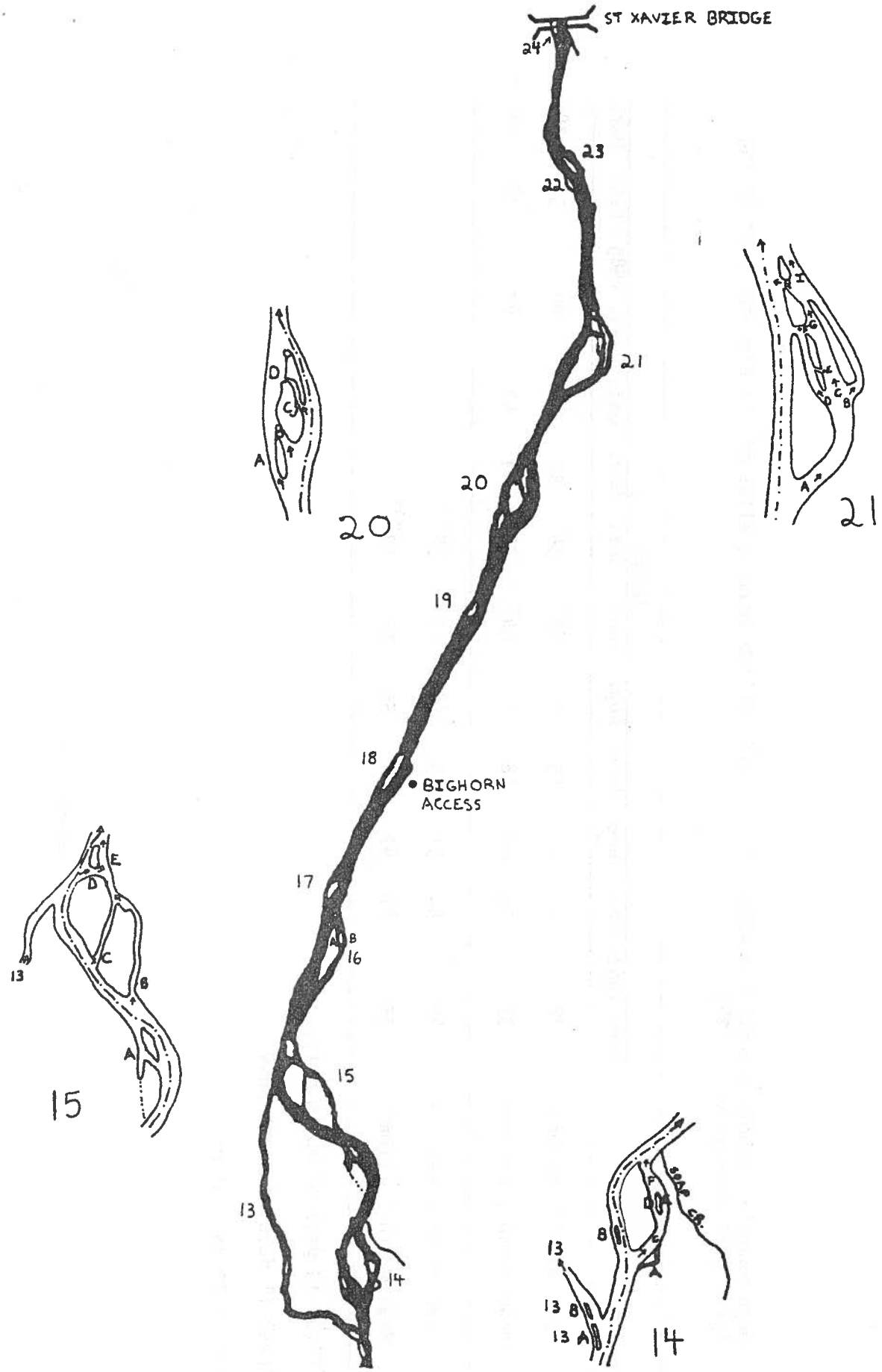

Fig. 7. Side-channel index map of the Bighorn River (River Mile 9 to Saint Xavier Bridge).

Table 6. Mean monthly maximum and minimum water temperatures at two gauging sites on the Bighorn River during April 1982 through March 1983

Station		Month											
		Apr. 1982	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1983	Feb.	Mar.
Fort Smith	Mean monthly maximum	38	39	41	49	62	64*	54**	50	44	40	38	38
	Mean monthly minimum	37	39	40	48	61	64*	54**	49	44	40	38	38
Two Leggins	Mean monthly maximum	40	46	51	55	65	63	58***					
	Mean monthly minimum	35	41	47	48	59	61	57***					

*First 13 days of month only.

**Last 11 days of month only.

***First 20 days of month only.

During the 1982 drawdown, about 260 catchable-sized trout and 1,900 young-of-the-year fish were observed stranded in side-channel pools 1-3 feet deep in the first 3 miles of river downstream from the Afterbay Dam. It was believed that fish would survive when the flow was reinstated, providing they were not killed by predators (including people). Only one dead catchable-sized trout was observed, an 8-inch brown trout.

In most side-channels as far downstream as Bighorn Access, some catchable-sized trout up to 20 inches long were observed stranded in the mid-channel pools along with numerous young-of-the-year trout. Mortality to young-of-the-year fish occurred at the head end of many of the dewatered side-channels (Fig. 8). Apparently, the small fish moved to the center of the channel with the decreasing flow and then sought refuge behind rocks while the flow dried up, leaving them stranded in 1-3 inches of water, or in many cases high and dry.

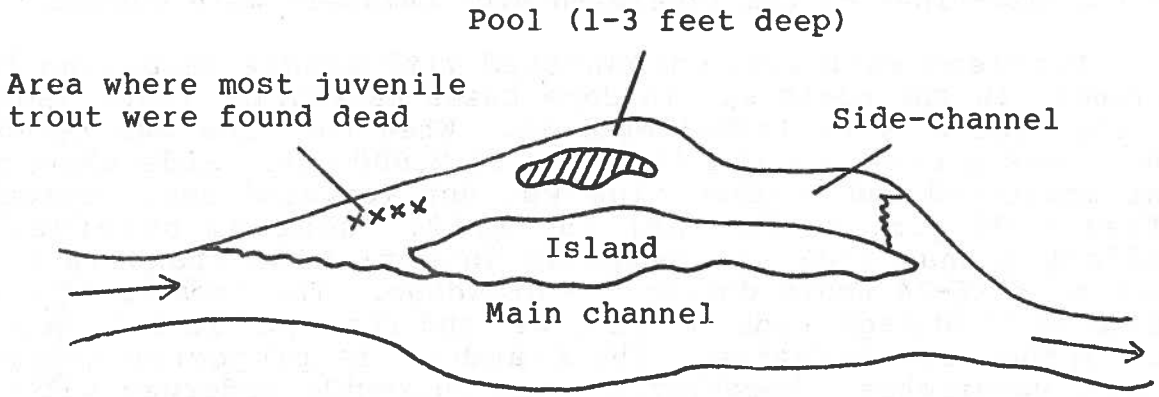

Fig. 8. Typical configuration of totally dewatered side-channel during Bighorn River drawdown to 400 cfs.

In two of the side-channels judged to have the highest density of dead young-of-the-year trout, a measured rectangular quadrant was laid out with surveyor's flagging and a thorough search was conducted to pick up all dead fish. The following results were obtained:

Quadrant 1 - 68 ft x 23 ft = 1,564 ft^2 - located at the head of SC1

Dead fish: 22 brown trout - all young-of-the year, mean length 4.0 inches; one rainbow trout - 3.9 inches; two suckers - 4.4 and 5.8 inches.

Quadrant 2 - 100 ft x 15 ft = 1,500 ft^2 - located at head of SC6A

Dead fish: 128 brown trout - all young-of-the-year, mean length 3.8 inches; eight rainbow trout - all young-of-the-year, mean length 3.8 inches; 11 longnose dace, mean length 2.7 inches; four suckers, mean length 5.2 inches.

Side-channel 6A was very wide and long. A visual estimate of the number of trout killed was 1,360 or about 10 times what was collected. In the quadrant examined, dead trout density was nearly one per square yard.

In the river section downstream from the Lind Access to the Bighorn Access, the effects of dewatering were very similar to what was observed and documented in the upper section. Most side channel flows were terminated, and dead young-of-the-year trout in the mid-lines of the dewatered side channels were common.

Problems were also encountered with people harassing fish stranded in the pools and in some cases harvesting them, legally in the case of Crow tribal members. When the flow was restored there was a very gradual increase to 2,000 cfs. Side-channel 1 was monitored and surface flow was not restored until sometime after 6:00 p.m. on October 15, 1982. General observation indicated that flow was depleted in most side-channels for a period of 16-24 hours during the drawdown. The impacts of drawdowns of this magnitude on the river and its aquatic life need to be further investigated. The drawdown is projected to be an annual occurrence. Negotiations are currently underway with the Bureau of Reclamation to reduce impacts of drawdowns of the magnitude described.

BROWN TROUT

LIFE HISTORY

Investigation was begun to document the timing and location of brown trout spawning in the Bighorn River and to monitor the development and early life history of these fish. The first brown trout redd was identified on October 14, 1982. Limited observation indicated very little spawning occurred prior to about November 1, 1982.

On November 17-18, 1982, a visual survey of the river from a boat was conducted from the Afterbay Dam 32 miles downstream to Two Leggins Access. About 155 brown trout redds were observed in the 12 miles from the Afterbay Dam downstream to Bighorn Acess. Most major side-channels had some observed spawning activity with concentrations of redds noted in the areas of side-channels 2, 3, 6C, 10, 12A and 13 (Fig. 6 and 7).

Limited spawning activity was observed November 18, 1982 downstream from Bighorn Access in the area of side-channels 20, 21 and 24. A total of 47 redds were counted. Limited visibility due to poor weather and slightly turbid water downstream from St. Xavier bridge made observations difficult. No redds were observed downstream from river mile 24 (Fig. 4).

Electrofishing surveys were begun on December 7, 1982 in the upper electrofishing section. By that time it was apparent that the redd count was several times higher than what was observed on November 17-18. Redds were much too numerous to count individually. Monitoring of the progression of spawning was done thereafter by checking the sexual development of fish captured by electrofishing.

On December 7, 1982 a total of 60 female brown trout were examined. Seven (12%) were gravid with eggs intact; 21 (35%) were ripe, releasing eggs when pressure was applied and 32 (53%) were mostly spent, having already spawned. The ratio of 47% gravid or ripe fish to 53% spent fish indicates that the first week of December in 1982 was near the peak of brown trout spawning in the upper Bighorn River. A total of 81 mature males were examined on this date and all were ripe spawners. This was a sex ratio of 1.35 males:1 female. Sixty-four fish were also examined that showed no evidence of sexual maturation; they were presumed to be nonspawners even though 53% were over 14 inches long. Most of those fish were probably nonmaturing females.

Some of the Age I+ male brown trout examined during December 1982 were precocious, being sexually mature at 10.5 inches long. The smallest mature female was 13.4 inches. Many females apparently spawned for the first time at Age II+.

Evidence indicated that smaller female brown trout, many of which were probably spawning for the first time, spawned later than their larger counterparts. Of 40 female brown trout less than 18 inches in length that were examined on December 7, 1982, 24 (60%) were either gravid or ripe and 16 (40%) were spent. Only 4 of the 20 (20%) females over 18 inches long were gravid or ripe, while 16 (80%) were already spawned out.

A second group of fish in the upper electrofishing section were sexed on December 13-14, 1982. Of 219 females examined only 2% were gravid, 32% were ripe and 66% were spawned out. This indicated spawning had progressed beyond the peak time period. A total of 217 ripe males were examined for a sex ratio of .99 male:1.0 female. A total of 240 nonmaturing fish were handled of which 52% were over 14 inches in length. It appeared that many females may not mature until they are Age III or older, and some other older fish may not spawn every year. Just as a week earlier the smallest precocious males were about 10 inches long and the smallest mature female was about 13.5 inches. By December 13-14, 1982 only four fish were still gravid with eggs not extrudable under pressure. All were 13.5-15.5 inches long,

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probably Age II+ females. About 56% of 119 female brown trout less than 18 inches long were still gravid or ripe, whereas 93% of 100 females longer than 18 inches had completed spawning.

Ripe female brown trout were still observed on January 8, 1983. It was presumed that most of the spawning activity had been completed. Very few fish were observed on redds.

In summary, the peak of brown trout spawning on the upper Bighorn River between the Afterbay Dam and Bighorn Access occurred during the first week of December with a protracted spawning period of mid-October to mid-January. Most of the spawning activity actually occurred between the middle of November and middle of December. Water temperatures during the period of November 15 to December 15 ranged from 43-51° F at the Afterbay Dam.

Brown trout eggs require about 800 daily temperature units to hatch in water in the 40-50° F range (Piper, et al. 1982). One temperature unit is equal to one degree Fahrenheit above freezing for a period of 24 hours. Thus, 24 hours at 42° F is 10 temperature units. Using this as a basis, eggs from a fish spawning at the Afterbay Dam on December 1, 1982 would have been subjected to 800 temperature units on about March 6, 1983.

Brown trout redds were excavated periodically through the winter to ascertain the developmental stage of the eggs. On February 16, 1983 nine redds were excavated. Two contained only dead eggs, three contained live eggs that were not yet eyed and four contained live eyed eggs. On April 1, 1983 four brown trout redds were excavated. Two contained sac fry and two contained eyed eggs that were well advanced, indicating hatching was near. On April 19, 1983 numerous free-swimming brown trout fry were found over sandy areas where current was slow. Based on the preceding observations, it is estimated that most brown trout fry hatched out during the period of late March through early April; and emergence from the gravel, which occurs about 2 weeks after hatching (T. Dotson, pers. comm.), occurred primarily during the month of April. By May 1, 1983 most brown trout fry should have been free-swimming.

POPULATION AND BIOMASS ESTIMATES

Two population estimates were conducted on the upper electrofishing section during this report period (Table 7). One set of marking runs was completed on May 20, 1982 and the other on December 14, 1982. One population estimate was also conducted on the lower electrofishing section with marking runs completed on May 20, 1982. Additional data and analysis are also presented for 1981 population estimates for comparative purposes.

The estimated population per mile of brown trout Age I and older in the upper Bighorn River electrofishing section has ranged during a 2-year period from a low of 2,384 in December

Table 7. Comparison of estimated population per mile for brown trout in a 6.7-mile section of the upper Bighorn River during July 1981, December 1981, May 1982 and December 1982 (arrows indicate population shifts to next age class).

Age	July 1981	Dec. 1981	May 1982	Dec. 1982
0	No estimate	7,735	No estimate	No estimate
I	1,868	991	3,442	2,103
II	1,420	935	704	1,025
III	390	197	921	287
IV & older	531	261	421	204
Total Population (I & older)	4,209	2,384	5,488	3,619

1981 to a high of 5,488 in May 1982 (Table 7). This increase was largely due to a new age class of fish entering the estimated population at Age I on January 1, 1982. The estimated population of Age I and older brown trout in December 1982 was 3,619 per mile, about 14% lower than the total of 4,209 per mile in July 1981, shortly before the river reopened to fishing (Table 7).

Analysis of estimated population sizes indicates there was little change in the population size or age structure of brown trout from July 1981 to December 1982. Fluctuations occurred due to strength and weakness of certain year classes, a factor largely unaffected by angling pressure. Year class strength can probably be more closely related to environmental factors such as flow patterns in the river.

Mortality of brown trout in various age classes during intervals between population estimates is presented (Table 8). More of the total annual mortality occurred during the summer period than during the winter. This is an indication that angling during the summer may be a significant mortality factor. Overall, total annual mortality on the Bighorn River is not excessive. From July 1981 to May 1982 the total annual mortality for Age I and older brown trout was 51.4% and ranged from 35.1% in Age Class II to 62.3% in Age Class I. For Age Classes III and IV+ and older where most of the angling mortality would be expected to occur, the total annual mortality was 55.9 and 53.1%, respectively. For the 1-year period from December 1981 to December 1982, the total annual mortality for Age I and older brown trout was only 36.4%. Overall mortality for the 1 and 1/2-year period between July 1981 and December 1982 was 64.0%.

An annual mortality rate of 55% in Age III+ to IV+ brown trout during 1979-1980 was not considered excessive in the Missouri River at Toston where population levels generally were less than 20% of what they are in the Bighorn (Rehwinkel 1982). On the Big Hole River "summer mortality" in age IV+ brown trout has been as high as 75% (Wells and Decker-Hess 1981). The annual mortality rate of brown trout Age II and older on the Gallatin river from fall 1979 to fall 1980 was 65.5% (Rehwinkel & Vincent 1982).

Vincent (1983) found a summer mortality rate of 62-73% for Age III and older brown trout on the Snoball section of the Madison River in 1975-1976. This was determined to be excessively high. It was sharply reduced to an average of 26% during 1978-1981 by a total angling closure. On the Pine Butte section of the Madison River, a change in regulations from a 10-trout or 10-pound limit to catch-and-release-only fishing reduced the summer mortality rate for Age III+ and older brown trout from 44% in 1977 to an average of 27% in 1978-1981 (Vincent 1983).

From this work on the Madison River, Vincent concluded that, "Given existing growth and recruitment rates, the summer mortality rates for Age III+ brown and rainbow trout could reach 50%

Table 8. Comparison of estimated mortality rate for brown trout in a 6.7-mile section of the upper Bighorn River from July-December 1981, December 1981-May 1982 and May-December 1982 (age class indicates age at beginning of interval).

Age Class	% Mortality		
	July-Dec. 1981	Dec. 1981-May 1982	May-Dec. 1982
I	46.9	29.0	38.9
II	34.2	1.5	+45.6
III	49.5	12.7	68.8
IV & older	50.8	4.4	51.7
Total (I & older)	43.4	14.2	34.1

without reducing these fish below their carrying capacity." While the Bighorn River cannot be directly compared to the Madison for a number of reasons, there appears to be adequate evidence that summer mortality and overall annual mortality of brown trout in the Bighorn River is not presently excessive. Summer mortality for Age III+ and older brown trout on the Bighorn River was 50.3% in 1981 and 63.4 in 1982. The 13% increase in summer mortality between 1981 and 1982 is cause for concern and the future levels will be monitored closely.

The number of large brown trout (greater than 18 inches) per mile in the upper electrofishing section of the Bighorn River has held remarkably steady following an initial decline after the river reopened to fishing. In July 1981 there were 573 brown trout over 18 inches per mile. In December 1981, May 1982 and December 1982, there were an estimated 352, 371 and 351 brown trout longer than 18 inches per mile of river.

The biomass of Age I and older brown trout in the upper electrofishing section of the Bighorn River has remained constant, ranging from a high of 4,375 pounds per mile in July 1981 to a low of 3,209 pounds per mile in December 1981 (Table 9). There has been a considerable amount of fluctuation in biomass within age classes as the fish grow and strong and weak year classes work through the system.

In general, there was a shift in biomass toward the smaller fish between spring and fall estimates. Biomass of Age III and older brown trout declined 51% from July to December 1981 and 56% from May to December 1982, while biomass of Age I and II brown trout increased 196% from May to December 1982 and 3% during July to December 1981. The consistency of total biomass estimates is another indication that angling pressure has had minimal effects on the brown trout population of the Bighorn River.

One population estimate was conducted on the lower electrofishing section of the Bighorn River during May 1982. This section extends from near the mouth of Rottengrass Creek (18 miles downstream from the Afterbay Dam) downstream for a distance of 5.3 miles. The estimated population during May 1982 was 590 - Age I, 436 - Age II, 180 - Age III, and 110 - Age IV and older brown trout per mile of river, a total of 1,316 brown trout Age I and older per mile of stream. This is roughly one-fourth the population density of the upper electrofishing section.

The biomass estimate in the lower electrofishing section was 916 pounds of brown trout per mile with 73 pounds per mile in Age Class I, 336 pounds per mile in Age Class II, 243 pounds per mile in Age Class III, and 264 pounds per mile in Age Class IV+ and older.

The lower electrofishing section showed a disproportionately high number and biomass of Age Class II brown trout when compared to the upper electrofishing section. Since brown trout reproduc-

Table 9. Comparison of estimated biomass per mile (pounds) for brown trout Age I and older in a 6.7-mile section of the upper Bighorn during July 1981, December 1981, May 1982 and December 1982.

Age	July 1981	Dec. 1981	May 1982	Dec. 1982
0	No estimate	697.6	No estimate	No estimate
I	376.4	666.5	296.9	1,144.7
II	1,599.1	1,372.5	573.5	1,431.0
III	812.4	432.4	1,423.7	572.0
IV & older	1,587.1	737.9	1,038.3	518.2
Total population (I & older)	4,375.0	3,209.3	3,332.4	3,665.9

tion appears to be considerably less in the lower section, it is possible that young brown trout are drifting down to the lower river sections to rear, and then returning to the upper section when they become sexually mature. A marking procedure could be used to analyze this. There were an estimated 93 brown trout per mile 18 inches or greater in length during May 1982 in the lower electrofishing section.

LENGTH FREQUENCIES AND AGE RELATIONSHIP

Length frequencies are presented for brown trout handled during each of the four electrofishing estimates in the upper electrofishing section (Fig. 9). Scale samples taken from about 10 brown trout per 1/2-inch class were analyzed during each estimate and used to assign age structure to the length frequencies. Age class boundaries for fish Ages 0, I and II were quite distinct. The division between Age Classes III and IV and older was less distinct with a considerable amount of overlap. Division points on the length frequency represent a median value.

Analysis of the length frequencies illustrate that electrofishing capture efficiency is much higher on larger fish in the Bighorn River. Fish in Age Classes III and IV and older made up 28.6-41.4% of the Age I+ fish handled during electrofishing, but only 13.6-24.5% of the estimated population of brown trout aged I and older. Thus, length frequencies from electrofishing cannot be used as an accurate estimator of age class strengths, due to these variable size-dependent capture efficiency rates. Age Class I fish made up 27.3-46.5% of the fish handled during electrofishing, but 41.6-62.7% of the estimated population.

CONDITION FACTORS

Condition factor is used to describe the "condition, plumpness, or well-being of a fish" (Carlander 1969). It is determined by dividing the weight (lb.) by the cube of the length (inches) and is represented by the symbol "C".

On the Bighorn River in the upper electrofishing section, the average condition factor of brown trout declined steadily as the average length of the fish increased. Fig. 10 displays graphically the data presented in Table 10. Examination of unpublished data from several other Montana rivers showed that this relationship was usually the case. However, in the upper Bighorn River there was an extremely steep decline and very low condition factors for large brown trout (i.e., fish longer than about 18 inches). Comparison of Bighorn River data with unpublished data from the Yellowstone, Boulder, Stillwater, Shields, Ruby, Big Hole and Beaverhead rivers showed that in general the condition factors of small brown trout (less than 10 inches) from the Bighorn were amongst the highest. The "C" for large brown trout (longer than 18 inches) from the Bighorn was the lowest encountered among the streams compared.

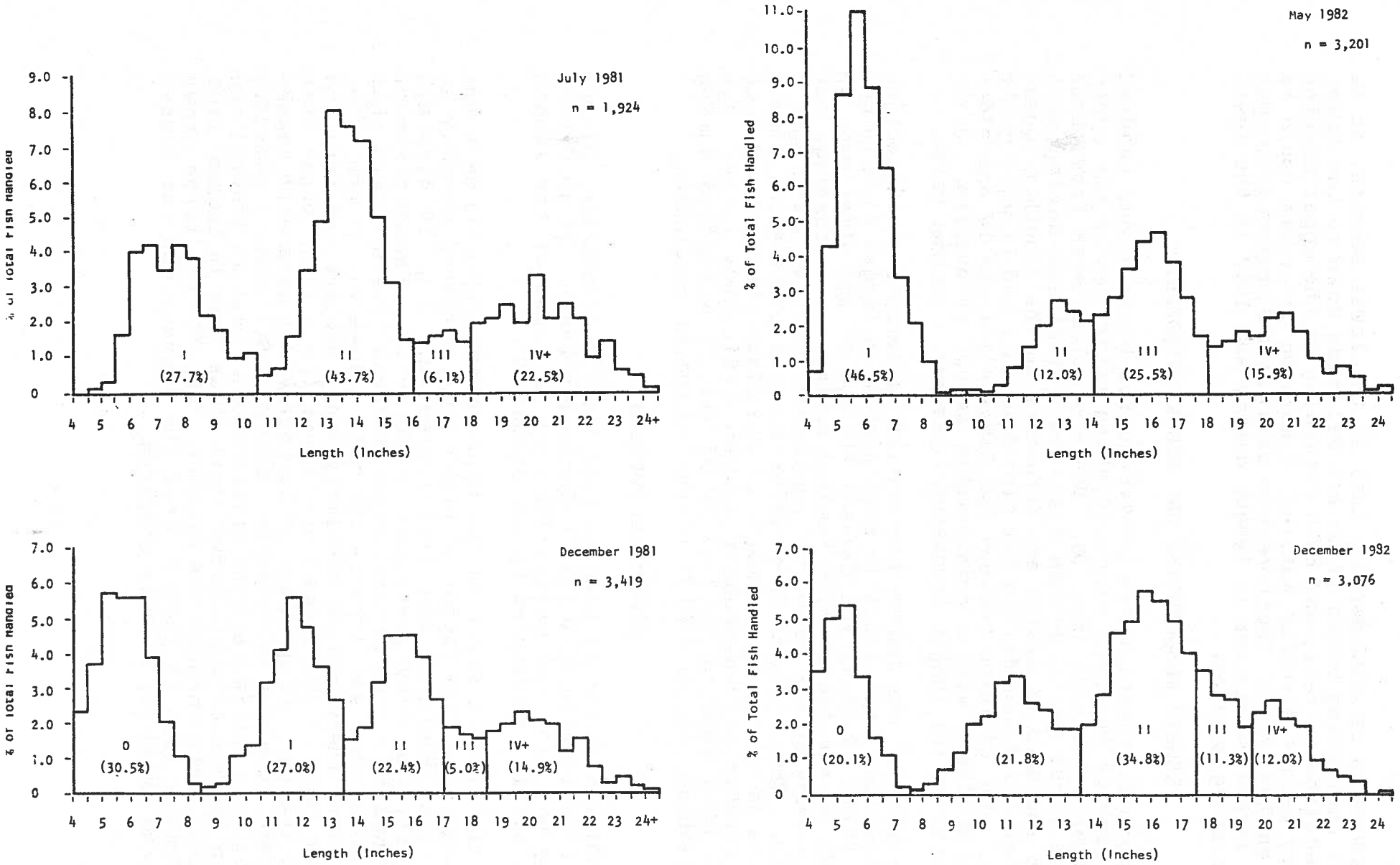


Fig. 9. Length frequencies for brown trout handled in the upper electrofishing section of the Bighorn River during July and December 1981 and May and December 1982. Approximate age class boundaries are shown with each age class listed and percentage of total within that block shown in parentheses.

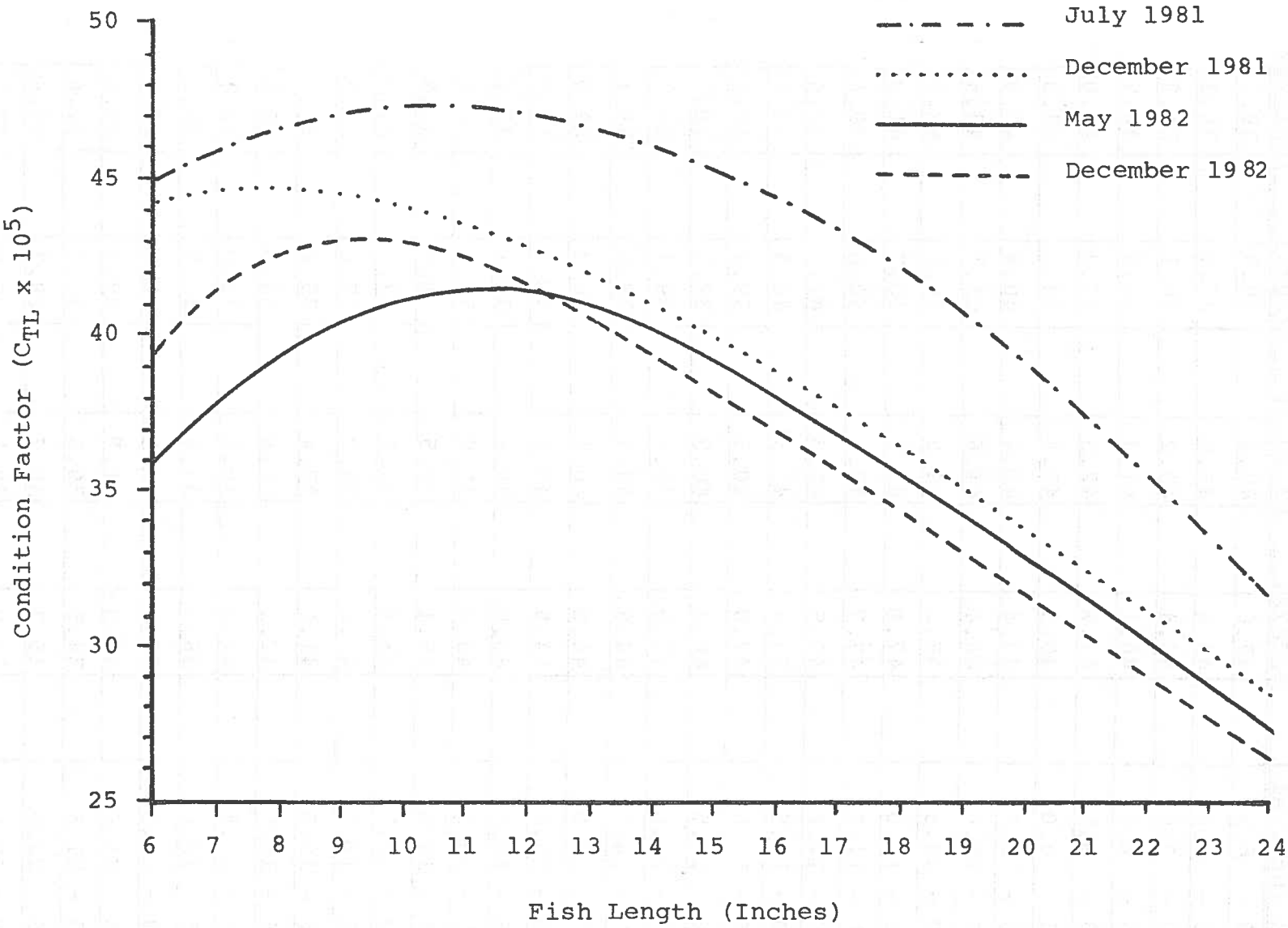


Fig. 10. Condition factors (C_{TL} x 10^5) of brown trout from the upper electrofishing section of the Bighorn River during July 1981, December 1981, May 1982 and December 1982. Curves are hand-fitted to data from Table 10).

Table 10. Condition factors ($C_{TL} \times 10^5$) of brown trout by 1/2-inch group from the upper electrofishing section of the Bighorn River during four time periods.

CONDITION FACTOR ($C_{TL} \times 10^5$)

Length Interval	7/26/81	12/10/81	5/20/82	12/14/82
6.0 - 6.5	45.6	45.8	39.9	38.2
6.5 - 7.0	45.4	45.5	37.9	36.8
7.0 - 7.5	46.4	45.2	36.1	34.3
7.5 - 8.0	46.1	41.4	34.9	44.9
8.0 - 8.5	47.8	42.5	36.3	47.0
8.5 - 9.0	48.3	42.4	34.3	44.3
9.0 - 9.5	47.4	48.4	40.4	43.9
9.5 - 10.0	46.4	48.6	41.8	43.5
10.0 - 10.5	46.2	44.6	49.8	42.3
10.5 - 11.0	47.8	43.2	40.7	41.0
11.0 - 11.5	47.7	42.1	40.0	39.4
11.5 - 12.0	47.5	41.3	41.6	39.4
12.0 - 12.5	47.4	41.5	40.4	37.6
12.5 - 13.0	47.0	40.3	39.9	36.4
13.0 - 13.5	46.3	40.9	39.7	38.5
13.5 - 14.0	45.0	39.4	39.1	39.7
14.0 - 14.5	44.5	42.2	38.6	39.1
14.5 - 15.0	44.8	40.5	38.3	39.0
15.0 - 15.5	44.9	40.3	38.7	38.5
15.5 - 16.0	43.9	39.9	38.1	37.4
16.0 - 16.5	43.8	38.9	37.6	36.8
16.5 - 17.0	45.1	38.5	38.0	36.5
17.0 - 17.5	45.4	37.7	37.3	35.7
17.5 - 18.0	41.6	38.7	37.6	36.3
18.0 - 18.5	41.6	37.4	35.4	34.6
18.5 - 19.0	42.2	37.6	34.3	34.8
19.0 - 19.5	41.0	35.2	34.0	32.5
19.5 - 20.0	38.3	33.6	31.6	30.8
20.0 - 20.5	36.5	33.8	31.1	29.7
20.5 - 21.0	36.9	31.8	29.7	29.0
21.0 - 21.5	34.5	30.5	30.0	28.6
21.5 - 22.0	35.3	30.7	29.2	27.6
22.0 - 22.5	34.0	29.1	29.6	27.3
22.5 - 23.0	31.8	29.5	28.0	27.7
23.0 - 23.5	33.9	30.2	28.7	28.6
23.5 - 24.0	32.5	30.4	28.9	28.3
Total	42.0	40.7	37.5	38.1

The average condition factor for brown trout in the upper electrofishing section on the Bighorn has steadily declined from $C = 43.93 \times 10^{-5}$ on July 26, 1981 to 38.10×10^{-5} on December 14, 1982, a decline of 13.3% (Table 10). Future electrofishing will determine whether this trend continues. During both 1982 estimates, the C factor for brown trout in the largest size groups (20.5 inches and longer) were generally less than 30×10^{-5}, an exceptionally low value (Table 10).

Reasons for the low condition factor of large brown trout were not determined. A nitrogen supersaturation problem associated with the Afterbay Dam caused blindness in some fish and during certain times of the year, mostly spring and summer, a high proportion of the brown trout exhibited external blisters and other signs of gas bubble disease (U. S. Fish and Wildlife Service 1981). The large brown trout were the most severely affected.

There also may be a shortage of forage fish in the Bighorn River. There are no sculpins and limited number of small mountain whitefish. This could also be a result of the gas supersaturation problem. A food habits study should be initiated to analyze forage fish utilization by brown trout in the Bighorn.

RAINBOW TROUT

POPULATION AND BIOMASS ESTIMATES

During July 1981 none of the 125 rainbow trout captured and marked were recaptured. Thus, no population estimate was achieved. Likewise, inadequate numbers of recaptured small rainbow trout made it impossible to estimate populations for rainbow less than 9 inches in length during succeeding attempts. Population parameters for estimates conducted in December 1981, May 1982 and December 1982 are presented (Table 11).

Variation within the rainbow trout population appeared to be directly related to the stocking of hatchery fish. On August 24-28, 1981, a total of 40,514 rainbow trout averaging 6.4 inches in length were stocked in the Bighorn River from the Afterbay Dam to Two Leggins bridge. In December 1981 these fish were 10.0 to 12.5 inches long. The estimated population of rainbow trout over 13 inches long in December 1981 was 114 fish per mile. Angling pressure during the summer had apparently sharply reduced what had been a substantial but unquantified population of large rainbow trout.

By May 1982 rainbow trout from the 1981 plant were 11.0-13.5 inches long. The estimated population of 9 to 13-inch rainbow trout was down only 5%, but the estimated numbers of rainbow longer than 13 inches had increased 443% (Table 11). The total estimated population of 9+ inch rainbow in May 1982 was up 77% and biomass was up 177% from December 1981. These increases were apparently due to the influences of the 1981 plant.

By December 1982 the majority of rainbow trout from the 1981 plant were 14.0-17.5 inches long. The total population had decreased 62% (9+ inch rainbow trout) (Table 11). As fish from the 1981 plant moved out of the 9 to 13-inch size range, the estimated population in this group plummeted down 90%. The estimated population of 13+ inch rainbow was down 40%. This was probably due partly to angling mortality. The total biomass of 9+ inch rainbow trout declined 57%.

Table 11. Estimated population parameters of rainbow trout in the upper 6.7 mile electrofishing section on the Bighorn River during December 1981, May 1982 and December 1982.

Parameter		Dec. 1981	May 1982	Dec. 1982
No. of rainbow trout/mile	9-13 in.	505	478	46
	13+ in.	114	619	371
	Total	619	1,097	417
Total rainbow trout biomass (pounds per mile) 9 inches and longer		589	1,631	699

The fact that fish from the 1981 plant were moving through the system was well demonstrated when the average length of all rainbow trout handled during electrofishing operations was compared. In July 1981, a total of 220 rainbow trout averaged 17.6 inches in length. In December 1981 following stocking and heavy fishing pressure, this figure dropped dramatically to a 12.7-inch average for 547 rainbow trout that were measured. Then, as the fish from the 1981 plant grew, so did the average length - to 14.9 inches for 563 fish measured in May 1982 and then 16.2 inches for 363 trout measured in December 1982.

The estimated number of rainbow trout 18 inches and longer per mile in the upper electrofishing section was 49 in December 1981. It increased 331% to 211 18-inch fish per mile in June 1982 and then decreased 78% to 47 18-inch fish per mile in December 1982.

The upper Bighorn River was not planted with rainbow trout during 1982. Consequently, the rainbow trout population should continue to decline during 1982, and the average length of

rainbow trout should increase. It appears certain that rainbow trout reproduction in the Bighorn River is limited. The population is heavily dominated and numbers regulated by the number of hatchery fish planted into the system. Future work should focus on identifying the reasons for the limited natural production of wild rainbow trout in the Bighorn River.

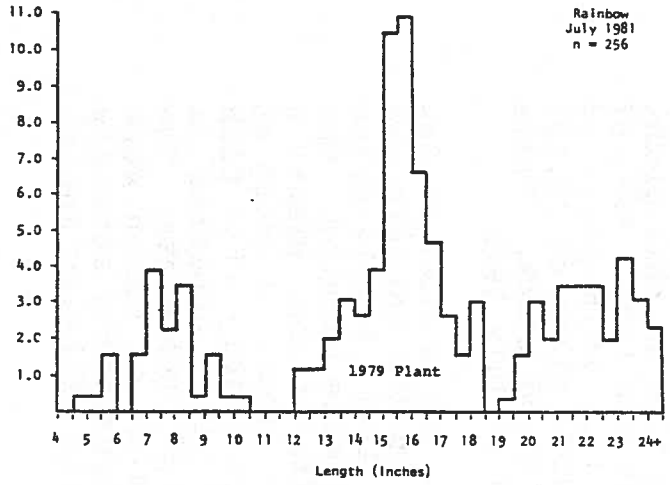
In the lower electrofishing section only one population estimate has been conducted. During May 1982 there were an estimated 204 9-13 inch rainbow trout per mile and 221 rainbow 13 inches and longer for a total estimate of 425 rainbow trout per mile. This was about 39% as high as the population of rainbow trout in the upper electrofishing section. The estimated biomass was 476 pounds per mile.

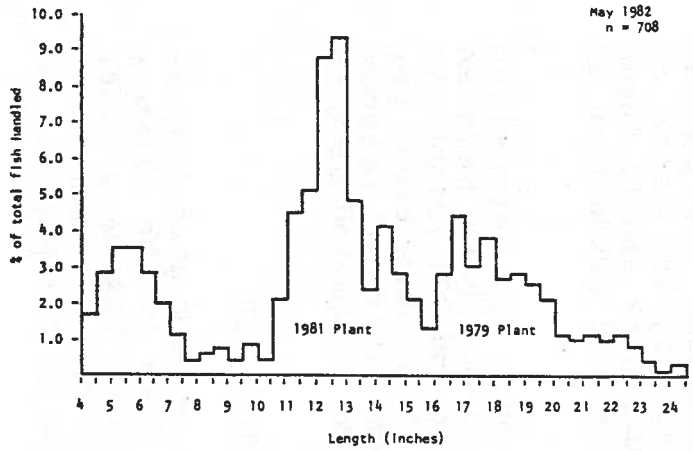
LENGTH FREQUENCIES AND AGE RELATIONSHIP

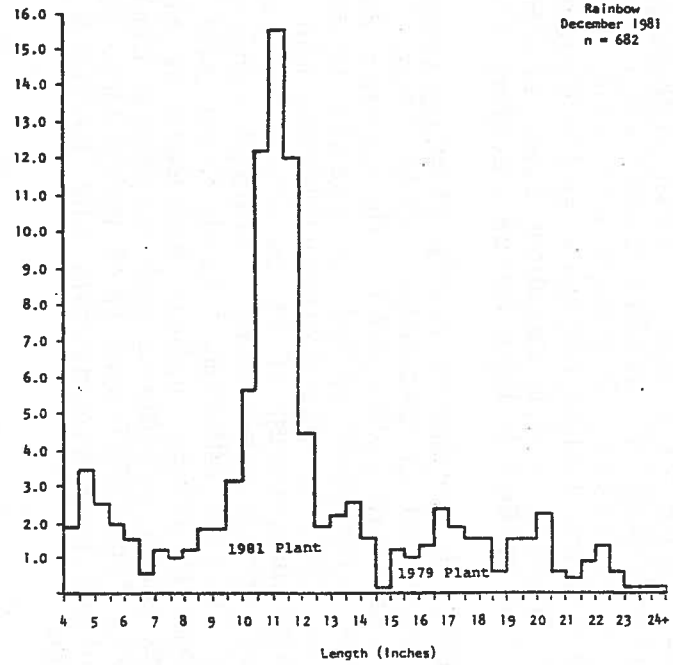
Analysis of length frequencies provides a very good indication of the dominance of hatchery-reared fish in the rainbow trout population. Because of the influence of hatchery fish, accurate aging of rainbow trout by the scale technique was found to be difficult, if not impossible. Analysis of the population by age groups was not accomplished.

However, because of the known stocking history in the river, age groups could be estimated by analyzing the length frequencies. It appeared that prior to the time the Bighorn River was reopened to fishing (July 1981 sample) there were three distinct size classes of rainbow trout (Fig. 11). A group of 4 to 10.5-inch long rainbow trout were apparently wild fish reared in the stream, probably Age Class I. The major population appeared to be comprised of 12 to 18.5-inch fish. A large share of these were undoubtedly from the May 1979 plant of 24,700 5-inch Arlee rainbow. Some wild Age II fish probably were also in this group. The third group of rainbow trout were 19-25 inches long. Many of these were likely 5 years old and from a July 1976 plant of 13,200 6-inch Arlee rainbow and a November 1976 plant of 20,125 3-inch Shasta strain rainbow from the Ennis brood stock. There were also 15,600 5-inch Arlee rainbow stocked in July 1975.

After 5 months of heavy fishing pressure, the population was again sampled in December 1981 (Fig. 11). In the interim the river had been restocked. On August 24-28, 1981, 40,514 Arlee rainbow trout averaging 6.4 inches in length were planted. The December 1981 sample clearly showed the results of that plant, a very dominant group of 10 to 12.5-inch rainbow trout. A group of rainbow trout less than 7 inches long were probably wild fish reared in the system. Fish from the 1979 plant appeared in considerably lower numbers and were in the 15-19 inch class. The 19-inch plus trophy-sized rainbow trout, most of which were probably from 1975 and 1976 stocking, were apparently severely reduced in numbers during the first 5 months of heavy angler pressure.







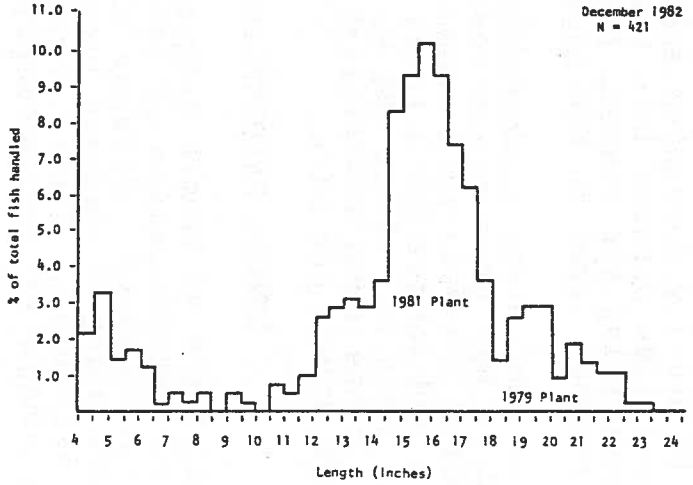


Fig. 11. Length frequencies for rainbow trout handled in the upper electrofishing section of the Bighorn River during July and December 1981 and May and December 1982. Origin of fish in peak length groups is shown.

The length structure of the population sampled in May 1982 was very similar to December 1981 with most peak size groups advancing about 1 inch in length (Fig. 11). No fish were planted during 1982.

A fourth sample was taken in December 1982. The group of fish from the 1981 plant was still heavily dominant with the peak length interval having advanced 3 inches during the 7 months from May to December - to 15.5-15.9 inches. The large fish from 1975-1976 plants were largely absent from the population after two summers of heavy angling pressure and/or natural mortality. Two probable groups of wild fish were in the 4 to 6.5-inch range (Age 0) and 11.5 to 14-inch range (Age I).

Some of the so-called "wild" fish may actually have been hatchery fish that washed downstream from the Afterbay Reservoir, which was planted annually from 1966-1982. During the period 1975-1982, anywhere from 40,000 to 93,000 rainbow trout 2-8 inches long were stocked in the Afterbay. In past years some movement downstream is known to have occurred (Stevenson 1975) and further documentation is presented later in this report.

CONDITION FACTORS AND LIFE HISTORY

Condition factors of rainbow trout in the Bighorn River were generally excellent. The average condition factors ($C \times 10^{-5}$) in the upper section were 43.83 in December 1981, 42.20 in May 1982 and 41.60 in December 1982. In the lower electrofishing section, the average condition factor of rainbow trout was 40.78 in May 1982.

The rainbow trout life history was not clearly established during this report period and needs further documentation.

HATCHERY VS. WILD ORIGIN

During the winter 1982 electrofishing surveys, which were conducted from December 7, 1982 through January 8, 1983, rainbow trout were examined for signs of dorsal fin erosion and crooked dorsal rays sometimes characteristic of hatchery-raised trout. Fish exhibiting these characteristics were probably hatchery-reared fish, whereas those not showing the characteristics may or may not have been hatchery trout. Hatchery fish do not always exhibit signs of dorsal fin erosion, depending on the amount of crowding at the hatchery, size at which they are planted and other factors.

Of 229 rainbow trout examined, almost one-third (32%) appeared to be hatchery fish. None of 19 rainbow trout less than 9 inches long were hatchery-positive, and only 2 of 18 (11%) between 9 and 13 inches showed hatchery-positive dorsal fins. Most of the rainbow trout examined were between 13 and 18 inches long. Of 151 trout in this size range, over 44% showed signs of

hatchery origin. Five of 41 trout over 18 inches in length (12%) showed hatchery-positive dorsal fin characteristics.

On June 9-10, 1982, 40,000 rainbow trout averaging 5.2 inches in length were planted in the Yellowtail Afterbay. These fish were marked by being fed tetracycline in their feed at the hatchery which leaves a characteristic ring in the bony parts, visible under a microscope when illuminated with ultraviolet light.

On October 8, 1982, 84 known marked hatchery fish were collected just downstream from the Afterbay Dam in the upper end of the Bighorn Canal by electrofishing. The canal had been shut down for the season and the fish had become stranded. The fish averaged 10.1 inches in length and lengths ranged from 7.6-11.5 inches. Average growth was over 1.2 inches per month. All 84 fish were dissected and examined. All 84 fish had strongly evident tetracycline marks on their bones. Of those 84 fish, 29 (35%) had dorsal fins that appeared normal, not showing any evidence of hatchery-caused deformity.

On December 7-14, 1982, 25 rainbow trout were collected from the upper electrofishing section of the Bighorn River to be examined for evidence of tetracycline marks. These fish ranged from 9.8-12.8 inches. Eleven of the 25 fish (44%) had positive tetracycline marks on their vertebrae, showing conclusively that some fish were migrating downstream from the Afterbay into the Bighorn River.

Of the 25 fish examined on December 7-14, 1982, 10 (40%) were considered to have hatchery dorsal fin characteristics. Eight of these 10 (80%) carried tetracycline markes when examined independently. Only 3 of the 15 fish (20%) with wild-appearing dorsal fins carried tetracycline marks. The 11 tetracycline-marked fish averaged 11.9 inches in length, an average growth of 6.7 inches in 6 months since planting.

On March 14, 1983, 14 rainbow trout between 10.5 and 15.5 inches in length were collected near the mouth of Soap Creek by electrofishing. Only one, 12.1 inches long, carried a positive tetracycline mark.

Conclusions drawn from the foregoing discussion are somewhat premature. However, it does appear certain that at least one-third and probably more than half of the rainbow trout in the Bighorn River system were hatchery fish during 1982-83.

MOUNTAIN WHITEFISH

During the December 1982 population estimates, an effort was made to capture all mountain whitefish that were observed. A total of 126 mountain whitefish were captured, a ratio of 1 mountain whitefish for every 24.7 brown trout and 3.5 rainbow

trout. This provided a rough idea of relative abundance of whitefish.

Whitefish captured ranged in size from 6.1-19.6 inches. One fish 18.4 inches long weighed 3.44 pounds. Age analysis of a sample of 72 whitefish from which scales were collected during December 1982 is presented (Table 12).

On December 13-14, 1982, 97 mountain whitefish captured by electrofishing were checked for evidence of sex by external examination. About 23% of the fish were not mature. Slightly over half (52%) were ripe males that extruded milt when pressure was applied. Twenty percent of the fish checked were ripe females, extruding eggs under pressure. Two females (2%) were gravid and not yet ready to spawn and four females (4%) appeared to be spent and had already spawned. Based on this limited sample, it appeared that mid-December was approaching the peak period for whitefish spawning in the Bighorn River.

RECOMMENDATIONS

1. Evaluate forage fish utilization by walleye on Bighorn Lake and recommend specific reservoir levels to enhance forage fish production. Investigate potential forage fish introductions.

2. Continue present annual stocking rates in Yellowtail Afterbay.

3. Work toward evaluating and elminating or reducing impacts on the Bighorn River fishery from nitrogen supersaturation and annual drawdowns. Efforts of the U. S. Bureau of Reclamation to solve both problems should be encouraged and supported.

4. Evaluate rainbow trout life history and spawning characteristics to determine causes of low reproductive success in the Bighorn River. DeSmet strain rainbow trout should be stocked in the Bighorn for 3 consecutive years (1983-1985), and then evaluated to determine spawning success, catchability, growth, longevity and food habits. Other strains of rainbow trout should be considered.

5. Brown trout food habits should be evaluated in the Bighorn River with emphasis on determining why condition factors of large brown trout are poor. Mottled sculpins (Cottus bairdi) should be introduced into the upper 12 miles of the Bighorn River to enhance the forage fish base for large brown trout.

6. Species-specific fishing regulations should be adopted to protect the limited rainbow trout population and encourage harvest of brown trout which are not being overharvested despite heavy fishing pressure.

Table 12. Age analysis of 72 mountain whitefish from scale samples collected in the upper Bighorn River electrofishing section during December 1982.

Age Class	No. of Whitefish	Mean Length (in)	Length Range (in)
0	9	7.0	6.1-7.5
I	4	12.5	11.9-13.6
II	18	14.6	13.7-16.3
III	18	15.6	13.8-17.1
IV	13	17.7	16.3-18.7
V	5	18.4	17.7-19.2
VI	4	18.5	18.0-19.6
VII	1	19.6	19.6

7. Evaluation of species composition in the Bighorn River from Two Leggins to the mouth should be carried on. Rainbow trout stocking should continue in reaches providing suitable trout habitat and water conditions.

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Waters referred to:

22-9835 Bighorn Lake
22-9834 Yellowtail Afterbay
22-0495 Bighorn River, Sec. 2
22-0490 Bighorn River, Sec. 1

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Brown trout
Rainbow trout
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Creel census