



The trout fishery of the lower Big Hole River, Montana, during 1977 and 1978  
by Vincent John Kozakiewicz

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE  
in Fish and Wildlife Management  
Montana State University  
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**Abstract:**

A partial creel census to determine the fishermen use and harvest was conducted during 1977 and 1978 on a 16 km section of the lower Big Hole River. Approximately 41 and 47% of the estimated total number of anglers using the study area in 1977 and 1978 respectively were interviewed. Anglers residing within 80 km of the study area comprised 62% of the fishermen interviewed in 1977 and 65% in 1978. About 64 and 62% of the anglers kept zero fish in 1977 and 1978 respectively. In 1977 0.05% of the anglers kept the bag limit of ten trout. Less than 3% of the anglers kept the bag limit of five trout in 1978. Catch rates of fish kept were 0.25 and 0.28 fish/hour in 1977 and 1978 respectively. In 1977 an estimated 5,397 anglers fished 15,698 hours on the study area. Bank anglers accounted for about 80% of the total number of anglers and 76% of the total hours fished. An estimated 3,987 anglers fished 9,945 hours on the study area in 1978. Bank anglers accounted for 62% of the anglers and 61% of the hours fished in that year. A total of 1,088 boats used the study area during the study with 41% of the use occurring in 1977. A total of 3,974 trout were harvested in 1977 with bank anglers catching 66%. In 1978 about 2,746 trout were harvested with bank anglers catching 48%. Brown trout constituted an estimated 78% of the harvest in 1977 and 72% in 1978. Age II and older fish comprised 99 and 98% of the brown trout harvest in 1977 and 1978 respectively. The April to September 1977 mortality rate for these brown trout was 43% with fishing mortality accounting for 64% of that mortality. Harvest of Age II and older brown trout was responsible for 70% of the annual mortality from fall 1977 to fall 1978. Harvest accounted for 44% of the annual mortality of Age III and older brown trout during the same period.

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Date August 3, 1979

In memory of  
Kenneth David Lorang, a friend and colleague.

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BIG HOLE RIVER, MONTANA, DURING 1977 AND 1978

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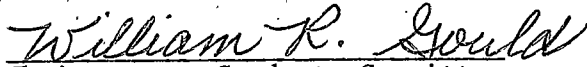
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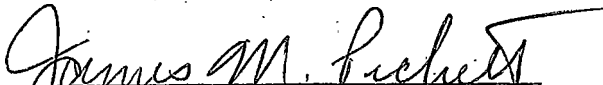
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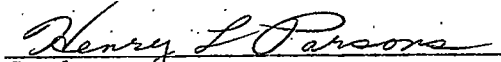
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MONTANA STATE UNIVERSITY  
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## TABLE OF CONTENTS

	Page
VITA. . . . .	iii
ACKNOWLEDGMENT. . . . .	iv
LIST OF TABLES. . . . .	vii
LIST OF FIGURES . . . . .	x
ABSTRACT. . . . .	xi
INTRODUCTION. . . . .	1
DESCRIPTION OF STUDY AREA . . . . .	3
METHODS . . . . .	7
General Pattern of Creel Census. . . . .	7
Selection of Census Days. . . . .	7
Sampling on a Census Day. . . . .	7
Modification of General Pattern of Creel Census. . . . .	8
Weekends-Floaters/Method A. . . . .	8
Weekends-Floaters/Method B. . . . .	9
Weekends-Floaters/Method C. . . . .	10
Weekdays-Floaters/Method A. . . . .	11
Weekdays-Floaters/Method B. . . . .	12
Weekdays-Floaters/Method C. . . . .	13
Weekends-Bank Anglers/Method A. . . . .	13
Weekends-Bank Anglers/Method B. . . . .	16
Weekends-Bank Anglers/Method C. . . . .	17
Weekdays-Bank Anglers/Method A. . . . .	17
Weekdays-Bank Anglers/Method B. . . . .	18
Estimates and Variances for Strata and Seasons. . . . .	18
Estimates of Fish Populations. . . . .	19
Age Determination and Statistical Analyses . . . . .	20
RESULTS . . . . .	21
Interviews . . . . .	21
Catch Rates. . . . .	24

## TABLE OF CONTENTS (Continued)

	Page
Fishing Pressure . . . . .	25
Boats On The Study Area . . . . .	33
Fish Harvested and Released . . . . .	38
Age Structure of Brown Trout Harvested. . . . .	49
Age Structure of Rainbow Trout Harvested. . . . .	53
Mortality Rates of Fish Populations . . . . .	57
Mortality Attributed to Harvest . . . . .	57
SUMMARY AND DISCUSSION . . . . .	59
LITERATURE CITED . . . . .	67
APPENDIX . . . . .	69

## LIST OF TABLES

Table	Page
1. The average length of the fishing day (in hours) on the lower Big Hole River. . . . .	21
2. The numbers and percents (in parenthesis) of male and female anglers in interviews on the lower Big Hole River.	23
3. The numbers and percents (in parenthesis) of the types of lures used by anglers on the lower Big Hole River . . . . .	23
4. The number of fish kept and released and fish kept (in parenthesis)/hour by floaters and bank anglers on the lower Big Hole River. . . . .	25
5. The estimated numbers of anglers and hours fished during each stratum in 1977 (95% confidence interval). . . . .	26
6. The estimated numbers of bank anglers and the hours fished on weekends-holidays and weekdays during each stratum in 1977. . . . .	29
7. The estimated numbers of floaters and hours fished on weekends-holidays and weekdays during each stratum in 1977. . . . .	30
8. The estimated numbers of anglers and hours fished during each stratum in 1978 (95% confidence interval). . . . .	31
9. The estimated numbers of bank anglers and hours fished on weekends-holidays and weekdays during each stratum in 1978. . . . .	34
10. The estimated numbers of floaters and hours fished on weekends-holidays and weekdays during each stratum in 1978. . . . .	35
11. The estimated numbers of boats on weekends-holidays and weekdays during each stratum in 1977 and 1978 (95% confidence interval). . . . .	36



## LIST OF TABLES (Continued)

Table	Page
12. The estimated numbers of brown and rainbow trout kept and released during each stratum in 1977 (95% confidence interval). . . . .	39
13. The estimated numbers of brown and rainbow trout kept and released by bank anglers on weekends-holidays and weekdays during each stratum in 1977. . . . .	41
14. The estimated numbers of brown and rainbow trout kept and released by floaters on weekends-holidays and weekdays during each stratum in 1977. . . . .	43
15. The estimated numbers of brown and rainbow trout kept and released during each stratum in 1978 (95% confidence interval). . . . .	45
16. The estimated numbers of brown and rainbow trout kept and released by bank anglers on weekends-holidays and weekdays during each stratum in 1978. . . . .	47
17. The estimated numbers of brown and rainbow trout kept and released by floaters on weekends-holidays and weekdays during each stratum in 1978. . . . .	50
18. The numbers of brown trout harvested in each age group on the lower Big Hole River in 1977. Percents are in parenthesis. . . . .	52
19. The numbers of brown trout harvested in each age group on the lower Big Hole River in 1978. Percents are in parenthesis. . . . .	54
20. The numbers of rainbow trout harvested in each age group on the lower Big Hole River in 1977. Percents are in parenthesis. . . . .	55
21. The numbers of rainbow trout harvested in each age group on the lower Big Hole River in 1978. Percents are in parenthesis. . . . .	56

## LIST OF TABLES (Continued)

Table	Page
22. The distribution of the numbers of trout kept by anglers on the lower Big Hole River during 1977 and 1978 (from completed trips only) . . . . .	70
23. The average length of brown trout creelred on the lower Big Hole River during each stratum in 1977 and 1978. .	71
24. The average length of rainbow trout creelred on the lower Big Hole River during each stratum in 1977 and 1978 . . . . .	72
25. The average weights (kg) of brown and rainbow trout creelred on the lower Big Hole River in 1977 and 1978. Sample sizes are in parenthesis. . . . .	73
26. Spring and fall estimates of the population of brown and rainbow trout and over summer mortality rates on the lower Big Hole River in 1977 (Wells and Nelson 1978) and 1978 (J. Wells personal communication) 80% confidence intervals in parenthesis. . . . .	74

LIST OF FIGURES

Figure	Page
1. Map of the study area. . . . .	4

## ABSTRACT

A partial creel census to determine the fishermen use and harvest was conducted during 1977 and 1978 on a 16 km section of the lower Big Hole River. Approximately 41 and 47% of the estimated total number of anglers using the study area in 1977 and 1978 respectively were interviewed. Anglers residing within 80 km of the study area comprised 62% of the fishermen interviewed in 1977 and 65% in 1978. About 64 and 62% of the anglers kept zero fish in 1977 and 1978 respectively. In 1977 0.05% of the anglers kept the bag limit of ten trout. Less than 3% of the anglers kept the bag limit of five trout in 1978. Catch rates of fish kept were 0.25 and 0.28 fish/hour in 1977 and 1978 respectively. In 1977 an estimated 5,397 anglers fished 15,698 hours on the study area. Bank anglers accounted for about 80% of the total number of anglers and 76% of the total hours fished. An estimated 3,987 anglers fished 9,945 hours on the study area in 1978. Bank anglers accounted for 62% of the anglers and 61% of the hours fished in that year. A total of 1,088 boats used the study area during the study with 41% of the use occurring in 1977. A total of 3,974 trout were harvested in 1977 with bank anglers catching 66%. In 1978 about 2,746 trout were harvested with bank anglers catching 48%. Brown trout constituted an estimated 78% of the harvest in 1977 and 72% in 1978. Age II and older fish comprised 99 and 98% of the brown trout harvest in 1977 and 1978 respectively. The April to September 1977 mortality rate for these brown trout was 43% with fishing mortality accounting for 64% of that mortality. Harvest of Age II and older brown trout was responsible for 70% of the annual mortality from fall 1977 to fall 1978. Harvest accounted for 44% of the annual mortality of Age III and older brown trout during the same period.

## INTRODUCTION

The lower Big Hole River lies between the towns of Divide and Twin Bridges. It is approximately 82 km of the highest quality trout habitat in Montana (Brown et al. 1965). It has supported a trout fishery since at least the early 1900's when the Union Pacific Railroad offered special train service from Butte to the Big Hole River for fishermen. Recently apparent increased use has caused certain sportsmen groups to become concerned about the fishery of the lower Big Hole River.

Fishermen use and harvest on the lower Big Hole River previous to this study were measured by limited creel censuses and the solicitation of fishermen logs. However, populations of brown (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) in a 6.9 km section of the lower river have been monitored periodically since 1969 (Elser and Marcoux 1971 and 1972, Peterson 1974, Wells and Nelson 1978). A comparison of estimates made in 1970 and 1977 showed the numbers of brown trout less than 45.7 cm in total length have increased. However, the numbers of brown trout 45.7 cm and larger and all size classes of rainbow trout larger than 18.0 cm have decreased over those years (Wells and Nelson 1978).

The purpose of this study was to determine angler use and harvest of brown and rainbow trout in a reach of the lower Big Hole

River and relate it to the existing populations. It was designed to measure the individual impacts of boat and bank fishermen. Field work was conducted from May into September of 1977 and 1978.

## DESCRIPTION OF THE STUDY AREA

The Big Hole River lies predominantly in Beaverhead County in southwestern Montana. It arises in the Bitterroot Mountains near the town of Jackson and flows approximately 182 km in a sinuous course to its confluence with the Jefferson River. From Jackson the river flows northward through the upper Big Hole valley then eastward to Divide. From Divide the river turns southward through the Big Hole canyon and the lower Big Hole valley then turns northward. It receives tributaries from both the Bitterroot and Pioneer mountains.

The Big Hole River drains a total land area of 6,413 km<sup>2</sup> (U.S.G.S. 1978). Major economic activities in the drainage are cattle ranching, haying, mining and recreation. The withdrawal of water from the river for irrigation of hayfields has been implicated as a major detriment to the fishery of the Big Hole drainage (Heaton 1960, Wipperman 1965, Wells and Nelson 1978). Heavy metals and siltation from two mining operations have entered the river in the past but corrective action was taken in 1959 (Heaton 1960).

The study area extended from the Trapper Creek Road Bridge at Melrose 16 km downstream to the boat pullout behind the Glen Bar (Fig. 1). The elevation of the study area at the U.S.G.S. gage site was 1,434 m above sea level (U.S.G.S. 1978). The average

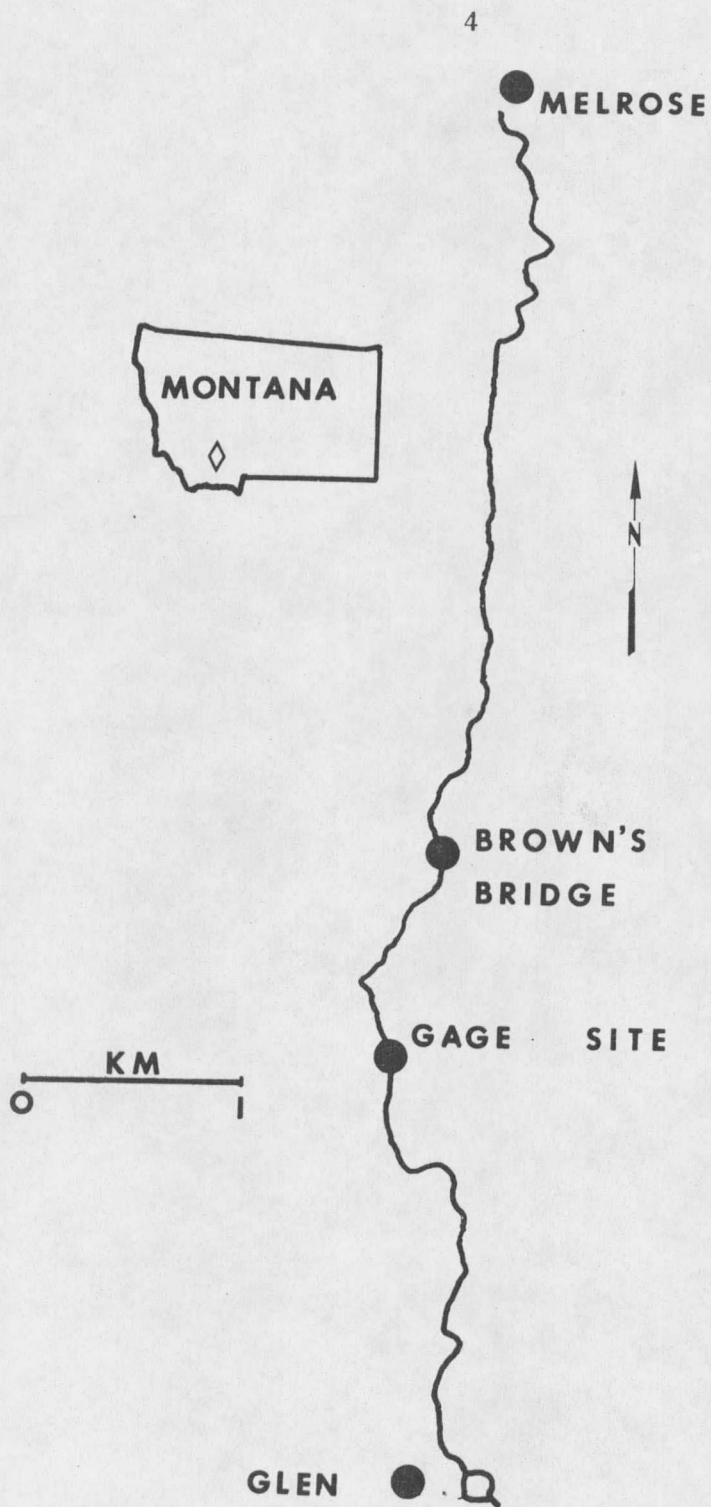


Figure 1. Map of the study area.



gradient for the lower Big Hole River was approximately 6.8 m per km and stream width was generally greater than 38 m (Montana Department of Fish and Game 1979).

The river within the study area was composed mostly of riffles and large pools. The substrate consisted mainly of cobble interspersed with gravel and sand. The riparian zone contained grasses, cottonwood (*Populus*), willow (*Salix*), rose (*Rosa*) and other deciduous shrubs.

The mean, minimum and maximum flows of the lower Big Hole River at the gage site in the study section for a 54 year period ending in 1977 were  $32.77 \text{ m}^3/\text{sec}$ ,  $1.39 \text{ m}^3/\text{sec}$  and  $405 \text{ m}^3/\text{sec}$  respectively (U.S.G.S. 1978). An unnatural maximum flow of  $651 \text{ m}^3/\text{sec}$  was recorded when the Wise River Reservoir dam failed in 1927. Mean and maximum flows in water year 1977 were below normal. The mean, minimum and maximum flows were  $19.45 \text{ m}^3/\text{sec}$ ,  $4.36 \text{ m}^3/\text{sec}$  and  $131 \text{ m}^3/\text{sec}$  respectively (U.S.G.S. 1978). The mean and maximum flows in water year 1978 were higher than those in the previous year. The mean, minimum and maximum flows were  $42.31 \text{ m}^3/\text{sec}$ ,  $3.34 \text{ m}^3/\text{sec}$  and  $204.89 \text{ m}^3/\text{sec}$  respectively (U.S.G.S. unpublished data). The minimum flow was recorded between the first fall and second spring of the study.

In the study section the river is entirely surrounded by private ranchland. Fishermen were provided access to the river

through the courtesy of the land owners. Floaters (anglers using boats) were allowed convenient access at the Trapper Creek Road Bridge, Brown's Bridge and the lower study section boundary. Bank anglers (fishing from shore and wading) were given walk-in access at numerous locations.

## METHODS

### General Pattern of Creel Census

#### Selection of Census Days

Creel censuses were conducted from May 21 to September 9, 1977 and from May 20 to September 8, 1978 to obtain estimates of angling pressure and harvest. Dr. David Bowden of Colorado State University designed the creel census used in this study. The census basically consisted of dividing the fishing season into strata of two weeks. Two weekend days, one Saturday and one Sunday, were randomly selected to be censused in each stratum. Two weekdays were randomly selected to be sampled from each week within each stratum. Weeks containing a holiday were considered to be separate strata. In these strata the census was conducted on both weekend days, the holiday and two of the remaining weekdays.

#### Sampling on a Census Day

The length of the fishing day was considered to extend from 6 A.M. to 10 P.M. Instantaneous counts (made within 1 hr) of bank anglers observed fishing were made four times each census day. The time of the first count was selected randomly to begin at 6, 7, 8, or 9 A.M. Each of the following three counts were made

at intervals of 4 hours.

The census day was divided into four 4-hr periods: 6-10 A.M., 10 A.M.-2 P.M., 2-6 P.M. and 6-10 P.M. Bank anglers were interviewed during one of the two earlier periods and one of the two latter periods. Floaters were interviewed during the remaining two periods. Approximately 75% of the floaters using the study area ended their trips at Glen and 25% at Brown's Bridge. The selection of the sampling location was weighted in proportion to the pressure so that the probability of sampling at Glen was three times that of sampling at Brown's Bridge.

Fishermen were interviewed individually. Information collected from interviews included length of time fished, methods of angling, residency and sex. The number, weight and total length of each fish kept and the number of fish released were recorded by species.

#### Modification of General Pattern of Creel Census

Several modifications of the basic sampling program were used. They were applied to increase sampling efficiency during periods of heavy boating and when additional manpower was available.

#### Weekends-Floaters/Method A:

All floaters terminating their fishing day at Brown's Bridge and Glen were interviewed by a creel clerk on all weekend days and

holidays within the stratum. An attempt was also made to interview anglers floating beyond Glen. Since virtually all floaters were contacted, each variable recorded was summed and no variance was calculated. This method was used in Strata 1-8, 13 and 1-9, 13 during 1977 and 1978 respectively when boating pressure was high.

#### Weekends-Floaters/Method B

A stationary creel clerk interviewed all floaters at Glen on all weekend days in the stratum. Each variable recorded at Glen was summed and no variance was calculated. The roving creel clerk sampled floaters at Brown's Bridge during two 4-hr periods per day on all weekend days in the stratum. A daily total and corresponding variance for each variable at Brown's Bridge were estimated using Formulae 1, 2 and 3.

$$T_i = 1.5(X_{i1} + X_{i2}) \quad \text{Formula 1}$$

$$V(T_i) = 1.5S^2 \quad \text{Formula 2}$$

$$S_i^2 = \frac{\sum X_{ij}^2 - (\sum X_{ij})^2 / m_i}{m_i - 1} \quad \text{Formula 3}$$

where  $T_i$  = the estimated total for day  $i$

$X_{ij}$  = the total on day  $i$  and 4-hr period  $j$

$V(T_i)$  = the variance of  $T$  on day  $i$

$S_i^2$  = The variance of the 4-hr periods sampled  
 and  $m_i$  = the number of 4-hr periods sampled on day i.

Daily estimates of variables from all floaters were obtained by adding the estimates of each variable from Glen and Brown's Bridge. This method was applied in Stratum 9 during 1977 when floating began to decrease.

#### Weekends-Floaters/Method C

The roving creel clerk contacted all floaters at both take-out sites on one Saturday and one Sunday per stratum. The estimate of each variable for both weekends within the stratum was obtained by doubling the total from the one Saturday and one Sunday. The variance of each variable was obtained by combining the appropriate data from all Saturdays sampled by this method in the formula:

$$S^2 = \frac{\sum (X_i - \bar{X})^2}{n-1} \quad \text{Formula 4}$$

where  $X_i$  = the total on day i

$\bar{X}$  = the mean for all the days sampled

and  $n$  = the number of days sampled.

The variance for the two Saturdays in a stratum was estimated as  $2S^2$ . Since a pooled estimator of variance was used, the variance was the same for each Saturday in strata subjected to this method.

The estimate and variance of each variable for Sundays were obtained

similarly. This method was applied in Strata 10-12 during 1977 and 1978 when floating was uncommon.

#### Weekdays-Floaters/Method A

Floaters were sampled 3 days per week by the roving creel clerk during two randomly chosen 4-hr periods on each census day. The method of choosing the site for contacting and counting floaters is described in the previous section Sampling on a Census Day.

Each variable from each 4-hr period was multiplied by 2 when obtained at Glen and 6 when obtained at Brown's Bridge. The resulting sums of each variable from the two 4-hr samples were added to give the estimate of the variable for the census day. Formulae 5 and 6 were used to determine estimates of daily totals and variances.

$$T_i = T_{i1} + T_{i2} \quad \text{Formula 5}$$

$$V(T_i) = \frac{1}{3}(T_{i1} - T_{i2})^2 \quad \text{Formula 6}$$

where  $T_i$  = the estimated total for day  $i$

$T_{i1}$  and  $T_{i2}$  = the total on day  $i$  and 4-hr period  $j$

and  $V(T_i)$  = the variance of  $T$  on day  $i$ .

The weekly total and variance for each variable was estimated as:

$$T = \frac{N}{n} \sum T_i \quad \text{Formula 7}$$

$$V(T) = \frac{N^2(N-n)S^2 + N\sum V(T_i)}{N \times n} \quad \text{Formula 8}$$

$$S^2 = \frac{\sum (T_i - \bar{T})^2}{n-1} \quad \text{Formula 9}$$

where T = the estimated weekly total

V(T) = the variance of the weekly total

N = the number of weekdays in the stratum

and n = the number of days sampled.

This technique was used for Strata 1-8 and 1-9 during 1977 and 1978 respectively when boating pressure was high.

#### Weekdays-Floaters/Method B

The roving creel clerk sampled floaters during one randomly chosen 4-hr period per day on two days per week. The method of choosing the site for contacting and counting floaters is described in the previous section Sampling on a Census Day. An estimate of the daily total for each variable was obtained by multiplying each variable by 4 or 12 when obtained at Glen and Brown's Bridge respectively. Estimates of weekly totals were calculated using Formula 7. The variance for a week was calculated as:

$$V(T) = N^2 S^2 / n \quad \text{Formula 10}$$

where N,  $S^2$  and n are defined for Formulae 7, 8 and 9. An over-estimate of the actual variance resulted from the use of Formula 10



due to the absence of daily variances. This technique was applied in Stratum 9 during 1977 when boating pressure began to decrease.

Weekdays-Floaters/Method C

The roving creel clerk contacted all floaters for the entire census day on two days per week. Low boating pressure made it possible to contact all boaters. Daily totals were obtained by summation and no daily variances were calculated. A weekly estimate of each variable was calculated using Formula 7. Variance was calculated as:

$$V(T) = N^2 \left( \frac{N-n}{n} \right) S^2 / n \quad \text{Formula 11}$$

where  $N$ ,  $S^2$  and  $n$  are as defined for Formula 7, 8 and 9. This procedure was applied in Strata 10-13 during 1977 and 1978.

Weekends-Bank Anglers/Method A

The roving creel clerk sampled bank anglers except those at Glen and Brown's Bridge. The number of hours fished in the area covered by the roving creel clerk was determined by averaging the number of anglers observed during the four instantaneous counts and multiplying by the length of the fishing day (16 hrs). Daily fishing pressure for bank anglers was determined from:

$$H = 16\bar{Y}$$

Formula 12

where  $H$  = the total number of hours fished per day

and  $\bar{Y}$  = the average number of anglers observed fishing during the four instantaneous counts.

Variance of the daily fishing pressure was determined as:

$$V(H) = 16^2 S^2 / 4 \quad \text{Formula 13}$$

where  $S^2$  = the variance of the four instantaneous counts.

The mean hours fished/completed trip was calculated from data from interviews. It was used to determine the number of anglers fishing on the census day in the following formula:

$$F = H / \bar{h} \quad \text{Formula 14}$$

where  $F$  = the estimate of the number of anglers

$H$  = the estimate of the number of hours fished during the day

and  $\bar{h}$  = the mean hours fished/completed trip.

The catch rate of fish kept and released by species was calculated from data obtained in interviews by dividing the number of fish caught by the number of hours fished. Only information from fishermen who had completed fishing was used when it represented 50% or more of the daily sample of fishing trips for the area covered by the roving creel clerk. Information from fishermen who had not completed fishing was included on days when the above condition was not met. The estimate of the number of fish caught was determined

by the equation:

$$C = \bar{c}H \quad \text{Formula 15}$$

where C = the estimate of the number of fish caught

$\bar{c}$  = the catch rate

and H = the daily estimate of hours fished.

Variance for the number of fishermen was calculated as:

$$V(F) = \frac{1}{(\bar{h})^2} (V(H) + F^2V(\bar{h})) \quad \text{Formula 16}$$

Variance for catch was calculated as:

$$V(C) = \bar{c}^2V(H) + H^2V(\bar{c}) \quad \text{Formula 17}$$

where V(F) = the variance of the number of fishermen

V(H) = the variance of the number of hours fished. (Formula 13)

V(C) = the variance of the catch.

and V( $\bar{h}$ ) and V( $\bar{c}$ ) =  $S^2$  in Formula 3 with the number of parties

substituted for  $m_i$ .

The large sample size obtained necessitated the application of a correction factor to the variances of the number of fishermen

and catch. V(F) and V(C) were multiplied by the factor:

$$\frac{H - \text{hours sampled}}{H} \quad \text{Formula 18}$$

H

The estimates of the daily total for each variable for bank fishermen at Glen and Brown's Bridge were collected by the stationary creel clerks waiting for floaters. Since virtually all bank anglers were contacted at these locations each recorded variable was summed and no variance was calculated.

The estimate of the daily total for each variable in the study area was obtained by adding the total obtained by the roving creel clerk to the totals collected by the two stationary creel clerks. The daily variance of each variable was calculated only from data taken by the roving creel clerk since stationary clerks obtained essentially complete counts. This method was applied in conjunction with Weekends-Floaters/Method A.

#### Weekends-Bank Anglers/Method B

Anglers except those at Glen and Brown's Bridge were sampled and data were analyzed by the methods described for variables obtained by the roving creel clerk in Weekends-Bank Anglers/Method A. The sample of the number of anglers, hours fished and fish kept and released by species at Brown's Bridge were obtained during the same two 4-hr periods censused in Weekends-Floaters/Method B. The estimate and variance for each variable were calculated from the formulae:

$$H_i = 2(H_{i1} + H_{i2})$$

Formula 19

$$V(H_i) = 4(H_{i1} - H_{i2})^2 \quad \text{Formula 20}$$

where  $H_i$  = the estimated total for day i

$V(H_i)$  = the variance of H on day i

and  $H_{i1}$  and  $H_{i2}$  = the total on day i and 4-hr period j.

The stationary creel clerk contacted bank anglers at Glen. Therefore the daily total of each variable obtained from this site was summed and no variance was calculated.

Daily totals and variances for the entire study area were obtained by adding data from Glen, Brown's Bridge and the remainder of the section. This method was applied in conjunction with Weekends-Floaters/Method B.

#### Weekends-Bank Anglers/Method C

Daily estimates and variances of all variables for the entire section including bank fishermen at Glen and Brown's Bridge were determined by the procedure described for variables obtained by the roving creel clerk in Weekends-Bank Anglers/Method A.

The estimates and variances of the stratum were calculated as described in Weekends-Floaters/Method C. Weekends-Bank Anglers/Method C was applied in conjunction with Weekends-Floaters/Method C.

#### Weekdays-Bank Anglers/Method A

The daily estimate and variance of each variable for bank fishermen except those at Glen and Brown's Bridge were determined

as described in Weekends-Bank Anglers/Method A. Daily estimates for the Glen and Brown's Bridge subsections were determined as described in Weekdays-Floaters/Method A.

Daily estimates and variances for the entire study area were obtained by adding data from Glen, Brown's Bridge and the remainder of the study section. Weekly estimates and variances were determined by using the combined daily estimates in Formulae 7, 8 and 9. This method was applied in conjunction with Weekdays-Floaters/Method A.

#### Weekdays-Bank Anglers/Method B

Estimates of daily totals and variances were obtained by the roving creel clerk as described in Weekends-Bank Anglers/Method A. The estimates and variances for each stratum were calculated by using the daily estimates in Formulae 7 and 11. This method was applied in conjunction with Weekdays-Floaters/Method B and C.

#### Estimates and Variances for Strata and Seasons

The estimate of each variable in each stratum was determined by adding the pertinent estimates obtained from floaters and bank anglers. Estimates from weekends and weekdays were calculated separately then combined.

The variance for each variable was either summed or estimated statistically. The variance for weekends in each stratum in which Weekends-Floaters/Method A and B were used in conjunction with

Weekends-Bank Anglers/Method A and B was obtained by adding the variances from the two methods. The variance for weekends in each stratum when Weekends-Floaters/Method C was used in combination with Weekends-Bank Anglers/Method C was obtained by adding the daily estimates from the two methods and using the combined estimates in Formula 4.

The estimate and variance of each parameter for floaters and bank anglers on weekdays were made by adding data from the two sources. Variances for each week or stratum were obtained by using Formula 8 and 9.

The seasonal estimate and its variance for each variable were obtained by combining figures from all strata in the fishing season.

#### Estimates of Fish Populations

The populations of brown and rainbow trout in the 16 km section of the lower Big Hole River were estimated in the spring and fall of 1977 and 1978. Personnel from the Montana Department of Fish and Game made mark and recapture estimates by electrofishing. Estimates of the population and biomass were computed using methods described in Vincent (1971 and 1974). Personnel from the Montana Cooperative Fishery Unit provided assistance in electrofishing.

### Age Determination and Statistical Analyses

Scales were taken from fish for age determinations. The age structure of the harvest was computed from fish in the creel and the age structure of the population was determined from fish captured during electrofishing operations. Mr. Jerry Wells, of the Montana Department of Fish and Game, aged fish in the population samples. He also examined the scales of fish taken in the harvest aged by the author.

Statistical tests were made using methods in Snedecor and Cochran (1978). Statistical analyses were performed using "MSUSTAT" programs on MSU's Sigma 7 computer and a Monroe 1785 desk calculator. Statistical differences were considered to be significant at  $P < 0.05$  and highly significant at  $P < 0.01$ .



























































































































