THE TROUT FISHERY ON A REACH OF THE UPPER YELLOWSTONE RIVER, MONTANA, DURING 1982

by

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APPROVAL

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VITA

Larry Dean Javorsky was born September 25, 1957 in Crete, Nebraska to Lloyd and Teresa Javorsky. He graduated from Crete Senior High School, Crete, Nebraska in May 1976 and attended Utah State University in Logan, Utah the following September. He received a Bachelor's degree in Wildlife Science from Utah State University in 1980, and began graduate studies at Montana State University in March 1982.

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And lastly, I wish to extend my most sincere thanks to the living God, whose design and creation is what I strive to understand and desire to preserve.

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ABSTRACT

A creel survey was conducted to determine fisherman use and harvest on the fishery in a 9.2 kilometer reach of the upper Yellowstone River from March 22 through September 19, 1982. Locals, non-local residents and nonresidents comprised 39, 34 and 27%, respectively, of the 860 anglers interviewed. Anglers fished a total of 3942 hours during the study period, expending 2046 hours (52%) on weekend-holidays and 1896 hours (48%) on weekdays. Of the hours fished, 55% were attributed to boat fishermen and 45% to shore anglers. Boat anglers landed trout at a rate of 0.83/hour and kept 37% of their catch. About 93% of their harvest was taken between July 12 and September 5. Shore fishermen had a 0.40 trout/hour landing rate, and kept 48% of the trout they landed. The total harvest of 978 trout by both boat and bank fishermen was composed of 58% brown, 24% rainbow and 18% cutthroat trout. Nearly 83% of the brown, 71% of the rainbow and 37% of the cutthroat trout harvested were age III and older. Mean lengths and weights of creeled brown and rainbow trout were significantly larger than those for cutthroat trout in all age classes. The harvest accounted for 64, 23, and 32% of the summer mortalities in brown, rainbow and cutthroat trout, respectively, when an estimated handling loss of 5% was included. Big, McDonald Spring, Mill, Mol Heron, Cedar and Tom Miner creeks were all found to contain spawning cutthroat trout, with the largest runs occurring in the latter two streams. Recaptures of tagged cutthroat trout indicated substantial movement up- and downstream in the Yellowstone River both to and from tributaries used for spawning.

INTRODUCTION

The upper reaches of the Yellowstone River contain 23% of Montana's 723 kilometers (km) of blue ribbon trout stream (Vincent and Clancey 1980). An apparent increase in fishing pressure in the last decade has caused local and state angler groups to become concerned about the effects of fishing on the trout populations of the upper Yellowstone River. There has been particular interest in the well-being of the Yellowstone strain of cutthroat trout (Salmo clarki), which is a state fish of concern (Holton 1980).

The concerns about this fishery prompted the Montana Department of Fish, Wildlife and Parks (MDFWP) to undertake two limited creel surveys in the 1970's. The first survey was conducted during the summer of 1974. Interviews with bank fishermen on several areas along the upper Yellowstone indicated heavy fisherman use and harvest of trout in and near the town of Livingston, Montana (Berg 1975). The second survey was conducted on a 9.5 km section of the upper river near Corwin Springs in 1978-1979. It was constituted largely of interviews with boat fishermen, and showed a high incidence of rainbow and cutthroat trout in the creel and catch compared to relatively low numbers in the population. This could, according to the investigators,

indicate a susceptibility to overexploitation (Vincent and Clancey 1980).

The purpose of this project was to establish baseline data on the fisherman use and harvest of both boat and bank fishermen on an unstudied 9.2 km reach of the Yellowstone River south of Livingston, and relate it to concurrent fish population estimates made on the section by personnel of the MDFWP. The spawning activities of cutthroat trout in several tributaries of the upper Yellowstone River system were also assessed with MDFWP personnel. Creel survey work was conducted from March 22 to September 19, 1982 and the spawning survey work from June 12 to July 26, 1983.

DESCRIPTION OF STUDY AREA

The Yellowstone River originates in Northwest Wyoming and flows northward through Yellowstone National Park and into southcentral Montana near Gardiner. It continues northward through Park County to Livingston, where it courses northeastward to its confluence with the Missouri River in North Dakota. Its total length is 1085 km (Montana Dept. Nat. Res. and Cons. 1976), and it is one of the last major undammed rivers in the continental U.S. (Berg 1975).

The study section lies on the upper Yellowstone River in Paradise Valley about 18 km south of Livingston. The river here lies in a 2-12 km wide valley flanked by the Absaroka Mountains on the east and the Gallatin Range on the west. It consists of riffles, runs, and pools, with a gradient of 1.5-3.5 meters (m) per km (Berg 1975).

Published records from a gage site 12 km below the study section (USGS 1983) provide the following physical and chemical characteristics. The river is about 1400 m in elevation at the gage site, and drains approximately 9197 km^2. Average discharge recorded intermittently for 56 years between 1897 and 1982 was 106.4 m^3/second (s) or 3.35 km^3/year. The average water temperature from October 1981 to September 1982

was 7.5°C, with a maximum of 19.5°C and minimum of 0.0°C.

For the period of the study in 1982 the peak flow was 738.9 m^3/s, the minimum flow was 29.2 m^3/s, and the mean flow was 216.1 m^3/s. The water flow profile during the 1982 study period is shown in Figure 1. The average water temperature from March to September of 1982 ranged from 3.5 to 17.5°C, the pH ranged from 7.7 to 8.1, and dissolved oxygen ranged from 9.0 to 12.0 milligrams(mg)/liter(l) or 98 to 112% saturation. Turbidity was normally about 2.0 NTU (nephelometric turbidity units) during the year, but rose to 38 NTU during high water in June. Hardness during the study period ranged from 110 mg/l (as $CaCO_3$) during low water to 33 mg/l at high water.

Major tributaries below the study section are Nelson, Armstrong and McDonald Spring creeks. All three are low-gradient streams with sand and silt bottoms and many macrophytes. Those above the section include Mill, Big, Tom Miner, Cedar and Mol Heron creeks, and are characterized by cobble and gravel substrates, relatively high gradients, and few macrophytes.

The survey section extended from the Mill Creek Bridge on Montana State Highway 476 to the Lower Loch Leven Access Site (Figure 2). The river here averaged

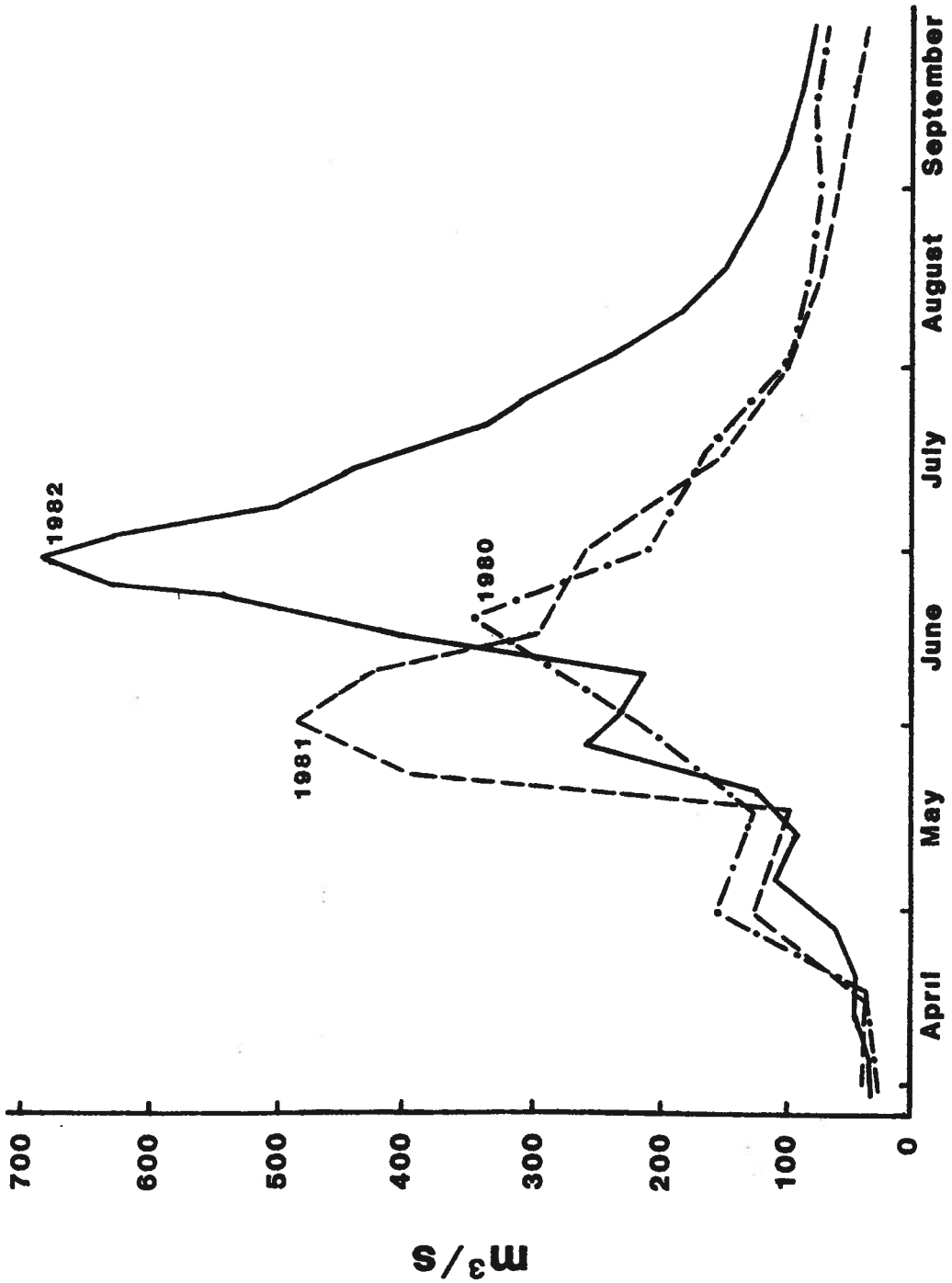

Figure 1. Mean water discharge in the Yellowstone River at a gage site 12 km below the study section.

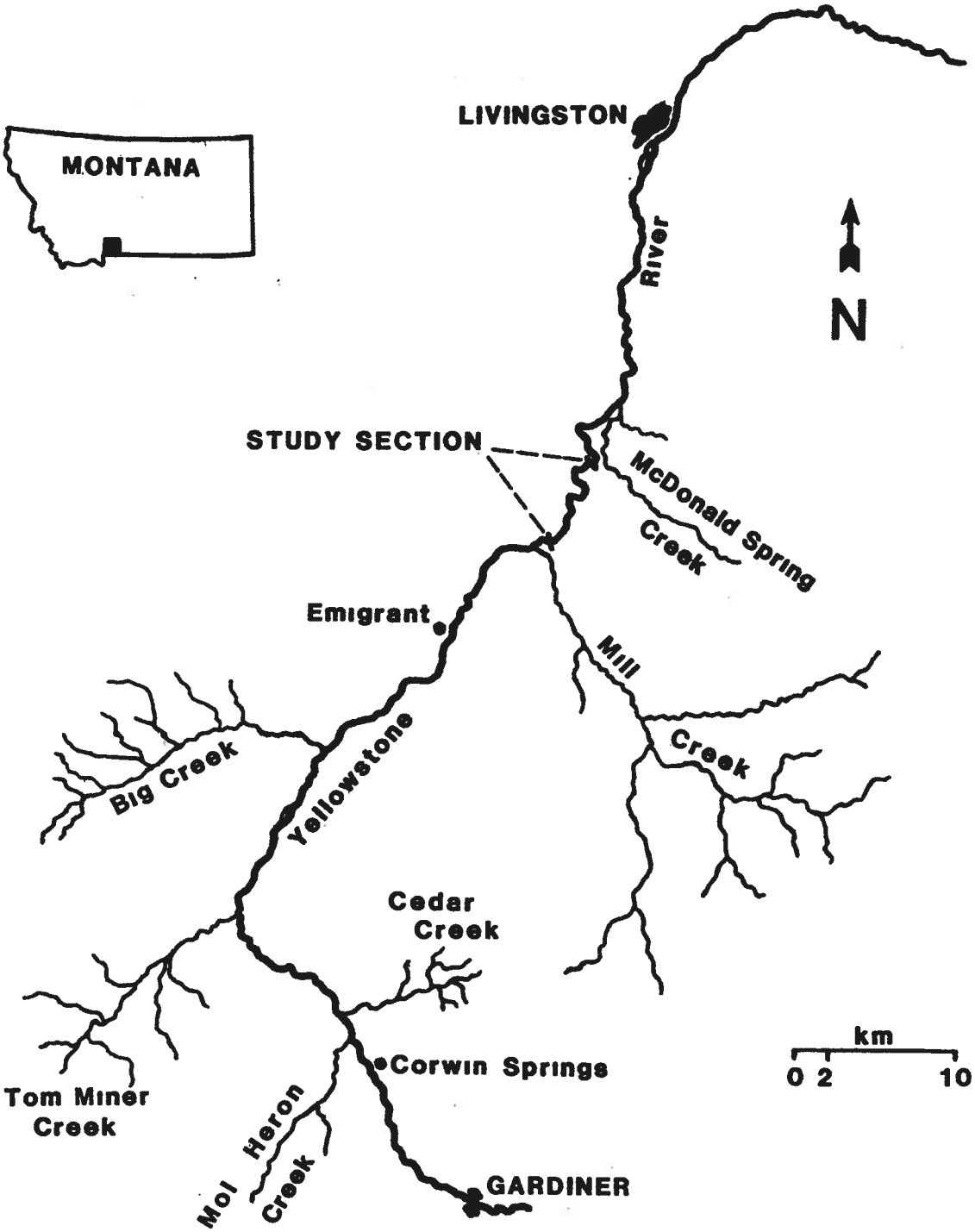

Figure 2. Map of the study area.

about 60 m wide, had approximately 2.1 m/km of gradient, and had a bottom substrate of large cobble and boulders interspersed with gravel and sand (Berg 1975). Riparian vegetation was mainly cottonwood (Populus), willow (Salix), and various shrubs, grasses and forbs. Land adjacent to the section is privately owned and used primarily for grazing, farming and homesites.

Fishing access to the study section was provided by three MDFWP Fishing Access Sites. The Mill Creek Bridge facility had a boat ramp, a small parking lot, and a shoreline where fishermen could walk both up- and downstream. The Paradise Fishing Access Site was approximately 0.4 km downstream from the bridge and had limited parking and restrooms. Camping facilities and a concrete boat ramp were located at the Loch Leven Access Site at the northern end of the study section. Loch Leven contained approximately 1.0 km of river frontage and direct access, and an additional 0.5 km of easement. Private landowners also occasionally gave access to shore fishermen in certain areas.

Gamefish commonly found in the study area are mountain whitefish (Prosopium williamsoni), brown trout (Salmo trutta), rainbow trout (S. gairdneri), and cutthroat trout. Non-game fish reported from the upper Yellowstone are the longnose dace (Rhinichthys

cataractae), longnose sucker (*Catostomus catostomus*), white sucker (*C. commersoni*), mountain sucker (*C. platyrhynchus*) and the mottled sculpin (*Cottus bairdi*) (Berg 1975).

METHODS

Creel Survey

A creel survey was conducted on the study section from March 22 to September 19, 1982. The sampling method used was modified after that of Neuhold and Lu (1957).

The study period was divided into 13 strata consisting of 2 weeks each. Each stratum was further subdivided into two substrata, one for weekdays and one for weekend days and holidays. The dates of all strata are given in Table 11.

Weekday substrata without holidays contained 10 days, while those with holidays contained 9 days. The days to be surveyed in each weekday substratum were chosen at random with the restrictions that (1) no more than 3 days per week were surveyed, and (2) each day of the week (Monday, Tuesday, etc.) was surveyed only once per substratum.

Weekend substrata had 4 days, except for those containing Memorial Day, Independence Day and Labor Day, which had 5 days. The first survey day of the first weekend substratum was randomly chosen, with subsequent survey days alternating between Saturday and Sunday. All three holidays were surveyed. This method

insured that 50% of the weekdays and weekend days, and all holidays, were surveyed.

The fishing day was considered to consist of all the daylight hours and varied in length from 12-16 hours (hr) during the study period (Table 11). Five counts were made on each survey day, and the intervals between counts were adjusted to account for the varying day length. The time of the initial count of the first day of each stratum was chosen randomly from either three or four starting times, depending on day length. The time of the initial count on each following survey day in that stratum was begun at the next latest initial count time until all beginning count times were used, after which the following initial count reverted to the earliest possible count time. The count times used during each stratum are given in Table 11.

Numbers of shore fishermen and boats were recorded separately in each count. Each count was made from points on both shorelines using 7x35 binoculars, and took approximately 45 minutes to conduct, which was less than the average length of the fishing day for all anglers and therefore could be considered to be an instantaneous count. Over 92% of the entire study section was observable from these points.

Interviews were conducted on 146 days of the study period in 1981, and as many fishermen as possible were

interviewed individually between counts. Each angler interviewed was classified as a local (residing in Park County, Montana), a non-local resident (residing in Montana outside of Park County), or a nonresident. Other data collected from each fisherman included: the number in the fishing party, mode of fishing (shore or boat), hours spent fishing, sex of fisherman, type of bait used, and the number of each species of fish caught and kept. When practical, creeled fish were measured for length and weight, and scales were taken for age determination. To increase the number of interviews obtained from boat fishermen, I also contacted virtually all boat fishermen that passed by or pulled out at the Lower Loch Leven Access Site (at the downstream end of the study section) during one AM (sunrise to 1:00 PM) and one PM (1:00 PM to sunset) period in each substratum during days on which fishermen counts were not made.

Fish Population Parameters

The populations of brown, rainbow and cutthroat trout in the 9.2 km section of the Yellowstone River studied were estimated in the spring and fall of 1982. Personnel from the MDFWP made mark and recapture estimates by electrofishing. The cutthroat trout captured were given individually numbered tags so their

movements could be monitored if they were recaptured. Population estimates were computed by Mr. Chris Clancey, Fisheries Biologist for the MDFWP, using methods described in Vincent (1971 and 1974).

McDonald Spring, Mill, Tom Miner, Cedar, Big and Mol Heron creeks were electrofished periodically during June and July of 1983 with personnel of the MDFWP to investigate the cutthroat trout spawning runs. The creeks were electrofished once per week until evidence of a spawning run was obtained, at which time they were electrofished at least twice per week. All cutthroat trout captured were weighed, measured, and tagged so that their movements could be followed in subsequent recaptures.

Age determinations were made from scales. The age structure of the harvest was determined from fish in the creel and the age structure of the population was computed from fish captured during electrofishing for population estimates. Fish from both samples were aged by Mr. Chris Clancey. Scales of fish taken in the harvest were also examined by the author.

Selected population parameters were compared statistically with t-tests or F-tests using methods described by Snedecor and Cochran (1978), with variances calculated by the MDFWP's CCPROG program. Statistical differences were significant at $p<0.05$.

RESULTS

Creel Survey

Interviews

Of the 860 anglers interviewed, 361 (42%) were shore anglers and 499 (58%) were boat fishermen. Males and females comprised 87% and 13% of the anglers, respectively. Male dominance of 80% or more of licensed anglers has also been reported on the Yellowstone River near Corwin Springs (Vincent & Clancey 1980), the lower Big Hole (Kozakiewicz 1979), and the Bighorn rivers (Stevenson 1975).

The largest proportion of fishermen were locals (39%), with non-local residents and nonresidents contributing lesser proportions (34 and 27%, respectively). The reported contribution of locals in other Montana fisheries has varied from 12% on the Bighorn River (Stevenson 1975) to 63% on the lower Big Hole River (Kozakiewicz 1979).

Fishermen were about evenly divided between those using artificial bait and those using either live bait or some combination of baits (Table 1). Artificial baits consisted of flies and "hardware" (lures of metal, wood, plastic, or other materials). Shore fishermen tended to use flies and hardware less often and live bait more often than boat fishermen. Also,

Table 1. The numbers and percentages (in parentheses) of anglers interviewed using various types of baits on the Yellowstone River in 1982.

Bait type	Shore	Boat		Total
		Private	Guided	
Artificial bait				
Flies	58(16)	91(25)	80(60)	229(27)
Hardware	65(18)	128(35)	7(5)	200(23)
Live bait				
Sculpins	9(2)	43(12)	9(7)	61(7)
Other	163(45)	11(3)	0	174(20)
Combination of baits	66(18)	93(25)	37(28)	196(23)
Total	361(99)	366(100)	133(100)	860(100)

fishermen in private boats tended to use flies less frequently and hardware more frequently than their counterparts in guided boats.

Twenty-nine percent of the boat fishermen interviewed were in boats operated by professional guides. This compares to 10.5% found on the lower Big Hole (Kozakiewicz 1979) and 77% on the upper Madison rivers (Vincent 1978).

The average length of the fishing day for shore anglers was 1.8 hr. This figure is significantly lower than the 2.5 hr found for shore fishermen on the lower Big Hole River (Kozakiewicz 1979) and the 4.2 hr on the Bighorn River (Stevenson 1975). The average length of the fishing day for shore anglers was

significantly lower on weekend-holidays (1.6 hr) than on weekdays (2.1 hr).

The average length of the fishing day for boat anglers within the study section was calculated to be 1.7 hr. This time period did not vary significantly between weekend-holidays and weekdays.

Fishing Pressure

Anglers fished nearly 4,000 hr in the study section (Table 2), with shore anglers accounting for 45% and boat anglers 55% of the pressure. The majority of the pressure from both shore (73%) and boat (93%) anglers occurred during the last 6 strata (June 28 - September 19), after the water level dropped (Figure 2) and the water cleared. Pressure was greatest during Stratum 12 (August 23 - September 5), which included the Labor Day weekend. This stratum accounted for approximately 17% of the total shore fishing pressure and 32% of the total boat fishing pressure, although it made up only 7% of the study period.

The estimated numbers of hours fished during weekend-holidays and weekdays were similar (Table 3), which showed a proportionately greater use on weekend-holidays. About 47% of the total hours fished by shore anglers and 56% of those fished by boat anglers occurred during weekend-holidays, which comprised only

Table 2. The estimated numbers of hours fished by shore and boat fishermen in each stratum on the Yellowstone River in 1982 (90% confidence intervals in parentheses).

Stratum	Dates	Shore	Boat	Combined
1	3/22-4/4	58	11	69
2	4/5-4/18	52	23	75
3	4/19-5/2	45	75	120
4	5/3-5/16	78	63	141
5	5/17-5/30	18	14	32
6	5/31-6/13	161	12	173
7	6/14-6/27	70	0	70
8	6/28-7/11	183	46	229
9	7/12-7/25	156	180	336
10	7/26-8/8	216	498	714
11	8/9-8/22	263	275	538
12	8/23-9/5	306	681	987
13	9/6-9/19	189	269	458
Total		1795(±252)	2147(±423)	3942(±494)

Table 3. The estimated numbers of hours fished by anglers during weekend-holidays and weekdays in each stratum on the Yellowstone River in 1982 (90% confidence intervals in parentheses).

	Weekend-holidays			Weekday		
Stratum	Shore	Boat	Combined	Shore	Boat	Combined
1	0	11	11	58	0	58
2	21	23	44	31	0	31
3	45	75	120	0	0	0
4	60	42	102	18	21	39
5	18	14	32	0	0	0
6	56	12	68	105	0	105
7	32	0	32	38	0	38
8	138	5	143	45	41	86
9	48	72	120	108	108	216
10	114	176	290	102	322	424
11	106	173	279	157	102	259
12	140	410	550	166	271	437
13	69	186	255	120	83	203
Total	847 (±161)	1199 (±272)	2046 (±316)	948 (±161)	948 (±272)	1896 (±316)

29% of the available fishing hours. Proportionately greater use on weekend-holidays was observed also by Kozakiewicz (1979) on the lower Big Hole River and Lyden (1975) on the West Gallatin River.

Catch Rates

The rates for landed and creeled trout for the 860 fishermen interviewed were 0.64 and 0.25 trout/hr, respectively. Shore fishermen landed about twice as many fish as they creeled (Table 4). They landed and creeled brown trout at a greater rate than for any other species, and their combined catch rate for landed brown trout was significantly higher than that for either cutthroat or rainbow trout. Landed and creeled catch rates of all trout combined for shore anglers on weekend-holidays did not differ significantly from those for weekdays.

Boat anglers had significantly higher rates of both landing and creeling trout than shore fishermen (Table 4). Total catch rates for creeled trout varied from 24-47% of total landed rates for boat fishermen. Again, brown trout were landed and creeled at significantly greater rates than other trout species. The catch rate for all trout combined was significantly lower on weekend-holidays than on weekdays for landed fish but not for creeled fish.

Table 4. Estimated catch rates (trout/hr) for fish landed and creeled by shore and boat anglers on the Yellowstone River in 1982.

Trout species	Landed			Creeled		
	Weekend-holidays	Weekday	Total	Weekend-holidays	Weekday	Total
			Shore anglers			
Brown	.17	.26	.20	.07	.11	.08
Rainbow	.10	.09	.10	.07	.05	.06
Cutthroat	.08	.13	.10	.04	.06	.05
Combined	.35	.48	.40	.18	.22	.19
			Boat anglers			
Brown	.42	.50	.45	.18	.25	.21
Rainbow	.11	.33	.21	.04	.09	.06
Cutthroat	.17	.17	.17	.04	.04	.04
Combined	.70	1.00	.83	.26	.38	.31

Numbers of Fish Landed and Creeled

About 41% of all trout landed were creeled (Table 5). Boat anglers landed over twice as many trout as shore fishermen but creeled about 8% less of their landed fish. About 57 and 67% of the trout boat fishermen landed and creeled, respectively, were brown trout. For shore anglers, brown trout constituted 51% of the trout landed and 43% of the trout creeled. Rainbow trout contributed from 20-30% of the total trout landed and creeled by both boat and shore fishermen, while cutthroat trout added from 13-27%.

Shore anglers accounted for 37% and boat anglers 63% of the total number of trout harvested (Table 6). The majority of the trout harvest of boat anglers (93%) occurred during Strata 9 - 12 (July 12 - September 5),

Table 5. Estimates of fish landed and creeled by shore and boat fishermen on the Yellowstone River in 1982.

Trout species	Shore		Boat		Combined	
	Landed	Creeled	Landed	Creeled	Landed	Creeled
Brown	403	158	926	410	1329	568
Rainbow	186	110	335	123	521	233
Cutthroat	207	98	352	79	559	177
Total	796	366	1613	612	2409	978

Table 6. Estimated numbers of trout creeled by anglers on the Yellowstone River during the study period in 1982 (80% confidence intervals in parentheses).

Stratum	Trout species			
	Brown	Rainbow	Cutthroat	Total
		Shore anglers		
1	4	4	0	8
2	0	0	0	0
3	4	0	2	6
4	3	3	9	15
5	2	0	0	2
6	31	20	12	63
7	3	3	7	13
8	10	21	5	36
9	29	17	5	51
10	14	9	0	23
11	43	22	11	76
12	11	11	43	65
13	4	0	4	8
Total	158(±38)	110(±28)	98(±36)	366(±59)
		Boat anglers		
1	4	0	0	4
2	0	0	0	0
3	0	0	0	0
4	12	0	0	12
5	0	0	0	0
6	3	0	0	3
7	0	0	0	0
8	0	2	0	2
9	26	34	12	72
10	159	22	6	187
11	115	20	11	146
12	79	41	44	164
13	12	4	6	22
Total	410(±88)	123(±37)	79(±26)	612(±99)
Grand total	568(±96)	233(±46)	177(±44)	978(±115)

which coincided with lower flows and good weather. About 76% of the total boat fishing pressure occurred during this time (Table 2), which comprised only 31% of the study period. In comparison, Strata 1 - 8 (March 22 - July 11) accounted for 62% of the study period but only 2% of the trout harvested by boat anglers due, perhaps, to the low temperatures and high flows during that period (see Figure 1).

The harvest by shore fishermen showed the same trend as with boat fishermen but it was not as pronounced. Strata 9 - 12 contained 52% of the shore fishing pressure and 59% of the harvest. Thirty-nine percent of the harvest and 37% of the fishing pressure by shore fishermen occurred during Strata 1 - 8, when the water was high (Figure 1) and weather mostly cool and overcast.

The numbers of brown and rainbow trout harvested by anglers were significantly greater on weekdays than on weekend-holidays (Table 7). However, significantly more cutthroat trout were harvested on weekend-holidays than on weekdays.

Age and Size of Trout Harvested

Scales and length and weight measurements were obtained from 105 creeled trout. The age groups with the largest representations were age IV and older brown

Table 7. Estimated harvest by anglers on the Yellowstone River during weekend-holidays and weekdays of the study period in 1982 (80% confidence intervals in parentheses).

Fisherman type	Trout species			
	Brown	Rainbow	Cutthroat	Total
Shore				
Weekend-holiday	61(±26)	56(±19)	43(±29)	160(±44)
Weekday	114(±41)	52(±22)	50(±27)	216(±54)
Boat				
Weekend-holiday	191(±41)	45(±17)	46(±21)	282(±61)
Weekday	217(±76)	75(±41)	27(±15)	319(±87)
Combined				
Weekend-holiday	252(±86)	101(±47)	89(±31)	442(±103)
Weekday	331(±60)	127(±26)	77(±36)	535(±75)

trout and rainbow trout, and age II cutthroat trout (Table 8). Mean weights of brown trout in all three age classes were significantly greater than the mean weights of equivalent-aged cutthroat trout. Age II and age IV and older rainbow trout had mean weights significantly greater than those for cutthroat trout of the same ages. The mean weights of age II and age III brown and rainbow trout were similar, but age IV and older brown trout had significantly greater weights than rainbow trout of comparable age.

Both age II and age IV and older brown and rainbow trout had mean lengths significantly greater than their counterparts in cutthroat trout. Age III brown trout

Table 8. Age composition and mean lengths (cm) and weights (g) of trout harvested from the study section on the Yellowstone River in 1982 (sample size in brackets; 90% confidence intervals in parentheses).

Age class	Trout species		
	Brown	Rainbow	Cutthroat
	Percent of species' harvest		
II	17[11]	29[5]	63[15]
III	10[6]	24[4]	13[3]
IV and older	73[46]	47[8]	24[6]
	Mean weights		
II	309(±53)	305(±41)	185(±25)
III	499(±73)	428(±77)	366(±66)
IV and older	937(±54)	721(±106)	542(±56)
	Mean lengths		
II	30.4(±1.2)	30.9(±0.9)	26.5(±1.2)
III	36.8(±0.5)	34.8(±0.4)	33.3(±2.3)
IV and older	45.1(±1.1)	41.5(±1.5)	38.1(±1.3)

were also significantly larger than age III rainbow and cutthroat trout.

Trout Population Estimates and Mortality Rates

Brown, rainbow and cutthroat trout made up 52, 29, and 19%, respectively, of the age II and older trout in the study section during spring 1982 (Table 9). At this time, the largest age classes were age IV and older brown trout and age II cutthroat trout. Rainbow trout could not be separated into age groups in either spring or fall population estimates.

In the fall of 1982, brown, rainbow and cutthroat trout comprised 70, 14 and 15%, respectively, of the trout in the study section. As in the spring, the largest age classes were age IV and older brown trout and age II cutthroat trout.

The summer mortality rates of rainbow and cutthroat trout were 39 and 26% greater, respectively, than for brown trout. Age II cutthroat trout had the greatest mortality rate of the individual age classes.

The estimated harvest (Table 6) accounted for 60, 21, and 29% of the calculated summer mortality (Table 9) of brown, rainbow and cutthroat trout, respectively, in the study section. In addition, handling has been shown to cause up to a 5% loss in trout released by fly

Table 9. Spring and fall population estimates and summer mortality rates of age II and older trout in the study section of the Yellowstone River in 1982 (80% confidence intervals in parentheses)(Clancey, C. 1984, pers. commun.).

Age class	Spring	Fall	Summer mortality rate (%)
	Brown trout		
II	609	315	48
III	468	354	24
IV and older	1488	957	36
Total	2565(±364)	1625(±256)	37
	Rainbow trout		
II and older			
Total	1424(±223)	336(±84)	76
	Cutthroat trout		
II	754	254	66
III and older	214	102	52
Total	968(±275)	356(±68)	63

and lure fishermen (Wydoski 1977). If this figure is applied to the numbers of released trout computed from Table 5, fishing mortality would account for 64, 23, and 32% of the calculated summer mortality of brown, rainbow and cutthroat trout, respectively.

Within age classes, the harvest comprised 78% of the age IV and older brown trout mortality, and 58% of the age III ond older cutthroat trout mortality.

Cutthroat Trout Spawning Activity

Big, McDonald Spring, Mill, Mol Heron, Cedar and Tom Miner creeks contained spawning cutthroat trout, with the latter two streams having the most with more than 21 spawners apiece. Cutthroat trout were not found in any of the streams prior to the advent of spawning activity, which began during the last half of June, peaked during mid-July, and terminated before the first week of August (Table 10). Nearly all (98%) of the spawning cutthroat trout were age III and older. The sizes of the cutthroat trout spawners in Cedar Creek and Tom Miner Creek were not statistically different.

Spawning cutthroat trout moved substantial distances to their spawning streams. Two cutthroat trout tagged in May of 1983 in the study section were

Table 10. Data collected on spawning cutthroat trout in selected tributary streams of the Yellowstone River in 1983 (90% confidence intervals in parentheses).

Creek	Peak of run	Number of trout	Mean weight (g)	Mean length(cm)
Cedar	7/8-7/12			
III-year old		75	409(±18)	32.1(±0.5)
IV-year old and older		21	658(±33)	38.1(±0.6)
Total		96	464(±23)	33.4(±0.6)
Tom Miner	7/15-7/19			
II-year old		4	104(±12)	20.7(±1.2)
III-year old		47	411(±23)	33.0(±0.7)
IV-year old and older		10	688(±71)	39.3(±1.4)
Total		61	440(±36)	33.0(±1.0)
All creeks combined:				
II-year old		7	123(±37)	21.2(±1.7)
III-year old		150	414(±13)	32.6(±0.3)
IV-year old and older		33	688(±42)	36.9(±2.0)
Total		190	451(±19)	33.1(±0.5)

captured spawning in Tom Miner Creek 35 km upstream 8 weeks later. A spawning cutthroat trout tagged in McDonald Spring Creek in the fourth week of June 1983 was caught 24 km downstream in the second week of October of the same year (Clancey, C. 1984, pers. commun.). Berg (1975) noted that spawning cutthroat trout in Cedar Creek had come from at least 19 km downstream where they had been marked as little as 2 weeks earlier, and one cutthroat trout marked while spawning in Big Creek was caught 50 km downstream 32 weeks later.

DISCUSSION

The fisherman use and harvest on the 9.2 km reach of the upper Yellowstone River consisted of 429 hr/km and 106 trout/km, respectively, from March 22 - September 19, 1982. These and other data collected in this study, and the population data obtained by personnel of the MDFWP will become the baseline data by which future changes in this area will be assessed.

Although no data have been collected previously on the section covered in this study, baseline data on fishermen use and harvest have been collected in partial creel surveys on other sections of the upper Yellowstone River. Vincent and Clancey (1980) recorded fishing pressure of 463 hr/km and a harvest of 133 trout/km on the Corwin Springs section of the Yellowstone River in 1978-1979. Berg (1975) found pressures of 266-318 and 919-998 hr/km in sections upstream and downstream from Livingston, respectively. These values are not strictly comparable to the data from this study because they were conducted using different methods and under differing weather conditions and flow regimes, but they may indicate that fishing pressure on the Yellowstone River is less above Livingston than below.

Information collected on trout in the harvest, the population estimates, and the spawning stream surveys were examined for indications of the well-being of the populations. Factors such as exceptionally high mortality rates, decreased recruitment into the fishable stock and/or the total fish population, reduced age structures, and spawners being composed primarily of one relatively young age group may indicate overfishing (Gulland 1980).

The summer mortality rate for age II and older brown trout was 37%, and did not appear to be of concern. This rate was the lowest of the three species of trout in the study area and was similar to the 43% summer mortality rate found for brown trout subject to "light harvest rates" on the lower Big Hole River (Kozakiewicz 1979). The summer mortality rates of 24% for age III and 36% for age IV and older brown trout resembled the 11-34% mortality rates for age III and older brown trout in two sections of the Madison River that had been designated closed and catch-and-release only, respectively, for several years (Vincent 1983).

Recruitment of age II fish into the brown trout population of the study section was estimated at 68 and 48/km in 1982 and 1983, respectively (C. Clancey 1984, pers. commun.), and were lower than those in other Montana studies. Vincent (1983) reported 114 and

206/km of like age brown trout in two sections of the Madison River in the spring of 1980 and 268/km in the spring of 1982. Similarly, figures for sections of the Big Hole and Gallatin rivers were 168 and 244 age II brown trout/km, respectively (Wells and Decker-Hess 1981, Rehwinkel and Vincent 1982). Only the upper Missouri River with 57 age II brown trout/km was similar (Rehwinkel 1982).

The apparent greater recruitment of age II brown trout in the study section of the Yellowstone River in 1982 may have been due to greater mean flows and higher mean water temperatures from fall 1980 to spring 1981 than in a similar time period the following year. The average flow in the Yellowstone River during the fall of 1980 (September 15-October 31) was 68 m^3/s, compared to 38 m^3/s in 1981 (USGS 1981, 1982 and 1983), which may have provided more spawning habitat in 1980. Wesche and Rechard (1980) demonstrated that there was a "preferred spawning discharge" that supplied the greatest area for spawning salmonids, and that discharges below this optimum level tended to reduce available spawning area.

The higher flows and water temperatures during the incubation period in 1980-1981 may have helped produce a larger year class. The mean winter flow (November 1-March 31) in 1980-1981 was 7 m^3/s greater than in 1981-

1982. Furthermore, there were only 3 days with flows less than 28 m^3/s during the winter of 1980-1981, and 26 such days during the winter of 1981-1982 (USGS 1981, 1982 and 1983). The mean monthly water temperatures from November through March ranged from 2.0-6.5° C during 1980-1981 and 0.5-5.0°C during 1981-1982 (USGS 1981, 1982 and 1983). The occurrence of lower flows and lower temperatures simultaneously in 1981-1982 may have increased the mortality of incubating brown trout eggs. Reiser and Wesche (1979) showed that freezing and extremely low temperatures increased the mortality of brown trout eggs even when redds were located in a suitable spawning environment.

Rainbow trout showed a 76% summer mortality in 1982, although population estimates the following spring indicated only an 18% annual mortality for age II and older rainbow trout (C. Clancey 1984, pers. commun.). These contradictions are not understood but could be explained by movements of rainbow trout out of the study area some time between the summer and fall estimates, or by movements into the area in the spring.

The summer mortality rate of age III and older cutthroat trout was 52%, and was higher than for the same age brown trout in the study section and for brown and rainbow trout in several other Montana rivers. The summer mortalities reported by Vincent (1983) for age

III and older brown trout and comparably aged rainbow trout on sections of the Madison River with closure and catch-and-release regulations were 41-18% and 34-2% lower, respectively. Summer mortality figures for age III and older brown and rainbow trout on the Big Hole River for 1980 were 38 and 37%, respectively (Wells and Decker-Hess 1981). However, Bjornn et al. (1977) recorded similar summer mortality rates of 54% and 47% for age III and older cutthroat trout in the St. Joe River and Kelly Creek, respectively, after restrictive regulations had been in effect for 4-5 years and all mortalities were assumed to be due to natural causes. It appears, therefore, that acceptable limits on mortality rates have not yet been determined.

Cutthroat trout were harvested in proportion to their abundance in the study section. They comprised 19% of the trout population in the section (Table 9) and 18% of the harvest (Table 6). Brown and rainbow trout were likewise harvested in proportion to their relative composition of the trout population. This is in contrast to the data collected on the Corwin Springs section of the Yellowstone River, which showed that cutthroat trout were more vulnerable to fishing pressure than were brown or rainbow trout (Vincent and Clancey 1980). Behnke (1971) also states that

cutthroat trout are "highly vulnerable" to angling pressure.

The recruitment of age II fish into the cutthroat trout population was estimated to be 82 and 28/km in 1982 and 1983, respectively (C. Clancey 1984, pers. commun.). As with the brown trout, the higher recruitment rate in 1982 was probably due to higher tributary streamflows apparent from higher flows in the Yellowstone River in 1980 (USGS 1981 and 1982). A correlation between water flow and fry recruitment in cutthroat trout was demonstrated by Drummond and McKinney (1965), who found that fry recruitment decreased both above and below an optimum flow regime. The influence of proper flows could affect cutthroat trout more than brown or rainbow trout in the Yellowstone River system due to their greater dependence on tributary streams for spawning habitat, and to their tendency to spawn during a time of year when water levels can fluctuate more dramatically.

The six tributaries of the Yellowstone River that were sampled for spawning cutthroat trout during the summer of 1983 were also sampled by Berg (1975) in an earlier study. The numbers of trout (5 or less) found in Big, McDonald Spring and Mill creeks during this study were similar to those reported by Berg (1975), which suggests that the recruitment of cutthroat trout

in the upper Yellowstone River system may be limited by lack of suitable spawning habitat. Many of the tributary streams to the Yellowstone River are completely dewatered immediately after spring run-off for irrigation (Berg 1975), thereby eliminating their availability for spawning even during years of suitable flows. Also, tag returns in the area indicate that cutthroat trout are moving up to 35 km to spawn in available stream habitat, which could indicate there are a limited number of suitable spawning tributaries.

The numbers of spawning cutthroat trout seen in 1983 in Cedar, Mol Heron and Tom Miner creeks were over three times greater than those reported in Berg's (1975) study, although the mean length and weight of the spawners in Cedar Creek was 2.4 cm and 136 g smaller, respectively, in 1983 than in 1973. Gresswell (1980) noted a decrease of approximately 2.7 cm in length from 1958 - 1966 for cutthroat trout spawners ascending Clear Creek from Yellowstone Lake, which he attributed to excessive harvest.

Seventy-nine percent of the spawners in Cedar and Tom Miner creeks were age III fish, 17% were age IV and older, and only 4% were age II. This age structure had a higher concentration of spawners in one age class than did other spawning populations in Montana. Zubik (1983) recorded 54 and 40% of the cutthroat trout

migrating from Hyalite Lake, Montana, as age III and age IV fish, respectively, in 1981, and in 1982 he found 38% age III, 43% age IV and 13% age V fish migrating from the lake. Spawning cutthroat trout in the Flathead River were found to consist of 60% age IV, 25% age V and 13% age VI fish in 1959 and 1960 (Johnson 1963).

Furthermore, the dominant age group of mature cutthroat trout taken in this study were probably first time spawners. Brown (1971) stated that cutthroat trout normally spawn first in their third year, which means that at least 83% of the cutthroat in these two creeks were first year spawners. This high proportion of young spawners may indicate a low escapement of older fish, which could be a result of overfishing (Gulland 1980).

In an attempt to determine the response of the trout populations to reduced fishing mortality, the MDFWP implemented new regulations on two sections of the upper Yellowstone River. Prior to May 1, 1984, the regulations in all sections of the river consisted of five brown, rainbow and cutthroat trout in aggregate with not more than one over 18 inches, and no bait restrictions. After this date, the regulations on the section from the Yellowstone Park boundary to the Emigrant Bridge are no cutthroat trout in the creel,

with no change in the regulations for brown and rainbow trout, and no bait restrictions. In the section from the Emigrant Bridge to the Pine Creek Bridge no cutthroat trout may be creeled, and four brown and/or rainbow trout less than 13 inches and one greater than 22 inches are allowed in the creel. Fishing in this section is now restricted to lures and flies only. Fishing regulations on the Yellowstone River downstream from the Pine Creek Bridge remain unchanged from 1983. The MDFWP will monitor the trout populations in these three areas to determine the effectiveness of these different regulations on the mortality rates and age structures of the populations.

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APPENDIX

Table 11. The count times established for each stratum in 1982 (Mountain Standard Time).

Stratum	Dates	Hours of daylight	Count times				
			First	Second	Third	Fourth	Fifth
1*	3/22-4/4	12	7:30	10:15	1:00	3:45	6:30
			8:00	10:45	1:30	4:15	7:00
			8:30	11:15	2:00	4:45	7:30
2*	4/5-4/18	13	7:30	10:15	1:00	3:45	6:30
			8:00	10:45	1:30	4:15	7:00
			8:30	11:15	2:00	4:45	7:30
			9:00	11:45	2:30	5:15	8:00
3*	4/19-5/2	14	6:30	9:30	12:30	3:30	6:30
			7:30	10:30	1:30	4:30	7:30
			8:30	11:30	2:30	5:30	8:30
4	5/3-5/16	15	6:30	9:30	12:30	3:30	6:30
			7:30	10:30	1:30	4:30	7:30
			8:30	11:30	2:30	5:30	8:30
5	5/17-5/30	15	6:30	9:30	12:30	3:30	6:30
			7:30	10:30	1:30	4:30	7:30
			8:30	11:30	2:30	5:30	8:30
6	5/31-6/13	16	6:00	9:00	12:00	3:00	6:00
			7:00	10:00	1:00	4:00	7:00
			8:00	11:00	2:00	5:00	8:00
			9:00	12:00	3:00	6:00	9:00
7	6/14-6/27	16	6:00	9:00	12:00	3:00	6:00
			7:00	10:00	1:00	4:00	7:00
			8:00	11:00	2:00	5:00	8:00
			9:00	12:00	3:00	6:00	9:00
8	6/28-7/11	16	6:00	9:00	12:00	3:00	6:00
			7:00	10:00	1:00	4:00	7:00
			8:00	11:00	2:00	5:00	8:00
			9:00	12:00	3:00	6:00	9:00
9	7/12-7/25	16	6:00	9:00	12:00	3:00	6:00
			7:00	10:00	1:00	4:00	7:00
			8:00	11:00	2:00	5:00	8:00
			9:00	12:00	3:00	6:00	9:00

Table 11. Continued.

Stratum	Dates	Hours of daylight	Count times				
			First	Second	Third	Fourth	Fifth
10	7/26-8/8	14	6:30	9:30	12:30	3:30	6:30
			7:30	10:30	1:30	4:30	7:30
			8:30	11:30	2:30	5:30	8:30
11	8/9-8/22	14	6:30	9:30	12:30	3:30	6:30
			7:30	10:30	1:30	4:30	7:30
			8:30	11:30	2:30	5:30	8:30
12	8/23-9/5	13	7:00	9:30	12:00	2:30	5:00
			8:00	10:30	1:00	3:30	6:00
			9:00	11:30	2:00	4:30	7:00
			10:00	12:30	3:00	5:30	8:00
13	9/6-9/19	12	7:30	10:15	1:00	3:45	6:30
			8:00	10:45	1:30	4:15	7:00
			8:30	11:15	2:00	4:45	7:30

*Not Daylight Savings Time