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FISHERIES OF THE UPPER YELLOWSTONE RIVER INCLUDING TRIBUTARY RECRUITMENT: REPORT FOR YEARS 1989, 1990 AND 1991

by

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EXECUTIVE SUMMARY

The Ninth Street sample section, located near the town of Livingston, Montana, of the Yellowstone River supported higher populations of trout 13 inches and longer (average of 795 per mile) during the ten year period between 1982 and 1991 than any other sample section in the upper river from Springdale, Montana up to state's border at Yellowstone National Park. The Corwin and Mill sample sections, located above Livingston, supported moderately high populations (average of about 434 and 415 per mile), while the Springdale section, below Livingston, supported the lowest populations (average of 315 per mile).

The abundance of age II brown trout appears to be regulated somewhat by flow regimes during incubation and age 0 stages. Low abundance of age II brown trout in 1990 and 1991 may be related, in part, to low flows caused by the 1988/89 drought. The population of larger brown trout (18 inches and larger) was higher in the lower river than upper river, but appears to reach an upper limit in each section which is probably related to security habitat and food availability. Abundance of older brown trout, mature age III and older fish, may fluctuate in a somewhat cyclic fashion. This potential cyclic fluctuation may be caused by brown trout regulating their own populations through cannibalism and competition. This mechanism is believed to also regulate numbers of rainbow and cutthroat trout, particularly within a "slot limit" portion of the river. Growth of brown trout is faster in the lower river, from Livingston down to Springdale, probably related to a combination of nutrient enrichment and a longer growing season related to water temperature. Estimated mortality rates for brown trout fluctuated and no clear pattern was observed.

Cutthroat trout abundance was highest and increasing in the upper river, Corwin Section, but appeared to be declining in the lower river. A "catch and release" regulation for cutthroat trout probably has resulted in higher numbers of cutthroat trout in the upper river, where recruitment of cutthroat trout is adequate. In the lower river, where recruitment has been variable, cutthroat populations have not responded as well. The "catch and release" regulation has not yet appreciably increased the number of larger (>16 inch) cutthroat trout.

As densities of rainbow trout increased, especially in the Ninth Street and Corwin sections, the number of larger rainbow trout within the population appear to decline. This suggests that a density dependent relationship may exist for rainbow trout.

Cutthroat trout had a higher incidence of obvious hooking scars than either rainbow or brown trout and all trout had a lower

incidence of hooking scars in the lower river. Brown and rainbow trout had the highest incidence of hooking scars within the "catch and release" regulation section.

Little angling pressure was observed in known brown trout spawning areas during the 1988 spawning season. The estimated pressure during the winter of 1988/89 from the Yellowstone River near Livingston was 3,202 angler hours or 2,497 angler days. The estimated harvest was 939 rainbow and 888 brown trout, and 3,727 mountain whitefish. Most of the pressure and harvest occurred near the mouth of Depuy Spring Creek.

A total of 1,229 brown trout redds were observed within the main stem Yellowstone River during an aerial survey on November 23, 1991. Redds were observed throughout the length of the river with high density spawning areas seen around Livingston, above Pine Creek, in the Wanigan side channels, in the main river near Grey Owl, and in side channels near Point of Rocks. Yellowstone cutthroat trout fry were trapped as they emigrated from spawning tributaries into the Yellowstone River. Fry trap results indicated that Cedar, Mol Heron, Rock, Tom Miner, Locke, and Peterson creeks contributed fry to the river. Numbers of fry trapped were variable between years.

KEYWORDS: management, regulation, population estimates, creel census, harvest, growth, recruitment, trapping, salmonids

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF TABLES

LIST OF TABLES
(continued)

LIST OF TABLES
(continued)

LIST OF FIGURES

LIST OF FIGURES
(continued)

INTRODUCTION

The Yellowstone River basin received instream flow protection through an Order of the Board of Natural Resources on December 15, 1978. As part of this order, the Montana Department of Fish, Wildlife and Parks (MDFWP) was instructed to update and enhance its justification for receiving the allocation. Monitoring of the Yellowstone River fish populations is being done to explore relationships between river flow, tributary stream flow, and fish populations.

During the 1988 legislative session, House Bill 707 gave the MDFWP the authority to study leasing of existing water rights to enhance stream flow in de-watered stream segments. This bill provides limited leasing authority and requires documentation of improvement to fisheries which result from enhanced stream flow. Fish population monitoring will be necessary to provide this documentation.

Angler harvest may effect the species composition and size (both number of fish and size of fish) of fish populations. Harvest effects must be evaluated to assess these changes. In 1984 two fishing regulations which further restrict angler harvest were initiated on the upper Yellowstone River. In the upper 50 miles of river no Yellowstone cutthroat trout (Oncorhynchus clarki bouvieri) could be kept by anglers. In the portion of the river between Emigrant Bridge and Pine Creek Bridge (a distance of 16.3 miles) a "slot limit" was instituted where anglers were allowed to keep five trout (excluding cutthroat) of which 4 must be under 13 inches and one may be over 22 inches (no trout between 13 and 22 inches can be kept). This slot limit provided additional protection for rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta). Trout populations were monitored within a portion of this slot limit segment and in sample sections within three other river segments without the "slot limit". This sampling should provide information to evaluate the effectiveness of the "slot limit" regulation. In 1988 the protection afforded Yellowstone cutthroat trout by a "catch and release" regulation first initiated in 1984 in the upper river above Pine Creek Bridge was extended to include the entire Yellowstone River. Cutthroat trout populations were monitored in the Yellowstone River to evaluate their response to the no harvest regulation with the goal of re-building cutthroat populations in the river.

Tributary streams providing important spawning and rearing habitat for river fish populations need to be identified and their relative importance to the river fishery assessed. Monitoring the relative number of cutthroat trout fry emigrating out of these tributaries will allow MDFWP to better manage the river fishery by

identifying which tributary streams could be enhanced by augmenting flow, providing access to spawning adult fish, or directly constructing spawning habitat. Tributary monitoring also provides information on the relative strength of each year class as they leave tributaries.

An important component of MDFWP's effort to protect and enhance fisheries is our ability to protect stream and river habitat under the Stream Protection Act of 1963 and the Natural Streambed and Land Preservation Act of 1975. The interaction of fisheries professionals and Conservation District Board members in reviewing permits with applicants provides important protection to stream and river banks and beds. Maintaining stream and river banks and beds helps maintain important fish habitat and protect fishery resources.

STUDY AREA DESCRIPTION

The study area encompasses the upper Yellowstone River from Montana's boundary with Wyoming at Yellowstone National Park down to Springdale, Montana (Figure 1). Additional sampling was also done to document recruitment from tributaries to the Yellowstone River including Cedar, Depuy's (sometimes referred to as Armstrong's) Spring, Emigrant Spring, Locke, Mission, Mol Heron, Nelson's Spring, Peterson, Rock, and Tom Miner creeks. Berg (1975) provided a description of the upper Yellowstone basin.

River flow at two sites, Corwin Springs and Carter's Bridge, are gauged by the U.S. Geological Survey. Their data illustrated that the river flow at Carter's Bridge were 89%, 90%, and 100% of average for the period of record (67 years) and 94%, 96%, and 103% of average for the period of record (86 years) at Corwin Springs in 1989, 1990 and 1991, respectively. Average monthly flow for 1984, 1988, and 1989 were lower than long-term averages, while average monthly flow for 1990 and 1991 were close to long-term averages (Figure 2). Monthly flow during the normal low-flow period (August through March) were lower than long-term averages for the years 1987 to 1991.

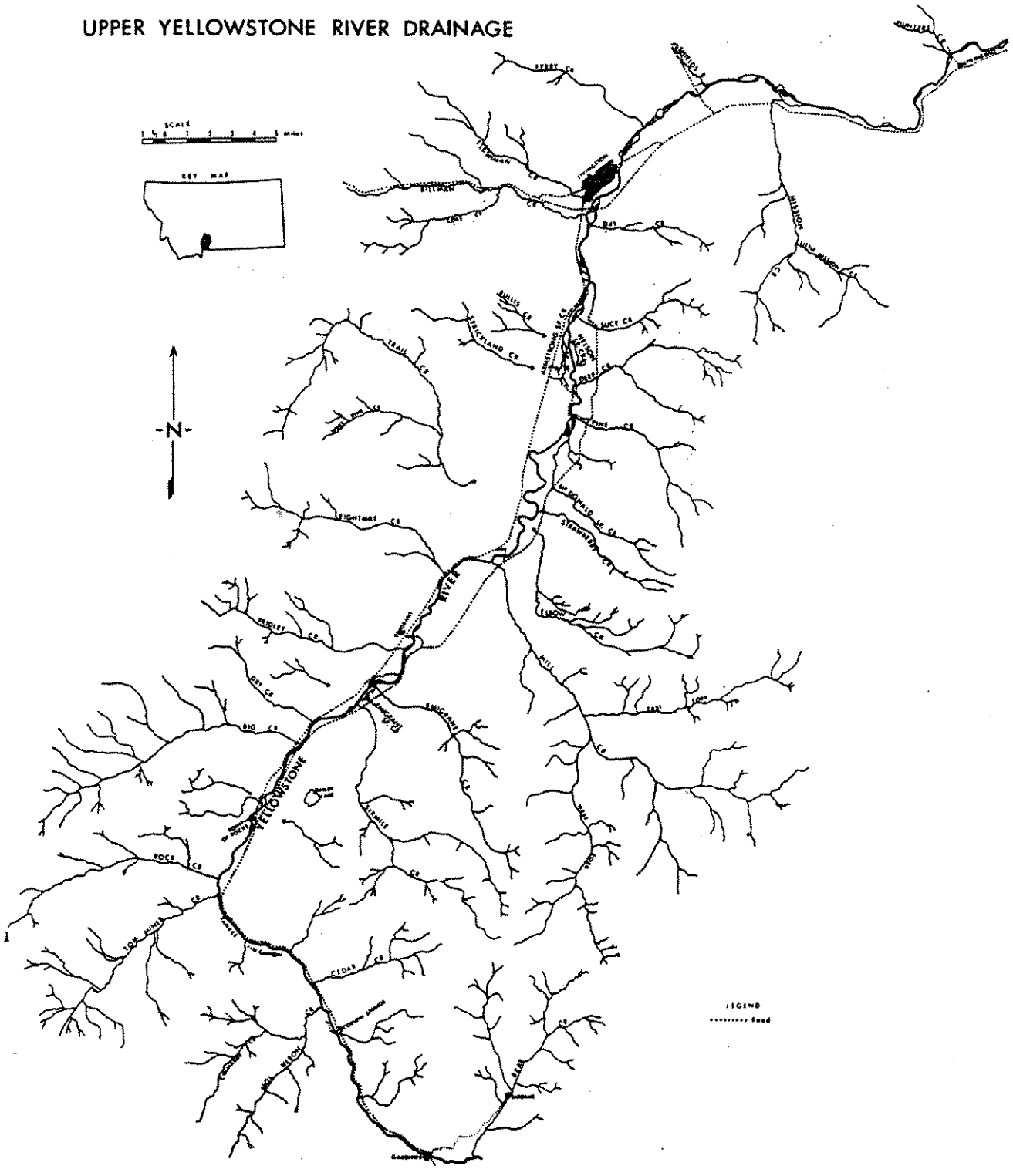
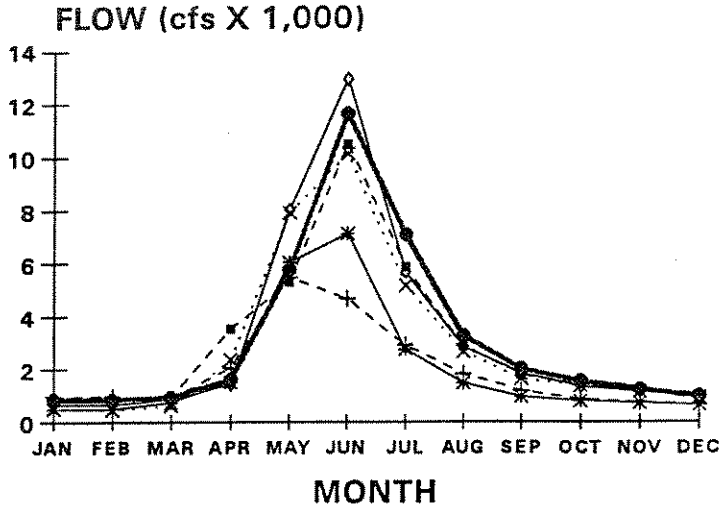


Figure 1. Map of the upper Yellowstone River showing sample sections in the main river, USGS gauge station sites, and tributaries sampled for recruitment.

CORWIN SPRINGS



CARTER'S BRIDGE

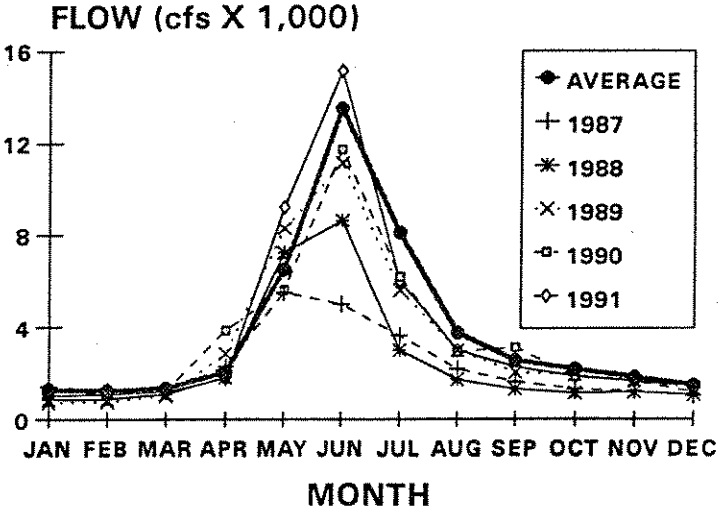


Figure 2. Average monthly flow for the years 1986 to 1991 and for the period of record in the Yellowstone River at Corwin Springs (top) and Carter's Bridge (bottom) Data provided by the U.S. Geological Survey.

METHODS

Yellowstone River Population Estimates

Population estimates were conducted in the Yellowstone River during the spring each year from 1989 through 1991. Estimates of all trout species were made in the Springdale, Ninth Street Bridge (designated "Ninth"), Mill Creek Bridge (designated "Mill"), and Corwin Springs sections (designated "Corwin") (Figure 1). During 1991 an estimate of trout was also made in a 2.7 mile long section below Carter's Bridge to determine if the Ninth Section represented the portion of the river above Livingston. A mountain whitefish estimate was made in the 1.4 mile Mallard's Rest Section during 1990 and 1991 (Figure 1). Mark-recapture sampling was done according to methods presented in Clancy (1985) except that fewer mark and recapture runs were necessary due to increased efficiency resulting from better equipment. Processing of fish included measuring and weighing all trout to the nearest 0.1 inch (TL) and 0.01 pound, taking scale samples for age interpretation from 10 fish per 0.5 inch length group, looking for past fin clips, looking for marks on recapture runs, and identifying visible hooking scars.

Estimates were calculated using the Mark/Recapture computer program (MRSYS Version 1.2) developed by MDFWP (Merry 1987) which uses equations and assumptions discussed by Vincent (1971). Population estimates were standardized to the estimated number of fish per mile of river length for comparison purposes. Since electrofishing is only efficient along the river's margins, estimates should not be considered total estimates for the river, rather they should be viewed as representing trends in abundance.

Length frequency histograms were plotted by species by year for all sample sections using MDFWP's LENGTHGP.PRG program and Harvard Graphics software, version 2.0 (Software Publishing Corporation 1987).

Age-Growth Estimates

Ages of brown trout were interpreted from scale samples. Annuli on scale samples from rainbow and cutthroat trout could not be reliably interpreted. Brown trout ages were estimated to age IV, however, determining ages was difficult and these results should be viewed with caution, especially for estimates made during 1990. Age estimates were used to partition population estimates by age class. For some of the population estimates, age II brown trout could not be reliably estimated because not enough brown trout in this age class were recaptured. Consequently, some estimates of age II fish should be considered an under-estimate. Scale samples collected in 1991 were believed to exhibit a growth

check within growth year 1988. This growth check was readily observed on age II fish, but it was difficult to determine whether circuli compression indicated a growth check or annulus on age III and older fish scales.

In addition to aging scale samples, brown and cutthroat trout believed to be age II have been fin clipped since 1983 using rationale developed by Clancy (MDFWP files). The lengths of clipped age II brown and cutthroat trout by section ranged between 6.5 and 11.0 inches since 1985 (Table 1). Recaptures of clipped fish in subsequent years allowed for verification of age interpretation from scales and afforded the opportunity to estimate length at age from "known age" fish. Potential biases associated with this technique include: 1) reduced growth for fish with clipped fins; and 2) the possibility that in years of slow growth only the fastest growing fish would be clipped at age II and, conversely, in years of fast growth only slow growing fish would be clipped as age II. It might reasonably be assumed that if a slow or fast growing fish was clipped any one year it would tend to grow at relatively the same rate in subsequent years.

Mortality Estimates

Annual brown trout mortality was estimated using the population by age estimate data from above. As pointed out above, these mortality estimates may be biased due to age interpretation biases and the problem of under-estimating the numbers of age II brown trout during some years.

Frequency of Obvious Hook Scars

The percentage of obviously hook scarred trout were calculated by species and section. These percentages should be considered minimum estimates of the proportion of hooked trout since only obvious hook scars were identified.

Yellowstone River Fall 1988 Creel Census

A creel census was conducted at known brown trout spawning areas within the Yellowstone River from October 19 to November 30, 1988 to determine if anglers were harvesting brown trout off their spawning beds. A total of 153 counts were made in three spawning areas (Wanigan, Pine Creek, Ninth Street) during 15 different days. As many anglers as possible were interviewed and an effort was made to interview anglers which had completed their angling trip. Each individual angler was interviewed. Anglers were asked how long they had fished and the numbers of fish they had caught and kept, and caught and released, by species. When possible, lengths were measured for kept fish. Anglers were also asked what terminal tackle they used and the location of their home.

Table 1. Length range of "known age II" brown and Yellowstone cutthroat trout and fin clipped in four study sections of the Yellowstone River from 1985 to 1991.

Section	Year	Length range clipped		Clip used
		Brown	Cutthroat	
Springdale	1985	8.0-11.0	8.0-9.9	adipose
	1986	8.0-11.0	8.0-9.9	r. pelvic
	1987	8.0-11.0	8.0-9.9	l. pelvic
	1988	8.0-11.0	8.0-9.9	adipose
	1989	8.0-11.0	8.0-9.9	r. pelvic
	1990	8.0-11.0	8.0-9.9	l. pelvic
	1991	8.0-11.0	8.0-9.9	adipose
Ninth Street	1985	8.0-9.9	8.0-9.9	adipose
	1986	8.0-9.9	8.0-9.9	r. pelvic
	1987	8.0-9.9	8.0-9.9	l. pelvic
	1988	8.0-9.9	8.0-9.9	adipose
	1989	8.0-9.9	8.0-9.9	r. pelvic
	1990	8.0-9.9	8.0-9.9	l. pelvic
	1991	8.0-9.9	8.0-9.9	adipose
Mill Bridge	1985	8.0-9.9	8.0-9.9	adipose
	1986	8.0-9.9	8.0-9.9	r. pelvic
	1987	8.0-9.9	8.0-9.9	l. pelvic
	1988	8.0-9.9	8.0-9.9	adipose
	1989	8.0-9.9	8.0-9.9	r. pelvic
	1990	8.0-9.9	8.0-9.9	l. pelvic
	1991	8.0-9.9	8.0-9.9	adipose
Corwin	1985	8.0-9.9	6.5-8.9	adipose
	1986	8.0-9.9	6.5-8.9	r. pelvic
	1987	8.0-9.9	6.5-8.9	l. pelvic
	1988	8.0-9.9	6.5-8.9	adipose
	1989	8.0-9.9	6.5-8.9	r. pelvic
	1990	8.0-9.9	6.5-8.9	l. pelvic
	1991	8.0-9.9	6.5-8.9	adipose

Yellowstone River Winter 1988/89 Creel Census

A winter creel census was conducted on the Yellowstone River from December 14, 1988 to April 11, 1989 to determine the level of fishing pressure and harvest around the town of Livingston. Concern had been expressed by local anglers that a disproportionate number of large brown trout were being harvested by anglers during the winter months. The river was segregated into six sections based on access: the area around the highway bridge by KPRK radio station; Mayor's Landing area; Ninth Street Bridge area; Carter's Bridge area; Bell Crossing area (near the Livingston Ditch diversion); and the mouth of Depuy's Spring Creek. Three sample periods were selected, December 14 to January 3, January 4 to February 14, and February 15 to April 11. From December 14 to January 3 a creel clerk counted all anglers at each area at three hour intervals. From January 4 to April 11 counts were made at two hour intervals. Sample days were randomly selected at a frequency of one weekend day and 2 weekdays per week within each sample period.

During sample days a creel clerk interviewed as many anglers as possible and concentrated on interviewing anglers which had completed their angling trip. Individual anglers were interviewed, so all angling parties consisted of a single angler. Anglers were asked how long they had fished and the numbers of fish they had caught and kept and caught and released by species. When possible, lengths were measured for kept fish. Anglers were also asked what terminal tackle they used and the location of their home.

The creel census data was entered into a microcomputer and run through the MDFWP's Creel Census program (McFarland and Roche 1987) to estimate catch rates, fishing pressure, and harvest. It became apparent that fishing pressure was higher near the mouth of Depuy's Spring Creek (designated Depuy's) than in the other five areas. In analyzing the data, sampling was stratified into two river sections with Section 1 designated as all sample areas except Depuy's and Section 2 was the area near Depuy's. A further breakdown between weekdays and weekend days was made for the two sample periods between January 4 and April 11. There were not enough sample days to stratify the period from December 14 to January 3 into weekend days and weekdays.

Recruitment

Yellowstone Cutthroat Spawner Trapping

Adult spawning Yellowstone cutthroat trout were trapped as they moved upstream and downstream in Cedar Creek from June 25 to July 15, 1991. This trap consisted of an up and downstream box

trap with diagonal leads extending to the water's edge from both the upstream and downstream entrances. The trap was checked daily. Water temperatures during trapping ranged from 42 to 58 F. Adult fish moving down through the traps were tagged with yellow visible implant tags (VI) numbered B02 through B23. Length, weight, sex, and state of maturity was recorded for each trapped fish.

Rainbow Spawner Trapping

Adult spawning rainbow were trapped from March 9 to March 23, 1990 as they moved downstream out of a spring channel of Yellowstone River adjacent to Depuy's (Armstrong) Spring Creek (Figure 1). A box trap was used with 0.5 inch hardware cloth leads extending diagonally across the channel. A small space was left along one side of one lead to allow any upstream migrating rainbow trout spawners passage upstream. The trap was checked daily. Water temperatures in the side channel during trapping ranged from 48 to 52 F.

Yellowstone Cutthroat Redd Counts

The number of identifiable Yellowstone cutthroat trout redds were counted in Cedar Creek on June 26 and July 16, 1991, in Locke Creek on July 22, 1991, and in Emigrant Spring Creek on July 26, 1991. Observer confidence classification criteria and reference locations were recorded according to methods reported above.

Rainbow Redd Counts

Rainbow spawning nests (redds) were counted in DePuy's and Nelson's spring creeks on February 26 and February 28, 1990, respectively (Figure 1). In Depuy's the count was made from the dam at the pond in front of the main house down to the culvert where the creek empties into the Yellowstone River. The water temperature of the creek was 49 F at the time of the survey. The water temperature of the Yellowstone River was 42 F. In Nelson's the survey was made from the head of the upper pond down to the Yellowstone River. The water temperature of the creek was 47 F at the time of the survey. Both creeks support resident rainbow trout populations which made it difficult to accurately assess use of these streams by rainbow from the Yellowstone River. All redds were classified according to confidence that the surveyor was observing an actual redd (sure, probably, and possibly) and relative size with small redds being less than two feet in diameter, medium redds being two to four feet in diameter, and large redds being larger than four feet in diameter. All large redds and a portion of the medium redds are assumed to have been constructed by river fish. The relative location of all redds were referenced to distance from the mouth of the creek.

Brown Trout Redd Count

Clancy (1987) recommended initiating aerial counts of brown trout redds in the main stem of the Yellowstone River to identify spawning patterns throughout the system. On November 23, 1991 an aerial survey was done of the Yellowstone River from Springdale, Montana to Gardiner, Montana to count the number of brown trout redds (spawning sites). A Hughes 500 helicopter was used. The redd count was conducted between 9:30 AM and 4:30 PM. All river channels which flowed water were counted. The weather was clear during the morning with increasing clouds during the afternoon. There were moderate winds during the day (20 to 30 mph). The portion of the river from the head of Ninth Street Island to Carter's Bridge was not surveyed due to high winds through the Allenspur Canyon.

Observed redds were classified into the three confidence classes (sure, probable, and possible) based on criteria listed above. In some areas several to numerous redds were located within a relatively small area. In these areas the observer tried to count individual redds based on the presence of observed pit and tailspill areas. Redds were fairly easy to identify from the air and most redds were classified into "sure" and "probable" categories. Final counts reported in the "Results" summed only "sure" and "probable" redds.

Spawning Tributary Electrofishing

Mol Heron Creek was electrofished on June 21, 1990 to document movement of Yellowstone cutthroat trout into Mol Heron Creek and to attempt to determine the upper extent of movement by spawning Yellowstone River cutthroat in Mol Heron Creek. A 1,000 foot sample section located adjacent to the county road bridge above the creek's mouth and a 675 foot sample section located near the Church Universal and Triumphant's bomb shelter complex were each electrofished once with a backpack shocker. The backpack shocker was not functioning properly. While several fish were captured, numerous fish were stunned momentarily, but not netted. This survey was done primarily to document possible effects of the Church Universal and Triumphant's diesel and gasoline fuel spills during April 1990 from their Mol Heron bomb shelter complex on resident and spawning cutthroat trout.

Fry Trapping in Tributaries

Two fry traps were placed in Depuy's Spring Creek near its mouth at the Yellowstone River from May 21 to June 7, 1990 in an effort to document the out-migration of rainbow trout fry to the Yellowstone River. Fry traps were modified from plans presented by

Fraley et al. (1986) by using a net bag with a drawstring at the cod end rather than a bottle.

Single fry traps were placed in Depuy's Spring Creek, Cedar Creek, and Mol Heron Creek during the summer's of 1990 and 1991 and in Emigrant Spring, Locke, Peterson, Rock, and Tom Miner creeks during 1991 in an effort to document the out-migration of Yellowstone cutthroat trout fry to the Yellowstone River. Fry traps in Cedar and Mol Heron creeks were operated from July 31 to September 13 in 1990 and from July 29 to September 6 in 1991. In Rock one fry trap was operated from July 29 to August 19, 1991 when it was removed because high water velocities were causing excessive fry mortality. In Tom Miner Creek one fry trap was operated from July 29 to August 8, 1991 when it was stolen. Single fry traps were operated in Emigrant Spring Creek from July 29 to August 18, 1991, in Locke and Peterson creeks from July 22 to August 13, 1991, and in Depuy's Spring Creek from August 7 to August 29, 1990 and from July 22 to August 8, 1991. The trap in Depuy's Spring Creek was difficult to operate due to the large amount of aquatic vegetation floating down the spring creek during trapping.

All fry traps were operated on an intermittent schedule, but when in operation traps were checked at least once a day. An attempt was made to operate traps at least one day each week which increased to two to three days each week when numerous fry were captured in traps. All captured fish were counted by species. It was difficult to differentiate between rainbow and cutthroat trout fry, but timing of fry emergence was believed to be a relatively reliable indication of species differences. Rainbow trout typically spawn prior to June 15 while cutthroat trout spawn after that time. All fry captured after July 15 were assumed to be cutthroat fry. All trout were classified by life stage with fry being newly emerged fry and young-of-the-year (YOY) being post-emergent, actively swimming fish.

Samples of emigrating fry were taken from fry traps in Locke, Peterson, Emigrant Spring, and Cedar creeks for electrophoretic analysis to assess the relative purity of these fry as Yellowstone cutthroat. Fry were collected over several trap days. These fry were frozen and sent to the University of Montana's Wild Trout and Salmon Genetics Laboratory for analysis. Preliminary results from these analyses were obtained via phone (personal communication, Robb Leary).

Mill Creek Spawning Habitat Survey

Mill Creek is a candidate stream for water leasing under House Bill 707. The primary purpose of leasing water would be to enhance recruitment of Yellowstone cutthroat trout to the Yellowstone River. Maintaining flow in the lower portion of this historic spawning tributary through August should allow fertilized cutthroat trout eggs, which are normally deposited in early July, to incubate within a wetted gravel environment, hatch, emerge from the gravels, and move down to the Yellowstone River during August and early September. At the present time, lower Mill Creek is de-watered during the cutthroat spawning and incubation season. To evaluate the potential spawning habitat in lower Mill Creek, a spawning habitat survey was done from the mouth of Mill Creek upstream approximately 1.8 miles. The area (square feet) of all potential spawning habitat (gravels 0.5 to 3.0 inches in diameter) were estimated based on where they were located within five channel cross sections (middle thalweg one fifth, between the thalweg and edges, and the two edges). Surface areas of spawning gravels were summed by location across the channel and by 1500 linear foot distance up from the creek's mouth.

Migration Barrier Modifications

Culverts suspected of blocking movement of mature Yellowstone cutthroat trout into upper Mol Heron, Cinnabar, and Rock creeks were retro-fitted with ladders. Ladders were constructed following a modification of the design of Clancy and Reichmuth (1990). In the Mol Heron and Cinnabar culverts, Trout Unlimited provided the materials and the Park County Road crew constructed and installed the ladders. The Yellowstone Fly Fishers, with help from the Mineral Hill Mine, placed a fish ladder into the old railroad culvert over Rock Creek.

RESULTS AND DISCUSSION

Yellowstone River Population Estimates

The Ninth Street Section supported higher populations of trout (averaging 795 trout 13 inches and larger per mile) than any of the other three sections monitored from 1982 to 1991 (Figure 3). The Corwin and the Mill sections supported the next highest populations (434 and 415 per mile, respectively), while the Springdale Section supported the lowest populations of those sections surveyed (315 per mile). Results and brief discussions for each species are presented below.

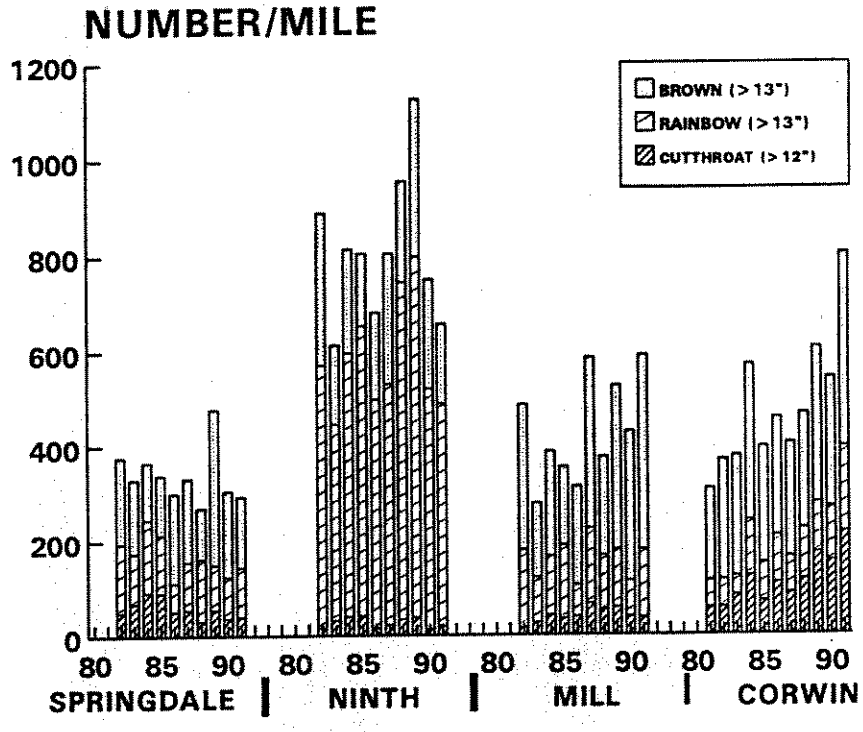


Figure 3. The number of Yellowstone cutthroat trout 12 inches and longer and rainbow and brown trout 13 inches and longer standardized to the number of fish per mile in the Springdale, Ninth Street Bridge (NINTH), Mill Creek Bridge (MILL), and Corwin Springs (CORWIN) sections of the Yellowstone River from 1982 to 1991 based on mark-recapture population estimates conducted in the spring.

Brown Trout

The 4.78 mile long Springdale Section supported an estimated 834 to 1,250 brown trout from 1989 to 1991 (Table 2). The 4.9 mile Ninth Section contained an estimated 1,057 to 2,905, the 5.75 mile Mill Section supported an estimated 2,533 to 2,845, and the 5.22 mile Corwin Section supported an estimated 1,946 to 2,911 brown trout from 1989 to 1991. The number of brown trout under 12.5 inches in the Ninth Section could not be estimated in 1990 because no marked fish in this size group were recaptured. An estimate of brown trout in a 2.7 mile long section below Carter's Bridge was 688 (SE: 87) fish 10.0 to 20.4 inches in 1991.

Brown trout in the Springdale Section averaged 15.2 inches (range: 6.1-26.6) and 1.23 pounds (range: 0.08-7.50) and 15.3 inches (range: 6.8-26.2) and 1.30 pounds (range: 0.08-6.28) in 1990 and 1991. In the Ninth Section brown trout averaged 14.4 inches (range: 7.8-25.4 and 1.06 pounds (range: 0.14-8.00) and 14.9 inches (range: 4.4-25.3) and 1.23 pounds (range: 0.05-over 10) in 1990 and 1991. In the Mill Section brown trout averaged 14.7 inches (range: 6.4-22.3) and 1.07 pounds (range: 0.13-3.80) in 1990. In the Corwin Section brown trout averaged 15.2 inches (range: 6.1-26.6) and 1.23 pounds (range: 0.08-7.50) in 1990. Length frequency histograms are presented in Appendix A.

The trend in the number of brown trout 13 inches and longer per river mile from 1981 to 1991 indicate that densities in 1989 were high in all four sections, 1990 densities were near average, and 1991 densities appeared low in the lower river sections and high in the upper river sections (Figure 4). There were an estimated 224 brown trout 13 inches and longer per mile in the Carter's Bridge Section in 1991, higher densities than in the Ninth Section in 1991 (169) and near the 10 year average density of 225 for 13 inches and longer brown trout in the Ninth Section from 1982 to 1991. Densities of brown trout 13 inches and longer in the Corwin Section have remained fairly stable during the past 10 years with moderately high densities recorded in 1984 and 1989 and record high densities estimated in 1991.

The densities of brown trout 18 inches and longer have fluctuated somewhat in all four sections (Figure 4). Densities in the Springdale, Ninth, Mill, and Corwin sections ranged from 9 to 52, 6 to 32, 25 to 64, and 3 to 14 per river mile, respectively. The lower three sections have relatively higher densities of larger brown trout than the upper Corwin Section. It appears that the densities of these larger brown trout climbed to some threshold

Table 2. Population estimates (SE) for designated length groups of brown, rainbow, and Yellowstone cutthroat trout in the Springdale, Ninth Street, Carter's Bridge, Mill Creek Bridge, and Corwin Springs sections of the Yellowstone River in the spring of 1989, 1990, and 1991.

Section	Species	Year		
		1989	1990	1991
		(SE) Length group		
Springdale	Brown	1,169 (100) 7.5-24.4	1,250 (101) 8.0-26.9	834 (80) 8.5-23.9
	Rainbow	1,213 (95) 7.5-18.9	1,190 (106) 6.0-18.9	1,491 (148) 7.5-19.9
	Cutthroat	527 (71) 8.0-15.4	534 (77) 7.0-18.9	630 (124) 8.5-16.0
Ninth Street	Brown	2,905 (391) 8.0-25.4	1,208 (177) 12.5-25.4	1,057 (100) 9.5-25.5
	Rainbow	9,026 (918) 7.5-20.4	7,360 (737) 6.0-23.4	4,883 (294) 7.0-19.9
	Cutthroat	275 (69) 10.0-16.4	83 (34) 10.0-16.4	201 (44) 8.0-17.5
Carter's Bridge	Brown	-	-	688 (87) 10.0-20.4
	Rainbow	-	-	3,681 (301) 7.0-19.4
	Cutthroat	-	-	75 (19) 11.0-14.9

Table 2. Continued.

Section	Species	Year 1989 (SE) Length group	1990	1991
Mill Creek Bridge	Brown	2,845 (199) 6.5-22.4	2,533 (143) 7.0-22.4	2,649 (206) 8.0-20.4
	Rainbow	1,005 (109) 6.5-20.4	640 (43) 7.5-20.4	977 (171) 10.0-17.9
	Cutthroat	678 (65) 7.5-17.4	435 (64) 7.0-16.4	571 (116) 8.5-15.9
Corwin Springs	Brown	2,911 (269) 7.5-19.0	1,946 (127) 5.5-22.4	2,347 (263) 8.5-20.9
	Rainbow	2,385 (262) 6.5-20.4	1,845 (120) 5.5-20.0	1,632 (256) 9.5-18.4
	Cutthroat	1,979 (157) 7.5-17.9	1,668 (103) 5.5-17.4	1,609 (284) 9.5-16.4

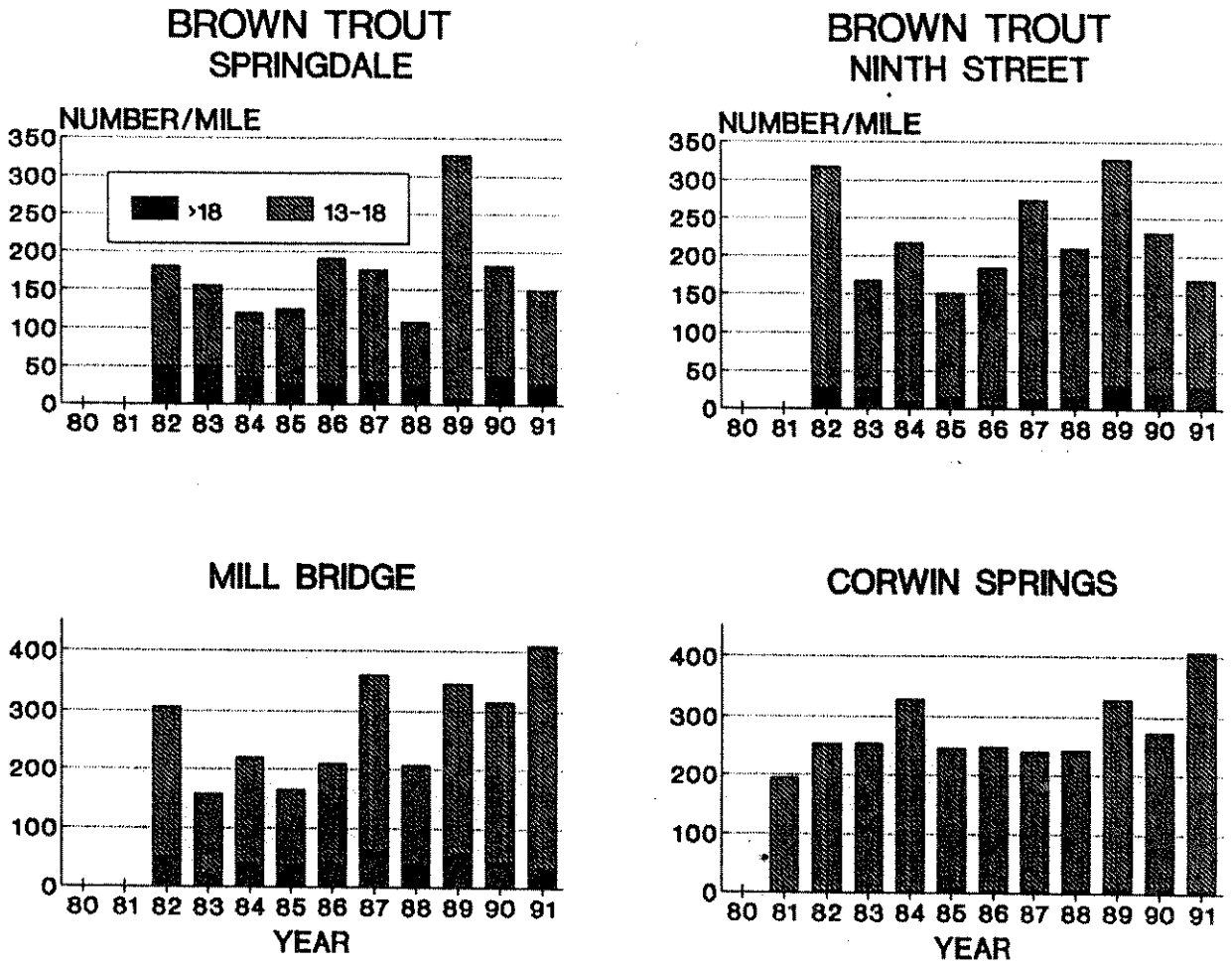


Figure 4. The number of brown trout 13 inches and longer and 18 inches and longer per mile of river in four study sections of the Yellowstone River from 1982 to 1991.

level within each section and then declined after one to two years at a high level. The threshold level is likely a function of security habitat and food availability within each section. The cyclic nature observed in their relative abundance may be related to increased mortality which may occur after a relatively large proportion of fish within the population reach older age classes.

The estimated number of age II brown trout in the Springdale, Ninth, and Mill sections declined in 1990 and 1991 (Table 3). It is possible these low numbers were due either to the drought years of 1988/89 reducing recruitment and/or juvenile survival or to problems associated with estimating age II trout discussed in the "Methods" section (Figure 2). These low numbers may result in poor populations of age III and older brown trout in future years. Future monitoring will confirm this possibility.

Rainbow Trout

The Springdale Section supported an estimated 1,190 to 1,213 rainbow trout from 1989 to 1991, while the Ninth Section contained an estimated 4,883 to 9,062, the Mill Section supported an estimated 640 to 1,005, and the Corwin Section supported an estimated 1,632 to 2,385 (Table 2). An estimate of rainbow trout in the 2.7 mile long section below Carter's Bridge was 3,681 (SE: 301) fish 7.0 to 19.4 inches in 1991.

Rainbow trout in the Springdale Section averaged 12.0 inches (range: 5.1-18.6) and 0.67 pounds (range: 0.05-2.36) in 1990 and 11.6 inches (range: 3.5-19.7) and 0.63 pounds (range: 0.04-2.53) in 1991. In the Ninth Section rainbow trout averaged 12.5 inches (range: 5.8-23.2) and 0.71 pounds (range: 0.05-4.58) in 1990 and 12.4 inches (range: 4.0-19.8) and 0.74 pounds (range: 0.04-2.58) in 1991. In the Mill Section rainbow trout averaged 13.6 inches (range: 6.0-20.2) and 0.88 pounds (range: 0.08-2.54) in 1990. In the Corwin Section rainbow trout averaged 12.2 inches (range: 5.8-19.7) and 0.64 pounds (range: 0.06-2.27) in 1990. Length frequency histograms are presented in Appendix A.

The trend in the density of rainbow trout 13 inches and longer from 1981 to 1991 does not follow any distinct pattern (Figure 5). Since estimates were conducted during the spring, rainbow trout were probably moving to or from spawning sites. Any movement through a sample section biases estimates and makes interpretation of the results difficult. Densities of rainbow trout 13 inches and longer were low in the Springdale and Mill sections in 1986 and 1990. There were an estimated 894 rainbow trout 13 inches and

Table 3. Estimated number of brown trout per mile by age and estimated mortality rates (%) in three sample sections of the Yellowstone River from 1982 to 1991.

Section Year	Age Class				Estimated mortality (%)	
	II	III	IV	V+	II to III	III to IV
Springdale						
1982	44					
1983	56	63			NP[1]/	
1984	145	44	35	52	21	45
1985	164	80	38	35	45	14
1986	53	127	52	48	23	35
1987	63	47	82	65	11	35
1988	121	39	17	55	38	63
1989	63	58	51	72	52	NP
1990	55	39	64	90	38	NP
1991	21	41	39	76	26	0
Ninth						
1982	75	152				
1983	162	66			12	
1984	342	118	53	109	27	19
1985	305	117	53	72	66	55
1986	118	174	50	54	43	57
1987	116	86	125	75	27	28
1988	249	101	34	78	13	61
1989	147	286	95	37	NP	6
1990[2]/	74	59	102	83	60	64
1991	35	38	78	61	49	NP
Mill						
1982	104	95				
1983	76	70	29	78	33	69
1984	100	59	67	103	22	4
1985	306	48	32	95	52	45
1986	170	139	35	93	55	27
1987	79	127			25	
1988	140	68			14	
1989	120	79	106	191	44	NP
1990	68	100	69	202	17	13
1991	29	72	165	196	NP	NP

[1]/ NP indicates no estimate possible because estimated number of trout III years old was higher than estimated number of trout II years old the previous year.

[2]/ Estimate of trout two years old in 1990 was very poor due to no recaptures of fish less than 12.5 inches. Efficiency estimated from fish 12.5 to 15.9 inches was used to estimate numbers of age two sized fish (8.0 to 12.5 inches).

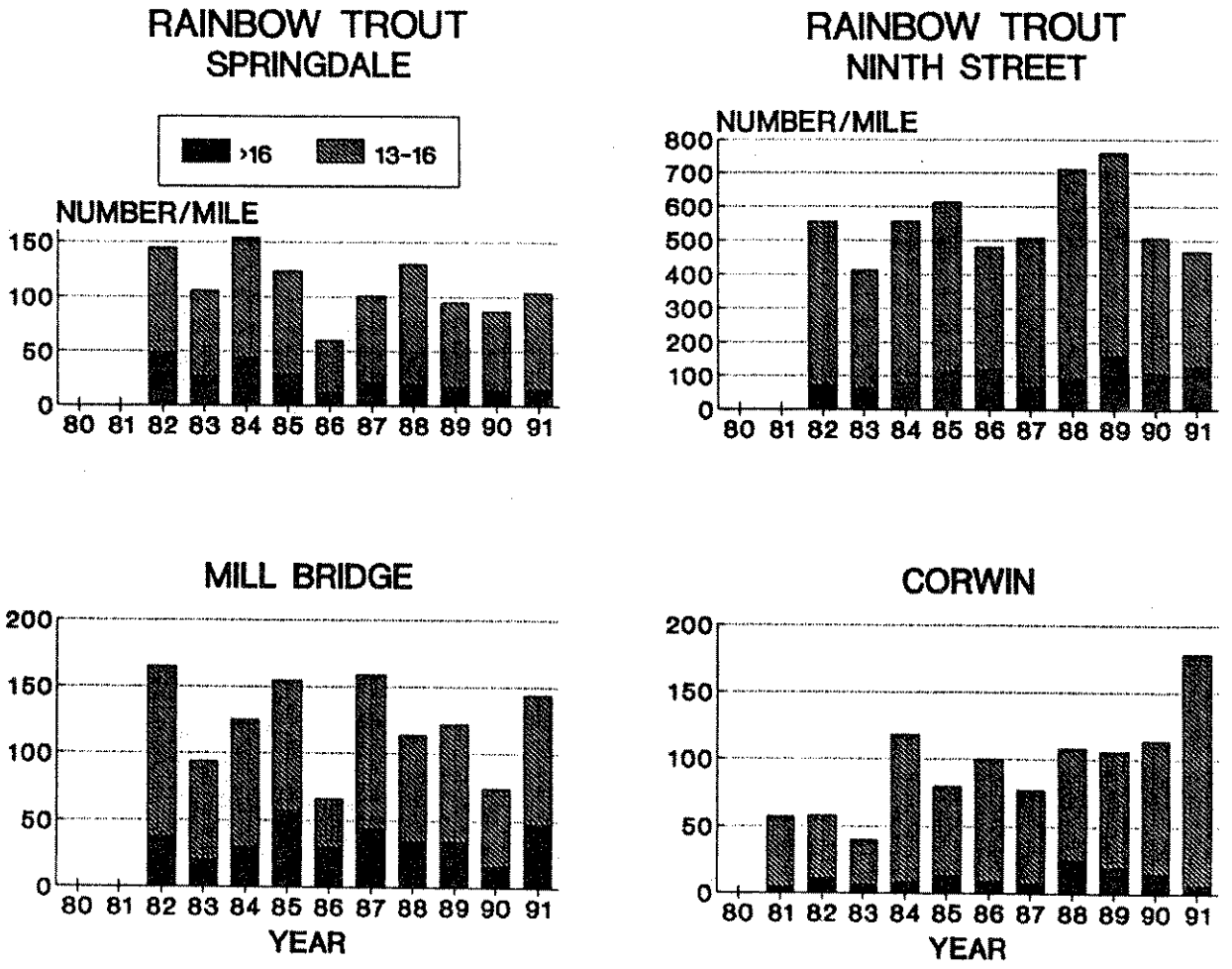


Figure 5. The number of rainbow trout 13 inches and longer and 16 inches and longer per mile of river in four study sections of the Yellowstone River from 1982 to 1991.

longer in the Carter's Bridge Section in 1991, compared to 469 per mile in the Ninth Section that same year and a 10 year average in the Ninth Street Section of 558 per mile from 1982 to 1991. Rainbow trout densities appear to be increasing in the Corwin area, but may be declining in the Ninth area.

Densities of rainbow trout 16 inches and longer dropped in the Springdale Section in 1986 and have remained low since that time (Figure 5). Densities of larger rainbows in the other three sections have fluctuated cyclicly. It appears that densities of these larger rainbows are presently declining in the Corwin Section as overall rainbow densities increase. The Carter's Bridge Section appears to support higher densities of larger rainbow trout (228/mile) than the Ninth Section (131/mile). This difference is probably related to the movement of mature rainbow trout seeking spawning sites in spring creeks immediately above this section. This movement leads to higher numbers of large rainbow trout in this section and causes an inflation of the estimate for larger rainbow trout. Based on the comparison of rainbow trout densities between the Carter's Bridge and Ninth Street sections, it is likely that the Carter's Bridge portion of the river supports higher densities of rainbow trout in the spring than the Ninth Street portion. Consequently, monitoring rainbow trout populations in the Ninth Street Section should detect changes in rainbow trout abundance better than monitoring in the Carter's Bridge Section.

Yellowstone Cutthroat Trout

The Springdale Section supported an estimated 534 to 630 cutthroat trout from 1989 to 1991, while the Ninth Section contained an estimated 83 to 275, the Mill Section supported an estimated 435 to 678, and the Corwin Section supported an estimated 1,609 to 1,979 (Table 2). An estimate of cutthroat trout in the 2.7 mile long section below Carter's Bridge was 75 (SE: 19) fish 11.0 to 14.9 inches in 1991.

Cutthroat trout in the Springdale Section averaged 11.2 inches (range: 6.5-18.6) and 0.57 pounds (range: 0.08-1.86) in 1990 and 11.2 inches (range: 6.1-16.0) and 0.58 pounds (range: 0.07-1.53) in 1991. In the Ninth Section cutthroat trout averaged 11.8 inches (range: 7.7-16.0) and 0.58 pounds (range: 0.13-1.16) in 1990 and 11.7 inches (range: 7.6-17.2) and 0.64 pounds (range: 0.16-1.81) in 1991. In the Mill Section cutthroat trout averaged 11.9 inches (range: 6.2-16.2) and 0.64 pounds (range: 0.08-1.47) in 1990. In the Corwin Section cutthroat trout averaged 12.0 inches (range: 5.8-17.2) and 0.62 pounds (range: 0.07-1.84) in 1990. Length frequency histograms are presented in Appendix A.

The trend in the number of cutthroat trout 13 inches and longer per river mile from 1981 to 1990 does not follow any distinct pattern (Figure 6). Since estimates are conducted during the spring, cutthroat trout may still be moving between sections in association with their pre-spawning movements. This movement biases estimates and makes interpretation of the results difficult. Densities of cutthroat trout 13 inches and longer were extremely low in the Ninth Section in 1990, but rebounded slightly in 1991. Densities in the Carter's Bridge Section were slightly higher (17/mile) than the Ninth Section (15/mile) in 1991. When the four sections are compared it appears that cutthroat trout populations in the lower river, below Mill Creek, have declined since 1985, while populations in the upper river have increased since 1985.

Mountain Whitefish

The 1.4 mile Mallard's Rest Section supported an estimated 24,049 (SE: 2,411) whitefish 7.0 to 20.9 inches in 1990 and 16,954 (SE: 1,518) whitefish 8.5 to 18.4 in 1991. There is no clear trend in the number of mountain whitefish 12 inches and longer per mile since 1973 (Figure 7). Except for the relatively low numbers estimated in 1986, 3,174 per mile, the numbers have remained relatively constant at from 4,980 to 7,237 per mile. If smaller whitefish (7.0 inches and larger) are included, the estimated number/mile jumps to from 6,586 per mile in 1986 up to 16,500 per mile in 1987.

Effects of Special Regulations

Catch and Release Regulation for Yellowstone Cutthroat

While populations of cutthroat trout 13 inches and longer have increased under the catch and release regulation in the upper river (Corwin), a positive response has not been observed in the lower river (Springdale, Ninth, and Mill sections on Figure 6). Since the catch and release regulation for cutthroat trout did not include the portion of the river below Pine Creek Bridge until after 1988, perhaps cutthroat trout populations in the Springdale and Ninth sections will respond later. The reasons for a lack of response in the Mill Section is discussed below.

The number of cutthroat trout 16 inches and longer have apparently not responded to the regulation throughout the river (Figure 6). Reasons for this lack of larger cutthroat are not clear, but it could be related to one or more of the following theories: 1) there may be enough hooking mortality to prevent many cutthroat trout from reaching this larger size; 2) the genetic component for fast growth and greater longevity has been lost; or 3) growth of mature fish is so slow that it may take several more years before many cutthroat trout reach 16 inch and longer sizes.

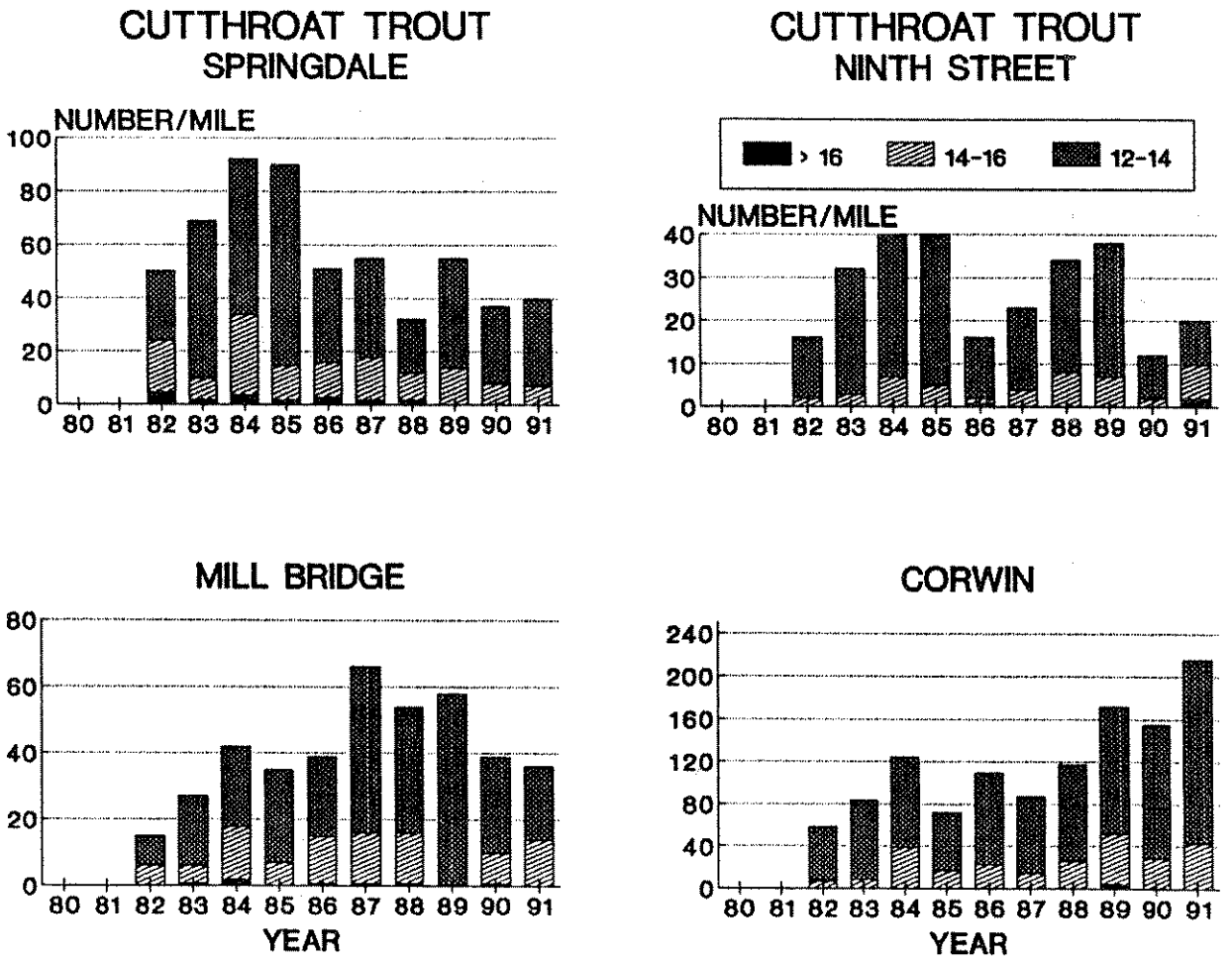


Figure 6. The number of cutthroat trout 13 inches and longer and 16 inches and longer per mile of river in four study sections of the Yellowstone River from 1982 to 1991.

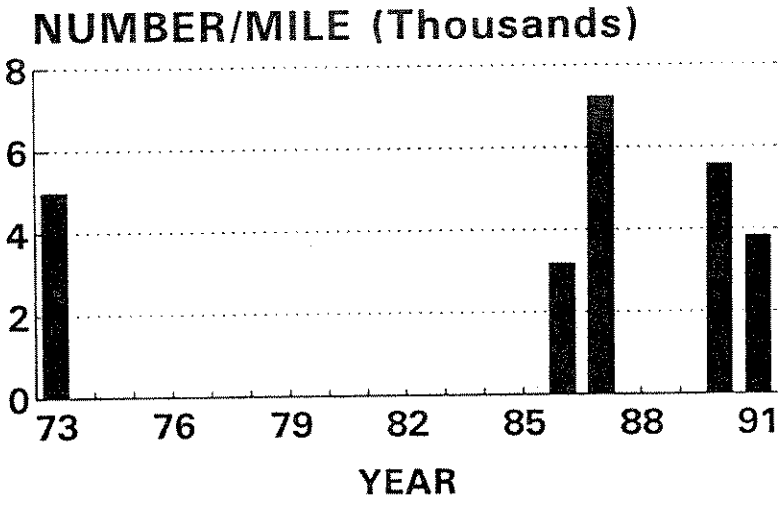


Figure 7. Estimated number of mountain whitefish 12.0 inches and longer per mile in the Mallard's Rest area of the Yellowstone River from 1973 to 1990.

Slot Limit for Rainbow and Brown Trout

The slot limit regulation imposed on the Yellowstone River essentially eliminates harvest of trout because of the wide range of lengths which cannot be harvested (13 to 22 inches). Few anglers keep fish under 13 inches and "trophy" fish over 22 inches make up a very small proportion of the trout population. In addition, angler attitudes have been changing over the past several years with more and more anglers releasing higher percentages of their catches. These factors made it difficult to evaluate the effects of the slot limit on trout populations.

Initiating a slot limit with terminal gear restrictions (artificial flies and lures only) in 1984 also might have lead to either an increase or decrease in angling pressure, depending on the use by anglers where bait fishing is not allowed. Unfortunately, it was impossible to evaluate changes in angling pressure within this slot limit portion of the Yellowstone River using annual Montana Statewide Angling Pressure mail surveys because this segment of the river was not differentiated within those surveys (McFarland 1989). The pressure survey for 1983, prior to initiation of the slot limit, estimated 31,903 angler days on a 51.9 mile portion of the river from the Shields River up to Tom Miner Creek (Appendix B). This translates to approximately 615

angler days/mile. In 1985, after initiating the slot limit, estimated angling pressure on this portion of the river increased to 38,950 angler days, which translates to about 750 angler days/mile (Appendix B). This result would indicate an 18% increase in pressure within the entire section, but did not allocate how much of this increase occurred within the slot limit portion. The trend in angling pressure within the portion containing the slot limit area can be separated after 1984 (Section 08B, Appendix B). This portion of the river received 262 and 275 angler days/mile in 1984 and 1985, respectively, immediately after the slot limit regulation was enacted. Pressure declined since that time to 75% of 1984/85 pressure in 1989 (188 angler days/mile) and preliminary 1991 data indicated angling pressure was about 50% of 1984/85 pressure (129 angler days/mile).

The effect of the slot limit on populations of rainbow and brown trout was evaluated by comparing abundance estimates conducted from 1982 to 1984 as pre-regulation abundance versus those estimates after 1984, when the regulation was first implemented, as post-regulation populations. The pre- and post-regulation estimates for the Mill Section, within the slot limit regulation portion of the river, were compared to the pre- and post-regulation estimates for the Ninth and Corwin sections, located below and above the slot limit portion of the river, respectively.

Average and median densities of brown trout 13 inches and longer, and 16 inches and longer in the Mill Section increased following the initiation of the slot limit, while densities of the same size groups declined in the Ninth Section and went up only slightly in the Corwin Section during the same time period (Tables 4 and 5; Figure 8). Densities of brown trout 13 inches and longer in the Mill Section increased fairly consistently through 1991, while densities of brown trout 16 inches and longer initially increased up to 1989, then have declined slightly (Figure 4).

Average and median densities of rainbow trout 13 inches and longer within the Mill Section were higher prior to the slot regulation than after, while densities in the two other sections were higher after the slot limit, even though no slot limit was imposed on these sections (Table 4 and Figure 8). Densities of rainbow trout 16 inches and longer went up in all sections (Table 5).

Brown trout have been shown to be less vulnerable to angling than other trout species (Schuck 1941). Under relatively high angling pressure, it is possible that regulating harvest with a slot limit may reduce harvest of brown trout more than other trout species because brown trout are not initially as vulnerable to

Table 4. Comparison of number of 13 inches and longer rainbow and brown trout per mile in the Ninth (downstream control with no special slot limit), Mill (slot-limit), and Corwin (upstream control with no special slot limit) before and after the slot limit was imposed.

	Rainbow Trout		Brown Trout	
Section	Pre-Slot	Post-Slot	Pre-Slot	Post-Slot
Ninth	555	613	318	151
	413	482	168	184
	557	508	217	274
		711		210
		760		328
		508		231
		469		169
Average	508	578	234	221
Median	555	508	217	210
Mill	165	155	306	165
	94	66	157	209
	125	159	220	360
		114		207
		122		346
		74		316
		144		410
Average	128	119	228	288
Median	125	122	220	316
Corwin	57	80	195	245
	58	100	253	248
	40	77	254	240
	118	108	328	242
		106		328
		114		273
		179		408
Average	68	109	258	283
Median	58	106	254	248

Table 5. Comparison of number of 16 inches and longer rainbow and brown trout per mile in the Ninth (downstream control with no special slot limit), Mill (slot-limit), and Corwin (upstream control with no special slot limit) before and after the slot limit was imposed.

	Rainbow Trout		Brown Trout	
Section	Pre-Slot	Post-Slot	Pre-Slot	Post-Slot
Ninth	67	119	110	59
	81	123	87	32
		71	79	75
		96		98
		164		116
		112		80
		131		81
Average	74	117	92	77
Median	74	119	87	80
Mill	38	58	175	103
	21	31	70	108
	31	45	152	194
		35		133
		35		236
		16		177
		48		208
Average	30	38	132	166
Median	31	35	152	177
Corwin	5	14	53	83
	12	10	83	71
	7	8	59	43
	9	26	94	69
		20		121
		15		95
		7		108
Average	8	14	72	84
Median	8	14	71	83

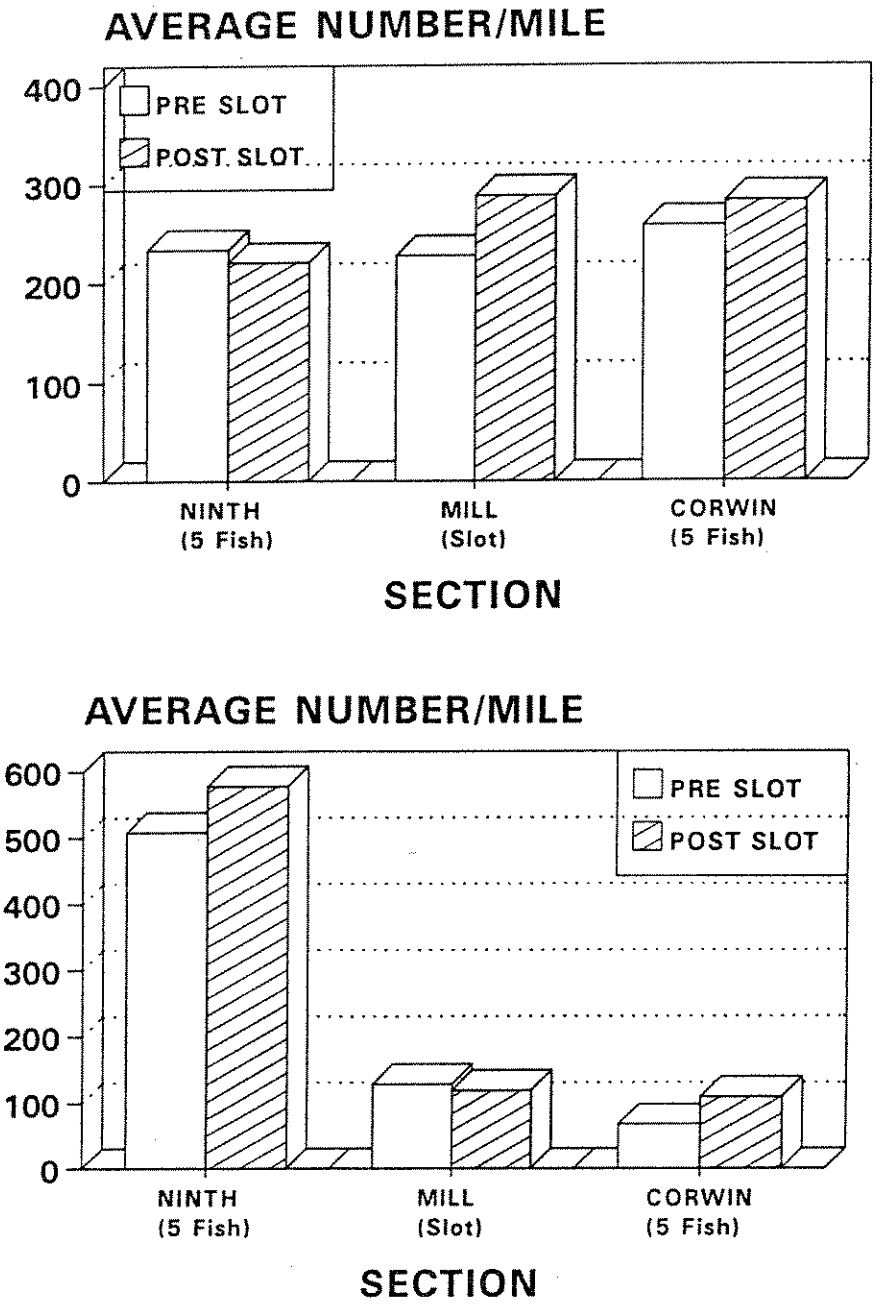


Figure 8. Comparison of the average number of brown trout (top) and rainbow trout 13 inches and longer per mile of river in three sections of the Yellowstone River "pre" and "post" 1984 when a special "slot limit" was place on the portion of river represented by the Mill Bridge Section.

anglers and the added protection afforded by a slot limit increases survival of brown trout. Average estimated mortality rates of brown trout from age III to age IV declined in the Mill Section after 1985 (from 39% to 20%), but increased in the Springdale (29% to 44%) and the Ninth (37% to 43%) sections (Table 3). It is likely that the reduction in mortality in the Mill Section was due to reduced angler harvest (mortality).

Brown trout populations may become more self-regulating, as a consequence of the cannibalistic foraging of large brown trout on smaller brown trout and intra-specific competition, if harvest is reduced, either through inability of anglers to harvest brown trout from secure habitats or through regulation. Oswald (1986 and 1989) documented cycles for recruitment of young brown trout in populations within both the Big Hole and Beaverhead rivers near Dillon, Montana. These recruitment cycles appeared to be related to the relative abundance of large brown in the population. During years when brown trout populations contained a high percentage of larger, older fish, recruitment of young brown trout into the population appeared to be low compared to years when larger, older fish made up a relatively small percentage of the total population.

Relatively high recruitment of young brown trout into the population occurred after a large portion of the older, larger fish died, presumably due primarily to natural causes. These cycles seemed more pronounced in the Maiden Rock Section of the Big Hole River, which has a slot limit, than in the Beaverhead River, where there is no slot limit, but which has abundant, secure cover habitat which is difficult to fish (personal communication, Dick Oswald). The variable annual flow regimes in the Beaverhead and Big Hole rivers during this study confounded this relationship. It may be that brown trout populations within the slot limit segment of the Yellowstone River will began to exhibit this same type of cyclic trend in recruitment rates and abundance over time.

Clark and Alexander (1985) found a decline in brown trout populations in the Au Sable River of Michigan after a slot limit was initiated, but that slot limit allowed for a more liberal harvest than the prior minimum size regulation and unfavorable environmental conditions probably reduced recruitment. Rainbow and brook trout abundance increased under the Au Sable slot limit, but these increases were attributed more to increased recruitment related to environmental variables than to regulation changes. Favro et al. (1980) used a computer model to predict the effects of slot limits on the percentage of larger fish within a population and reported that the model indicated that there would be no increase in the percentage of larger fish. This predicted result was not observed over the short-term in brown trout populations within the slot limit portion of the Yellowstone River (Table 5) or

in the slot limit portion of the Big Hole River (Oswald 1986 and 1989).

Cutthroat populations in the Mill Section did not continually increase through 1991, even with the initiation of catch and release regulations and terminal gear restrictions in 1984, while cutthroat populations continued to increase through 1991 in the Corwin Section which had catch and release regulations with no gear restrictions (Figure 6). It appears that after cutthroat trout populations initially expanded in the Mill Section from 1987 to 1989 they began declining from 1990 to 1991. Densities of mid-sized (13 to 16 inches) rainbow trout also appeared to be depressed by the slot limit. Several potential factors might have lead to this decline including: 1) low water years during 1987 and 1988 which lowered recruitment rates; 2) increased hooking mortality in the slot limit area; and/or 3) increased competition and predation from conspecific brown trout. Brown trout numbers increased in the Mill Section, probably in response to the slot limit, and their increase may have reduced cutthroat and rainbow densities.

Age-Growth Estimates

Average lengths of brown trout at ages II, III, and IV during 1989 to 1991 interpreted from scale growth showed that brown trout in the lower river generally grew at faster rates than those in the upper river (Table 6). Since ages were difficult to interpret from scales these results must be viewed with caution. The average length of age II brown trout throughout the river ranged between 8.5 to 10.6 inches. Age II browns in the lower river (Springdale and Ninth sections) averaged about 10 inches and age II browns in the upper river (Mill and Corwin sections) averaged about 9 inches. Some variation in growth between years was observed with smaller average lengths for age II brown trout in all sections but the Ninth Section during 1990. This smaller length at age II may be related to poor growth during the drought year of 1988, when these fish were age 0.

Average lengths of "known age" brown trout were calculated by section (Tables 7 to 9). Average lengths of age II fish in the tables should be disregarded when comparing "known age" lengths to average lengths of aged fish because fish were arbitrarily clipped based on set length groups (Table 1). The average lengths of "known age" age III and older brown trout in the Springdale Section were similar to average lengths for browns assigned as age III from scale samples (Table 6 versus 7). Brown trout in the Springdale Section grew about four inches from age II to III, then growth declined to about two inches from age III to IV, and again declined to about one inches per year after age IV.

Table 6. Average length (range) of age II, III, and IV brown trout determined from scale samples obtained in the spring in four sample sections of the Yellowstone River during 1989 to 1991.

		Average length (range) at age		
Section	Year	2	3	4
Springdale	1989	10.6 (7.8-13.2)	14.0 (12.0-15.6)	16.2 (14.8-18.4)
	1990	9.9 (6.1-13.1)	13.4 (11.3-14.9)	15.7 (13.9-17.1)
	1991	10.2 (7.0-12.5)	13.4 (10.7-15.1)	15.4 (13.2-16.7)
Ninth	1989	9.9 (8.4-11.0)	13.2 (10.1-15.8)	16.1 (15.2-17.2)
	1990	10.1 (7.8-12.5)	12.9 (10.6-14.6)	14.9 (13.3-16.6)
	1991	9.9 (6.8-11.2)	13.2 (11.1-14.9)	15.9 (13.2-17.7)
Mill	1989	9.5 (6.9-12.4)	13.2 (10.7-15.0)	15.9 (14.7-17.2)
	1990	8.5 (6.6-10.8)	12.4 (9.1-14.8)	15.3 (13.7-17.1)
	1991	9.5 (6.3-11.7)	13.0 (10.9-14.7)	15.4 (13.5-18.0)
Corwin	1989	9.4 (8.0-10.7)	11.6 (10.1-13.0)	14.1 (12.9-15.8)
	1990	8.8 (5.8-10.6)	12.5 (10.7-14.4)	14.3 (13.0-15.3)
	1991	8.6 (6.9-9.6)	12.2 (9.4-15.2)	14.5 (12.5-16.5)

Table 7. Average length (inches) of "known-age" brown trout marked as age II during spring sampling and recaptured later in the Springdale Section of the Yellowstone River from 1984 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1984		14.2 (6)				
1985		13.1 (16)	16.5 (2)			
1986		13.9 (35)	15.3 (7)	15.8 (1)		
1987	10.1 (76)	13.9 (17)	16.0 (20)	16.3 (3)		
1988	10.0 (96)	14.2 (17)	16.5 (4)	17.7 (2)		
1989	10.1 (94)	14.4 (15)	16.1 (4)	16.1 (7)	17.8 (3)	18.4 (2)
1990	9.6 (87)	13.4 (19)	15.4 (10)	16.9 (8)	17.7 (5)	18.7 (3)
1991	10.0 (56)	14.2 (14)	15.4 (12)	16.4 (8)		18.4 (2)
Averages	10.0 (409)	13.9 (139)	15.7 (59)	16.5 (29)	17.7 (8)	18.5 (7)

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

Table 8. Average length (inches) of "known-age" brown trout marked as age II during spring sampling and recaptured later in the Ninth Street Bridge Section of the Yellowstone River from 1984 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1984		12.6 (8)				
1985		12.1 (14)	14.2 (7)			
1986	9.4 (84)	12.9 (28)	14.5 (5)	16.1 (5)		
1987	9.2 (82)	13.4 (12)	14.5 (13)	16.2 (8)	16.7 (3)	
1988	9.3 (86)	13.4 (11)	16.3 (7)	17.4 (8)	16.1 (1)	18.7 (1)
1989	9.4 (50)	13.4 (14)	16.4 (3)	17.5 (4)	17.4 (9)	
1990	9.2 (36)	12.3 (2)	15.1 (8)	16.8 (4)	17.5 (4)	
1991	9.4 (32)	12.8 (2)	16.2 (5)	15.9 (7)	16.4 (2)	19.5 (3)
Averages	9.3 (370)	12.9 (91)	15.1 (48)	16.6 (36)	17.1 (19)	19.3 (4)

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

Table 9. Average length (inches) of "known-age" brown trout marked as age II during spring sampling and recaptured later in the Mill Creek Bridge Section of the Yellowstone River from 1984 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1984		12.7 (15)				
1985		13.5 (19)	15.5 (20)			
1986	9.2 (267)	13.2 (50)	16.7 (5)	16.9 (9)		
1987	9.0 (184)	13.7 (49)	15.7 (35)	16.8 (10)	17.1 (9)	
1988	9.2 (70)	14.4 (44)	16.5 (19)	17.2 (19)	17.4 (2)	19.2 (1)
1989	9.0 (203)	14.1 (11)	16.5 (32)	17.2 (23)	17.3 (16)	
1990	8.8 (99)	12.7 (41)	15.9 (19)	16.5 (31)	16.7 (19)	18.3 (7)
1991	9.2 (42)	13.5 (27)	15.6 (37)	16.5 (28)	17.4 (25)	19.0 (2)
Averages	9.1 (865)	13.5 (256)	16.0 (167)	16.8 (120)	17.1 (71)	18.5 (10)

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

The average lengths of "known age" age III and older brown trout in the Ninth Section were slightly smaller than lengths averaged from ages interpreted from scale samples (Table 6 versus 8). The potential biases associated with designating specific length groups as "known age" in the "Methods" section may have contributed to this difference. "Known age" brown trout in the Ninth Section did not grow as rapidly as those in the Springdale Section. Reasons for different growth rates may be related to: 1) nutrient enrichment of the Yellowstone River from the city of Livingston's sewage treatment effluent; and/or 2) high trout densities in the Ninth Section. High trout densities may contribute to lower growth rates due to competition for limited food resources by high numbers of trout, while nutrient enrichment may increase growth rates.

The average lengths of "known age" age III brown trout in the Mill Section were slightly larger than lengths based on scales, but scale and "known age" average lengths were similar for age IV (Table 6 versus 9). Annual growth averaged 4.4 inches from age II to age III and about 2.5 inches from age III to age IV (Table 9). Annual growth then declined to under one inch per year. Annual growth rates typically decline as fish mature and begin to expend energy for reproduction rather than growth. In the Yellowstone browns typically mature around age III.

Average lengths of "known age" cutthroat trout were also calculated by section (Tables 10 to 12). Overall average lengths by age indicated cutthroat trout grew about three inches from age II to III, then about two inches from age III to IV, before growth declined to about one inch per year after age IV in all three sections.

Mortality Estimates

Estimated numbers of brown trout per river mile by age class were used to estimate mortality rates between age II and III and between age III and IV. Mortality rates fluctuated and no clear pattern of mortality was observed (Table 3). Relatively high mortality rates between age II and III were estimated from 1984 to 1985 in all sections, from 1988 to 1989 in the Springdale and Mill sections, and from 1985 to 1986 and 1989 to 1990 in the Ninth Section. The biases associated with age and population estimation explained in the "Methods" portion probably caused some of these fluctuations. It might be worthwhile to investigate whether environmental variables, most notably river flow and winter ice conditions, contribute to these fluctuations in mortality rates.

Table 10. Average length (inches) of "known-age" Yellowstone cutthroat trout marked as age II during spring sampling and recaptured later in the Springdale Section of the Yellowstone River from 1985 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1985		11.8 (10)				
1986		12.6 (10)	15.4 (1)			
1987	9.2 (32)	12.6 (10)	13.7 (1)	15.6 (3)		
1988	9.2 (112)	11.7 (3)	15.1 (4)			
1989	9.2 (31)	11.8 (17)	12.6 (3)	14.9 (2)	15.3 (1)	
1990	8.9 (82)	11.7 (6)	13.3 (4)	14.2 (1)		
1991	9.1 (74)	12.2 (11)	14.2 (3)	14.0 (3)	15.6 (1)	
Averages	9.1 (331)	12.1 (67)	14.0 (10)	14.8 (9)	15.4 (2)	

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

Table 11. Average length (inches) of "known-age" Yellowstone cutthroat trout marked as age II during spring sampling and recaptured later in the Ninth Street Bridge Section of the Yellowstone River from 1985 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1985		10.8 (4)				
1986	9.2 (70)	11.9 (5)	12.2 (2)			
1987	9.1 (73)	11.8 (8)	11.8 (1)	13.6 (1)		
1988	9.2 (80)	11.7 (8)	13.7 (1)	14.8 (2)	14.0 (1)	
1989	9.1 (27)	11.8 (10)	12.4 (5)		15.1 (1)	15.2 (1)
1990	9.2 (9)	11.4 (2)	12.7 (3)	15.1 (1)		
1991	9.1 (29)	12.6 (2)	12.7 (2)	13.9 (3)	15.0 (2)	
Averages	9.2 (288)	11.7 (39)	12.5 (14)	14.3 (7)	14.8 (4)	15.2 (1)

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

Table 12. Average length (inches) of "known-age" Yellowstone cutthroat trout marked as age II during spring sampling and recaptured later in the Mill Creek Bridge Section of the Yellowstone River from 1985 to 1991. Numbers in parentheses indicate sample sizes. Year classes can be followed along diagonals.

	Average length (in) at age					
Year	II[1]/	III	IV	V	VI	VII
1985		11.2 (13)				
1986	9.2 (267)	12.2 (9)	12.9 (7)			
1987	9.0 (184)	12.3 (16)	13.7 (4)	13.7 (3)		
1988	9.2 (70)	11.9 (19)	13.5 (6)	14.5 (1)		
1989	9.0 (203)	11.7 (22)	12.5 (12)	14.1 (10)	14.3 (1)	
1990	8.8 (99)	11.8 (8)	12.7 (14)	13.2 (13)	14.5 (3)	15.1 (1)
1991	9.2 (42)	13.7 (8)	14.2 (2)	13.4 (4)	16.7 (1)	
Averages	9.1 (865)	12.0 (95)	12.9 (45)	13.6 (31)	14.9 (5)	15.1 (1)

[1]/ The mean length and sample size of age II fish represent the average length of fish clipped during that year.

Incidence of Obvious Hook Scars

Cutthroat trout had a higher incidence of obvious hooking scars than other trout species and rainbow had a higher incidence than brown trout in all sections (Table 13). Hooking scars were less common in the lower river than the upper river which may be related to level of fishing pressure and that anglers probably keep more fish in the lower river. Brown trout had a higher incidence of hooking scars in the Mill Section than the other sections, probably related to the slot limit regulation in this section.

Table 13. Incidence (%) of obvious hooking scar occurrence in Yellowstone cutthroat, rainbow, and brown trout in the Springdale, Ninth, Mill,and Corwin sections of the Yellowstone River during spring, 1990 and 1991 sampling.

		Species		
Section	Year	Cutthroat trout	Rainbow trout	Brown trout
Springdale	1990	8.2	4.4	3.9
	1991	13.2	6.3	6.6
	Average	10.7	5.3	5.2
Ninth	1990	10.7	6.6	7.4
	1991	6.7	7.9	4.9
	Average	8.7	7.2	6.1
Mill	1990	14.5	10.1	9.1
	1991	13.7	10.4	9.1
	Average	14.1	10.2	9.1
Corwin	1990	16.4	9.0	5.7
	1991	14.3	11.9	5.2
	Average	15.3	10.4	5.4

Yellowstone River Fall 1988 Creel Census

Very little angling pressure was observed at known brown trout spawning sites during the 1988 spawning season. The total number of anglers counted in three areas surveyed three times a day for 15 days was 17. A total of one rainbow and one brown trout were found in anglers' creels during the survey and no estimate of harvest could be made due to the low number of anglers, interviews, and creeled fish. The one brown trout and one rainbow trout observed in anglers' creels were 15.0 and 10.1 inches long, respectively. All anglers interviewed were from the Livingston area.

Due to the limited amount of fishing pressure and relatively low success rate observed for the few anglers interviewed, it is believed that fishing pressure on spawning brown trout in the Yellowstone River is not a problem at this time. Low river flow associated with the 1988 drought may have affected this result.

Yellowstone River Winter 1988/89 Creel Census

A total of 105 and 118 anglers were interviewed after completing trips in the two sections (Table 14). A total of 141 and 262 anglers (complete and incomplete trips combined) were interviewed in sections 1 (all areas except Depuy's Spring Creek mouth) and 2 (Depuy's), respectively.

Anglers fished an estimated 3,202 hours (2,497 angler days) during the winter (Table 14). The Depuy's section (Section 2) received an estimated 1,763 hours of angling pressure (1,415 angler days), while the rest of the surveyed areas (Section 1) received an estimated 1,439 hours (1,082 angler days). The average trip lasted less than two hours for all sample periods and sections except for Depuy's during the first sample period (Table 14). The average number of anglers per count and fishing pressure increased as winter progressed. Weekend angler counts were generally higher than weekday counts except for the Depuy's area during the January 4 to February 14 time period.

Catch rates for all rainbow and brown trout and mountain whitefish captured (kept and released) averaged 0.55, 0.58, and 0.52 fish per hour for Section 1, and 1.04, 0.46, and 1.79 for the Depuy Section (2) (Table 15). Catch rates for rainbow and brown trout and mountain whitefish which were kept averaged 0.29, 0.28, and 0.43 fish per hour for Section 1, and 0.30, 0.25, and 1.60 for the Depuy Section. The total harvest of rainbow trout was 939 fish with 526 taken at Depuy's and 413 taken from the rest of the sample areas. The total harvest of brown trout was 888 fish with 491 taken at Depuy's and 397 taken along the rest of the river. The

Table 14. Number of days, days sampled, number of counts, number of interviews, hours fished, anglers per count, and angling pressure by sample period (WE = weekend days; WD = week days) from a creel survey conducted on the Yellowstone River near Livingston from December 14, 1988 to April 11, 1989. Standard deviations are in parentheses.

Parameter (Section)	12/14/88 to 01/03/89	01/04 to 02/14 WE	01/04 to 02/14 WD	02/15 to 04/11 WE	02/15 to 04/11 WD	Total
Days in period	21	12	30	16	40	119
Days sampled	11	5	10	8	16	50
Counts	33	21	47	35	74	201
Interviews	33	71	50	85	163	403
Completed trips (1)	0	22	10	22	50	105
(2)	7	28	18	30	35	118
Total (1)	6	26	13	33	62	141
(2)	27	45	37	52	101	262
Hours fished						
(1)	-	1.0 (0.2)	0.9 (0.3)	1.3 (0.2)	1.5 (0.2)	
(2)	2.2 (0.5)	1.1 (0.1)	1.1 (0.1)	1.2 (0.2)	1.4 (0.2)	
Anglers/count						
(1)	0.2 -	1.5 (0.5)	0.5 (0.2)	2.1 (0.5)	1.9 (0.3)	
(2)	0.8 (0.2)	0.4 (0.4)	1.6 (0.3)	2.8 (0.4)	1.9 (0.3)	
Pressure						
Angler hours						
(1)	51 -	165 (50)	132 (51)	338 (72)	773 (122)	1,439
(2)	155 (47)	43 (43)	425 (77)	453 (69)	749 (120)	1,763
Total	206	208	557	791	1,522	3,202
Angler days						
(1)	23	159	141	257	503	1,082
(2)	70	39	405	384	545	1,415
Total	93	198	546	641	1,048	2,497

Table 15. Estimated average catch rates (number/hr) and harvest of fish with standard deviations (in parentheses) from a creel survey conducted on the Yellowstone River near Livingston from December 14, 1988 to April 11, 1989.

SECTION Parameter	12/14/88 to 01/03/89	01/04 to 02/14 WE	01/04 to 02/14 WD	02/15 to 04/11 WE	02/15 to 04/11 WD	Total
SECTION 1						
Rainbow trout						
Catch rate (Caught fish)	0.40 -	1.55 (0.59)	0.24 (0.13)	0.35 (0.11)	0.33 (0.10)	0.55
Catch rate (Kept fish)	0.40 -	0.39 (0.13)	0.24 (0.13)	0.28 (0.08)	0.26 (0.09)	0.29
Harvest	25 -	64 (29)	31 (21)	93 (35)	200 (75)	413
Brown trout						
Catch rate (Caught fish)	0.67 -	1.16 (0.51)	2.13 (0.60)	0.16 (0.07)	0.23 (0.07)	0.58
Catch rate (Kept fish)	0.67 -	0.32 (0.12)	0.79 (0.27)	0.16 (0.07)	0.18 (0.06)	0.28
Harvest	45 -	53 (25)	104 (54)	53 (27)	142 (54)	397
Mountain whitefish						
Catch rate (Caught fish)	2.83 -	0.64 (0.62)	0.24 (0.17)	0.10 (0.06)	0.53 (0.27)	0.52
Catch rate (Kept fish)	2.16 -	0 -	0.24 (0.17)	0.08 (0.05)	0.67 (0.31)	0.43
Harvest	111 -	0 -	31 (25)	27 (19)	516 (253)	685

Table 15. Continued.

SECTION Parameter	12/14/88 to 01/03/89	01/04 to 02/14 WE	01/04 to 02/14 WD	02/15 to 04/11 WE	02/15 to 04/11 WD	Total
SECTION 2						
Rainbow trout						
Catch rate (Caught fish)	2.84 (1.39)	0.74 (0.23)	1.06 (0.29)	1.35 (0.33)	0.52 (0.11)	1.04
Catch rate (Kept fish)	0.51 (0.15)	0.33 (0.11)	0.39 (0.10)	0.19 (0.07)	0.24 (0.05)	0.30
Harvest	79 (33)	14 (17)	166 (51)	85 (34)	182 (47)	526
Brown trout						
Catch rate (Caught fish)	0.82 (0.30)	0.29 (0.10)	1.08 (0.38)	0.45 (0.14)	0.23 (0.05)	0.46
Catch rate (Kept fish)	0.23 (0.12)	0.27 (0.10)	0.51 (0.16)	0.26 (0.09)	0.14 (0.03)	0.25
Harvest	36 (22)	12 (12)	216 (80)	119 (47)	108 (31)	491
Mountain whitefish						
Catch rate (Caught fish)	1.77 (0.80)	2.31 (0.86)	3.84 (1.42)	0.88 (0.53)	1.21 (0.49)	1.79
Catch rate (Kept fish)	0.85 (0.32)	2.17 (0.88)	3.74 (1.43)	0.71 (0.52)	1.21 (0.49)	1.60
Harvest	131 (63)	94 (101)	1,588 (672)	323 (241)	906 (397)	3,042

total harvest of mountain whitefish was 3,727 fish with 3,042 taken at Depuy's and 685 taken along the rest of the river.

Very few of the creeled trout examined were longer than 16.0 inches (Figure 9). The average lengths of creeled rainbow (n=90), brown trout (n=81), and mountain whitefish (n=30) were all 13.4 inches.

The majority of the anglers fishing the river during the winter lived in the Livingston area (80%), 15% lived in Montana outside the Livingston area, and 5% lived outside Montana. The majority of anglers used worms as bait (40%). The other terminal gear types, in decreasing frequency of use, were maggots (17%), flies (16%), eggs (13%), lures (7%), and sculpins (5%).

The majority of anglers fishing the Yellowstone River near Livingston during the winter used maggots for bait, indicating these anglers were targeting whitefish. However, some anglers were harvesting a relatively high number of trout in a few specific areas where they concentrated. A relatively small proportion of these trout were longer than 16.0 inches. It appears that harvested trout were mostly 10.0 to 15.0 inches long, a length group within the river's trout population which was abundant at the time of the survey, based on population estimates conducted in the Ninth and Mill sections during the springs of 1988 and 1989 (Figure 9 versus Appendix A4 to A9).

More fish were harvested at the Depuy's Spring Creek mouth area than other areas of the river which indicates a relatively high density of fish and, consequently, angler use of this area. It is possible that this segment of the river is used as over-wintering habitat by fish from throughout the Yellowstone River. Since this segment of the river remains ice-free during most of the winter due to the inflow of several spring creeks, it seems reasonable that fish would migrate to this portion of the river during the winter.

Future sampling efforts should try to document if fish from throughout the Yellowstone River do migrate into this portion of the river during the winter. It may be that limited winter habitat is regulating fish abundance in the Yellowstone River, especially during years of low winter flow and severe cold temperatures. A logical way to document this type of movement would be to tag fish in this portion of the river during the winter months and document movements into other portions of the river through angler returns

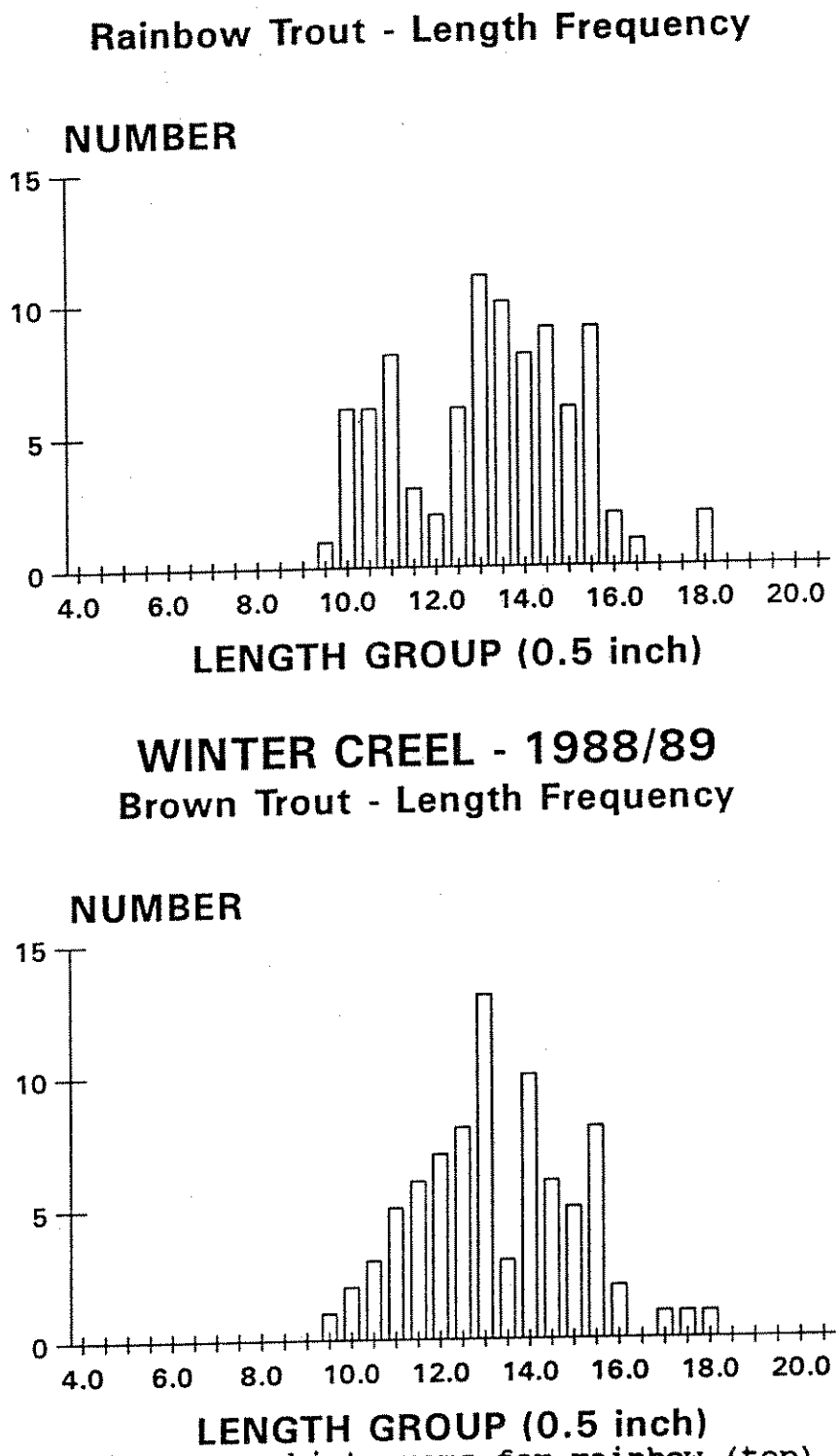


Figure 9. Length frequency histograms for rainbow (top) and brown trout (bottom) captured by anglers from the Yellowstone River during the winter of 1988/89 near Livingston.

of tags. This technique was to be tried in the winter of 1990/91, however due to problems with the sampling boat no sampling could be accomplished. Tagging of trout in this portion of the river will again be attempted during the winter of 1991/92.

Recruitment

Yellowstone Cutthroat Trout Spawners

A total of two adult cutthroat trout were trapped moving upstream and 24 were trapped moving downstream in Cedar Creek from June 25 to July 15, 1991 (Figure 10). One cutthroat/rainbow hybrid and one YOY brown trout were captured in the downstream trap. The two adult cutthroat which were captured moving upstream were captured on July 3 and 4. A 13.3 inch ripe female was captured July 3 and a 10.3 inch ripe male was captured July 4. Cutthroat were first captured in the downstream trap on July 3 and were regularly captured through July 15 (Figure 10). It appears that spawning fish move into Cedar Creek prior to July. Females were slightly smaller than males and the sex ratio was 19 males to 6 females (3.2:1) (Table 16).

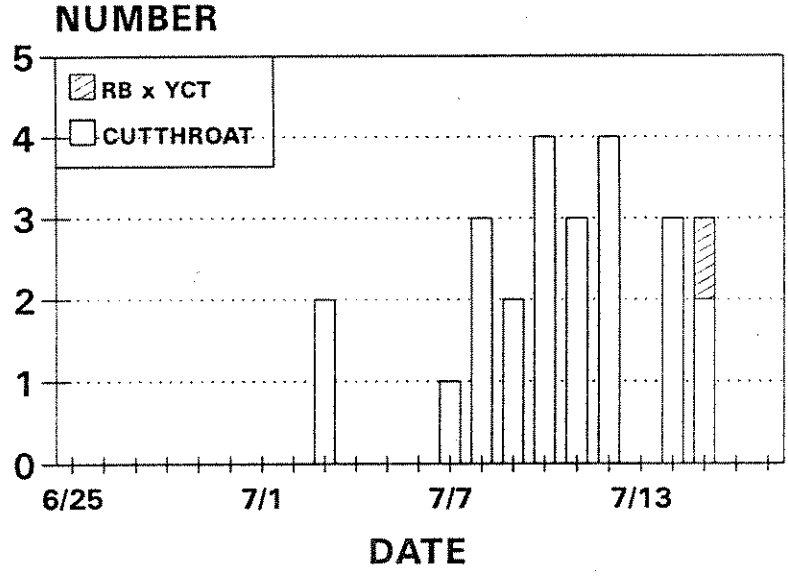


Figure 10. Catch of adult Yellowstone cutthroat and hybrids between cutthroat and rainbow trout in a downstream trap near the mouth of Cedar Creek during 1991.

Table 16. Average lengths and weights and sex ratio (male:female) for adult cutthroat trout captured in up and downstream traps in Cedar Creek during 1991.

Males (n=19)		Females (n=6)		Total (n=26)		Sex ratio
Length	Weight	Length	Weight	Length	Weight	
13.6	0.83	13.2	0.75	13.6	0.84	3.2:1

Rainbow Trout Spawners

A total of 30 rainbow trout were trapped as they moved downstream out of the spring side channel of the Yellowstone River. A total of 22 males and eight females were captured (2.8 males: 1 female). All captured trout were classified as spent. The average length of the males was 16.1 inches (range: 9.8 to 18.4). The average length of the females was 17.1 (range: 14.0 to 23.5). No females were captured after March 16, while 13 males were captured after that date. No fish were captured after March 20. The spawning use of this side channel was extensive during 1990. Only the late portion of this spawning run was sampled, therefore, the total number of rainbow which used this spawning area and the initiation and duration of spawning could not be estimated.

Yellowstone Cutthroat Trout Redd Counts

Cedar Creek

Only June 26, 1991 a redd survey in Cedar Creek from its mouth upstream approximately 3,000 feet to the major irrigation diversion found five redds (Table 17). On July 16, 1992 a survey of this same portion of creek found 34 redds, of which 26 were in the "sure" and "probable" classes. The July 16 survey extended upstream beyond the first major irrigation diversion, but no additional redds were observed. Several adult fish were observed during the July 16 survey indicating that spawning may have still been occurring. Most of the redds were observed in the 1,000 feet of stream channel immediately above the mouth. The trapping results and redd count results verified that most Yellowstone cutthroat trout spawned in Cedar Creek after June 26 during 1992, however, most of the adults probably moved into the creek prior to July. Some spawning may have occurred after July 16. Water temperatures during this time period ranged between 42 and 58 F.

Table 17. Results of cutthroat trout redd surveys conducted in Cedar Creek on June 6, and July 16, 1991.

Date Location (ft above mouth)	Confidence Class			
	Sure	Probable	Possible	Totals
June 26				
0 to 1,000	0	2	0	2
1,000 to 2,000	1	1	0	2
2,000 to 3,000	1	0	0	1
July 16				
0 to 1,000	4	8	3	15
1,000 to 2,000	0	7	4	11
2,000 to 3,000	1	5	2	8

Emigrant Spring Creek

A redd survey done in Emigrant Spring Creek (located on Rich Kinkie's property) on July 26, 1991 found six cutthroat trout redds of which four where in the "sure" and "probable" classes. This result suggests the imprint plants of fertilized cutthroat trout eggs done by Clancy (1987) were probably successful.

Locke Creek

A redd survey conducted on July 22, 1991 in Locke Creek from its mouth up approximately 900 feet to the culvert under Interstate 90 found 13 redds (Table 18). Of these 10 were ranked in the "sure" and "probable" classes.

Table 18. Results of redd survey conducted in Locke Creek on July 22, 1991.

Location (ft above mouth)	Confidence Class			Comments
	Sure	Probable	Possible	
0 to 300	0	2	1	Road at 100'
301 to 600	2	5	1	Road at 586'
601 to 900	0	0	1	

Rainbow Trout Redd Counts

Depuy's Spring Creek

A total of 57 redds were counted on February 26, 1990 in Depuy's Spring Creek (Table 19). Based on the assumption that river fish constructed larger redds than spring creek resident fish, because of their larger size at maturity, 10 large redds were most likely constructed by Yellowstone River spawners and some of the 38 medium size were probably constructed by river spawners. Most spawning by river origin spawners appeared to be located in the lower 2,000 feet of the creek, based on river spawners building a larger redd (Table 19).

Nelson's Spring Creek

A total of 132 redds were counted on February 28, 1990 in Nelson's Spring Creek (Table 19). Of the 132 observed redds, 57 were large and 69 were medium size. Again, most spawning was occurring in the lower 2,000 feet of the spring creek with the highest spawning density observed from 1,000 to 2,000 feet above the mouth (Table 19).

Table 19. Rainbow redd counts made in 1990 on February 26 in DePuy's Spring Creek and February 28 in Nelson's Spring Creeks by confidence class (sure, probable, possible), size class (small: <2 ft diameter; medium: 2 to 4 ft diameter; large: > 4 ft diameter), and relative location in relation to river.

Creek Location (ft above mouth)	Confidence class	Size of redd			
		Small	Medium	Large	Total
Depuy's					
0 to 1,000	Sure	1	8	5	14
	Probable	0	10	0	10
	Possible	0	1	0	1
	Total	1	19	5	25
1,000 to 2,000	Sure	1	6	2	9
	Probable	1	6	2	9
	Possible	0	0	0	0
	Total	2	12	4	18
2,000 to 3,000	Sure	2	2	0	4
	Probable	4	5	0	9
	Possible	0	1	0	1
	Total	6	8	0	14
3,000 to 3,700	Sure	0	0	1	1
	Probable	0	1	0	1
	Possible	0	1	0	1
	Total	0	2	1	3

Table 19. Continued.

Creek Location (ft above mouth)	Confidence class	Size of redd			
		Small	Medium	Large	Total
Nelson's					
0 to 1,000	Sure	1	10	20	31
	Probable	1	15	5	21
	Possible	0	3	0	3
	Total	2	28	25	55
1,000 to 2,000	Sure	1	22	27	50
	Probable	3	16	3	22
	Possible	0	2	0	2
	Total	4	40	30	74
2,000 to 2,200	Sure	0	3	2	5
	Probable	0	3	0	3
	Possible	0	0	0	0
	Total	0	6	2	8

Brown Trout Redd Count

A total of 1,233 redds were counted in the Yellowstone River on November 23, 1991 (Table 20). Eliminating "possible" redd observations from the survey yielded a total of 1,229 redds, or an average of 15 redds per mile of river. Aerial surveys of a 70 mile portion of the South Fork of the Snake River by Idaho Fish and Game personnel in fixed wing aircraft recorded 8.6 to 11.4 redds per mile of river (personal communication, Steve Elle, Idaho Fish and Game, Idaho Falls, Idaho).

High density spawning sites which Clancy (1985 and 1987) found were used again in 1991 (Table 20). These sites included the Livingston side channels (area near Ninth Island), Pine Creek Island channels, Wanigan side channels, main river near Grey Owl

Table 20. Brown trout redd counts in the Yellowstone River from Springdale up to Gardiner observed during a helicopter survey done on November 23, 1991.

River section	Redd class criteria			Total	Redds per mile
	Sure	Probable	Possible		
Springdale to East End access	30	11	3	44	9.8
East End access to Pig Farm access	8	6	3	17	4.3
Pig Farm access to Highway 89 bridge	23	24	2	49	7.8
Highway 89 bridge to Livingston	31	22	2	55	10.6
Livingston to head of Ninth Street Island	34	8	0	42	10.8
Carter's Bridge to Pine Creek bridge	83	18	0	101	14.2
Pine Creek bridge to Mallard's Rest FAS	167	30	0	197	67.9
Mallard's Rest FAS to Mill Creek bridge	61	14	0	75	10.6
Mill Creek bridge to Emigrant bridge	151	23	0	174	27.6
Emigrant bridge to Big Creek	196	16	1	213	27.3
Big Creek to Point of Rocks	52	27	1	80	20.5
Point of Rocks to Joe Brown FAS	15	28	0	43	5.1
Joe Brown FAS to Corwin Springs bridge	31	24	2	57	12.1
Corwin Springs bridge to Gardiner	53	33	0	86	11.8
TOTALS	935	284	14	1,233	15.0

FAS, and side channels near Point of Rocks. The highest density section (almost 68 redds per mile) found in 1991 was between Pine Creek bridge and Mallard's Rest FAS. High density spawning sites observed in 1991 which Clancy had not previously located included the river between Corwin and Gardiner; the Park Branch Canal side channel; and mid-river sites at the upriver boundary of the Nelson property, above Wanigan, near Point of Rocks FAS, and below House Rock in Yankee Jim Canyon. Based on the distribution of redds many spawning brown trout probably move upriver to spawn. Clancy's (1987) tagging studies also found this movement pattern.

Spawning Tributary Electrofishing

Two Yellowstone cutthroat (lengths of 12.8 and 13.3 inches) and one rainbow trout (15.1 inches), all believed to be spawners originating from the Yellowstone River, were captured by electrofishing in Mol Heron Creek immediately upstream from its mouth on June 21, 1990. Fifteen Yellowstone cutthroat trout, all believed to be stream residents, were captured at the CUT bomb shelter complex on the same date. The average length and weight of the fifteen fish captured at the bomb shelter complex were 8.9 inches (range: 6.1 to 11.3) and 0.35 pounds (range: 0.14 to 0.71), respectively. Culverts in the county road which crosses Mol Heron and Cinnabar creeks in Section 25 (T08S:R07E) likely restricted spawning movements of trout upstream in both creeks above Section 25.

Electrofishing documented the presence of spawning cutthroat and rainbow trout in Mol Heron Creek. It appears some spawning fish utilized the creek in 1990 following the diesel and gasoline fuel leaks into the ground and creek at the CUT bomb shelter complex. Electrofishing also documented the presence of cutthroat trout in Mol Heron Creek in the vicinity of the bomb shelter complex. These fish were probably stream residents and appeared in good condition.

Fry Trapping in Tributaries

Trapping of cutthroat trout fry emigrating from Yellowstone River tributaries documented the importance of tributary streams for cutthroat trout recruitment and the variability of fry production between years. Total fry catches, expressed as number of cutthroat trout fry per trap day, illustrated that some tributaries produced relatively high numbers of fry to the river and, in some cases, recruitment was variable between years (Figure 11). Daily trap catches of fry are reported below for each sampled tributary.

YCT FRY TRAP (#/trap day)

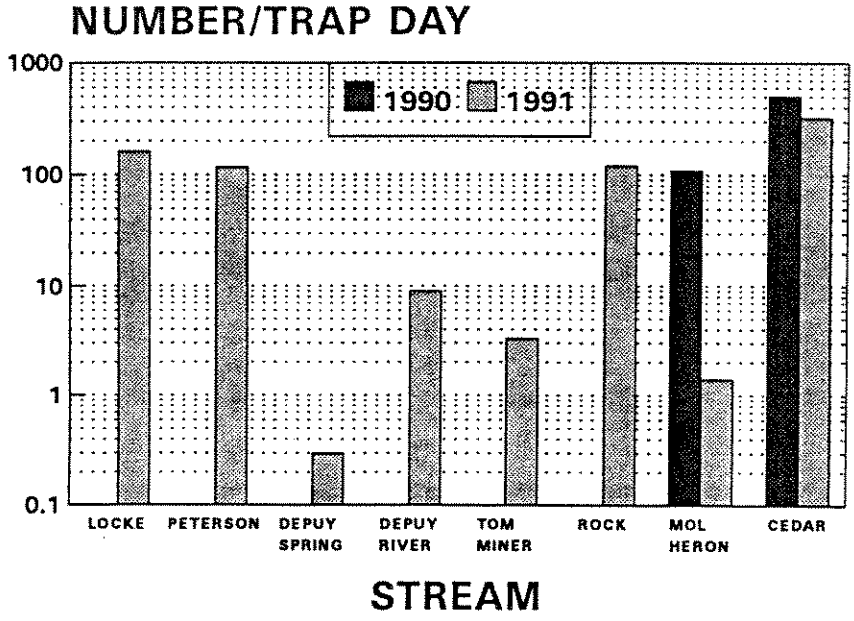


Figure 11. Relative number of cutthroat trout fry, reported as the average number of fry trapped per trap sample day, captured emigrating from tributaries to the Yellowstone River from 1989 to 1991.

Cedar Creek

A total of 5,534 Yellowstone cutthroat trout fry were captured in one fry trap operated 11 nights in Cedar Creek from July 31 to September 13, 1990. The majority of these fry were trapped in late August (Figure 12). This stream is obviously an important spawning tributary for Yellowstone River cutthroat trout. Thirty-two sculpins were also trapped. A total of 2,572 Yellowstone cutthroat fry were trapped in one fry trap during eight nights of trapping between July 29 and August 24, 1991 (Figure 12). Most of these fish were trapped during mid- to late August. Preliminary genetic analyses of a sample of fry emigrating from Cedar Creek in 1991 indicated that the sample fish were approximately 96% Yellowstone cutthroat trout and 4% rainbow trout (personal communication, Robb Leary, U of M Wild Trout and Salmon Genetics Lab). Dr. Leary believed they were at least third generation hybrids.

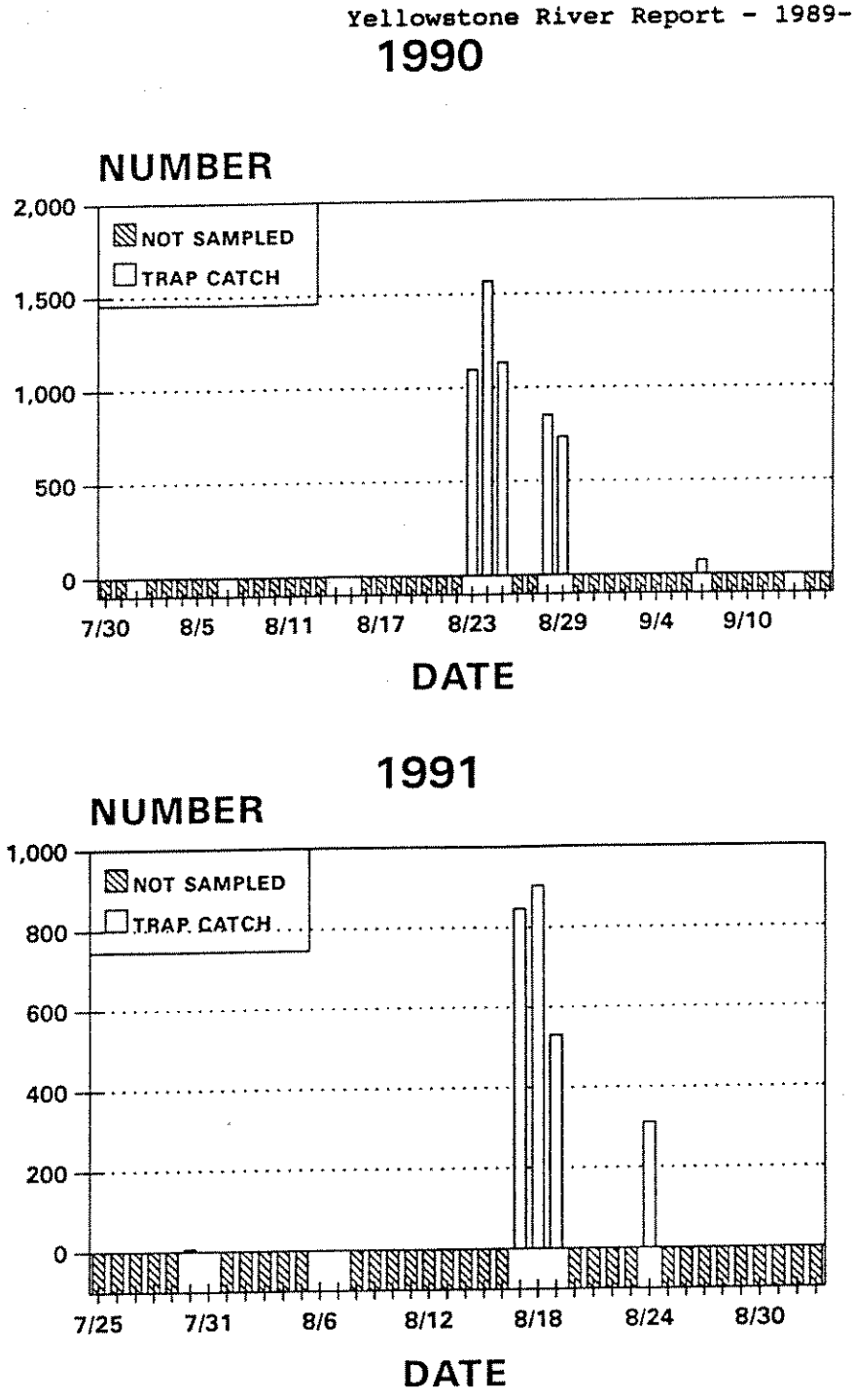


Figure 12. Number of cutthroat fry captured by date in a fry trap set in Cedar Creek during 1990 (top) and 1991 (bottom).

Depuy's Spring Creek

A total of 374 rainbow trout were captured in two fry traps operated during nine nights from May 21 to June 7, 1990. Of these 373 rainbow trout, 363 were fry and 11 were older YOY. Some captured YOY were over 2.0 inches in length, indicating that rainbow trout spawning probably occurred over an extended time period which may start as early as late fall. The peak of rainbow trout fry out-migration documented during trapping occurred in early June (Figure 13), however, fry emigration may have occurred and peaked over a longer and/or earlier time period. Other fish trapped included one brown trout just over two inches in length, six suckers, six longnose dace, and two sculpins.

A total of eight trout fry believed to be Yellowstone cutthroat trout were captured in one fry trap operated from August 7 to August 29, 1990. All were captured in late August. Three sculpins, seven sucker or mountain whitefish fry, and one YOY rainbow trout were also captured.

A total of eight rainbow and one Yellowstone cutthroat trout fry were captured during four nights of fry trapping between July 22 and August 4, 1991 (Figure 13). Three sucker fry were also trapped.

Depuy River Channel

A total of one brown trout, 17 rainbow, 46 Yellowstone cutthroat, and six unidentified fry were captured in one fry trap operated during five nights from July 22 to September 6, 1991 in the river side channel adjacent to Depuy's Spring Creek (Figure 14). This side channel receives water from Depuy's Spring Creek near its head. Most of the fry were trapped in early August.

Emigrant Spring Creek

A total of 78 Yellowstone cutthroat fry, two rainbow YOY, and two brown trout YOY were captured in a fry trap operated for four nights from July 29 to August 18, 1991 (Figure 15). This result indicated that the stream rehabilitation and imprint planting of wild Yellowstone cutthroat trout embryos by Clancy and Trout Unlimited may have been somewhat successful (Clancy 1987). Preliminary genetic analyses of a sample of fry emigrating from Emigrant Spring Creek indicated that of six sample fish, five were pure Yellowstone cutthroat trout and one was a pure rainbow trout (personal communication, Robb Leary, U of M Wild Trout and Salmon Genetics Lab).

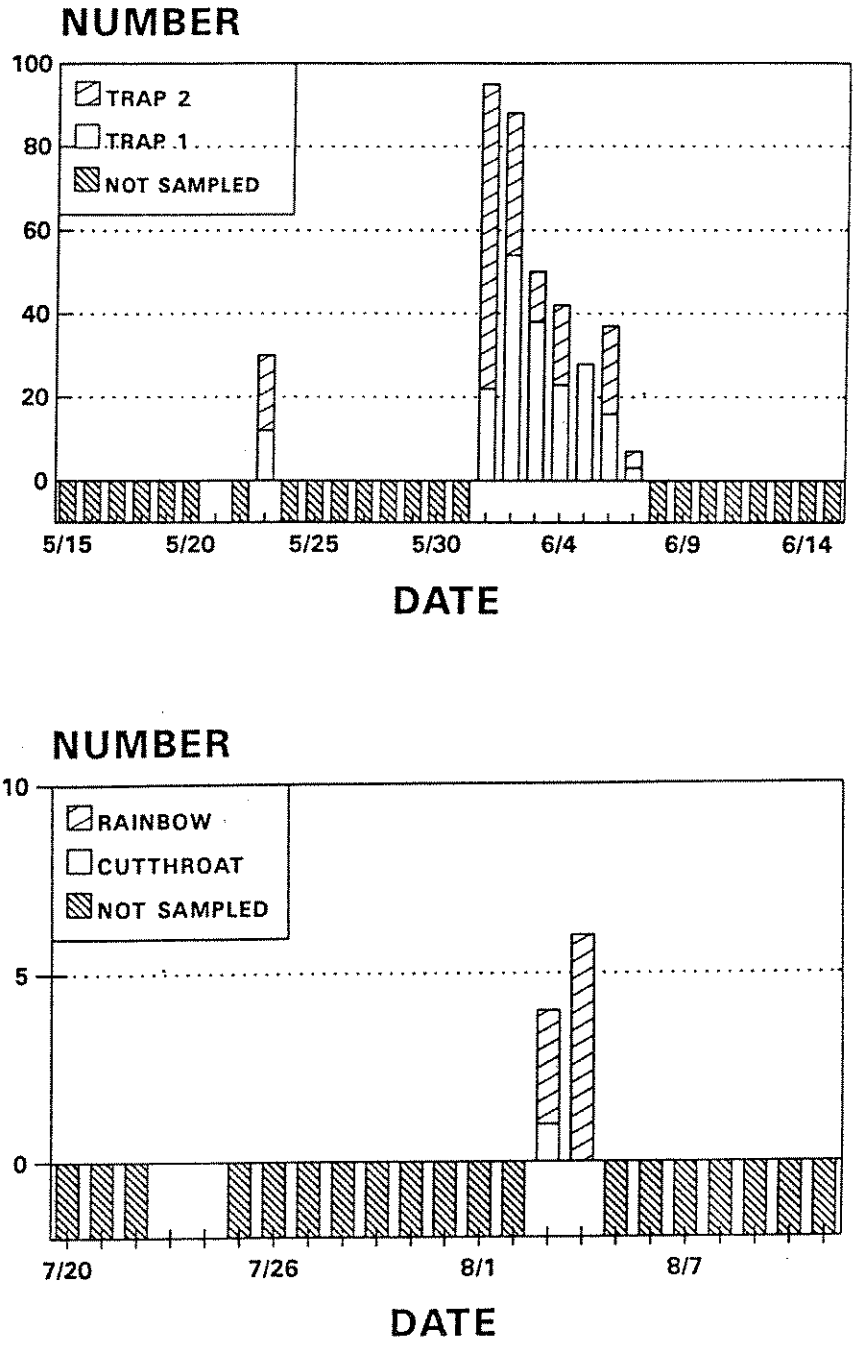


Figure 13. Number of rainbow and cutthroat trout fry captured by date in Depuy's Spring Creek during 1990 (top) and 1991 (bottom).

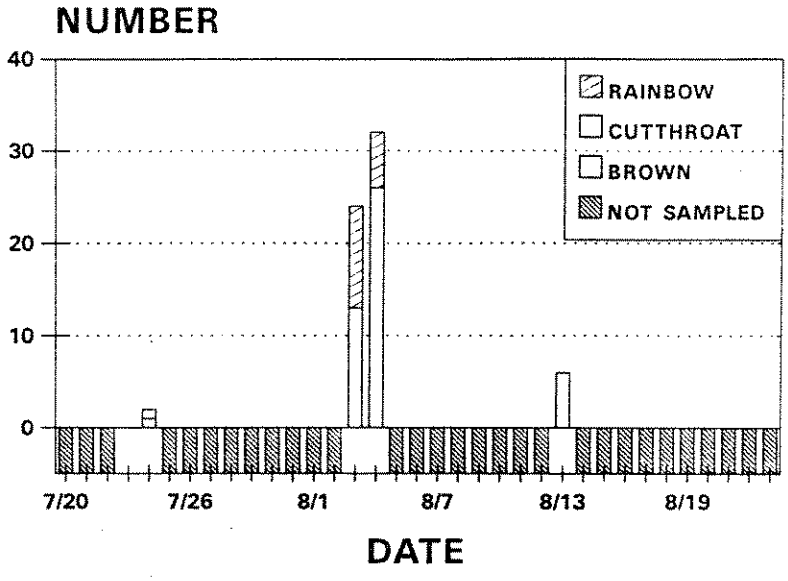


Figure 14. Number of rainbow, brown, and cutthroat trout fry captured by date in the Depuy River channel during 1991.

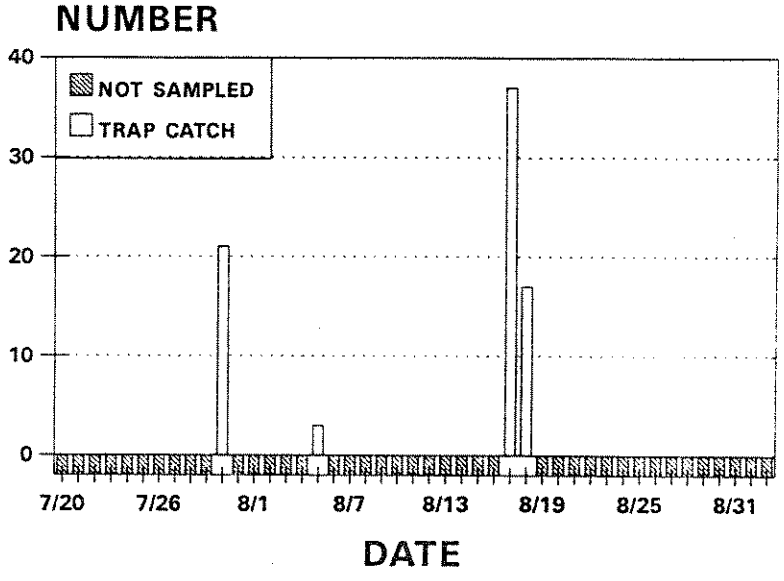


Figure 15. Number of rainbow, brown, and cutthroat trout fry captured in Emigrant Spring Creek during 1991.

Locke Creek

A total of 972 Yellowstone cutthroat fry were trapped in one fry trap during six nights of trapping between July 22 and August 13, 1991 (Figure 16). Most of these fish were trapped from late July to early August. It may be that some cutthroat fry moved out of Locke Creek prior to July 22, when the fry trap was first operated in the creek. Preliminary genetic analyses of a sample of fry emigrating from Locke Creek indicated that the sampled fish were approximately 98% Yellowstone cutthroat trout and 2% rainbow trout (personal communication, Robb Leary, U of M Wild Trout and Salmon Genetics Lab). Dr. Leary indicated that these fish were not first generation hybrids. He believed they were at least third generation hybrids.

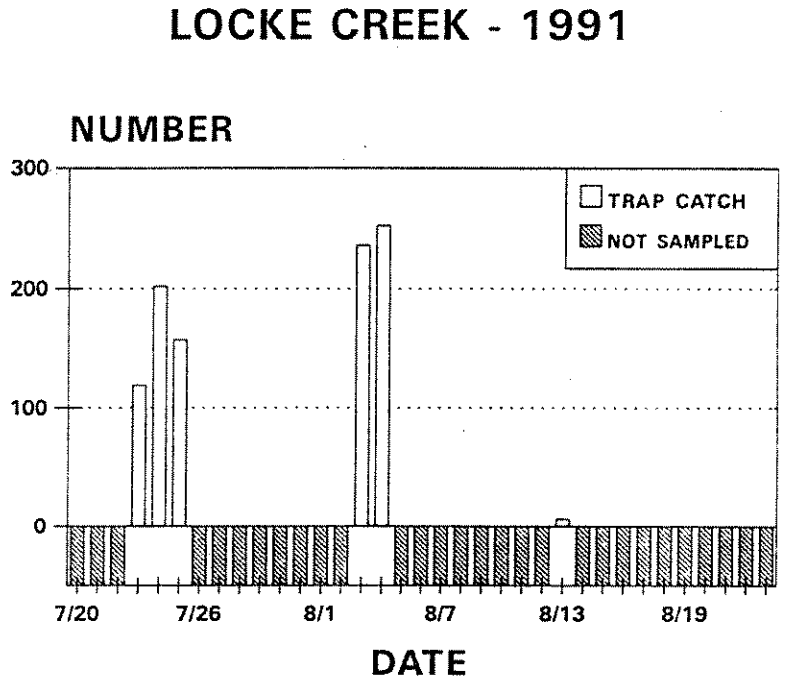


Figure 16. Number of cutthroat fry captured by date in Locke Creek during 1991.

Mol Heron Creek

A total of 1,199 Yellowstone cutthroat trout fry were captured in one fry trap operated during eleven nights in Mol Heron Creek from July 31 to September 13, 1990. The majority of these fry were captured in mid- to late August (Figure 17). Four YOY and yearling brown trout and 13 sculpins were also captured. Only 11 Yellowstone cutthroat trout fry were captured in a fry trap in Mol Heron Creek operated during eight nights between July 29 and August 24, 1991 (Figure 17). An intense thunderstorm hit the Mol Heron and Cinnabar drainages during July 25, 1991. This thunderstorm caused numerous mud and debris slides in the drainage and resulted in extremely high streamflow which carried high sediment and debris loads down the stream channel. It is likely that this event caused extremely high embryo mortality within the Mol Heron drainage and resulted in little to no recruitment of cutthroat trout from this drainage in 1991. Estimates of age II cutthroat trout in the Corwin Section during 1993 may reflect this poor recruitment from Mol Heron Creek.

Peterson Creek

A total of 821 Yellowstone cutthroat fry were trapped in one fry trap during seven nights between July 22 and September 16, 1991 (Figure 18). Most of these fish were trapped during early August. During 1991 cutthroat trout emerged and emigrated from Peterson Creek over an extended time period, compared to other streams sampled. Preliminary results from genetic analyses of a sample of fry emigrating from Peterson Creek indicated that the sample fish were approximately 77% Yellowstone cutthroat trout and 23% rainbow trout (personal communication, Robb Leary, U of M Wild Trout and Salmon Genetics Lab). Robb Leary indicated that these fish were not first generation hybrids. He believed they were at least third generation hybrids.

Rock Creek

A total of 603 Yellowstone cutthroat fry were trapped in one fry trap during five nights of trapping between July 29 and August 17, 1991 in Rock Creek (Figure 19). Most of these fish were trapped on August 17. The trap was taken out on that date because high water velocities through the trap were causing high fry mortalities in the trap. This trap was operated above the concrete railroad culvert and trap results indicate that cutthroat trout were successful in moving above this culvert in 1991, documenting the success of the fish passage ladder installed by the Yellowstone Fly Fishers.

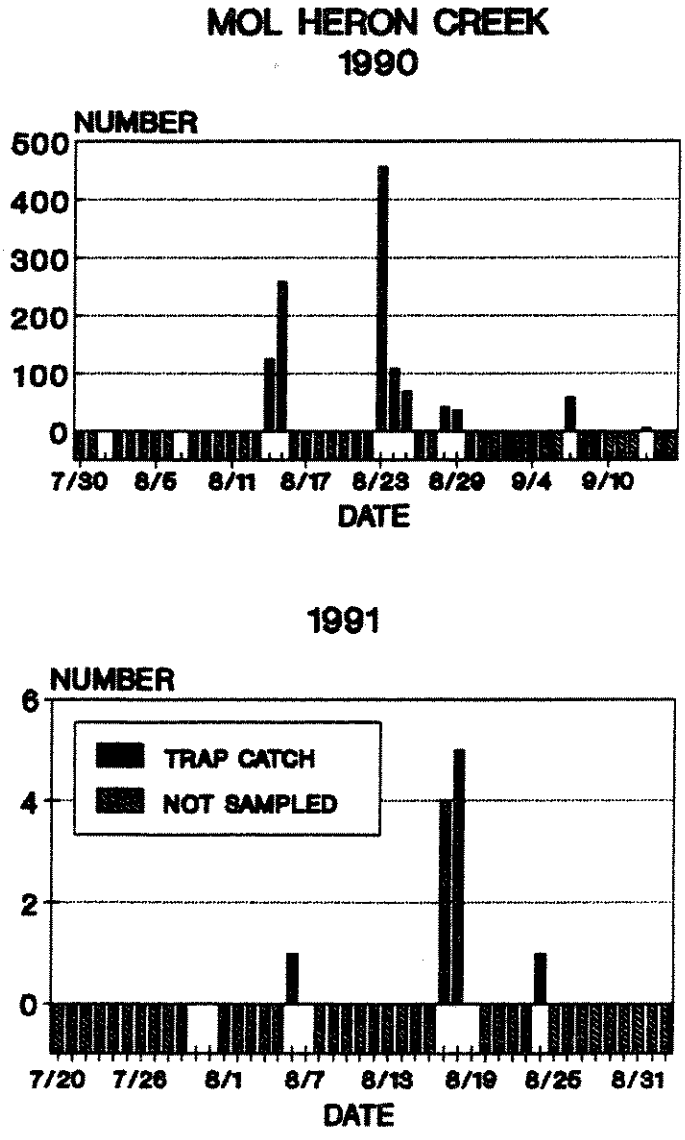


Figure 17. Number of cutthroat fry captured by day in Mol Heron Creek during 1990 (top) and 1991 (bottom).

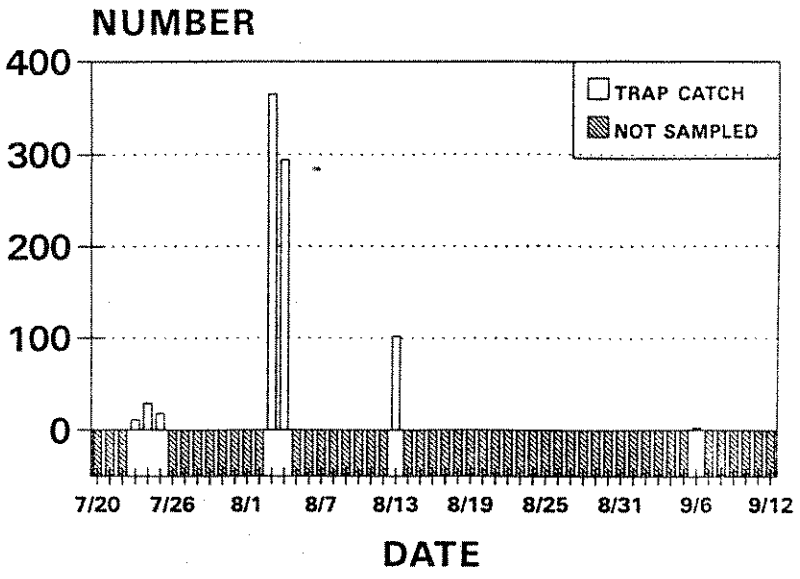


Figure 18. Number of cutthroat fry captured by date in Peterson Creek during 1991.

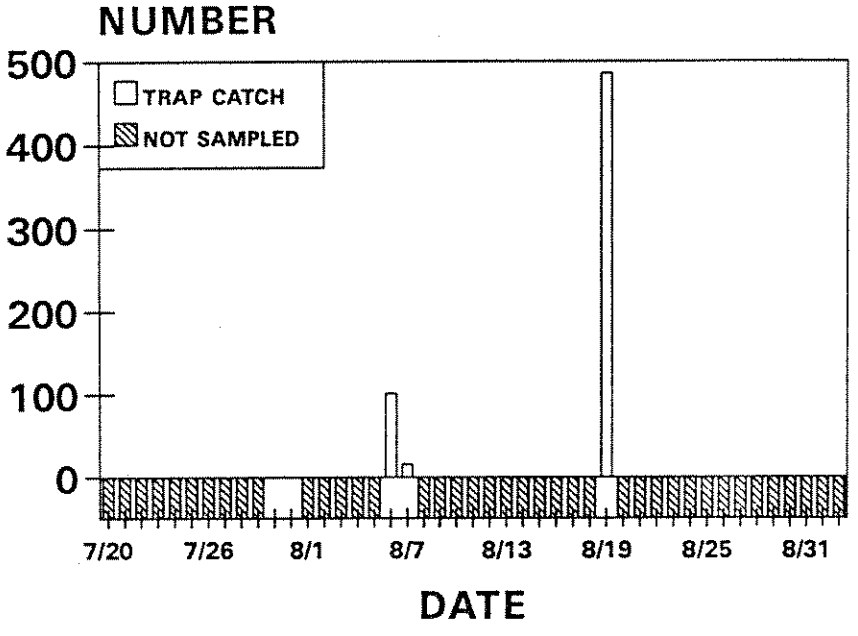


Figure 19. Number of cutthroat fry captured by date in Rock Creek during 1991.

Tom Miner Creek

A total of 10 cutthroat trout fry were captured in a trap operated in Tom Miner Creek from July 29 to August 8 when the trap was stolen. All 10 fry were captured on August 7.

Mill Creek Spawning Habitat Survey

Over 9,000 square feet of spawning habitat was observed in the lower 1.5 miles of Mill Creek. The majority of this spawning habitat was located within the lower 0.5 mile segment from the mouth upstream (Table 21). Most spawning habitat was observed along the edges of the stream channel indicating that much of the spawning habitat would be de-watered at moderate streamflow. However, a significant amount of spawning habitat (over 1,300 square feet) would be covered by water even at low streamflow, provided spawning fish could access the area 7,500 to 9,000 feet above the mouth. Over 300 square feet would be available in the lower 1,500 feet of Mill Creek at lower flow.

Migration Barrier Modifications

Culverts in Mol Heron, Cinnabar, and Rock creeks were modified to enhance upstream fish passage by retro-fitting them with fish ladders. A cursory assessment of fish movement past the Rock Creek culvert in 1991 found that Yellowstone cutthroat fry were indeed produced above the culvert. It is unknown whether cutthroat fry were produced above this culvert prior to 1991.

The ladders within the Mol Heron drainage were not directly assessed for their effectiveness by placing fry traps above the ladders. During the installation of the ladder in the Cinnabar culvert, the culvert was found to have been broken in the center with the floor of the downstream portion of the culvert approximately one to two feet below the floor of the upstream portion. The ladder did not fit along the floor of the culvert across this break resulting in two of the ladder's rungs being one to two feet above the floor of the culvert. This ladder had to be removed in 1991 due to the intense thunderstorm, discussed above, causing debris and mud flow into Cinnabar Creek which threatened to plug the culvert and potentially wash out the road. The suspended ladder rungs caught debris entering the culvert. If this ladder is to be replaced it would need to be re-constructed on-site to fit exactly within the culvert.

Table 21. Estimated surface area of spawning habitat (square feet) located in the lower 1.7 mile portion of Mill Creek stratified by location within the stream channel based on a survey conducted on October 24, 1990.

Distance above mouth (ft)	Square feet of spawning habitat		
	Edges	Mid-edges	Thalweg
0 to 1,500	2,500 +[1]/	800 +[1]/	300 +[1]/
1,500 to 3,000	3,000 +[2]/	6	1
3,000 to 4,500	300 +[1]/	0	0
4,500 to 6,000	200 +[1]/	150	190
6,000 to 7,500	265	110	0
7,500 to 9,000	50	8	800
Total	6,315 +[1]/	1,074 +[1]/	1,291 +[1]/

[1]/ When a "+" sign appears it means that there was either hundreds or thousands of square feet.

[2]/ Thousands of square feet were observed between 1,500 and 1,800 feet above the mouth.

ACKNOWLEDGEMENTS

Chris Clancy was the fisheries biologist during 1988 and 1989 and all pre-1990 data was collected under his direction. Bob Wiltshire was the field technician during all of this study. Gary Senger and Yancy Sutter were also field workers with MDFWP during the study. Their assistance in the field and office was appreciated. Scot Shuler of the Gallatin National Forest assisted with cutthroat fry trapping during 1991. Bob McFarland assisted with data entry and analyses. Dick Vincent, Regional Fisheries Manager, provided valuable comments on an early draft of this report. Bob Auger, stream keeper on Depuy's Spring Creek, and Bill Dana and Edwin Nelson, landowners along Nelson's Spring Creek, graciously allowed access to their spring creeks to monitor redds and fry emigration. The Yellowstone Fly Fishers and Joe Brooks Chapter of Trout Unlimited provided assistance installing fish ladders in Rock Creek, Mol Heron Creek, and Cinnabar Creek culverts. The Park County Road Crew built and installed the fish ladders in the Mol Heron and Cinnabar Creek culverts.

WATER CODES

Water name	Code
Armstrong's (Depuy's) Spring	22-0140
Cedar Creek	22-1078
Cinnabar Creek	22-1134
Emigrant Spring Creek	22-2368
Locke Creek	22-3775
Mill Creek	22-4172
Mol Heron Creek	22-4270
Nelson's Spring Creek	22-4305
Peterson Creek	22-4620
Rock Creek	22-4984
Yellowstone River (Sec 07B)	22-7058
Yellowstone River (Sec 08)	22-7071 and 22-7072
Yellowstone River (Sec 09)	22-7084

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APPENDIX A

Length frequency histograms for
brown, rainbow, and cutthroat trout
and mountain whitefish captured
in the Yellowstone River from 1989 to 1991.

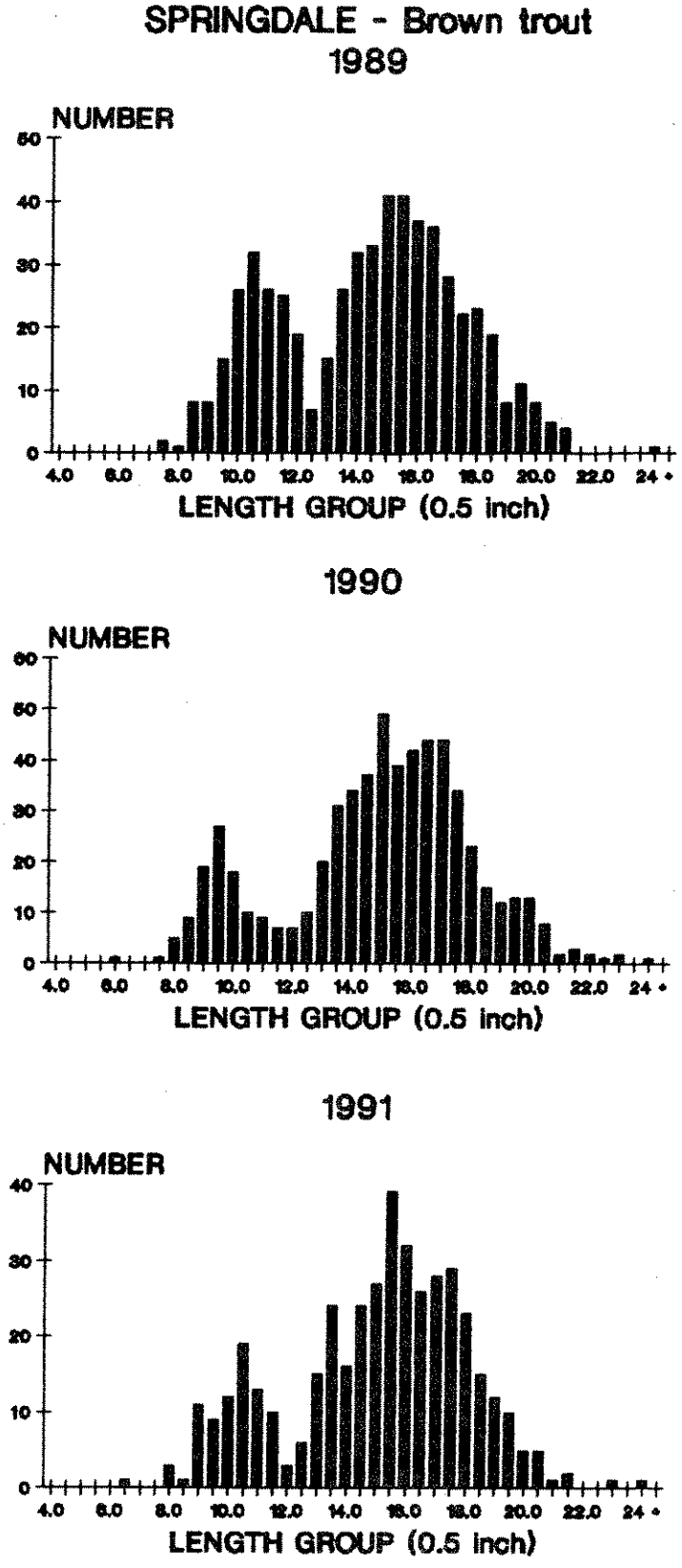


Figure A1. Length frequency histograms for brown trout captured in the Springdale Section during 1989, 1990, and 1991.

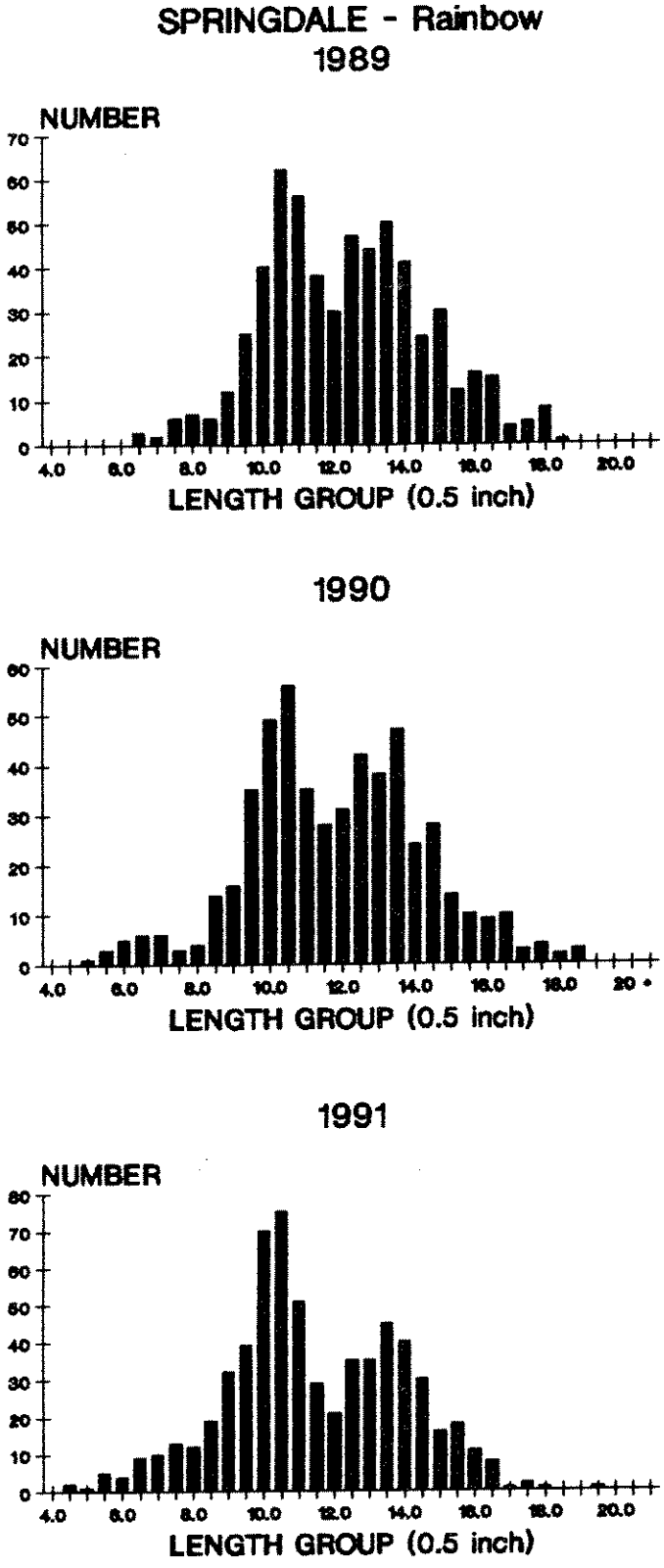


Figure A2. Length frequency histograms for rainbow trout captured in the Springdale Section during 1989, 1990, and 1991.

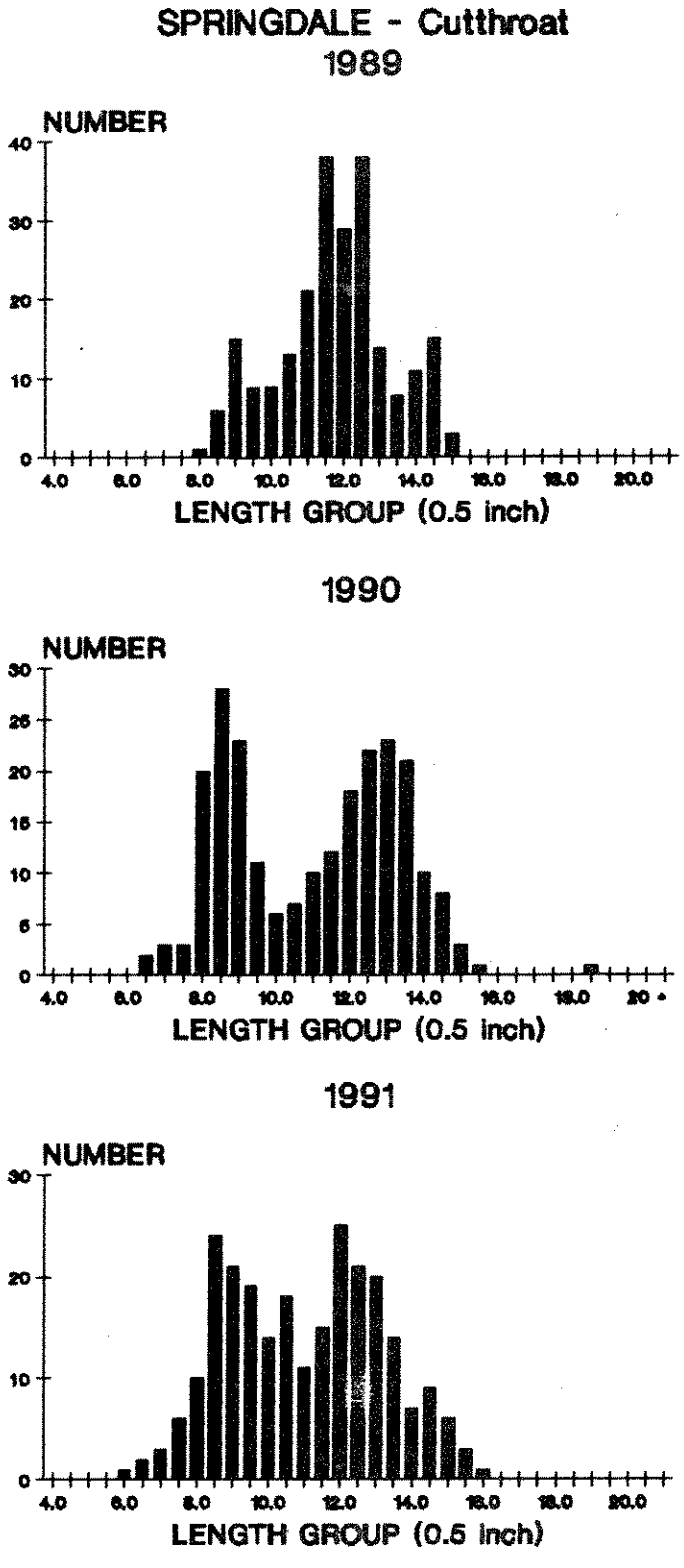


Figure A3. Length frequency histograms for Yellowstone cutthroat trout captured in the Springdale Section during 1989, 1990, and 1991.

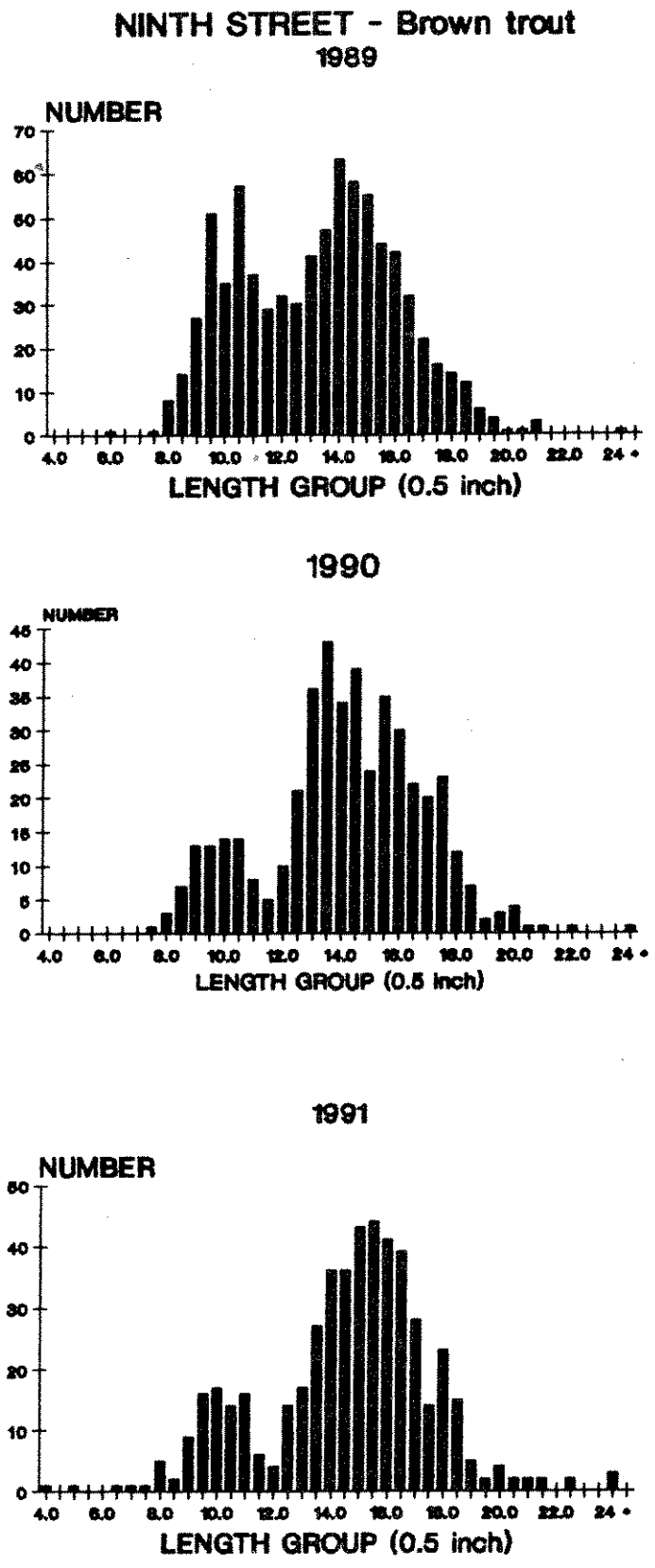


Figure A5. Length frequency histograms for brown trout captured in the Ninth Street Section during 1989, 1990, and 1991.

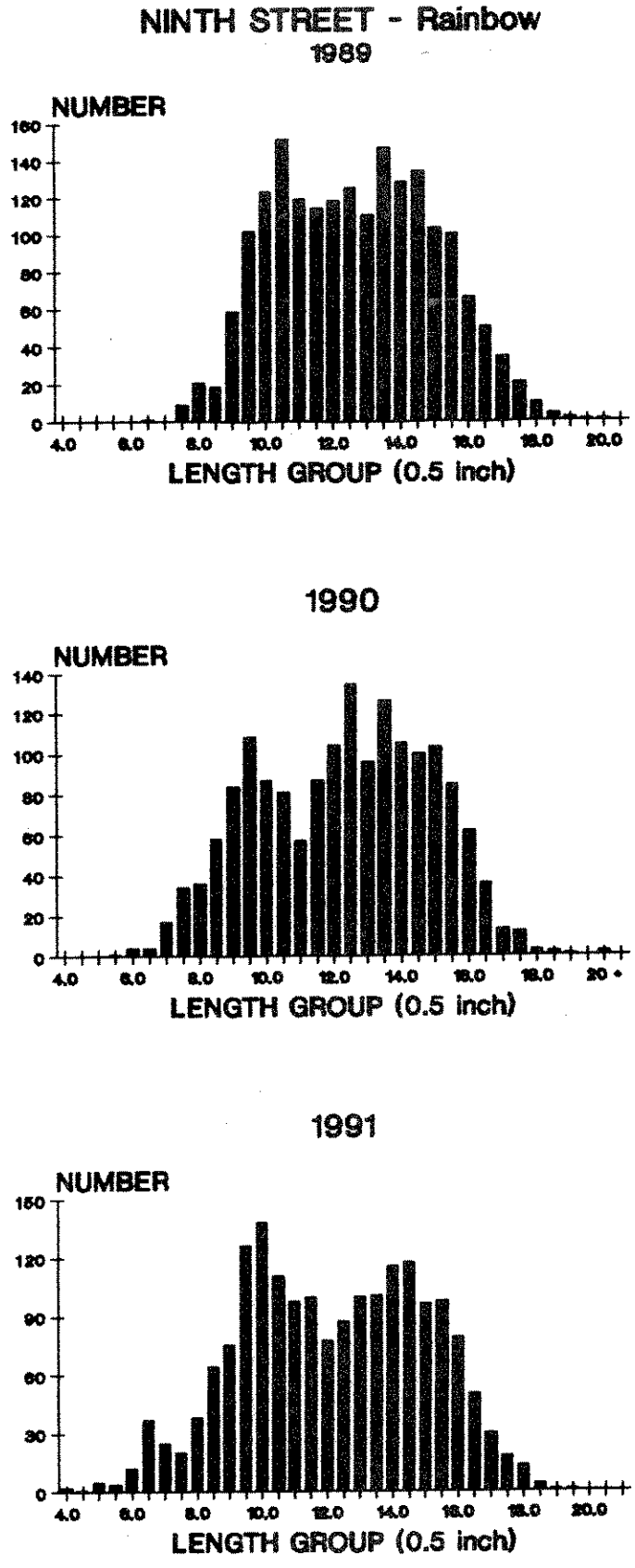


Figure A5. Length frequency histograms for rainbow trout captured in the Ninth Street Section during 1989, 1990, and 1991.

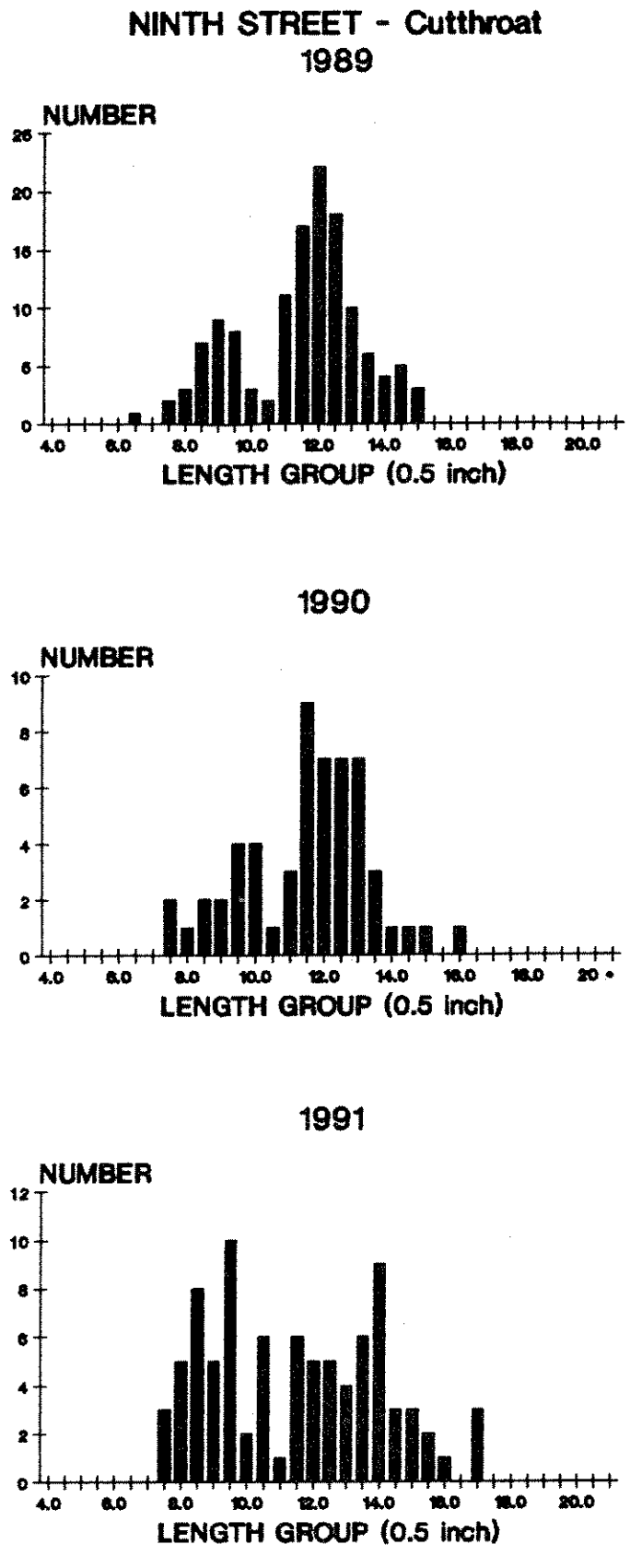


Figure A6. Length frequency histograms for Yellowstone cutthroat trout captured in the Ninth Street Section during 1989, 1990, and 1991.

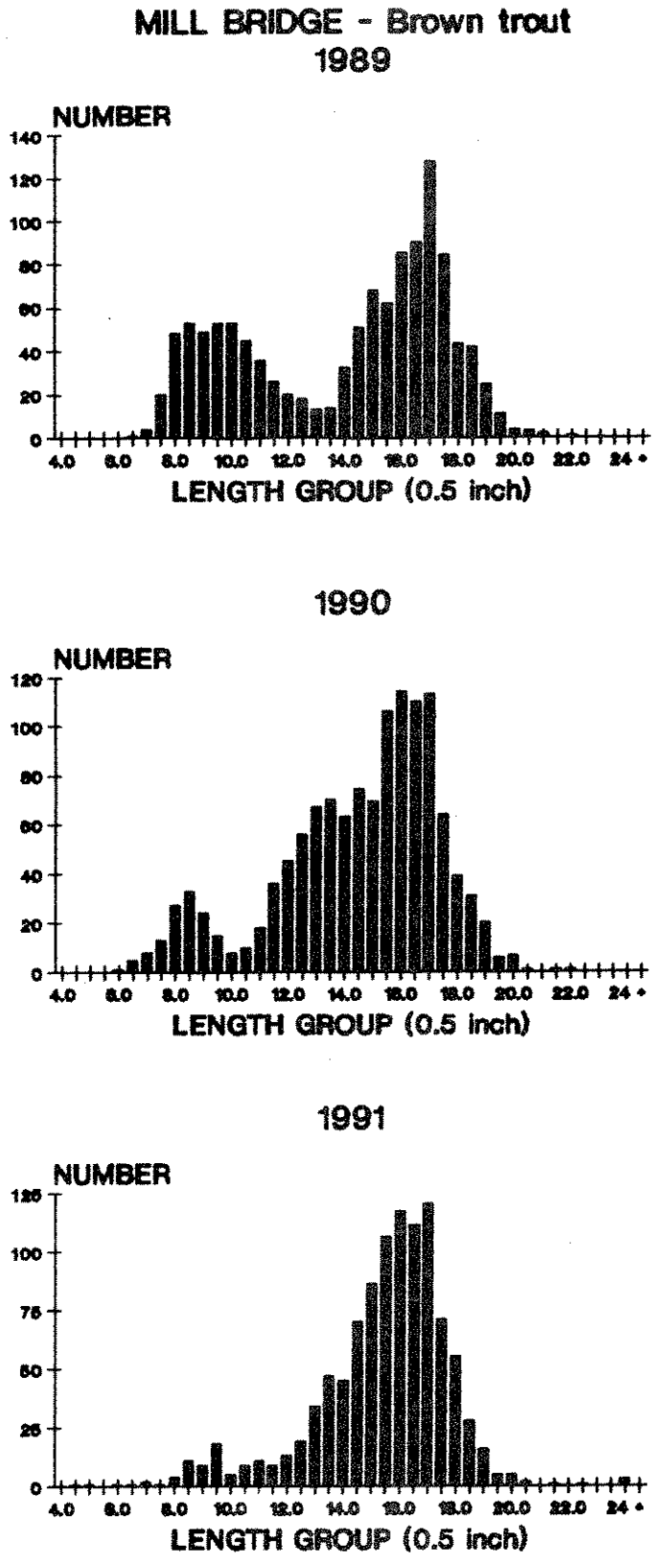


Figure A7. Length frequency histograms for brown trout captured in the Mill Creek Section during 1989, 1990, and 1991.

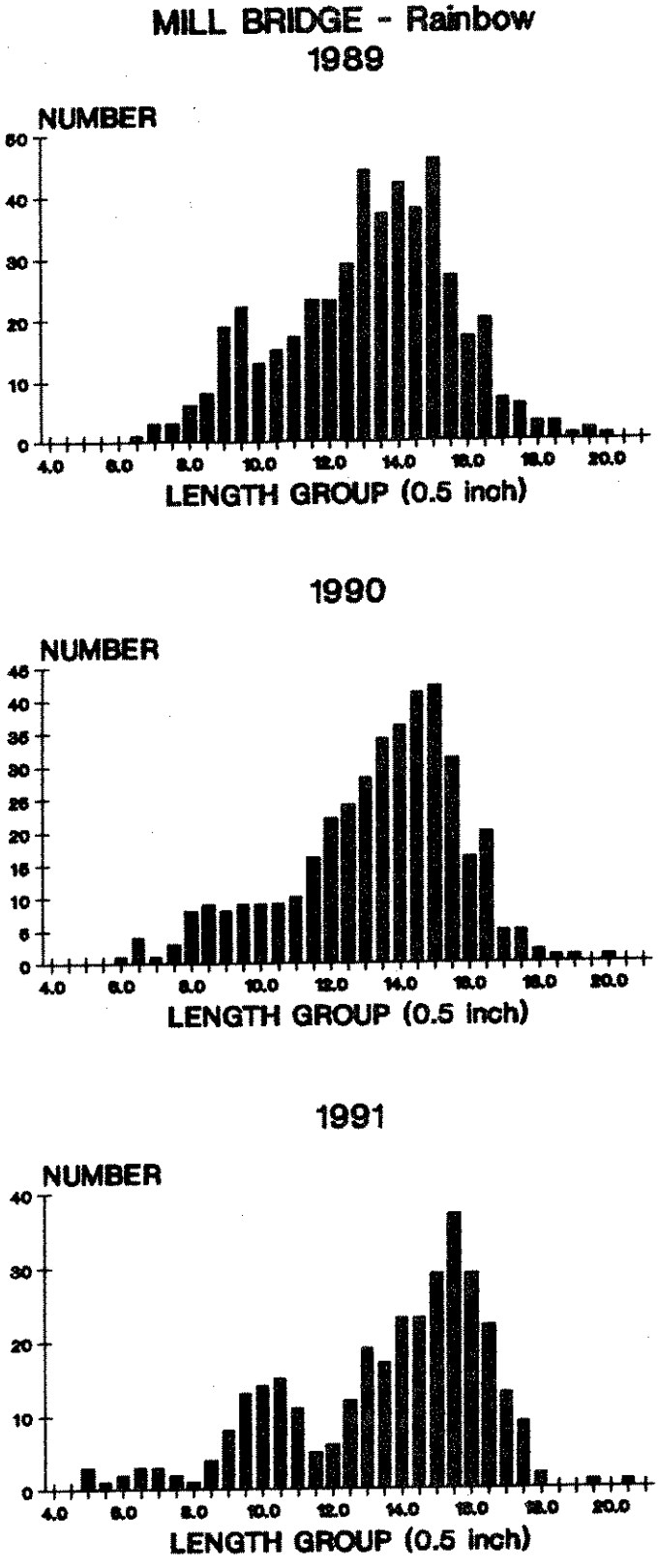


Figure A8. Length frequency histograms for rainbow trout captured in the Mill Creek Section during 1989, 1990, and 1991.

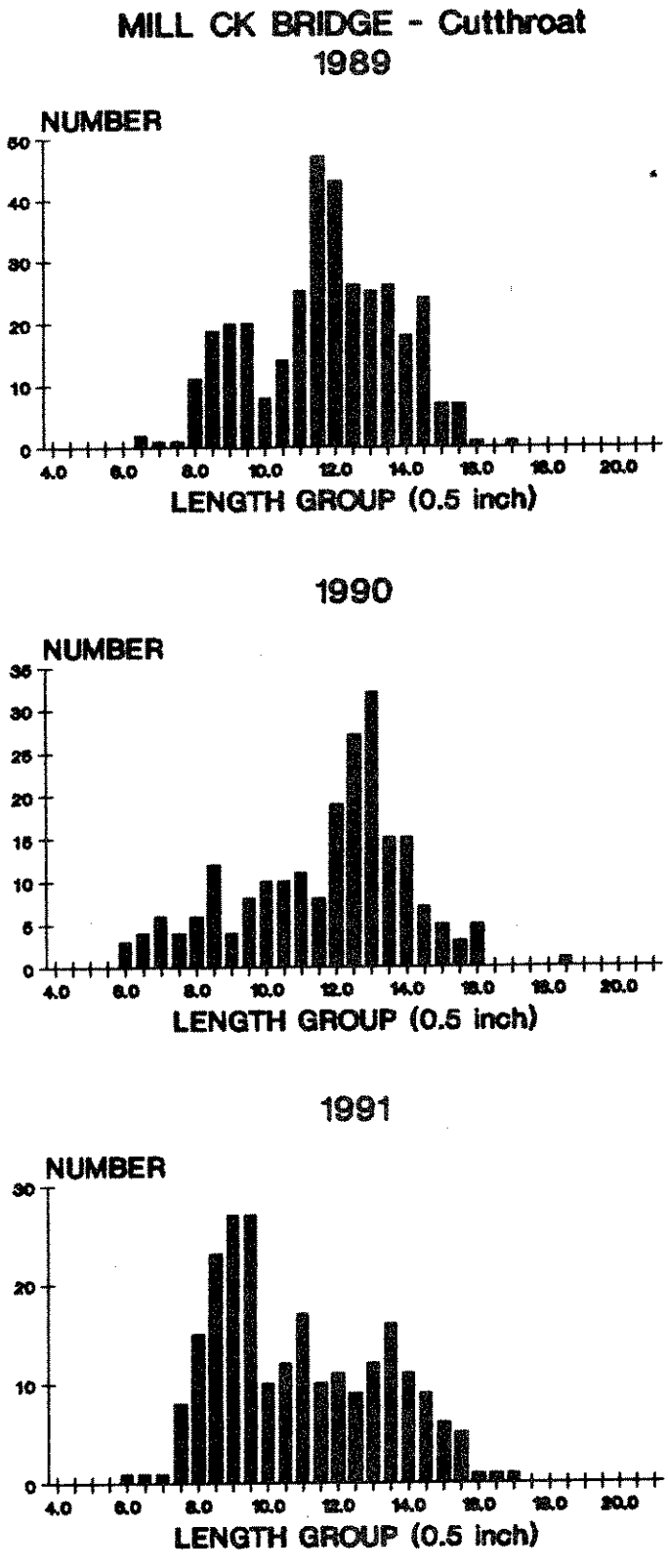
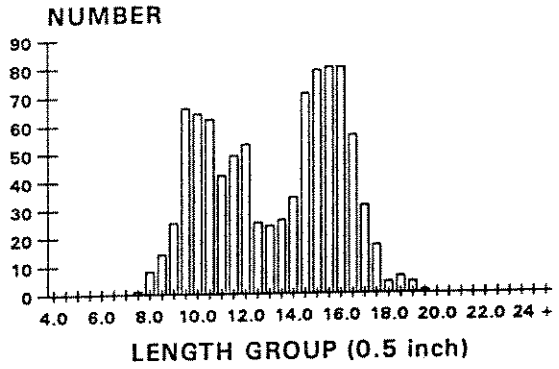
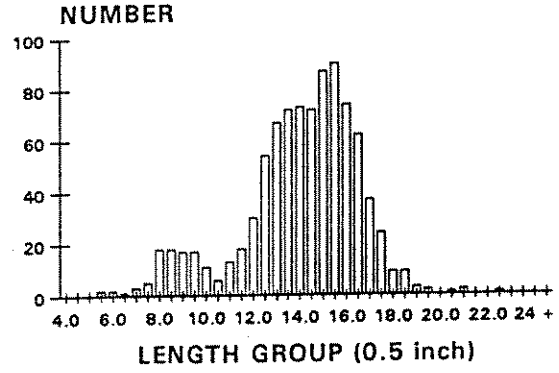


Figure A9. Length frequency histograms for Yellowstone cutthroat trout captured in the Mill Creek Section during 1989, 1990, and 1991.

CORWIN - Brown trout
1989



1990



1991

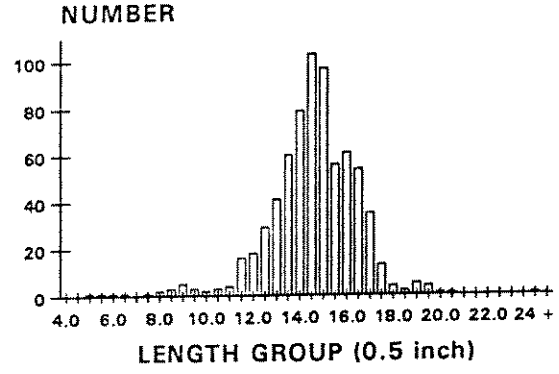
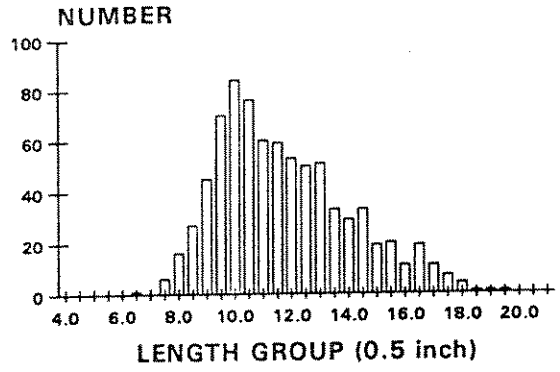
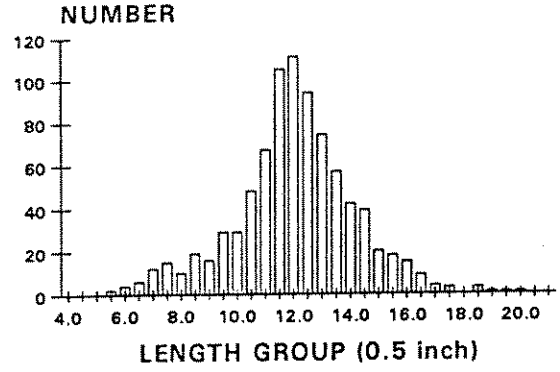


Figure A10. Length frequency histograms for brown trout captured in the Corwin Section during 1989, 1990, and 1991.

CORWIN - Rainbow
1989



1990



1991

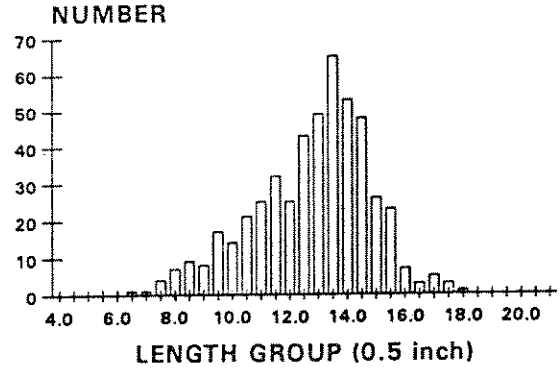


Figure A11. Length frequency histograms for rainbow trout captured in the Corwin Section during 1989, 1990, and 1991.

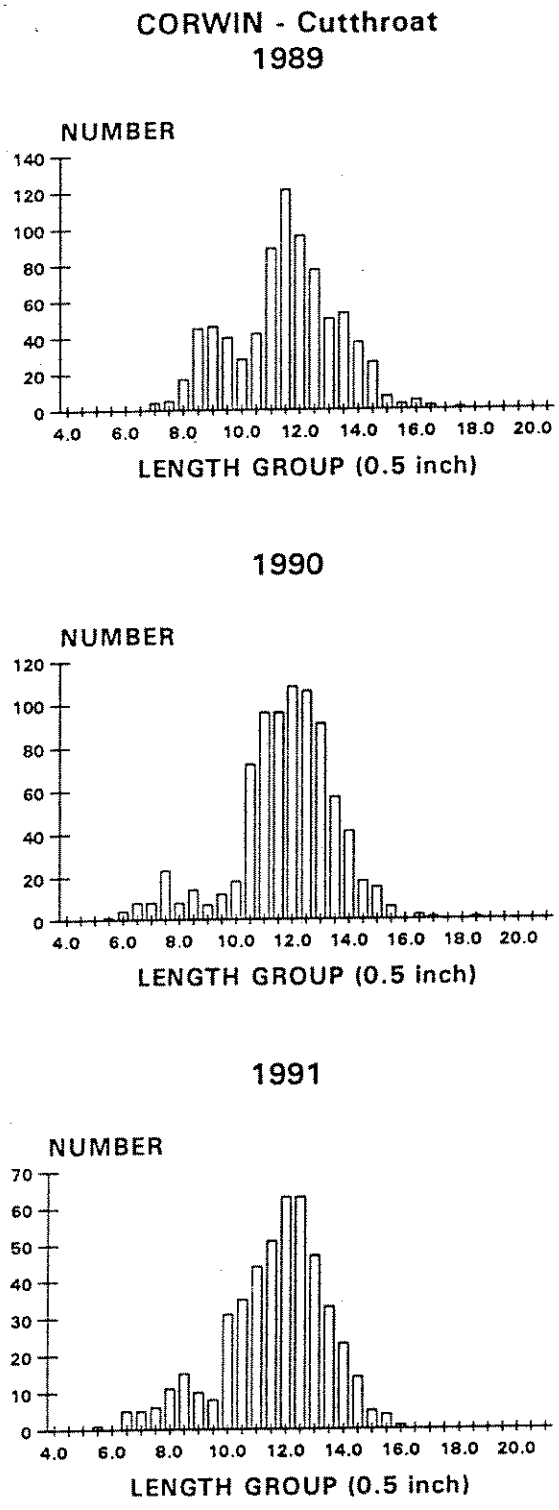


Figure A12. Length frequency histograms for Yellowstone cutthroat trout captured in the Corwin Section during 1989, 1990, and 1991.

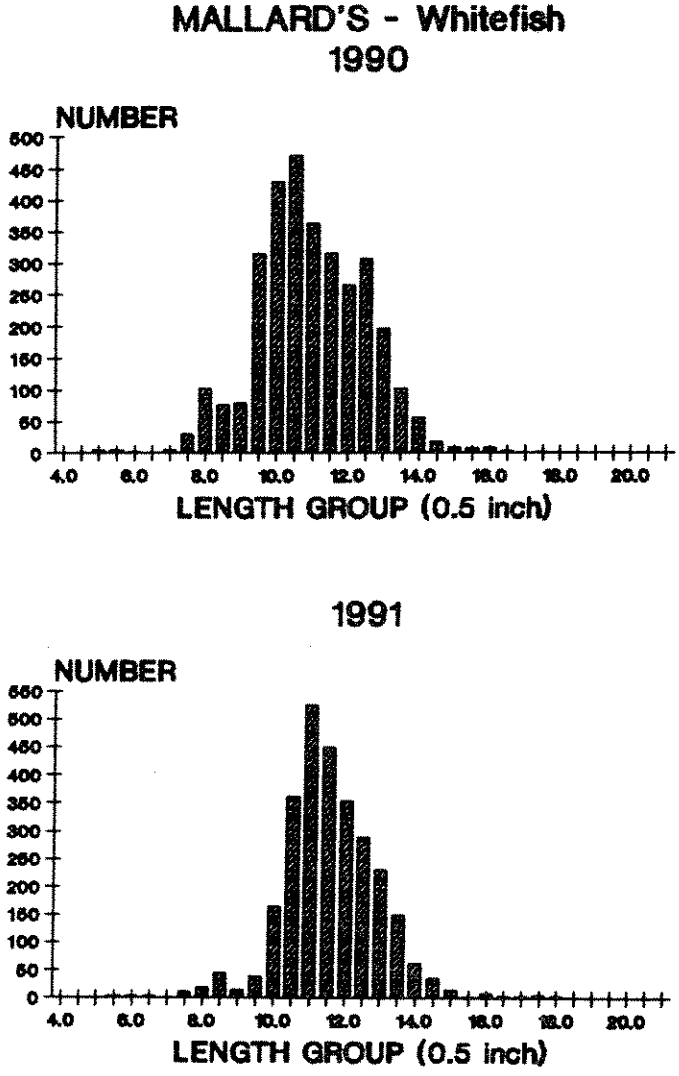


Figure A13. Length frequency histograms for mountain whitefish captured in the Mallard's Rest Section during 1990 and 1991.

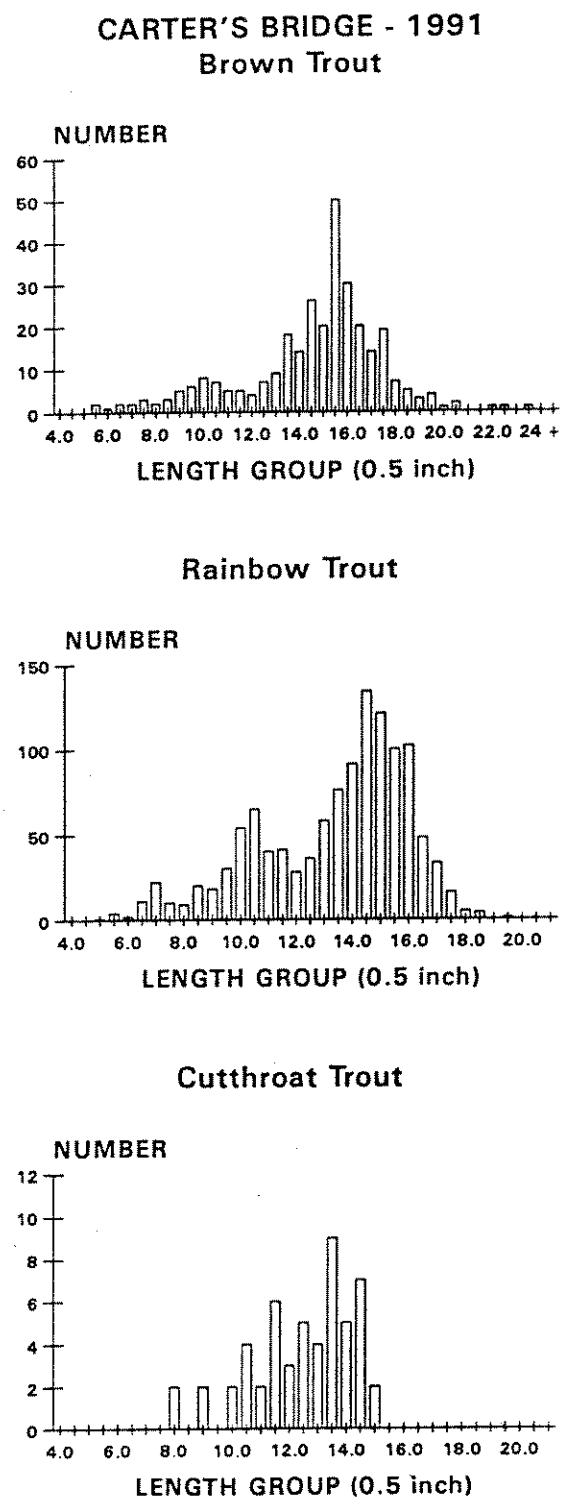


Figure A14. Length frequency histograms for brown, rainbow, and Yellowstone cutthroat trout captured in the Carter's Bridge Section during 1991.

APPENDIX B

Summary of Montana Statewide Angling Pressure Mail Survey Results for Sections 07, 08, and 09 Yellowstone River 1984 to 1991

Appendix B1. Angling pressure (trips) estimated for different sections of the Yellowstone River from the Montana statewide angling pressure mail survey for 1982 to 1985, 1989, and 1991. Standard errors for each estimate in parentheses. The 1991 data is preliminary.

WATER: YELLOWSTONE RIVER SEC 07 WATER CODE: 227056

Year	Pressure (SE)			Trips Surveyed			Rankings	
	Total	Resident	Non-res	Total	Resident	Non-res	State	Reg
1982	11590 (3135)	9752 (2682)	1838 (1624)	82	74	8	45	10
1983	6520 (1849)	6315 (1842)	205 (153)	28	25	3	81	14
1984	2231 (1581)	2231 (1581)	0 (0)	4	4	0	165	22
1985	-	-	-	-	-	-	-	-
1989	330 (201)	204 (157)	126 (126)	6		2	491	59

WATER: YELLOWSTONE RIVER SEC 07A WATER CODE: 227057

Year	Pressure (SE)			Trips Surveyed			Rankings	
	Total	Resident	Non-res	Total	Resident	Non-res	State	Reg
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	4579 (1588)	3983 (1568)	596 (255)	20	13	7	100	15
1985	4697 (1759)	4560 (1757)	137 (97)	23	21	2	97	14
1989	493 (185)	457 (182)	36 (36)	10	21	1	374	48
1991	4967 (921)	4269 (904)	698 (177)	150	123	27		

Appendix B1. Continued.

WATER: YELLOWSTONE RIVER SEC 07B WATER CODE: 227058

Year	Pressure (SE) Total	Pressure (SE) Resident	Pressure (SE) Non-res	Trips Surveyed Total	Trips Surveyed Resident	Trips Surveyed Non-res	Rankings State	Rankings Reg
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	9114 (2575)	8773 (2569)	341 (170)	30	26	4	53	15
1985	5659 (1451)	4711 (1384)	948 (437)	42	27	15	82	22
1989	4935 (1142)	3774 (1070)	1161 (399)	95	27	25	88	26
1991	5750 (1001)	5308 (994)	442 (121)	161	142	19		

WATER: YELLOWSTONE RIVER SEC 08 WATER CODE: 227070

Year	Pressure (SE) Total	Pressure (SE) Resident	Pressure (SE) Non-res	Trips Surveyed Total	Trips Surveyed Resident	Trips Surveyed Non-res	Rankings State	Rankings Reg
1982	44001 (6356)	38366 (6160)	5635 (1565)	285	257	28	8	5
1983	31903 (5383)	23620 (5181)	8283 (1458)	227	111	116	14	6
1984	-	-	-	-	-	-	-	-
1985	4394 (2058)	2987 (1750)	1407 (1083)	17	9	8	105	28
1989	188 (136)	74 (74)	114 (114)	3	9	2	711	146

Appendix B1. Continued.

WATER: YELLOWSTONE RIVER SEC 08A WATER CODE: 227071

Year	Pressure (SE) Total	Resident	Non-res	Trips Surveyed Total	Resident	Non-res	Rankings State	Reg
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	17955 (3595)	13661 (3430)	4294 (1076)	83	39	44	28	11
1985	25663 (4301)	19637 (4150)	6026 (1129)	184	103	81	17	7
1989	24738 (2329)	15581 (2019)	9157 (1160)	492	103	223	21	8
1991	25941 (2226)	18190 (2045)	7751 (880)	763	490	273		

WATER: YELLOWSTONE RIVER SEC 08B WATER CODE: 227072

Year	Pressure (SE) Total	Resident	Non-res	Trips Surveyed Total	Resident	Non-res	Rankings State	Reg
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-
1984	8471 (1918)	5453 (1649)	3018 (979)	42	18	24	59	16
1985	8893 (2006)	6697 (1828)	2196 (827)	47	27	20	55	13
1989	6079 (982)	4049 (896)	2030 (401)	126	27	49	72	21
1991	4160 (817)	2538 (639)	1622 (510)	124	67	57		

Appendix B1. Continued.

WATER: YELLOWSTONE RIVER SEC 09 WATER CODE: 227084

Year	Pressure (SE)			Trips Surveyed			Rankings	
	Total	Resident	Non-res	Total	Resident	Non-res	State	Reg
1982	6705 (2303)	4170 (1855)	2535 (1365)	45	26	19	82	18
1983	11960 (2498)	4892 (1387)	7068 (2077)	135	24	111	45	15
1984	6249 (2339)	4242 (2139)	2007 (945)	28	12	16	79	21
1985	7407 (1536)	4756 (1411)	2651 (607)	59	22	37	65	16
1989	9268 (1501)	6879 (1438)	2389 (428)	192	22	66	53	15
1991	13972 (1497)	9921 (1395)	3871 (544)	393	254	139		