TROUT UNLIMITED

17 June 1980

Dr. Robert Behnke
Department of Fisheries and
Wildlife Biology
Colorado State University
Fort Collins, CO 80523

Dear Dr. Behnke:

Keith has been asked to comment on the NPS Catch and Release regulations in the Soda Butte Creek drainage of Yellowstone Park. As I am unfamilar with the fishery, could you please advise:

a. Are Catch and Release regulations a sound management for that drainage?
b. What salmonids are present in that drainage?
c. Are there any specific problems associated with this request that you are aware of?

Thank you Dr. Behnke. I will try to call you on 23 June when your secretary indicated you would be back from Texas.

Sincerely,

Pam

Pamela K. McClelland
Resource Assistant

THE ACTION ORGANIZATION
Washington, D.C. Headquarters • 118 Park Street, S.E. • Vienna, Virginia 22180 • (703) 281-1100

10/8/82

Dr Behnke -

We received your note and papers on West slope cutthroat's, and I now have copies - Thanks.

We finally got some time to send out last years annual report. You are the first one to receive one. If you have comments I would appreciate hearing them.

Sincerely,

Leo.

Y.L. 87,450 acres? = 77,000 p. 11

ca 5hr/acre overfish - Emerald - w.s. cutts!

* 5hr/acre overfish Y.L.

82 - hr/ac./yr C & R Y.R. - ca 300-500 ?. 122 days/season 4hr. ...
catch 1/hr. = 400 per acre - actual pop. to

how many times each fish C & R.? $\bar{x}$ size > 1lb. = 500 lb. /acre/yr catch

hook mortality .5% per capture 3% overall = caught 6 times

- figure out pop.

U. S. DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

Yellowstone Fishery Investigations
P. O. Box 184
Yellowstone National Park, Wyoming 82190

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF THE INTERIOR
INT-423

U.S. MAIL

Kurt! Here are some research topics you & I may want to submit proposals for. Does NPS-CSU unit have special overhead rates to handle proposals thru CSU?

Dr. Robert Behnke
Dept. of Fisheries and
Wildlife Biology
Colorado State Univ.
Ft. Collins, CO 80523

Emerald L.:
– Program
– cards
Hubbs to Tommy

21

[1983]

Hooking Mortality of Cutthroat Trout in a Catch-And-Release Segment of the Yellowstone River, Yellowstone National Park

Daniel J. Schill
J. S. Griffith

Department of Biology
Idaho State University
Pocatello, Idaho 83201

Draft

ABSTRACT

The number of trout dying from hooking mortality in a 4.5-km study area was assessed directly by searching for cutthroat trout carcasses in established snorkeling routes. We divided our estimate of angler-induced mortalities by both creek census and cutthroat trout abundance data to estimate single capture hooking mortality and the rate of exploitation resulting from catch-and-release angling in the study area. The average number of times cutthroat trout were recaptured during the study period was estimated using the results of the creel census and cutthroat trout abundance data. The hooking mortality rate per single capture was 0.3%. In 1981 cutthroat trout which died after capture and release by anglers comprised 3% of the estimated population. Cutthroat trout in the study area were captured an average of 9.7 times during the study in 1981.

INTRODUCTION

The increased demand for sport fishing in North America has required the development of innovative management techniques, one of which is the implementation of restrictive regulations such as minimum length requirements, slot limits, and catch-and-release programs. A major underlying assumption here is that fish released because they do not meet harvest specifications survive to reproduce or be caught again, necessitating that hooking mortality be low. Special gear restrictions, typically artificial lures and flies only, are often used in conjunction with these types of regulations. Numerous studies have been conducted to date concerning various aspects of hooking mortality and these studies indicate that mortality rates of salmonids caught with artificial lures and flies average 6.1 and 4.1% respectively (Wydoski 1977).

Despite the many studies concerning the topic, very little is known about hooking mortality in wild salmonid populations, perhaps because of problems involved in holding test fish for observation. Past investigators working in lakes have confined test fish in floating livecars (Hunsaker et al. 1970; Warner and Johnson 1978). However, confining wild fish in this manner may induce additional stress (Wydoski et al. 1976) and result in overestimates of hooking mortality. Stress induced by holding could be especially important in fluvial situations if test fish were crowded and forced to maintain unfavorable holding positions.

The need to confine test fish for observation has also hindered the investigation of hooking mortality rates in fish caught more than a single time. If, as suggested by Wydoski (1977), the effects of stress are cumulative, hooking mortality may be substantial in fish recaptured more than once in a relatively short time period. Elevated mortality rates in fish captured repeatedly could markedly reduce the effectiveness of special regulations in waters receiving intense levels of angler use.

Our study was designed to examine hooking mortality in a fluvial cutthroat trout (Salmo clarki bouvieri) population which appeared to be subjected to repeated recapture. The study area, a segment of the Yellowstone River in Yellowstone National Park, is managed under catch-and-release regulations and restricted to the use of artificial flies and lures only. It is one of the most intensively fished wild trout fisheries in North America, sustaining about 5,000 angler-days per kilometer during the 3.5-month 1981 angling season (Jones et al. 1982).

The immense popularity of this fishery, along with a probable increase in angler effort in the future, has prompted concerns about the potential impacts of catch-and-release angling on the cutthroat trout population. Yellowstone National Park management goals state that cutthroat trout populations in the park should closely represent the natural state, unexploited by man. If cutthroat trout in the Yellowstone River experience hooking mortality rates similar to those of salmonids in previous studies, the potential for impact does exist, particularly if the effects of recapture are cumulative.

As a result of these concerns, we conducted a hooking mortality study in a segment of the Yellowstone River during 1980 and 1981. The study was designed to visually assess hooking mortality occurring in the fishery through the use of snorkel and SCUBA techniques. The specific objectives of the study were to (1) estimate the hooking mortality rate per single capture for cutthroat trout in the study area, (2) estimate the frequency of recapture for cutthroat trout within the study area, and

(3) determine the fraction of the cutthroat trout population in the study area that die as a result of hooking mortality. A secondary objective was to evaluate the effects of this exploitation on the structure of the cutthroat trout population in the study area.

STUDY AREA

The Yellowstone River originates in the Bridger-Teton Wilderness of western Wyoming and flows northward into Yellowstone Lake within Yellowstone National Park. The river drains the lake from the northern shore at an elevation of 2600 m. The 4.5-km of the river examined in this study begins 3-km downstream from the Yellowstone Lake outlet (Fig. 1).

We conducted population estimates in three segments of the study area totaling 2.4 km in length (Table 1). The uppermost segment (Cable Car) marks the beginning of the study area and lies approximately 250 m above LeHardy Rapids which form a partial barrier to migrating cutthroat trout during spring runoff. The Big Eddy study segment begins 1100 m below LeHardy Rapids and contains numerous lodgepole pine (*Pinus contorta*) deadfalls which project up to 25 m into the river from both shorelines. The Buffalo Ford segment of the river contains four long gravel bars as well as two side channels approximately 20 m in width.

River discharge during the study period (1 July - 25 August) decreased from 105 to 45 m^3/ second in 1980 and from 104 to 41 m^3/second in 1980 and from 104 to 41 m^3/ second in 1981 (U.S.G.S. 1981, 1982). Underwater visibility, measured as the maximum distance at which an object the size of an adult cutthroat trout could be clearly recognized by an underwater observer, was considerably better in 1980 ($\overline{X}$=5.6m) than in 1981 ($\overline{X}$-3.4m). Visibility was briefly reduced to a low of 2 m in mid-August of both years while large amounts of plankton were flushed from Yellowstone Lake. This period lasted from 7-17 August in 1980 and 12-18 August in 1981. Water temperatures ranged from 11.0 to 16.8 C and 11.1 to 15.6 C during 1980 and 1981, respectively, peaking during the last week of July in both years.

The Yellowstone cutthroat trout is the most abundant fish present in the study area and attains a relatively large average size. Ninety-four percent of the cutthroat landed by anglers in the study area during 1980 exceeded 30.5 cm in total length and the average length of all cutthroat trout caught was 39.3 cm (Jones et al. 1981). Snorkeling observations indicated the presence of very few juvenile fish less than 25 cm in total length, except for young-of-the year which are present after mid-July. Raleigh and Chapman (1971) suggest that most young-of-the-year cutthroat trout in the river are the progeny of spawners from the lake and that they move upstream to reside in the lake until mature.

Three additional fish species are present within the study area in low densities. Redside shiners (Richardsonius balteatus) were found primarily in two shallow backwater areas in the upper half of the study area. The longnose sucker (Catostomus catostomus) was the only species present which could be confused with the target species (cutthroat trout) during snorkeling observations. However, this species was found in only three deep pools within the study area and underwater visibility was sufficient to prevent misidentification. Longnose dace (Rhinichthys cataractae) were present in several shallow riffle areas of the river.

METHODS

Hooking mortality in the study area was assessed directly by snorkeling established routes and searching for dead cutthroat trout. We checked our efficiency in locating dead trout in the river by releasing a known number of individually-marked trout carcasses throughout the study area. The mortality estimate derived from this procedure was applied to the number of trout landed and released in the study area to determine the probability of an individual trout dying as a result of single capture. The same mortality data were applied to cutthroat trout abundance estimates to determine the percentage of trout in the river which died from hooking-related causes.

Two weeks prior to the opening of the angling season in 1980, we conducted a preliminary snorkeling survey of the study area to locate areas most likely to retain cutthroat trout carcasses. Deep pools, eddies, and deadfalls were all considered likely areas to be searched. As a result of the preliminary survey we established a single longitudinal route in each study section which included approximately 15 of these areas. The routes were snorkeled three times per week by the same observer from 10 July to 24 August 1980. The carcass census was conducted from 10-14 July to document natural mortality of cutthroat trout prior to the 15 July opening of the angling season. The number and location of all dead cutthroat trout located during the study period were recorded on an underwater slate and the carcasses were removed from the river.

The same general procedure was used during 1981 with the exception that two divers were used to increase the area of the river being searched.

In addition, SCUBA gear was used to search for carcasses in a 7-m-deep pool located at the lower end of the study area. Both divers snorkeled a fixed route in each study section three times per week between 1 July and 24 August. As in 1980, snorkeling was conducted prior to the 15 July opening of the angling season to document natural mortality.

To assess our efficiency in recovering carcasses in 1981 we released a total of 131 dead cutthroat trout throughout the 4.5 km study area. These fish were released in two separate groups during July and August. On 13 July we marked 45 carcasses with internal anchor tags (Dell 1968) and color-coded survey tape which was inserted between the gills. The survey tape was included in the event that carcasses became lodged in debris where recovery would be dangerous. We released the marked fish individually in areas which traditionally received heavy fishing pressure or in portions of the river that we knew contained substantial numbers of adult trout as a result of prior snorkeling observations. All of these fish were cutthroat post-spawners collected dead in Yellowstone Lake tributaries. The fish had been frozen for storage and thawed prior to use. The point of release for each individual carcass was recorded. While snorkeling the river in search of actual river mortalities in the established routes described previously, we noted the tag number and location of any of these introduced carcasses and removed them from the river.

The majority of post-spawners used in the release trial had been dead several days prior to being collected and frozen. These fish had undoubtedly lost body salts and taken on water during the initial stages of decomposition. In addition, we were unsure of the effect freezing and thawing would have on the gas bladder which could potentially affect the buoyancy of a carcass after death. To determine whether these carcasses drifted in a manner similar to trout dying in the study area, we released 86 dead cutthroat trout obtained from three different sources on 1 August 1981. Thirty thawed post-spawners were used along with an equal number of gillnetted fish collected in Yellowstone Lake two days before the release trial. The gillnetted fish had not been frozen but had a longitudinal slit in the peritoneal cavity which had been used to sex the fish. The final group of fish were obtained by angling the day before the trial. These fish were kept alive until the time of release and were sacrificed just prior to their introduction into the river. Groups of carcasses (one from each source) were released as they were in the first trial. We used a X^2 test of association to evaluate our ability to recover carcasses from each of the three sources.

We also released 20 cutthroat carcasses in a 2-km portion of the river immediately above the Cable Car study site on 1 August to determine if dead cutthroat trout drifted into the study area from up river. All carcasses released into the river were Yellowstone cutthroat trout ranging from 26 to 50 cm in total length.

In estimating cutthroat trout mortality in the study area during 1981 we assumed the percentage of introduced carcasses recovered in the established routes accurately reflected our efficiency in locating actual river mortalities. By applying our efficiency estimate to the total number of dead Yellowstone River fish found we estimated mortality in the 4.5 km study area for the period between 15 July and 24 August 1981. We did not apply the 1981 efficiency estimate to 1980 data since underwater visibility and the number of divers varied between years.

To obtain an estimate of angling mortality on a per capture basis we used creel census data provided by the U.S. Fish and Wildlife Service. The creel census was conducted using the Voluntary Fisherman Report (VFR) system in which raw data obtained voluntarily from angler report cards is adjusted for sampling bias using results of previous manned and voluntary creel surveys (Jones et al. 1977). Our estimate of angling mortality in the study area was divided by the number of fish landed during the same time period to provide an estimate of the single capture hooking mortality rate.

We then compared angling mortality to the total trout population present in the study area. Since electrofishing had proven inefficient in the past (Musser 1967) we assessed cutthroat abundance by snorkeling (Schill and Griffith-in review). Population estimates were conducted in the three study sites on 11-12 July and 4-5 August 1981. We calculated a mean density estimate (weighted by study site area) for the 2.4-km length of the river actually counted and expanded this estimate to include the entire study area. The mean of the July and August study area population estimates was divided into our angling mortality estimate to calculate the percentage of cutthroat trout in the study area population which died as a direct result of angling. The same mean study area population estimate was divided into the total number of cutthroat landed to estimate the average frequency of capture for cutthroat trout residing in the study area.

RESULTS

Pattern of Mortality

Snorkeling of the established routes proved to be an effective technique in locating cutthroat trout carcasses in the Yellowstone River, and indicated that the pattern of mortality was similar in both years (Fig. 2). A total of 59 and 72 dead cutthroat trout were found during the 1980 and 1981 study period, respectively. In both years less than 4% of the carcasses were found prior to the opening of the angling season and then a sharp increase in the number located occurred during the week of the season opener. The number of dead cutthroat trout located during the first three weeks of the angling season comprised 83 and 81% of all carcasses located during the 1980 and 1981 study years, respectively.

The sequence of carcass detections paralleled closely the number of cutthroat trout caught by anglers in the study area during the same time periods. A relatively small number of cutthroat were reported by anglers as having been landed illegally prior to the opening of the angling season in both years and landings increased sharply during the opening week of the season (Fig. 3). The number of cutthroat trout landed per week declined sharply in both study years after the opening week of the season in a manner similar to the number of carcasses found. Statistical analysis indicates a significant positive correlation (r=0.84, 5 df) between the number of cutthroat landed and the number of carcasses located in each weekly interval in 1980. A significant correlation also existed between these two variables using 1981 data (r=0.92, df 6).

In both study years cutthroat trout carcasses tended to accumulate in three locations within the established snorkeling routes. A large eddy at the downstream end of the study area contained 60 and 64% of all carcasses located in 1980 and 1981, respectively. In addition, a substantial number of carcasses were found in two 50-m segments of the Big Eddy study site which contained numerous deadfalls along the shoreline. Dead cutthroat trout tended to become entrapped in the branches of deadfalls and these two areas contained 21 and 16% of all carcasses located in 1980 and 1981, respectively. The remaining carcasses found in both study years were distributed throughout the snorkeling routes.

We recovered slightly under one-third (30.5%) of the 131 carcasses introduced into the study area during 1981 and all but two of these fish were found within three days of their introduction. Of the 45 carcasses released in the river on 13 July, fourteen (31.1%) were recovered. The mean drift distance of these recoveries was 1298 m. The recovery rate for carcasses released in the 1 August trial was nearly identical (30.2%).

Recovery rates for each of the three types of carcasses placed in the river at the same locations during the 1 August trial were similar. Chi-square analysis indicated no significant difference existed between recovery rates (X^2=1.51, 2 df).

None of the 20 carcasses placed above the Cable Car study site were recovered downstream in the study area. This was not unexpected since the 2 km segment of the river in which they were released has a low gradient and includes several deep pools exceeding 7 m in depth.

Mortality Estimate Per Capture

By applying the 30.5% average recovery efficiency to the number of actual river mortalities located (72), we estimated that 236 cutthroat trout died in the study area between 15 July and 25 August 1981. Results of the U.S. Fish and Wildlife Service creel census (R. Jones, U.S. Fish and Wildlife Service, personal communication) indicate that 72,698 cutthroat trout were caught in the study area between 15 July and 25 August 1981. By dividing the estimated mortality (236 fish) by the number of cutthroat trout landed and released, we calculated a 0.32% hooking mortality rate per single capture in 1981.

Exploitation and Recapture

A substantial amount of cutthroat trout movement occurred in the study area in 1981. The number of cutthroat trout present in the study area more than doubled between the two population estimates conducted on 11-12 July and 4-5 August (Table 2). The majority of cutthroat trout immigrating into the study area in late July probably were post-spawners returning from the extensive gravel beds located upstream at the Yellowstone Lake outlet. We divided the average of the two population estimates (7,500 fish) into the estimated hooking mortality for the study area (236 fish) to obtain an estimated exploitation rate of 3.2%. This estimate applies only to those fish released and does not include illegal harvest, which may have been substantial.

The exploitation rate calculated above applies to a population in which many individuals are apparently recaptured a number of times. Dividing the estimated number of cutthroat trout caught during the study period (72,698) by the average population present during the same period (7,500), gives a recapture estimate of 9.7 times per individual fish.

DISCUSSION

Pattern of Mortality

The chronological pattern in which carcasses were found indicates that most of the estimated 236 cutthroat trout which died in the study area between 15 July and 25 August 1981 did so after being caught and released by anglers. This estimate does not include fish that may have been removed from the river by predators. However, several other sources of mortality must be considered for these fish, including natural deaths and fatal woulds inflicted by predators.

Predation would not affect the hooking mortality rate reported in this study unless substantial numbers of cutthroat trout received fatal wounds from predators but were not captured or only partly consumed. In this event, these carcasses would presumably drift in a manner similar to hooking mortalities. Although a number of potential predators are present in the vicinity of the Yellowstone River catch-and-release area, including bald eagles (*Haliaeetus leucocephalus*), white pelicans (*Pelecanus erthrorhynchos*), otter (*Lutra canadensis*), common mergansers (*Mergus merganser*), and California gull (*Larus californicus*), only the latter was commonly observed within the study area. We did not observe gulls preying upon the adult cutthroat trout and suspect they preferred young-of-the-year cutthroat trout which were common in shallow shoreline areas. More importantly, wounds inflicted by predators are generally obvious (Alexander 1979) and we did not observe puncture woulds or lacerations on any of the carcasses located in the river during both study years.

Natural deaths in the study area would be expected from delayed spawning stress, natural aging processes, or disease. We located a small number of carcasses prior to the opening of the angling season in both study years (Fig. 2) and assume these fish died from natural causes but it is possible that some of this mortality may have been the result of illegal angling which occurred during this time period. We believe that natural deaths remained low during the angling seasons in both 1980 and 1981. Conditions in the Yellowstone River from mid-July to the end of August are probably near the optimum for cutthroat trout survival. Water temperatures typically remained below 14.5 c in July and August and food availability peaked during this period as a result of aquatic invertebrate emergence and the discharge of plankton from Yellowstone Lake. The delayed spawning mortality that may have been a factor in pre-angling season mortalities would be expected to decline as cutthroat trout in the study area fully recovered from spawning which was apparently completed by the end of June in 1981.

Since a strong correlation existed in both study years between the number of carcasses located and numbers of cutthroat trout caught by anglers, we believe that the large majority of dead cutthroat trout found in the study area died as a result of hooking mortality. We have treated all of the mortalities as angling-related while acknowledging that a small unknown number may have been natural deaths.

Previous investigators have reported that hooking mortality is caused by either physical damage to a vital organ or severe muscular exhaustion and fatigue. Vital organ damage usually occurs as a result of hook wounds in the gills, eyes, or esophogeal area and death often occurs within 24 hours of initial capture (Stringer 1967; Marnell and

Hunsaker 1970; Warner 1978. Stress-related deaths may occur over a period of several weeks and have been associated with elevated lactic acid concentrations in the blood (Parker and Black 1959; Wydoski 1977).

The snorkeling technique used to estimate mortality did not enable us to determine whether the majority of deaths were stress-related or the direct result of physical damage. Only four of the dead trout we located in 1981 had obvious signs of hook damage and in all cases death appeared to have resulted from injury to gill tissue. However, many of the carcasses located appeared to have died several days prior to being found, making observation of hook wounds difficult and precluding detailed autopsies. Consequently, we are reluctant to conclude that handling stress was the major cause of hooking mortality in the study area. Damage to a vital organ was the major cause of death in Yellowstone cutthroat trout caught in Yellowstone Lake on treble hook lures and single hook flies (Hunsaker et al. 1970; Marnell and Hunsaker 1970).

There are several factors that could have affected the accuracy of our 30.5% efficiency estimate derived from carcass introductions. The initial placement of introduced carcasses could have biased the estimate, particularly if these carcasses did not drift appreciable distances before being located. We avoided placing introduced carcasses in or immediately above pools or deadfalls that were included in the established snorkeling routes. As a result, the distance drifted by recovered carcasses was 1298 m, a sufficient distance, we believe, to reduce the initial influence of carcass placement on recovery rates.

If scavengers in the area remove a substantial number of dead trout from the river, the introduction of the test fish may have flooded the system and resulted in an overestimate of our recovery efficiency and a corresponding underestimate of hooking mortality. Scavenging appeared to be minimal during the 1980 study period when carcasses were not introduced into the river. Dead cutthroat trout throughout the river underwent decomposition in the same locations in which they were initially found. The only scavenger commonly observed in the study area was the California gull and these birds appeared to prefer the shallow Buffalo Ford portion of the river. Even though scavenging of carcasses appeared to be low in 1980, we kept the number of carcasses introduced into the river during 1981 to a minimum. We assumed that scavenging of introduced carcasses occurred at a rate similar to that of dead Yellowstone River fish.

Mortality Rate Per Capture

One problem with past hooking mortality studies is that, with the exception of Klein (1966), test fish have been caught and released by biologists rather than by members of the general angling public. It is conceivable that anglers may kill a greater percentage of fish than do biologists as a result of careless or improper handling techniques, and results from these studies may underestimate the mortality rates that actually occur in a typical fishery.

The estimated mortality rate per single capture in this study (0.3%) is considerably lower than the results obtained for salmonids by most previous investigators. The mortality rate for hatchery-reared Atlantic salmon (Salmo salar) was 6.0% for fish caught on treble hook lures and 4.2% for those captured using artificial flies (Warner 1979). Test fish in that study were captured from hatchery rearing ponds at Enfield, Maine, and held for 10-14 days to determine mortality rates. Hooking mortality rates for wild Yellowstone cutthroat trout caught in

Yellowstone Lake and held in floating livecars were of a similar magnitude; 4% of the fish captured with flies and 2.7% of those captured with lures died after 10-30 days of observation (Marnell and Hunsaker 1970). Bouck and Ball (1966) reported a much greater hooking mortality rate of 87% for hatchery rainbow trout (Salmo gairdneri) caught with artificial lures and played to exhaustion.

However, several investigators have obtained hooking mortality estimates of less than 1%. Hatchery cutthroat trout caught with single and treble hook flies at the Yellowstone River Trout Hatchery in Montana died at a rate of 0.3% (Dotson 1982), a proportion identical to the results of this study. T. Bjornn, Id. Coop. Fish.Res. Unit, (personal communication) reported mortality rates of 0.4% and 0.8% for 520 Idaho hatchery cutthroat trout caught on barbed and barbless flies, respectively.

2X greater but insignif.

Obviously a substantial amount of variability exists in the hooking mortality rates reported for salmonids, probably due to the fact that a number of factors such as type of hook, fish species, water temperature, size of fish, and length of playing time varied among these studies. We believe the relatively low hooking mortality rate experienced by Yellowstone River cutthroat trout may be related to several of these factors, especially the latter two.

The effect of fish size on hooking mortality rate has not been examined in controlled experiments. In general, there has been a tendency to use fish in the 20-30 cm size range (often hatchery catchables) in past studies and very little is known about hooking mortality in salmonids outside of this size range. We believe the large size of the cutthroat trout in our study area may have contributed to the low mortality rate reported. Injuries to the vital organs of large fish should occur less frequently than in smaller fish simply as a result of the physical distance from the upper and lower jawbones. These structures have been identified by Dotson (1982) and Warner (1978) as the most commonly hooked body parts. For example, a relatively small (15-25 cm) fish hooked in the corner of the mouth with a #8 or #10 hook may still receive injuries to the eyes because the distance from the jaws is only 0.4-0.5 cm. We have observed this type of injury often in juvenile steelhead trout caught with artificial flies. In the case of larger fish such as those 38-40 cm trout typically caught in our study area, this dimension is about twice as great and may be enough to preclude eye injuries.

A characteristic of the Yellowstone catch-and-release fishery which may affect hooking mortality is the short time in which most fish are landed after hooking. We observed the time required for 58 anglers to land cutthroat trout in the study area in July 1980. The average landing time was 1.7 minutes, a shorter playing time than might be expected for fish of this size in a large river. Since stress-related deaths appear to be the result of severe muscular exertion (Parker and Black 1959), an increase in the length of playing time could conceivably result in elevated mortality rates. Marnell and Hunsaker (1970) reported no significant difference in mortality rates of cutthroat trout played for 5 and 10 minutes before release. However, subsequent research (Wydoski et al. 1976) has shown that playing times of short duration have little effect on several blood chemistry parameters used as indices of physiological stress. Changes in plasma glucose levels of wild and hatchery rainbow trout did not increase significantly from initial levels when fish were played for 1, 2, or 3 minutes while fish played for both 4 and 5 minutes had significantly higher levels. A similar situation existed with plasma osmolality levels. These results may explain how cutthroat trout in the study area can be recaptured repeatedly in a short time period with apparently minimal effects from handling stress.

There may also be a genetic basis for some of the variation in hooking mortality rates observed within an individual species, particularly in situations where handling stress is an important factor. Mazeaud et al. (1977) reported wide biological variations in the quantitative hormonal response of individual fish to a particular stress and suggested the possibility of genetic selection for lines of high or low stress response. Klar et al. (1978) determined that LDH B^2 phenotype significantly influenced both mortality rates and blood lactate levels in rainbow trout stressed with low levels of dissolved oxygen for 60 minutes. If LDH isozymes produce similar results in salmonids subjected to angling stress, the potential exists for genetic selection of fish stocks with a low stress response to playing and handling. This type of selection may be prevalent in populations managed under catch-and-release or similar strict harvest restrictions where a large percentage of the fish are caught and released. The number of generations needed to select for this type of trait would depend on the magnitude of hooking mortality when special regulations were first instituted, the number of loci involved, and the type of inheritance mechanism. A maximum of three generations of Yellowstone River cutthroat trout have been subjected to special regulations and whether or not this type of selection has occurred is unknown. - but they have all spawned at least once before catching..

Studies investigating the effects of water temperature on hooking mortality rates have yielded conflicting results. Cutthroat trout survival was not measurably affected by water temperatures in the range of 3 to 17 C for fish caught with artificial lures in Yellowstone Lake (Marnell and Hunsaker 1970). However, there was a significant positive correlation between water temperature (range 8.9-16 C) and hooking mortality in hatchery rainbow trout captured with artificial flies in four Montana trout hatcheries (Dotson 1982). The number of carcasses found in our study area did not correspond to fluctuations in river water temperature in either 1980 or 1981.

The hooking mortality rate reported in this study was calculated using estimates of both angler catch and instream mortality. As a result, an unknown amount of experimental error is incorporated into the 0.3% estimate. However, it is important to note that large errors in both the creel census data and our estimate of hooking mortality in the study area would have little effect on the mortality rate per single capture. For example, a 50% reduction in the estimated number of cutthroat trout caught and a 50% increase in the estimated number killed by anglers would still result in a hooking mortality rate of less than 1%.

Exploitation, Recapture

Results of this study indicate that 3% of the study area population died in 1981 as a result of hooking. Evaluating the effects of this exploitation rate on the Yellowstone River cutthroat population is hindered by the lack of information on unfished cutthroat populations in large rivers. A 14-km segment of the Yellowstone River located immediately below the catch-and-release area has been closed to angling since 1963

Studies investigating the effects of water temperature on hooking mortality rates have yielded conflicting results. Cutthroat trout survival was not measurably affected by water temperatures in the range of 3 to 17 C for fish caught with artificial lures in Yellowstone Lake (Marnell and Hunsaker 1970). However, there was a significant positive correlation between water temperature (range 8.9-16 C) and hooking mortality in hatchery rainbow trout captured with artificial flies in four Montana trout hatcheries (Dotson 1982). The number of carcasses found in our study area did not correspond to fluctuations in river water temperature in either 1980 or 1981.

The hooking mortality rate reported in this study was calculated using estimates of both angler catch and instream mortality. As a result, an unknown amount of experimental error is incorporated into the 0.3% estimate. However, it is important to note that large errors in both the creel census data and our estimate of hooking mortality in the study area would have little effect on the mortality rate per single capture. For example, a 50% reduction in the estimated number of cutthroat trout caught and a 50% increase in the estimated number killed by anglers would still result in a hooking mortality rate of less than 1%.

Exploitation, Recapture

Results of this study indicate that 3% of the study area population died in 1981 as a result of hooking. Evaluating the effects of this exploitation rate on the Yellowstone River cutthroat population is hindered by the lack of information on unfished cutthroat populations in large rivers. A 14-km segment of the Yellowstone River located immediately below the catch-and-release area has been closed to angling since 1963 and may contain the last remaining unexploited cutthroat trout population in a large fluvial system. However, the predominately deep, slow-moving habitat present in this area is even less conducive to electrofishing than the catch-and-release segment of the river and angling proved to be inefficient as a method for obtaining population data.

A comparison of our results to previous studies involving different species is limited by dissimilarities in life history or large differences in the exploitation rates. Ricker (1963) concluded that an annual exploitation rate of only 5% was sufficient to cause major reductions in the relative weight and abundance of older age groups in several marine species subjected to commercial fishing. However, the population examined in that study contained 12-15 age groups and the results are probably not applicable to shorter-lived cutthroat trout. Numerous investigators have reported impacts of angling on salmonid populations but exploitation rates involved have been much greater than the value reported in this study. Exploitation of brown trout (Salmo trutta) and rainbow trout (Salmo gairdneri) averaged 50 and 55%, respectively, during three fishing seasons in a branch of Willow River, Wisconsin, managed under general regulations (Hunt 1981). Average biomass was less than half the value estimated for another stream portion managed under special regulations. Avery and Hunt (1981) concluded that annual exploitation rates of 11-24% were sufficient to markedly skew size and age composition of wild brown trout populations toward smaller, younger individuals in four central Wisconsin streams. We do not believe that a 3% decline in cutthroat trout abundance in the productive Yellowstone River is substantial enough to significantly alter the age structure or mean size of the population. The average age of cutthroat in the Yellowstone-catch-and-release area has increased steadily from 3.75 to 5 years since the inception of the current regulation program and the mean length of fish landed has increased from 363 to 391 mm (Jones et al. 1982).

Recatchability

Yellowstone River cutthroat trout were caught an average of ten times during the 1981 study period, or the equivalent of once every five days. Obviously the potential for error in this recapture rate exists since it was calculated from two widely varying population estimates and assumes emigration during the study period was negligible. However, we believe the estimate is realistic in the case of the Yellowstone River population. Since 85% of the fish caught in the study area during the 1981 season were captured between 15 July and 25 August (R. Jones, U.S. Fish and Wildlife Service, personal communication) our recapture estimate is probably a close approximation of recapture rates for the entire season.

The estimated frequency of capture is probably conservative for many cutthroat trout in the study area. McLaren (1970) reported that only 26% of the brown trout in a small Pennsylvania stream were captured by anglers during a 72 day period. Although results of that study are not directly applicable to the Yellowstone situation, an unknown percentage of fish in the study area were probably never captured. This would imply that a number of other individuals in the population were caught considerably more than 10 times. In addition, approximately 65% of the cutthroat landed in the study area during 1981 were captured in a 1 km portion of the study area which included the Buffalo Ford study segment (R. Jones, U.S. Fish and Wildlife Service, personal communication). Since this portion of the river did not contain an unusually large concentration of fish (Table 2), individual cutthroat trout residing there must have been captured more frequently than fish located throughout the remainder of the study area.

Studies designed to evaluate the recatchability of fish have yielded differing results. The catchability of pike (Esox lucius) declined by 96% for those fish caught a single time with artificial lures (Beukemia 1970). However, wild brown trout captured up to three times maintained a constant capture probability of 0.25-0.27 (McLaren 1970).

The catchability of cutthroat trout in the study area did appear to decline during the season. Catch rates declined from 1.39 to 1.02 fish per hour (R. Jones, U.S. Fish and Wildlife Service, personal communication) during the first three weeks of the season even though results of population estimates indicate the study area population more than doubled (Table 2).

While the overall catchability of the population apparently declined during the angling season, our observations indicate that Yellowstone River cutthroat trout are unusually susceptible to recapture. In the week prior to the opening of the 1981 angling season we captured 76 cutthroat trout with artificial flies in a 50-m section of the river and marked them with internal anchor tags. While marking these fish we captured one individual cutthroat trout four times within 24 hours and two additional trout were recaptured within 2 hours of their original capture. Unfortunately, anglers removed most of these tags in the first few days of the season, prohibiting us from examining cumulative recapture rates in individual fish during the entire season. For example, one angler removed tags from 12 cutthroat trout. However, the observation that one individual angler recaptured 16% of the original marked fish during the first two days of the angling season is, we believe, an indication of the vulnerability of Yellowstone River cutthroat trout to angling.

The unusually high recapture rates reported for cutthroat trout in the study area may be related to behavioral adaptations of the fish in response to extreme levels of angler effort. Angler effort in the study area during the 45 day study equates to 41 angler hours per hectare per day (R. Jones, U.S. Fish and Wildlife Service, personal communication), a level of use which may be unsurpassed in a wild salmonid fishery. Perhaps as a result of habituation to this intense level of angling pressure, fish in the river are not disturbed by the presence of anglers. In fact, data collected during the 1981 study period indicate that cutthroat trout in the study area prefer feeding stations immediately below wading anglers (Schill 1983). Cutthroat trout were attracted to the drifting invertebrates dislodged by a wading angler and often foraged within 0.5 m. It seems logical to suspect that a fish which prefers to feed in the presence of an angler may be more susceptible to recapture than one which flees. However, this line of reasoning necessitates that a significant number of Yellowstone River cutthroat trout cannot learn to distinguish between actual food organisms and angler offerings. This may be the case in the study area since the more gullible fish are not creeled by anglers.

- So. Platte 4-5 x greater Poudre higher by 1.5

Acknowledgements

We thank Bob Gresswell, John Varley and Ron Jones of the U.S. Fish and Wildlife Service and Dr. Mary Meagher of the National Park Service for their logistical support, and greatly appreciate the efforts of volunteer divers. Ted Bjornn and Ron Jones graciously provided us with valuable unpublished data.

References

Alexander, G.R. 1979. Predators of fish in coldwater streams. Pages 153-170 in Clepper, editor. Predator-prey Systems in Fisheries Management. Sport Fishing Institute, Washington, D.C., U.S.A.

Avery, E.L., and R.L. Hunt 1981. Population dynamics of wild brown trout and associated sport fisheries in four central Wisconsin streams. Department of Natural Resources, Technical Bulletin No. 121, Madison, Wisconsin, USA.

Beukemia, J.J. 1970. Acquired hook-avoidance in the pike (Esox lucius L.) fished with artificial and natural baits. Journal of Fish Biology 2:155-160.

Bouck, G.R. and R.C. Ball 1966. Influence of capture methods on blood characteristics and mortality in the rainbow trout (Salmo gairdneri). Transactions of the American Fisheries Society 95:170-176.

Dell, M.B. 1968. A new fish tag and rapid, cartridge-fed applicator. Transactions of the American Fisheries Society 97:57-59.

Dotson, T. 1982. Mortalities in trout caused by gear type and angler-induced stress. North American Journal of Fisheries Management 2:60-65.

Griffith, J.S., D.J. Schill, and R.E. Gresswell. In press. Underwater observation as a technique for assessing fish abundance in large rivers in the west. Proceedings of the 63rd Conference of the Western Association of Fish and Wildlife Agencies, 1983.

Hunsaker, J., II, L.F. Marnell, and F.P. Sharpe 1970. Hooking mortality of Yellowstone cutthroat trout. Progressive Fish Culturist 32:231-235.

Hunt, R.L. 1981. A successful application of catch and release regulations on a Wisconsin trout stream. Department of Natural Resources, Technical Bulletin No. 119, Madison, Wisconsin, USA.

Jones, R.D., J.D. Varley, D.E. Jennings, S.M. Rubrecht, and R.E. Gresswell 1977. Fishery and aquatic management program in Yellowstone National Park; Technical report for calendar year 1976. United States Department of the Interior - Fish and Wildlife Service, Mammoth, Wyoming, USA.

Jones, R.O., P.E. Bigelow, D. Carty, R.E. Gresswell, and S.M. Rubrecht 1981. Fishery and aquatic management program in Yellowstone National Park; Technical report for calendar year 1980. United States Department of the Interior - Fish and Wildlife Service, Mammoth, Wyoming, USA.

Jones, R.D., R.E. Gresswell, P.E. Bigelow, and R.A. Valdez 1982. Fishery and aquatic management program in Yellowstone National Park; Technical report for calendar year 1981. United States Department of the Interior - Fish and Wildlife Service, Mammoth, Wyoming, USA.

Klar, G.T., C.B. Stalnaker, and T.M. Farley 1979. Comparative blood lactate response to low oxygen concentrations in rainbow trout (Salmo gairdneri), LDH B^2 phenotypes. Comparative Biochemistry and Physiology 63A:237-240.

Klein, W.D. 1966. Mortality of trout caught on artificial lures and released by fishermen. Transactions of the American Fisheries society 95:326-328.

Marnell, L.F., and D. Hunsaker, II 1970. Hooking mortality of lure caught cutthroat trout (<u>Salmo clarki</u>) in relation to water temperature, fatigue and reproductive maturity of released fish. Transactions of the American Fisheries Society 99:684-688.

Mazeaud, M.M., F. Mazeaud, and E.M. Donaldson 1977. Primary and secondary effects of stress in fish: some new data with a general review. Transactions of the American Fisheries Society 106:201-212.

McLaren, J.T. 1970. Vulnerability of wild brown trout to fly fishing under catch and release regulations. M.S. Thesis. Pennsylvania State University, State College, Pennsylvania, USA.

Musser, B.D. 1967. Migration Patterns and annual catch of adult cutthroat trout (<u>Salmo clarki</u>)in the Yellowstone River. U.S. Fish and Wildlife Service, Progress Report, Mammoth, Wyoming, USA.

Parker, R.R., and E.C. Black 1959. Muscular fatigue and mortality in troll caught chinook salmon (<u>Onchorhynchus tshawtytscha</u>). Journal of the Fisheries Research Board of Canada 16:95-106.

Raleigh, R.G. and Chapman, D.W. 1971. Genetic control in lakeward migration of cutthroat trout fry. Transactions of the American Fisheries Society 100:33-40.

Ricker, W.E. 1963. Big effects from small causes: two examples from fish population dynamics. Journal of the Fisheries Research Board of Canada 20:257-264.

Schill, D.J. and J.S. Griffith. Estimation of cutthroat trout abundance in the Yellowstone River by underwater observation. Submitted to the North American Journal of Fisheries Management.

Schill, D.J. Hooking mortality of cutthroat trout in a catch-and-release segment of the Yellowstone River, Yellowstone National Park. M.S. Thesis, Idaho State University, Pocatello, Idaho, USA.

Stringer, G.E. 1967. Comparative hooking mortality using three types of termingal gear on rainbow trout from Pennask Lake, B.C. The Canadian Fish Culturist 39:17-21.

United States Geological Survey 1981. Water resource data for Wyoming. U.S. Geological Survey, Laramie, Wyoming, USA.

United States Geological Survey 1982. Water resource data for Wyoming. U.S. Geological Survey, Laramie, Wyoming, USA.

Warner, K. 1979. Mortality of landlocked Atlantic salmon hooked on four types of fishing gear at the hatchery. The Progressive Fish Culturist 41:99-102.

Warner, K., and P.R. Johnson 1978. Mortality of landlocked Atlantic salmon (Salmo salar) hooked on flies and worms in a river nursery area. Transactions of the American Fisheries Society 107:772-775.

Wydoski, R.S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 in R.A. Barnhart and T.D. Roelofs, editors. A National symposium on catch-and-release fishing. Humbolt State University, Arcata, California, USA.

Wydoski, R.S., G.A. Wedemeyer, and N.C. Nelson 1976. Physiological response to hooking stress in hatchery and wild rainbow trout (Salmo gairdneri). Transactions of the American Fisheries Society 105:601-606.

Table 1. Physical parameters of the three study sites in the Yellowstone River, August 1981.

Study Site	Maximum depth (m)	Length (m)	Channel width (m)	Area (hectares)	Substrate
Cable Car	2.5	350	86	3.01	cobble boulders
Big Eddy	2.5	1316	73	10.03	gravel cobble boulders
Buffalo Ford	2.0	750	99[1]	8.87	cobble gravel

[1] excluding side channels

Table 2. Estimated numbers of cutthroat trout present in the Yellowstone River study sites and estimates for the entire study area during 1981.

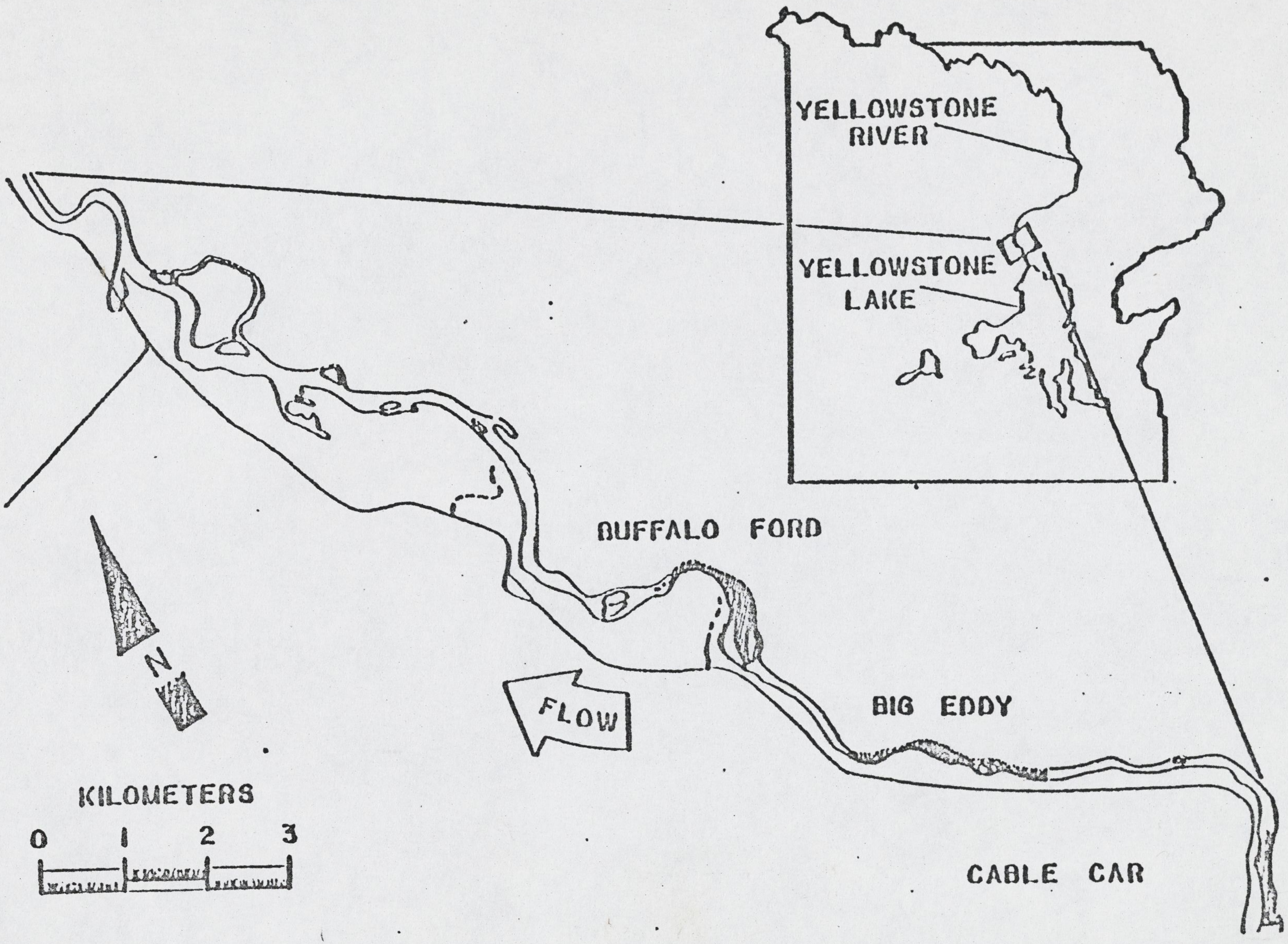
	Date of estimate	
Location	July 11-12	August 4-5
Cable Car	494	3250
Big Eddy	665	1364
Buffalo Ford	1225	1067
Entire Study Area	4510	10489

Figure 1. Location of study segments on the Yellowstone River in Yellowstone National Park.

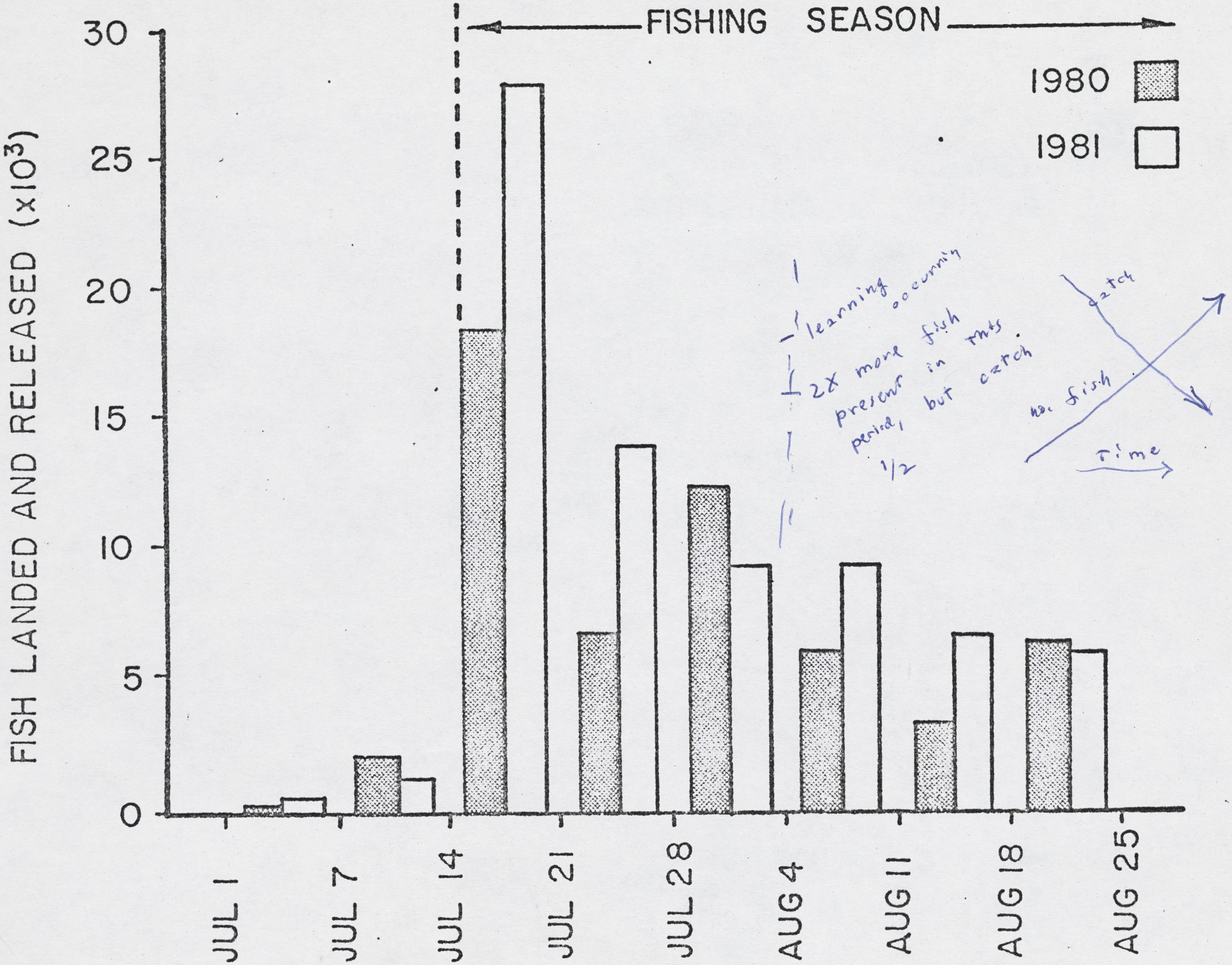
Figure 2. The number of cutthroat trout carcasses located during weekly intervals while snorkeling established routes in the Yellowstone River, 1980 and 1981.

Figure 3. The number of cutthroat trout caught and releaed by anglers during weekly intervals in the 4.5-km study area, 1980 and 1981.

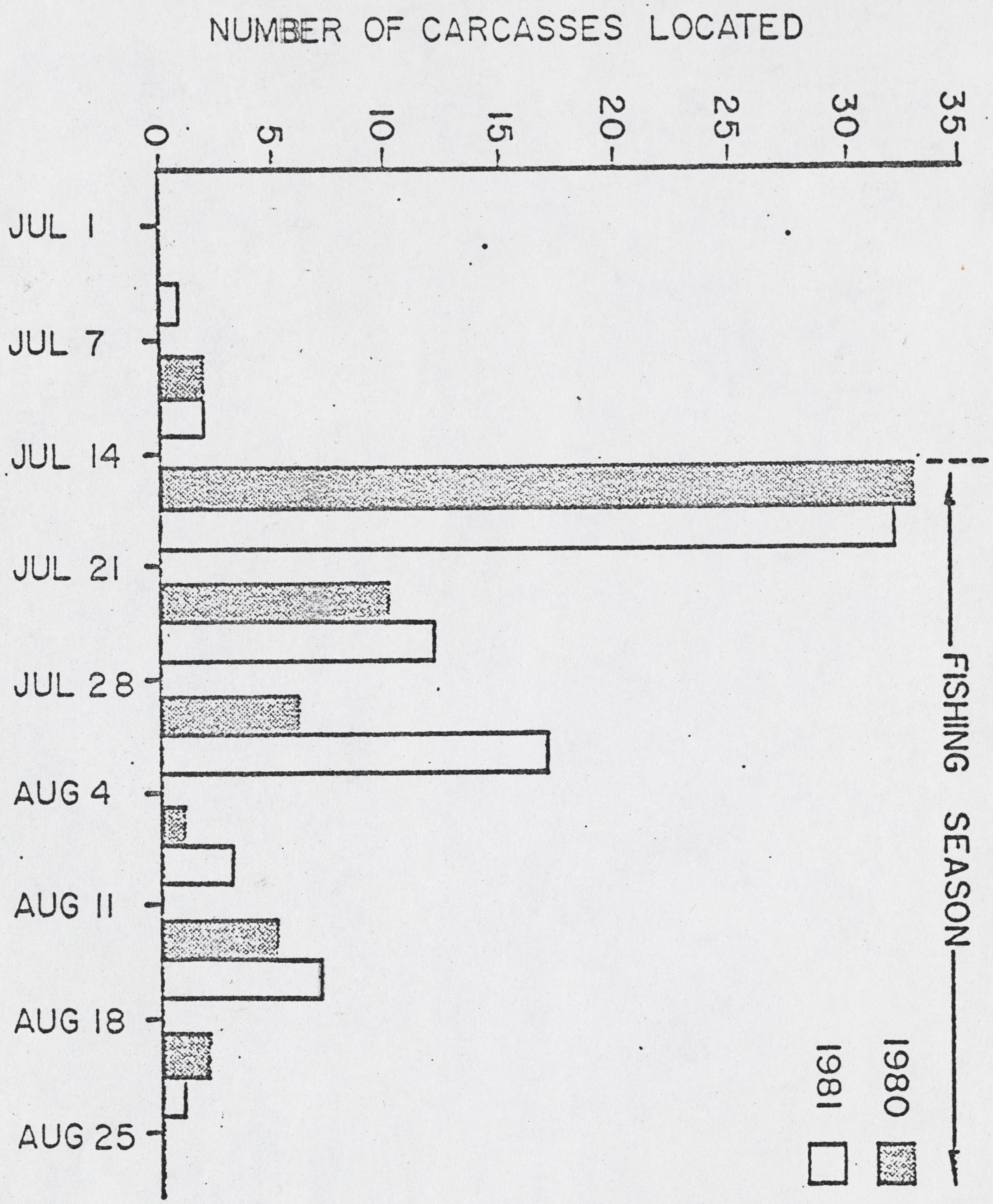
YELLOWSTONE NATIONAL PARK



Schill
Fig 2



FISHING SEASON
1980
1981
FISH LANDED AND RELEASED (x10³)
30
25
20
15
10
5
0
JUL 1
JUL 7
JUL 14
JUL 21
JUL 28
AUG 4
AUG 11
AUG 18
AUG 25
learning occurring
2X more fish present in this period, but catch 1/2
catch
no. fish
Time


NUMBER OF CARCASSES LOCATED
0
5
10
15
20
25
30
35
JUL 1
JUL 7
JUL 14
JUL 21
JUL 28
AUG 4
AUG 11
AUG 18
AUG 25
FISHING SEASON
1980
1981

Sch. 11 Fig 3

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Yellowstone Fishery Investigations
P.O. Box 184
Yellowstone National Park, Wyoming 82190

IN REPLY REFER TO:
L.L.

March 9, 1983

Dr. Robert Behnke
Dept. of Fisheries and
Wildlife Biology
Colorado State University
Ft. Collins, CO 80523

Dear Bob:

As we discussed on the phone (2/8/83), several research projects have been submitted to the Department of the Interior for funding under a special jobs bill. Enclosed is a copy of research topics of our interest with the projects we submitted indicated with estimated cost values. The dollar values we are asking for should be substantial enough to cover all costs (graduate student, seasonals for his or her assistance, travel, lodging, etc.). I will keep you posted as the possibilities for this funding develop.

Sincerely,

Leo

Leo Lentsch

P.S. I was able to enclose a brief description of these projects.

Estimated costs:

Aquatic Research Topics - 1983

$ 30,000

1. Describe the biology and status of the Westslope cutthroat trout (Salmo clarki lewisi) in Yellowstone Park.

2. Describe riparian plant communities in Yellowstone with the objective of understanding past and present occurrence and successional relationships.

3. Evaluate the concentration, migration and fate of heavy metal pollutants in roadside waters of Yellowstone Park, with special emphasis on biomagnification.

$ 25,000

4. An evaluation of hooking mortality on the Firehole River during stressful high temperature periods.

5. Assess the effects of human predation on stock density, dynamics and age-structure of a multi-species predator prey ecosystem (Lewis-Shoshone Lakes; lake and brown trout).

$ 35,000

6. Food availability and diet comparison in conjunction with fish distribution in Yellowstone Lake (cutthroat trout, longnose sucker and redside shiner).

7. Use of natural tags (parasites) to identify spawning stocks in Yellowstone Lake.

$ 20,000

8. Evaluate various known methods of ageing fish on the cutthroat trout of Yellowstone Lake.

Priority: 2

Title: Food availability and diet comparison in conjunction with competition between native cutthroat trout and introduced nongame fishes (longnose suckers and redside shiners) in Yellowstone Lake.

Contract or Day Labor: Contract

Obligation Date: July 15, 1983

Part of FY 84 Program? No

Total Amount: $35,000.00 (2 years)

Housing Required: Yes

Description: The Yellowstone cutthroat trout (Salmo clarki bouvieri) was native to the lake basin, but populations of introduced longnose suckers (Catostomus catostomus) and redside shiners (Richardsonius balteatus) increased during the 1950's and 1960's. Since competition for limited food resources has often been cited as a cause of declining fishery quality where valuable sport fishes coexist with nongame species, investigation concerning food availability and diet comparison among the fishes of Yellowstone Lake is imperative. This study would include investigation of species distribution in order to evaluate the possibilities of temporal and spacial niche overlap during various stages of the life cycle.

Priority: 3

Title: An evaluation of hooking mortality on the Firehole River during stressful high temperature periods.

Contract or Day Labor: Contract

Obligation Date: July 15, 1983

Part of FY 84 Program? No

Total Amount: $25,000.00

Housing Required: Yes

Description: Summer temperatures in the Firehole River often reach levels approaching the lethal limits of trout in this important rainbow and brown trout fishery. Although various studies throughout the country have indicated low mortality on released trout which were captured by anglers using lures or flies, there is some indication that increased water temperatures may cause subsequent rises in post-release mortality. This study should determine the mortality of angler released trout throughout the season with special emphasis on those periods when water temperatures are highest.

Priority: 5

Title: Development of a valid aging procedure for Yellowstone cutthroat trout.

Contract or Day Labor: Contract

Obligation Date: July 15, 1983

Part of FY 84 Program? No

Total Amount: $20,000 (2 years)

Housing Required: Yes

Description: Without the assurance that fish aging procedures are valid, the interpretation of results of fishery management practices is nebulous. Regulations on Yellowstone Lake are designed to allow trout to live to older ages. The current method of aging trout from Yellowstone Lake is by use of scales. However, aging old trout by the scale method is difficult and creates uncertainty about the true age of the fish. To evaluate the results of fishery management practices on Yellowstone Lake, a method needs to be developed which will provide a procedure which eliminates uncertainty from the fish age determination.

Priority: 6

Title: Determination of the range, status, and biological condition of westslope cutthroat trout within Yellowstone National Park.

Contract or Day Labor: Contract

Obligation Date: July 15, 1983

Part of FY 84 Program? No

Total Amount: $30,000.00 (2 years)

Housing Required: Yes

Description: The existence, location, genetic purity, and biological condition of populations of westslope cutthroat trout occurring within Yellowstone National Park should be determined. Research should provide vital information which can be used to protect and enhance the present status of the westslope cutthroat within the park. To provide this information an extensive fishery survey of the Gallatin River drainage should be performed.

1964

The Use of Restrictive Regulations in Managing Wild Salmonids in Yellowstone National Park, with Particular Reference to Cutthroat Trout, *Salmo clarki*.

John D. Varley

United States Fish and Wildlife Service
P. O. Box 18
Ahsahka, Idaho 83520

Abstract

For over thirty years the primary management emphasis on wild salmonids in Yellowstone National Park has been the use of highly restrictive sport fishing regulations. Although restoring more natural (i.e. pristine) populations for their own instrinsic value was an important objective, each more restrictive rule most often came about as the direct result of excessive harvests and a deterioration in angling quality. These regulations, particularly since 1973, have significantly helped to restore population numbers and improve age-group hierarchies. According to the defined interests of a large and diverse cross section of sport anglers from across North America, a greater sustained recreational yield can be created by restrictive regulations than by other management scenarios, and at lesser cost. A simplified economic example of the relative value of a wild cutthroat fishery shows that one 14.5km reach of the Yellowstone River provided more angler entertainment than one moderately sized trout hatchery could probably produce. Each salmonid species reacted to similar regulations in different ways, as did populations of the same species in different types of waters. The cutthroat trout, however, is particularly suited to catch-and-release only fisheries because of its extraordinary vulnerability to angling, low release mortality, and long life. As such, the species has shown to provide sport angling in the upper limits of optimum, as defined by the fishermen themselves.

Introduction

Yellowstone National Park, by its establishment act of March 1, 1872, was "dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people" and "for the preservation, from injury or spoilation of all timber, mineral deposits, natural curiosities or wonders... and their retention in their natural condition". As a result of this act and subsequent legislation, the park has been managed as a natural area[1] so as to conserve, perpetuate, and portray as a complete ecosystem the indigenous biota, geology and scenic landscape. It is significant that fishes stand alone as the single component of the park ecosystem that remain exploited by man. This places fishing in direct conflict with the basic purpose of the park. Angling is a consumptive use of a portion of an ecosystem which generally causes substantial alteration of natural energy pathways.

However, in the mandate to protect the natural systems, concessions must be made to provide for public access and use. A network of roads and trails for transportation, accommodations for food and shelter, and administrative facilities must be provided. These are all

---

[1]The difference between wilderness and naturalness are subtle but real. A "wilderness" need only be wild and uninhabited by man while "natural" implies a pristine, unaltered condition where all natural processes are allowed to occur unhindered.

consumptive uses that severely impact the park, although less than one percent of Yellowstone's 890,300 hectares is permanently altered in such a manner. In this same sense, sport fishing has a 100-year precedent in the park, and anglers represent a numerically strong (and vocal) special interest group. Park administrators and fishery managers are then faced with a problem of accommodation between the primary purpose of maintaining the natural area, and continuing sport fishing as an established activity.

Efforts to achieve compatability have been evolving since 1936 and are articulated in the objectives of the current fishery management program:

> To provide for the protection, perpetuation, and restoration of the natural aquatic environments, native fishes, and the associated fauna and flora.
>
> To provide for recreational fishing by the conservative and controlled use of native and nonnative fish populations. This will be accomplished by regulations that will insure high quality fishing as part of the park experience without endangering fish populations, or impairing the wildlife, scenic, scientific, ecological and historical values of the park and their enjoyment by nonfishing visitors.

Regulations to restore or protect fishes and maintain high quality angling involve manipulating season dates, restricting baits, using creel and size limits, and designating certain species or waters for catch-and-release fishing only. Additionally, certain waters are closed to protect rare or endangered species, nesting birds, or to provide vistas for enjoyment of scenic landscapes and undisturbed wildlife (including fishes).

"High-quality angling" is defined as the opportunity to fish for rare native species or nonnative wild trout in pristine waters where angling removals do not exceed natural replenishment rates, or on a year-to-year basis, reduce fish numbers, sizes, and age groups from that which would occur in the absence of fishing.

This management approach requires a distinction between catching and killing fishes. This distinction is especially important since all fish stocking for catch-out purposes was ended nearly 30 years ago in an attempt to restore natural conditions. Wild stocks, therefore, bear the pressure of steadily increasing public fishing. Management practices have had to be innovative to keep abreast of increasing trends of parkwide fishing use, explosive increases in backcountry visitation, and growing interest in "specialized" angling, such as fly fishing.

Historical Perspective

Prior to the creation of the National Park Service in 1916, the U. S. Army had jurisdiction over Yellowstone and relied on the U. S. Fish Commission (USFC) for advice on fishery matters. The Commission was basically a fish culture and distribution entity, and a harvest-oriented agency with little interest in "preservationist" attitudes. USFC began field work in 1889 and by 1899 had established the first of three fish cultural stations in the park. Early fishery management was based on the personal whims of the Army officers and USFC culturists. Fish culturists thought that stocking could completely replace natural reproduction and insure heavy creels. In cooperation with the Army, they planted much of the 40 percent of the Park that was originally fishless due to the presence of waterfalls which prevented natural upstream emigration of fishes. They also stocked nonnative or exotic fishes from Europe and parts of North America into waters that already sustained healthy native populations.

During the expansion period for fisheries (from 1889 to the 1930's), practically anything suggested was acceptable and turned out to be very costly in terms of native fish extinctions, the loss of pristine environments, and the very concept of naturalness.

Somewhat belatedly, park administrators became concerned about the effects of stocking nonnative species into native trout and grayling populations. This concern led to the development of the first stocking policy in 1936, which stated:

1. Nonnative fish shall not be stocked into waters containing native fish.

2. Propagation and stocking of native species shall be encouraged.

3. Distribution of nonnative fish species shall not be expanded.

4. No artifical lake or stream improvements shall be made.

5. Introduction of nonnative aquatic fish food organisms shall not be made.

6. Selected waters shall be left barren of fish.

At the time, this was a radical fisheries policy, but in terms of natural area management, it was a significant improvement.

Between the 1930's and 1960's, this policy remained in effect, but sport fishing continued to be managed for the greatest possible harvest. Although unstated, park fisheries were managed under the philosophy of "maximum sustained yield" (MSY); a concept which sets as a goal and a restraint a harvest at the highest average catch that can be taken from a population under given environmental conditions. In achieving MSY, a population would be reduced substantially from the virgin condition, and anglers would find their catch per unit effort substantially less and with fewer large fish in their creels than at some other time in history. Exceeding MSY in combination with fluctuating environmental conditions often causes a recruitment failure and the population decreases to a fraction of its original size. If exploitation continues, such populations respond slowly, if at all, from such collapses. By 1968, the harvest of cutthroat stock in Yellowstone Lake, the park's largest and most famous fishery, had exceeded its calculated MSY (Benson and Buckley 1963) in at least five different years, and collapsed (Gresswell and Varley, in review). The situation on Yellowstone Lake was not unique; fish populations in many of the Park's other waters were also at historic lows.

To correct these abuses and restore damaged populations, park personnel chose more restrictive regulations as being the most palatable alternative. Reductions in creel limits had been the most popular conservation measure for decades. Creel limits were originally unlimited in the park and, on Yellowstone Lake, were gradually reduced to five fish per day in 1948; three fish in 1953; and two fish in 1970. These creel adjustments had little direct effect on annual harvests. Smaller creel limits reduced angler use and effort for one to three years following the change, which in turn reduced harvests, but the effect was always temporary. Similarly, past experience with tackle restrictions, minimum size limits, and zone closures showed they either had neutral or negative effects on populations. In the long term, the most probable reason these regulations had little positive effect was because of "unlimited entry" of fishermen into the fisheries. As a fairly consistent fraction of the total number of park visitors, the population of fishermen has doubled about every 20 years since 1940, a rate that is projected to continue.

Given this reality, regulatory options to restore trout populations while allowing for sport fishing are few: limiting the number of fishermen, limiting the hours they are allowed to fish, reducing the fishing season, or fishing on a catch-and-release basis only. Because the visitor season in the park is only about 90 days, limiting the number of anglers (restricting permits), limiting the number of days or hours they can fish, or shortening the season discriminates against large segments of the public. Catch-and-release regulations discriminate against people who want to kill fish, but unlike the other options, still gives them the choice of whether to fish or not.

Since 1973, catch-and-release regulations have been used increasingly to restore trout populations. It was thought that optimum sport fishing could be maintained at current or higher levels of use if trout stocks were at population densities well above MSY levels, if fish were caught and released with comparatively few individuals being intentionally killed.

The principal objective of the catch-and-release program has been to enable compatability between the activities of fishermen and nature. In retrospect, both the Yellowstone ecosystem and anglers have substantially benefited. In general, catch-and-release regulations have improved population numbers and age/size structure over that which occurred in the past 40 years, and by accepted measures of angling quality, provided recreational fishing superior to that which existed before the restrictions.

Park Fisheries

In recent years, the National Park Service at Yellowstone has issued about 200,000 free fishing permits per year; more licenses than 12 states in the USA. Anglers make up a composite group from all fifty states, all Canadian provinces and numerous foreign countries, although the largest single segment (approximately 25 percent) are from states surrounding the park. Recent annual use has ranged between 250,000-400,000 angler-days, and effort between 600,000-1,000,000 angler-hours. Cutthroat trout populations in Yellowstone Lake and River make up about two-thirds of the parkwide use. The remaining one-third is spread over approximately 45 lakes and 500 streams. Average landing rates (all fish creeled plus those captured and released) have averaged about one fish per hour for approximately 130 park fisheries. Creel rates (harvested only) have been much lower, averaging about 0.2 fish per hour.

Representing 70 percent of the total fish landed are three subspecies of native cutthroat trout, *Salmo clarki*; the abundant Yellowstone subspecies, *S. c. bouvieri*; and two less common forms, the westslope cutthroat trout, *S. c. lewisi*, and the finespotted Snake River cutthroat trout (unnamed subspecies).

Yellowstone Park has one species of fish, the Montana grayling, *Thymallus arcticus montanus*, and over a dozen waters restricted to catch-and-release only. A number of other waters, including Yellowstone

Lake, are partially catch-and-release as a result of maximum or minimum length limits.

Sport Fishing Quality

As generally accepted in Yellowstone the past 10 years, angling quality has included three basic elements: setting, action and size. Pristine waters and forests, and angling for wild fish in relatively uncrowded environments form the setting, and are somewhat of a given in the national park.

To establish what constitutes a satisfying trip to fishermen in terms of numbers of fish landed and sizes caught, which according to Brown (1968) were the two most important factors in quality trout fishing, we interviewed over 20,000 anglers in the late 1970's after they had completed fishing in the park. Voluntary, anonymous responses were returned by mail from anglers fishing virtually all park waters, both catch-and-release and catch-and-keep fisheries, in the approximate proportion each fishery was used.[2]

Not surprisingly, the results indicated that the percentage of individuals expressing satisfaction with their park angling experience steadily increased, although at a decreasing rate, as the numbers and sizes of fish landed increased (Figures 1 and 2).

---

[2]Although the results of some responses on these lengthy mail questionnaires indicated a need to correct for nonresponse bias, the responses to other questions indicated a high degree of agreement between personal interviews and the mail form. As it was impossible to test the satisfaction indices in that fashion, at that time, the results given here are uncorrected for nonresponse bias, if any.

Angler satisfaction increases dramatically with the first several fish landed, starts to level off after the third fish, and levels further after six to eight fish are landed. Note that 18 percent of the respondents were satisfied with their trip even though they landed no fish. Although angler satisfaction increases dramatically with first fish caught, optimum levels begin when the third fish is landed, where about 80 percent of anglers expressed satisfaction.

In the relationship of angler satisfaction to fish size, a minimum acceptable length of about 178mm is indicated, followed by a near linear increase to 292mm, and a decreasing curvilinear rate thereafter to 533mm (the largest size listed on the questionnaire). Although the notion of "bigger is better" prevails, optimum fishing may begin in the area of the break on the curve, where average fish size ranges between 300-350mm, and where one-half to two-thirds of the fishermen expressed satisfaction.

The satisfaction that is derived from a fishing trip is admittedly much more complex than defined here (e.g. see Wydoski's 1977 review). However, examining Yellowstone's sport fisheries using these relationships provided a benchmark from which to measure differences or changes in angling quality (e.g. species differences and regulation changes).

stock quality
8 - 12

7 inches
11.5 inches

Sport Fish Vulnerability

With the possible exception of a brook trout population, each species of trout in Yellowstone reacted similarly to catch-and-release regulations in that population numbers increased in concert with a greater frequency of older and larger fish. However, these more robust populations have not always shown to improve sport fishing quality, as the response of each species to angling was very different (Varley 1980).

The cutthroat trout responded especially well to restrictive regulations, particularly catch-and-release only rules, for a variety of reasons: the species has a very low release mortality (Hunsaker et al 1970, Marnell and Hunsaker 1970), recently estimated to be as low as 0.3 percent mortality per single capture for Yellowstone River trout (D. Schill and J. S. Griffith, person communication, 1983), and longevity ranging up to 11 years (Gresswell 1980). Perhaps equally important was the depressed status of many park populations, which with any significant reduction in harvest would produce improvements with dramatic statistical results.

The evidence obtained in Yellowstone seems to suggest that the primary reason cutthroat trout populations are so susceptible to overharvest (and even extinction over much of their original range) is due to their extraordinary vulnerability to angling. Excess harvests are most obvious in waters where they are the lone sportfish, such as

Yellowstone Lake and River. Unlike the reduced fishing effort that might typically be expected following a collapse in a single species fishery, this vulnerability is more insidious in mixed species fisheries where effort does not necessarily decline. Here the gradual disappearance of cutthroat trout from waters in which multiple species are present appears to be a result of their removal at consistently higher rates than other sport fish (McPhee, 1966).

The vulnerability of cutthroat trout in relation to other Yellowstone species can be compared in a theoretical way by combining actual differences in catchability with angler exploitation data related by Behnke (1978) (Figure 3). This generalized model demonstrates the relative ease with which cutthroat trout populations can be depleted by relatively low fishing effort. The model may even be conservative; the population in Yellowstone Lake collapsed after years of effort in the range of 10-14 hours per hectare per year, although a spawn-taking operation contributed to the decline (unpublished data of R. E. Gresswell and J. D. Varley).

The important point to be made is that there are significant differences in the vulnerability of species to sportfishing. Highly catchable, late maturing and long-lived species, like the cutthroat trout, require a much higher level of protection than less catchable and/or early maturing species.

Yellowstone River Case History

A largely roadside 14.5km section of the Yellowstone River provides a fascinating and fairly typical example of the effect of a catch-and-release only regulation on a cutthroat trout population. Prior to the 1973 regulation change, this heavily-fished section sustained between 40,000-50,000 angler-days use in about a 45-day period (Table 1). In the first year of catch-and-release, use dropped by 44 percent (Figure 4). The regulation change was undoubtedly part of the reason for the decline, but a general drop in parkwide visitor use was also a factor. By 1981, angler use had recovered and exceeded that measured prior to the regulation change (Table 1, Figure 4).

Coincident with the decline in fishermen on the Yellowstone River was increased use on park catch-and-keep fisheries. The conclusion reached (Varley 1980) was that catch-and-release regulations on several fisheries in 1973 caused a significant redistribution of anglers in the park, but the total parkwide use continued its almost annual increase.

Catch-per-unit-effort (CPUE) on cutthroat trout, which averaged about 0.5 trout per hour between 1951-72, jumped sharply up in 1973-74, and steadily declined thereafter (Figure 5). Although an inverse relationship between angler use and CPUE is apparent (Figures 4-5), it is significant that the CPUE in 1981 was double that observed in 1951-72 despite increases in angler use (up 8 percent) and effort (up 31 percent) (Table 1, Figure 5). In 1981, 2.6 trout were landed per angler-day. Fitting this value to the parkwide relationship between angler satisfaction and the numer of trout landed predicts a satisfaction rate of 78 percent. The actual percentage measured in 1981 was 75 percent.

Perhaps more importantly, a substantial number of fishermen have been added to the "successful" angler category. In 1967, for example, 33 percent of the fishermen landed one or more trout per trip whereas in 1981 the figure was 67 percent.

The effect of catch-and-release only policy on trout size and age is substantial (Varley 1980). Cutthroat trout spawners sampled annually between 1974-81 at LeHardy's Rapids showed significant increases in average age and size and in the frequency of "trophy" size trout in the population (Figure 6). Similarly, the average size of trout landed by anglers in 1981, 391mm, was substantially larger than the mean size measured in creels between 1951-72 (Table 1). Fitting the 391mm average size to the parkwide relationship between angler satisfaction and fish size (Figure 2) predicts a satisfaction rate of 77 percent. The actual percentage measured in 1981 was 86 percent, probably close to the maximum angler satisfaction that can be achieved in any park fishery.

Economic Value of Wild Cutthroat Trout

The short 14.5km section of the Yellowstone River, its wild cutthroat trout population, and its catch-and-release fishery can provide a revealing example of the relative value of a wild fish in economic terms. Using a simplistic economic "model", termed here "avoided fish hatchery costs", the potential replacement costs of the 1981 river fishery can be computed.

The costs of various sizes of hatchery-reared fish were determined using a curve (Figure 7) fitted to data on actual transactions between public and private buyers, and sellers from the southern Idaho commercial trout industry in 1982 (the costs of fish produced in public hatcheries are reportedly comparable).

As previously mentioned, the average size of cutthroat trout landed from the Yellowstone River in 1981 was 391mm. To buy a trout of this size for a catch-out fishery would cost approximately $1.55 per fish (Figure 7). Thus, it is possible to assume that the first time the 391mm cutthroat trout was caught, it was worth about $1.55 in "avoided fish hatchery costs".[3]

---

[3]There are other obvious costs/values that are being ignored in this economic discussion, e.g. the hatchery fish has a "meat" value that the released cutthroat trout does not, and the wild fish are not "free"; there are relatively small administrative, law enforcement, and fish management costs on a per fish basis. None of these factors are considered large enough to affect the basic premise stated.

Recalling this species' extraordinary vulnerability (Figure 3), recent research (D. Schill and J. S. Griffith, personal communication, 1983) has shown that this same 391mm trout is likely to be caught and released ten times during the season, an average of once every five days. Therefore, in avoided fish hatchery costs, the first summer's value of this fish is $15.50. Given an average estimated 3-year catchable life, the computed value is $46.50 per cutthroat trout.

The value of the entire 1981 fishery can also be estimated, based on 127,100 separate "catches" of trout averaging 391mm in length. At $1.55 per capture, the fishery represents a potential value of $197,000 for the year.

Based on several recent transactions in the western USA, a public or private production hatchery large enough to provide a catch-out fishery of this proportion would cost approximately $2,339,000 to construct and require an annual operations/maintenance budget of about $171,600. Depreciating this hatchery over a 30-year useful life gives an average annual cost of $180,000.

Of course, the big flaw in this simple economic argument is that an equivalent fishery could not be reproduced. Ignoring the park setting, its aesethetics, wild trout, and all of those other intangibles that make a fishing trip pleasurable, the simple fact is that a public agency charging $8, $10, or even $20 per year for a trout fishing license cannot afford to raise 391mm cutthroat trout for the creel at $1.55 each.

It seems logical to conclude that this modestly sized, low cost cutthroat fishery produces angling recreation equivalent (or better) to the expensive trout hatchery. It has always been the relatively low-cost wild fisheries used by license buyers that have subsidized and made possible many of the more expensive trout programs, such as put-and-take fisheries. In this perspective, it would seem to be in the long-term interest of both sport fishermen and managers to do all that is possible to preserve remaining wild populations.

Acknowledgements

I thank J. S. Griffith Jr., J. Martin, and one anonymous reviewer for their thoughtful review comments. D. Schill and J. S. Griffith graciously provided me with prepublication results of their work concerning the recatchability of Yellowstone River cutthroat trout. Other results were provided by the U. S. Fish and Wildlife Service technical assistance staff in Yellowstone National Park. This work was funded by the U. S. Fish and Wildlife Service and the National Park Service.

Table 1. Fishery statistics for the portion of the Yellowstone River placed under catch-and-release only regulations in 1973. An average value for 1951-1972 is given as representative of the era before the regulation. The values measured in 1981 are presented as the typical post-regulation condition.

	Average 1951-1972	1981
Angler use (days-trips)	45,000	48,800
Total effort (angler hours)	87,500	126,800
Catch-per-unit effort (fish per hour)	0.5	1.0
Length of angler day (hours per trip)	1.9	2.6
Trout creeled	29,900	1,800 [1]
Angler days per kilometer	3,100	3,370
Angler hours per hectare	440	630
Average size cutthroat trout landed (mm)	343	391

[1] Illegal catch.

Figure Captions

Figure 1. The relationship between anglers satisfied with their fishing experience and the number of fish they landed, Yellowstone National Park.

Figure 2. The relationship between anglers satisfied with their fishing experience and the size of fish landed, Yellowstone National Park.

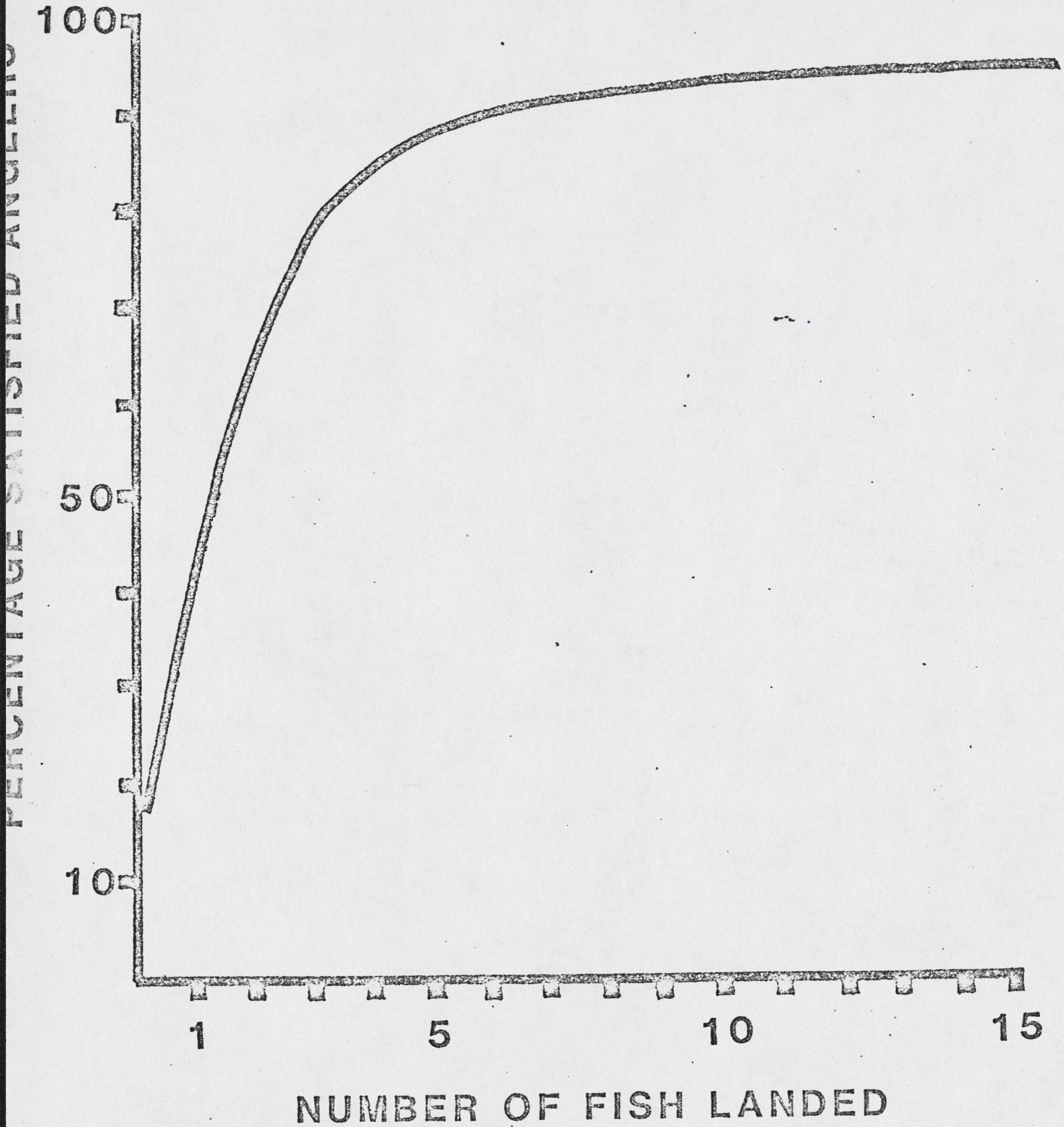
Figure 3. Differences in the susceptability of Yellowstone sport fish species to angling and a hypothetical model of how vulnerability relates to angling effort and the proportion of the population removed.

Figure 4. The pattern of angler use on a portion of the Yellowstone River placed under catch-and-release only regulations in 1973.

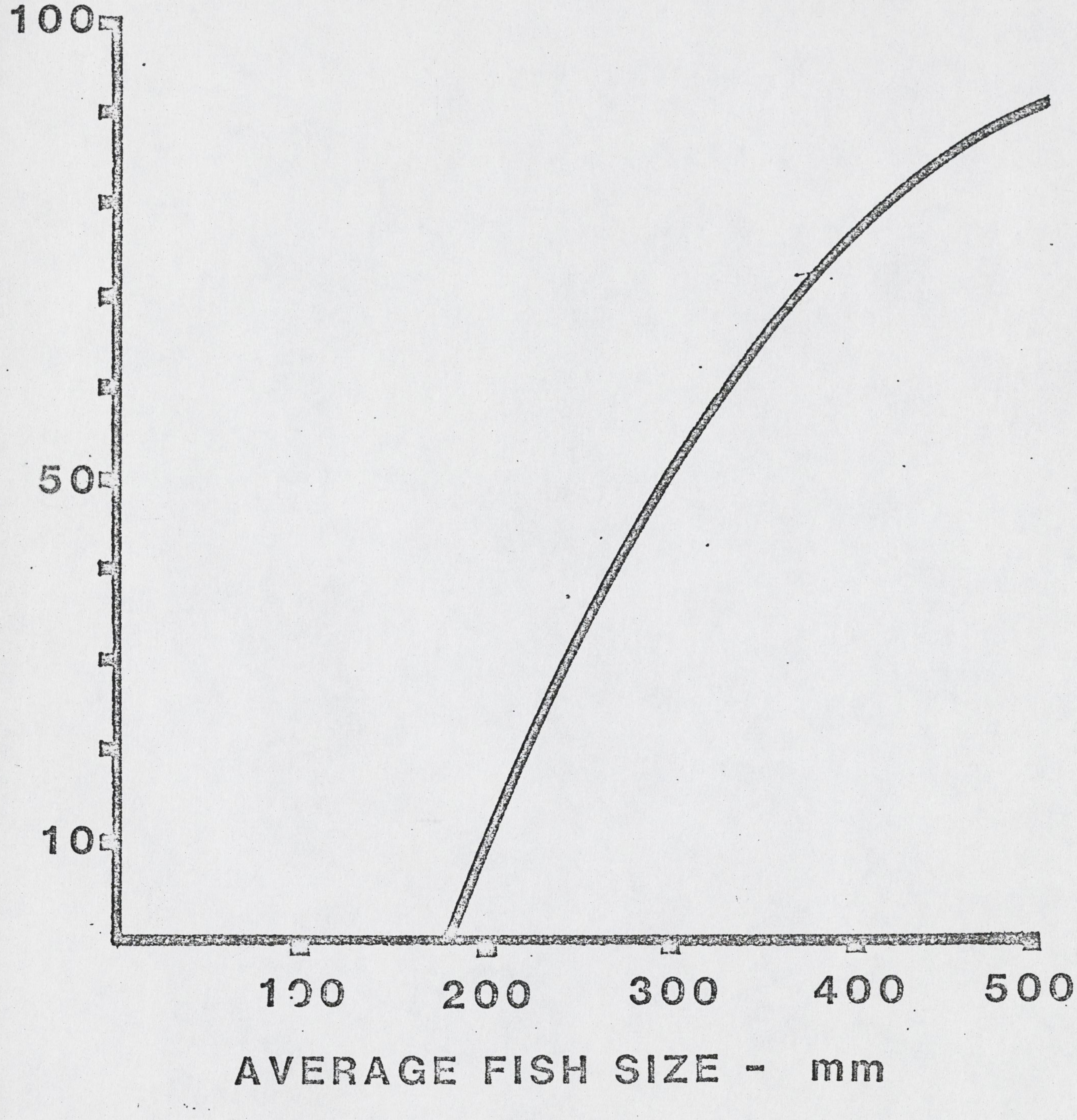
Figure 5. The pattern of catch-per-unit effort on a portion of the Yellowstone River placed under catch-and-release only regulations in 1973.

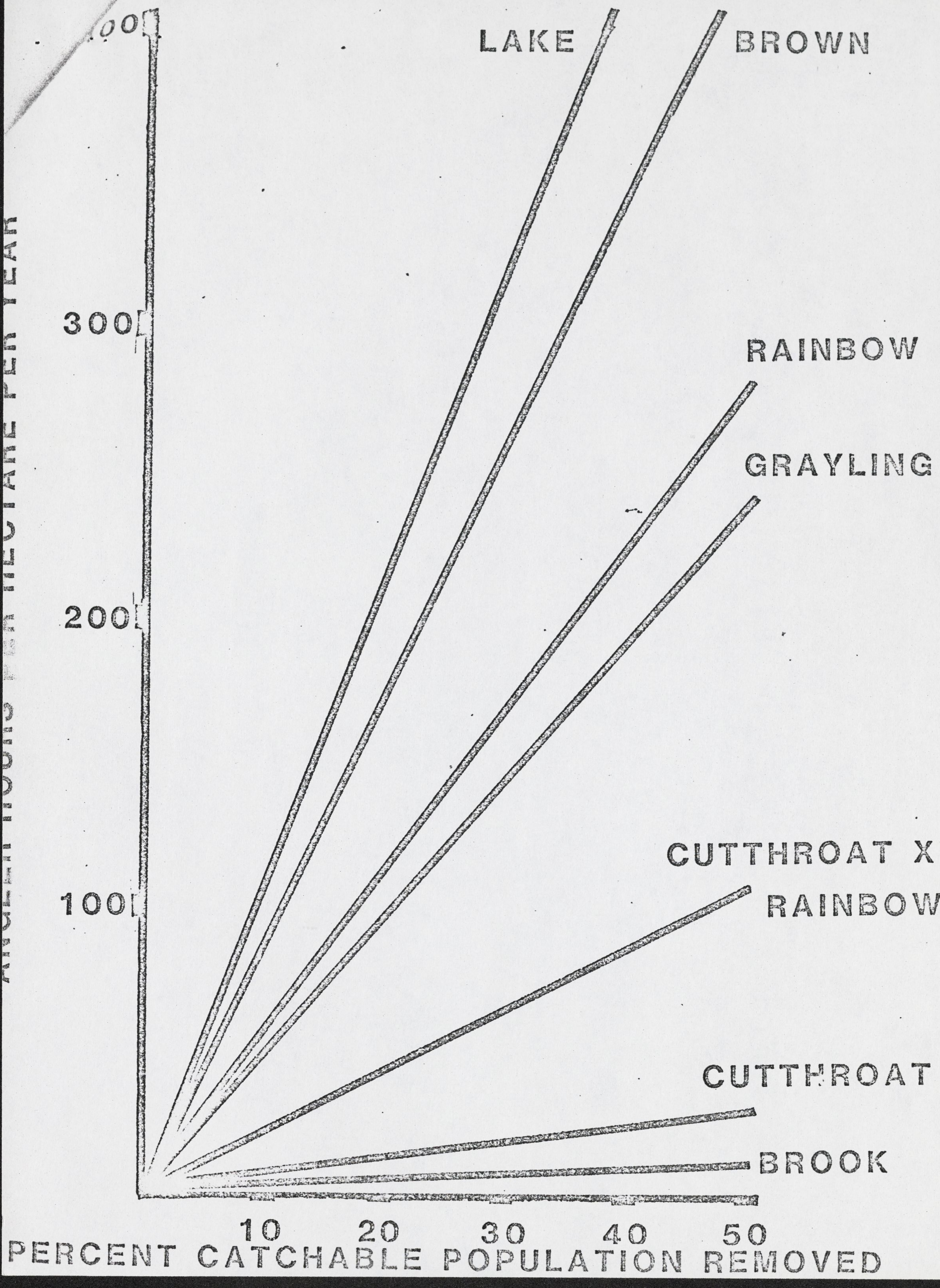
Figure 6. Changes in the age and length of cutthroat trout spawners following implementation of catch-and-release only regulations in 1973.

Figure 7. The relationship between trout size and the cost per delivered trout, as observed in the southern Idaho commercial trout industry 1981-1982.

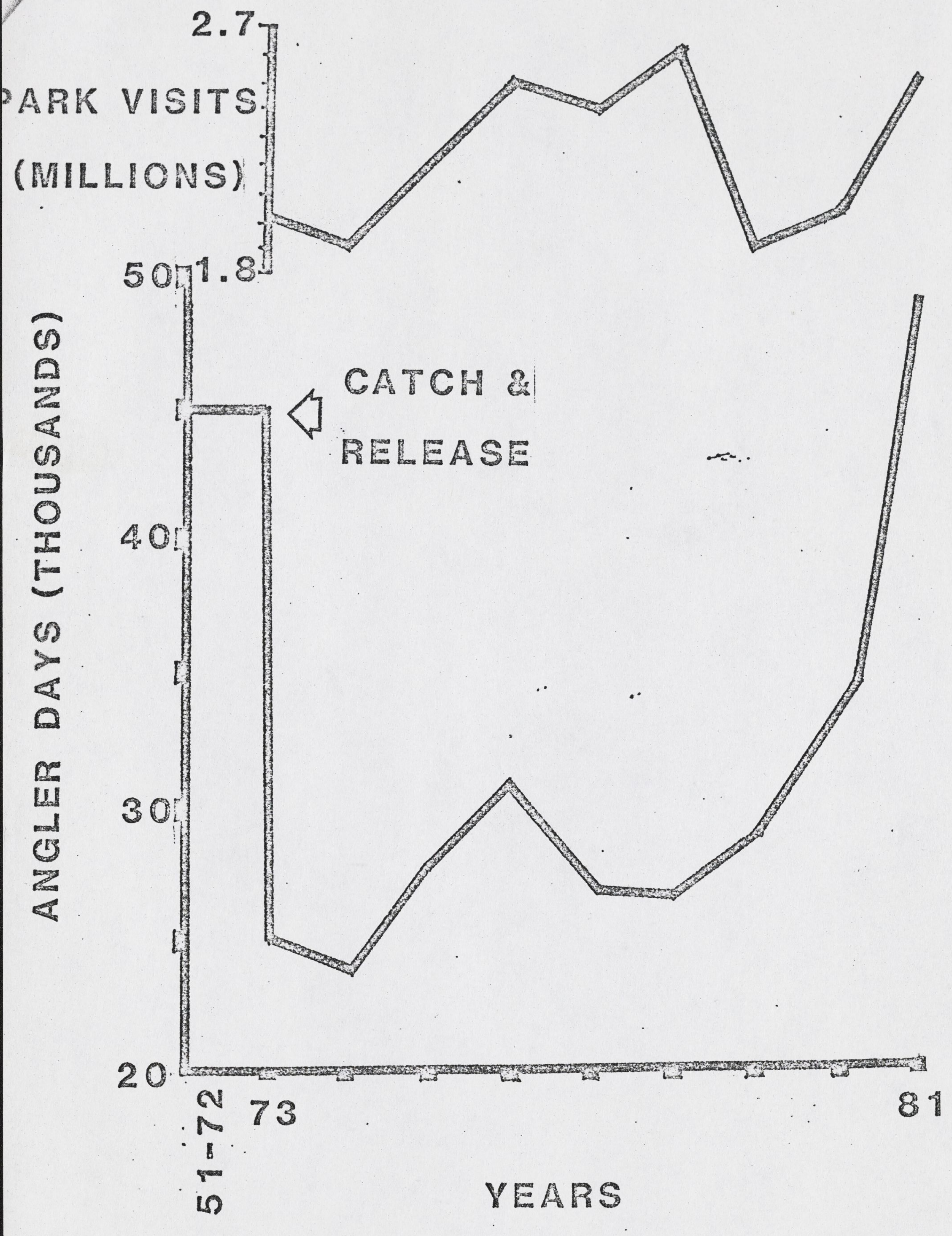


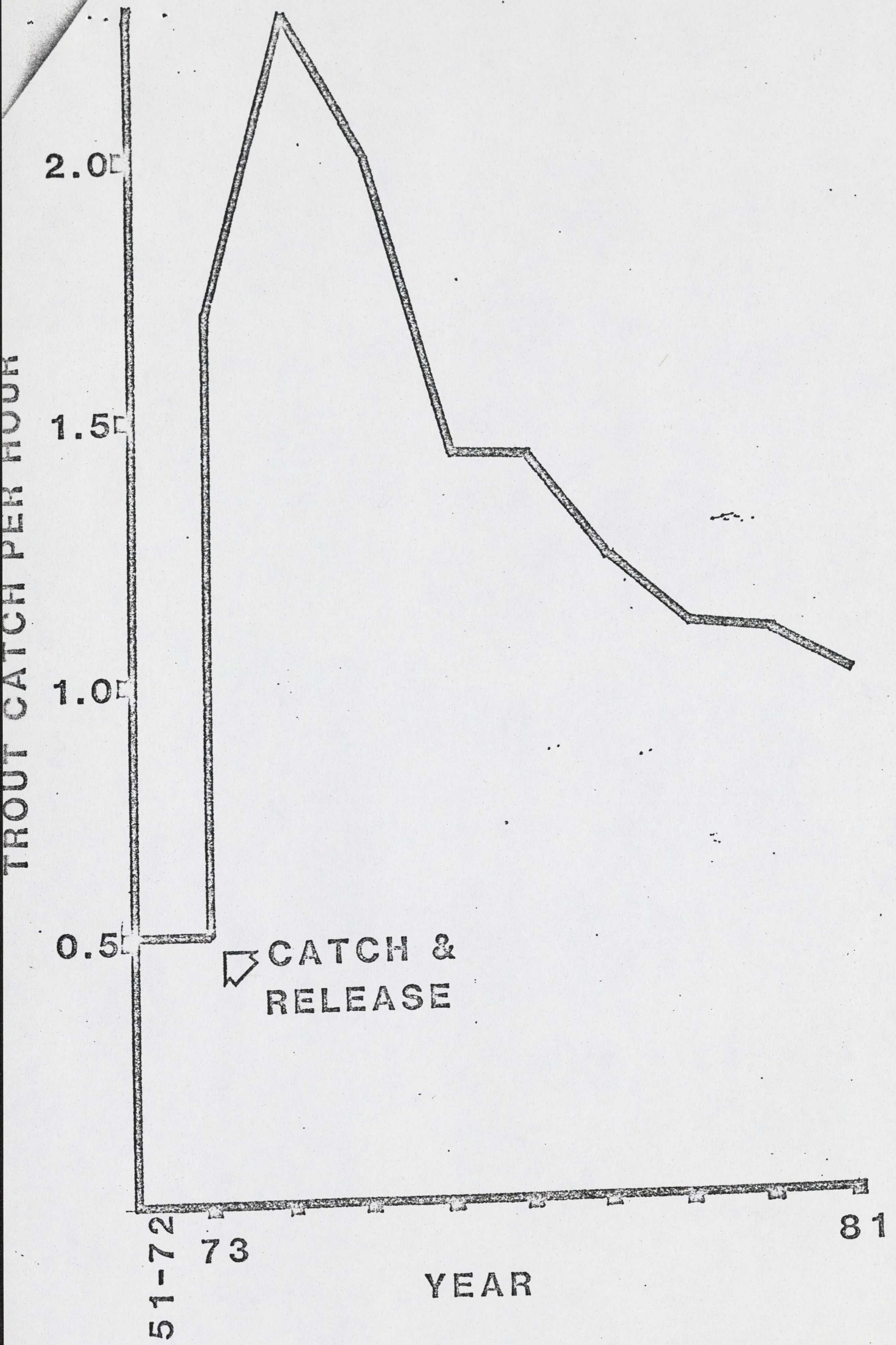
PERCENTAGE SATISFIED ANGLERS
100
50
10
1
5
10
15
NUMBER OF FISH LANDED


100
50
10
100
200
300
400
500
AVERAGE FISH SIZE - mm

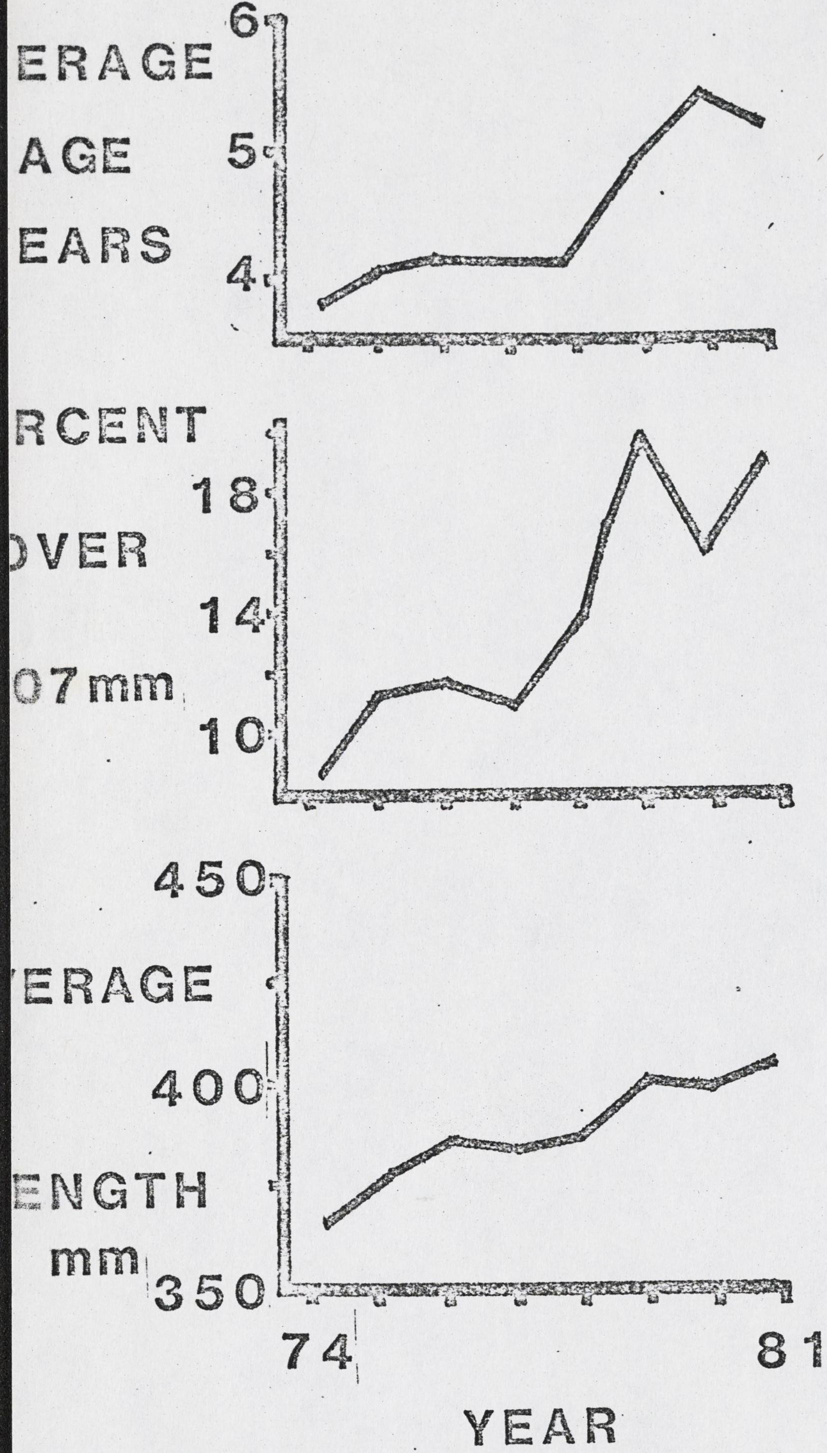


400
300
200
100
ANGLER HOURS PER HECTARE PER YEAR
LAKE
BROWN
RAINBOW
GRAYLING
CUTTHROAT X
RAINBOW
CUTTHROAT
BROOK
10
20
30
40
50
PERCENT CATCHABLE POPULATION REMOVED

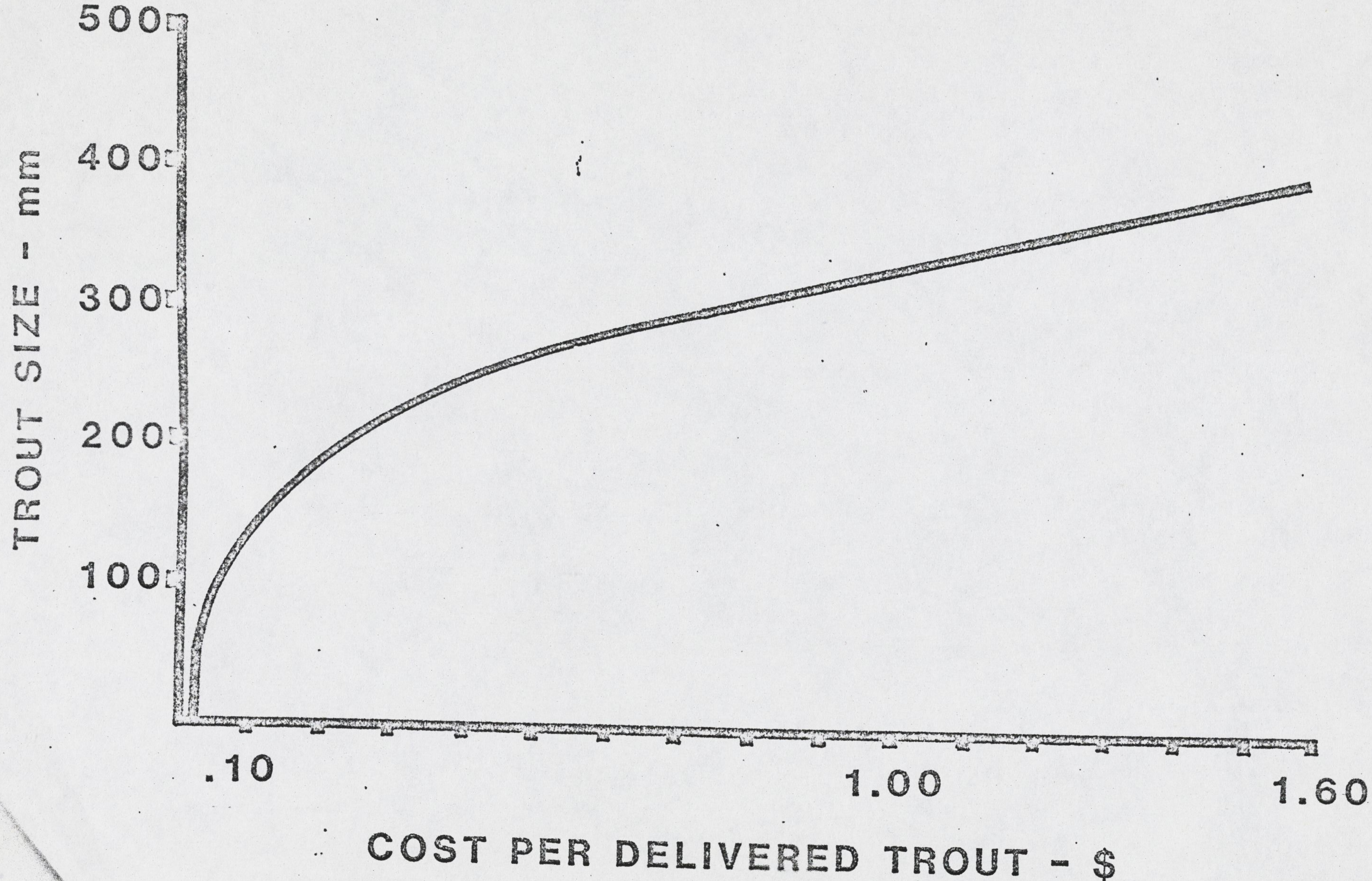

2.7
PARK VISITS
(MILLIONS)
1.8
50
40
30
20
ANGLER DAYS (THOUSANDS)
CATCH &
RELEASE
51-72
73
81
YEARS



TROUT CATCH PER HOUR
2.0
1.5
1.0
0.5
CATCH & RELEASE
51-72
73
81
YEAR



ERAGE
AGE
EARS
6
5
4
RCENT
OVER
07mm
18
14
10
450
ERAGE
400
ENGTH
mm
350
74
81
YEAR



500
400
300
200
100
TROUT SIZE - mm
.10
1.00
1.60
COST PER DELIVERED TROUT - $

[ca 1985]

Dr.

I thought you might find some interest in this — Leo

Note Lewis River – highest catch rate — approximately 2400 hrs total pressure = 480/km or 128/ha

Madison River – 50,000 hrs total ≈ 1250/km or 281/ha

The Riverine Browns of Yellowstone

The first stocking of brown trout *Salmo trutta* in the waters of Yellowstone National Park (YNP) occurred in 1889 when approximately 1,000 Loch Leven browns were put in the Firehole River. In 1890, 3350 Loch Leven brown trout were stocked in Lewis Lake and 9,800 Von Bauer browns were put in Nez Perce Creek. From 1889 through 1955 (cessation of fish stocking activities), over 5 million brown trout were stocked in Yellowstone Park. These fish were generally distributed in the Madison, Snake (Lewis), and Yellowstone (Gardner) River drainages. The present range of brown trout in Yellowstone National Park includes significant populations in eight rivers: Firehole, Gallatin, Gardner, Gibbon, Lewis, Madison, Snake, and Yellowstone. These rivers constitute the riverine brown trout fisheries of Yellowstone National Park (Table 1).

Firehole River

Almost 17,000 days of angler use are spent each year fishing on the Firehole River. This river supports the 3rd most popular stream fishery in YNP. Prior to 1889, the Firehole River above Firehole Falls was fishless. Since 1951, fishing gear has been restricted to artificial flies with a single hook. Harvest has been restricted to two fish longer than 16 inches since 1970.

where you J. ... a lot

Based on angler statistics calculated from the Volunteer Angler Report (VAR), the average catch rate for brown trout on the Firehole River is 0.33 fish/hour, or it requires an average angler 3 hours to catch one brown trout (Table 1). Over 15,000 brown trout are caught in the Firehole each year. Only 4% of the fish caught are creeled (kept) each year, however, anglers tend to favor keeping the larger fish. Over the last 5 years, anglers kept

[ca 1985]

The Riverine Browns of Yellowstone

The first stocking of brown trout Salmo trutta in the waters of Yellowstone National Park (YNP) occurred in 1889 when approximately 1,000 Loch Leven browns were put in the Firehole River. In 1890, 3350 Loch Leven brown trout were stocked in Lewis Lake and 9,800 Von Bauer browns were put in Nez Perce Creek. From 1890 through 1955 (cessation of fish stocking activities), over 5 million brown trout were stocked in Yellowstone Park. These fish were generally distributed in the Madison, Snake (Lewis), and Yellowstone (Gardner) River drainages. The present range of brown trout in Yellowstone National Park includes significant populations in eight rivers: Firehole, Gallatin, Gardner, Gibbon, Lewis, Madison, Snake, and Yellowstone. These rivers constitute the riverine brown trout fisheries of Yellowstone National Park (Table 1).

Firehole River

Almost 17,000 days of angler use are spent each year fishing on the Firehole River. This river supports the 3rd most popular stream fishery in YNP. Prior to 1889, the Firehole River above Firehole Falls was fishless. Since 1951, fishing gear has been restricted to artificial flies with a single hook. Harvest has been restricted to two fish longer than 16 inches since 1970.

where you fish matters a lot

Based on angler statistics calculated from the Volunteer Angler Report (VAR), the average catch rate for brown trout on the Firehole River is 0.33 fish/hour, or it requires an average angler 3 hours to catch one brown trout (Table 1). Over 15,000 brown trout are caught in the Firehole each year. Only 4% of the fish caught are creeled (kept) each year, however, anglers tend to favor keeping the larger fish. Over the last 5 years, anglers kept

31% of the brown trout caught between 16-18 inches, and 98% of the captured brown trout between 18-20 inches. Only 3% of all fish caught in the Firehole River are longer than 16 inches. At this percentage, the Firehole River ranks 7th of the eight rivers in terms of catch rate of large fish. To determine why such a large percentage of fish caught in the Firehole River are less than 16 inches, a study to estimate hooking mortality, longevity, and distribution of these fish will be initiated in 1986.

Gallatin River

Few anglers pursue brown trout on the Gallatin River compared to other park waters. No official record of the stocking of brown trout in the Gallatin River exists. However, anglers report catching an average of about 1,200 brown trout in the river each year (Table 1). Generally, 4 hours of fishing are required to catch one brown trout. About 10% of these fish are longer than 16 inches. On the average, 150 or 13% of brown trout that are caught each year are creeled. Of these, approximately 30% are 16 inches or longer.

To this date, the fish populations inhabiting the Gallatin River have not been sampled by fishery personnel in YNP. As part of the stream survey program, however, most of the tributaries to the Gallatin River have been surveyed and in the near future the Gallatin River itself will be closely evaluated.

Gardner River

Brown trout inhabit the Gardner River from Osprey Falls downstream to the Yellowstone River. During the fall, brown trout from the Yellowstone River migrate as far as 40 miles to spawn in this stream. Loch Leven brown trout were first stocked in the Gardner River in 1930. Since 1973, brown trout harvest in the Gardner River has been limited to two fish. Further, since 1979, the river between Mammoth and North boundary has been occassionally closed to fishing between 1 September and 31 October to protect spawning fish.

Anglers generally have better success at catching brown trout in the Gardner River than in most of the other park waters (Table 1). On average, 2 hours of fishing are required for each trout caught. Approximately 3,900 brown trout are caught in the Gardner each year. Of these, only 1% are 16 inches or longer. This river also has the highest creel rate of all the brown trout fisheries (0.06 fish/hour). Almost 450 or 12% of the caught fish are creeled.

No explanation is available at this time for the low percentage of fish caught in this river that are longer than 16 inches. One plausable explanation is that the main use of the Gardner River by brown trout could be as a spawning and rearing area. Large fish from the Yellowstone River enter the Gardner to spawn and leave soon after. Since the spawning period is generally closed to fishing, anglers do not catch these large fish. We are currently evaluating the Gardner River as a spawning tributary and as holding habitat for larger fish. We hope to have some answers soon.

Gibbon River

The Gibbon River is very similar to the Firehole River. Approximately 12,000 days of angler use are spent each year fishing on this stream; making it the fourth most popular stream fishery in the park. Brown trout were first stocked in the Gibbon river in 1928 when 43,000 Loch Leven browns were introduced. It is feasible that brown trout inhabited the section of the

Gibbon River below Gibbon Falls (Lower Gibbon River) earlier than this date since brown trout were stocked in the Firehole River in 1889. Since 1970, the Lower Gibbon River has been managed with a 14-inch minimum length 2-fish creel limit. The Upper Gibbon River (above Gibbon Falls) has had a harvest restriction of two fish any size since 1973.

Anglers generally catch 5 brown trout for every 2 hours of effort on the Gibbon River (Table 1). During the fishing season about 11,500 brown trout are caught each year in this river. Almost 4% of these fish are longer than 16 inches. Similar to the Firehole River, anglers tend to keep a higher percentage of larger than smaller fish. The percentage of caught fish that are creeled, however, has been almost 2 times higher in the Gibbon River than Firehole River. The number of fish creeled per hour of angling is also higher in the Gibbon River.

To investigate the factors responsible for the low percentage of fish caught by anglers longer than 16 inches, fish population estimates were initiated in the Gibbon River in 1985. Results at this initial analysis will be forthcoming in our 1986 annual report.

where you fish matters a lot

Lewis River

Brown trout have probably inhabited the Lewis River since the 1890's. Although there is no official record of brown trout being stocked in the Lewis River, Lewis Lake was stocked with brown trout in 1890. Almost 4,500 angler days are spent each year fishing the Lewis River. Since 1973, the Lewis River from Lewis Falls downstream has been managed under catch and release regulations. This section of river supports the only brown trout fishery in YNP managed under catch and release regulations.

The roadside section of the Lewis River managed under catch and release

wrong caller

fishing maintains the highest catch rate for brown trout in the park (Table 1). On average, each angler catches 3 brown trout for every 4 hours of effort. Fishing pressure in this area has been relatively low and anglers catch about 1,800 trout each year. This stream also maintains a brown trout population that provides anglers with large fish. Almost 21% of the fish caught by anglers are longer than 16 inches. Further, 3% of the fish caught are 20 inches in length or longer. Illegal harvest has been reported, however, it is insignificant.

In 1984, we performed population estimates on this section during the spring and fall. The percentage of fish longer than 8 inches in the population estimates averaged 10%. Based on our estimates, these fish are caught and released three times during a fishing season. We speculate that the number of large fish in this section of the Lewis River may be limited by fish habitat. Although the catch and release regulation has not been as effective at improving the quality of this fishery, as it has been in cutthroat trout populations in YNP, it appears to be providing protection for long fish. Further analysis of the relationships between fish habitat, fish size, and fishing pressure in the Lewis River will be completed soon.

Madison River

The Madison River supports the most popular brown trout fishery in YNP. Like the Firehole, Gibbon, and Lewis Rivers, brown trout have inhabited the Madison River since the 1890's. Native sport fish to the Madison River are the grayling, westslope cutthroat trout, and mountain whitefish. The grayling and westslope cutthroat trout have virtually been replaced by brown and rainbow trout. Since 1951, fishing gear has been restricted to artificial flies with a single hook. Harvest has been restricted to two fish longer than 16 inches since 1970.

Angler spend an average of 50,000 hours fishing the Madison River each year. These anglers catch about 17,500 brown trout at an average catch rate of 0.35 brown trout/hour (Table 1). Approximately 25% of the brown trout caught (4,375) are 16 inches in length or longer and 16% (720) of these fish are creeled. Almost 280 illegal size fish (less than 16 inches in length) are creeled each year. Similar to the Firehole and Gibbon Rivers, anglers tend to creel a higher percentage of the largest fish caught.

Since 1984, we have been investigating the Madison River fishery. Sample stations were established on two sections of the river: National Park Meadows and the Barns. Preliminary results from these surveys indicate that most brown trout longer than 16 inches were located in the Barns section. Approximately 23% more 16 inch brown trout inhabited the Barns than National Park Meadow section. Over 21% of the brown trout in the Barns section and 7% of the brown trout in the National Park Meadows section were longer than 16 inches. This dissimilarity in the size distribution of brown trout in the two areas might be attributed to differences in fish habitat or angler use. In 1981, it was recommended that brown trout and mountain whitefish in the Madison River be managed under a maximum size restriction and rainbow trout be managed under a catch and release regulation; however, these regulations have never been implemented. With the new information we are currently collecting on the Madison River, we are carefully evaluating the need for such regulations. Revised recommendations will be forthcoming in the near future.

Snake River

Brown trout may be found in the Snake River from the park boundary upstream to the Heart River confluence. No official record exists for the stocking of brown trout in the Snake River within YNP. Their presence here, has probably resulted from migrations out of the Lewis River. Since 1973, brown trout in the Snake River have been managed under a two fish any size creel limit.

About 1,100 days of angler use are spent each year fishing on the Snake River making this location one of the least popular brown trout waters. The average catch rate for brown trout here is 0.26 fish/hour (Table 1). On an average year, about 800 brown trout are captured. Over the last 5 years, about 21% of these fish were longer than 16 inches and over 6% were longer than 20 inches. Almost 13% of the captured fish are creeled each year. This exploitation rate is one of the highest among brown trout waters in YNP.

Since 1983, we have been sampling the fish populations in the Snake River. Brown trout were not as frequently sampled as cutthroat trout or mountain whitefish. In June and August of 1984, captured brown trout averaged 5.6 and 5.2 inches, respectively. No large brown trout were caputred. Possibly the large brown trout reported by anglers are fish caught in the Lewis River as it joins the Snake River. We will be continuing our sampling in this area to better understand the Snake River brown trout fishery.

Yellowstone River

The Yellowstone River contains the least popular riverine brown trout fishery in YNP. Only 1,000 hours of effort are expanded each year in the pursuit of brown trout in the Yellowstone River. Brown trout are believed to inhabit the Yellowstone River from Knowles Falls downstream. However, the Yellowstone River below the Yellowstone River Falls has never been sampled by Fishery Biologists. The brown trout that inhabit this section of the Yellowstone River were probably introduced soon after the Gardner River was stocked in 1930. Since 1973, this section of the Yellowstone River has had a 2 fish any size harvest restriction.

The Yellowstone River has the highest exploitation rate of all the brown trout waters in YNP (Table 1). Over 13% of the captured brown trout are creeled each year. On an average year, about 258 brown trout are captured in the Yellowstone River. Of these, about 8% are longer than 16 inches and none are longer than 18 inches.

Table 1. Angler statistics on the capture and creel of brown trout from the major rivers in Yellowstone National Park.

Water	Brown trout caught					Brown trout creeled expressed as Percent of fish caught			
	Fish per hour	Total Number	Percent of fish			Total Number	16-18"	18-20"	>20"
			16-18"	18-20"	>20"				
Firehole River	0.33	15,280	2.50	0.52	0.14	4.12	31.41	97.47	0.00
Gallatin River	0.23	1,170	8.70	1.88	0.00	12.97	30.39	59.09	0.00
Gardner River	0.48	3,860	0.67	0.36	0.00	11.57	0.00	57.14	0.00
Gibbon River	0.40	11,500	2.24	1.15	0.35	8.94	24.12	31.82	40.00
Lewis River (roadside catch & release)	0.75	1,760	13.55	4.38	3.02	0.46	0.00	0.00	0.00
Madison River	0.35	17,500	17.81	5.46	1.98	5.79	15.23	16.11	26.30
Snake River	0.26	800	11.28	2.88	6.39	12.78	18.89	26.09	62.75
Yellowstone River (Knowles Falls downstream)	0.23	260	7.75	0.00	0.00	13.18	0.00	0.00	0.00