Summary of 1987-2001 Data from the Canyon Reservoir Tailrace with Implications for Establishment of a Put-Grow-and-Take Rainbow Trout Fishery

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ABSTRACT

The Canyon Reservoir tailrace is a 22.2-km, hypolimnetic-release tailrace trout fishery located below Canyon Reservoir on the Guadalupe River in Comal County, Texas. Because of its location in south-central Texas, water temperatures from May through October were thought to exceed lethal levels for rainbow trout (*Oncorhynchus mykiss*). Therefore, the fishery was maintained on a put-and-take basis through stockings of catchable-size trout. Survival of rainbow trout through the summer in 1966, 1993 and 1994, and anecdotal reports of oversummer survival from the public in other years, stimulated interest in a put-grow-and-take fisheries management strategy, even though extensive water temperature data had never been collected. Based on oversummer survival in these years, annual stocking of fingerlings was initiated in 1996. However, if temperature-induced mortality occurred frequently, the success of these stockings would be limited or completely negated.

Water temperature data collected from 1989 to 2001 confirmed that during most years water temperatures at the Canyon Reservoir outflow remained below the upper limit (21.1 C) recommended for a tailrace trout fishery. Oversummer survival of rainbow trout was confirmed in 8 of 9 October electrofishing surveys conducted from 1992 to 2001. However, water temperatures in the section of the tailrace > 6.3 km downstream from 1997 to 2001 often exceeded 21.1 C. Mortality of rainbow trout fingerlings stocked from 1996 to 2000 > 6.3 km from the outflow appeared to be high. During 1992 and 1997, inflow and outflow from the reservoir were very high relative to other years, and cold hypolimnetic water from the reservoir was exhausted by early summer. Water temperature even at the outflow during these years consistently exceeded 21.1 C. Electrofishing results those years indicated the rainbow trout population in the entire tailrace was severely reduced or eliminated.

Under the Canyon Dam outflow operating policy that was in place during this study, the section of the tailrace from the outflow to 6.3 km downstream would be most suitable for put-grow-and-take management. However, even this section will be subject to years when the entire trout fishery will be eliminated during the summer. In May 2003, a water release contract between GRTU and the Guadalupe Blanco River Authority (GBRA) was implemented with the specific objective of keeping water temperature below 21.1C from May through September in sections of the tailrace > 6.3 km downstream. Water temperatures and oversummer survival in the tailrace should be re-evaluated under these new conditions.

CONTENTS

INTRODUCTION

Tailrace trout fisheries are an important part of many state fisheries programs in the southern United States (Baker 1959, Fry and Hanson 1968, Axon 1975, Wiley and Dufek 1980). Hypolimnetic releases often keep water temperatures below optimal levels for endemic warmwater fish populations (Hickman and Hevel 1986, Ruane et al. 1986), making rainbow trout an acceptable replacement sport fish (Fry and Hanson 1968, Axon 1975, Hess 1980, Harper 1994). Tailrace trout fisheries can provide local economic benefits that greatly outweigh costs associated with stocking (Axon 1975, Forshage 1976, Weithman and Haas 1982, Choi et al. 1993, Harper 1994) and provide diversified fishing opportunities.

Rainbow trout were first stocked in the Canyon Reservoir tailrace, a hypolimnetic reservoir release tailrace located in south-central Texas, in 1966 by TPWD (White 1968). It is one of the most popular winter trout fisheries in Texas (TPWD, unpublished data). During the period covered by this study, rainbow trout were annually stocked at public and private access sites within the Canyon Reservoir tailrace (Table 1, Figure 1).

While the tailrace always has supported a popular put-and-take winter fishery, water temperatures from May through October were thought to exceed lethal levels for trout. Elevated water temperatures have limited the scope of other tailrace trout fisheries until reservoir releases were made for maintaining suitable downstream water temperatures. Axon (1975) reported water temperature in the White River below Bull Shoals Reservoir, Arkansas was a factor limiting that rainbow trout fishery, until the U.S. Army Corp of Engineers (USACE) agreed to provide adequate flows for keeping water temperatures there below 21.1 C. Similarly, the Oklahoma Department of Wildlife Conservation made reservoir release recommendations for maintaining downstream water temperatures at or below 21.1 C on the Mountain Fork River below Broken Bow Reservoir (Harper 1994). Thus, 21.1 C can be considered a maximum threshold water temperature for maintaining tailrace trout fisheries. Directly below the stilling basin of Canyon Dam water temperature was reported to never exceed 18.5 C from November 1969 through January 1971 (Hannan and Young 1974), although extensive water temperature monitoring had never been conducted in downstream areas.

In addition to high water temperatures, dissolved oxygen levels may be a concern in the management of tailrace rainbow trout fisheries, as hypolimnetic water is often anoxic. The United States Fish and Wildlife Service (USFWS) reported the dissolved oxygen lethal level for adult and juvenile rainbow trout is approximately $\leq$ 3mg/l, depending on environmental conditions, especially temperature (USFWS 1984). Decreased rainbow trout catch rate at dissolved oxygen levels $<$ 6 mg/l (Weithman and Haas 1984), and decreased body condition and growth at levels $<$ 4.0 mg/l (Devlin and Bettoli 1999) have been reported. Under normal operating conditions, hypolimnetic water from Canyon Reservoir is mechanically oxygenated as it is being released into the tailrace to maintain a minimum dissolved oxygen level of 6 mg/l. Exceeding or meeting this minimum level is a requirement of the Federal Energy Regulatory Commission (FERC) Canyon Reservoir Hydropower Plant License (GBRA, Project No. 3865-003, December 4, 1986). A mean dissolved oxygen level $\geq$

6 mg/l is used by the Texas Commission on Environmental Quality (TCEQ) to classify those Texas streams in the highest aquatic life use subcategory (TNRCC 1995). The TCEQ puts the Guadalupe River below Canyon Reservoir in the category of Texas stream segments having the highest water quality (TNRCC 1995). White (1968) reported that from January 1967 to February 1968, dissolved oxygen levels ranged from 7 to 13 mg/l, with normal levels between 8 and 10 mg/l. For trout waters in Missouri, the minimum standard for dissolved oxygen was 6 mg/l (Weithman and Haas 1984). As long as the Canyon Hydropower Plant FERC license requirements are met, dissolved oxygen levels in the Canyon Reservoir tailrace should at least meet this standard.

Inflows and outflows have a great effect on Canyon Reservoir's hypolimnetic water temperature (Groeger and Tietjen 1998). During years with below average rainfall (dry years), water residence time is relatively long (low inflow/outflow) and hypolimnetic waters in Canyon Reservoir remain cold throughout the summer. During years with above average rainfall (wet years), residence time is much shorter (high inflow/outflow) and the hypolimnion much warmer. In addition, as the flood pool of the reservoir is evacuated during wet years, the warmer metalimnion descends toward the bottom as the hypolimnion is depleted. During wet years, summer water temperature at the outflow might exceed the level suitable for sustaining rainbow trout. Therefore, the frequency of wet years might dictate the success of a fisheries management strategy dependent on stocked trout surviving for multiple years.

Oversummer survival and acceptable growth of rainbow trout from an April stocking was documented in the Canyon Reservoir tailrace in October 1966 (White 1968), although the distance below the outflow where this occurred was not specified. Many anecdotal reports of oversummer survival were also received by TPWD from the public. Evidence of growth and oversummer survival stimulated interest in developing a put-grow-and-take fishery. If water temperature < 21.1 C could be maintained so trout could survive from one winter to the next, and growth was acceptable, it was thought developing this type of fishery might be possible. Stocking of fingerling rainbow trout for grow-out was implemented in 1996 (Table 1).

Understanding the tailrace's true potential for developing a put-grow-and-take trout fishery required gathering additional water temperature data from downstream areas and additional evidence of oversummer survival and growth. Measuring the utilization level of the trout fishery might also be helpful for explaining temporal and spatial population differences. Therefore, specific objectives of this study were to: 1) determine the water temperature regime of the Canyon Reservoir tailrace, from the outflow to 22.2 km downstream, 2) determine if trout are oversummering in the tailrace, 3) measure growth and body condition of the tailrace trout, and 4) determine angler utilization of the tailrace trout fishery.

METHODS

Study Areas

Canyon Reservoir

Canyon Reservoir, a 3,335-ha flood control reservoir located in Comal County, Texas, was created in 1964 when the Guadalupe River was impounded. It is classified as an oligo-mesotrophic, hard water, deep storage, bottom draining, reservoir (Hannan et al. 1979). Thermal stratification is normally present from May through November with anoxic conditions existing in the hypolimnion from July through November (Hannan and Young 1974).

Canyon Reservoir Tailrace

The Canyon Reservoir tailrace is a section of the Guadalupe River extending 22.2 km below the stilling basin of Canyon Reservoir. The lower boundary was set because it was assumed this would be the furthest distance downstream where oversummer survival might occur. A bridge at this point also provided a landmark for enforcement of fishing regulations. During the study period, public access for trout fishing was available at four sites in this section (Figure 1). GRTU and a trout-fishing club also leased private fishing access for their members. Access to these areas for non-members was only gained by floating into the area.

Although there were many low water dams, Horseshoe Falls, located 2.4 km below the stilling basin, was the only possible barrier to upstream movement of trout.

Water from Canyon Reservoir was discharged from a fixed depth of 41 m below the surface, at a conservation pool elevation of 277 m msl. In 1989, a 6-megawatt hydropower plant constructed at the stilling basin by the GBRA became operational. Under the FERC hydropower permit, minimum outflow into the tailrace during non-drought periods was 2.5 m^3/sec, but under drought conditions outflow was reduced to reservoir inflow. A minimum dissolved oxygen level of 6 mg/l was also required. Meeting requirements of the FERC permit was mandatory only when the reservoir was below conservation pool and water releases were regulated by GBRA. When the reservoir was in the flood pool the USACE dictated reservoir releases. Outflow rate when the reservoir was below conservation pool level was determined by inflow into the reservoir and downstream water rights (GBRA, personal communication). Fishes such as black basses (*Micropterus* spp.) and striped bass (*Morone saxatilis*) were present in the tailrace in low densities (Terre and Magnelia 1996) and may have preyed on stocked trout.

The tailrace was regulated under statewide 5 trout daily bag limit (rainbow and brown trout (*Salmo trutta*), their hybrids and subspecies, in any combination) and no minimum length limit regulations until 1 September 1997, at which time 457-mm minimum length and one trout (rainbow and brown trout, their hybrids and sub-species) daily bag limits were initiated in the stretch from 6.3 to 22.2 km below the dam. Trout harvested in this area must be caught on an artificial lure, although anglers may fish with any bait type. These latter regulations were restricted to this stretch because of strong public sentiment for maintaining two popular put-and-take sites in the upper 6.3 km, and documented oversummer survival in the downstream portion of the tailrace during October 1993 and 1994.

Water Temperature and Flow

At the onset of this study, little water temperature data was available, other than a single monthly measurement taken at the second bridge crossing on River Road, 22.2 km downstream from the outfall (beginning in 1987) and a daily mean water temperature at the Canyon Dam hydropower plant (beginning in 1989). In July 1997, TPWD personnel deployed three ONSET™ water temperature loggers 1.0, 17.1 and 22.2 km downstream of Canyon Dam (Figure 1). Two additional loggers were deployed in 1999, 6.3 and 11.7 km downstream from the outfall. When available, data collected by the 1.0-km and 22.2-km loggers were used in summary statistics, rather than data gathered by GBRA.

Water temperature loggers were deployed attached to the inside of a 305-mm length of 76-mm diameter plastic pipe with 8-10, 18-mm holes. Each end of the pipe was closed using 76-mm plastic end-cap grates. A 1.8-kg lead weight was attached to the lower end of the pipe to anchor it. Pipe and logger were chained and locked to suitable anchor points in an area of good flow.

Flow rate data at the Sattler, TX gauging station (#08167800), 2.9 km downstream from the stilling basin of Canyon Dam, were provided by the United States Geological Survey (USGS) and used throughout the study as a measure of the outflow from Canyon Dam. Inflow into the reservoir was measured by the USGS at the Spring Branch gauging station (#08167500), just upstream from Canyon Reservoir. Flow rates at these stations were recorded every 15 minutes.

Oversummer Survival

In October 1992, 10 boat electrofishing sites were sampled during daylight hours from the Canyon Dam hydropower plant to 17.0 km downstream (Table 2) for the purpose of documenting oversummer survival of catchable-size trout stocked by TPWD in the winter/spring of 1991-92. Boat electrofishing was again conducted in the same section at 15 fixed sites during daylight hours in June and October 1993 and 1994. Total electrofishing effort at each site in each of these years was 0.25 hours. A Coffelt™ model VVP-15 pulsator using unpulsed direct current was used to minimize electrofishing injuries to trout (Reynolds and Kolz 1988, Sharber and Carothers 1988, Holmes et al. 1990, Taube 1992). Pulsator settings were held constant between sites. Rainbow trout collected were released in the approximate middle of the site in which they were captured to minimize the chance of catching them again at subsequent sites. Total electrofishing catch per hour (CUE(TOT)) was used to draw inferences regarding rainbow trout population density changes between June and October surveys. Total electrofishing catch rates of rainbow trout by station were transformed by the formula $\log_{10}$(trout/hour + 1). Means of transformed June and October total catch rates from each year were then compared using a Students *t*-test (alpha = 0.05).

For five GRTU stockings during 1993 and 1994, rainbow trout were fin clipped (Table 1) for the purpose of subsequently identifying individuals from these stockings. Each stocking had a unique fin clip. Trout were anesthetized using a carbon dioxide bath (Post 1979), fin clipped, dipped for 10-

15 seconds in a 3% salt solution and released.

Boat or backpack electrofishing (Smith Root™ backpack Model 12-A POW) was again conducted annually from 1996 through 2001 for the purpose of documenting oversummer survival of fingerling and catchable-size rainbow trout (Table 2). Fingerlings (mean size range = 62–130 mm) produced by the TPWD Possum Kingdom Fish Hatchery were stocked at public and private access points along the first 17.1 km of the tailrace from 1996 through 2000 (Table 1).

Since catchable-size rainbow trout were stocked in early October prior to electrofishing in 1996, 1999 and 2000, only trout < 200 mm total length and having juvenile parr markings (Pflieger 1975) were considered fingerlings that oversummered.

Growth and Body Condition

All trout collected in electrofishing surveys were measured (mm) and weighed (g), except for fingerling trout collected by backpack electrofishing in December 1996 and October 2000, which were measured only. Mean length at stocking for fingerlings was calculated from a sample (25-50) at each stocking. Mean length at capture for fingerlings was calculated using lengths from all individuals collected.

Relative weight (Wege and Anderson 1978) was calculated using the standard weight equation by Anderson and Neumann (1996).

Angler Utilization

A roving creel survey was conducted during daylight hours from December 1993 through February 1994 at three TPWD stocking locations (Figure 1). During each creel survey, an attempt was made to interview every angler at each site. All anglers actively fishing were counted. When every angler was interviewed and/or counted the creel clerk moved to the next stocking location. When all sites were creeled the survey was terminated. Starting location, survey start time, and direction of movement between sites were chosen at random each survey day. Creel questions are described in TPWD Inland Fisheries Assessment Procedures Manual (unpublished manual 1993). Sampling effort was assigned in proportion to expected angling effort to improve survey efficiency (Malvestuto et al. 1978, Stanovick and Nielsen 1991). Since angling activity was expected to be highest on or just after stockings, sampling effort was intensified near these dates. During the 88-day creel period, 20 surveys were conducted. Estimates of fishing pressure, harvest, and catch were calculated according to equations described by Phippen and Bergersen (1991), except harvest estimates were calculated using a daily mean harvest rate calculated from individual angler interviews. Harvest estimates were calculated by site over the entire creel period. Total harvest over the entire creel period was calculated by adding the harvest estimates for all three sites. Percent return of trout stocked by TPWD was calculated by dividing the estimated total number harvested by the total number stocked. Angler catch, harvest and release rates were transformed by the formula $\log_{10}(\text{trout/hour} + 1)$ and means compared among sites using a one-way analysis of variance (ANOVA) (alpha = 0.05). A Tukey-Kramer HSD multiple range test was used to determine which means differed significantly (alpha = 0.05).

Another roving creel survey using standard TPWD Inland Fisheries assessment procedures (unpublished manual 1993) was conducted from July through September 1994 to document harvest during this period. Creel locations, interview procedures and sampling effort were the same as those previously described for the December 1993 through February 1994 survey.

RESULTS AND DISCUSSION

Water Temperature and Flow

Median monthly outflow from 1987 through 2001 was lowest in August, September and October (Figure 2). Similarly, for 1987-2001, combined monthly median or upper ranges of water temperature 22.2 km downstream exceeded 21.1 C from May through October and also exceeded the lethal temperature reported for rainbow trout (25 C) (USFWS 1984) in July, August and September. Mean water temperature at the Canyon Dam outflow rose to its maximum value in October, but remained below 21.1 C (Figure 2). Mean maximum temperature in the Canyon Reservoir hypolimnion generally occurs in October (Groeger and Tietjen 1998). Maximum water temperature at the dam discharge during October and November can be attributed to thermal destratification in Canyon Reservoir during these months (Hannan and Young 1974). Based on this general overview of water temperature and outflow, the time period from May through October was confirmed as the period when temperature-induced mortality of trout was most likely to occur.

Data collected from 1997 through 2001 (Figures 3-7) verified that water temperature from May to October often exceeded 21.1 C at all locations except closest (within 1.0 km) to Canyon Dam. This threshold temperature was exceeded consistently, even at this location in 1997. Water temperature in downstream stations often started to exceed 21.1 C by May or June and did not fall below this level until October.

From 1987 through 2001 inflow and outflow from May through October for Canyon Reservoir was highly variable (Table 3), resulting in changing conditions in hypolimnetic temperature (Groeger and Tietjen 1998). Water temperature at the dam or 1 km downstream in years with low inflow/outflow (e.g., 1996 and 2000) was cold relative to other years, although downstream it was generally warmer (Table 3). Low outflows and warming as water slowly moved downstream probably contributed to elevated downstream temperature during those years. In 2000, a low outflow year, temperature at the 1-km station exceeded 21.1 C for only 4 hours when flow was reduced from 1.6 to 0.5 m^3/sec in late August (Figure 6). However, by early May that year, water temperature at the next downstream station (6.3 km) was already > 21.1 C, and by early July consistently exceeded this level. Temperatures at stations further downstream were > 21.1 C as early as March and did not return to < 21.1 C until October.

In years with high outflows, such as 1992 and 1997, temperatures were warmer relative to other years (Table 3). Even though flow from the dam was higher relative to other years, cold hypolimnetic water was exhausted by mid-to-late summer (Groeger and Tietjen 1998). In 1997 temperature exceeded 21.1 C even at the station closest to the dam during the summer and was not < 21.1 C until November (Figure 3). Over the 15-year study period 6 years could be characterized as having either low (1989, 1996, 2000) or high (1987, 1992, 1997) inflow/outflow.

Moderate flows occurred in nine of the 15 years, but consecutive years of moderate flows occurred on only three occasions. Three years was the longest stretch (1993-1995) for moderate flow conditions (Table 3). Even during years of moderate flow (1998, 1999, 2001) water temperature often exceeded 21.1 C at stations > 6.3 km downstream during the summer (Figures 4,5,7).

Oversummer Survival

Oversummer survival was documented in 8 of the 9 years when electrofishing was conducted (Table 2). However, in most years only the section within 6.3 km of the outflow held oversummer survivors (Table 2). For example, in October 2000, fingerlings were collected by backpack electrofishing at sites 1, 2 and 7, but none were collected at sites 9 and 10. Because of concerns with downstream water temperatures in 2000, a low outflow year, the first 6.3 km of the tailrace were stocked with the entire production (105,533), with 41,370 of these stocked at stocking site 5. It is likely water temperature-induced mortality during the summer was responsible for the lack of fingerlings collected at electrofishing site 9.

In 1996, another year with low outflow (Table 3), fingerling trout were collected from October to December at sites < 6.3 km from the outflow (Table 2). Extensive electrofishing at electrofishing sites 12-18 yielded no fingerlings. Electrofishing sites 14-18 were in close proximity to stocking sites 11 and 12, which were stocked with 10,000 fingerlings in May 1996. Although no temperature data were available from that section of the tailrace in 1996, median outflow that year was similar to that in 2000 (Table 3). The inability to collect stocked fingerlings in downstream areas close to where they were stocked was probably due to high temperatures, as was documented in 2000. In 1989, another year with low outflow (Table 3), it is likely that mortality of trout in downstream areas of the tailrace was also very high.

High inflows and outflows from the reservoir also produced water temperatures in the tailrace unsuitable for oversummer survival. During years when inflows and outflows were high (e.g., 1992 and 1997; Table 3) water temperatures at the Canyon Dam outflow (1992) and the monitoring station 1 km below Canyon Dam (1997) were high relative to other years (Table 3, Figure 3). During years when inflow/outflows are high, cold hypolimnetic water is often evacuated from the reservoir by mid-to-late summer (Groeger and Tietjen 1998). Despite extensive electrofishing in October 1992 (Table 2) from the dam to 17.0 km downstream, only one rainbow trout was captured. This section was stocked with 21,495 adult rainbow trout the previous winter/spring (Table 1). Similarly, boat electrofishing in October 1997 at eight sites from the dam to

17.1 km downstream yielded no trout despite stocking this area with more than 100,000 fingerlings. During a high inflow/outflow year such as 1987 (Table 3), similar results might be expected. During high inflow/outflow years, mortality from high water temperature in the entire tailrace would likely be very high, if not complete.

In late September 1998, a year with relatively moderate flow (Table 3), boat electrofishing was completed at only three sites (1, 4, 9), all within 6.3 km of the outflow. A major flood occurred in mid-October 1998 which prevented further electrofishing at sites downstream from site 9. Fingerling ($N = 10$) and adult ($N = 2$) trout were collected at electrofishing sites 4 and 9 (Table 2), although at electrofishing site 9 only one fingerling was collected despite the stocking of 79,298 in this area in April. No fingerlings were sampled directly below the dam at electrofishing site 1 (Table 2) despite this area being stocked with a large number in April (Table 1). The inability to collect fingerling at this site is puzzling, since they were present in June when they were collected by boat electrofishing ($N = 22$), and water temperatures remained below 21.1 C in the interim (Figure 4). Although electrofishing was not completed in fall 1998 at downstream sites, water temperature at 17.1 km in 1998 consistently exceeded 21.1 C from June through October (Figure 4). Mortality of the 80,300 fingerlings stocked in this area was probably high.

Relatively moderate flows were also experienced in May through October 1999 (Table 3). Except for a short period of time (30 minutes) in early September when water temperature rose to 21.6 C, it remained below 21.1 C at the 1.0-km station (Figure 5). Water temperature at the 6.3-km station in 1999 exceeded 21.1 C in August and late September for short periods of time (1-2 hours). (Figure 5). Fingerlings were collected in late October 1999 directly below the dam and up to 6.3 km downstream (Table 2). Eighty-four percent (22,483) of the 1999 stocking was released in this portion of the tailrace. Fingerling trout were not collected > 6.3 km below the dam, likely because of high temperatures there. For example, water temperatures at the 11.7-km station consistently exceeded 21.1 C from July through October (Figure 5).

In October 2001, adult rainbow trout were collected electrofishing as far as 17.2 km downstream (Table 2). Water temperatures in 2001 remained below 21.1 C at the 1.0-km and 6.3-km monitoring sites throughout the summer, but consistently exceeded this threshold at 11.7 km (Figure 7). Despite these elevated temperatures in June, July and August at the 17.1-km monitoring site, rainbow trout adults ($N = 2$) were collected at electrofishing sites 17 and 18 (Table 2). Perhaps these were individuals in the population least susceptible to high water temperature, or they migrated into the area in September after flows increased and water temperatures decreased.

Rainbow trout were captured as far as 17.2 km downstream in both June and October 1993 and 1994, although electrofishing catch rates in June (1993, $N = 28$; 1994, $N = 55$) were significantly greater ($P<0.01$) than in October (1993, $N = 7$; 1994, $N = 13$) of each year. Electrofishing sites 12-19 accounted for most of the trout collected in both years (Table 2). Unfortunately, extensive water temperature monitoring was not conducted in downstream areas to confirm if water temperatures there were excessive. These years also had more moderate flows relative to the high and low inflow/outflow years described previously (Table 3).

Fin clipped rainbow trout stocked by GRTU made up 64 and 38% of the catch in 1993 and 1994 electrofishing collections, respectively (Table 4). All fin clipped trout were collected at electrofishing sites > 6.3 km downstream from the dam. Of the fin clipped trout caught in 1993 and 1994 electrofishing collections, 77 and 85%, respectively, were from the stocking closest (March) to the electrofishing survey. No trout marked in November 1993 were recovered. Residence time of trout from March stockings would have been less than that of prior GRTU stockings, decreasing exposure to causes of mortality. Since the total number of fish stocked of each fin clip type during each year was similar (Table 1), this may explain why trout from these stockings were more numerous in electrofishing collections. On Lake Taneycomo, Missouri, no stocked cohort of rainbow trout remained in the tailrace for more than 6.5 months (Weiland 1994). That author suggested intense fishing pressure as the cause for the short residence time of stocked trout. Mark-and-recapture studies from bi-weekly stocking on the Mountain Fork tailrace trout fishery, Oklahoma, indicated carryover from one stocking to the next of only 16% (Harper 1994). Survival and return rate of radio-tagged, catchable-size rainbow trout in the Clinch River below Norris Dam, Tennessee, was only 7% (Bettinger and Bettoli 2002). The authors attributed this to rapid, long-range movements and high levels of activity that were energetically inefficient, making them more vulnerable to predation. No trout from the Canyon Reservoir tailrace marked in 1993 were collected in 1994. Further, no trout marked in either 1993 or 1994 were collected in any subsequent-year electrofishing surveys.

Growth and Body Condition

Growth of stocked fingerlings was documented in 1996, 1998, 1999 and 2000 (Table 5), although a growth rate could not be calculated because of stockings on multiple dates and an inability to differentiate between fish from different stockings. White (1968) reported growth of 12.5 mm/month for tagged rainbow trout stocked in the Canyon Reservoir tailrace at 203-228 mm. This rate of growth is similar to that reported for rainbow trout (>200 mm) stocked in the tailrace below Center Hill Reservoir, Tennessee (13 mm/month) (Devlin and Bettoli 1999), but below that reported for the tailrace below Dale Hollow Dam, Tennessee (18 mm/month) (Little 1967) and the White River below Bull Shoals Dam, Arkansas (23 mm/month) (Baker 1959). A paucity of both benthic and drifting aquatic invertebrates in the Canyon Reservoir Tailrace, due to a lack of adequate habitat for the development of productive macroinvertebrate communities (Halloran and Arsuffi 2000), may be a concern for rapid grow-out of trout in the tailrace.

Mean relative weight (Wege and Anderson 1978) of all stocked fingerlings collected in all samples was 98 (Wr range = 67-132; N = 102), which describes a fish having good body condition. Adult trout collected during fall electrofishing surveys in 1992, 1993, 1994 and 2001 had a mean Wr of 100 (Wr range = 65-158; N = 42).

Angler Utilization

During the December 1993 through February 1994 creel survey, 307 parties representing 578 anglers were interviewed. Total estimated fishing pressure was estimated at 35,570 angler-hours (703 angler-hours/ha) (Table 6). Directed fishing pressure and percent harvest in the Canyon

Reservoir tailrace was high, relative to other tailrace trout fisheries (Table 7). A high percentage of the trout stocked at TPWD stocking sites were harvested during the creel period (Table 6). Total angler catch rates were not significantly different among the three creel sites (0.90-0.93 trout/angler-hour; $P>0.05$); however, harvest and release rates at creel site 3 were significantly lower and higher, respectively, ($P<0.05$) than those at site 1 (Table 6). Perhaps voluntary catch-and-release witnessed by creel clerks at site 3, stocking by GRTU and others in hard-to-access private lease areas in 1993 and 1994, and the shorter residence time of trout from the GRTU March stockings may explain why more trout were captured at electrofishing sites 12-19 in 1993 and 1994.

Only 16 anglers were contacted in the tailrace during the July-September 1994 creel survey. No catch of trout was recorded, although six anglers were seeking rainbow trout.

CONCLUSIONS

Evidence of oversummer survival from 1992 to 2001 suggests a put-grow-and-take trout fishery in at least a portion of the Canyon Reservoir Tailrace is possible. However, in most years outflow from Canyon Reservoir was not adequate for this type of fishery in areas further than 6.3 km downstream. In years when inflows and outflows are high, the tailrace trout population would likely be completely eliminated due to evacuation of cold hypolimnetic water from Canyon Reservoir.

Without the protection of a minimum length limit it appears most trout stocked at TPWD stocking sites were harvested shortly after being stocked; however, the section of the tailrace where trout received protection from the minimum length limit had water temperatures frequently above 21.1 C. Because of high water temperatures in this section, stockings of fingerlings for grow-out and use of a minimum length limit are not practical. During the study period there was only one instance where two consecutive years of oversummer survival in the minimum length limit section was documented. Unless flows can be guaranteed for maintaining water temperatures < 21.1 C, the goal of developing a put-grow-and-take trout fishery in this section of the tailrace will not be attained. The first 6.3 km of the tailrace would be a better choice for put-grow-and-take management, although adoption of a length limit regulation in this area would infringe on two popular put-and-take areas, and would likely be highly controversial.

Successful use of put-grow-and-take fisheries management actions on the Canyon Reservoir tailrace will take cooperation from controlling authorities to assure water temperatures remain < 21.1 C on a consistent basis. In May 2003, a water release contract between GRTU and GBRA was implemented with the specific objective of keeping water temperatures < 21.1C from May through September in sections of the tailrace > 6.3 km downstream from the dam. Water temperatures and oversummer survival in the tailrace should be re-evaluated under these new conditions.

LITERATURE CITED

Anderson, R.O., and R. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Axon, J.R. 1975. Review of coldwater fish management in tailwaters. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 28:351-355.

Baker, R.F. 1959. Historical review of the Bull Shoals Dam and Norfolk Dam tailwater fishery. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 13:229-236.

Bettinger, J.M. and P.W. Bettoli. 2002. Fate, dispersal, and persistence of recently stocked and resident rainbow trout in a Tennessee tailwater. North American Journal of Fisheries Management 22:425-432.

Bowman, D.W., T.R. Bly, S.P. Filipek, C.A. Perrin, J.D. Stark and B.K. Wagner. 1994. Angler use, success, and characteristics on Greers Ferry tailwater, Arkansas, with implications to management. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 48:499-511.

Choi, S., D.F. Schreiner, D.M. Leslie, Jr. and J.L. Harper. 1993. Economic analysis of the Mountain Fork River trout fishery in southeastern Oklahoma. Oklahoma Current Farm Economics 66(3):29-41.

Devlin, G.G. and P.W. Bettoli. 1999. Seasonal fluctuations in growth and condition of trout in a southeastern tailwater. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 53:100-109.

Forshage, A. 1976. Cost/benefit analysis of a catchable rainbow trout fishery in Texas. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 29:293-300.

Fry, J.P. and W.D. Hanson. 1968. Lake Taneycomo: A cold-water reservoir in Missouri. Transactions of the American Fisheries Society 97:138-145.

Groeger, A.W. and T.E. Tietjen. 1998. Hydrological and thermal regime in a subtropical reservoir. International Review of Hydrobiology Special Issue 83: 83-92.

Halloran, B.T. and T.L. Arsuffi. 2000. Foraging of introduced rainbow trout in relation to benthic macroinvertebrates and drift in the Guadalupe River tailwater below Canyon Reservoir, TX. Special report to the Guadalupe River Chapter of Trout Unlimited.

Hannan, H.H. and W.J. Young. 1974. The influence of a deep-storage reservoir on the physicochemical limnology of a central Texas river. Hydrobiologia 44:177-207.

Hannan, H.H., I.R. Fuchs and D.C. Whitenberg. 1979. Spatial and temporal patterns of temperature, alkalinity, dissolved oxygen and conductivity in an oligo-mesotrophic, deep-storage reservoir in central Texas. Hydrobiologia 66:209-221.

Harper, J. L. 1994. Evaluation of a year-round put-and-take rainbow trout fishery in the Mountain Fork River. Oklahoma Department of Wildlife Conservation, Federal Aid in Sport Fish Restoration Project F-37-R, Job 18, Oklahoma City. 24 pp.

Hess, T. B. 1980. An evaluation of the fishery resources of the Chattahoochee River below Buford Dam. Georgia Department of Natural Resources, Federal Aid in Sport Fish Restoration Project F-26-7, Atlanta. 52 pp.

Hickman, G.D. and K.W. Hevel. 1986. Effect of a hypolimnetic discharge on reproductive success and growth of warmwater fish in a downstream impoundment. Pages 286-293 *in* G.E. Hall and M.J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division, American Fisheries Society, Bethesda, Maryland.

Holmes, R., D.N. McBride, T. Viavant and J.B. Reynolds. 1990. Electrofishing induced mortality and injury to rainbow trout, arctic grayling, humpback whitefish, least cisco, and northern pike. Alaska Department of Fish and Game, Fishery Manuscript No. 90-3.

Little, J.D. 1967. Dale Hollow tailwater investigations. Tennessee Wildlife Resource Agency, Federal Aid in Sport Fish Restoration, Project F-30-R, Nashville. 71pp.

Malvestuto, S.P., W.D. Davies and W.L. Shelton. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. Transactions of the American Fisheries Society 107:255-262.

Oliver, M.L. 1984. The rainbow trout fishery in the Bull Shoals-Norfork tailwaters, Arkansas, 1971-81. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 38:549-561.

Phippen, K.W. and E.P. Bergersen. 1991. Accuracy of a roving creel survey's harvest estimate and evaluation of possible sources of bias. Pages 51-60 *in* D. Guthrie, et. al., editors. Creel and angler surveys in fisheries management. American Fisheries Society Symposium 12, Bethesda, Maryland.

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Department of Conservation. 342 pp.

Post, G. 1979. Carbonic acid anesthesia for aquatic organisms. Progressive Fish-Culturist 41:142-144.

Reynolds, J.B. and A.L. Kolz. 1988. Electrofishing injury to large rainbow trout. North American Journal of Fisheries Management 8:516-518.

Ruane, R.J., C.E. Bohac, W.M. Seawell and R.M. Shane. 1986. Improving the downstream environment by reservoir release modifications. Pages 270-277 *in* G.E. Hall and M.J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division, American Fisheries Society, Bethesda, Maryland.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 8:117-122.

Stanovick, J.S. and L.A. Nielsen. 1991. Assigning nonuniform sampling probabilities by using expert opinion and multiple-use patterns. Pages 189-194 *in* D. Guthrie, et al., editors. Creel and angler surveys in fisheries management. American Fisheries Society Symposium 12, Bethesda, Maryland.

Taube, T.T. 1992. Injury, survival and growth of rainbow trout captured by electrofishing. Masters thesis, University of Alaska, Fairbanks. 87 pp.

Terre D.R. and S.J. Magnelia. 1996. Survey report for the Guadalupe River in Kendall and Comal counties, Texas, 1995. Texas Parks and Wildlife Department, Federal Aid in Sport Fish Restoration Project F-30-R, Job No. 21, Austin. 54 pp.

TNRCC (Texas Natural Resource Conservation Commission). 1995. Texas surface water quality standards. Texas Natural Resource Conservation Commission, Austin. 130 pp.

USFWS (United States Fish and Wildlife Service). 1984. Habitat suitability information: rainbow trout. Document OBS-82/10.60. 64 pp.

Wege, G.J. and R.O. Anderson. 1978. Relative weight: a new index of condition for largemouth bass. Pages 79-91 *in* G.D. Novinger and J.D. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division, Special Publication 5, Bethesda, Maryland.

Weiland, M.A. 1994. An evaluation of the causes for the decline of the Lake Taneycomo trophy rainbow trout fishery. Masters thesis, University of Missouri-Columbia. 107 pp.

Weithman, A.S. and M.A. Haas. 1982. Socioeconomic value of the trout fishery in Lake Taneycomo, Missouri. Transactions of the American Fisheries Society 111:223-230.

Weithman, A.S. and M.A. Haas. 1984. Effects of dissolved-oxygen depletion on the rainbow trout fishery in Lake Taneycomo, Missouri. Transactions of the American Fisheries Society 113:109-124.

White, R.L. 1968. Evaluation of catchable rainbow trout fishery. Texas Parks and Wildlife Department, Federal Aid in Sport Fish Restoration Project F-2-R-15, Job E-9, Austin. 24 pp.

White, R.L. 1969. Evaluation of catchable rainbow trout fishery. Texas Parks and Wildlife Department, Federal Aid in Sport Fish Restoration Project F-2-R-16, Job E-9, Austin. 18 pp.

Wiley, R.W. and D.J. Dufek. 1980. Standing crop of trout in the Fontenelle tailwater of the Green River. Transactions of the American Fisheries Society 109:168-175.

Table 1. Stocking history for adult (ADL) and fingerlings (FNG) rainbow trout in the Canyon Reservoir tailrace from 1987 through 2001 by the TPWD, GRTU and others. Fin clips, right pelvic (RPEL), left pelvic (LPEL), adipose (AD), left pectoral (LPEC) and right pectoral (RPEC), were used to identify some of the trout stocked by GRTU. When multiple stocking locations are listed, the number is the total for all locations combined. Stocking locations are identified in Figure 1.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
01/07/87	TPWD		18,300	ADL	
01/28/87	TPWD		17,850	ADL	
02/24/87	TPWD		20,810	ADL	
12/02/87	TPWD		15,070	ADL	
12/29/87	TPWD		8,000	ADL	
01/15/88	TPWD		10,000	ADL	
02/02/88	TPWD		8,388	ADL	
12/02/88	TPWD	1,5,7,12	9,925	ADL	
12/13/88	TPWD	1,5,7,12	9,990	ADL	
01/19/89	TPWD	1,5,12	8,465	ADL	
03/06/89	TPWD		6,071	ADL	
03/10/89	TPWD	12	2,268	ADL	
11/22/89	TPWD	1	2,139	ADL	
		5	1,140	ADL	
		12	1,658	ADL	
12/06/89	TPWD	1	1,953	ADL	
		4,5,12	2,000	ADL	
12/20/89	TPWD	1	2,000	ADL	
		5	2,013	ADL	
12/27/89	TPWD		1,190	ADL	
01/02/90	TPWD		2,012	ADL	
01/03/90	TPWD	5,12	2.027	ADL	
01/17/90	TPWD	1,5,12	3,007	ADL	
01/22/90	GRTU	9,10,13	800	ADL	
01/31/90	TPWD	1	1,491	ADL	
		5,9,12	1,502	ADL	
12/06/90	TPWD	1	2,000	ADL	
		5	1,000	ADL	
		9	500	ADL	
		12	996	ADL	
12/11/90	GRTU		900	ADL	
12/11/90	Other	8	600	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
12/20/90	TPWD	1	1,998	ADL	
		5,7,12	2,530	ADL	
01/03/91	TPWD	1	2,011	ADL	
		5,7,9,12	2,491	ADL	
01/16/91	TPWD	5,9,12	2,016	ADL	
01/17/91	TPWD	1	1,989	ADL	
01/21/91	GRTU		900	ADL	
01/31/91	TPWD	1	1,511	ADL	
		4,5,12	1,499	ADL	
02/15/91	GRTU	6	500	ADL	
		9	100	ADL	
		10	150	ADL	
		13	250	ADL	
02/20/91	TPWD	1,5,12	3,061	ADL	
11/03/91	GRTU		2,400	ADL	
11/03/91	Other	8	900	ADL	
12/05/91	TPWD	1	2,561	ADL	
		5	1,220	ADL	
		12	1,221	ADL	
12/18/91	TPWD	1	2,483	ADL	
12/19/91	TPWD		2,522	ADL	
02/07/92	TPWD	1	2,502	ADL	
		5,7,12	2,505	ADL	
02/14/92	TPWD	1	1,250	ADL	
		5,12	1,264	ADL	
03/06/92	TPWD	1,5,12	1,467	ADL	
12/03/92	TPWD	1	2,431	ADL	
		5,12	2,578	ADL	
12/08/92	Other	8	700		
12/08/92	GRTU		930	ADL	
12/17/92	TPWD	1	2,502	ADL	
		5,9,12	2,510	ADL	
01/18/93	GRTU		1,200	ADL	
01/18/93	Other	8	800	ADL	
01/21/93	TPWD		963	ADL	
		5	2,049	ADL	
		12	1,991	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
02/4/93	TPWD	1	2,505	ADL	
		5,12	2,502	ADL	
02/18/93	TPWD	1	2,488	ADL	
		5	1,251	ADL	
		12	1,251	ADL	
02/23/93	GRTU	6	380	ADL	RPEL
		13	734	ADL	RPEL
02/23/93	Other	8	1,000	ADL	
03/04/93	TPWD	1	300	ADL	
03/22/93	GRTU	6	712	ADL	LPEL
		10	63	ADL	LPEL
		13	606	ADL	LPEL
03/22/93	Other	8	800	ADL	
05/22/93	GRTU		1,800	ADL	
11/28/93	Other	8	1,333	ADL	
11/30/93	GRTU	6	301	ADL	AD
		7	92	ADL	AD
		9	75	ADL	AD
		10	114	ADL	AD
		13	256	ADL	AD
12/02/93	TPWD	1	2,525	ADL	
		5	1,247	ADL	
		9	419	ADL	
		12	832	ADL	
12/16/93	TPWD	1	2,482	ADL	
		5,7,12	2,499	ADL	
01/13/94	TPWD	1	2,274	ADL	
		5,7,12	2,239	ADL	
01/17/94	Other	8	667	ADL	
01/18/94	GRTU	6	408	ADL	LPEC
		7	35	ADL	LPEC
		9	60	ADL	LPEC
		10	205	ADL	LPEC
		13	221	ADL	LPEC
02/03/94	TPWD	1	2,498	ADL	
		5	1,255	ADL	
		12	1,256	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
02/17/94	TPWD	1	1,508	ADL	
		5	751	ADL	
		12	751	ADL	
02/25/94	TPWD	1	1,861	ADL	
02/27/94	Other	8	1,333	ADL	
03/01/94	GRTU	6	370	ADL	RPEC
		7	88	ADL	RPEC
		9	59	ADL	RPEC
		10	213	ADL	RPEC
		13	172	ADL	RPEC
03/03/94	Other	8	667	ADL	
11/19/94	GRTU	4	75	ADL	
		6	375	ADL	
		7	75	ADL	
		9	75	ADL	
		10	300	ADL	
		13	300	ADL	
		14	300	ADL	
12/08/94	TPWD	1	1,803	ADL	
		5,12	1,472	ADL	
12/12/94	Other	8	1,333	ADL	
12/29/94	TPWD	1	2,054	ADL	
		5	1,030	ADL	
		12	1,033	ADL	
01/01/95	Other	8	533	ADL	
01/19/95	TPWD	1	2,101	ADL	
		5	1,007	ADL	
		12	1,006	ADL	
01/14/95	GRTU	4	70	ADL	
		6	270	ADL	
		7	75	ADL	
		9	125	ADL	
		10	270	ADL	
		13	270	ADL	
		14	270	ADL	
02/04/95	TPWD	5,12	2,502	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
02/16/95	TPWD	1	1,440	ADL	
		5,12	1,565	ADL	
02/23/95	Other	8	933	ADL	
02/25/95	GRTU	4	30	ADL	
		6	160	ADL	
02/25/95		7	30	ADL	
		9	35	ADL	
		10	130	ADL	
		13	130	ADL	
		14	135	ADL	
03/06/95	TPWD	1	1,483	ADL	
03/18/95	GRTU	4	100	ADL	
		6	350	ADL	
		7	100	ADL	
		9	100	ADL	
		10	350	ADL	
		13	350	ADL	
		14	350	ADL	
10/02/95	TPWD	5	760	ADL	
		9	380	ADL	
		12	1,140	ADL	
11/18/95	GRTU	4	107	ADL	
		6	453	ADL	
		7	113	ADL	
		9	113	ADL	
		10	227	ADL	
		13	427	ADL	
		14	367	ADL	
		15	360	ADL	
12/08/95	TPWD	1	1,500	ADL	
		5	701	ADL	
		7	303	ADL	
		12	412	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
12/16/95	GRTU	4	113	ADL	
		6	453	ADL	
		7	113	ADL	
		9	113	ADL	
		10	227	ADL	
		13	487	ADL	
		14	431	ADL	
		15	429	ADL	
12/29/95	TPWD	1	1,506	ADL	
		5,12	1,405	ADL	
01/19/96	TPWD	1	1,509	ADL	
		5,7,12	1,405	ADL	
02/10/96	GRTU	4	200	ADL	
		6	780	ADL	
		7	300	ADL	
		9	350	ADL	
		10	400	ADL	
		13	750	ADL	
		14	700	ADL	
		15	720	ADL	
02/16/96	TPWD	1	1,498	ADL	
		5	600	ADL	
		6	250	ADL	
		12	600	ADL	
02/28/96	TPWD	1	1,195	ADL	
		5,7,12	758	ADL	
03/09/96	GRTU	4	200	ADL	
		6	600	ADL	
		7	300	ADL	
		10	400	ADL	
		13	700	ADL	
		14	600	ADL	
		15	700	ADL	
05/02/96	TPWD	12	18	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
05/08/96	TPWD	7	5,070	FNG	
		11	5,070	FNG	
		12	5,070	FNG	
05/30/96	TPWD	1	6,836	FNG	
		4	6,836	FNG	
		5	6,836	FNG	
06/27/96	TPWD	1	10,033	FNG	
		2	10,033	FNG	
		3	10,033	FNG	
10/06/96	TPWD	1	900	ADL	
		7	385	ADL	
		12	385	ADL	
11/30/96	GRTU	4	91	ADL	
		6	273	ADL	
		7	182	ADL	
		12	91	ADL	
		13	201	ADL	
		14	402	ADL	
		15	402	ADL	
12/06/96	TPWD	1	1,128	ADL	
		5	378	ADL	
		7	381	ADL	
		12	379	ADL	
12/11/96	Other	8	2,000	ADL	
12/23/96	GRTU	4	57	ADL	
		6	342	ADL	
		7	114	ADL	
		12	57	ADL	
		13	229	ADL	
		14	400	ADL	
		15	342	ADL	
12/30/96	TPWD	1	1,130	ADL	
		5,7,12	1,134	ADL	
01/13/97	Other	8	1,000	ADL	
01/21/97	GRTU	13	300	ADL	
		15	500	ADL	
01/23/97	TPWD	1,5,7,12	2,256	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
01/25/97	GRTU	6	428	ADL	
		7	71	ADL	
		12	71	ADL	
		14	214	ADL	
		15	214	ADL	
02/08/97	GRTU	4	158	ADL	
		6	158	ADL	
		7	105	ADL	
		12	53	ADL	
		13	210	ADL	
		14	368	ADL	
		15	316	ADL	
02/14/97	TPWD	1	1,178	ADL	
		5	478	ADL	
		7	231	ADL	
		12	471	ADL	
02/22/97	GRTU	4	79	ADL	
		6	105	ADL	
		7	210	ADL	
		12	26	ADL	
		13	237	ADL	
		14	158	ADL	
		15	131	ADL	
03/04/97	TPWD	1,12	937	ADL	
04/02/97	Other	7	99	ADL	
04/07/97	TPWD	1	17,800	FNG	
		5	17,800	FNG	
		9	17,800	FNG	
04/15/97	TPWD	7	14,233	FNG	
		11	14,233	FNG	
		12	14,233	FNG	
05/08/97	TPWD	4	12,000	FNG	
		9	12,000	FNG	
05/29/97	TPWD	5	8,949	FNG	
		5	35	ADL	
		12	9,051	FNG	
11/22/97	GRTU		3,000	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
12/04/97	TPWD	1	1,403	ADL	
		5	468	ADL	
		7	117	ADL	
		12	353	ADL	
12/08/97	Other	8	3,500	ADL	
12/13/97	GRTU		3,000	ADL	
12/20/97	GRTU		3,000	ADL	
12/22/97	TPWD	1	2,157	ADL	
		5,7,12	1,432	ADL	
01/02/98	TPWD	1	2,154	ADL	
		5,7,12	1,440	ADL	
01/31/98	GRTU		3,000	ADL	
02/13/98	TPWD	1	2,141	ADL	
		5	712	ADL	
		7	177	ADL	
		12	541	ADL	
02/27/98	TPWD	1	1,617	ADL	
		5,7,12	1,217	ADL	
03/01/98	TPWD	5	717	ADL	
04/02/98	TPWD	1	37,243	FNG	
		5	35,436	FNG	
		12	44,000	FNG	
04/07/98	TPWD	1	39,348	FNG	
		5	43,862	FNG	
		12	34,822	FNG	
05/22/98	TPWD		176	ADL	
		9	1,478	FNG	
		12	1,478	FNG	
10/04/98	TPWD	1	1,600	ADL	
11/21/98	GRTU		2,500	ADL	
12/01/98	Other	8	3,500	ADL	
12/05/98	GRTU		2,500	ADL	
12/12/98	GRTU		2,500	ADL	
12/19/98	GRTU		2,500	ADL	
12/21/98	TPWD	1	2,390	ADL	
		5,7,12	1,740	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
01/04/99	TPWD	1	2,369	ADL	
		5,7,9	1,622	ADL	
02/12/99	TPWD	1	2,438	ADL	
		5,7,9	1,128	ADL	
02/26/99	TPWD	1	2,332	ADL	
		5	778	ADL	
		7	194	ADL	
		12	583	ADL	
03/07/99	TPWD	5	800	ADL	
06/15/99	TPWD	5	16,178	FNG	
06/21/99	TPWD	1	2,117	FNG	
		4	2,117	FNG	
		5	2,117	FNG	
		7	2,117	FNG	
		9	2,117	FNG	
10/03/99	TPWD	1	1,200	ADL	
11/16/99	TPWD	1	3,000	ADL	
		5	1,000	ADL	
		7	3,000	ADL	
		9	250	ADL	
		12	1,000	ADL	
11/19/99	GRTU		2,597	ADL	
12/03/99	GRTU		810	ADL	
12/07/99	Other	8	4,800	ADL	
12/21/99	TPWD	1	1,500	ADL	
		5	404	ADL	
01/04/00	TPWD	1	1,502	ADL	
		5	401	ADL	
01/07/00	GRTU		2,020	ADL	
02/14/00	TPWD	1	1,198	ADL	
		5	400	ADL	
		12	300	ADL	
03/02/00	TPWD	1	1,100	ADL	
		5	400	ADL	
		12	100	ADL	
03/03/00	+TPWD	5	599	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
03/30/00	TPWD	1	25,000	FNG	
		5	25,000	FNG	
04/03/00	TPWD	5	1,425	ADL	
06/14/00	TPWD	1	10,977	FNG	
		5	10,977	FNG	
06/15/00	TPWD	1	5,393	FNG	
		2	8,700	FNG	
		3	5,393	FNG	
		4	8,700	FNG	
		5	5,393	FNG	
06/22/00	TPWD	1	507	ADL	
10/01/00	TPWD	1	1,200	ADL	
12/08/00	TPWD	1	2,030	ADL	
		5	609	ADL	
		7	204	ADL	
		12	609	ADL	
12/15/00	GRTU		3,740	ADL	
12/27/00	TPWD	1	2,245	ADL	
		5	564	ADL	
		7	293	ADL	
		12	842	ADL	
01/05/01	GRTU		4,469	ADL	
01/19/01	TPWD	1	1,932	ADL	
		5	483	ADL	
		7	242	ADL	
		12	725	ADL	
02/15/01	TPWD	1	1,200	ADL	
		5	300	ADL	
		7	150	ADL	
		12	450	ADL	
03/11/01	TPWD	5	1,386	ADL	
03/29/01	TPWD	1	315	ADL	
10/07/01	TPWD	1	1,532	ADL	
11/02/01	GRTU		2,982	ADL	
11/13/01	TPWD	1	800	ADL	
		5	500	ADL	
		7	200	ADL	
		12	500	ADL	

Table 1. Continued.

Date	Stocking entity	Stocking location[a]	Number	Size[a]	Fin clip[b]
12/08/01	Other	8	3,600	ADL	
12/13/01	TPWD	1	1,520	ADL	
		5	453	ADL	
		7	115	ADL	
		12	565	ADL	
12/13/01	GRTU		2,000	ADL	
12/28/01	TPWD	1	1,522	ADL	
		5	458	ADL	
		7	118	ADL	
		12	570	ADL	

[a] Blanks indicate information is missing.
[b] Blanks indicate fish were not fin clipped.

Table 2. Summary of rainbow trout electrofishing sampling data from 19 sites[a] in the Canyon Reservoir tailrace, 1992-2001. If unequal effort was used among sites, effort is shown below catch in parentheses. Blanks indicate sampling did not occur.

Date	Effort (hrs)	*N* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Fish/hour
10/13/92	2.50	0	0	0	1	0	0		0			0	0				0				0.4
06/22/93	3.75	1	1	0	0	0	0			0	0	0	4	5			4	4	4	5	7.5
10/26/93	3.75	1	0	0	0	0	0			0	0	0	1	1			1	2	1	0	1.9
06/07/94	3.75	1	0	0	2	0	0			1	1	0	12	25			5	3	2	3	14.7
10/26/94	3.75	0	0	0	1	0	0			0	0	0	0	3			0	6	1	2	3.5
10/30/96[b]	0.50	59				3															124.0
10/31/96[b]	1.08								2	1											2.7
									(0.68)	(0.40)											
11/07/96[b]	1.76															0	0	0	0		0.0
																(1.10)	(0.25)	(0.25)	(0.25)		
11/21/96[b]	1.52												0		0						0.0
													(0.96)		(0.56)						
11/26/96[b]	1.49						0	6						0							4.0
							(0.61)	(0.35)						(0.53)							
12/05/96[bc]	1.60	79																			49.3
11/20/97[b]	2.00	0			0					0			0	0			0	0	0		0.0
06/29/98	0.63	17	8																		39.7
		(0.08)	(0.55)																		
09/28/98	0.75	0			11					1											21.8
06/21/99	0.25																8				32.0
10/21/99[b]	2.40	2			0					3			0	0			0	0	0		2.1
		(0.25)			(0.31)					(0.25)			(0.43)	(0.41)			(0.25)	(0.25)	(0.25)		
10/25/99[bc]	0.29	13																			44.8
10/31/00[bc]	0.52	16	13					6		0			0								67.3
		(0.08)	(0.08)					(0.2)		(0.08)			(0.08)								
10/04/01	2.0	1			10					3			4	1			0	1	1		10.5

[a] Electrofishing sites are identified in Figure 1.
[b] Only trout identified as fingerlings are included.
[c] Backpack electrofishing; all other are boat electrofishing.

Table 3. Median inflow and outflow (m^3/sec) of Canyon Reservoir, and mean water temperature (C) at various distances downstream from the outflow of Canyon Dam, May-October, 1987-2001. Water temperature ranges are indicated below means in parentheses.

			Mean water temperature					
Year	Median inflow	Median outflow	Dam	1.0 km[a]	6.3 km[b]	11.7 km[b]	17.1 km[c]	22.2 km[d]
1987	28.2	51.2						23.2 (16.8–28.6)
1988	6.6	7.3						20.1 (16.8–22.5)
1989	1.6	2.9	12.6 (11.5–13.5)					21.7 (15.0–25.6)
1990	7.8	9.6	16.6 (13.5–18.5)					19.7 (16.7–21.4)
1991	5.8	8.9	15.6 (13.5–17.5)					19.0 (16.5-21.2)
1992	18.2	21.4	20.6 (18.5–22.5)					22.2 (18.8–24.3)
1993	6.2	4.6	15.9 (14.5–17.0)					21.5 (18.3–24.7)
1994	5.2	4.0	15.3 (14.5–16.5)					20.1 (14.9–24.5)
1995	6.2	5.3	16.2 (13.8–17.5)					19.4 (16.5–23.1)
1996	1.5	2.5	14.3 (13.2–15.0)					25.1 (18.4–30.1)
1997	23.5	33.2		23.3 (16.5–24.6)			23.6 (18.9–27.0)	21.2 (15.3–24.3)
1998	6.1	6.2		16.6 (14.5–22.4)			21.2 (16.5–26.8)	22.0 (16.7–30.3)
1999	4.1	4.4		16.5 (14.7–21.6)	18.6 (15.2–22.8)	19.9 (13.5–25.4)	21.2 (14.0–26.8)	22.0 (13.0–29.4)
2000	1.6	2.0		14.9 (13.3–23.1)	20.1 (12.2–31.3)	22.4 (11.8–28.9)	24.4 (12.4–30.9)	25.6 (12.5–32.4)
2001	6.1	5.6		15.8 (13.6-19.5)	17.4 (14.1-20.9)	19.1 (15.9-24.7)	20.0 (14.6-26.4)	20.7 (15.1-26.3)

[a] Daily means reported by GBRA at the Canyon Dam hydropower plant from 1May to 14 July 1997 were used to calculate means. From 14 July 1997 to 9 March 1999 temperature was recorded every 60 minutes. From 9 March 1999 to 31 October 2001 temperature was recorded every 30 minutes.

[b] Temperature was recorded from 15 June 1999 to 31 October 2001 every 30 minutes.

[c] Temperature was recorded from 14 July 1997 to 9 March 1999 every 60 minutes and 9 March 1999 to 31 October 2001 every 30 minutes. Data from 14 August 1997 to 26 August 1997 were lost due to tampering (logger pulled out of water), 22 May 1999 to 26 May 1999 due to tampering (logger pulled out of water), 21 June 1999 to 30 July 1999 due to theft of the logger, and 23 June 2000 to 27 June 2000 due to logger malfunction.

[d] Prior to 5 November 1997 only monthly measurements were made at this location by GBRA. From 5 November 1997 to 9 March 1999, data were collected every 60 minutes and from 9 March 1999 to 31 October 2001 every 30 minutes. Data from 4 August 2001 through 10 October 2001 were lost due to logger malfunction.

Table 4. Comparison of the number of all rainbow trout caught in electrofishing collections by site in the Canyon Reservoir tailrace, June and October, 1993 and 1994. The number of marked trout collected and the identifying fin clip are also included. Electrofishing locations are identified in Figure 1 and fin clip descriptions defined in Table 2.

Year	Site	Total collected June	Number marked June	Fin clip June	Total collected October	Number marked October	Fin clip October
1993	1	1	0	0	1	0	0
	2	1	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
	9	0	0	0	0	0	0
	10	0	0	0	0	0	0
	11	0	0	0	0	0	0
	12	4	4	LPEL (4)	1	1	LPEL (1)
	13	5	2	LPEL (1)	1	1	LPEL (1)
				RPEL (1)			0
	16	4	2	LPEL (2)	1	1	LPEL (1)
	17	4	4	LPEL (3)	2	0	0
				RPEL (1)			0
	18	4	2	LPEL (2)	1	1	LPEL (1)
	19	5	4	LPEL (2)	0	0	0
				RPEL (2)			
	TOTAL	28	18	R-PEL (4)	7	4	RPEL (0)
				L-PEL (14)			LPEL (4)
1994	1	1	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	2	0	0	1	0	0
	5	0	0	0	0	0	0
	6	0	0	0	0	0	0
	9	1	0	0	0	0	0
	10	1	0	0	0	0	0
	11	0	0	0	0	0	0
	12	12	10	RPEC (10)	0	0	0
	13	25	3	RPEC (1)	3	0	0
				LPEC (2)			
	16	5	4	RPEC (2)	0	0	0
				LPEC (2)			
	17	3	2	RPEC (2)	6	1	LPEC (1)
	18	2	1	RPEC (1)	1	1	RPEC (1)
	19	3	1	RPEC (1)	2	0	0
	TOTAL	55	21	LPEC (4)	13	2	LPEC (1)
				RPEC (17)			RPEC (1)

Table 5. Summary of growth and condition information for stocked rainbow trout fingerlings collected in electrofishing surveys, Canyon Reservoir tailrace, Texas.

Date stocked	Mean length at stocking (mm)	Grand mean length at stocking (mm)	Electrofishing date	Mean days between stockings and electrofishing	Mean length at collection (mm)	N	Mean Wr at collection
05/08/1996	64.0	76.0	10/30/1996	148	158.0	62	103.0
05/30/1996	93.0		12/05/1996	183	169.2	79	[a]
06/27/1996	71.0						
04/02/1998	74.0	77.2	06/29/1998	69	160.1	22	89.0
04/07/1998	66.5						
05/22/1998	91.0						
06/15/1999	130.0	127.0	10/21/1999[b]	123[c]	171.6	18	92.5
06/21/1999	124.0						
03/30/2000	62.0	86.0	10/31/2000	162	171.0	35	[a]
06/12/2000	95.0						
06/15/2000	101.0						

[a] No weights were taken.
[b] Lengths and weights from 10/21 and 10/25 were combined to increase sample size.
[c] Calculated from 10/21/1999.

Table 6. Summary of angler creel statistics for the Canyon Reservoir tailrace rainbow trout fishery, December 1993-February 1994. Values with the same letter are not significantly different.

Site[a]	Catch rate[b]	Harvest rate[b]	Release rate[b]	Angler-hours[c]	Harvest estimate[c]	Number stocked	Percent return
1	0.90A	0.50A	0.40A	16,462 ± 135	10,892 ± 130	13,148	82.8
2	0.93A	0.49A,B	0.44A,B	7,860 ± 76	4,732 ± 69	5,206	91.0
3	0.90A	0.33B	0.57B	11,248 ± 101	4,010 ± 50	4,791	84.0

[a] Creel sites found in Figure 1.
[b] Fish/hour.
[c] ± one standard deviation.

Table 7. Comparison of creel parameters among several put-and-take tailrace trout fisheries.

Tailrace	Catch rate (fish/hour)	Harvest rate (fish/hour)	Directed pressure (angler-hours)	Percent harvested	Time period
Canyon Tailrace, TX	0.90 - 0.93	0.33 - 0.50	35,570	86	Estimated from 1 December 1993 to 28 February 1994 at stocking sites 1,5 and 12.[a]
Canyon Tailrace, TX	0.52 and 1.03		4,840	59	Catch rates on weekdays and weekends, respectively 11 March to 14 May 1967.[b]
Canyon Tailrace, TX			6,000	35	30 May to 28 July 1968.[c]
Possum Kingdom Tailrace, TX			36,357	51	Directed angling hours during all of 1973.[d]
Mountain Fork, OK		0.56	13,669	50	Harvest rate based on a 5-year average. Mean fishing pressure on the entire 19.3-km section of the Mountain Fork during December-February 1989-1993.[e]
Bull Shoals-Norfolk, AR	0.52-0.80	0.10 -0.13	783,600 - 1,306,053	46.1 - 98.4	Ranges of annual values from 1971, 1972, 1973, 1980 and 1981.[f]
Chattahoochee River, GA		0.22-0.52	34,207-129,923	45-56	Ranges from individual sites creeled in 1977 and 1978.[g]
Lake Tanycomo, MO	0.54 and 0.57				Total angler catch rate during 1962 and 1963, respectively, in the upper section of the reservoir. Rainbow trout made up 99% of the catch.[h]
Dale Hollow, TN				77	Return from 1964-67 adult rainbow trout stockings.[i]
Greers Ferry, AR	0.58 - 0.71	0.46 - 0.64	249,000 - 329,563	51.7 - 62.0	Ranges of annual values from 1988 - 1992.[j]

[a] Stocking sites are identified in figure 1.
[b] White 1968.
[c] White 1969.
[d] Forshage 1976.
[e] Harper 1994.
[f] Oliver 1984.
[g] Hess 1980.
[h] Fry and Hanson 1968.
[i] Little 1967.
[j] Bowman et al. 1994.

Figure 1. Location of water temperature monitoring, electrofishing, stocking, public access and creel sites used from 1987 to 2001, Canyon Reservoir tailrace, Texas. Map is not to scale.

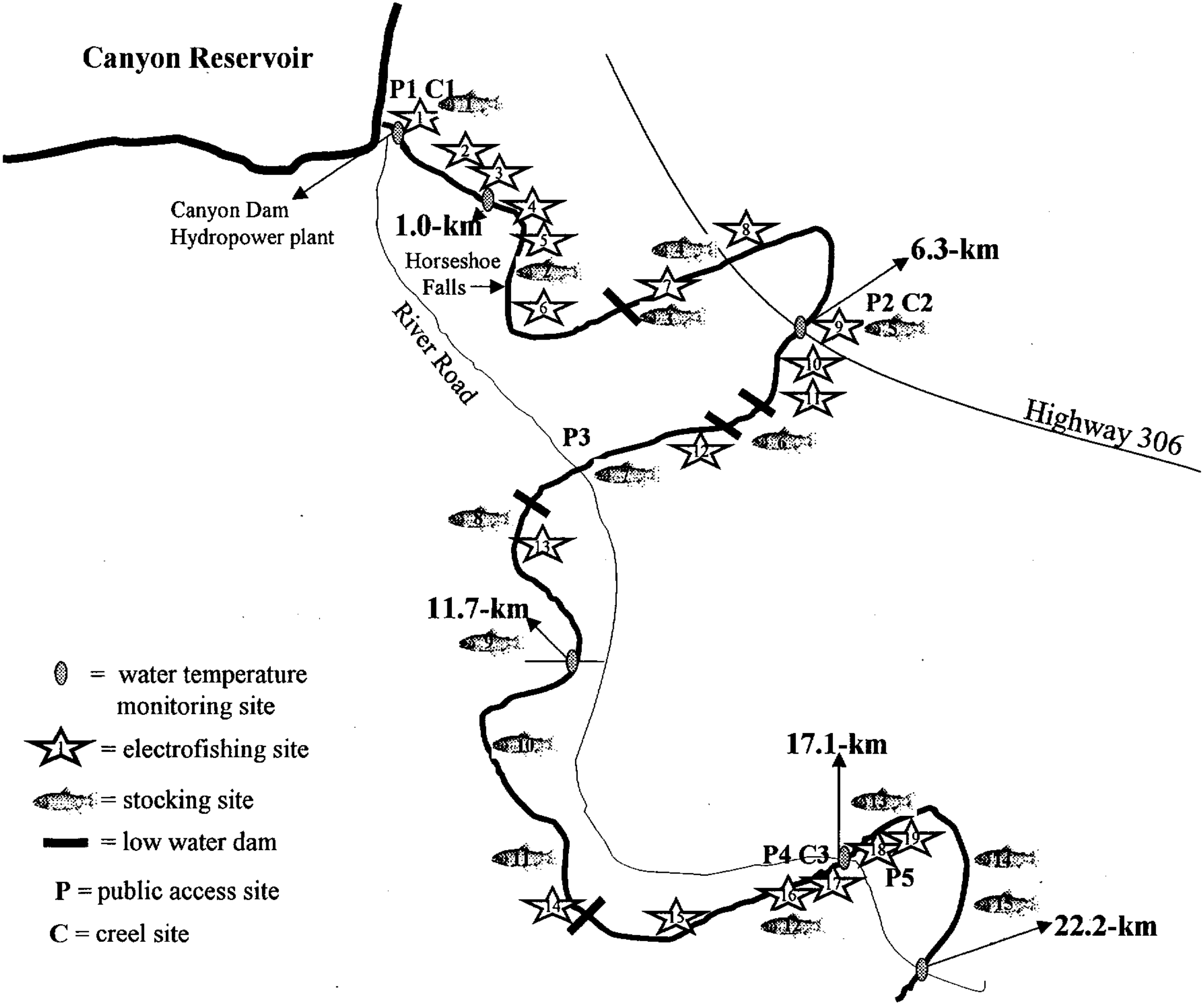
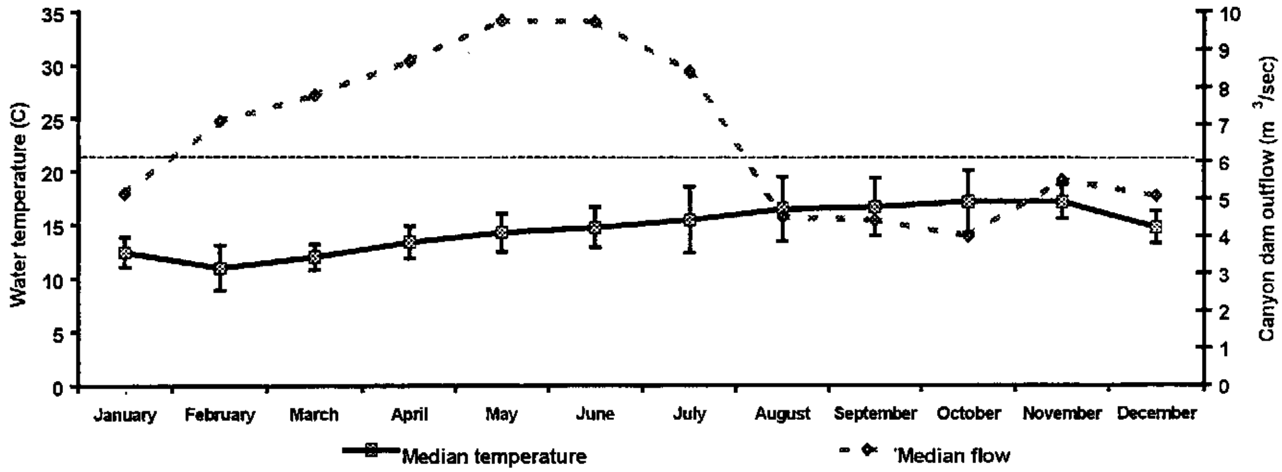
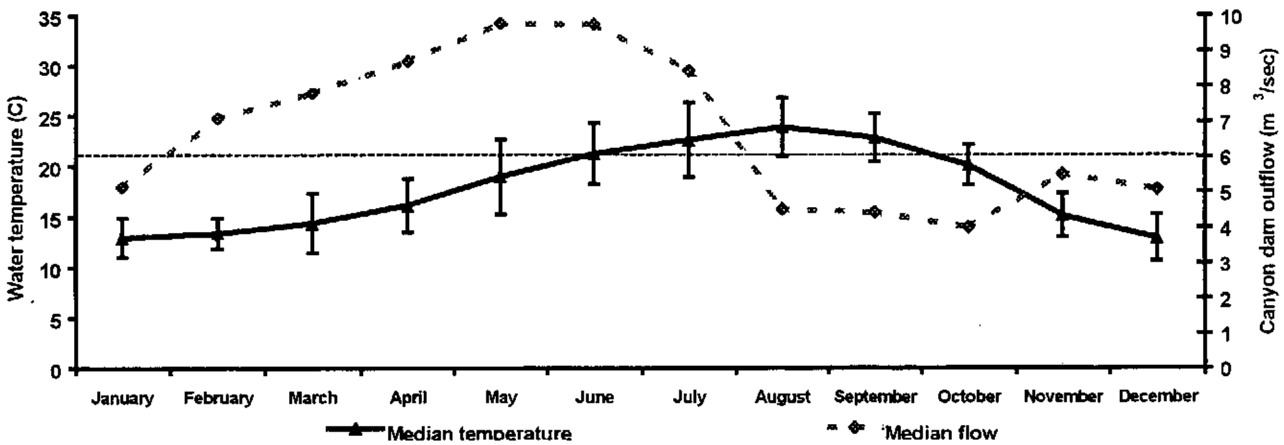

Canyon Reservoir
P1 C1
Canyon Dam
Hydropower plant
1.0-km
Horseshoe
Falls
River Road
P3
6.3-km
P2 C2
Highway 306
11.7-km
17.1-km
P4 C3
P5
22.2-km
= water temperature monitoring site
= electrofishing site
= stocking site
= low water dam
P = public access site
C = creel site

Figure 2. A general overview of water temperature and flow in the Canyon Reservoir tailrace, Texas, 1987-2001. Upper graph shows values at the Canyon Dam hydropower plant; lower graph shows values 22.2 km downstream. Water temperature data at the Canyon Dam hydropower plant and 1.0 km downstream were combined for each month between 1987 and 2001 to calculate median values for each month. Bars are + or – one standard deviation. Median outflow for each month was calculated using monthly means between 1987 and 2001. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994).

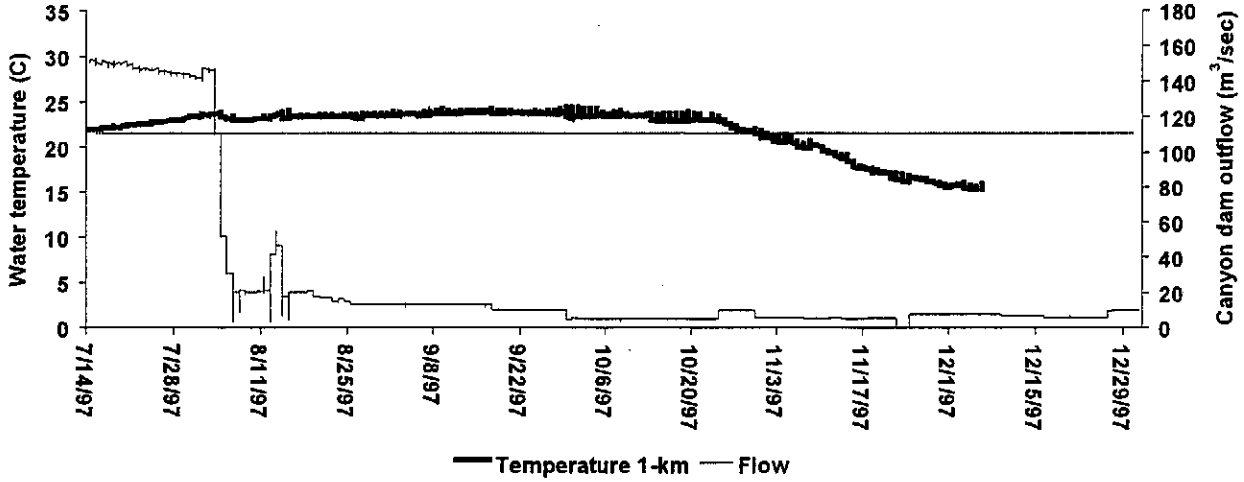


Water temperature (C)
Canyon dam outflow (m ³/sec)
January
February
March
April
May
June
July
August
September
October
November
December
Median temperature
Median flow

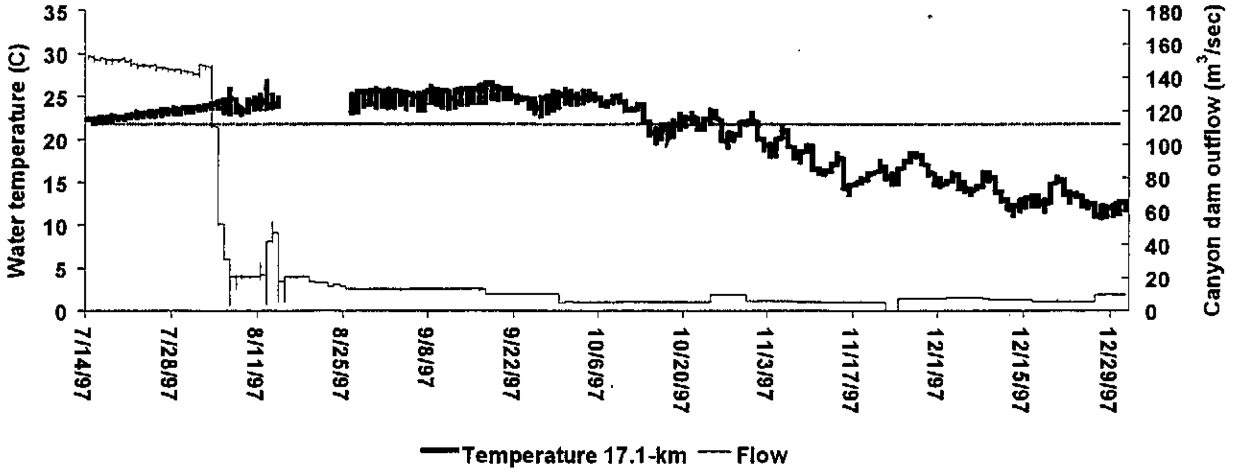


Water temperature (C)
Canyon dam outflow (m ³/sec)
January
February
March
April
May
June
July
August
September
October
November
December
Median temperature
Median flow

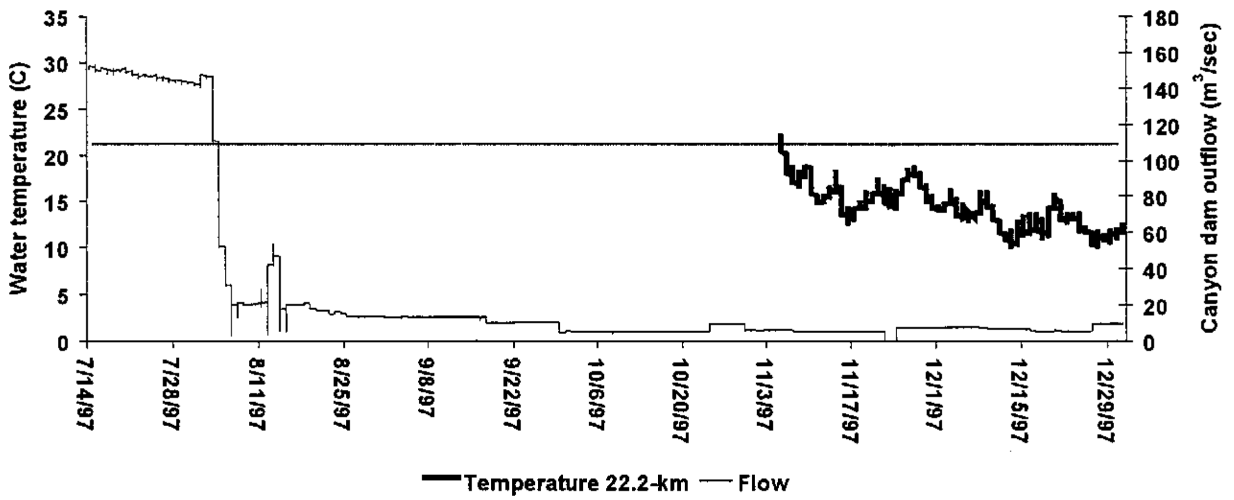
Figure 3. Water temperature 1.0 km, 17.1 km and 22.2 km downstream from the outflow of Canyon Reservoir, Texas. Flow rate was recorded by the USGS at the Sattler, TX gauging station. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994).



Water temperature (C)
35
30
25
20
15
10
5
0
Canyon dam outflow (m^3/sec)
180
160
140
120
100
80
60
40
20
0
7/14/97
7/28/97
8/11/97
8/25/97
9/8/97
9/22/97
10/6/97
10/20/97
11/3/97
11/17/97
12/1/97
12/15/97
12/29/97
Temperature 1-km
Flow

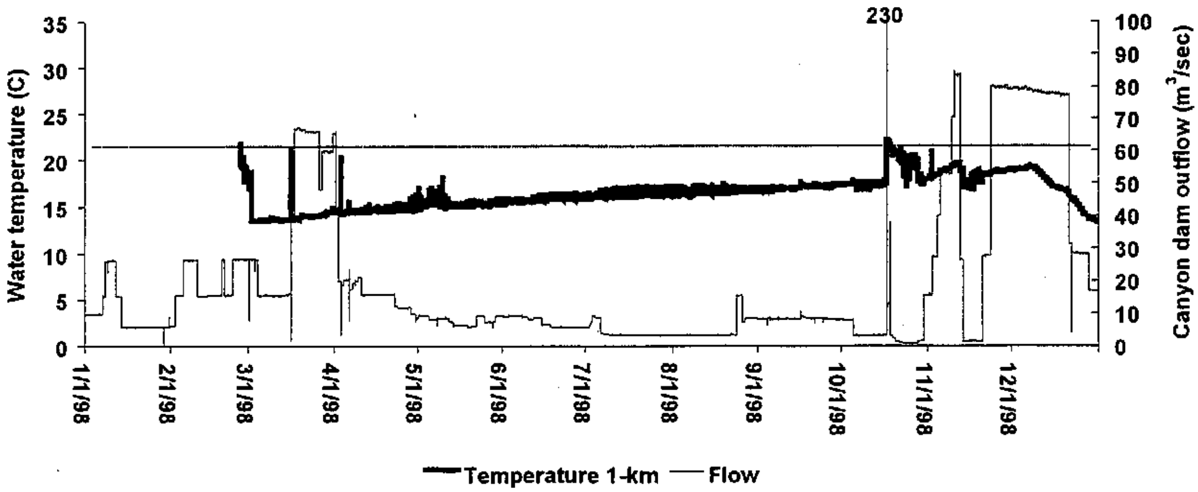


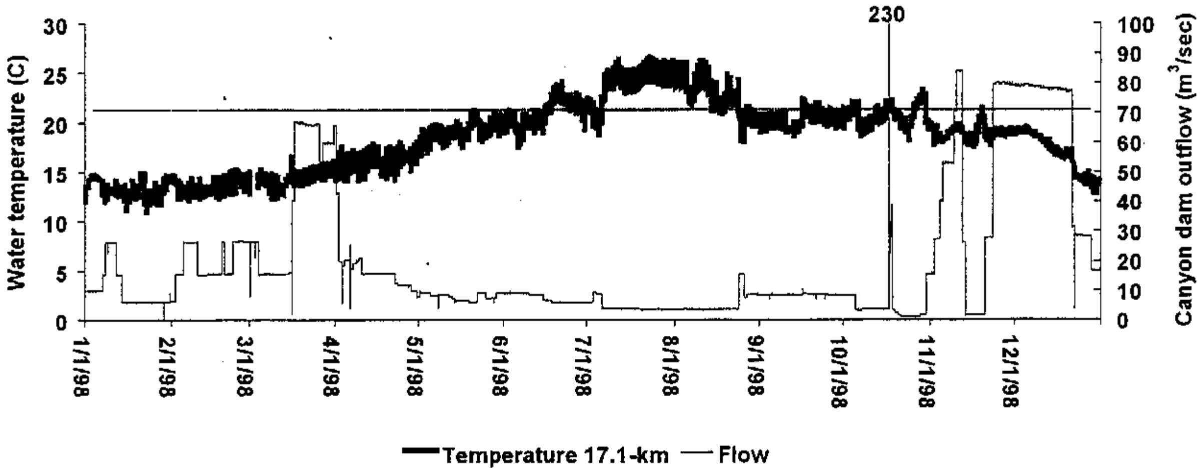
Water temperature (C)
35
30
25
20
15
10
5
0
Canyon dam outflow (m^3/sec)
180
160
140
120
100
80
60
40
20
0
7/14/97
7/28/97
8/11/97
8/25/97
9/8/97
9/22/97
10/6/97
10/20/97
11/3/97
11/17/97
12/1/97
12/15/97
12/29/97
Temperature 17.1-km
Flow



Water temperature (C)
35
30
25
20
15
10
5
0
Canyon dam outflow (m^3/sec)
180
160
140
120
100
80
60
40
20
0
7/14/97
7/28/97
8/11/97
8/25/97
9/8/97
9/22/97
10/6/97
10/20/97
11/3/97
11/17/97
12/1/97
12/15/97
12/29/97
Temperature 22.2-km
Flow

Figure 4. Water temperature 1.0 km, 17.1 km and 22.2 km downstream from the outflow of Canyon Reservoir, Texas. Flow rate was recorded by the USGS at the Sattler, TX gauging station. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994). Flow rate on 17 October 1998 reached 230 m^3/sec.


230
Water temperature (C)
Canyon dam outflow (m^3/sec)
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
1/1/98
2/1/98
3/1/98
4/1/98
5/1/98
6/1/98
7/1/98
8/1/98
9/1/98
10/1/98
11/1/98
12/1/98
Temperature 1-km
Flow


230
Water temperature (C)
Canyon dam outflow (m^3/sec)
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
1/1/98
2/1/98
3/1/98
4/1/98
5/1/98
6/1/98
7/1/98
8/1/98
9/1/98
10/1/98
11/1/98
12/1/98
Temperature 17.1-km
Flow

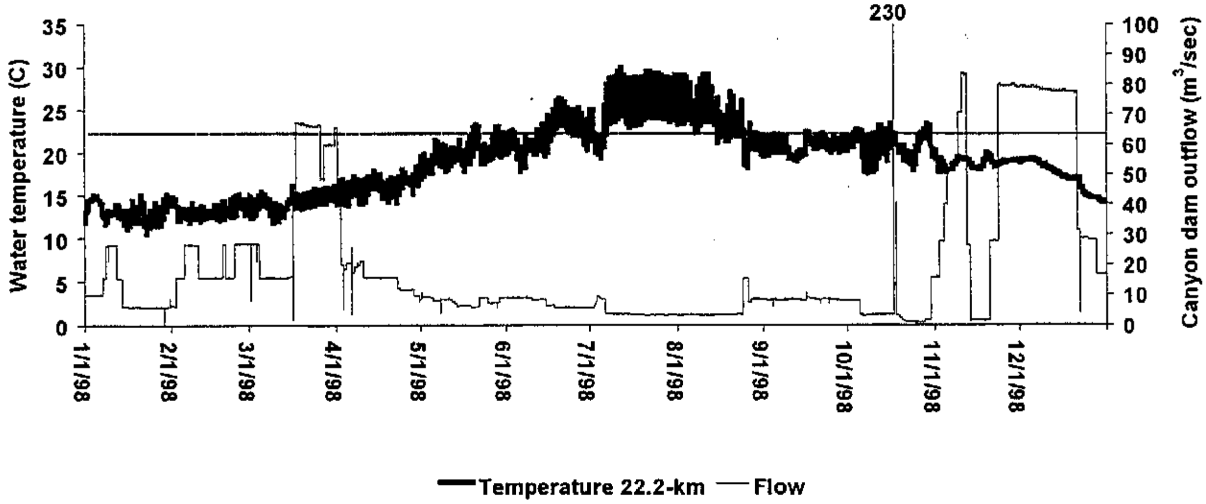
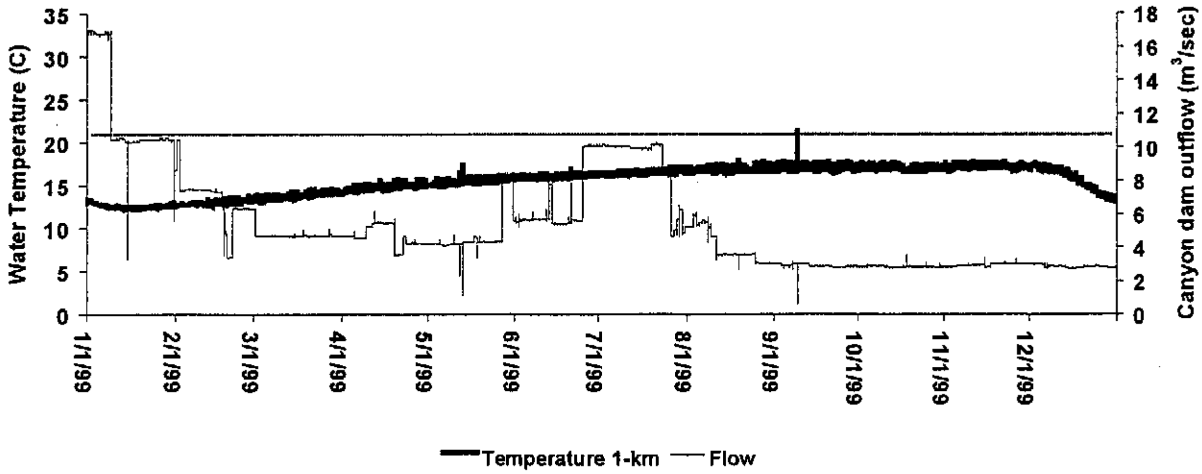
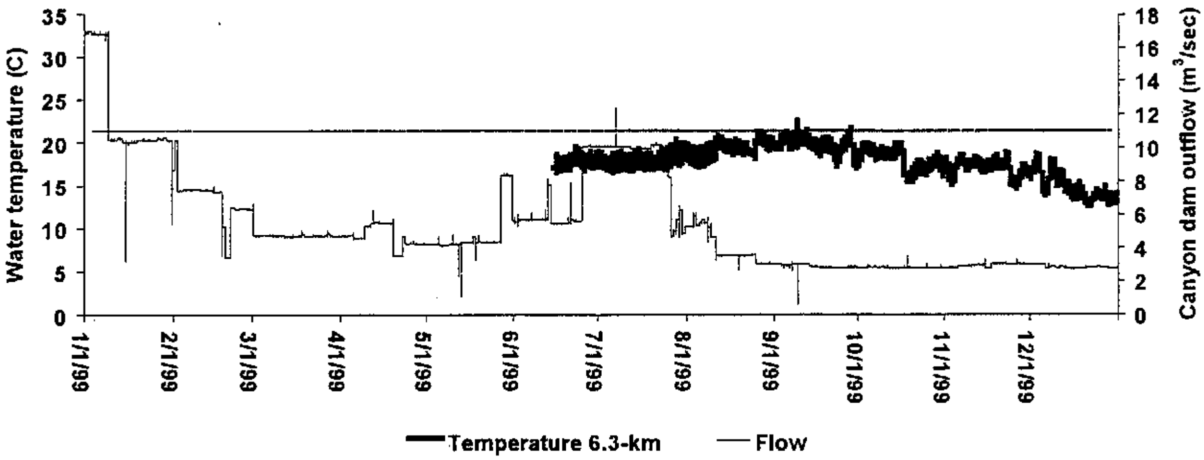

230
Water temperature (C)
Canyon dam outflow (m^3/sec)
35
30
25
20
15
10
5
0
100
90
80
70
60
50
40
30
20
10
0
1/1/98
2/1/98
3/1/98
4/1/98
5/1/98
6/1/98
7/1/98
8/1/98
9/1/98
10/1/98
11/1/98
12/1/98
Temperature 22.2-km
Flow

Figure 5. Water temperature 1.0 km, 6.3 km, 11.7 km, 17.1 km and 22.2 km downstream from the outflow of Canyon Reservoir, Texas. Flow rate was recorded by the USGS at the Sattler, TX gauging station. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994).


Water Temperature (C)
Canyon dam outflow (m³/sec)
35
30
25
20
15
10
5
0
18
16
14
12
10
8
6
4
2
0
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
6/1/99
7/1/99
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
Temperature 1-km
Flow


Water temperature (C)
Canyon dam outflow (m³/sec)
35
30
25
20
15
10
5
0
18
16
14
12
10
8
6
4
2
0
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
6/1/99
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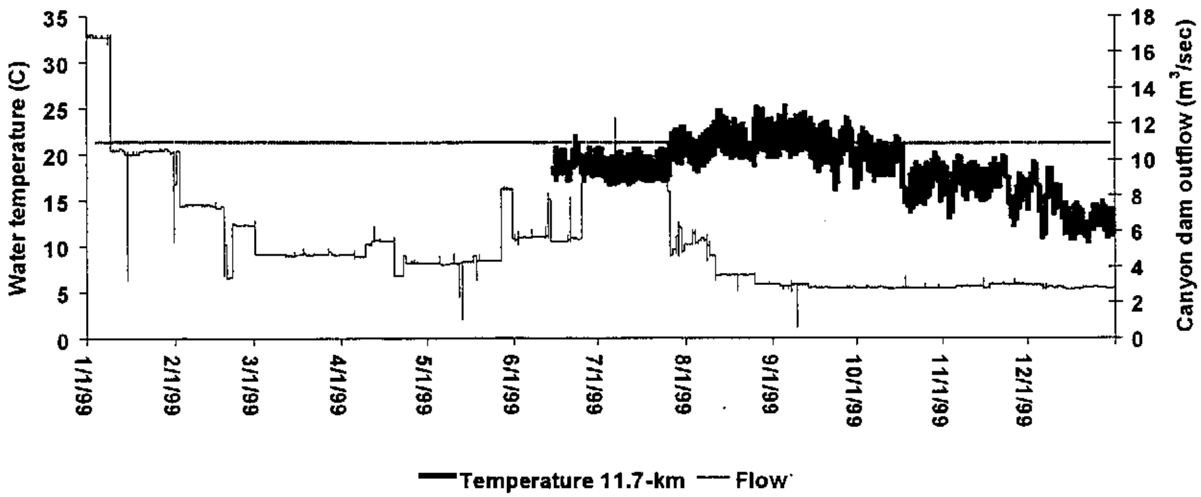
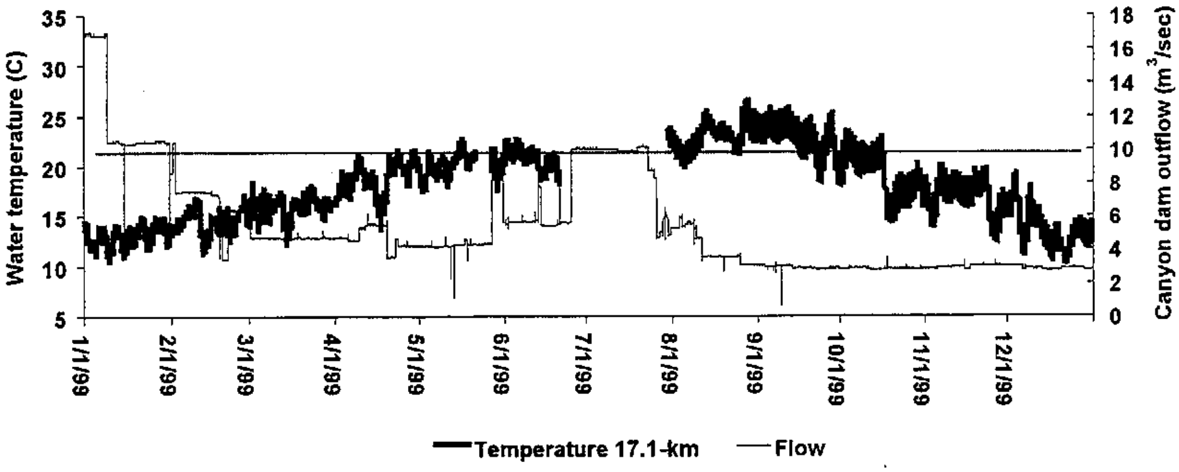
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
Temperature 6.3-km
Flow


Water temperature (C)
Canyon dam outflow (m³/sec)
35
30
25
20
15
10
5
0
18
16
14
12
10
8
6
4
2
0
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
6/1/99
7/1/99
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
Temperature 11.7-km
Flow


Water temperature (C)
Canyon dam outflow (m^3/sec)
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
6/1/99
7/1/99
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
Temperature 17.1-km
Flow

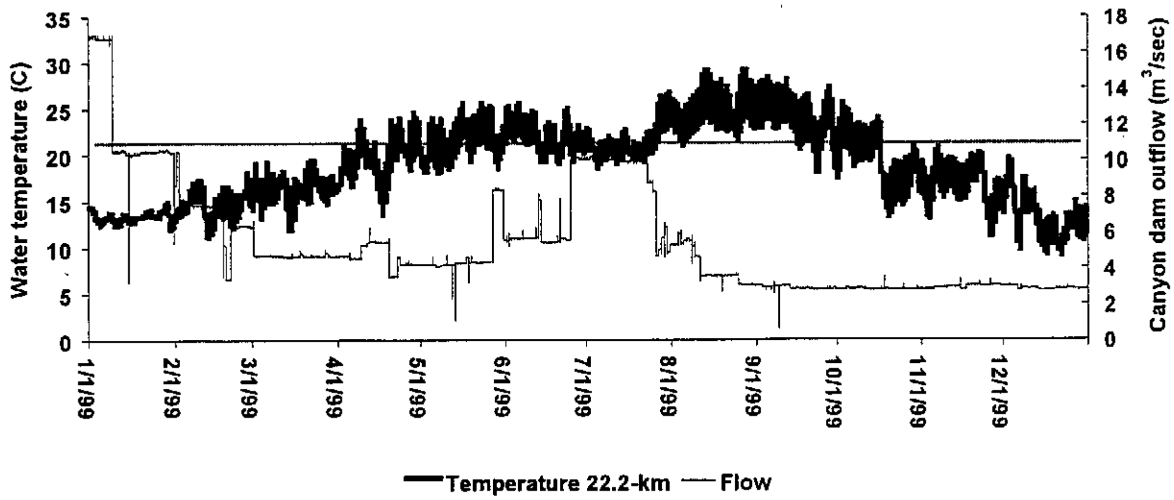
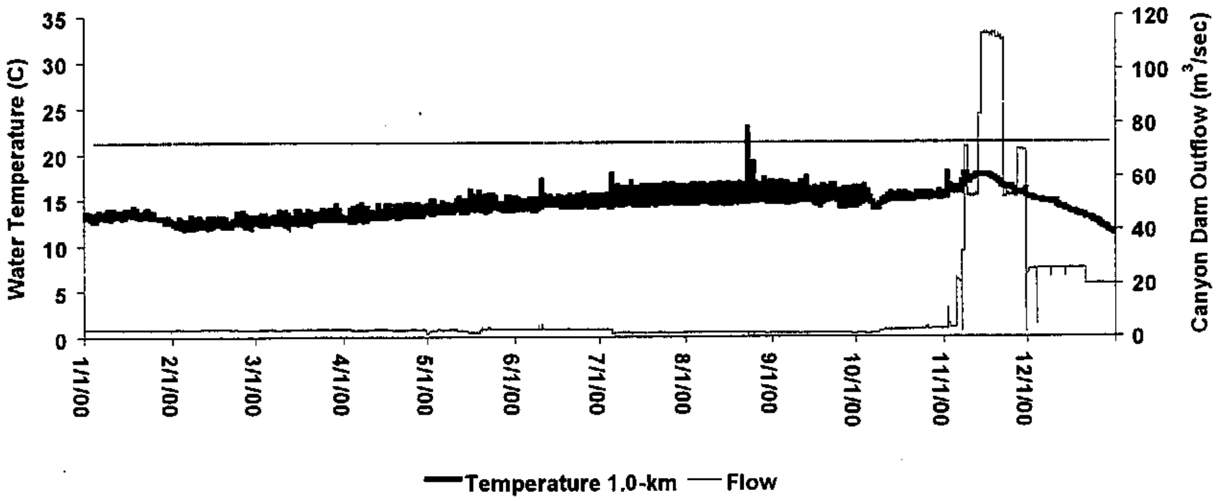
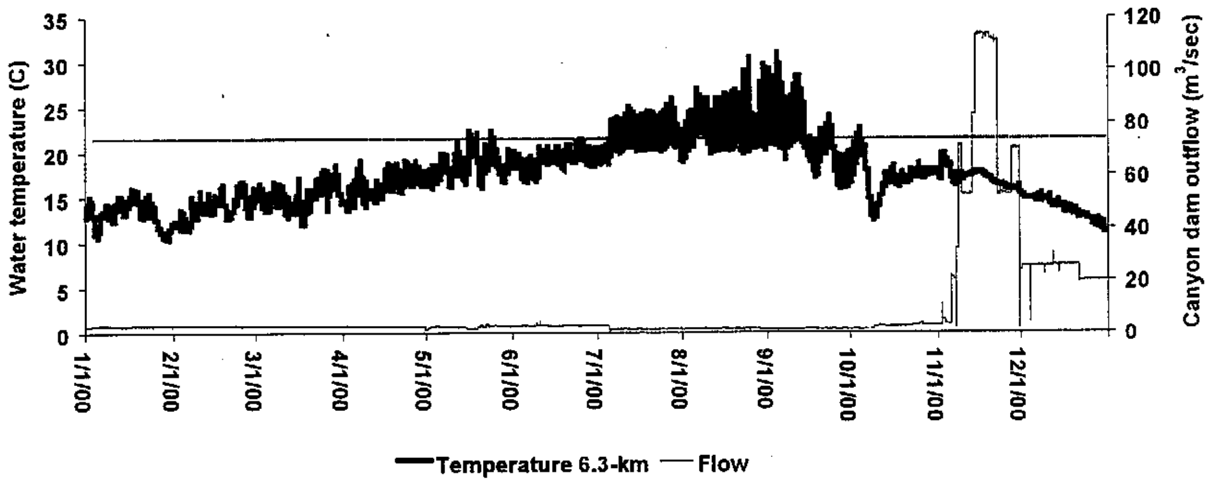

Water temperature (C)
Canyon dam outflow (m^3/sec)
1/1/99
2/1/99
3/1/99
4/1/99
5/1/99
6/1/99
7/1/99
8/1/99
9/1/99
10/1/99
11/1/99
12/1/99
Temperature 22.2-km
Flow

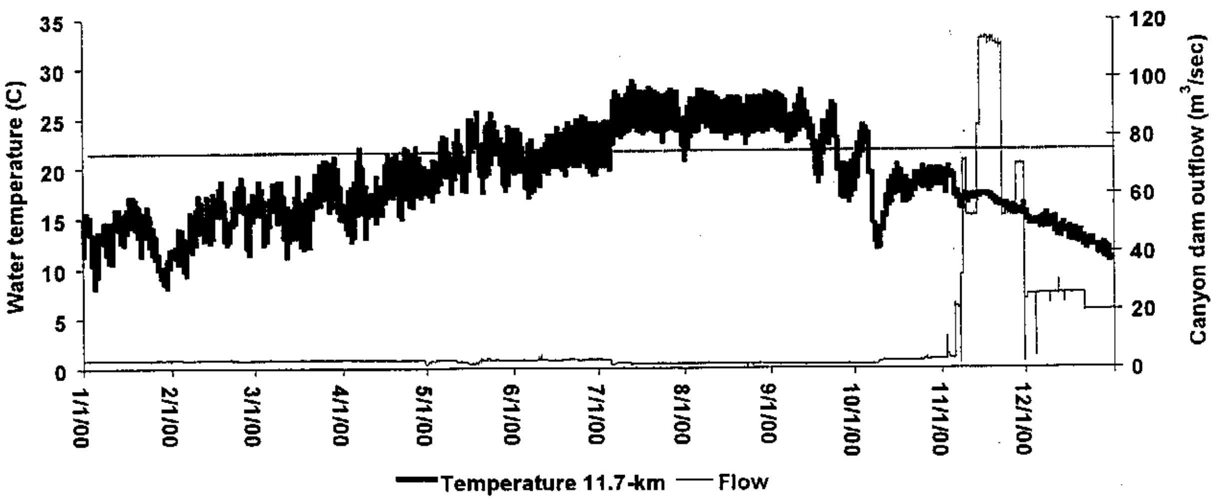
Figure 6. Water temperature 1.0 km, 6.3 km, 11.7 km, 17.1 km and 22.2 km downstream from the outflow of Canyon Reservoir, Texas. Flow rate was recorded by the USGS at the Sattler, TX gauging station. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994).



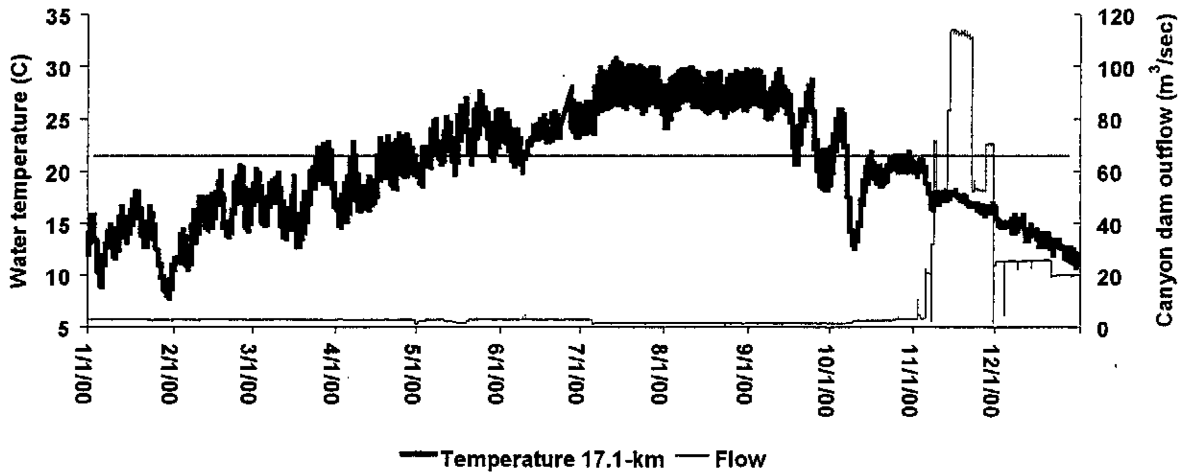
Water Temperature (C)
Canyon Dam Outflow (m³/sec)
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
Temperature 1.0-km
Flow



Water temperature (C)
Canyon dam outflow (m³/sec)
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
Temperature 6.3-km
Flow



Water temperature (C)
Canyon dam outflow (m³/sec)
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
Temperature 11.7-km
Flow


35
30
25
20
15
10
5
Water temperature (C)
120
100
80
60
40
20
0
Canyon dam outflow (m^3/sec)
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
Temperature 17.1-km
Flow

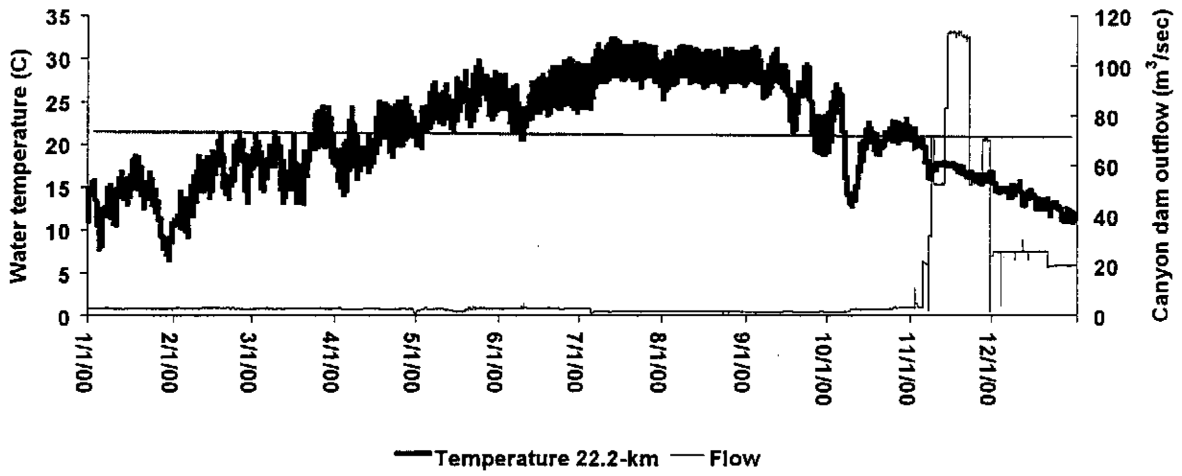
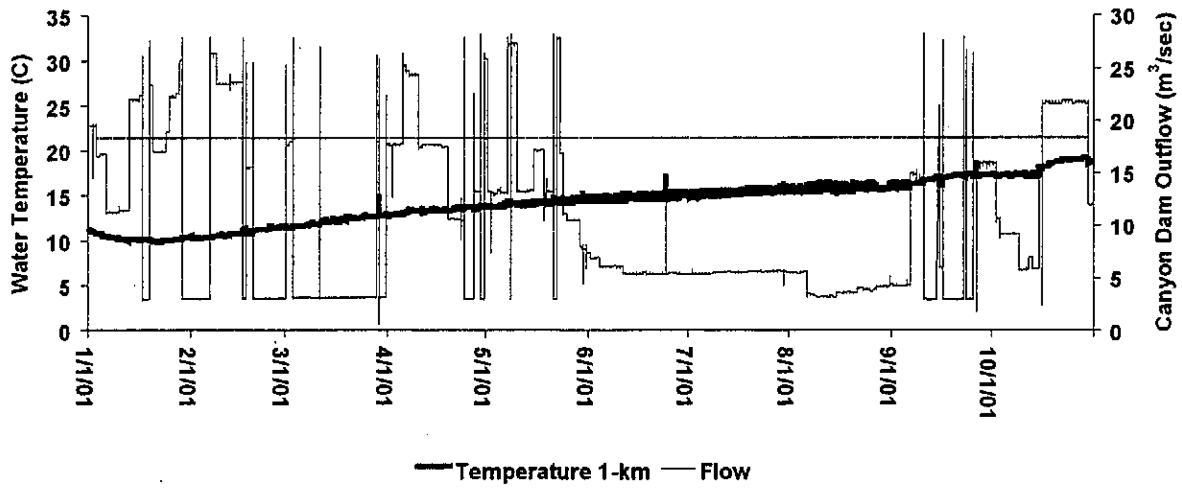
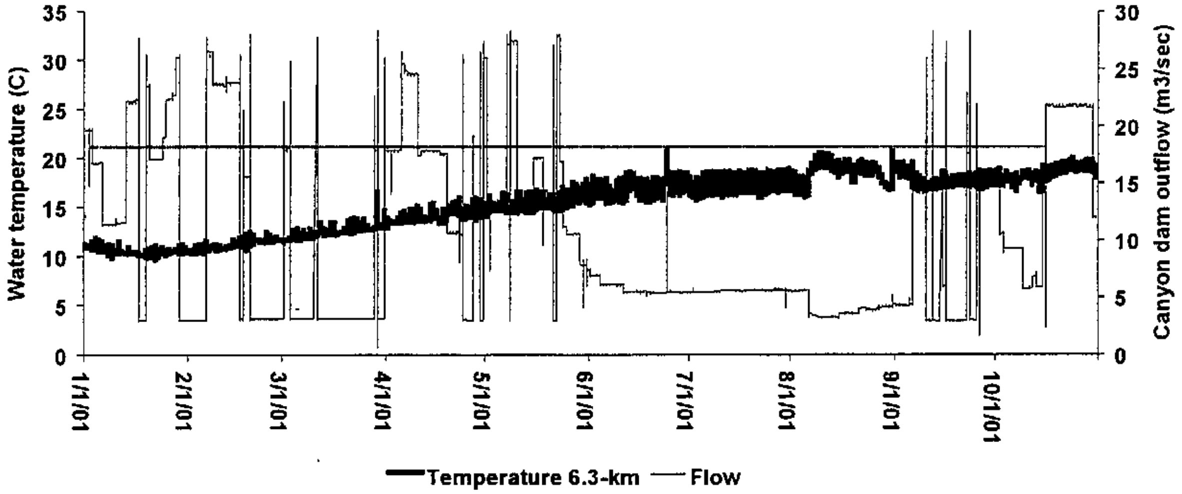

35
30
25
20
15
10
5
0
Water temperature (C)
120
100
80
60
40
20
0
Canyon dam outflow (m^3/sec)
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
10/1/00
11/1/00
12/1/00
Temperature 22.2-km
Flow

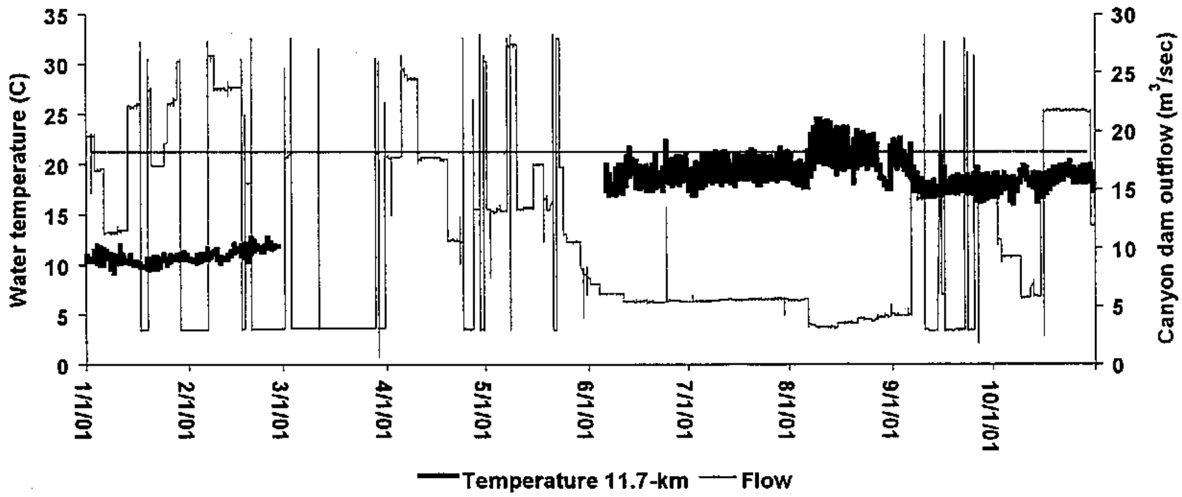
Figure 7. Water temperature 1.0 km, 6.3 km, 11.7 km, 17.1 km and 22.2 km downstream from the outflow of Canyon Reservoir, Texas. Flow rate was recorded by the USGS at the Sattler, TX gauging station. Horizontal line represents 21.1 C, the maximum recommended for tailrace trout fisheries (Axon 1975, Harper 1994).



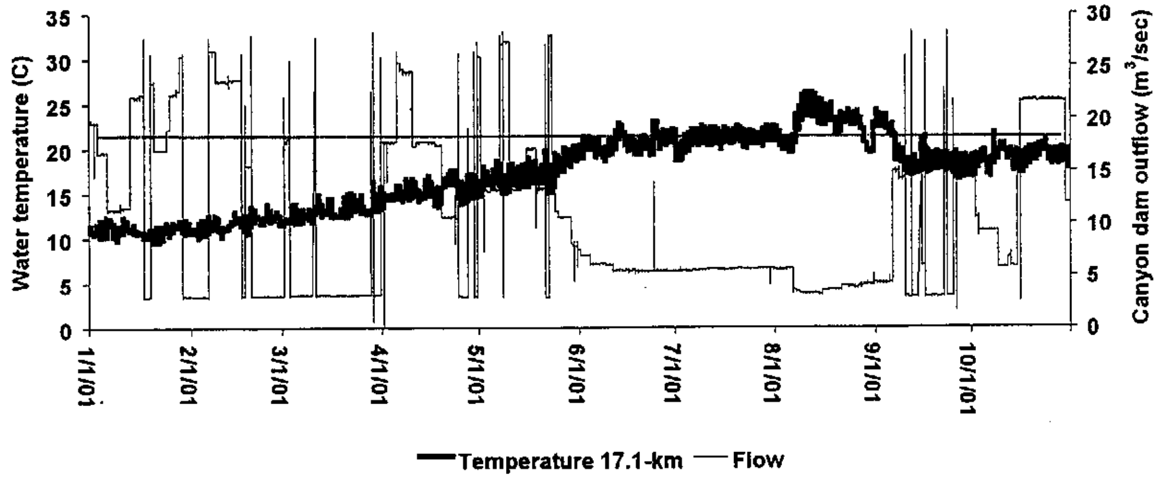
Water Temperature (C)
Canyon Dam Outflow (m3/sec)
1/1/01
2/1/01
3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
8/1/01
9/1/01
10/1/01
Temperature 1-km
Flow

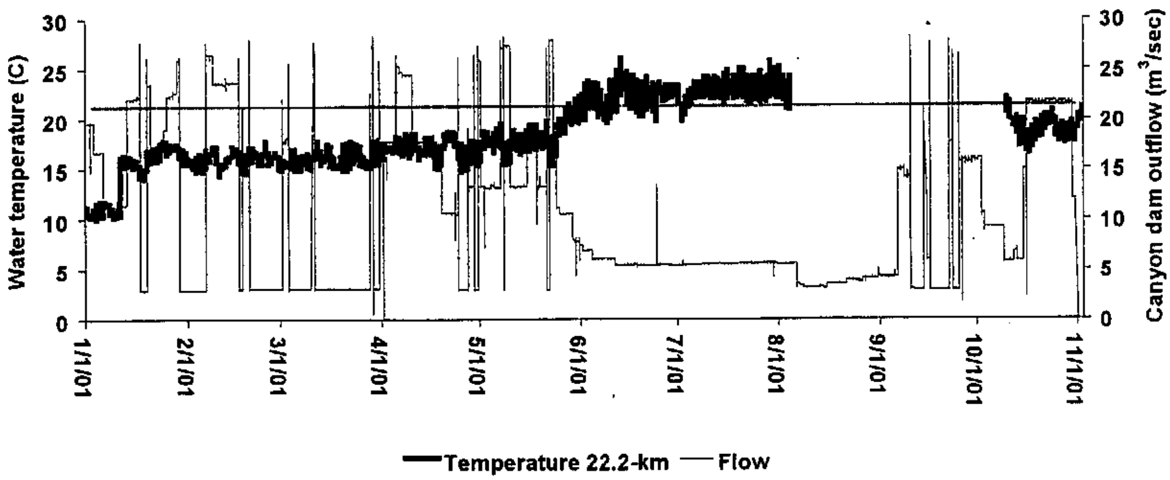


Water temperature (C)
Canyon dam outflow (m3/sec)
1/1/01
2/1/01
3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
8/1/01
9/1/01
10/1/01
Temperature 6.3-km
Flow



Water temperature (C)
Canyon dam outflow (m3/sec)
1/1/01
2/1/01
3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
8/1/01
9/1/01
10/1/01
Temperature 11.7-km
Flow


Water temperature (C)
Canyon dam outflow (m³/sec)
35
30
25
20
15
10
5
0
1/1/01
2/1/01
3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
8/1/01
9/1/01
10/1/01
Temperature 17.1-km
Flow


Water temperature (C)
Canyon dam outflow (m³/sec)
30
25
20
15
10
5
0
1/1/01
2/1/01
3/1/01
4/1/01
5/1/01
6/1/01
7/1/01
8/1/01
9/1/01
10/1/01
11/1/01
Temperature 22.2-km
Flow