Responses of rainbow (Oncorhynchus mykiss) and brown trout (Salmo trutta) to creation of access into a spawning tributary
by Scott Irven Snelson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences
Montana State University

Abstract:
The purpose of this study was to determine the use of Deep Creek as a spawning tributary by brown trout (Salmo trutta) and rainbow trout (Oncorhynchus mykiss) from the Missouri River and nearby Canyon Ferry Reservoir, after removal of a barrier across the stream. Movements of adult trout into the creek and outmigration of juveniles were monitored with traps at a concrete weir at the siphon site during 1992, 1993 and 1994. Large numbers of adult rainbow trout were captured moving upstream during spring, 719 in 1993 and 1,959 in 1994. Wild rainbow trout and two hatchery strains, DeSmet and Eagle Lake (identified by marks and dorsal fin erosion) trout were represented. Wild and hatchery strains differed in timing of spawning runs, with wild fish entering the stream and peaking in numbers before hatchery fish in both years. Hatchery fish accounted for 48.2% of the adult rainbow trout entering Deep Creek in 1993 and 76% in 1994. Of the adults tagged at the weir in 1993, 13% of the wild trout and 18.3% of the hatchery trout returned in 1994. Ages of wild adults captured in 1993, determined through scale samples, were ages 3 (6.0%), 4 (67.2%), 5 (22.4%), and 6 (3%). Growth patterns on their scales suggested that <1.5% had left their natal streams at age 0, 42.4% at age 1, 53% at age 2, and 4.5% at age 3. Few adult brown trout responded to the new access, with captures at the weir during late summer-early fall of four in 1993 and six in 1994. Length-class distribution of outmigrating juvenile rainbow trout (153 in 1993, 233 in 1994) was <23% age 0, about 62% age 1, and about 16% age 2 or greater. Length-class distribution of outmigrating juvenile brown trout (215 in 1993, 67 in 1994) was about 44% age-0 and 56% age-1. Included among the outmigrant brown trout were hatchery-origin, age-0 fish released into Deep Creek, virtually all of which moved downstream their first year. Results suggest that young rainbow produced in Deep Creek tend to remain within the stream during their first year before migrating downstream.

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APPROVAL

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Scott I. Snelson

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, citations, bibliographic style, and consistency and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The purpose of this study was to determine the use of Deep Creek as a spawning tributary by brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) from the Missouri River and nearby Canyon Ferry Reservoir, after removal of a barrier across the stream. Movements of adult trout into the creek and outmigration of juveniles were monitored with traps at a concrete weir at the siphon site during 1992, 1993 and 1994. Large numbers of adult rainbow trout were captured moving upstream during spring, 719 in 1993 and 1,959 in 1994. Wild rainbow trout and two hatchery strains, DeSmet and Eagle Lake (identified by marks and dorsal fin erosion) trout were represented. Wild and hatchery strains differed in timing of spawning runs, with wild fish entering the stream and peaking in numbers before hatchery fish in both years. Hatchery fish accounted for 48.2% of the adult rainbow trout entering Deep Creek in 1993 and 76% in 1994. Of the adults tagged at the weir in 1993, 13% of the wild trout and 18.3% of the hatchery trout returned in 1994. Ages of wild adults captured in 1993, determined through scale samples, were ages 3 (6.0%), 4 (67.2%), 5 (22.4%), and 6 (3%). Growth patterns on their scales suggested that <1.5% had left their natal streams at age 0, 42.4% at age 1, 53% at age 2, and 4.5% at age 3. Few adult brown trout responded to the new access, with captures at the weir during late summer-early fall of four in 1993 and six in 1994. Length-class distribution of outmigrating juvenile rainbow trout (153 in 1993, 233 in 1994) was < 23% age 0, about 62% age 1, and about 16% age 2 or greater. Length-class distribution of outmigrating juvenile brown trout (215 in 1993, 67 in 1994) was about 44% age-0 and 56% age-1. Included among the outmigrant brown trout were hatchery-origin, age-0 fish released into Deep Creek, virtually all of which moved downstream their first year. Results suggest that young rainbow produced in Deep Creek tend to remain within the stream during their first year before migrating downstream.

INTRODUCTION

Availability of suitable spawning habitats in tributaries is a critical factor affecting the success of wild trout populations in Montana. The important role of tributary spawning habitats in Montana has been described by Spoon (1985) for the Upper Missouri River, Sanborn (1990) for the Big Horn River, Sando (1981) for the Beaverhead River, and Byorth (1990) for the Yellowstone River. The availability of spawning habitat in tributaries to the Missouri River upstream from Canyon Ferry Reservoir is considered to be a major factor limiting the natural reproduction of brown trout, *Salmo trutta*, and rainbow trout, *Oncorhynchus mykiss*, from the reservoir and this part of the Missouri River (Montana Department of Fish, Wildlife and Parks [MFWP] 1991). Similarly, in a survey of reservoir fisheries in 11 states of the western U.S.A., Gebhards (1975) found that lack of spawning habitat was the factor most frequently mentioned as limiting to the establishment of wild trout populations.

Deep Creek is a third order stream which enters the Missouri River only about 8 km above Canyon Ferry Reservoir and thus could be a major spawning tributary for trout from the reservoir (Figure 1). However, prior to 1992, the creek had been separated from the Missouri River during a major portion of the spring and fall spawning seasons for rainbow and brown trout because it was intersected by an irrigation canal, the Montana Ditch. Deep Creek flows west from its headwaters in the Big Belt Mountains in southwestern Montana and enters the Missouri River near Townsend. The intersection of the Montana Ditch and Deep Creek is about 1 km upstream from the Missouri River.

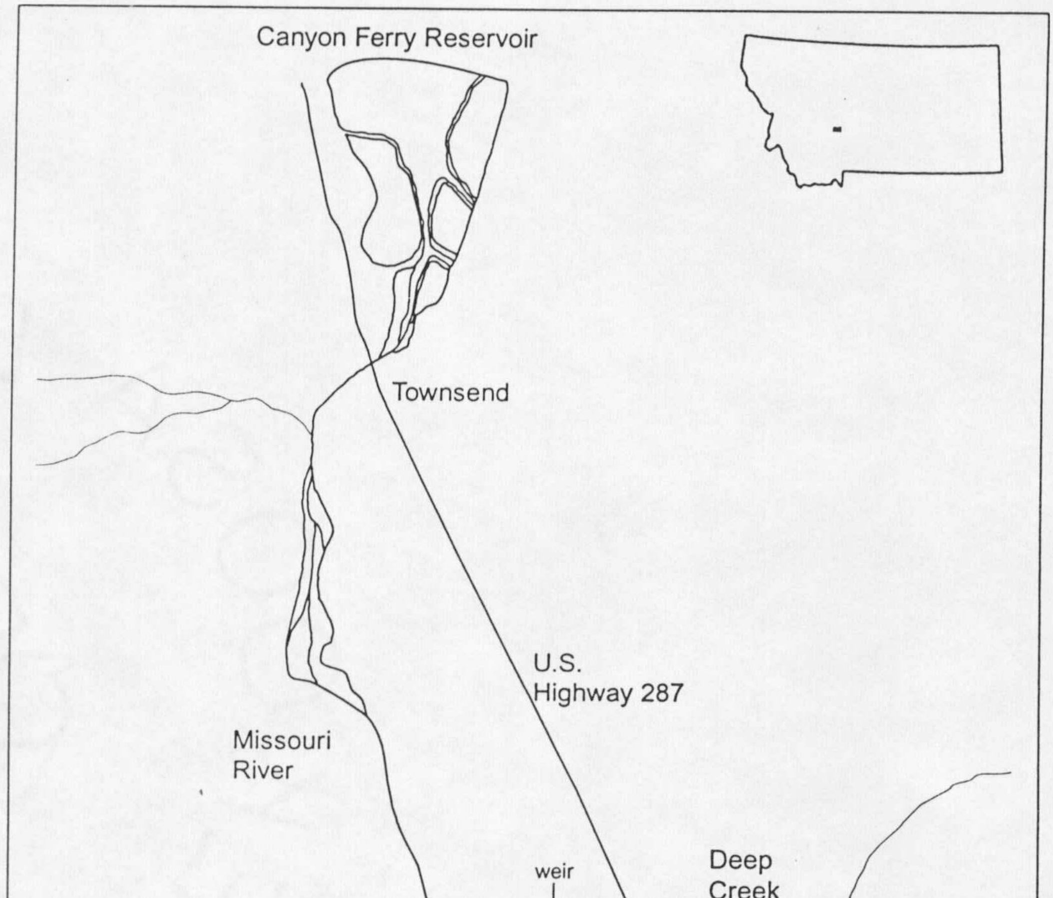

Figure 1. Location of the Deep Creek study site (Jeanes 1996).

Previously, the ditch formed a diversion completely across the creek (Figure 2). A gate in the diversion was closed during the irrigation season, typically from about mid-April to late October (Ronald Spoon, MFWP, pers. comm.), diverting creek water into the ditch and its downstream outlets. An overflow structure allowed some creek water to drop over the barrier and to flow downstream, particularly during periods of high discharge.

In the fall of 1992, a large concrete "siphon", actually a large underground conduit, was constructed to divert the Montana Ditch beneath Deep Creek (Figure 2). The siphon was constructed to allow Deep Creek to flow unimpeded to the Missouri River and thereby provide access into the creek for spawning trout. A low concrete weir was constructed about 25 m upstream from the siphon site, for monitoring fish movements. Deep Creek thus became accessible as a spawning tributary for brown and rainbow trout from Canyon Ferry Reservoir and the Missouri River. The connection with the Missouri River also provided a downstream migration corridor for young trout produced within the creek, and eliminated their diversion into the ditch.

The siphon project was undertaken as partial mitigation for the turbine retrofit of Toston Dam farther upstream on the Missouri River. It was predicted that brown trout would be the species most impacted by the Toston Dam retrofit (MFWP 1991). Brown trout are thus the intended primary beneficiaries of the Deep Creek siphon project. In addition to the siphon construction, approximately 27,000 brown trout fingerlings were stocked in Deep Creek each year by MFWP during Septembers of 1992, 1993, and 1994. These were released approximately 2 km upstream from the weir, in an effort to imprint

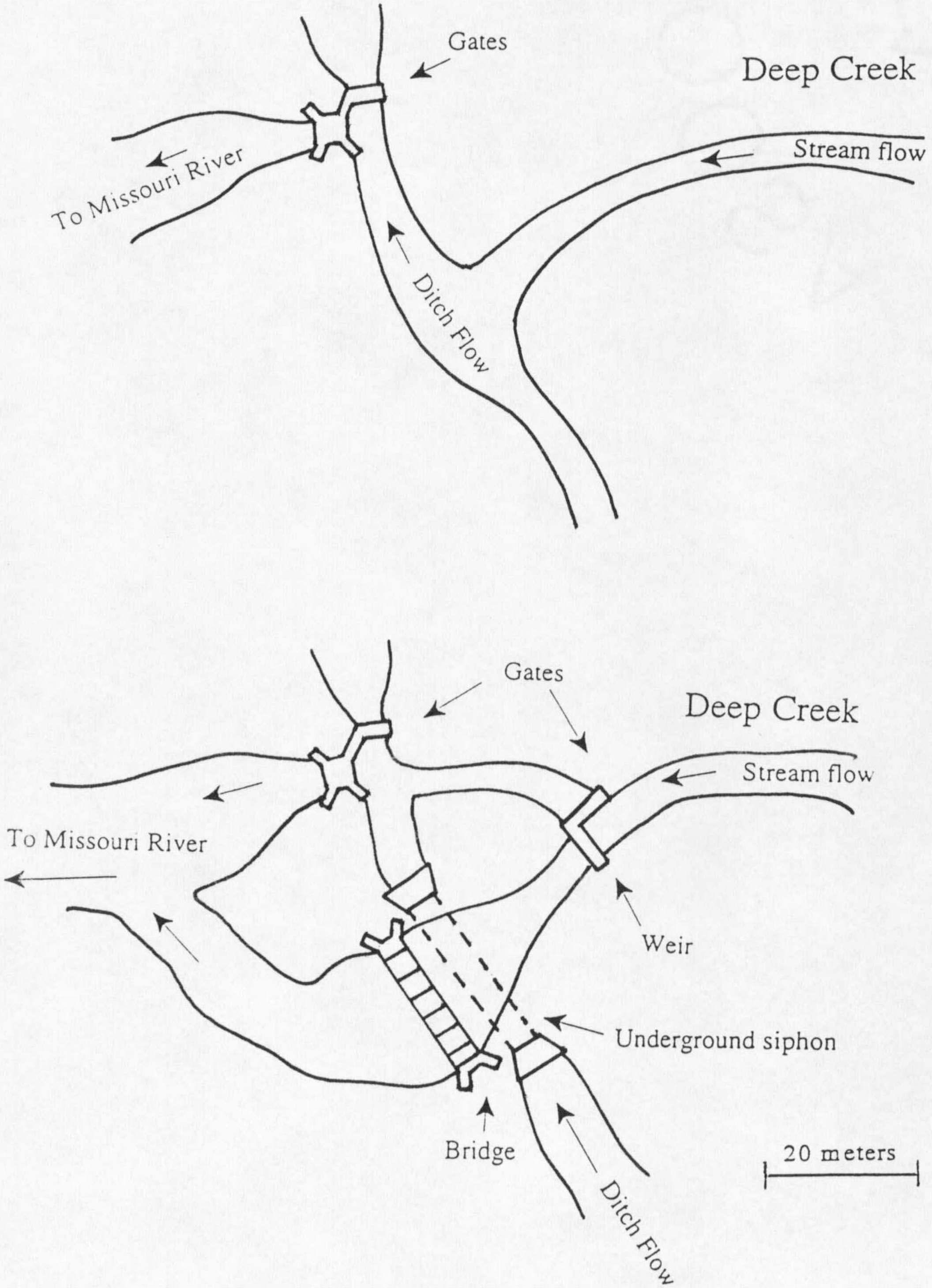

Figure 2. Deep Creek at the confluence with the Montana Ditch before (upper figure) and after (lower figure) construction of the by-pass siphon (adapted from Inter-Fluve 1990).

them to the stream and enhance the potential for their later return as spawning adults. An additional 54,000 brown trout fingerlings per year were planted during the same period in the Missouri River and Canyon Ferry Reservoir.

With the creek previously blocked by the ditch for much of the spring and fall spawning seasons of rainbow and brown trout, and with creek flow (and any downstream migrating young) diverted into the ditch for most of the ice-free period, it was assumed that there were very few, if any, rainbow trout in the Missouri River or Canyon Ferry Reservoir that had originated from and were imprinted to Deep Creek. Fidelity to natal streams for spawning has been described often (Lindsey et al. 1959, Altukov 1994, Mitsuo and Epinos 1994), but straying to non-natal streams also occurs and may be a mechanism by which new or depopulated streams can be colonized (Quinn et al. 1991). It was not known if spawning fish would respond to the newly created access into the creek. To evaluate responses of brown and rainbow trout to the creation of continuous, relatively unimpeded access into and out of the creek, the study tested the following hypotheses:

1. Creation of access into Deep Creek, by elimination of the barrier previously formed by the Montana Ditch, would result in attraction of adult brown and rainbow trout into the creek during their respective spawning migrations.

null hypothesis: Creation of access into Deep Creek would not result in attraction of adult brown and rainbow trout during their respective spawning migrations.

2. Creation of a downstream migration corridor, by elimination of the barrier and of the diversion of creek flow into the Montana Ditch, would result in downstream outmigration from Deep Creek of juvenile brown and rainbow trout produced within the creek.

null hypothesis: Creation of a downstream migration corridor would not result in the downstream outmigration of juvenile brown and rainbow trout produced in the creek.

To test these hypotheses, the objectives of this study were: (1) To determine the upstream movement into Deep Creek of adult brown and rainbow trout during their respective spawning seasons, by monitoring an upstream trap at the weir; and (2) To determine the downstream movement of juveniles of both species by monitoring downstream traps at the weir. Hatchery-reared trout have been planted directly into Canyon Ferry Reservoir, and these fish would provide an additional evaluation of whether the siphon project would result in the attraction of spawning trout into Deep Creek. Because of their hatchery origin, trout would be entering a novel, non-natal stream to spawn. An additional intended objective, of determining numbers and locations of redds excavated in the creek above the weir, could not be pursued because high flows and water turbidities precluded visual determinations.

In conjunction with observations to fulfill these principal objectives, other observations would be made on relative numbers of wild and hatchery-origin trout entering Deep Creek to spawn, the age and size distribution among adults in the spawning run, the temporal pattern of movement and size distribution of young moving downstream out of the creek, and distribution and abundance of trout in Deep Creek within 1 km above the weir.

METHODS

Trapping of Upstream Migrating Adults

Rainbow and brown trout migrating upstream into Deep Creek were captured with a box trap placed above one of four headboard slots at the concrete weir. The weir extended completely across the stream and, depending on flow volumes and numbers of headboards placed in each slot, produced a 50-80 cm drop to the stream surface below. Upstream migrants were prevented from jumping over the weir except at the trap entrance by a grate of 4-cm diameter PVC pipe which extended horizontally 125 cm from the weir. An opening in the grate at the trap entrance allowed trout to jump into a holding area from which they could pass through a funneled entrance into the main body of the trap.

Trout were removed from the trap daily, sedated with MS-222, then measured (total length) and weighed, and sex was determined. Scale samples were taken from fish (Jearld 1983) for age determination and the appearance of the dorsal fins was noted as a secondary indicator of hatchery origin. Trout were tagged with individually numbered floy tags to allow individual fish migration patterns to be determined and to identify fish that returned to spawn in Deep Creek in 1994. Fish were examined for fluorescent scale marks using an ultraviolet light box to determine wild or hatchery origin and hatchery strain. The fish were then placed in a screened holding pen until they regained equilibrium, then released upstream of the weir. Traps for upstream migrants were maintained at the weir from early September until mid November in 1992, March 31 to October 29 in 1993 and March 8 to November 5 in 1994. A chi-square test ($p<0.05$) was used to determine if hatchery or wild trout returned to spawn in 1994 in proportions significantly different than those tagged in 1993. The null hypothesis was that the proportion of previously tagged wild fish to previously tagged hatchery-origin fish, returning to spawn in Deep Creek, would be equal to the proportion of wild fish to hatchery fish tagged in 1993.

Large numbers of rainbow trout have been planted in Canyon Ferry Reservoir each year. Beginning in the 1980's these rainbow trout have been batch marked with fluorescent scale marks (Table 1) according to strain, as part of a study by MFWP to evaluate the performance of different strains. Fin clips have been used to identify specific plants of these rainbow trout.

Table 1. Rainbow trout stocked into Canyon Ferry Reservoir from 1986-1993, including total numbers stocked with strain-identifying fin clips and spray markings (MFWP, unpublished).

Year	DeSmet Age- 0	DeSmet Age- 1	Eagle Lake Age- 0	Eagle Lake Age-1	Arlee Age-0
1986		62,000 [1]			1,035,639 [2]
1987			251,303 [1]		724,686 [2]
1988	135,513 rp		121,587 [1]		766,045 [2]
1989			130,000 [1]		852,158 [2]
1990		223,665 rp	474,623 [1]		
1991		442,237 [2]			
1992		609,017 [2]	469,744 [1]	379,946[1]	
1993	450,000 [2]		950,000 [1]		

[1] Spray-marked with green fluorescent scale marking
[2] Spray-marked with red fluorescent scale marking
rp Right pelvic fins clipped prior to release

A student t-test was used to determine if there was a difference in mean lengths of fish marked with right-pelvic-fin clips between 1993 and 1994. Differences were considered significant at the $p < 0.05$ level.

Fish Aging

Wild rainbow trout were aged from their scales to determine age distribution among the adults entering Deep Creek. It was expected that many hatchery fish could be identified by their specific marks (Table 1) and would thus be of known age (Jearld 1983). Scale samples from wild trout were numbered and a random sample of 67 was selected from these using the EXCEL spreadsheet random number generator from 271 possible samples. Cellulose acetate impressions of scale samples were examined at 48X and 72X magnification using a microfiche reader. The outer edge of each annulus was counted as a year. The outer edge of scales from fish captured during spring and early summer was counted as a year to account for the presumed beginning of the annual rapid growth period.

Estimates of years of stream residence, prior to emigration to the more productive reservoir, of migrating adult wild rainbow trout, were made by using the relative increase in spacing of circuli as the fish enter the reservoir or the Missouri River. Annuli associated with relatively densely spaced circuli nearest the scale focus were counted as years of stream residence (Figures 3, 4 and 5). Annuli associated with obviously wider

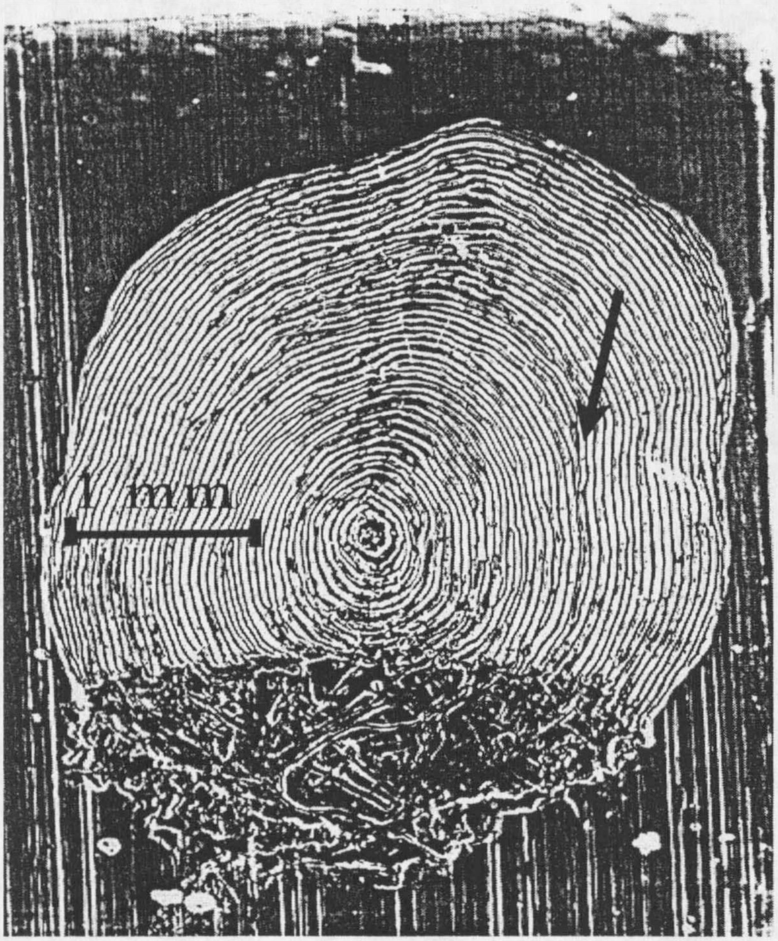

Figure 3. Acetate scale impression from an age-2, Eagle Lake rainbow trout (hatchery strain) captured at the Deep Creek weir in 1993. The arrow indicates the first annulus. This fish was planted into Canyon Ferry Reservoir.

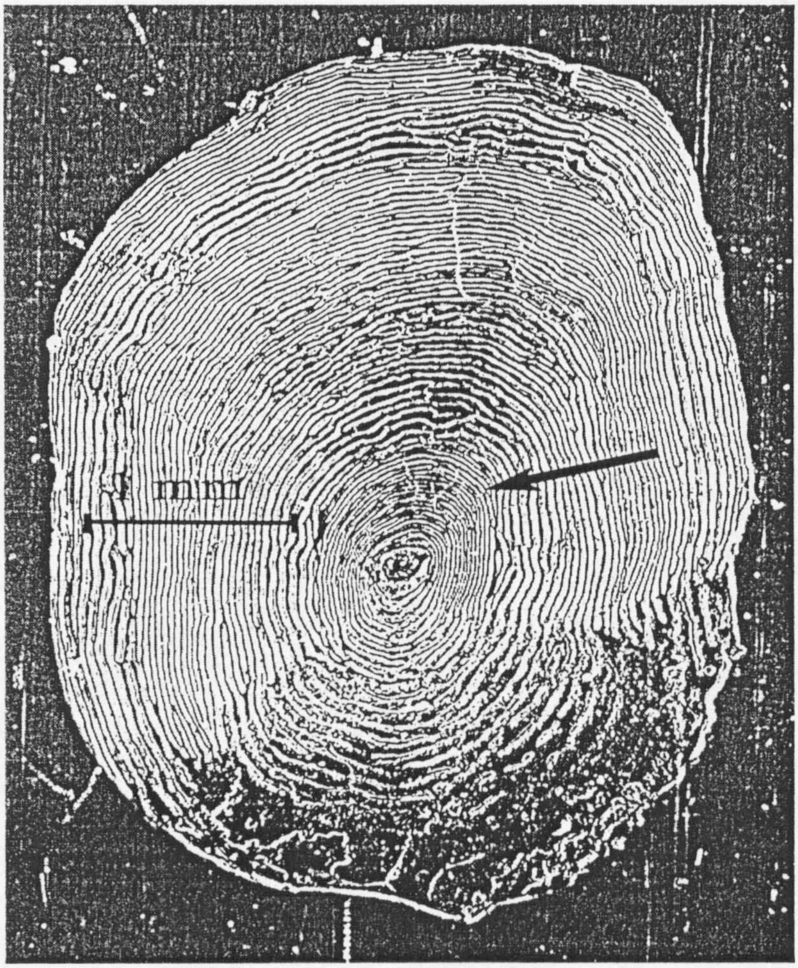

Figure 4. Acetate scale impression from an age-3, wild rainbow trout captured at the Deep Creek weir in 1993. The arrow indicates the age-1 annulus. Circuli on the inside of the arrow represent tributary growth, while circuli on the outside of the arrow represent growth in Canyon Ferry Reservoir or the Missouri River.

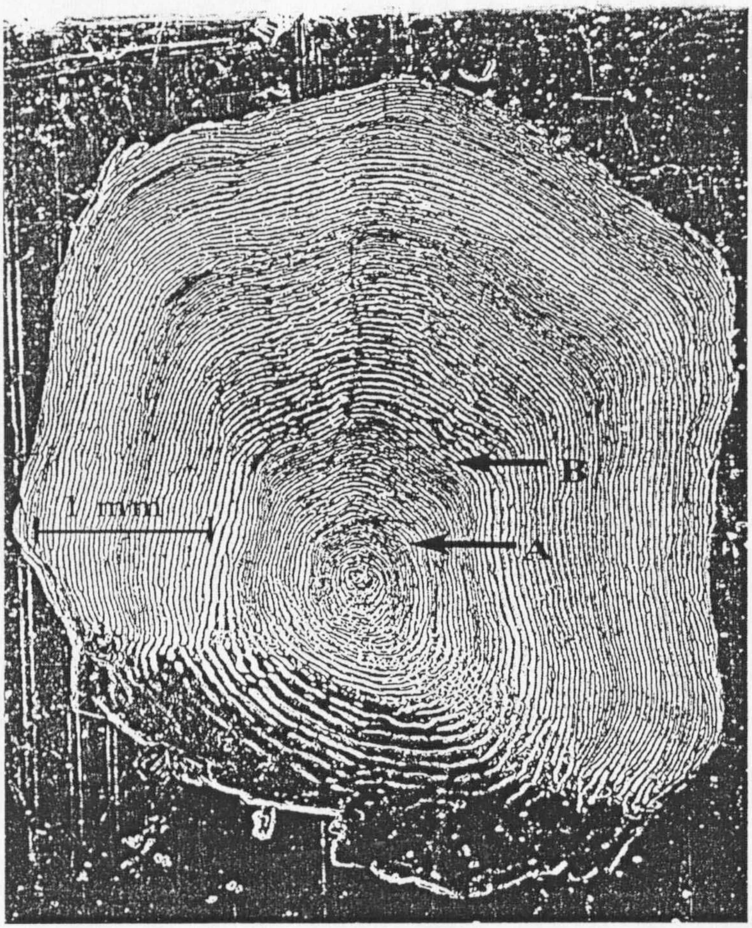

Figure 5. Acetate scale impression from an age-5, wild rainbow trout captured at the Deep Creek weir in 1993. Arrow A indicates the age-1 annulus, Arrow B represents the age-2 annulus. The ciruli outside arrow B represent growth in Canyon Ferry Reservoir or the Missouri River.

circuli spacing patterns were counted as years spent in the reservoir or Missouri River (Seelbach and Whelan 1988). Mean length differences between age groups were calculated using ANOVA performed with the EXCEL spreadsheet package. Differences were considered significant at the $p < 0.05$ level.

Comparisons of Migrations of Wild and Hatchery Trout into Deep Creek

Long term annual gill netting data (MFWP, unpublished) were used to compare percent composition of adult trout captured in Canyon Ferry Reservoir with those captured moving upstream into Deep Creek. Such comparisons would provide evaluation of whether wild trout originating from within the Canyon Ferry Reservoir drainage and hatchery trout planted into the reservoir would differ in their responses to creation of access into Deep Creek. A chi-square test was used to test the null hypothesis that the proportion of strains of rainbow trout captured at the Deep Creek weir was similar to the proportion of strains captured in the reservoir gill nets ($p<0.05$).

Comparisons were also made of relative numbers of wild and hatchery fish marked in 1993 and recaptured in 1994 at the weir as they migrated upstream. For statistical comparison (chi-square test), the null hypothesis being tested was that the proportions of wild and hatchery fish returning in 1994 would be similar to the proportions originally captured and marked in 1993.

Temperature and Stream Flows

Stream temperature and discharge were monitored to determine the parameters associated with the entrance of trout into Deep Creek. Temperature was recorded approximately 15 m upstream from the weir in 1993 and approximately 5 m upstream from the weir in 1994 with a Taylor recording thermograph, which was calibrated with a hand-held thermometer. Mean daily temperatures were calculated by adding the daily minimum and maximum thermograph readings and dividing by 2. Weekly mean temperatures were calculated as the average of mean daily temperatures.

Stream discharge rates were estimated in m^3/s (CMS) from water level measurements taken from a battery-powered recorder and from a staff gauge near the recorder. Both the staff gauge and water level recorder were located approximately 150 m upstream from the weir. I estimated discharge by comparing the water-level measurements with stage-discharge relationships derived by MFWP (unpublished) for the staff gauge and water level recorder on Deep Creek in 1993 and 1994. MFWP calibrated stage-discharge relationships by estimating discharge at transect sites near the weir, following methods described by Orth (1983) and using electronic current meters to estimate current velocities across the transect sites (Ronald Spoon, pers. comm.). Weekly mean discharge rate was estimated by summing the daily discharges and dividing by the number of days for which estimates were made during that week.

Trapping of Downstream Migrating Juveniles

Drift nets of 1 mm nylon mesh (mouth opening of 58 X 63 cm) were hung below the weir, under the PVC grate. The PVC grate prevented both upstream passage of adult trout and entry into the nets by adults moving downstream. The nets sampled water that passed through 53-cm slots in the headboards and plunged 0.5 m to and through the PVC grate. The pyramid shaped, 2.4 m-long, nylon nets funneled into 10-cm diameter PVC pipes at their trailing ends. The PVC pipe extended approximately 20 cm into a 125 cm x 75 cm x 75 cm screened box covered on four sides with 1 mm mesh nylon netting. The top of the box was covered with a 13 mm plywood lid and the end of the screened box that accepted the PVC pipe was covered by 13 mm plywood. This plywood end effectively provided velocity refuge for fish captured in the nets. One to three drift nets were deployed across the weir depending on flows and debris movement. In 1994 a 3.5 m long wooden flume was installed in one of the weir slots providing a stronger structure to achieve a better subsample of fish during higher than expected flows. The flume emptied into a 1.25 m^3 screened holding pen lined with 1 mm nylon mesh.

Trout were removed from the out-migrant nets at least daily, measured, examined for fin clips and released downstream of the weir. The 27,000 brown trout fingerlings stocked into Deep Creek each September of 1992, 1993, and 1994 were marked before release with fin clips. Due to high stream flows during the 1993 and 1994 seasons, traps regularly were damaged or became dislodged, making estimates of total outmigration and relative timing of outmigration of <300 mm trout unreliable. Fry traps were operated from Early April to the end of October in 1993 and from the end of March to August 30 in 1994.

In addition to juveniles, a few downstream-migrating adults were also sampled. A subsample of adults was allowed to enter drift nets set to capture juvenile out-migrating trout by removing the PVC grate material above the juvenile traps. A subsample of outmigrating adults was also made when they entered a wooden flume that was placed in one of the four weir slots. Otherwise, adult fish were prevented by the PVC grate from entering downstream drift nets. They passed over the weir via flow over the headboards.

Distribution and Abundance of Trout in Deep Creek

To determine if age-0 trout reared within Deep Creek were moving downstream out of the creek, as was indicated by fish captured at the weir, electrofishing mark-recapture surveys were conducted between the weir and the Highway 87 bridge approximately 1 km upstream. A Coffelt backpack unit powered by a gasoline engine was used for the surveys. In 1993, the marking run was conducted on September 19 and the recapture run, 2 d later on October 18. In 1994, the marking run was on October 12 and the recapture run, 6 d later on October 18. Fish captured on the first run were marked with an upper caudal fin clip, and total length was recorded for all trout captured. Although the surveys during the 2 d of each year were intended to be replicate mark-recapture population estimates, intermittent equipment malfunctions in 1994 allowed only one-third of the 1993 section to be re-sampled. Population estimates and confidence limits for 1994 were multiplied by 3 for comparisons between years. The modified Peterson method was used to derive population estimates (Everhart and Youngs 1981). Data obtained from these samples were also used to determine length-frequency distributions and percent composition of juvenile trout present in the stream. Comparisons of length-distributions of trout <300 mm, between fish captured at the weir, and fish captured during electrofishing population estimates above the weir, were performed using ANOVA. Differences were considered significant at the $p < 0.05$ confidence level.

RESULTS

Upstream Movement of Adult Rainbow Trout

In 1993, the first spring of access into Deep Creek, 719 adult rainbow trout migrating upstream were captured at the weir. This was an underestimate of the total run because trap efficiency dropped dramatically in the third week in May due to high water (Figures 6 and 7). The high water allowed fish to swim over and around the trap and to jump over the PVC grate. Rainbow trout were observed jumping over the weir grates during this high water period.

Apparent peak upstream migration for all strains occurred in the 4th week of April in 1993 when the mean weekly temperatures reached approximately 8 C and flow in the creek was about 0.9 CMS. This assumes that peak migration did not occur after trap efficiencies dropped in the third week of May (Figure 7).

In 1993, 372 wild rainbow trout (with no evidence of dorsal fin erosion and no detectable fluorescent scale marks) were captured migrating into Deep Creek. These wild rainbow trout constituted 51.2% of the total 1993 sample. Approximately 21% (N=85) of these wild adults were male.

The other 48.8% of adult rainbow trout captured moving upstream in 1993 were, or appeared to be, of hatchery origin. Green fluorescent marks were observed on 81 rainbow trout, indicating they were Eagle Lake (EL) strain hatchery rainbow trout. These accounted for 11.1% of the total rainbow trout captured and 23% of the total hatchery

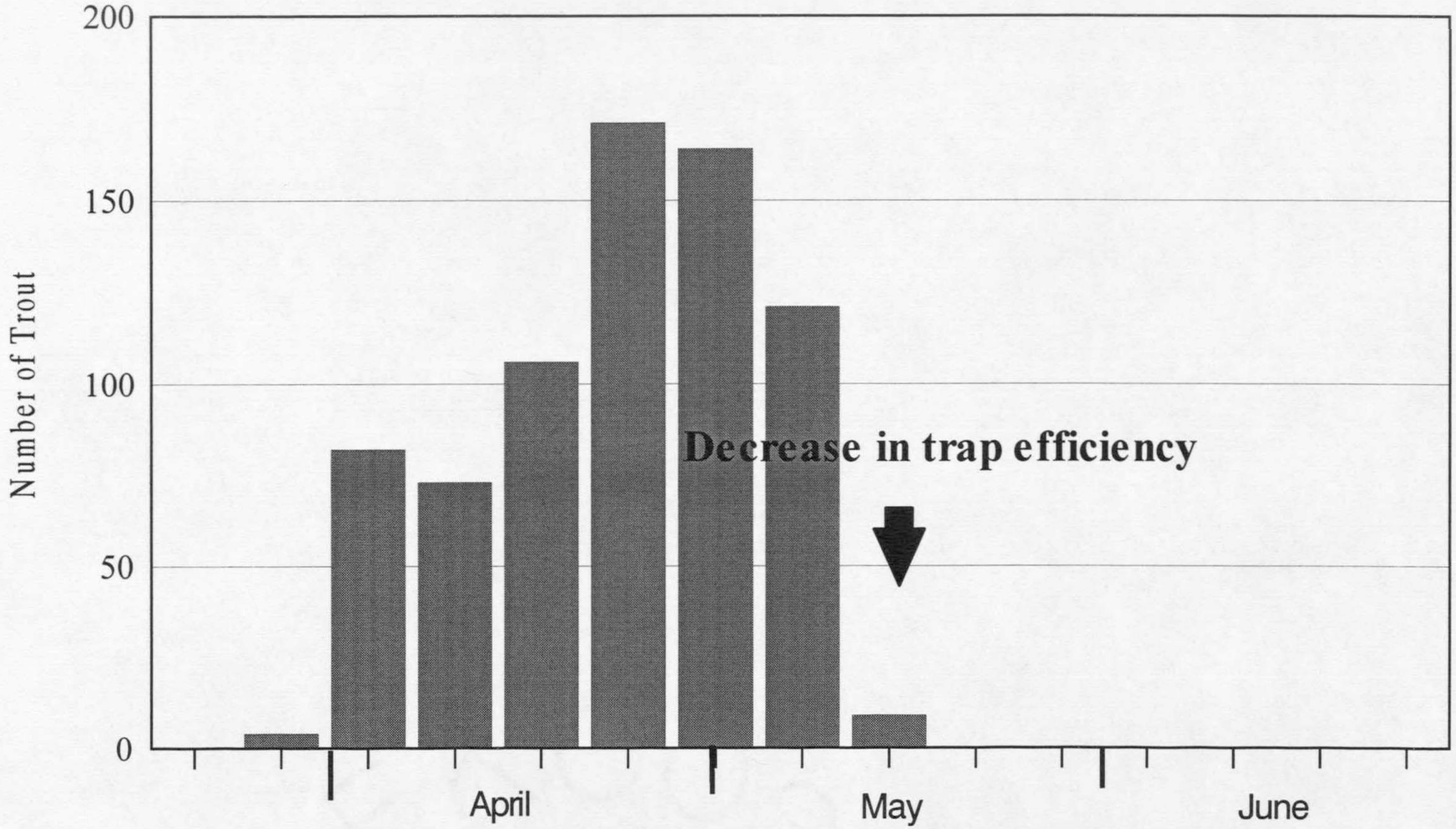

Figure 6. Weekly totals for adult rainbow trout captured at the Deep Creek upstream migrant trap in 1993 (N=727).

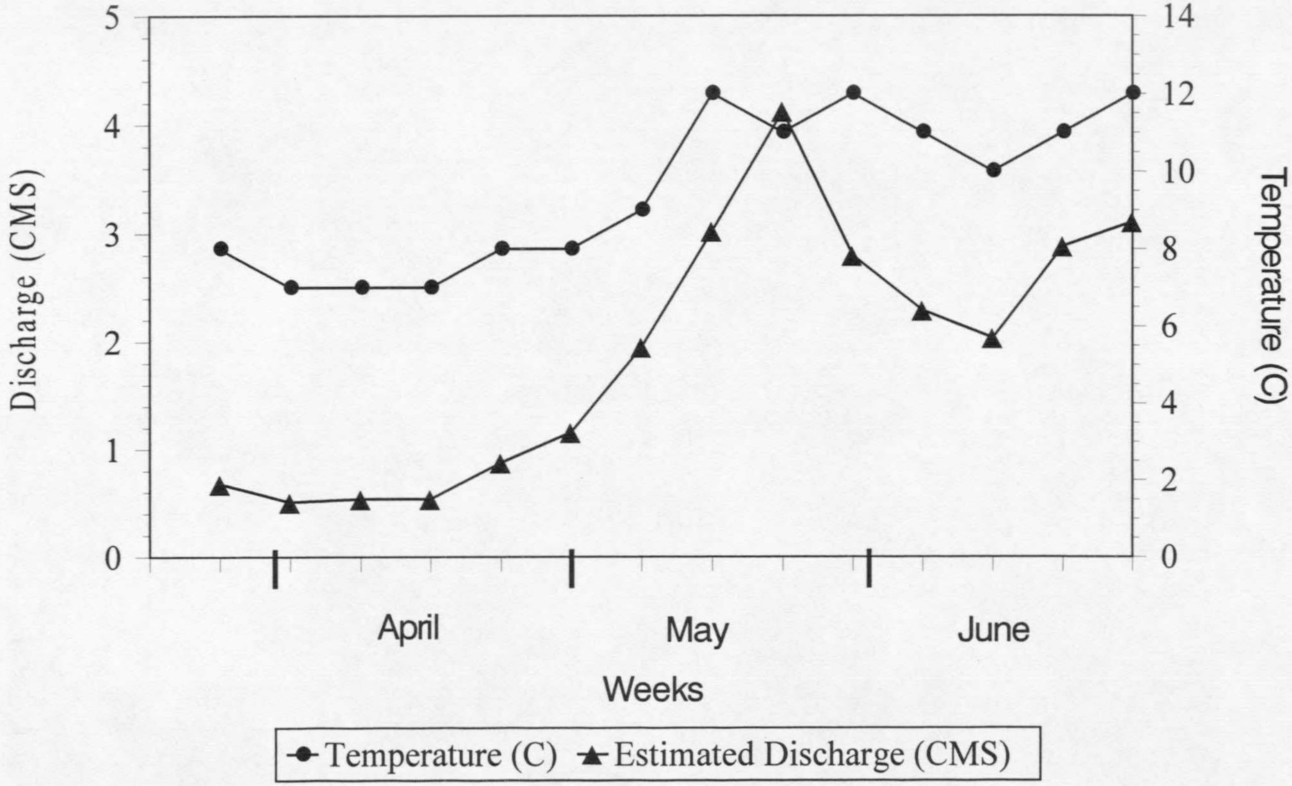

Figure 7. Weekly mean stream discharge (CMS) and weekly mean stream temperature (C) for Deep Creek, March-June 1993.

origin rainbow trout. Red fluorescent marks were observed on 193, indicating they were DeSmet (DS) strain hatchery rainbow trout. These fish accounted for 26.5% of the total rainbow trout captured in 1993 and 54% of the total hatchery origin fish. An additional 81 fish had no detectable fluorescent markings but showed evidence of hatchery-caused dorsal fin erosion. These fish accounted for 11.1% of the total fish captured and 23% of the total hatchery fish captured.

We captured 1,959 individual adult rainbow trout during spring 1994. Although some trout were still able to avoid the trap during high water in 1994, modifications in trap design substantially increased efficiency. The trap's holding area was increased, and adjustable supports were added to the trap to allow it to be raised and lowered with changing flow conditions. Downstream migrating adults were captured in downstream fry traps or in the downstream flume. This sample revealed that at least 56 of 85 outmigrants captured either were tagged or had a scar behind their dorsal fin, giving evidence that a floy tag had been inserted earlier, indicating that roughly 66% of the upstream migrants were captured and tagged. Data from this sample show that time spent in the creek, above the weir, by individual fish varies widely from 0 to 51 d. The mean stay in the creek, above the weir, was 16 d (SD 14.97, N=37).

Peak upstream migration of all strains of rainbow trout occurred in the fourth week of April in 1994 (Figure 8) when the weekly mean of daily mean thermograph readings reached 9 C and flow was about 2.0 CMS (Figure 9). In 1994, daily thermograph readings varied from hand held thermometer readings at the weir by as much

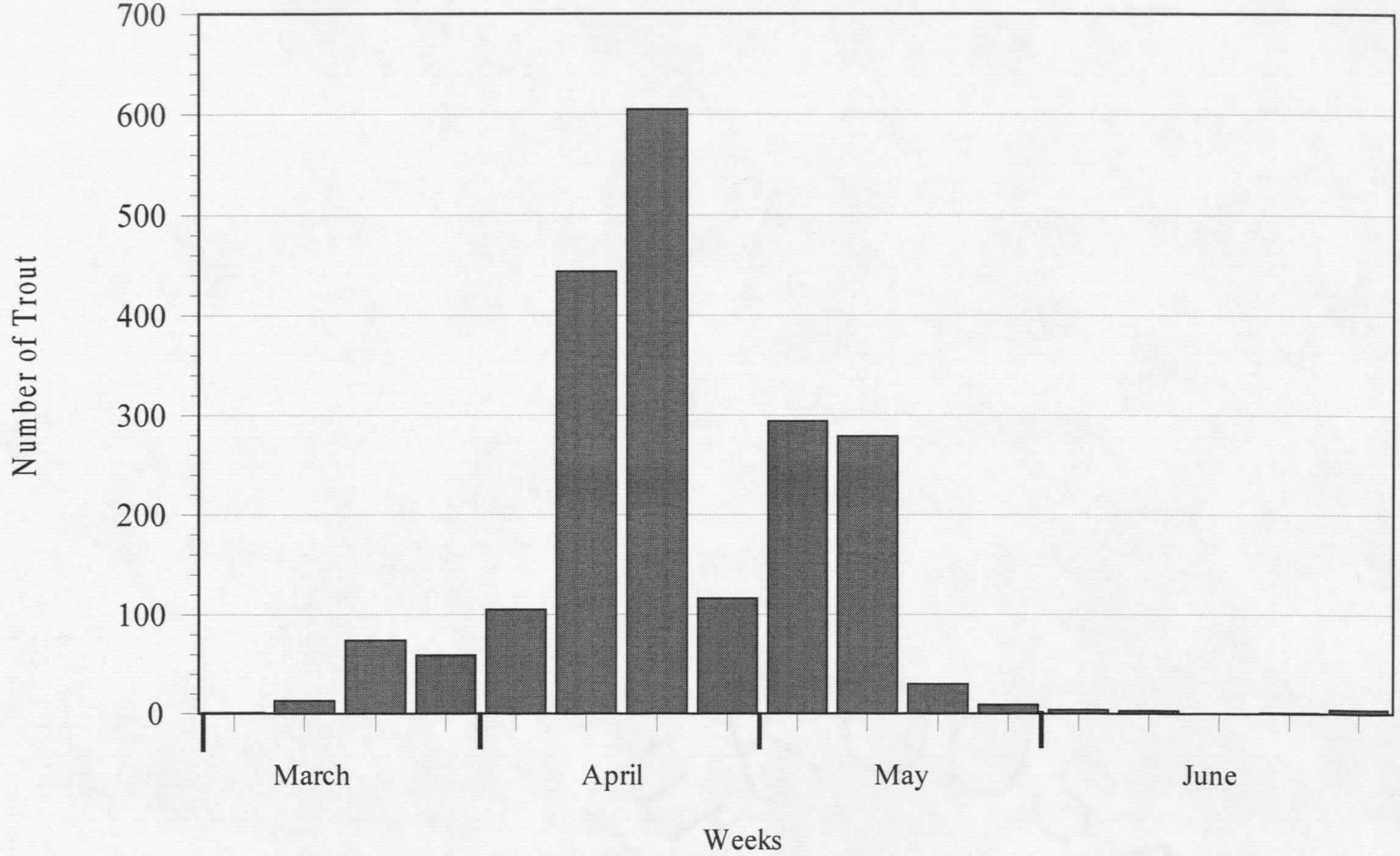

Figure 8. Weekly total number of adult rainbow trout captured at the Deep Creek upstream migrant trap in 1994 (N=2026).

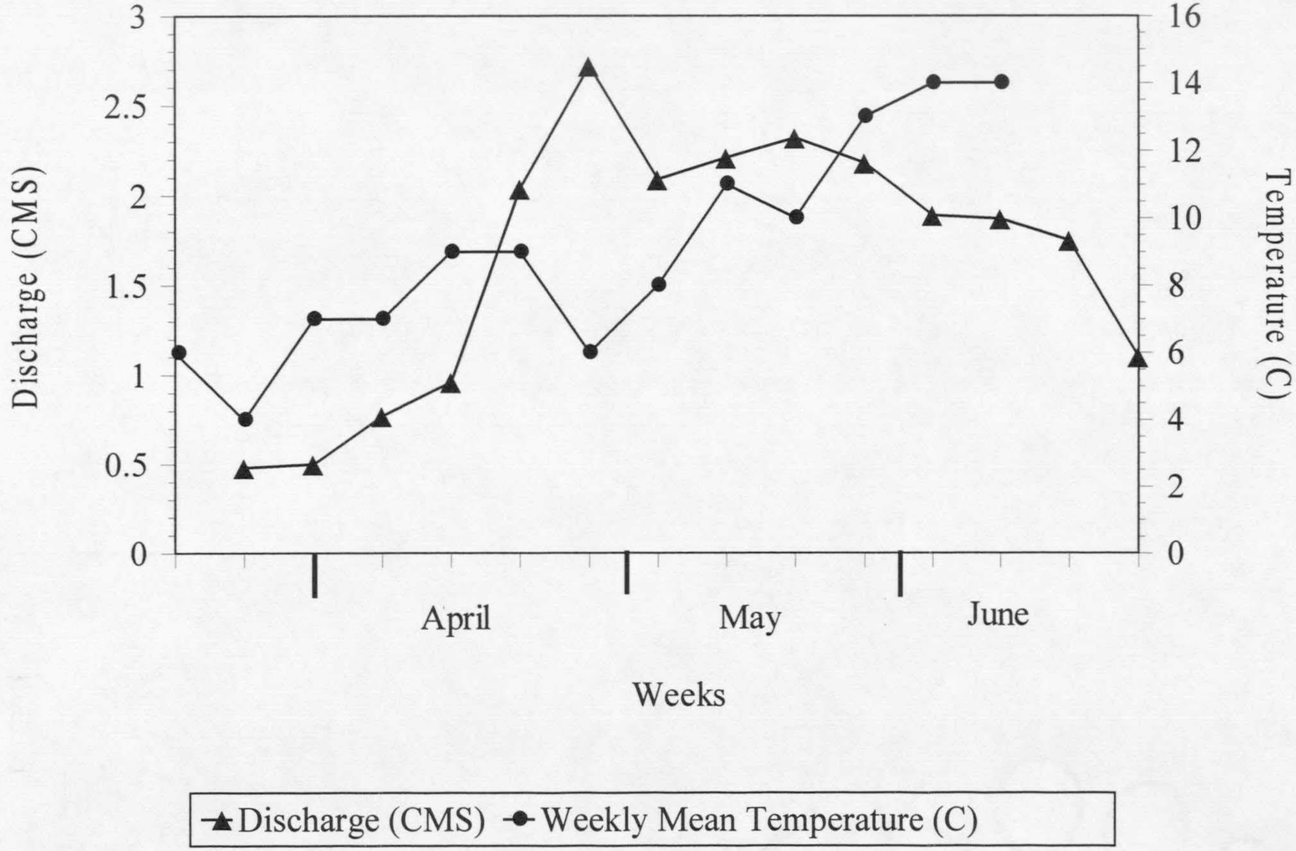

Figure 9. Weekly mean stream discharge (CMS) and weekly mean temperature (C) for Deep Creek, March-June 1994.

as 2 C· This appeared related to frequent burial of the thermograph probe in sediments. This problem was not encountered in 1993.

Among the adult rainbow trout captured moving upstream in 1994, 404 (24%) appeared to be wild fish, 384 (22.8%) had fluorescent marks of the EL strain, 506 (30%) had fluorescent marks of the DS strain, and 392 (23.3%) appeared to have dorsal fin erosion of hatchery-origin fish but had no detectable fluorescent marks.

Therefore, in both 1993 and 1994, large percentages of the adult rainbow trout captured moving upstream into Deep Creek during the spawning season originated from hatchery plants and were entering a stream novel to their origin (the hatchery). These included at least 48.2% of the 719 captured in 1993, and over 76% of the more than 1,950 adult rainbow trout moving upstream in 1994.

Timing of Migrations Among Rainbow Trout Strains

Temporal patterns of adult rainbow trout migrations into Deep Creek differed between strains in both 1993 and 1994. In 1993, wild rainbow trout began arriving in weekly totals exceeding 25 by the first week in April. Peak upstream migration for wild adults occurred during the fourth week in April with a median date of April 18, 2 weeks prior to the peak of hatchery strain adults (Figure 10). Hatchery strain rainbow trout appeared to be peaking during the second week in May when high water severely reduced the efficiency of the migrant trap. During the same week, the total of wild migrants had dropped to less than 30 trout. Eagle Lake rainbow trout appeared to peak a week earlier,

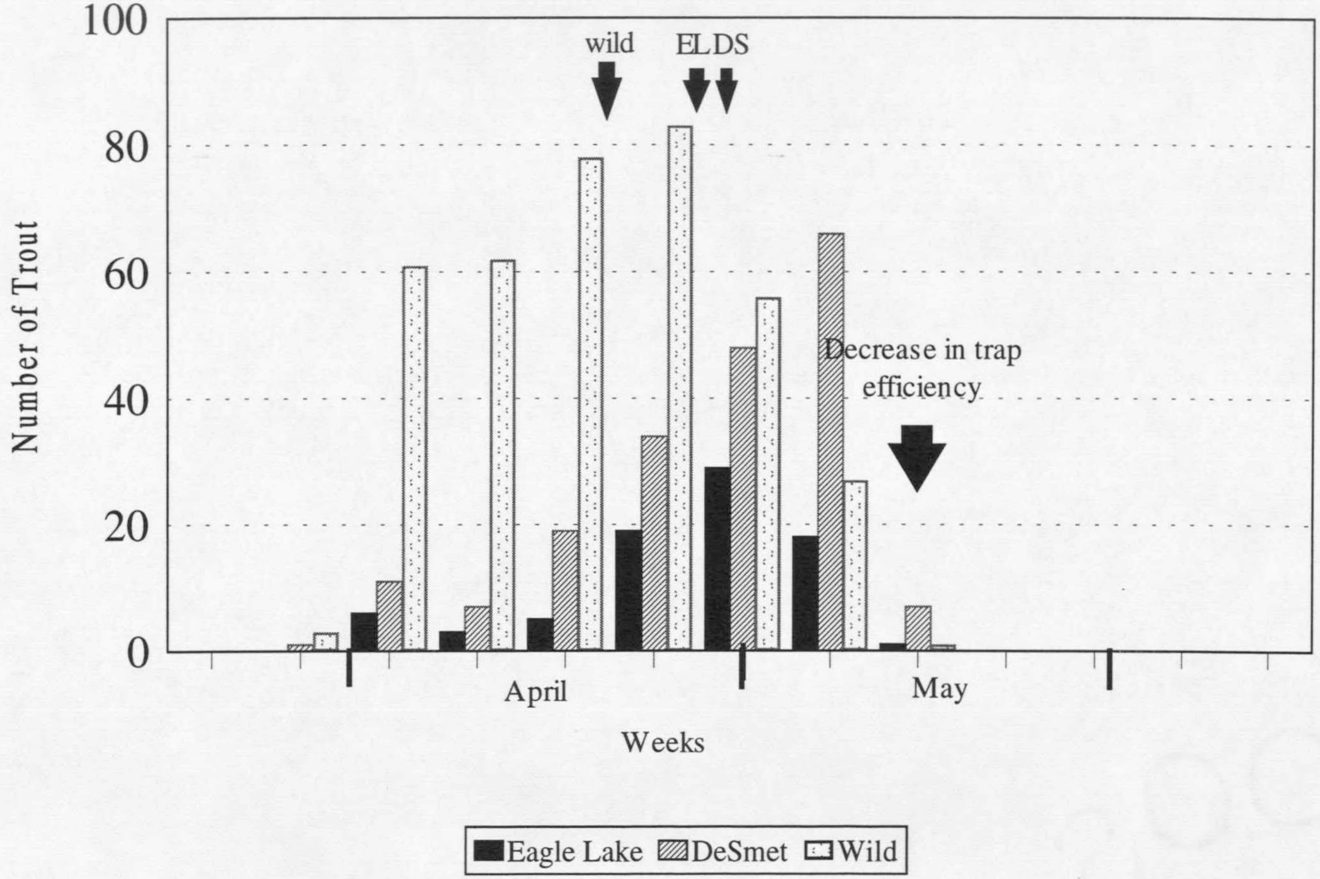

Figure 10. Weekly total number of adult wild, Eagle Lake (EL), and DeSmet (DS) rainbow trout captured at the Deep Creek weir in 1993 (N=646). Arrows indicate median upstream capture date.

with a median capture date of April 26, than DeSmet rainbow trout, having a median capture date of April 29.

There was a similar pattern in 1994 (Figure 11). Wild adult rainbow trout began arriving in weekly totals exceeding 25 during the third week in March and had a median capture date of April 11. A weekly total greater than 25 was not reached by hatchery origin rainbow trout until the second week in April. Peak upstream migration for wild rainbow trout occurred in the third week in April and numbers began declining when migration of hatchery origin trout peaked in the fourth week in April. Weekly totals of wild adults were about 10% that of hatchery origin fish in the first week in May. Timing of migration appeared similar between the two hatchery strains, with numbers of both strains fluctuating in parallel. However, as in 1993, declines in numbers of Eagle Lake rainbow trout started about a week earlier in May (median capture date of April 20) than DeSmet rainbow trout (median capture date of May 1).