UPPER RUBY RIVER FLUVIAL ARCTIC GRAYLING REINTRODUCTION

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Fluvial Arctic Grayling Workgroup

and

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ABSTRACT

The Montana Fluvial Arctic grayling work group identified the Ruby River as the first site chosen to help meet part of the restoration goal of four self-sustaining populations, within three historic drainages, by 2020. Restoration efforts began in 1997 when 30,000 young-of-the-year grayling were planted in the upper Ruby River, above Ruby Reservoir. In 1998 and 1999, 10,000 and 7,000 age-1 grayling were stocked, respectively. Grayling were monitored in six 1000 ft. sections and in four mark/recapture electrofishing sections. Rainbow/cutthroat hybrid and brown trout populations were monitored to assess interspecific relationships. Grayling movement and distribution were monitored by marking grayling with coded-wire tags in three different locations on the fish (snout, dorsal fin, or anal fin) and placing them in three different planting locations. Movement from planting sites was calculated. Survival of the 1997 plant was poor. Survival of the 1998 and 1999 plants is encouraging. In 1999, 76 grayling from the 1998 plant were collected during electrofishing surveys. Population estimates for grayling planted in 1999 were as high as 441 per mile in the Vigilante section. Downstream movement and one case of upstream movement were observed. The majority of the grayling remained near planting locations. Spring 2000 will be the first year the planted grayling will reach sexual maturity and potentially spawn in the upper Ruby. Grayling will be planted in summer 2000 to establish multiple year classes. Monitoring will continue in future years to assess survival and success of the planted grayling.

INTRODUCTION

Arctic grayling *Thymallus arcticus* once ranged in the Missouri River drainage upstream of the Great Falls of the Missouri near the present day city of Great Falls, Montana. Their native range included the Missouri River and it tributaries: the Sun, Smith, Teton, Madison, Gallatin, Jefferson, Beaverhead, and Big Hole rivers. During the 20th century, the range of fluvial, or river dwelling, grayling became restricted to the Big Hole River, Montana. This comprises about 4% of their historic native range. Many factors contributed to the decline of fluvial Arctic grayling, including climatic changes, introduction of non-native species, over harvest by anglers, and habitat alteration (Vincent 1962; Kaya 1992a).

Abundance of the Big Hole River grayling population declined to low levels through the mid-1980s. The Fluvial Arctic Grayling Work Group (FWG), made up of various agencies, universities, and interest groups, was created out of concern for the declining Big Hole grayling population. Restoration and protection of fluvial Arctic graying in the Big Hole River and its native range in Montana are the focus of the work group. The restoration goal developed by this group is, by the year 2020, to have at least five stable, viable populations distributed among at least three of the major river drainages (e.g., Big Hole, Jefferson, Beaverhead, Madison, Gallatin, Sun, and Smith) within the historic range of Montana grayling (MFGW 1995).

As part of the restoration effort, the upper Ruby River was chosen as an introduction site in the Jefferson drainage. Historically, fluvial grayling once thrived in reaches of the upper Ruby River (Byorth and Magee 1999). The restoration reach encompasses the area from Ruby Reservoir upstream to the Three Forks of the Ruby River (Figure 1). The area was selected based on an assessment of potential introduction sites within the native range of fluvial grayling by Kaya (1992b). The upper Ruby has more than 40 miles of river that historically encompassed suitable grayling habitat, including adequate pools and runs, flow, temperature, and geomorphology (Byorth 1997; Byorth and Magee 1999). These characteristics are still present today. A public

road bordering the majority of the upper Ruby River allows access for planting and monitoring of grayling. Rainbow/cutthroat hybrids are the predominant species in this area but are at low abundance. Brown trout are also present in this area also at very low densities (MFWP Files 1996-1998).

The restoration goal for the upper Ruby River is to establish a stable, naturally reproducing population by 2005. The objectives of the restoration are to:

1) Monitor survival, movements, and densities of introduced grayling to determine factors affecting success of reintroduction.

2) Through monitoring, document natural reproduction by 2002.

3) Attain stable to increasing population densities in sampling sections where natural reproduction equals or exceeds annual mortality for three consecutive years (Byorth 1997).

METHODS

Discharge and Temperature Monitoring

Discharge of the Ruby River was monitored by using U. S. Geological Survey (USGS) data collected from January through September at the USGS Gage Station located 0.4 miles upstream of Cottonwood Creek, 6.0 miles upstream of Ruby Reservoir, at Puller Hot Springs (Figure 1).

Water temperature was monitored using Onset Hobotemp and Stowaway temperature loggers at Cottonwood Camp, Vigilante Camp, Warm Springs Bridge, Ledford Bridge, and Sweetwater Bridge in 1997, 1998, and 1999. The Bear Creek site replaced Cottonwood Camp in 1998 and 1999. The temperature logger at Vigilante Camp malfunctioned in 1999 and did not record any data. Temperature data were downloaded using Onset software, transferred into Microsoft Excel files, and converted into daily maximum, minimum, and average temperatures.

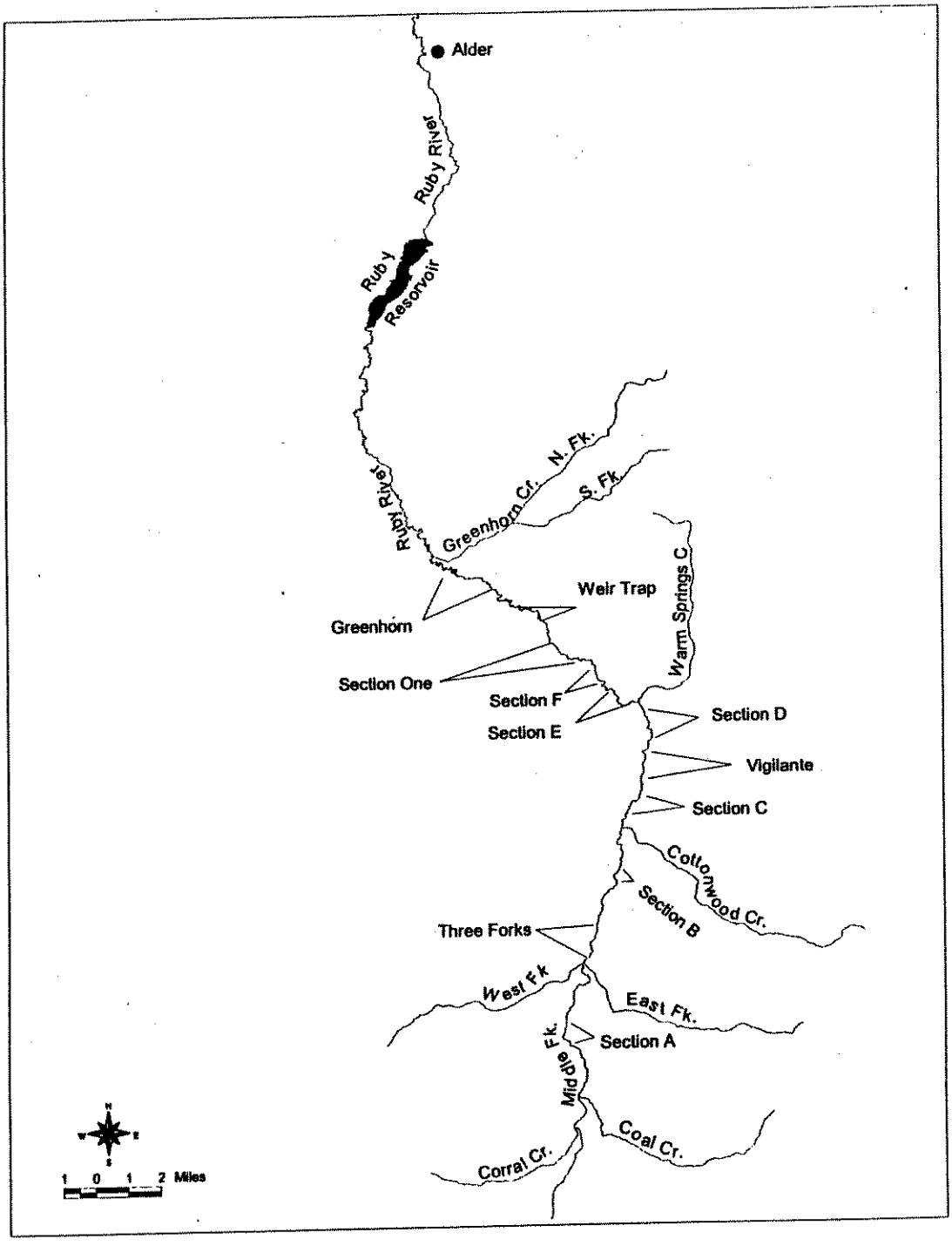

Figure 1. Map of upper Ruby River showing the locations of the electrofishing sections and weir trap.

Grayling Introductions

The grayling planted in 1997 through 1999 were all progeny of a Big Hole River brood stock maintained at Axolotl Lakes, Montana. The grayling at Axolotl Lakes were spawned each year and the eggs were transferred to the Bluewater Springs Trout Hatchery in Bridger, Montana for rearing.

A total of 30,000 young-of-the-year (YOY) grayling from Bluewater Springs Trout Hatchery were planted in the upper Ruby River at four locations on September 9, 20, and 28 in 1997. The average total length of grayling planted was 1.69 in. At Middle Fork Bridge and an access site one-half mile downstream from the bridge, 5,920 and 1,184 grayling were planted, respectively. The Vigilante site and Jug Creek Bridge each received 6,512 grayling. Grayling were held in live cars to assess planting survival and were released after 44-48 hours of acclimation. An additional 4,840 grayling were planted at the Broken Arrow Ranch Bridge and upstream from the Vigilante Guard Station on September 24. These fish were also placed into a live car and released after 48 hours of acclimation.

Due to poor survival of young-of-the-year grayling planted in1997, age-1 grayling were planted in 1998. To assess up and downstream movement and survival based on planting location, on June 25, 1998, a portion of the age-1 grayling were marked with coded-wire tags at the Bluewater Springs Trout Hatchery. The grayling were separated into three equal lots and approximately one third of each lot received a coded-wire tag in one of three locations; the snout, the base of the dorsal fin, or the base of the anal fin. A retention test was conducted on June 26 to determine tag loss. This consisted of scanning 200 tagged grayling from each tag placement group with a wand detector and recording tag loss.

In 1998, a total of 9,804 grayling with an average total length of 9.3 in. were planted in the upper, middle, and lower locations within the restoration reach. In the upper reach, 3,320 grayling were planted at the Middle Fork Bridge and Three Forks Cow Camp on July 13, of

which 1,250 had snout tags. In the middle reach, 3,120 grayling, including 1,250 with dorsal fin tags, were planted on July 13 and 15 at Jug Creek Bridge and the Bear Creek access. In the lower reach, at the Vigilante Bridge and the Warm Springs confluence, a total of 3,364 grayling were planted, including 1,250 with anal fin tags. A sub-sample of approximately 100 fish at each site was retained for 2-4 days in live cars to assess short-term planting survival.

On June 21 and 22, 1999, age-1 grayling at the Bluewater Springs Trout Hatchery were divided into three groups and implanted with coded-wire tags in the same body locations as 1998. All of the grayling in each group were implanted with a coded-wire tag. Snout, dorsal fin, and anal fin tags were placed in 2,520 grayling, 2,326 grayling, and 2,503 grayling, respectively. All grayling received an adipose fin clip to identify year class and allow them to be differentiated from the grayling planted in 1998. On June 22, tag retention was assessed for each of the three groups using a wand detector. Tag retention was also examined at the planting sites before the fish were released.

In order to decrease potential intraspecific competition with the 1998 plant, the number of grayling planted was reduced from 9,804 in 1998 to 7,339 in 1999. The average length of the grayling planted in 1999 was 9.8 inches. On July 12, 2,520 grayling with snout tags were planted at the Middle Fork Bridge and Three Forks Cow Camp. A total of 2,316 grayling with dorsal tags were planted on July 12 and 14 at the Jug Creek Bridge and the Bear Creek access. On July 14, a total of 2,503 grayling with anal tags were planted at the Vigilante Bridge.

Population Monitoring

Electrofishing mark-recapture surveys were conducted in the fall of 1997, 1998, and 1999 in historic survey sections to document survival, population abundance, recruitment, age-class strength, and distribution. These sections included the Three Forks section, the Vigilante section, Section One and the Greenhorn section (Figure 1). Six 1000 ft. monitoring sections, labeled A-F,

were established in 1997 to further assess planted grayling distribution and survival (Figure 1). These reaches were monitored in fall 1997, 1998, and 1999 using one-pass electrofishing surveys. Rainbow/cutthroat hybrids and brown trout were also sampled in all of the sections to document density and relative abundance.

Electrofishing was completed with a mobile-anode DC system powered by a 4,000 watt generator coupled with a Coffelt Mark XXII-M rectifying unit mounted on a Coleman Crawdad or a driftboat. Target species were captured and held in a live well. The fish were anesthetized in a Tricaine Methanesulfonate (MS-222) and water bath. Total length (to 0.1 in.) and weight (to 0.01 lb.) were collected and the fish were fin clipped as a temporary mark. Scales were collected for aging from rainbow/cutthroat hybrids and brown trout during all three years. In 1999, scales were also collected from a small number of grayling that were planted in 1998 and 1999. Population estimates were calculated with Mark/Recapture 4.0 (Montana Fish, Wildlife & Parks 1994). In order to compare densities between historic and 1000 ft. sections, catch-per-unit-effort (CPUE) was calculated for grayling, rainbow/cutthroat hybrids, and brown trout in 1997 through 1999. The CPUE in the historic sections was calculated by using the total number of fish captured during the marking run and was standardized to 1000 ft. The CPUE results were analyzed for each section as well as the entire reintroduction area.

A weir-fish trap was installed in the Ruby River, upstream from the confluence with Ice Creek to monitor downstream movement. The trap was operated in both 1998 and 1999 from July through November (Figure 1). All grayling captured during electrofishing and in the weir trap were scanned with a wand detector to determine the presence and location of coded-wire tags. This information was used to assess downstream movement and distribution of grayling from the different planting locations. Gill nets are used in the spring and fall to determine if grayling are moving into Ruby Reservoir.

In 1999, the number of age-2 grayling (1998 grayling) in each section and the entire study area were expressed as a percentage of the total number of grayling captured in order to assess survival. This method was chosen because not enough age-2 fish were collected to produce a population estimate.

Growth and condition were calculated in October, approximately 90 days post planting, for grayling planted in 1998 and 1999. To assess growth of planted grayling, the average length of the grayling when planted and the average length of grayling captured in the Vigilante section in the fall were compared. Condition was calculated the same way using condition factors produced by Mark/Recapture version 4.0 (Montana Fish, Wildlife & Parks 1994). The Vigilante section was chosen because of high grayling numbers and its central location in the study area.

RESULTS

Discharge and Water Temperatures

From 1997 through 1999, daily maximum temperatures ranged from 68.7-74.1 °F. Temperatures did not exceed 77° F, the upper incipient lethal temperature for grayling (Lohr et al. 1996). The highest daily maximum temperature recorded was 74.1 °F on July 13, 1999 at the Three Forks. Maximum mean daily temperatures during the three years ranged from 60.4-66.4 °F. The maximum mean daily temperature was 66.4 °F at the Ledford Bridge logger on July 24, 1997(Table 1). The daily maximum and maximum mean daily temperatures during all three years occurred in July and August.

Flows in the upper Ruby from 1995 through 1999, between January and September, ranged from 80-1,770 cfs. Each year peak discharge occurred from late May to late June. The maximum discharge of 1,770 cfs occurred on June 6, 1995. The minimum discharges occurred between January and March and did not fall below 80 cfs (Table 2).

Location	1997				1998				1999			
	Max (°F)	Date	Max Mean (°F)	Date	Max (°F)	Date	Max Mean (°F)	Date	Max (°F)	Date	Max Mean (°F)	Date
Three Forks	site not used	---	site not used	---	site not used	---	site not used	---	74.1	7/13	64.0	7/30
Cottonwood Camp	logger missing	---	logger missing	---	site not used	---	site not used	---	site not used	---	site not used	---
Bear Creek	site not used	---	site not used	---	68.7	8/12	60.4	8/12	70.5	7/30	61.2	7/30
Vigilante Camp	70.2	7/24	63.1	7/24	68.7	8/12	61.8	8/12	*	---	*	---
Warm Springs Bridge	70.2	7/24	66.0	7/24	71.4	8/12	65.9	8/12	72.3	8/26	66.4	8/26
Robb Creek Bridge	72.6	7/24	66.4	7/24	70.2	7/19	65.3	7/19	69.9	7/13	64.8	7/28
Sweetwater Bridge	69.6	7/28	66.0	7/24	69.9	7/19 7/26	66.1	7/19	69.9	7/28 7/30	64.7	7/13

Table 1. Maximum daily temperatures, maximum daily mean temperatures, and date of occurance in the upper Ruby River from 1997 through 1999.

Year January-September	Maximum Discharge (cfs)	Dates at Maximum Discharge	Minimum Discharge (cfs)	Dates at Minimum Discharge
1995	1770	6/6	80	1/3-1/5
1996	1330	6/10	90	2/28
1997	1580	6/2	80	1/13 2/6-2/7
1998	1250	6/26	90	2/7-2/28 3/1
1999	1000	5/31	106	3/6

Table 2. Comparisons of upper Ruby River discharge data from January through September at the USGS gage above Ruby Reservoir, 1995 to 1999.

Population Monitoring

Grayling

In 1997, very few young-of-the-year grayling were captured during the mark-recapture surveys and abundance estimates could not be made for any of the sections examined. A total of 48 grayling were captured in four of the sections, ranging from 1 in the Vigilante (CPUE 0.1/1000 ft.) to 13 in Section D (CPUE 13/1000 ft.) (Figure 2).

Estimates were calculated for the Three Forks and Vigilante Sections in fall 1998. They were 406 (SD 10) per mile and 780 (SD 417) per mile, respectively (Figure 3). Grayling were captured in every other section, except for Section F. Grayling were variably distributed with CPUE ranging between 0/1000 ft. in Section F and 164/1000 ft. in Section D (Figure 2). Of the 1,009 grayling collected in fall 1998, 19 were between 6.0 and 7.9 in. While the length range of grayling planted in 1998 included fish as small as 6.0 in., only one of these fish had a coded-wire tag indicating that it was planted in 1998. Some of the remaining 18 fish may have been planted in 1997.

Grayling population estimates were calculated for the Three Forks Section, the Vigilante Section, and Section One in fall 1999. The Vigilante section was the highest with 441 (SD 74) per mile and Section One was the lowest at 19 (SD 5) per mile (Figure 3). Grayling were captured in all of the 1000 ft. sections. Downstream sections had lower CPUE with the highest occurring in Section D (90/1000 ft.) (Figure 2). A total of 76 age-2 grayling were captured and represented 9% of all of the grayling that were captured in fall 1999. The highest numbers of age-2 grayling were captured in the Three Forks Section. No age-2 grayling were collected in Section B, Section C, Section F, or the Greenhorn Section (Table 3).

Grayling population estimates, from 1998 to 1999, in the Three Forks and Vigilante Sections decreased, and the CPUE also decreased in the Three Forks Section, Section B, Section

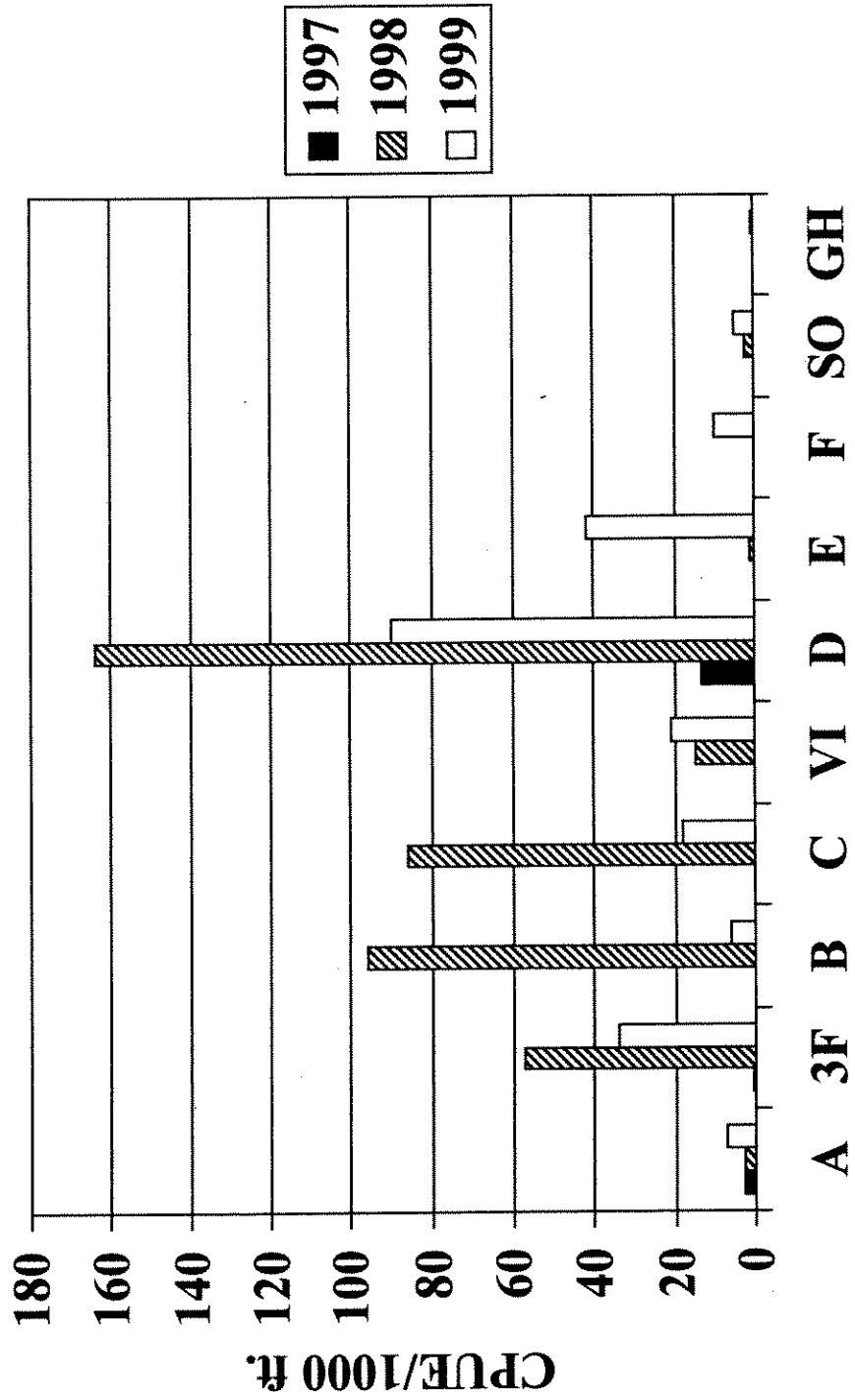

Figure 2. Catch-per-unit-effort of Arctic grayling standardized to 1000 ft. for six 1000 ft. sections (A-F) and four mark/recapture sections (3F=Three Forks VI=Vigilante SO=Section One GH=Greenhorn) in the upper Ruby River.

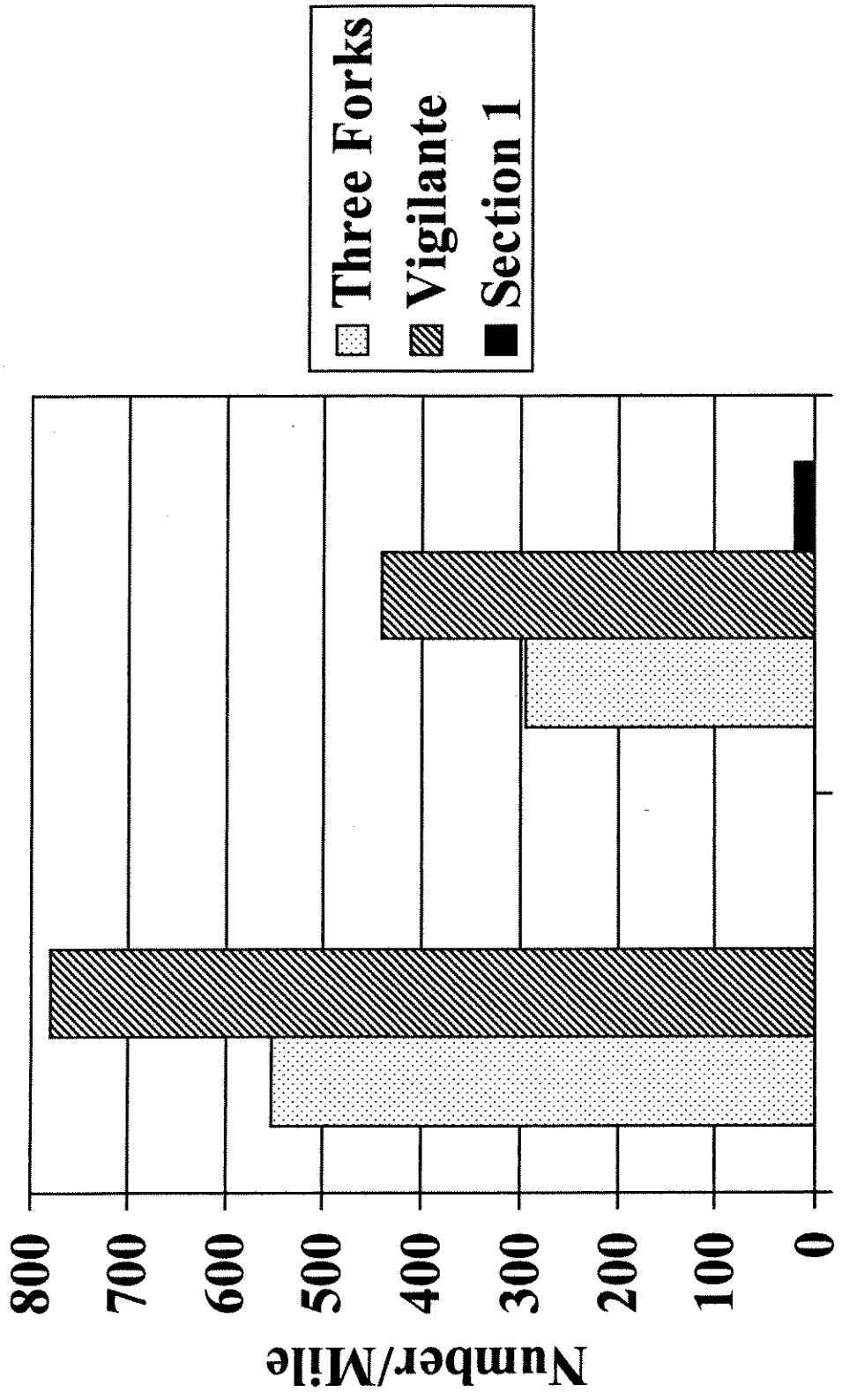

Figure 3. Arctic grayling population estimates from Three Forks, Vigilante, and Section One standardized to number per mile for 1998 and 1999.

Location	Number of Age-2 Grayling	Total Number of Fish Collected	% of Total that are Age-2
Section A	3	7	42.9
Three Forks	40	291	13.7
Section B	0	6	0
Section C	0	19	0
Vigilante	28	374	7.5
Section D	3	90	3.3
Section E	0	42	0
Section F	0	0	0
Section One	2	11	18.2
Greenhorn	0	7	0
Total	76	847	9.0

Table 3. Number of age-2 grayling, total number of grayling collected, and percentage of the total number that were age-2 fish at each site in 1999.

C, and Section D (Figure 3). Grayling were more widely distributed in 1999 with higher CPUE in sections A, E, F, and Section One (Figure 2).

Rainbow/Cutthroat Hybrids

Since the introduction of Arctic grayling in 1997, rainbow/cutthroat hybrid populations have been stable to increasing through out the upper Ruby River.

Rainbow/cutthroat hybrids were collected in all of the sections and population estimates for fish ≥ 6 in. were calculated for all four of the historic sections in 1997. Section One was the highest with 1,652 (SD 394) per mile and the Greenhorn Section was the lowest with 123 (SD 41) per mile (Figure 4 and 5). The highest CPUE for rainbow/cutthroat hybrids was 93/1000 ft. in Section E. The lowest CPUE was 5/1000 ft. in the Greenhorn Section (Figure 6).

In 1998, rainbow/cutthroat hybrids were collected in all of the sections and population estimates were calculated for the four historic sections. Section One and the Greenhorn section, again, had the highest and lowest estimates with 1,820 (SD 123) per mile and 167 (SD 42) per mile, respectively (Figure 4 and 5). Section F had the highest CPUE at 100/1000 ft. in 1998. The lowest CPUE was 4/1000 ft. in the Greenhorn Section (Figure 6).

Trends observed in 1997 and 1998 continued in 1999. Section One had the highest population estimate at 1,598 (SD 58) per mile. The Greenhorn Section was the lowest with an estimate of 219 (SD 49) per mile (Figures 4 and 6). Section E had the highest CPUE with 432/1000 ft. In 1999, Section B had the lowest CPUE at 4/1000 ft. (Figure 6).

From 1997-1999 rainbow/cutthroat population estimates for fish ≥ 6 in. increased at the Three Forks, Greenhorn, and Vigilante Sections (Figures 7, 5, and 8). During this same time period CPUE increased at all but three of the sections (Section A, Section B, and Section C) with some variation. Sections E, F, and Section One had large increases in CPUE in 1999 (Figure 6).

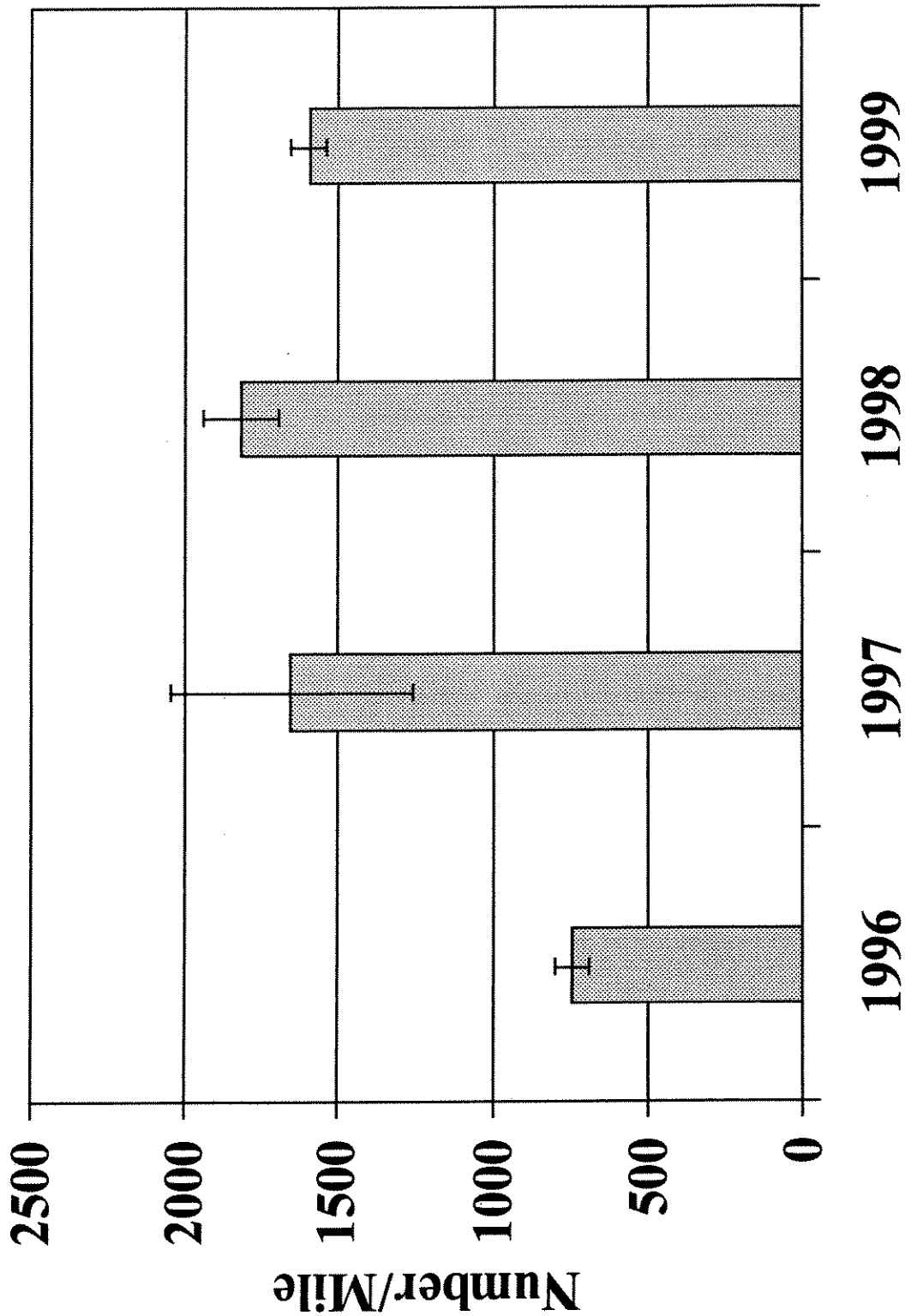

Figure 4. Rainbow/cutthroat hybrid population estimates for Section One standardized to number per mile from 1996-1999.

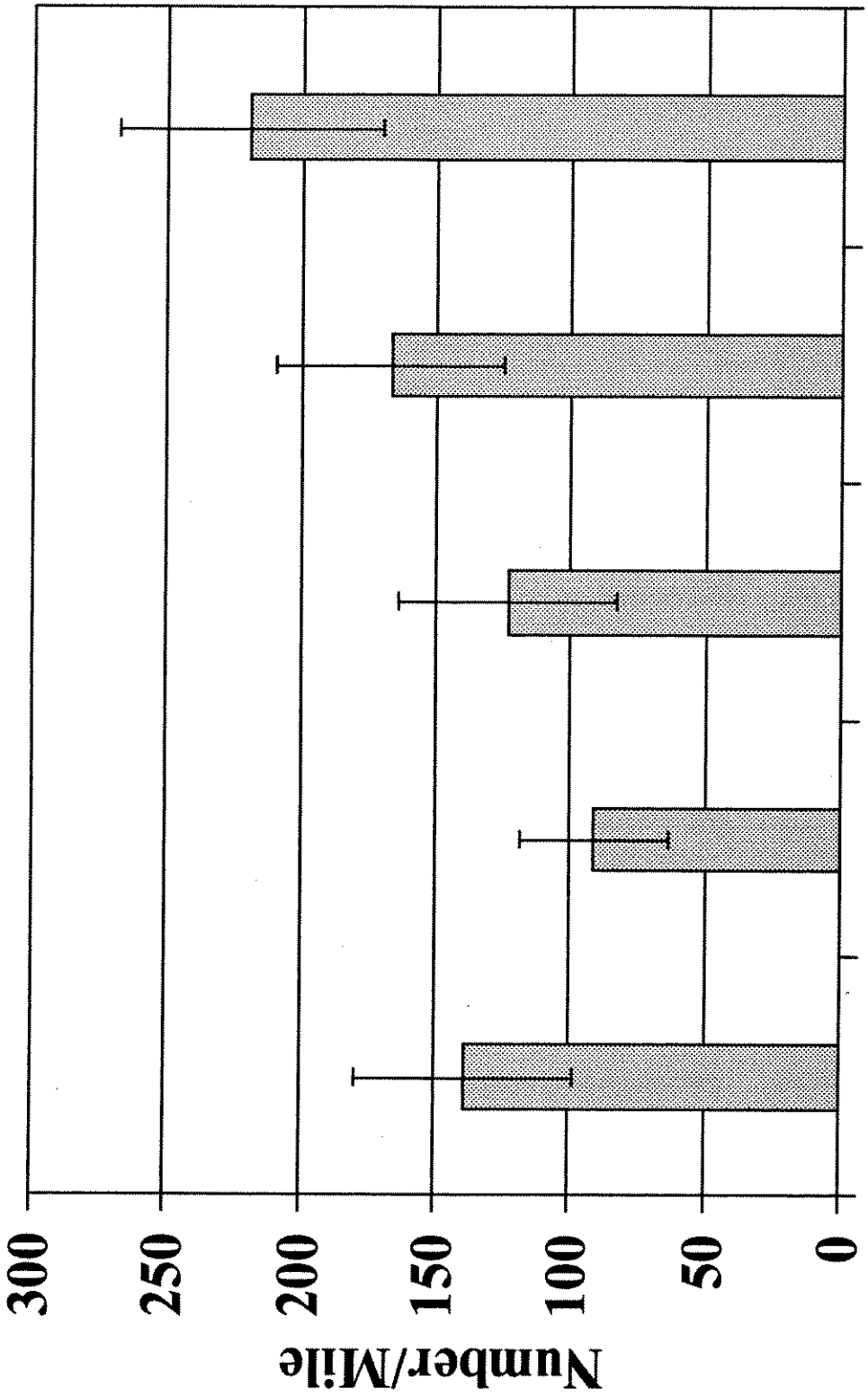

Figure 5. Rainbow/cutthroat hybrid population estimates for the Greenhorn section standardized to number per mile from 1995-1999.

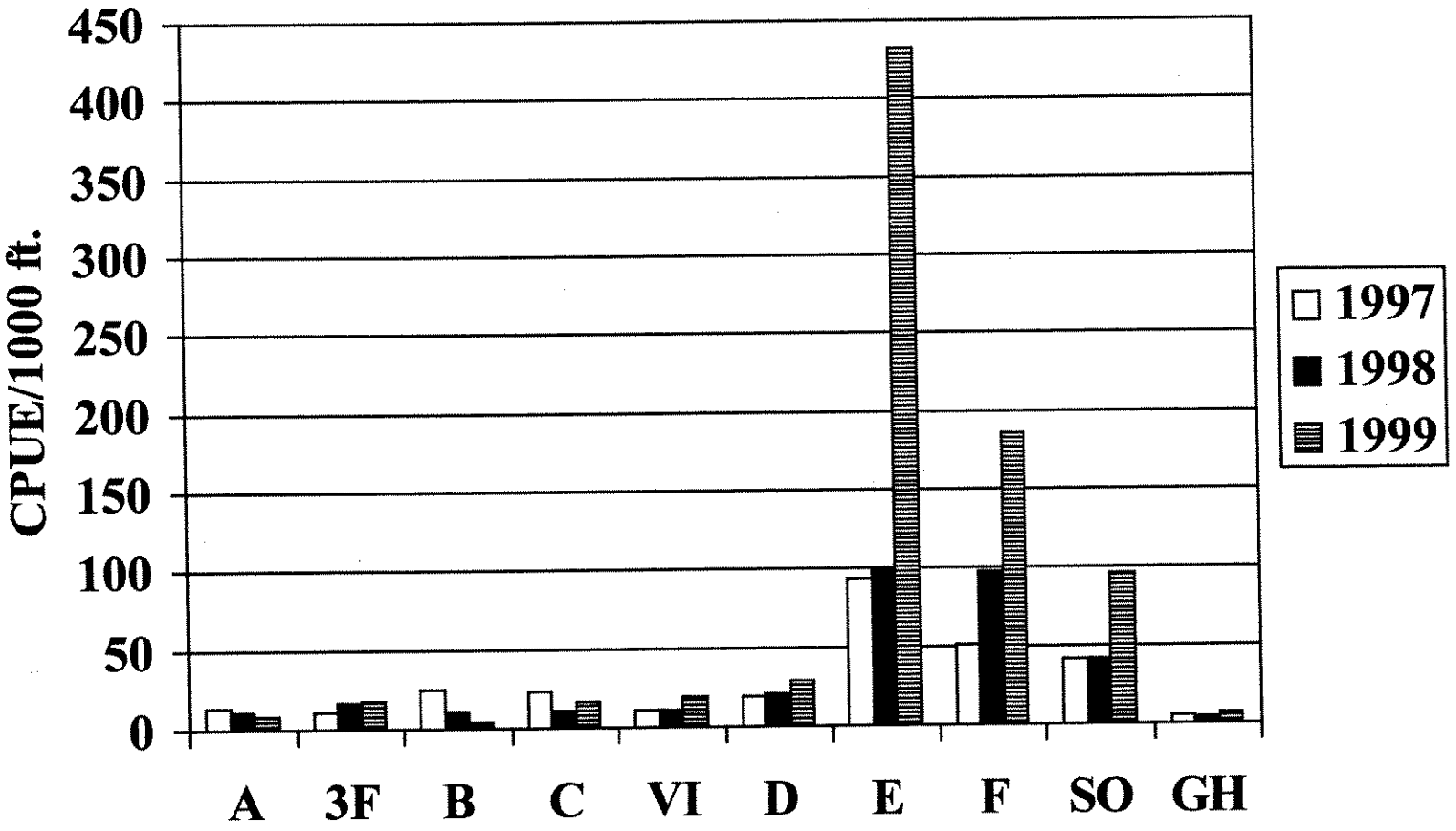

Figure 6. Catch-per-unit-effort of rainbow/cutthroat hybrids standardized to 1000 ft. for six 1000 ft. sections (A-F) and four mark/recapture sections (3F= Three Forks VI=Vigilante SO=Section One GH=Greenhorn) in the upper Ruby River.

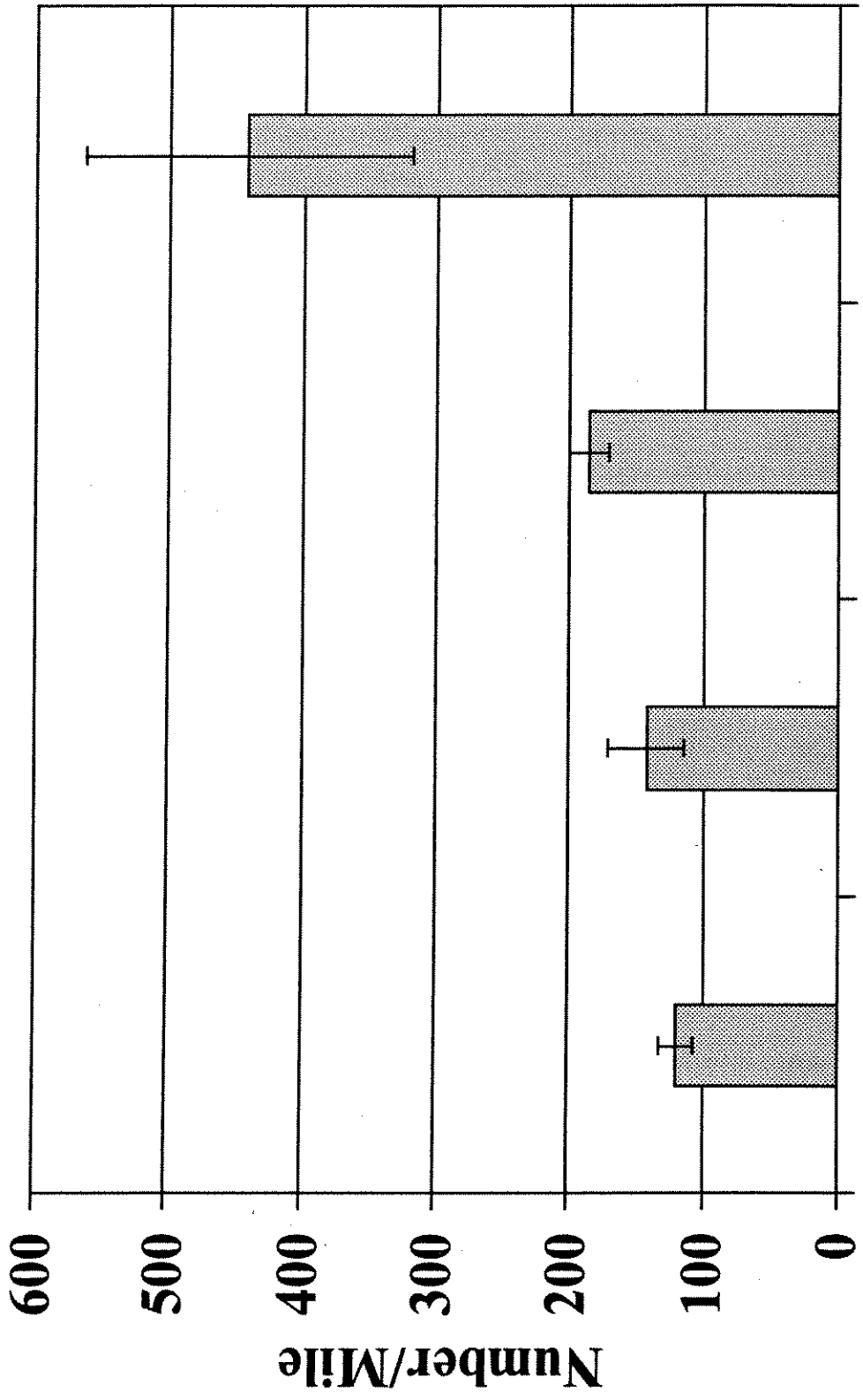

Figure 7. Rainbow/cutthroat hybrid population estimates for the Three Forks section standardized to number per mile from 1996-1999.

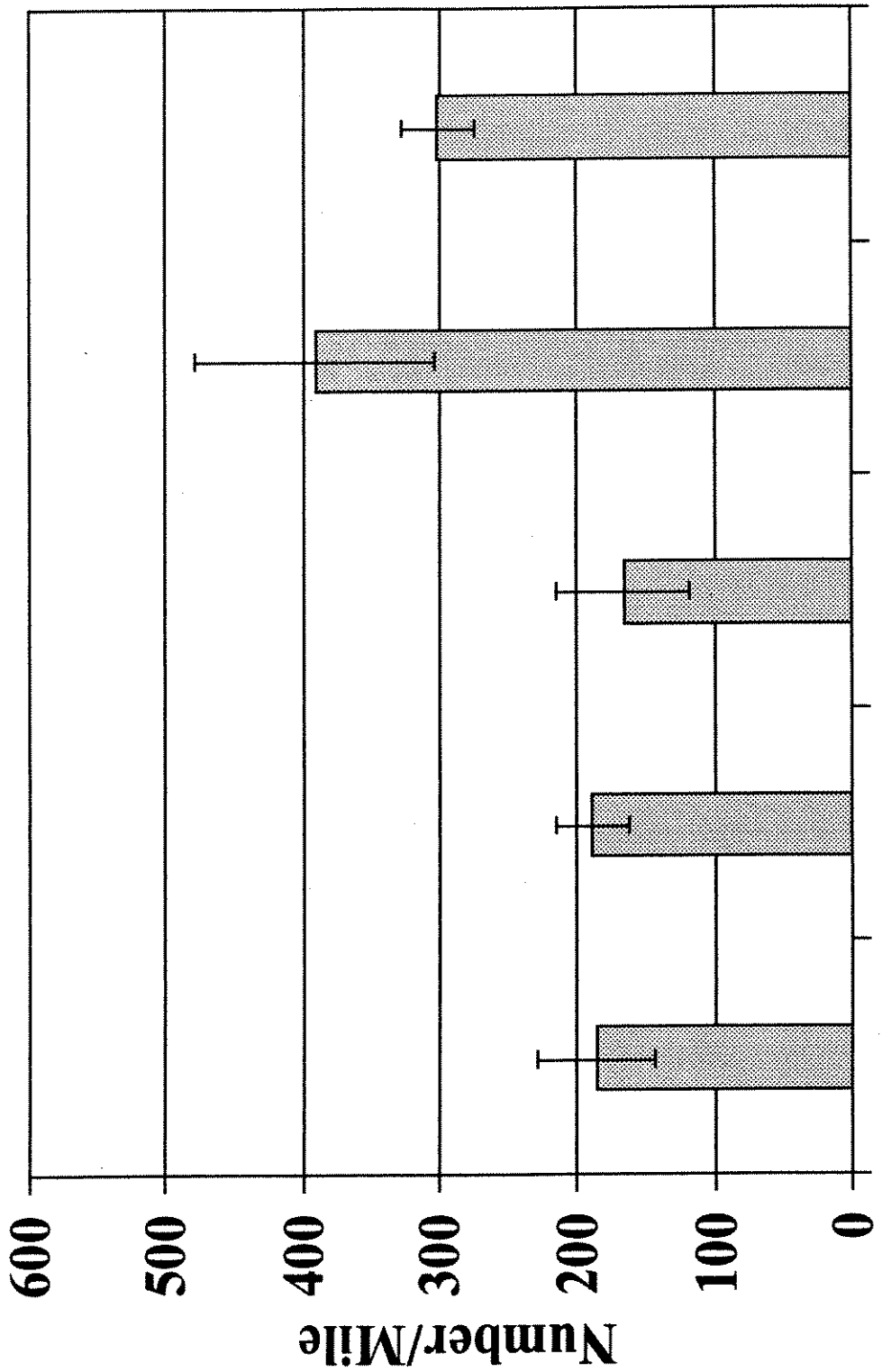

Figure 8. Rainbow/cutthroat hybrid population estimates for the Vigilante section standardized to number per mile from 1996-1999.

Brown Trout

In 1997-1999, brown trout were only captured in the lower four sections of the study area (Section E, Section F, Section One, and the Greenhorn Section). Population estimates were calculated for Section One and the Greenhorn section from 1997 to 1999. Brown trout density increased further downstream and the Greenhorn section had the highest estimates for all three years. These estimates increased from 429 (SD 98) per mile in 1997 to 579 (SD 114) per mile in 1999 (Figure 9). The estimates in Section One increased from 18 (SD 3) per mile in 1997 to 54 (SD 9) per mile in 1999 (Figure 10). Of the four sections, the Greenhorn Section had the highest CPUE in all three years (Figure 11).

Growth and Condition Factor of Grayling

In 1998, the mean length of grayling increased from 9.3 in. to 9.9 in. (0.6 in.) from July to October (90 days post plant). The range of length was from 6.1 in. to 12.1 in. in October. Mean weight increased from 0.24 lb. to 0.27 lb. (0.03 lb.), and mean condition factor decreased from 30.43 to 27.80 (2.63). In October 1999, the mean length of these fish increased to 11.0 in., a 1.1 in. increase, and ranged from 10.1 in. to 11.7 in. The mean weight increased 0.14 lb. to 0.41 lb. and the mean condition had increased to 30.61 during this same time period (Table 4).

Growth was similar in 1999. Grayling on average grew 0.6 in. from 9.8 in. to 10.4 in. when they were captured in October (90 days post plant). In October, lengths ranged from 4.9 in. to 12.5 in. Mean weight increased 0.04 lb. from 0.30 lb. to 0.34 lb. and condition factor decreased slightly from 30.98 to 30.2 (Table 4).

Grayling Movement

Retention of coded-wire tags, 48 hours post-tagging, in 1998 was 98.0%, 96.0%, and 97.5% for snout, dorsal, and anal tags, respectively. Results were similar in 1999 with 94.8%

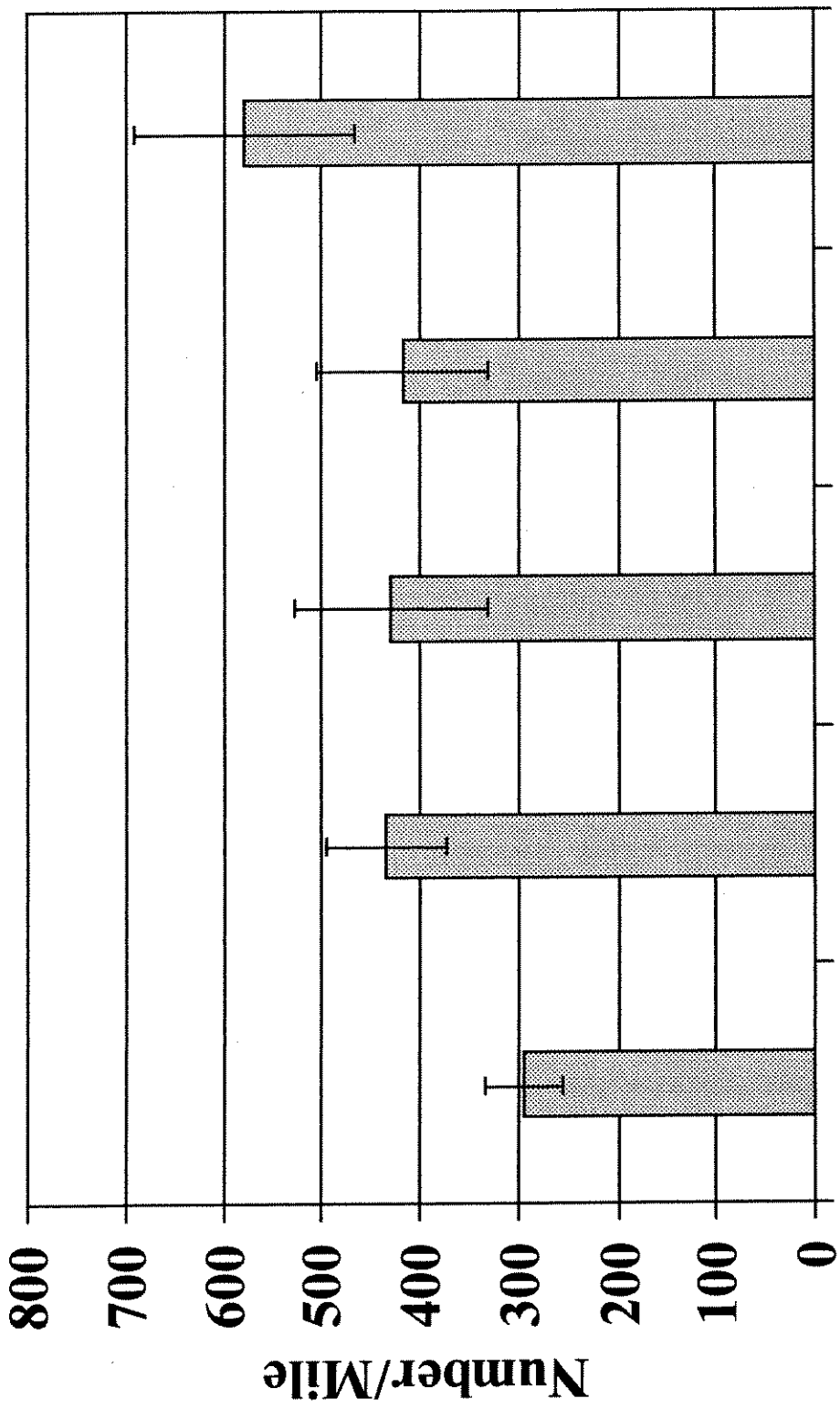

Figure 9. Brown trout population estimates for the Greenhorn section standardized to number per mile form 1995-1999.

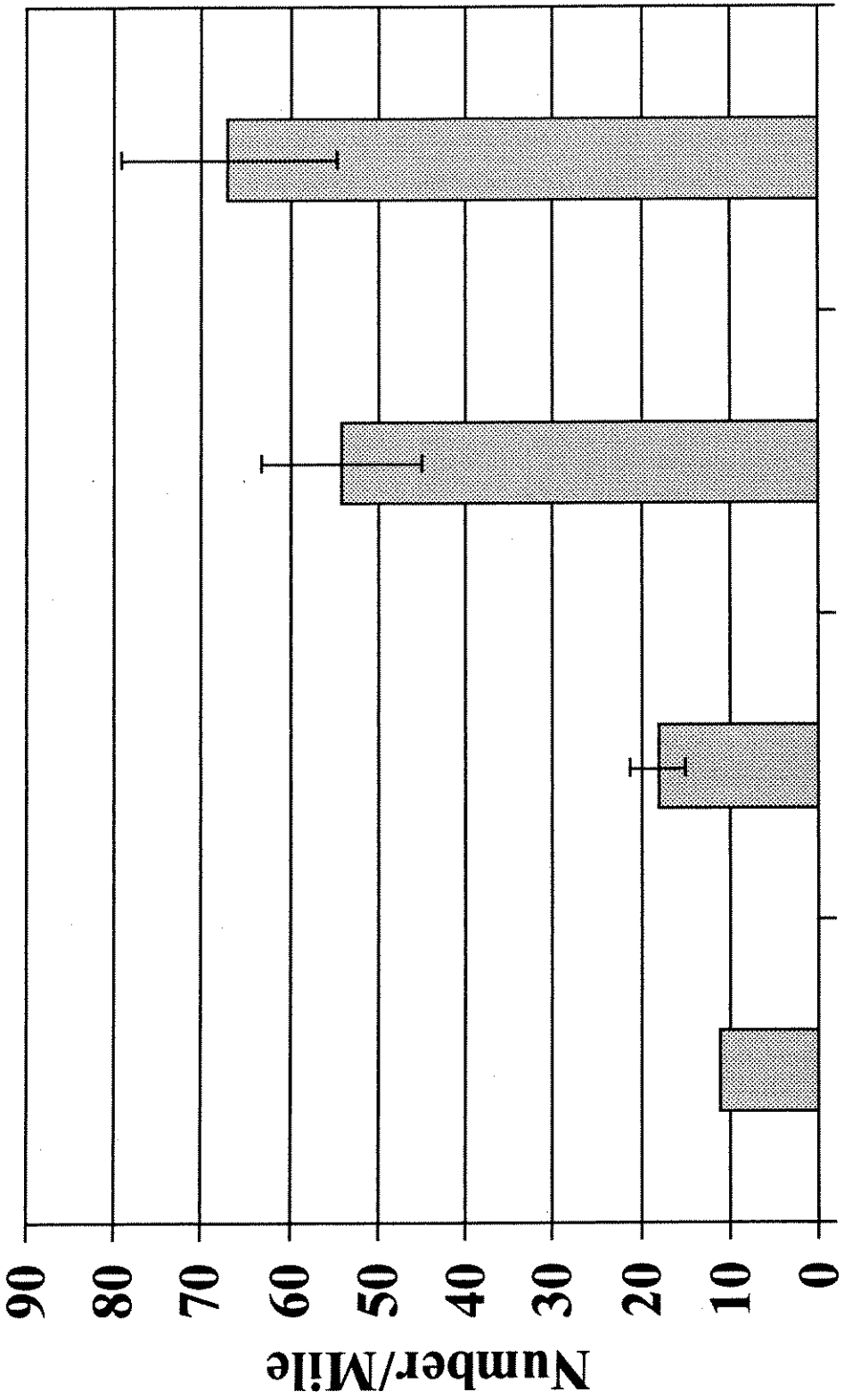

Figure 10. Brown trout population estimates for Section One standardized to number per mile from 1996-1999.

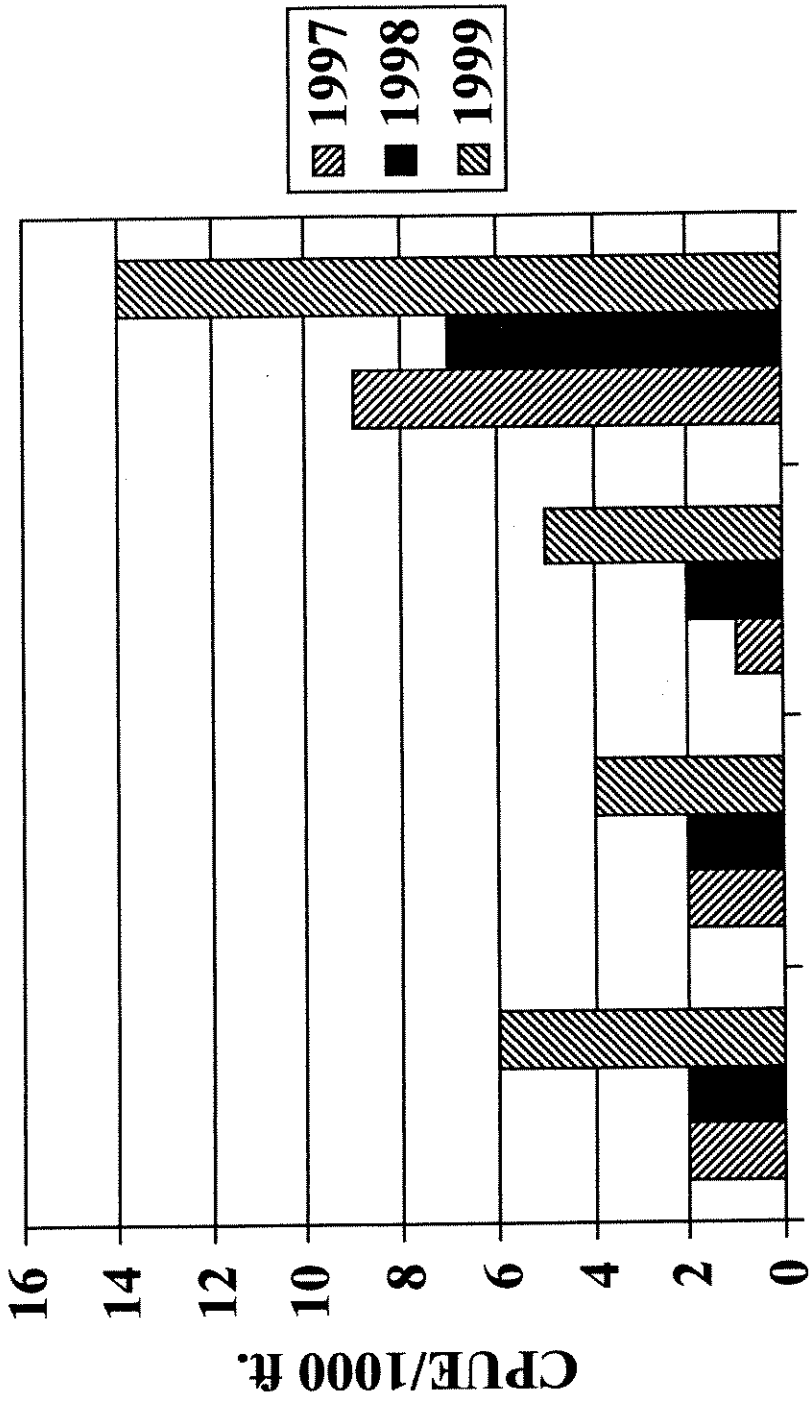

Figure 11. Catch-per-unit-effort of brown trout standardized to 1000 ft. for two 1000 ft. sections (E and F) and two mark/recapture sections (SO=Section One GH=Greenhorn) in the upper Ruby River.

Year Planted	Time of Plant			Fall 1998			Fall 1999		
	Length	Weight	Condition	Length	Weight	Condition	Length	Weight	Condition
1998	9.3 in.	0.24 lb.	30.43	9.9 in.	0.27 lb.	27.80	11.0 in.	0.41 lb.	30.61
1999	9.8 in.	0.30 lb.	30.98	---	---	---	10.4 in.	0.34 lb.	30.20

Table 4. Length, weight, and condition factor of grayling at the time of planting and 90 days post planting in fall 1998, and fall 1999 for grayling that were planted in the upper Ruby River, MT in 1998 and 1999.

snout tag, 97.4% dorsal tag, and 99.5% anal tag retention. Retention immediately prior to release remained high for all three groups with 94.5%, 97.6%, and 98.9% retention for snout, dorsal, and anal tags, respectively.

Little movement of grayling with coded-wire tags was observed in fall 1998. The movement that did occur was downstream. Ten tagged grayling were captured in a section different than they were planted in. The largest movement, 10.3-12.3 miles, was from Section A or Three Forks downstream to Section D. The smallest movement documented was two fish that moved 5.0-6.5 miles downstream from Section B or C to Section D (Table 5).

Five age-1 grayling were captured at the Ice Creek trap between July 22 and 31 1998. Two of these had anal tags and were mortalities. These fish were planted at either the Vigilante Bridge or in Section D, approximately 8.0 and 8.6 miles upstream of the trap, respectively. The other three grayling were captured between August 1 and November 30. Two were mortalities and the other was in poor condition. None of these three fish had coded-wire tags. The fish captured on November 7 had a fin clip that was administered during the mark-recapture survey in the Vigilante section, approximately 8 miles upstream, earlier in the fall.

Grayling were more widely distributed in 1999 than 1998. The majority of the movement was downstream, although one fish moved upstream. The largest downstream movement was 15.0-17.0 miles from Section A or Three Forks to Section One. A grayling that moved 4.3-5.0 miles from Vigilante or Section D to Section C was the only upstream movement that was observed in fall 1999 (Table 6).

In 1999, a total of eight grayling were captured at the Ice Creek trap between July 22 and October 27. Six were age-1 fish that had anal coded-wire tags indicating that they were planted in the Vigilante section or Section D and had moved 7 to 10 miles. One fish was not scanned and another did not have a coded-wire tag. Four of the eight fish captured were mortalities.

Location	Number of fish with snout tags	Distance from planting site	Number of fish with dorsal tags	Distance from planting site
Vigilante Fall 1998	7	9.9-11.6 miles downstream	---	---
Section D Fall 1998	1	10.3-12.3 miles down stream	2	5.0-6.5 miles down stream

Table 5. Movement of grayling that were planted in the upper Ruby River in 1998. The tag location that was in each section and distance moved from planting site is shown.

Location	Number of fish with snout tags	Distance from planting site	Number of fish with dorsal tags	Distance from planting site	Number of fish with anal tags	Distance from planting site
Section B Summer 1999	30	5.8-3.8 miles downstream	23	Tag used in this section	---	---
Section B Fall 1999	1	5.8-3.8 miles downstream	5	Tag used in this section	---	---
Section C Spring 1999	3	7.3-5.3 miles downstream	---	Tag used in this section	---	---
Section C Summer 1999	5	7.3-5.3 miles downstream	46	Tag used in this section	---	---
Section C Fall 1999	4	7.3-5.3 miles downstream	13	Tag used in this section	1	4.3-5.0 miles upstream
Vigilante Spring 1999	5	11.6-9.6 miles downstream	9	5.8-4.3 miles downstream	3	Tag used in this section
Vigilante Fall 1999	84	11.6-9.6 miles downstream	158	5.8-4.3 miles downstream	63	Tag used in this section
Section D Summer 1999	2	12.3-10.3 miles downstream	4	6.5-5.0 miles downstream	90	Tag used in this section
Section D Fall 1999	19	12.3-10.3 miles downstream	23	6.5-5.0 miles downstream	41	Tag used in this section
Section E Fall 1999	5	13.0-11.0 miles downstream	6	7.2-5.7 miles downstream	---	---
Section F Fall 1999	2	15.5-13.5 miles downstream	3	9.7-8.2 miles downstream	4	3.9-3.2 miles downstream
Section One Fall 1999	1	17.0-15.0 miles downstream	3	11.2-9.7 miles downstream	4	5.4-4.7 miles downstream

Table 6. Movement of recaptured grayling with coded-wire tags in 1999 is shown by section. The number of fish that moved and the distance from the planting location is shown.

In December 1999, an unconfirmed report of a grayling being caught through the ice on Ruby Reservoir was made to the Fish, Wildlife & Parks office in Dillon, Montana. This was the first indication of any grayling moving into the reservoir. No grayling have been captured in gill nets that are used to monitor the reservoir in spring and fall.

DISCUSSION

Population Monitoring

It appears that survival of the 1997 plant was very low. This may have been a result of the small size of the fish when they were planted and the transition from hatchery to river residence. Grayling numbers in the upper Ruby were higher in 1998. This was mainly due to the introduction of age-1 grayling in the summer of 1998. Survival of the 1998 plant was better than the 1997 plant, with 9% (76 fish) of the grayling captured in 1999 being age-2 fish from the 1998 plant. In 1999, grayling were more widely distributed. Grayling estimates were lower in the upper sections of the river (Three Forks and Vigilante), and were higher in the lower sections (Section One and Greenhorn). The initial survival of the 1999 plant appears to be good based on the population estimates and CPUE calculated in fall 1999.

A similar increase in post-planting growth was seen in both the 1998 and 1999 plants. Condition factors were also similar, and weight increased for both plants. In fall 1999, an increase in condition of grayling from the 1998 plant indicates that the grayling were able to find suitable habitats and adequate food for survival in the upper Ruby River. The average condition factors of grayling (6-12 in. in length) in the upper Ruby River are similar to those in the Big Hole River. In 1999, Big Hole River grayling (6-12 in. in length) captured in the Wisdom Section had an average condition factor of 30.62 (MFWP files).

Grayling have not had a negative impact on rainbow/cutthroat hybrid or brown trout population abundance or condition. Rainbow/cutthroat estimates in the four historic sections

have remained stable or increased since reintroduction began in 1997. The estimates increased at the Three Forks and Greenhorn Sections in 1999 as well. The Vigilante Section estimate decreased from 1998 to 1999, but it remained higher than the 1997 estimate. Section One saw a decrease in 1999 to a level just below that of 1997. CPUE for rainbow/cutthroat hybrids increased from 1997 to 1999 in all but three sections. Brown trout estimates also increased in Section One and the Greenhorn Section from 1997 to 1999. While increases in trout abundance may be attributed to both flow regimes and habitat conditions, planted grayling have not contributed to declines in these populations.

Predation by rainbow/cutthroat hybrids on age-1 grayling planted in 1998 and 1999 is most likely minimal. In the Vigilante Section, the average length of grayling was 9.8 in. and the average length of rainbow/cutthroat was 11.0 in. in 1999. In this section, there were 27 rainbow/cutthroat per mile that were greater than 14.0 in. Most of the rainbow/cutthroat would not be able to or would have a difficult time preying on the grayling because of the similarity in size.

Grayling Movement

Very little movement of tagged grayling was observed in 1998. The movement that was observed was downstream. In 1999, more movement was observed than 1998. It also tended to be downstream with the exception of one fish that moved upstream. Grayling that were collected at the Ice Creek trap tended to be mortalities or fish in poor condition. This suggests that these fish were not moving downstream as a means of dispersal but were unable to adapt to the upper Ruby River environment and were in poor physical condition. Although some downstream movement is occurring it appears that the majority of the planted grayling are staying near the planting locations. An initial concern was that the planted grayling would migrate downstream into Ruby Reservoir, adapt lacustrine lifestyles, and lose fluvial traits and characteristics.

Coded-wire tag retention in grayling was within the range of retention in other studies. A study by Blankenship (1990) showed tag retention rates of 94.7%-98.7% for coho *Oncorhyncus kisutch* and chinook salmon *Oncorhyncus tshawytscha*. Dussault and Rodriguez (1997) found tag retention to be 91.6% for Atlantic salmon and 97.5% for brook trout *Salvelinus fontinalis* in their study. Blankenship (1990) found that there was no change in the rate of tag loss after 29 days and that tag loss stopped after 17 days. This suggests that the tag retention rate of the grayling that were planted in 1999 is very accurate since retention was determined 20 days post tagging. Variation in tag retention can be caused by experience of the tagger and the technique used (Elrod and Schnieder 1986; Buckley and Blankenship 1990). This explains part of the variability of retention seen in planted grayling.

Conclusion

The upper Ruby River appears to providing suitable habitat for the survival and growth of planted fluvial grayling. Water temperature and discharge do not fluctuate as severely as in the Big Hole River and may not play as large of a role as a limiting factor. There have been no negative impacts on the rainbow/cutthroat and brown trout populations in the upper Ruby River caused by the introduction of grayling. The survival of the 1997 plant was very poor. In contrast, survival of the 1998 and 1999 plants have been encouraging. Growth and condition factors of surviving fish indicate that some grayling have been able to adapt and successfully exit in the upper Ruby River. Spring 2000 will be the first year that grayling planted in 1998 (age-3) may begin to spawn. Spawning and survival of juvenile grayling to maturity will be the next test in the upper Ruby River. Summer 2000 will be the fourth year of planting fluvial grayling into the upper Ruby River. Population monitoring will continue in 2000 to determine the success of the 1998 through 2000 plants. Monitoring will also continue in order to detect any limiting factors that may be affecting the success of the restoration effort.

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