SIZE, ABUNDANCE, AND SEASONAL HABITAT UTILIZATION OF AN UNFISHED TROUT POPULATION AND THEIR RESPONSE TO CATCH AND RELEASE FISHING

by

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APPROVAL

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VITA

Denise Wilson Vore was born in San Jose, California on December 2, 1958. She was the second of 4 children born to Donald and Joan Wilson. She graduated from Sam Barlow High School in Gresham, Oregon in 1977. After attending Oregon State University and the University of Montana, she graduated with a B.S. degree in Zoology in 1984. From 1985 until 1987, she worked at various jobs and then returned to school at Montana State University to begin graduate study in Fish and Wildlife Management.

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ABSTRACT

Few studies have assessed the effects of catch and release fishing on a previously unfished trout population or provided information on seasonal habitat use. Four sections of Rattlesnake Creek were studied from March 1985 through February 1987. I examined the effects of catch and release fishing on a population of trout that had not been fished for 45 years. Seasonal and diel habitat use were also evaluated. Cutthroat, bull, and brook trout were present in Rattlesnake Creek. Size and abundance of cutthroat and bull trout were large compared to other similar streams. Two years of catch and release fishing had no measurable effect on size or abundance of trout. Among all cutthroat trout tagged, 22% were recaptured and 68% of those over 400 mm total length were caught and released. These and other data collected on Rattlesnake Creek indicate the extreme vulnerability of cutthroat trout to angling. Cutthroat trout behavior during late spring days was related to spawning. Feeding was the dominant activity during summer days and cover seeking dominated during winter days. Diel shifts were most noticeable during winter. Twice as many trout were counted at night during the winter. Winter night counts were similar to summer day counts.

INTRODUCTION

Catch and release fishing was first instituted in the Great Smokey Mountains National Park in 1954 (Barnhart 1989). It is currently used to establish and maintain high quality fisheries by decreasing angling mortality. Several studies have shown the effects of catch and release fishing (Anderson and Nehring 1984, Thurow and Bjornn 1978, Varley and Gresswell 1988). However, there have been few opportunities to study the effects of catch and release fishing on a previously unfished trout population.

Rattlesnake Creek was closed to fishing for 45 years. It was protected as Missoula, Montana's municipal water supply. In 1985, a 25 km section of Rattlesnake Creek, above the confluence of Beeskove Creek, was opened to catch and release fishing. Approximately 12 km immediately below Beeskove Creek remains closed to fishing.

This study was designed to determine the characteristics of an unfished trout population and evaluate its response to catch and release angling. With the recent decline in many interior cutthroat trout populations (Behnke 1972) and their known vulnerability to angling (MacPhee 1966), it is becoming increasingly important that we understand the dynamics of unfished populations and the effects of angling on remaining populations. Results from this study will provide a point of reference for comparing trout populations in relatively pristine systems with those in heavily impacted and managed streams. Until we understand the structure of undisturbed fisheries and their habitats, protection and enhancement efforts will lack both a rational context and effective direction. Population abundance, size, habitat use, and species composition of trout in Rattlesnake Creek were the elements examined in the study. Abundance and size of trout were expected to exceed that of other similar-sized, but fished, streams.

Seasonal changes in abundance and habitat use were also investigated. Limited information is available about seasonal fluctuations in trout populations or their habitat requirement during the late fall and winter periods in temperate latitudes. Collection of information during late fall and winter can be difficult due to icing, subzero temperatures, and snow. Studies which have evaluated seasonal population fluctuations and habitat use have concentrated on juvenile anadromous fishes (Taylor 1988, Bustard and Narver 1975, Hillman and Griffith 1987, and Everest et al. 1985). Seasonality has been investigated to a lesser extent in brook and brown trout populations (Cunjak and Power 1986 & 1987, Hartman 1963, Maciolek and Needham 1952, Chisholm and Hubert 1987). Seasonal and diel fluctuations in cutthroat trout (*Oncorhynchus clarki lewisi*) abundance, habitat use, and behavior was evaluated in this study. Specific objectives of my study were to:

1. Determine population abundance, size, and species composition in two unfished sections and two fished sections of Rattlesnake Creek.

2. Conduct a creel census to determine angler distribution, angler use, catch, catch composition, and catch per unit effort.

3. Identify seasonal movement patterns of trout in Rattlesnake Creek.

4. Describe seasonal and diel cutthroat trout habitat use and behavior.

STUDY AREA

The Rattlesnake Creek drainage is located in west central Montana, 8.3 km north of Missoula (Figure 1). The drainage includes approximately 21,053 ha and is within the Lolo National Forest.

The general topography of the drainage is mountainous with glacially formed valleys. Geologic parent material in the area includes argillite, quartzite, and limestone of the Precambrian Belt series as well as Cambrian shales and limestones (Nelson & Dobell 1961). Climate of the region is semi-arid with an average annual precipitation of 32 cm (Knoche 1968).

Vegetation varies from a spruce-fir forest in the upper drainage to an open pine-larch forest below Franklin Bridge (Figure 1). Trees and shrubs of the riparian area include: cottonwood (*Populus trichocarpa*), alder (*Alnus rubra*), willow (*Salix* spp.), and rose (*Rosa* spp.). Occasionally the valley bottom opens up in to small grassy meadows. Fescues (*Festuca* spp.), wheatgrasses (*Agropyron* spp.), pinegrasses (*Calamagrostis* spp.), and bluejoint (*Calamagrostis* spp.) are the most common graminoids (Adelman 1979).

Rattlesnake Creek originates on the flanks of McLeod and Triangle peaks, and flows south-southwest to its confluence with the Clark Fork of the Columbia River at Missoula (Figure 1). It is a third order stream with a gravel, rubble substrate. The watershed is characterized by relatively high peak discharge per unit area (Van der Poel 1979). Average annual discharge during the study period

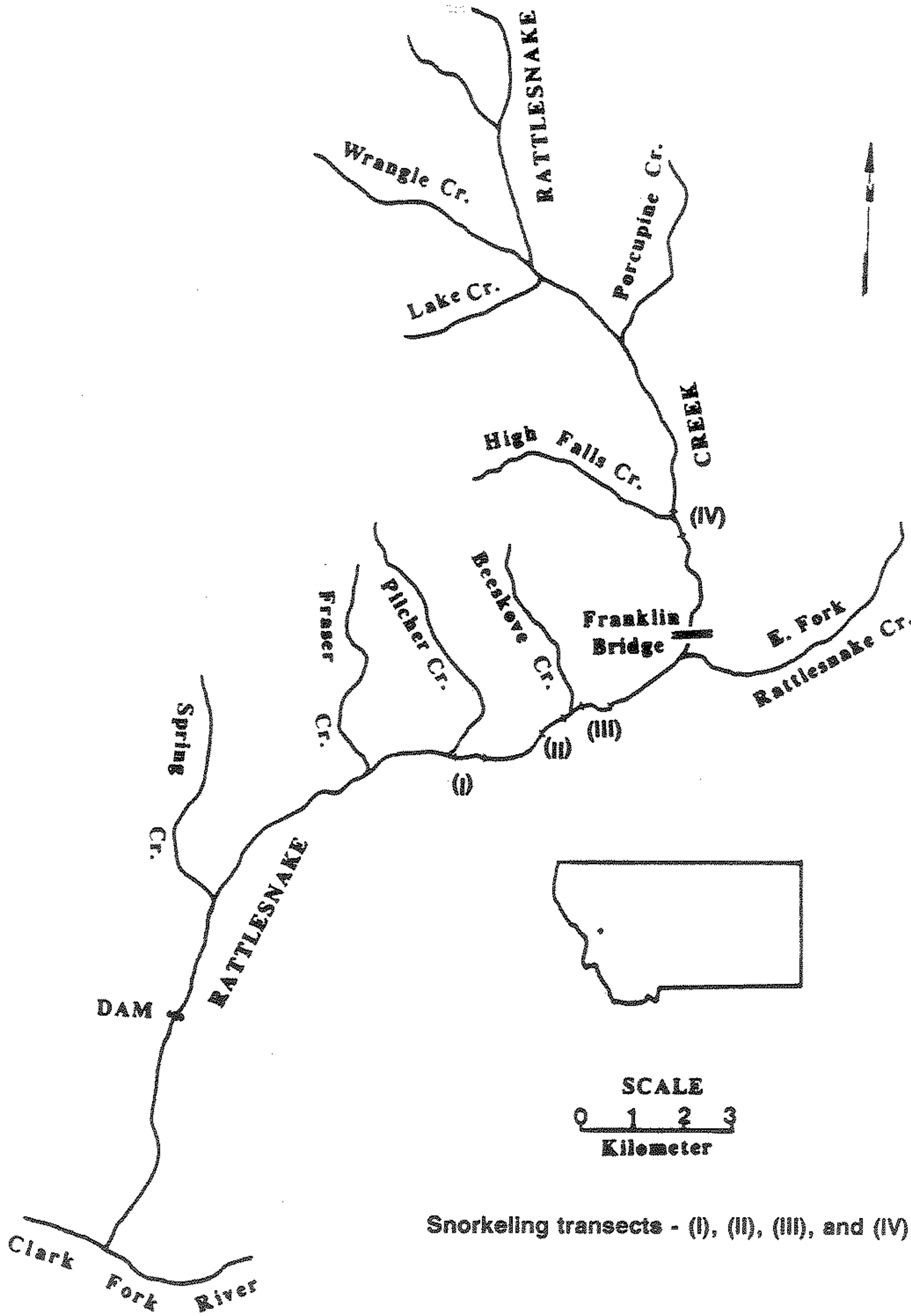


Figure 1. Drainage map of Rattlesnake Creek and study section locations.

was 41.9 cfs. Peak discharge usually occurs in May or early June. The creek descends 1613 m in 37.0 km for a mean gradient of 4.3%; mean gradient in the study sections is 1.75% (USFS-Lolo 1976). Water pH ranges from 6.6 to 7.6 and water alkalinity varies from 13 to 21 mg/L. Additional water chemistry data collected by the Mountain Water Company are included in Table 22, Appendix A. Rattlesnake Creek's nine perennial tributaries include Wrangle, Lake, and High Falls creeks, which originate from glacial lakes. Porcupine, East Fork of Rattlesnake, Beeskove, Pilcher, Fraser and Spring Creeks originate from springs. More than 40 lakes are located in the upper drainage.

From 1956 to 1964, 52,800 m^3 of timber were harvested from Lake Creek, Wrangle Creek, and upper Rattlesnake Creek drainages (Adelman 1979). Cattle grazing occurred along Spring Creek during the same period. Currently, the Rattlesnake Creek drainage is managed primarily as a watershed and secondarily as a recreational area (USFS Management Plan, 1984). A 12.2 m-high dam, 4 km upstream from the mouth, prevents all upstream fish migration from the Clark Fork River. A natural 4.6 m falls located above High Falls Creek is also an upstream migration barrier. Common recreational activities in the Rattlesnake Creek drainage are camping, fishing, mountain biking, horseback riding, and hiking. Fishing regulations prohibit angling from the dam upstream to Beeskove Creek. Catch and release fishing is allowed from Beeskove Creek to the headwaters.

METHODS

Study Section

Four 610 m study sections were selected on Rattlesnake Creek (Figure 1). Sections I and II were established in the closed-to-fishing area below Beeskove Creek. Section I was located in the same area as the Montana Department of Fish, Wildlife, and Parks 1984 survey (Don Peters, MDFWP, personal communication). Section II was selected because of its similar habitat and close proximity to the catch and release fishing area (section III). Section III was located immediately above Beeskove Creek where heavy fishing pressure was anticipated. Section IV, near High Falls Creek, was selected to represent species composition and fishing pressure in the upper drainage. This section was 15.3 km from the nearest road, above a long cascade and several beaver ponds. The lower boundary of each section was permanently marked with angle iron posts (Table 23, Appendix A).

Cutthroat Trout Genetics

Cutthroat trout were sampled from Rattlesnake Creek in 1985 and 1986 for genotype determination. The 1985 sample (N=30) was collected above High Falls Creek (Figure 1) and the 1986 sample (N=30) was taken from the Pilcher Creek area. Samples were immediately placed on ice and delivered to the University of Montana genetics laboratory for analyses. Through electrophoresis, 45 protein loci in muscle, liver and eye tissues were examined.

Population Estimates

Population estimates of cutthroat, bull (*Salvelinus confluentus*), and brook trout (*S. fontinalis*) were made in the summer and fall of 1985 and 1986; spring estimates were made in sections I and II in 1985. Population estimates were calculated using Chapman's modification of the Peterson mark and recapture technique (Ricker 1975):

$$\frac{(M+1)\ (C+1)}{(R+1)} - 1 = N$$

M = number of fish marked
C = number of fish captured
R = number of fish recaptured
N = population estimate

Because low water conductivity made electrofishing inefficient, angling was used to collect fish for marking, and recapture counts were made by snorkeling. Trout were caught with dry or submerged barbless flies and landed using a net. Each trout was measured to the nearest millimeter, weighed to the nearest gram, and sexed (when possible). Scale samples were collected from below and slightly posterior to the dorsal fin for age determination. Trout longer than 100 mm were marked. Two size groups (100-200 mm and 300-400 mm) were marked with fingerling tags and two (200-300 mm and 400+ mm) with type FD-68B Floy anchor tags. I used different tag colors for each size group and different color combinations for each population estimate, allowing identification of trout size and period of marking. Marked fish were released at or near the site of capture. Marking runs were repeated until a 20% or greater recapture rate was reached.

Snorkel-recapture counts were performed by a two-person crew; one in the water counting marked and unmarked fish and one on the bank recording data. To insure accurate snorkel counts:

1. Only trout over 100 mm were counted and counts were made at mid-day when skies were clear.

2. A 6.3 mm neoprene dry suit was used to extend the time the snorkeler could comfortably spend in the water under a variety of conditions.

3. Snorkel observations were made with the observer moving slowly upstream along the shallowest stream edge. To avoid disturbing trout, they were counted from the base of pools and runs whenever possible.

Montana Department of Fish, Wildlife, and Parks personnel helped electrofish section I in summer 1985 and sections I, II, & III in fall 1986. Electrofishing was used to collect supplementary data on bull trout and juvenile trout of all species.

Snorkel counts were substituted for population estimates in late fall and winter. Cold temperatures during these periods made marking trout difficult. Daytime snorkel counts were conducted in section IV on October 29, 1985, in sections I and II on February 10 and 11, 1986 and, in sections II and III on January 9 and February 22, 1987. Winter nighttime counts (using an underwater flashlight) were performed on February 10, 1986 and January 9, 1987. Water temperature, air temperature, phase of moon, estimated discharge and ice condition was recorded for each winter count.

Creel Census

A creel census was conducted from April 13th to October 31, 1985 and from April 15 to September 30, 1986. A creel clerk stationed at Beeskove Creek (Figure 1) conducted personal interviews from 7:00 am to 7:00 pm on 10 randomly selected days of each month. The sample was stratified into 5 weekend days and 5 weekdays. Angling location, size of party, angler residence, hours fished, fishing method, and catch composition were recorded (Table 24, Appendix A). Angling location was assigned to one of three areas: Beeskove Creek upstream to Franklin Bridge, Franklin Bridge upstream to Porcupine Creek, and Porcupine Creek to the headwaters (Figure 1). Booklets were available to anglers for recording species, size, location and tag numbers of trout caught. Access to the creek is limited to a 9.7 km trail which facilitated accurate creel counts. Supplementary creel information was collected from a volunteer creel survey. Data collection forms were provided at Beeskove Creek and were designed to encourage participation and accuracy (Table 24, Appendix A).

Estimated fishing pressure and hours fished were determined using the method suggested by Johnson and Wrablewski (1972). Estimates and error were calculated from a season-long sample, rather than shorter interval samples, to increase the accuracy of the estimate (Best and Boles 1956) and to more closely approximate a normal curve (Newhold and Lu 1957). Confidence intervals were determined using the following equation (Bob McFarland, MDFW&P personal communication):

$$CI= s/n\ (td)\ (1.96)$$

s=standard deviation of the sample
n=number of days sampled
td=total days estimated

Estimates of total catch and cutthroat/hour were calculated using the method of Neuhold and Lu (1957). Due to limited fishing pressure above Porcupine creek, the two areas above Franklin Bridge were combined for data analysis.

Fish Movement

Upstream-downstream Idaho picket weirs were placed at the upper and lower ends of section II (Figure 1) from July 21 through October 3, 1986. Weir panels were 0.35 m long and 0.6 m high and contained 1.9 cm holes every 2.5 cm. One and one half meter lengths of 1.9 cm thin-walled electrical metalic tubing were pounded into each hole. I used five panels on each upstream lead and 0.6 cm hardware cloth was used for downstream leads. All leads were angled from the trap box to the bank. Trap boxes were 1.2 by 1.0 m with hardware cloth funnel entrances.

Traps were checked and cleaned daily. Each trout trapped was measured, weighed, and tagged. Scales were collected and the fish was released in the direction of travel. Recaptured tagged trout from all sections were also used to assess movement.

Water Temperature and Discharge

Water temperature data were collected from April 14 through October 22, 1986 and from February 22 through February 29, 1987 with a Taylor 7-day recording thermograph installed below Beeskove Creek (Figure 1). The thermograph was periodically calibrated using a laboratory thermometer. At other locations, water temperatures were measured with a laboratory thermometer.

Stream discharge was measured below Beeskove Creek using a Price AA current meter applying the method recommended by the USGS (Buchanan and Somers 1969). Flows were taken periodically from July through October, 1985 and June through October, 1986.

Habitat Variables

An interagency habitat and fish population study by the United States Forest Service Lolo National Forest and Montana Department of Fish, Wildlife, and Parks began in 1985 and continued through 1986. I used their methodology to facilitate comparisons between Rattlesnake Creek and other regional streams (Peters 1987).

Forty equidistant transects, one every 16.4 m, were established perpendicular to the stream flow in each study section. At each transect, wetted width, depth, bank condition, gradient, elevation, and cover, other than pool cover, were measured. Depth measurements were taken at 1/4, 1/2, and 3/4 the stream width, and the average of the four was calculated. Gradient was measured with a clinometer over three long subsections and elevation was determined from USGS maps.

The remaining parameters were evaluated using methods adapted from Platts (1979). Dominant substrate size was identified at 0.31 m increments along each transect (Table 1). Substrate composition for each section was determined by averaging the 0.31 m observations of all 40 cross sections. Stream bank condition and pool classification were measured according to Platts (1979) (Tables 2 and 3). Cover, including turbulence, debris, overhanging brush, and boulders. was visually identified and measured linearly along each transect. Habitat variables were standardized for analysis by converting measured variables to ratios of the total (Peters 1987).

Table 1. Classification of substrate material (Platts 1979).

Classification	Particle diameter
boulder	304.8 mm or larger (> 12 inches)
rubble	76.1 - 304.7 mm (3 to 11.9 inches)
gravel	4.7 - 76.1 mm (0.2 to 2.99 inches)
fines	4.69 mm or smaller (< 0.19 inches)

Table 2. Numerical ratings used to classify streambank environment (Platts 1979)

cover*		condition		type	
forest	2.0	excellent	2.0	sod,root	2.0
brush	1.5	good	1.5	brush,rubble	1.5
grass	1.0	fair	1.0	grass,gravel	1.0
absent	0.5	poor	0.5	fines	0.5

*cover - type of vegetation dominating the stream banks.
condition - stability of the stream bank to water flows.
type - a habitat type that can be a single or combination of factors.

Table 3. Pool quality rating criteria (Platts 1979)

Description	Rating
Maximum pool diameter exceeds average stream width. Pool is over 1 m (3.28 ft) in depth or over 0.6 m (1.97 ft) in depth with abundant fish cover.	5
Maximum pool diameter exceeds average stream width. Pool is less than 0.6 m in depth with intermediate to abundant cover.	4
Maximum pool diameter is less than average stream width. Pool is over 0.6 m in depth with intermediate to abundant cover.	3
Maximum pool diameter is less than average stream width. Pool is less than 0.6 m in depth and has intermediate to abundant cover.	2
Maximum pool diameter is less than average stream width. Pool is less than 0.6 m in depth and has no cover.	1

RESULTS

Population Characteristics

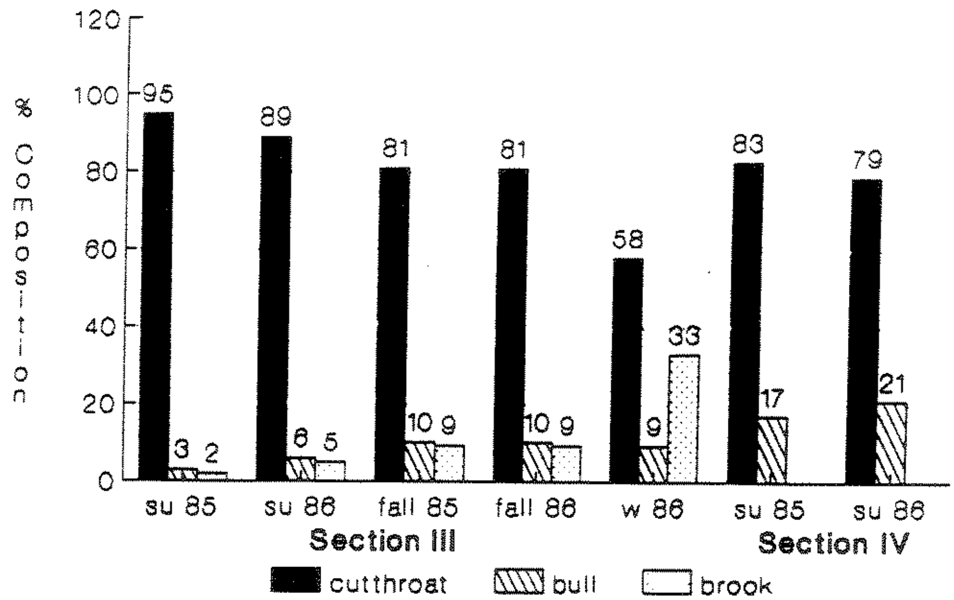
Species Composition

Four fish species were present in the Rattlesnake Creek study sections. Salmonid species included: westslope cutthroat, bull, and brook trout. Slimy sculpins (*Cottus cognatus*) were also present. Mountain whitefish (*Prosopium williamsoni*) are present in lower Rattlesnake Creek and the Clark Fork River, however, they were not found in Rattlesnake Creek above the dam.

Based on all 1985 and 1986 snorkel counts (N=2574), species composition in the study area was 83% cutthroat trout (N=2129), 10% bull trout (N= 267), and 7% brook trout (N=178) (Figure 2). Brook trout were not captured in or above section IV and were most common in section I (Figures 2 and 3). Bull trout were present in all sections with the highest numbers found in section IV (Figures 2 and 3). Estimated relative abundance of cutthroat trout decreased from 85% in 1985 to 80% in 1986 (Figures 2 and 3).

Genotype Determination

Westslope cutthroat trout in Rattlesnake Creek have hybridized with rainbow and Yellowstone cutthroat trout. The 1985 High Falls Creek specimens were 96% westslope cutthroat, 4% rainbow and 2%



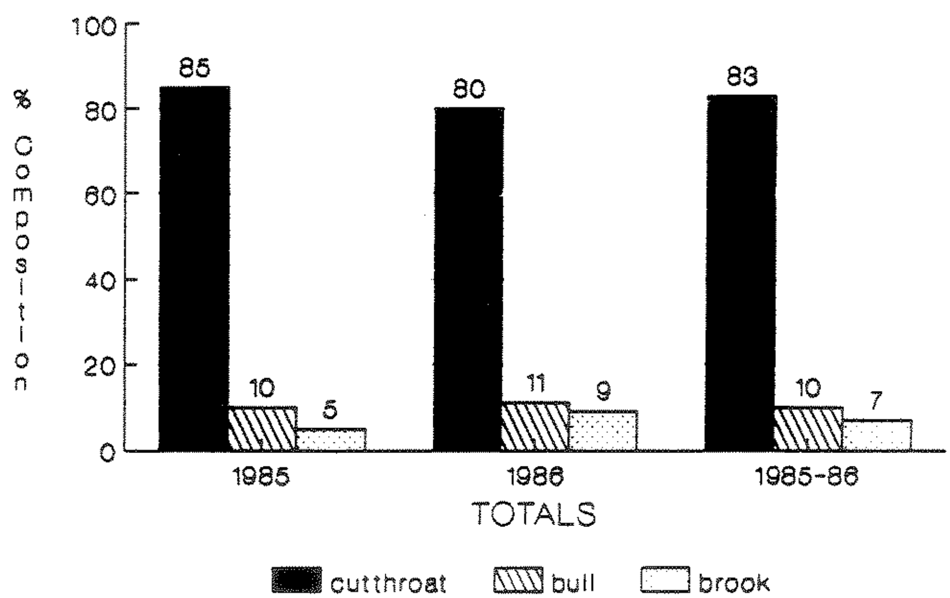
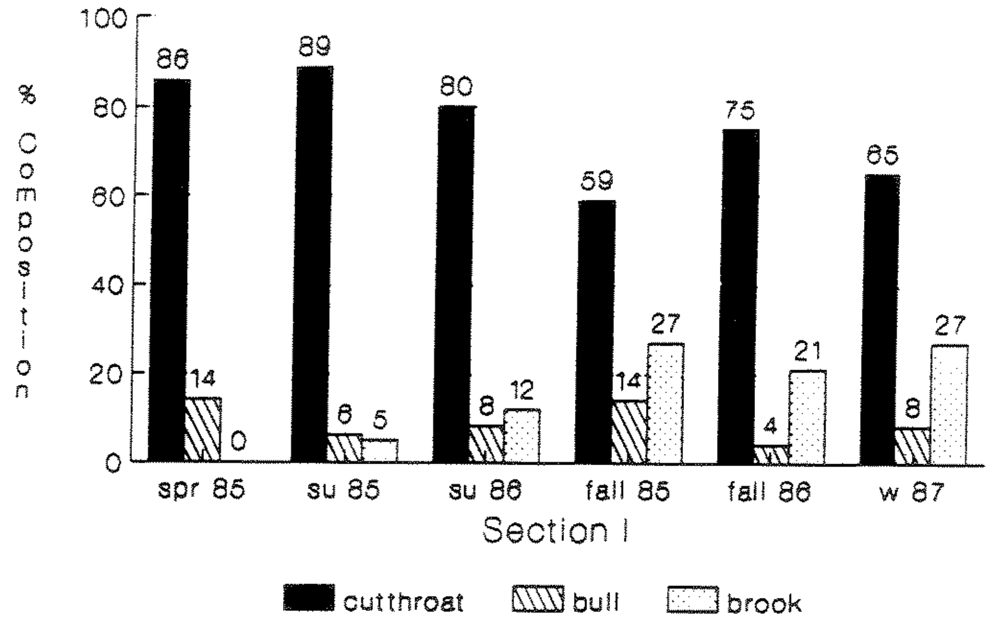


Figure 2. Seasonal species composition and distribution in sections III, IV, and total species composition on Rattlesnake Creek, 1985, 1986, and 1987.



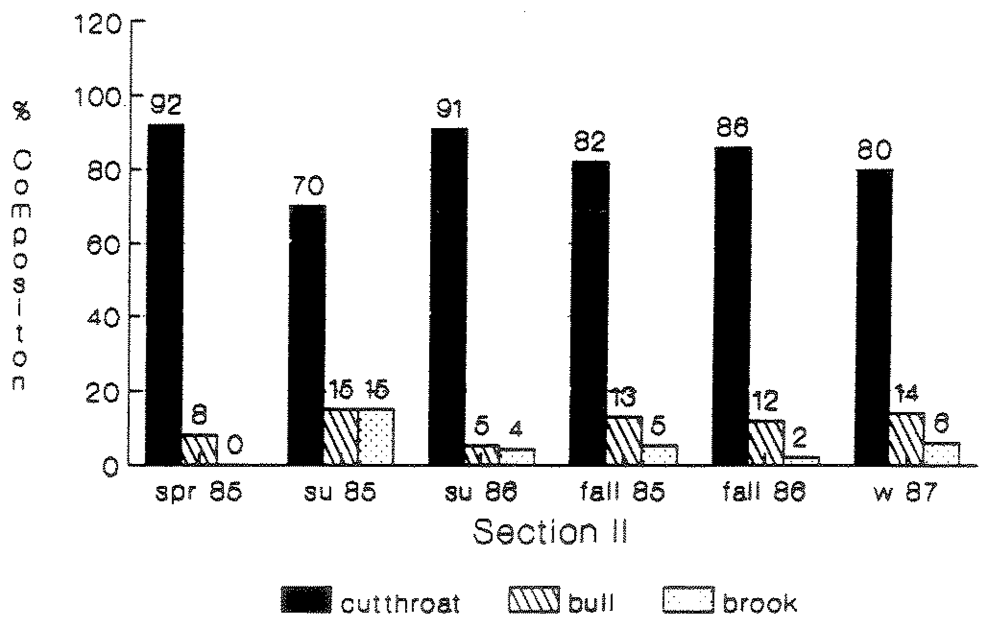


Figure 3. Seasonal species composition and distribution in section I and II of Rattlesnake Creek, 1985, 1986, and 1987.

Yellowstone cutthroat trout, while the 1986 Pilcher Creek sample had a genetic make-up of 80% westslope cutthroat and 20% rainbow trout (Table 25, Appendix A). A significantly lower amount of westslope cutthroat trout genetic material was present in the lower Pilcher Creek sample (X^2=25.554, p-value=.001) indicating that the two populations are at least partially reproductively isolated (Rob Leary, University of Montana personal communications).

Hybridization between rainbow and cutthroat trout presents a problem of visual recognition (Marnell 1978). There was no attempt to visually distinguish hybrids in this study.

Trout Size

Cutthroat trout sampled by angling ranged from 101 mm to 460 mm total length (N=1132). Mean length and weight were 236 mm and 172 g, respectively (Table 4). Greater effort was expended to capture small trout in 1986; therefore, mean length and weight for 1986 (226 mm and 152 g) were less than in 1985 (257 mm and 210 g). In the lower three sections, 20% of cutthroat marked were larger than 300 mm; the largest (480 mm) was caught above the dam and downstream of the study sections. Cutthroat trout average and maximum length and weight were lower in section IV and in section (I) than in the middle sites (Table 4). Summer size distribution for 1985 and 1986 by section is included in Figures 12 and 13, Appendix B. Seasonally, average cutthroat trout lengths were highest during fall of 1985 when fewer small trout were captured (Table 4).

Table 4. Comparison of cutthroat (Ct), brook and bull trout lengths (mm) and weights (g) by stream section during summer (su) and fall in Rattlesnake Creek, 1985 and 1986.

Section Season		Number 1985	Number 1986	Mean length (range) 1985	Mean length (range) 1986	Mean weight 1985	Mean weight 1986
Section I							
Su	Ct	74	106	221 (104-452)	220 (129-426)	159	145
	Brook	34	19	158 (104-264)	189 (145-232)	54	78
	Bull	27	0	193 (104-467)	-	141	-
Fall	Ct	12	52	348 (165-432)	247 (120-425)	435	228
	Brook	1	30	188 (188)	150 (108-207)	41	35
	Bull	0	5	-	275 (104-478)	-	382
Section II							
Su	Ct	59	104	269 (119-417)	244 (115-441)	231	212
	Brook	9	13	180 (130-234)	190 (145-309)	68	79
	Bull	0	4	-	327 (207-535)	-	508
Fall	Ct	26	92	338 (213-450)	216 (101-435)	408	143
	Brook	0	14	-	177 (106-233)	-	65
	Bull	0	33	-	253 (102-675)	-	305
Section III							
Su	Ct	54	108	300 (150-432)	231 (107-460)	340	161
	Brook	3	10	145 (132-152)	196 (157-251)	23	91
	Bull	0	2	-	302 (102-675)	-	305
Fall	Ct	25	96	323 (208-417)	219 (103-417)	290	135
	Brook	3	29	229 (213-246)	185 (104-257)	141	70
	Bull	1	17	358 (358)	244 (109-440)	452	168
Section IV							
Su	Ct	150	174	224 (127-330)	215 (119-400)	113	107
	Bull	2	13	210 (208-211)	250 (190-365)	133	159
Totals	Ct	400	732	257 (104-452)	226 (101-460)	210	152
	Brook	50	115	170 (104-264)	177 (104-309)	60	64
	Bull	30	74	208 (104-467)	257 (102-675)	151	264
1985-86 Total							
	Ct		1132	236		172	
	Brook		143	175		63	
	Bull		102	241		199	

Growth, as determined from recaptures, ranged from 106.5 mm/ year for 100-200 mm trout to 18.7 mm/year for trout > 400 mm (Table 5). Scales for 1985 were read by Don Peters, Montana Department of Fish, Wildlife, and Parks (Figures 14 and 15, Appendix B). The lowest growth rates were from section IV which is in the upper drainage where lower water temperatures occur.

Brook trout ranged in total length from 104 mm to 309 mm (N=143). Average length and weight were 175 mm and 63 g, respectively (Table 4). Ninety-seven percent of the brook trout captured were < 300 mm total length.

Total length of bull trout sampled in Rattlesnake Creek ranged from 102 mm to 667 mm (Table 4). Average length was 241 mm and average weight was 231 g. Twenty-five percent of all bull trout collected in the fall of 1986 (N=55) were more than 300 mm total length. The largest bull trout trapped was 711.2 mm total length and weighed 3266 g. Bull and brook trout recapture rates were too low to determine growth.

Population Abundance

The hook-and-line mark, snorkel recapture methodology was efficient at estimating trout populations (Table 6). Marking took approximately 8 days spread over an average of 26 days. Angling marking runs were more efficient when conducted every other day or early in the day before angling pressure increased. Overall mark/recapture efficiencies for cutthroat, bull, and brook trout

Table 5. Mean Growth rates of cutthroat trout determined from recapture measurements, 1985 and 1986.

Size (mm)	Number	mm/year
100-200	5	106.5
200-300	35	45.9
300-400	35	32.0
400+	10	18.7

Table 6. Summer and fall mark/recapture efficiencies (%) in Rattlesnake Creek, 1985 and 1986.

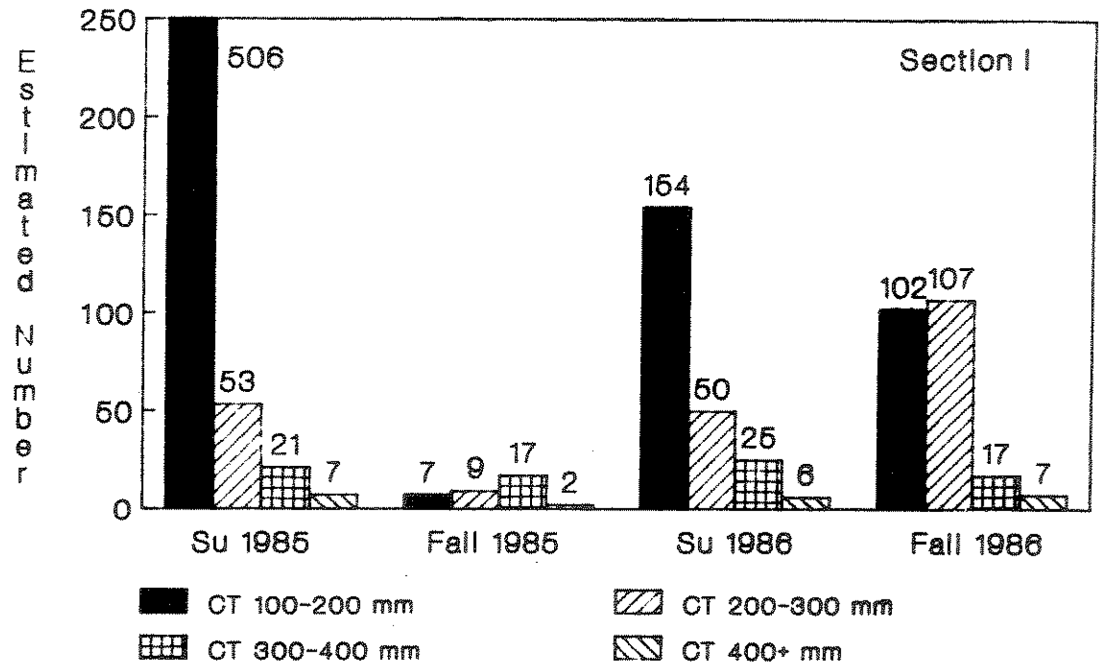
Year	Section I		Section II		Section III		Section IV	
Size (mm)	Su	Fall	Su	Fall	Su	Fall	Su	Mean efficiency
1985								
All CT	58	50	51	42	35	60	45	
100-200	51	50	36	0	36	27	42	
300+	81	50	74	65	35	86	100	
All Bull	11							
All Brook	13		22					
All CT	43	39	44	26	34	35	51	44
100-300	44	31	37	16	33	23	50	34
300+	43	53	61	57	40	89	60	64
All Bull	–	20	50	3	50	18	46	41
All Brook	26	7	0	0	20	10	–	12

were 44%, 41%, and 12%, respectively (Table 6). Mark/recapture efficiencies for cutthroat trout > 300 mm averaged 64% which was significantly higher than the mark/recapture efficiencies for cutthroat trout < 300 mm (34%) (p=0.003). Estimates for brook and cutthroat trout < 300 mm should be regarded with caution.

Estimated cutthroat trout abundance (summer day 1985 and 1986) was greatest in section I, followed by sections IV, III, and II (Figures 4 and 5). Average number of cutthroat in section I, II, III and IV (0.61 km each) was 409, 215, 260, and 308, respectively (Tables 26-33, Appendix A). Section II followed by sections III, I, and IV had the greatest abundance of cutthroat trout > 300 mm total length. In general, the sections with the greatest abundance of cutthroat trout contained the lowest numbers of trout > 300 mm. Average fall daytime estimates indicates that section III contained the greatest number of cutthroat trout (170) followed by sections II (169) and I (128). Fall estimates were not completed in section IV.

Bull trout were fairly evenly distributed among the four sections (Figures 2 and 3). Section I contained the highest number of brook trout (average 110) (Figures 2 and 3, Tables 26-33, Appendix A). Estimates of brook and bull trout abundance were sometimes not possible due to low numbers marked or recaptured.

Seasonal fluctuations in cutthroat trout population estimates were greatest for the 100-200 mm size group (Figures 4 & 5). Trout longer than 200 mm showed fewer fluctuations. Annual cutthroat trout



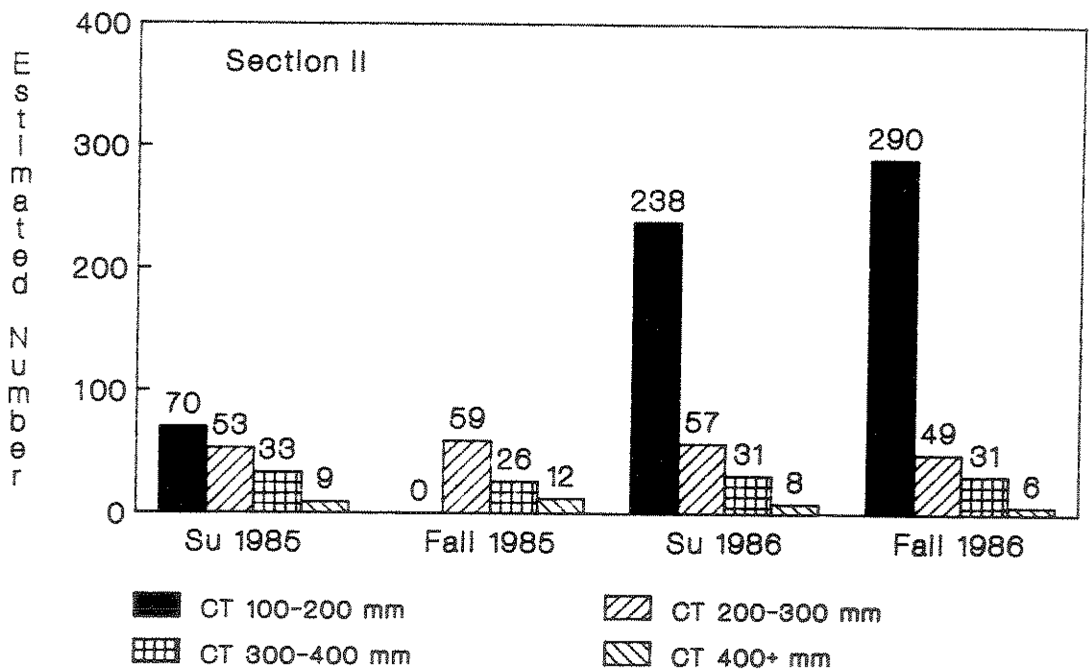


Figure 4. Estimated number of cutthroat trout by size class, season, and section (0.6 km) in Rattlesnake Creek. Confidence intervals shown in Tables 28, 29, 32, and 33, Appendix C.

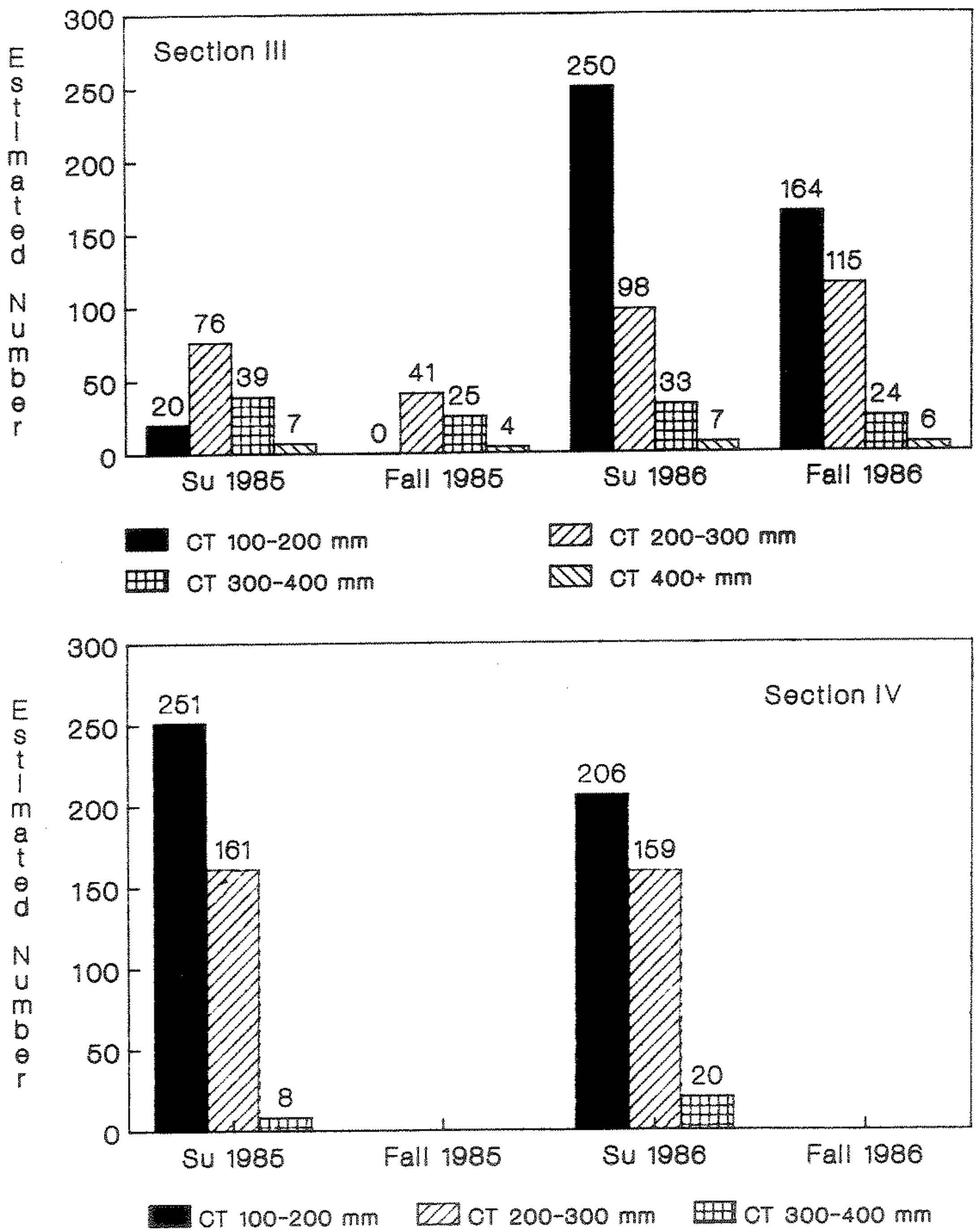


Figure 5. Estimated number of cutthroat trout by size class, season, and section (0.6 km), in Rattlesnake Creek. Confidence intervals shown in Tables 30, 31, 34, and 35, Appendix C.

population fluctuations, from 1985 to 1986, were also seen mainly in the 100-200 mm size-class (Table 7 & 8). In summer, confidence intervals for the 1985 and 1986 estimates of cutthroat trout > 200 mm all overlap while those for trout < 200 mm do not overlap. In fall, a similar but more variable pattern was noted (Table 8).

Creel Census

Angler Hours and Pressure

In 1985 and 1986, angling pressure was low and catch rates were high on Rattlesnake Creek. In 1985, an estimated 457 anglers fished the stream during the 25-week census period compared to 254 in 1986 (Table 9). Estimated hours fished also decreased from 1184.5 in 1985 to 658.6 in 1986. During the same period catch rates increased slightly from 3.0 cutthroat/hour to 3.4 cutthroat/hour.

Anglers were not evenly distributed along Rattlesnake Creek. Sixty-four percent of angling occurred in the lower area between Beeskove Creek and Franklin Bridge, while 36% fished from Franklin Bridge to Porcupine Creek (Figures 1 & 6). Although cutthroat trout were on the average larger in the more heavily fished area (Table 4), catch rates were approximately 0.5 cutthroat/hour less below Franklin Bridge (2.6 cutthroat/hour) than above Franklin Bridge (3.0 cutthroat/hour).

Weekday and weekend angler use was not equally distributed; 1985-86 weekday pressure averaged 1.4 anglers/day while weekend-holiday pressure averaged 3.0 anglers/day. Estimated angler use

Table 7. Comparison of 1985 and 1986 summer daytime cutthroat trout population estimates for four sections of Rattlesnake Creek. Confidence intervals are shown in parentheses.

Size (mm)	Section I 1985	Section I 1986	Section II 1985	Section II 1986	Section III 1985	Section III 1986	Section IV 1985	Section IV 1986
All	597 (176)	221 (45)	138 (36)	276 (62)	150 (51)	369 (97)	374 (68)	385 (59)
100-200	506 (195)	154 (51)	70 (45)	238 (114)	20 (14)	250 (119)	251 (103)	206 (52)
200-300	53 (30)	50 (12)	53 (26)	57 (18)	76 (45)	98 (32)	161 (30)	159 (31)
300-400	21 (15)	25 (16)	33 (11)	31 (6)	39 (15)	33 (16)	8 (4)	20 (10)
400+	7 (5)	6 (3)	9 (4)	8 (4)	7 (5)	7 (5)	0	0

Table 8. Comparison of 1985 and 1986 fall daytime cutthroat trout population estimates in three sections of Rattlesnake Creek. Confidence intervals are shown in parentheses.

Size (mm)	Section I 1985	Section I 1986	Section II 1985	Section II 1986	Section III 1985	Section III 1986
All	43 (25)	212 (77)	71 (36)	267 (83)	62 (23)	277 (70)
100-200	7 (8)	102 (55)	0 -	290 (210)	0 -	165 (75)
200-300	9 (9)	107 (88)	59 (75)	50 (25)	41 (30)	115 (65)
300-400	17 (9)	17 (5)	27 (13)	31 (10)	25 (10)	24 (7)
400+	2 (2)	7 (6)	12 (6)	6 (4)	4 (3)	6 (4)

Table 9. Total estimated anglers, hours fished and cutthroat (Ct) caught per hour, Rattlesnake Creek, April through September, 1985 and 1986.

Period	# days sampled (# days est.)	Estimated anglers (95% CI)	Estimated hours (95% CI)	Ct/hr
1985				
Weekday	28 (118)	123 (44.5)	645.5 (353.4)	
Weekend	32 (51)	334 (117.9)	539.1 (198.5)	
Total	60 (169)	457 (162.4)	1184.5 (588.2)	3.02
1986				
Weekday	23 (128)	64 (25.8)	316.2 (309.9)	
Weekend	31 (55)	190 (107.0)	342.4 (166.9)	
Total	54 (183)	254 (132.8)	658.6 (512.5)	3.37
TOTAL	114 (353)	711 (295.2)	1843.1 (1119.4)	-

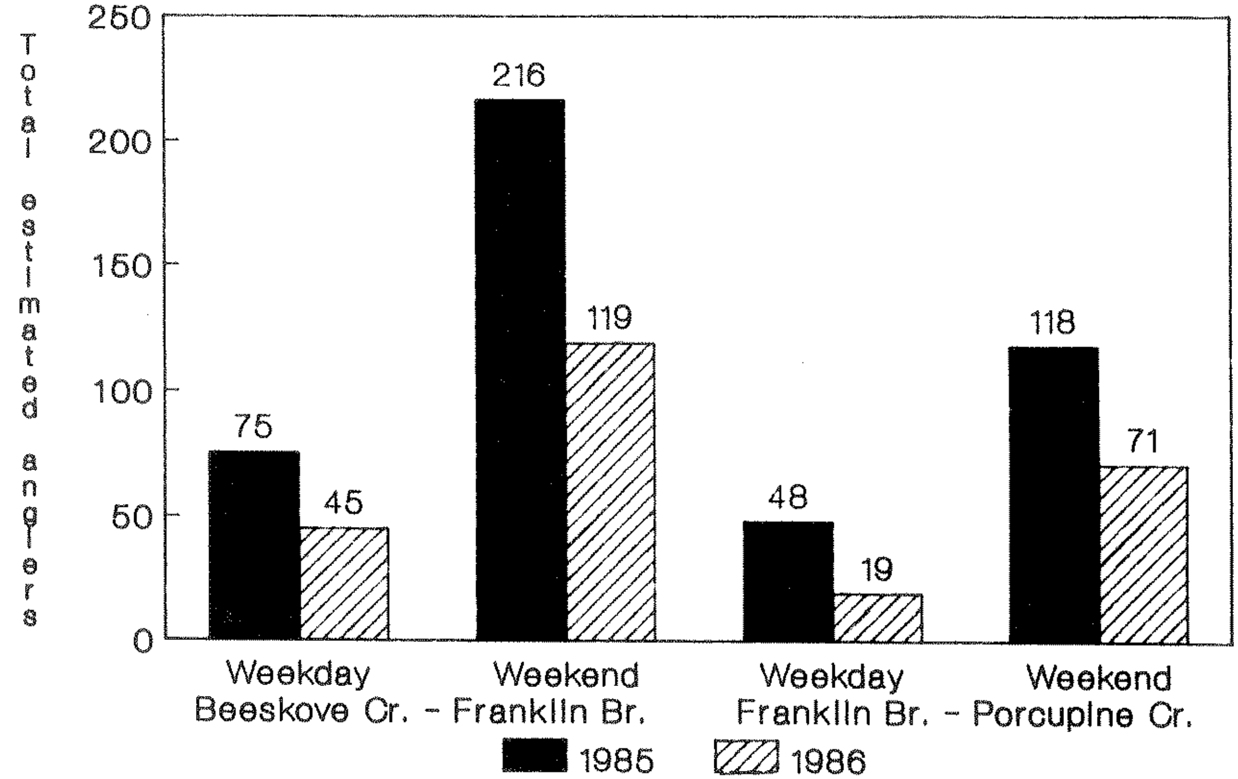


Figure 6. Estimated number of anglers in two areas of Rattlesnake Creek during weekdays and weekend days, 1985 and 1986.

peaked in mid-summer. In 1985, July was the highest angler use month (128) followed by August (78), June (77), May (70), September (53), and April (50). In 1986, estimated angler use was highest in August (110) followed by July (88), June (59), May (38), September (22), and April (11). Most anglers used flies (78%); the remainder (22%) used lures. Angler residency was not determined due to insufficient data.

Catch and Catch Composition

Cutthroat trout made up the greatest proportion of the anglers' catch. During the 12 month census period, 879 (92%) cutthroat, 83 (5%) brook, and 29 (3%) bull trout were reported caught and released. Compared to 1985 and 1986 estimated species abundance (Figure 3), cutthroat trout (> 100 mm) were caught in higher proportions than their relative abundance (79.5%).

The total estimated cutthroat trout catch declined from 3,577 in 1985 to 2,042 in 1986, paralleling the decrease in angler use (Table 9). The catchable (> 100 mm) cutthroat population in areas open to fishing (sections III and IV) showed no increasing or decreasing trend between summer 1985 and 1986 (Table 7). Total brook and bull trout catch could not be estimated because of small sample size.

Recapture Rates

Tag return data indicate that even with relatively low fishing pressure, 22% of the cutthroat trout marked were recaptured (Table 10). Recapture rate increased with size of fish. Cutthroat trout over

Table 10. Number and size distribution of cutthroat trout marked and recaptured by angling in 1985 and 1986.

Size	# Marked	# Recapt. (%)	# Recapt. 3+ times	Max. # recapt. per fish/yr.
100-200	458	38 (8)	1	3
200-300	396	93 (24)	19	4
300-400	159	77 (48)	25	5
400+	31	21 (68)	11	12
Total	1044	229 (22)		

400 mm had the highest recapture rate (68%) and the greatest incidence of recapture for a single trout (12 times in 12 months). Only 8% of the 100-200 mm cutthroat trout were recaptured and the maximum recapture rate was three times in 12 months.

Movement

Based on trapping and angler recapture, cutthroat trout movements were small and direction of movement was variable. Of 1,044 cutthroat trout tagged, 21% (N=222) were reported caught. Twelve percent (N=26) of these fish had moved out of the section where they were tagged. Nine cutthroat trout moved upstream and 17 moved downstream (Table 11); direction of movement was not significantly different (p=0.17). Downstream movement was significant for cutthroat trout < 300 mm (p=.016) but additional trapping data suggest this is not a widespread trend. Only 3% (N=7) of the recaptured trout moved more than 1.6 km; six of the seven were less than 300 mm total length. Bull and brook trout movement could not be determined from tag return data.

Fifty-six cutthroat, 28 brook, and 30 bull trout were captured in traps above and below section II between July 21 and October 3, 1986 (Table 12). Mean total lengths for cutthroat, brook, and bull trout were 167.9, 135.5, and 364.0 mm, respectively. Sixty-five trout movedupstream and 49 moved downstream, but direction of movement was not significantly different (p=0.16). Twenty-seven cutthroat < 300 mm moved upstream and 24 moved downstream; directional movement

Table 11. Movement of cutthroat trout based on tag returns, 1985 and 1986. Only movement out of section tagged is recorded.

Size (mm)	Number marked	Number recaptured	Number moved	Direction moved up	Direction moved down
100-200	458	38	3	0	3
200-300	396	93	11	2	9
300-400	159	70	6	4	2
400+	31	21	6	3	3
Total	1044	222	26	9	17

Table 12. Number, size, and direction of travel of trout trapped in Rattlesnake Creek, 1986.

Species	Number	Average length	< 300 mm (%)	Movement direction up	Movement direction down
Ct	56	167.9	51 (91)	32	24
Brook	28	135.5	28 (100)	17	11
Bull	30	364.0	10 (33)	16	14
Total	114			65	49

for the smaller cutthroat trout was also not significant ($p=0.78$) (Table 13). Most cutthroat and all brook trout trapped were < 300 mm total length (Figure 7). However, only 33% of the bull trout trapped were < 300 mm (Figure 7). Much of the bull trout movement was associated with spawning; at least 38% were spawning adults.

Overall, 74 trout (all species) were documented moving upstream and 66 downstream (Tables 11 & 12). Trout showed no significant preference for direction of movement ($X^2=0.35$, $p=0.55$). The largest recorded movement was 16.9 km downstream.

Habitat

Habitat Characteristics

Habitat criteria were measured in September 1986 (Table 14). Mean gradient for the four study sections on Rattlesnake Creek was 1.77%. Sections I and IV had gradients of 1.6% and 1.5% and sections II and III, both with long riffle areas, had a 2.0% gradient. Stream width (average 10.9 m) and depth (average 0.32 m) were similar between sections.

Substrate composition varied little between sections (Table 14). Overall, substrate composition consisted of 2.5% fines, 16% gravel, 55.5% rubble, and 26% boulders. Good spawning gravel was available throughout the Rattlesnake Creek drainage.

Pool-riffle ratio in study sections was 33:67. Forty-six percent of all pools in Rattlesnake Creek were class 4 or 5. Section I had 77%

Table 13. Directional movement, by size class, of cutthroat trout trapped in Rattlesnake Creek, July 21-October 3, 1986.

Size (mm)	Number Moved	Upstream	Downstream
100-200	41	25	16
200-300	10	2	8
300-400	5	5	0
400+	0	0	0
Total	56	32	24

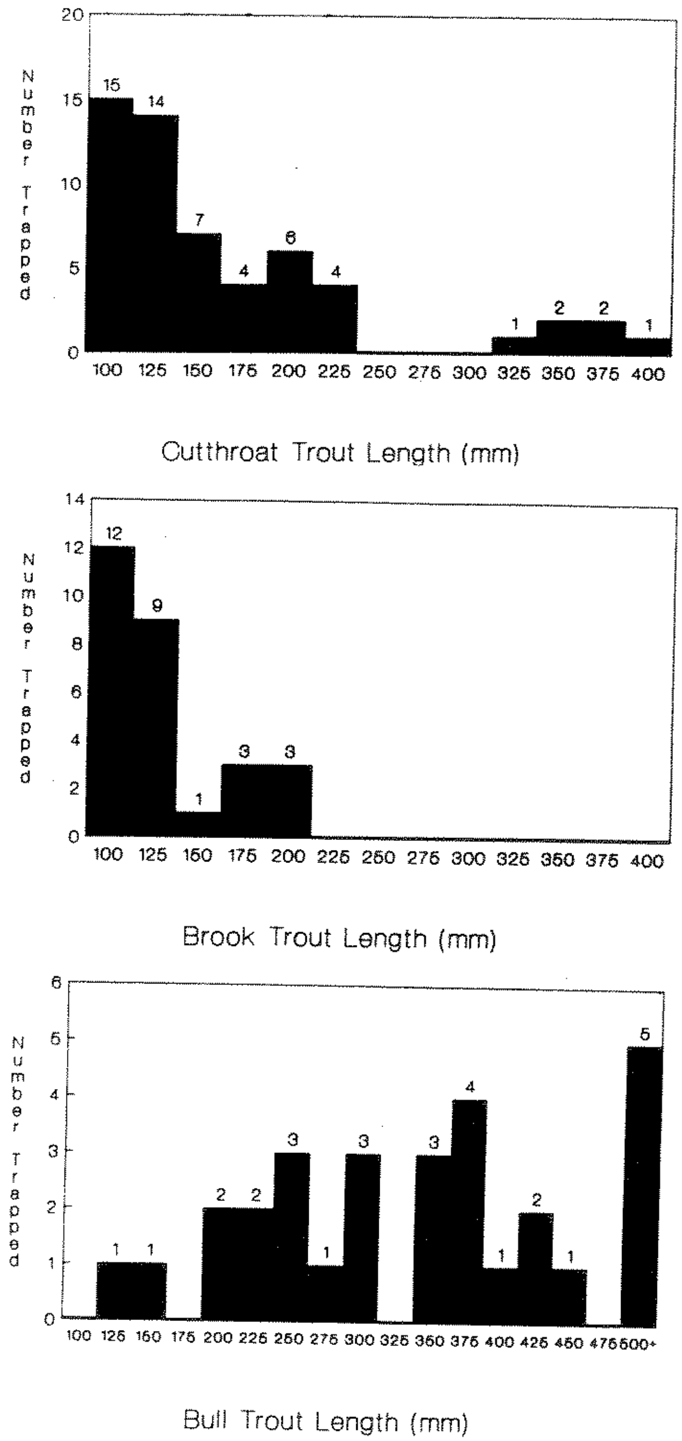


Figure 7. Length frequencies of cutthroat, brook, and bull trout trapped in Rattlesnake Creek between July 21 and October 3, 1986.

Table 14. Habitat data collected on Rattlesnake Creek, September, 1986.

Type	Section I	Section II	Section III	Section IV
% pools	40	37	35	20
% riffle	60	63	65	80
Pool class %				
I	11	32	7	12
II	12	23	23	28
III	30	3	19	14
IV	13	10	28	22
V	34	32	23	24
Substrate %				
Boulder	29	28	29	18
Rubble	48	65	57	52
Gravel	21	6	12	25
Fines	2	1	2	05
% bank & instream cover	32	?	27	15
Average width (m)	11	11	10	12
Average depth (m)	0.34	0.24	0.31	0.37
Average gradient (%)	1.6	2.0	2.0	1.5
Banks				
Excellent	97	96	98	97
Good	3	4	1	2
Fair	0	0	1	1
Poor	0	0	0	0
Elevation (m)	1187	1219	1225	1398

high class pools (3+) compared to 45% in section II. Instream and bank cover was available on approximately 25% of the stream.

Temperature and Discharge

Water temperatures in Rattlesnake Creek, 1985-86, ranged from 16.7°C to -2.2°C. Temperatures below 0°C may be in error. Monthly water temperature during the study ranged from 0°C to 11.4°C (Figure 8) compared to 1958-65 minimum and maximum temperatures of 16.7°C and 0°C (Aagaard 1969).

Stream discharge measured in 1985 and 1986 ranged from 10.2 cfs to 113 cfs (Figure 8). High water discharge could not be measured with available equipment. Flows in 1985 and 1986 varied (Figure 8). In 1985, summer flows were lower than in 1986, however, late season rains in 1985 increased fall discharge (Figure 8).

Habitat Use and Behavior

From spring 1985 to winter 1987, 27 snorkel counts of trout in Rattlesnake Creek were made. Several additional snorkel observations were made throughout the year. Most habitat use and behavior data collected during snorkeling were qualitative.

Spring 1985-Day

Few fish were catchable in the spring. Only fourteen cutthroat and one bull trout were marked in sections I and II between March 26 and April 8, 1985 (Table 15). All fish were longer than 300 mm total length. A snorkel recapture run was performed on April 9, 1985.

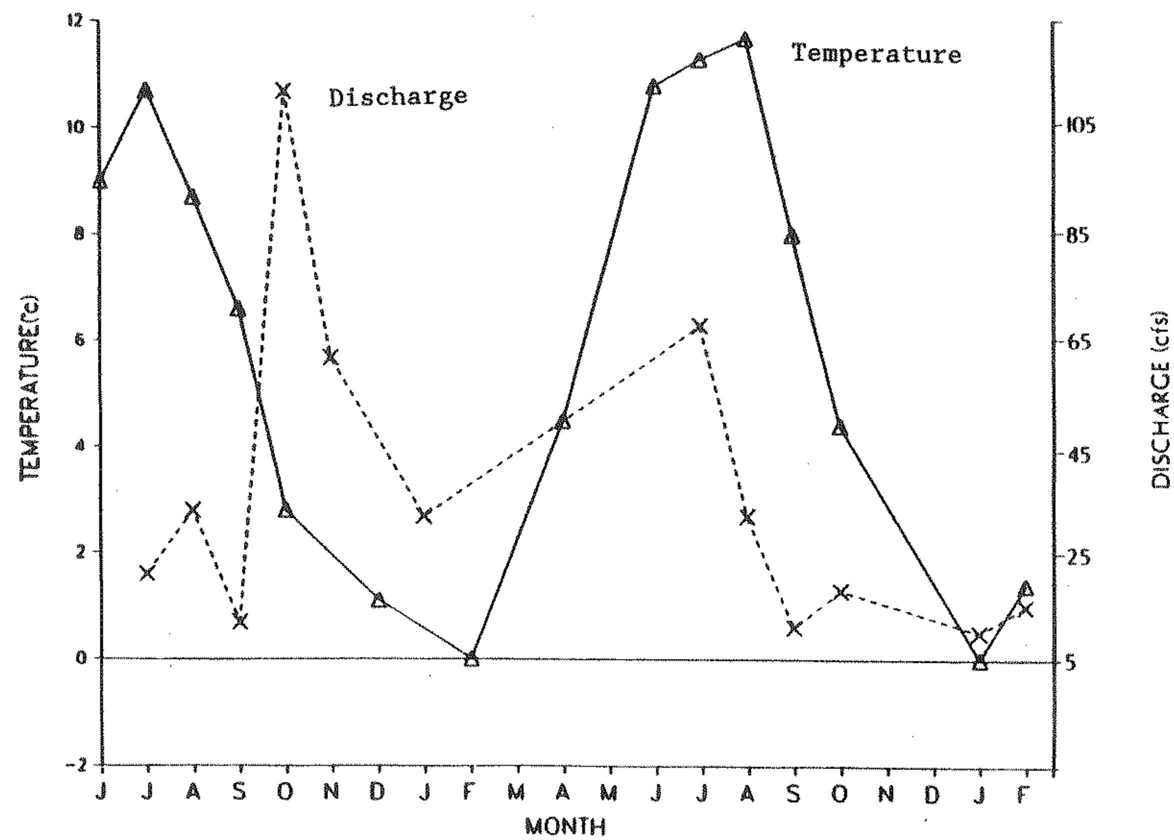


Figure 8. Stream discharge and mean temperatures taken on Rattlesnake Creek below Beeskove Creek from June 1985 through February 1987.

Table 15 . Number of cutthroat trout marked, captured, and recaptured in Sections I and II of Rattlesnake Creek, spring 1985.

Species	Size (mm)	Section I			Section II		
		M*	C	R	M	C	R
Cutthroat	100-200	0	0	0	0	0	0
	200-300	0	1	0	0	0	0
	300-400	8	22	4	3	6	2
	400+	2	2	2	1	0	0
	Total	10	25	6	4	6	2
Bull	400+	1	1	1	0	1	0

* M=marked C=captured R=recaptured

Water temperature was 4.4°C. Few cutthroat were observed in section I (N=25) or section II (N=6) (Table 15). All cutthroat trout, except one, were larger than 300 mm and all bull trout (N=2) were larger than 400 mm (Table 15).

Trout mainly occupied pools and runs, exhibited neutral rheotaxis (moved in all directions relative to the current), and moved in a "milling" fashion. Large trout generally ignored the diver and no fish were observed feeding. During marking runs, however, trout sluggishly took both dry and wet flies. Hierarchical or territorial social structures were not observed.

Summer 1985 - Day

Summer snorkeling was conducted from June 4 through August 25. Water temperatures ranged from 7.8 to 16.7°C. In the four study sections, 649 cutthroat trout were observed. Eighty-eight percent of the cutthroat were < 300 mm total length (Tables 26-29, Appendix A) and 51% of these were observed in section I. The shift from a dominance of large adult cutthroat trout in spring to smaller cutthroat in summer occurred sometime during high water.

Between June 4 and July 2 adult trout aggregated at the tail portion of high class pools (4 and 5) and in runs where spawning gravel was available. Aggressive behavior associated with spawning was observed. By mid-July, flows in Rattlesnake Creek dropped to 13.8 cfs. Adult cutthroat trout moved out of low velocity pools runs into riffle areas. Trout activity during this period appeared to be associated with feeding.

Small-sized cutthroat trout (< 300 mm) occupied pocketwater within riffle areas throughout the summer. They were observed immediately downstream of boulders, debris, or in other regions of reduced current. Small trout usually positioned themselves downstream from larger trout indicating a hierarchical, size-related social structure.

Active drift and surface feeding was exhibited by all cutthroat trout observed. Individuals maintained relatively stationary position close to the bottom and adjacent to fast currents, moving both laterally and upward to feed and returning to their original position. Some trout were observed feeding on 2-3 food items during the time of observation (approximately 1-3 minutes). Positive rheotaxis was observed during this period. Cutthroat trout were commonly observed in open, unshaded areas several meters from debris or bank cover. Areas with moss-covered substrate (*Fontinalis* spp) were avoided by cutthroat but not by brook trout.

Summer 1986 - Day and Night

Daytime habitat selection and behavior patterns observed during summer 1986 were similar to those described for summer 1985. On July 28, a nighttime snorkel count was performed in section I. Nighttime abundance (94) was similar to daytime abundance (98) (Table 30, Appendix A). Size distribution of cutthroat trout showed little variation from day to night. Several of the same locations occupied during the day were used at night by the same or similar-sized cutthroat trout.

Fall 1985 - Day

A gradual decline in numbers of cutthroat trout < 200 mm was observed in sections I, II, and III between September 10 and September 21, 1985 (marking runs). During this period minimum temperatures dropped from 6.7° to 1.1° C. Water temperatures, during snorkel counts, ranged form 2.2 ° C to 5.0 ° C. Fall counts of cutthroat trout < 300 mm were significantly lower (X^2=335, $p<0.05$) than summer counts (Figures 9-11). Only three cutthroat trout <200 mm were observed in the three sections snorkeled in fall 1985 (Figure 8). Numbers of trout 300-400 mm fluctuated irregularly while those > 400 mm remained virtually unchanged (Figures 10 & 11).

A daytime snorkel count was conducted in section IV on October 29, 1985. Water temperature was 2.8° C. Trout in section IV were smaller than trout in the other sections; only 5% were > 300 mm. Numbers of 100-200 mm trout observed decreased slightly from 80 (summer) to 74 (fall) (Figure 11). Contrary to observations in the lower three sections, densities of 200-300 mm cutthroat trout increased from 80 (summer) to 147 in fall. Transitions in trout habitat selection took place between August 4, 1985 (summer snorkel) and mid-September (fall marking period). Temperatures during the period dropped from an average of 7.8°C (low=6.1°C) to 4.6°C (low 1.1°C). Aggregation and a decrease in feeding activity were noted. By October 17, 1985, trout were concentrated in pools. Several species and size classes of trout occupied the same pools with no

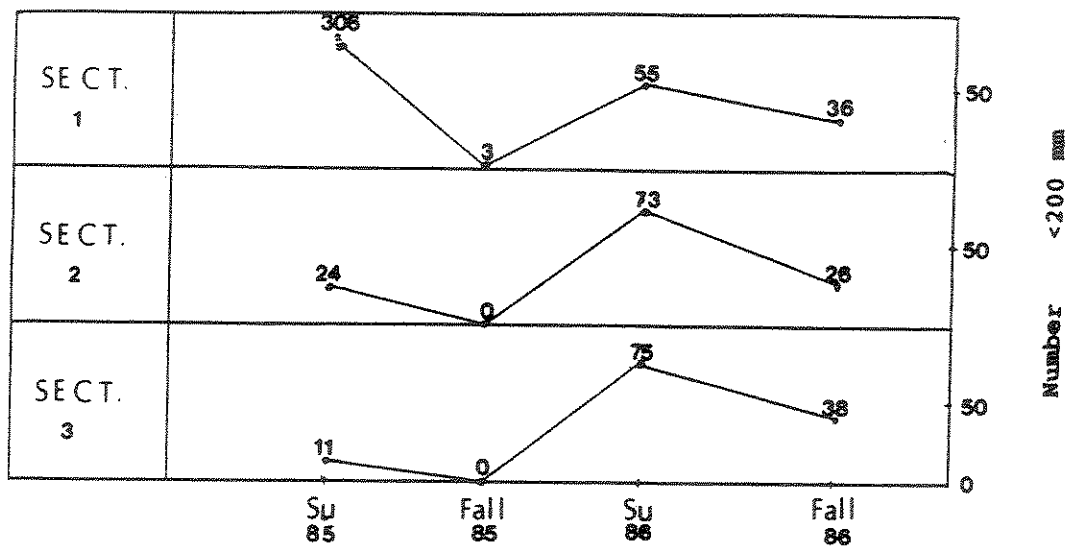


Figure 9. Number of cutthroat trout <200 mm total length counted in sections I-III during the day in Rattlesnake Creek, summer and fall 1985 and 1986.

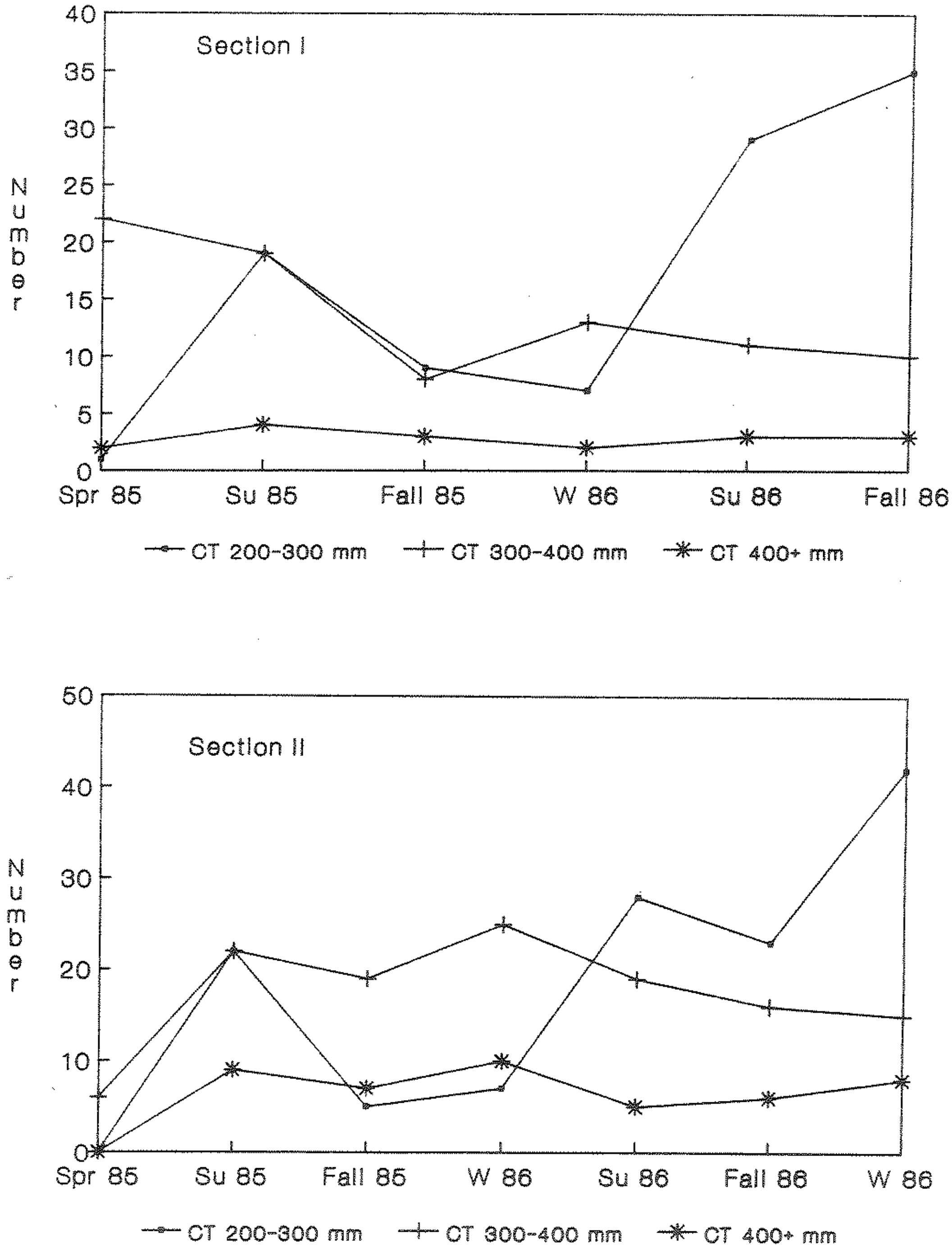
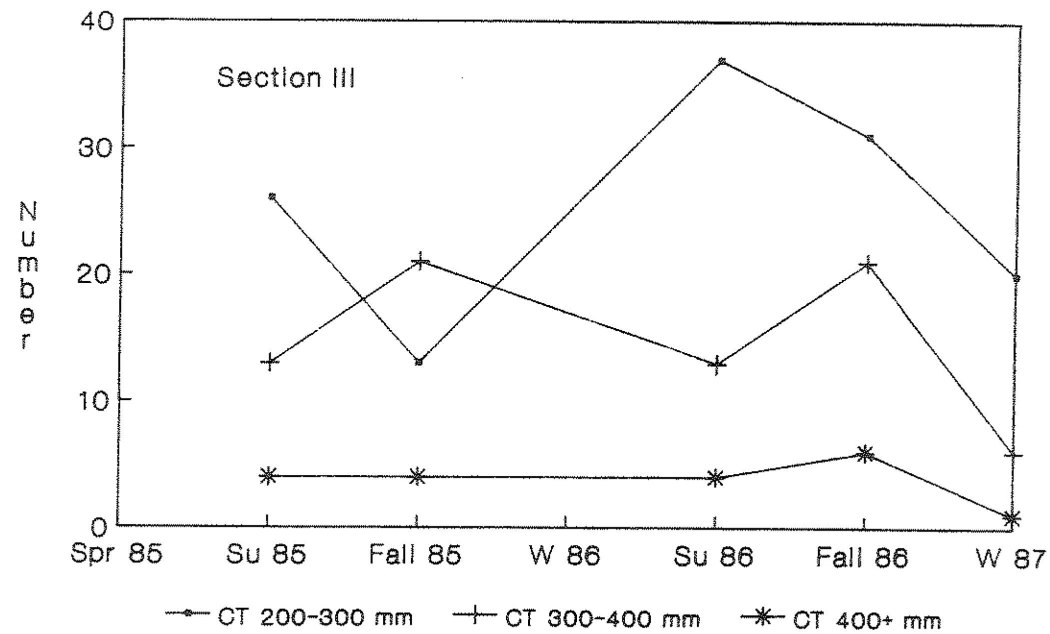


Figure 10. Number of cutthroat trout > 200 mm total length counted seasonally during the day in sections I and II of Rattlesnake Creek, 1985 and 1986.



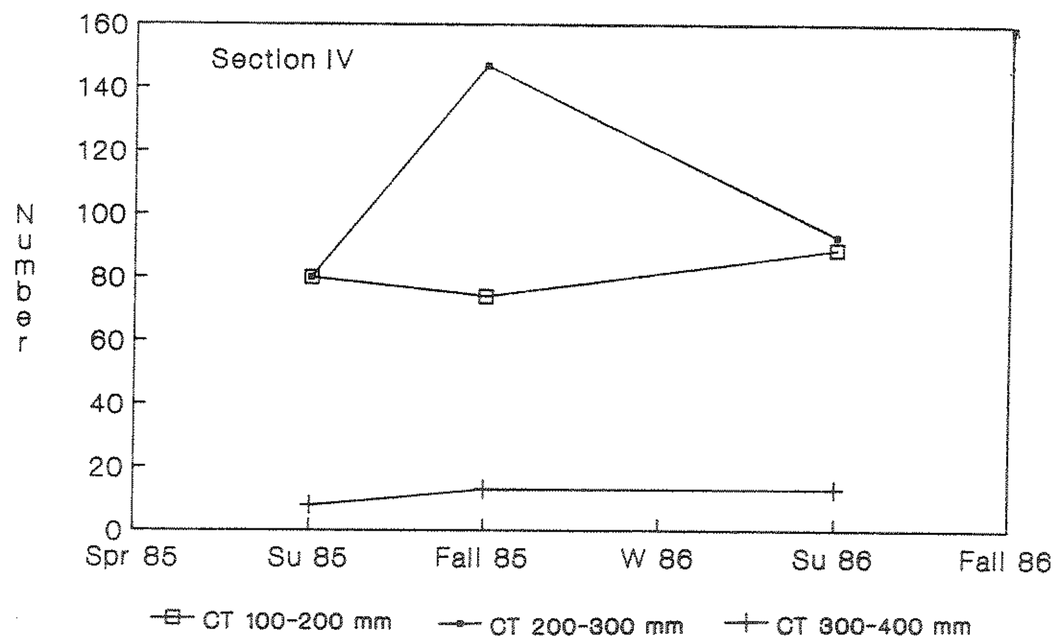


Figure 11. Number of cutthroat trout > 100 mm total length counted seasonally during the day in sections III and IV of Rattlesnake Creek, 1985 and 1986.

observed aggressive interactions.

Fall 1986 - Day and Night

In fall 1986, daytime snorkel counts were made in sections I, II, and III. Nighttime counts were made in sections II and III. Point measurements of water temperatures ranged from 4.2° to 5.0°C (Table 16). Minimum water temperature, measured with the thermograph, was 1.4°C in 1985 compared to 2.8 °C in 1986. Stream discharge was substantially different between years (Figure 8).

Cutthroat trout aggregated in pools during fall 1986 but daytime numbers of small trout did not decrease as dramatically as observed in 1985 (Figure 9, Table 16). Although decreases were not as pronounced as in 1985, 1986 summer and fall counts were significantly different (X^2=55.2, $p<0.05$). Day and night counts varied but without consistent trends (Table 16).

Winter 1985-86 - Day and Night

Three patterns of ice formation were observed in the lower three study sections. In section I, anchor ice formed in riffles while shelf ice formed on pools. Some shelf ice formed in section II, however this section appeared to be influenced by groundwater input and generally remained ice free. The surface of section III froze and snow accumulated on the ice.

One nighttime and four daytime snorkel counts were performed during winter 1985-86. Thick mats of aquatic vegetation were more

Table 16. Comparison of cutthroat trout abundance during fall 1985 and 1986 snorkel counts in sections I, II, and III of Rattlesnake Creek. Water temperatures shown in parentheses.

Size (mm)	Section I 1985 day (5°C)	Section I 1986 day (4.2°C)	Section II 1985 day (2°C)	Section II 1986 day/night (5°C) -	Section III 1985 day (4°C)	Section III 1986 day/night (5°C) -
100-200	3	36	0	26/62	0	38/27
200-300	9	35	5	23/14	13	31/25
300-400	8	10	19	16/15	21	21/12
400+	3	3	7	6/1	4	6/3
Total	23	84	31	71/92	38	96/67

abundant in winter than in spring or summer.

On December 9, 1985, section I was snorkeled between 2:00 and 4:00 pm. Skies were clear and shelf ice extended out from banks. Air and water temperatures were not recorded. Twenty-seven cutthroat, 16 brook and 6 bull trout were counted (Table 17). Numbers of cutthroat trout < 300 mm remained low, similar to fall (Table 17).

In December, daytime abundance of cutthroat, brook and bull trout was highest in pools (Table 18), with as many as 17 in one pool. Three trout (Ct 100-200, Ct 300-400, and bull 300-400 mm) were observed adjacent to a run in shallow water. Two of the three were resting on the substrate. All three sought cover when disturbed. Trout sought cover under shelf ice, in debris, or in submerged leaf piles and were generally more easily disturbed in winter than in summer.

On February 11, 1986, another winter daytime count was performed in section I from 12:00 to 2:00 pm. Skies were clear and air and water temperatures were -7.2°C and 0°C, respectively. Anchor ice was present in riffle areas, shelf ice extended out from logs, boulders and banks, and frazil ice was suspended in the water column. Forty-six cutthroat, 14 brook and 6 bull trout were observed (Table 17). Comparisons with total numbers of cutthroat trout counted on December 9th shows an increase from 27 to 46 (Table 17). The increase occurred primarily in the < 300 mm size classes.

In February 1986, trout were congregated in pools (Table 18) with

Table 17. Summer (su) 1985, fall 1985, and winter (w) 1985-86 daytime cutthroat trout counts and winter 1985-86 brook and bull trout counts in Section I of Rattlesnake Creek.

Size (mm)	Cutthroat				Brook		Bull	
	Su [1]	Fall [2]	W [3]	W [4]	W [3]	W [4]	W [3]	W [4]
100-200	306	3	5	16	10	13	0	1
200-300	19	9	6	16	6	1	0	2
300-400	19	8	14	10	0	0	1	0
400+	4	3	2	4	0	0	5	3
Total	348	23	27	46	16	14	6	6

1 = 8/4/85
2 = 10/29/85
3 = 12/9/85
4 = 2/11/86

Table 18. Number of cutthroat, brook and bull trout counted, by habitat type, in Rattlesnake Creek, 1985 and 1986.

Date	Section	Pool	Run	Riffle
12/9/85	I	34	12	3
12/11/85	II	40	33	5
2/10/86	II	48	13	3
2/10/86 Night	II	74	26	12
2/11/86	I	62	16	15
1/9/87	II	78	31	4
1/9/87 Night	II	73	28	10
Total		409	159	52

as many as 36 in a single pool. All trout in riffle areas were < 200 mm except one which was 200-300 mm. Several trout used shelf ice for cover; none were observed in areas with anchor ice.

On December 11, 1985, section II was snorkeled during mid-day. Skies were partially cloudy but visibility was good. Frazil ice was present and shelf ice extended out from banks, boulders, and logs. Air and water temperatures were -12°C and 1°C, respectively. Fifty-eight cutthroat, 4 brook and 16 bull trout were observed (Table 19). Although the numbers of cutthroat < 200 mm increased over fall , the winter count of cutthroat < 300 mm (N=24) was almost half the summer count (N=46).

Again, most trout were observed in pools and runs (Table 18). Trout per pool ranged from 2 to 17. Larger, higher quality pools generally contained more trout. One exceptionally high quality run (long with abundant cover and possible influences from groundwater recharge) contained 32 trout. Five trout were observed in pocketwater within a long riffle area. One of the five was a 100-200 mm bull trout that was wedged between two cobbles (in the substrate) with only the tail visible. The bull trout did not flee from the diver until touched. Two other bull trout were observed resting on the substrate. All other trout were easily disturbed. Sculpins were noted and a very large bull trout (estimated 700 mm) was observed. On February 10, 1986, Section II was snorkled between 1:15 and 3:20 pm. Skies were 80% overcast. Lighting was good. Shelf ice was present around a few boulders. Thick mats of moss were observed

Table 19. Summer (su), fall (f), and winter (w) day and night cutthroat counts for section II of Rattlesnake Creek, 1985. Also includes February 10, 1986 daytime (W) and nighttime (N) counts for brook and bull trout.

Size (mm)	Cutthroat				Brook		Bull	
	Su[1]	F[2]	W[3]	W/N[4]	W[3]	W/N[4]	W[3]	W/N[4]
100-200	24	0	17	16/35	4	2/3	2	6/3
200-300	22	5	7	9/18	0	1/2	4	4/6
300-400	22	19	25	17/24	0	0/0	3	3/6
400+	9	7	9	4/11	0	0/0	7	2/2
Total	77	31	58	46/88	4	3/5	16	15/17

1 = 7/10/85
2 = 10/17/85
3 = 12/11/85
4 = 2/10/86

throughout the section. Air and water temperatures were -1.1°C and 1.7°C, respectively. Forty-six cutthroat, 3 brook and 15 bull trout were observed (Table 19). Trout numbers were similar to those counted in the same section on December 11, 1985 (Table 27, Appendix A).

Seventy-five percent of the trout were in pools (Table 18) and each pool contained 4-13 trout. Trout in the riffle areas were 100-200 mm total length. One trout was observed resting on the substrate under moss. All other trout were alert. Two fish had fresh gash marks near their tail. Bull trout occupied positions closer to the substrate than cutthroat trout and inhabited high class pools with abundant cover. A single cutthroat trout was observed feeding.

A night dive was performed in section II on February 10, 1986 beginning at 7:30 pm. The moon was not visible. Air temperature was -6.7°C; water temperature was 0.6°C. Two bull trout were attracted by the light while all other trout appeared unaffected.

Eighty-eight cutthroat, 5 brook and 17 bull trout > 100 mm total length were observed (Table 19). Numbers of cutthroat trout counted at night were almost double daytime winter counts (Table 19). Increases were noticeable in all size classes (Table 19). Winter nighttime counts of 100-300 mm cutthroat trout (N=53) more closely approximated summer daytime counts (N=46) than winter daytime counts (N=24 & 25).

As during the day, most trout were observed in pools at night during winter 1985-86 (Table 18). Trout in riffle areas were of all size classes. One cutthroat trout (100-200 mm) was observed resting on the substrate.

Winter 1986-87 - Day and Night

Winter daylight dives were performed on January 9 (section II), and February 22 (section III). A winter night dive was performed on January 9, 1987. Air and water temperatures recorded in 1986-87 were similar to 1985-86 (Air range=-15 to -1.1°C; water range= -1.1 to 2.2°C). Average air temperatures for the entire winter (November - February) were 1.8°C warmer in 1986-87 (personal communications National Weather Service, Great Falls, MT).

The January 9, 1987 daytime snorkel count was performed in section II from 1:30 to 3:40 pm. Air and water temperatures were -15.0 and 0°C, respectively. Visibility was excellent and shelf ice was present. Cutthroat trout numbers were less variable in 1986-87 than in 1985 during winter (Table 20). Ninety-seven cutthroat were counted during 1986 winter days, compared to 125 during summer days and 71 during fall days (Table 20). Numbers of trout < 300 mm (N=74) were intermediate between summer (N=101) and fall (N=49) 1986 numbers.

A nighttime snorkel count was also performed in Section II. Air and water temperature were -13.3 and -1.1°C, respectively, and the moon was 3/4 full. The nighttime count (N=84) was similar to the daytime count (N=97) (Table 19). Diel variation was not as evident as in 1985-86. Still, fewer trout were seen in winter than in summer.

Table 20. Number of three species of trout observed in section II of Rattlesnake Creek, January 9, 1987 during day (W) and night (N) compared to summer (S), fall (F) and winter (W) 1985-86.

Size (mm)	Cutthroat 1985 S^1	W^2	1986 W^3	S^4	F^5	1987 W/N^6	Brook 1987 W^6	Bull W^6
100-200	24	17	16	73	26	32/44	4	1
200-300	22	7	9	28	23	42/20	8	3
300-400	22	25	17	19	16	15/18	0	2
400+	9	9	4	5	6	8/2	0	5
Total	77	58	46	125	71	97/84	12	11

1 = 7/10/85
2 = 12/11/85
3 = 2/10/86
4 = 7/12/86
5 = 11/1/86
6 = 1/9/87

Section III, which froze over completely in 1985-86, was partially open on February 22, 1987. Trout in each of the five pools snorkeled were physically confined due to heavy icing in riffle sections. Fifty-seven cutthroat trout were counted (Table 21). This compares to entire section counts of 54 and 129 in summer and 38 and 96 in fall. In Section III, numbers of trout per pool were similar to section II which generally remained ice free.

Although difference in seasonal and diel abundance were less evident in 1986-87 than in 1985-86, behavior was similar between years. Trout aggregated in high class pools and runs (up to 34/pool). Aggressive behavior was not observed. Cutthroat trout used shelf ice for cover. In one instance, 15 cutthroat trout < 300 mm were observed crowded under an area of shelf ice. The ice was intentionally broken and that night no cutthroat trout were observed in the area. The section was not snorkeled the next day. Debris cover and submerged leaf piles were used frequently when ice was not available. Five trout were seen resting on the bottom and several trout (at least 8) faced downstream. Behavior observed in 1987 which was not consistent with other years included no trout observed in the substrate, none feeding, and trout being less active and alert on January 9th.

Table 21. Summer (su) 1985 and 1986, fall 1985 and 1986, and winter (w) 1986-87 daytime cutthroat trout counts in Section III of Rattlesnake Creek.

Size	Su[1]	Fall[2]	Su[3]	Fall[4]	Night[5]	W[6]
100-200	11	0	75	38	27	30
200-300	26	13	37	31	25	20
300-400	13	21	13	21	12	6
400+	4	4	4	6	3	1
Total	54	38	129	96	67	57

1 = 6/20/85
2 = 10/18/85
3 = 7/13/86
4 = 10/29/86
5 = 10/31/86
6 = 2/22/87

DISCUSSION

Population Characteristics

Species Composition

Based on snorkel counts, species composition in Rattlesnake Creek was 83% cutthroat, 10% bull and 7% brook trout. Brook trout were the only exotic trout species found in Rattlesnake Creek. They were not present in or above section IV. Whitefish, although probably native to the lower reaches of Rattlesnake Creek, were also not present in the study sections.

Local residents believe species relative abundance may have changed during the past 50 years. According to three long-time residents from the Rattlesnake Creek area, cutthroat trout were the dominant species in the early 1920's. In the 1930's, access and fishing pressure increased. One fisherman admitted to taking 100+ fish at regular intervals. Heavy fishing pressure continued from the mid-1920's until it was prohibited in 1937. By the late 1930's, brook trout composition had increased to approximately 35-40% of the catch (personal communication, Forest Poe, Ed Ray, and Ray Nelson). After Rattlesnake Creek was closed to fishing, cutthroat trout densities increased and brook trout densities decreased. Cutthroat trout are again the dominant species and brook trout have been present for the last 50+ years. This suggests that in the absence of fishing pressure and the presence of adequate habitat, cutthroat trout may be able to outcompete brook trout.

Competition between native and introduced salmonids is often listed as a reason for the decline of native species; however, experimental tests of interspecific competition between natives and exotics have not been rigorous (Fausch 1988). There are few detailed accounts and descriptions of instances where brook trout have outcompeted cutthroat trout (Liknes 1984). Griffith (1988) suggests that brook trout replace cutthroat where the latter have been eliminated. In the laboratory and in a small stream in northern Idaho, equal-sized brook trout did not effectively displace cutthroat trout (Griffith 1972). In the same study, brook trout initiated 40% fewer aggressive encounters than cutthroat trout. In a lake setting, Magnan (1988) showed that the presence of other fish species had a negative impact on brook trout populations.

The greater comparative size of cutthroat trout in Rattlesnake Creek may partially explain why they are currently dominant over brook trout. Size was the primary factor in determining the winner of antagonistic encounters between wild cutthroat and hatchery rainbow (Petrosky and Bjornn 1988) and between brook trout and brown trout (Fausch and White 1981). In Rattlesnake Creek, average cutthroat trout length is 61 mm greater than brook trout.

Greater fitness and adaptive behavior of native cutthroat trout may also contribute to their dominance in Rattlesnake Creek. Early studies of native versus introduced trout stocks showed that native trout had a competitive advantage over introduced species due to greater fitness and adaptive behavior (Needham and Slater 1944; Miller 1954, 1958; Reimers 1957; in Petrosky and Bjornn 1988). Rattlesnake Creek appeared to provide optimal cutthroat trout habitat which may increase their competitive advantage.

Shifts in species composition between cutthroat and brook trout are often attributed to the presence or absence of angling. Differences in angling vulnerability of brook and cutthroat trout has been shown by MacPhee (1966) and Griffith (1972). MacPhee (1966) found that cutthroat trout were twice as easy to catch as brook trout. Moyle and Vondracek (1985) state that once cutthroat trout are replaced by another salmonid species, they are unlikely to regain that space. In cases of continuing habitat degradation, introgression, and over-exploitation this may hold true. However, there is some observational evidence in Rattlesnake Creek that cutthroat trout declines may have been reversed.

Westslope cutthroat trout in Rattlesnake Creek were hybridized with rainbow and Yellowstone cutthroat trout. Genetic results from the 1985 High Falls Creek specimen were 96% westslope cutthroat, 4% rainbow and 2% Yellowstone cutthroat trout, while the 1986 Pilcher Creek sample had a genetic make-up of 80% westslope cutthroat and 20% rainbow trout. Yellowstone cutthroat trout have been stocked in some of the high mountain lakes in the upper drainage and rainbow trout were probably planted or they may have migrated upstream from the Clark Fork River (before the dam was built). Cutthroat trout size in the lower sections may be influenced by their genetic make-up.

Trout Size and Abundance

Trout size varied between fished and unfished sections (Figures 12 and 13, Appendix B), but differences were more likely related to habitat rather than angling pressure. For example, trout were smallest in section IV (Table 4) which is higher in the drainage (Figure 1) where water temperatures are lower. If the small size of trout in section IV was due to fishing pressure, even smaller trout would have been expected in section III where angler pressure was greater (Figure 6). This was not the case. In addition, section II (unfished) and section III (fished) had similar-sized cutthroat trout.

Abundance of trout also varied between fished and unfished sections. However, these differences can not be attributed to fishing. Section IV (fished) contained larger numbers of cutthroat trout (1985=374, 1986=385) than the unfished section II (1985=153, 1986=276) (Tables 27, 29, 31, and 33, Appendix A).

One year of catch and release fishing, after a 45 year closure, did not reduce abundance or average size of cutthroat trout. The decrease in average length from 257 mm in 1985 to 226 mm in 1986 was probably due to increased emphasis on marking smaller trout. Population abundance fluctuated seasonally and annually but there were no consistent trends. A follow-up study would provide more information on long-term effects of catch and release fishing.

High numbers of resident trout, especially large trout, were found throughout Rattlesnake Creek. Average summer cutthroat trout numbers were 520/ kilometer with 11% over 300 mm. Average length of bull trout (241 mm) was also large for this size of stream. Resident bull trout up to 711 mm were captured during fall trapping. Numbers of bull trout per kilometer could not be calculated due to small sample size. Although present, brook trout were small (average length=175 mm) and generally occupied side channels and beaver ponds.

Comparable cutthroat and bull trout sizes are not found in similar, fished tributaries of Rock Creek or the Bitterroot, Clark Fork, and Flathead rivers (Peters 1988, Thomas 1984, Shepard et al. 1982). For example, Peters (1988) did not capture cutthroat trout larger than 305 mm in either Daly Creek or the West Fork of Rock Creek in 1985, 1986, and 1987. Similarly, Thomas (1984) found the maximum size of cutthroat trout to be 305 mm in 15 tributaries to the Clark Fork River. On nine tributaries to the Bitterroot River, no bull trout larger than 315 mm were captured (Peters 1987). The St. Joe and Coeur d'Alene River drainages in northern Idaho also support fewer numbers of large cutthroat even in streams with restrictive regulations (Thurow and Bjornn 1978, Lewynsky and Bjornn 1983). Thurow and Bjornn (1978) found that only 1% of the cutthroat trout were larger than 250 mm in Big and Marble Creeks (open to fishing) while in Quartz and Simmons Creeks (trophy-fish regulations), an average of 7% of the cutthroat trout were larger than 250 mm. In Yellowstone Park, only larger drainages contain comparable sizes and numbers of cutthroat trout (Carty et al. 1986).

The large size of cutthroat and bull trout can probably be attributed to the lack of fishing pressure. In a study of an unexploited population of smallmouth bass (*Micropterus dolomieui*), the population had an unusually high percentage of large fish (Reed and Rabeni 1989). Changes in trout size have been documented with regulation changes. Large trout (>405 mm) increased from 1.9% to 9.1% of the population after a slot limit was implemented on the South Fork Snake River (Thurow et al. 1988). Similar increases have been documented in Yellowstone Park (Gresswell and Varley 1988) and the St. Joe River in Idaho (Thurow and Bjornn 1978). The Rattlesnake Creek study and others (MacPhee 1966, Parma and Deriso 1990) have shown that angling is size selective. Larger fish are often more vulnerable to angling pressure and therefore removed from the population first.

<u>Snorkel Method</u>

Population abundance and species composition were determined primarily by snorkeling. According to Griffith et al. (1983), the feasibility of using snorkeling as a data collection technique depends on compatible data needs, good water clarity, safety, and behavior of fish (observability). Our data needs were compatible, water clarity in Rattlesnake Creek was good, flows were generally low enough to snorkel safely, and observability was good except for with brook and bull trout. Since the emphasis of this study was on cutthroat trout, observability of brook and bull trout was not a major factor. Additional reasons for selecting the snorkel method in Rattlesnake Creek were the low water conductivity and corresponding inefficiency of electrofishing. The snorkel method has proven successful over a wide range of stream sizes (Northcote and Wilkie 1963, Schill and Griffith 1984, Slaney and Martin 1987, Zubik and Fraley 1988, Hankin and Reeves 1988), but Hankin and Reeves (1988) found snorkel counts were most accurate in small streams similar to Rattlesnake Creek.

To increase accuracy of the snorkel method, Peterson mark-recapture estimates were calculated. Trout were marked by angling and "recaptured" by snorkel observation. Hook and line mark, followed by snorkel-recapture estimates (or snorkel-Peterson estimates) were determined to be the best of three underwater methods tested by Zubik and Fraley (1988). Possible sources of errors were reduced by marking approximately 20% of the trout population when possible (Vincent 1971) and by using four tag colors (one for each size class) to increase the accuracy of size estimation (Slaney and Martin 1987). An assumption of the Peterson method may have been violated. Immigration or emigration may have occurred between the mark and recapture runs. This assumption is often violated using other methods.

Disadvantages of the snorkel method include diver error and low observability of small cutthroat trout and all brook and bull trout (Millis and Pardue 1984, Slaney and Martin 1987, Shepard and

Graham 1983). Supplemental electrofishing runs were made to increase the accuracy of estimates in these groups. Diver error (double counts and failure to detect trout) was reduced by snorkeling only on days with good lighting and by moving slowly upstream in order to decrease chance of disturbing trout.

Angler Use and Catch

Even with the relatively low fishing pressure in Rattlesnake Creek, cutthroat trout were caught in higher proportions (92%) than their relative abundance (79.5%). Westslope cutthroat trout are opportunistic feeders and their lack of selectivity makes them extremely vulnerable to anglers.

Cutthroat trout vulnerability to angling has been well documented (Schill et al. 1986, MacPhee 1966). MacPhee found that cutthroat trout were about twice as easy to catch as brook trout. Schill et al. (1986) reported that cutthroat in Yellowstone Park were captured an average of 9.7 times in 108 days. Twenty-one percent of cutthroat tagged in Rattlesnake Creek were recaptured and one trout was caught 12 times in 12 months. Rainbow trout have been shown to be much less vulnerable. Riehle et al. (1989) reported that rainbow trout in a catch and release area were only caught three times during each angling season. The decline of westslope cutthroat trout is often attributed to over-exploitation (Likness and Graham 1988, Griffith 1988, Gresswell and Varley 1988).

Angling in Rattlesnake Creek was size selective. Cutthroat over

400 mm had the highest angling recapture rate (68%) while the 100-200 mm cutthroat recapture rate was only 8%. Gard and Seegrist (1972) reported that wild trout could support a substantial harvest over time and remain viable but the remaining population would not have many large trout. Other authors report a decrease in size with increased exploitation (Barnhart 1989, McDonald and Hershey 1989, Olson and Cunningham 1989). According to Parma and Deriso (1990), size-selective angling may alter phenotypic composition among survivors. Based on these findings, other western Montana streams may no longer be able to produce cutthroat trout as large as those in Rattlesnake Creek.

Good survival among caught and released cutthroat trout in Rattlesnake Creek was indicated by the high percent of recaptures and stable numbers of large cutthroat trout between 1985 and 1986. Schill et al. (1986) reported hooking mortality for cutthroat trout on the Yellowstone River to be less than 1%.

During this study, creel census data indicated that catch and release regulations on Rattlesnake Creek protected larger, older cutthroat trout and, within the short duration of the study, trout densities did not decrease. In 1985 and 1986, angling pressure was low and catch rates were high. In 1985, an estimated 457 anglers fished the stream during the 25-week census period compared to 254 in 1986. Catch rates increased from 3.0 cutthroat/hour in 1985 to 3.4 cutthroat/hour in 1986, which indicates that pressure in 1986 did not decrease due to a lack of angler success. Catch rates were varied in other studies but angling pressure was generally higher (Carty et al. 1986, Thurow and Bjornn 1978, Peters 1983, and Shepard et al. 1982). Catch rates were 0.9 trout/hour on the Yellowstone River with 36,600 angler days in 1985 (Carty et al. 1986). Catch rates were 1.3 cutthroat/hour on Big Creek, a tributary to the St. Joe River in Idaho, with 1015 anglers (Thurow and Bjornn 1978). On Rock Creek, catch rates for cutthroat, brown, brook, and rainbow trout were 1.2 trout/hour (Peters 1983). Of these studies, only the Flathead river system and tributaries had higher catch rates (9.6 cutthroat/hour) (Shepard et al. 1982).

Seasonal Movement Patterns

Based on trapping and angler recapture, cutthroat trout movements were small and direction of movement was variable. Only 11% of 222 recaptured fish moved out of the section where they were tagged. Nine of them moved upstream and 17 moved downstream. Only seven of the recaptured trout moved more than 1.6 km; six of the these were less than 300 mm total length. Brook and bull trout movements could not be determined from tag return data.

Traps were installed in Rattlesnake Creek in 1986 after recording a large number of cutthroat trout 100 to 200 mm total length (306 captured) moving through section I in August, 1985. Although the traps were set between July 21 and October 3, 1986, a similar movement pattern was not recorded. Forty-six cutthroat, 28 brook, and 30 bull trout were captured in traps above and below section II.

Most cutthroat and brook trout trapped were less than 300 mm total length.

Everest (1971) suggested that fry migration may be a function of crowding. As fish grow the amount of living space declines, and this crowding may initiate a downstream movement. The large numbers of 100-200 mm cutthroat trout I observed moving through section I may support the crowding hypothesis. Bachman (1984) found that hatchery trout were often excluded from access to territories by resident trout, suggesting that subordinate trout may generally tend to be displaced. Most cutthroat trout which moved in Rattlesnake Creek were < 300 mm. Jones et al. (1978) noted that peak migration in Hatchery Creek occurred during a hard rainstorm. Flows increased in Rattlesnake Creek in August, 1985 but not in 1986. Riley et al. 1992 postulated the existence of two components of stream fish populations: a large static and a small mobile component. Static trout establish territories and mobile trout presumably move when they are unable to compete for space. Based on the tag returns, trapping, and observations in Rattlesnake Creek, there is evidence for both a static and a mobile component.

Seasonal Habitat Utilization and Behavior

Summer

Habitat selection and behavior of cutthroat trout during daylight hours in early summer (June 1-23) was associated with spawning. Adult trout selected pools and runs where gravels were available.

Trout exhibited aggressive behavior and fed frequently.

Habitat selection and behavior during mid-summer (June 23 - September 15) appeared related to feeding. As pool and run habitats stagnated, adult trout moved into riffle areas. Campbell and Neuner (1985) found that in summer, rainbow trout were located adjacent to fast moving water where they could take advantage of incoming drift organisms. Trout in riffle areas generally were visually isolated from each other and aggressive behavior was infrequently observed. In Rattlesnake Creek cutthroat < 300 mm generally inhabited riffle areas throughout the summer. Trout < 100 mm usually occupied waters near the stream margins or in side channels where water velocities were low. In the summer, Hillman et al. (1987) observed 95% of age-0 chinook salmon in pool or glide habitat where velocities were also low.

Observations during one summer nighttime dive (July 28), indicate that cutthroat trout occupied the same habitat at night as during the day. Campbell and Neuner (1985) found that rainbow trout moved inshore to rest during summer nights. We did not observe this movement, although other factors (moonlight etc.) could have affected this behavior.

Fall

Trout aggregated in high class pools (4 or 5, Table 3) during autumn days when water temperatures dropped below 6.5 $^{\circ}$C. Campbell and Neuner (1985) reported similar behavior in rainbow trout. Cunjak and Power (1986) also observed brook trout aggregating in fall. Other behaviors (aggressiveness, feeding, placement in water column, etc.) were intermediary between summer and winter in Rattlesnake Creek.

Numbers of cutthroat trout < 300 mm decreased in fall 1985 in sections I, II, and III, but no similar decrease was observed in 1986. Higher mean water temperatures in 1986 may partially account for this difference. Everest et al. (1985) reported numbers of steelhead trout decreased during fall. Although Bjornn (1971) concluded that low temperatures induced fish to seek shelter in the substrate, in 1986, when water temperatures dropped to 0°C, cutthroat trout numbers in Rattlesnake Creek did not decrease. This suggests that water temperature was not the only factor influencing trout behavior. Other factors may have included lack of ice formation and shorter duration of subzero periods.

Fall night-time snorkel counts were not conducted in 1985. In 1986 day and night counts were similar. This contrasts with findings of Campbell and Neuner (1985) who reported that adults, juvenile, and fry emerged from the substrate during fall nights (8-3°C). Hillman et al. (1987) found that some of their marked juvenile chinook salmon moved to areas along undercut banks where dense growths of sedges and grasses offered cover. Substrate and other cover was available in Rattlesnake Creek in the fall but was not used until winter. During this study water temperatures during fall 1986 may have been too mild to induce this behavior.

Winter

Observations made in 1985-86 during five winter snorkel counts indicated that habitat use and behavior changed between summer and winter. In winter, trout aggregated in pools similar to fall and made less use of riffle areas. Chapman and Bjornn (1969) suggested that there were energy saving advantages for trout that occupied deeper, quieter water associated with cover in the winter. Although pools and runs were preferred in Rattlesnake Creek, some trout (N=52) were observed in riffle habitat during winter. Hillman et al. (1987) did not observe any juvenile chinook salmon in riffle habitat.

Trout observed in Rattlesnake Creek generally faced upstream, but it was not uncommon to see them "milling" in other directions. Several were closely associated with the bottom and a few were seen resting directly on the substrate. Rainbow trout have been observed resting on the streambed during winter nights (Campbell and Neuner 1985). Hierarchical size-related social structures and aggressive interactions were not observed in Rattlesnake Creek. Small trout (< 200 mm) were observed swimming adjacent to large trout (>350 mm) without any reaction from the larger fish. Aggressive interactions may represent an unprofitable energy expenditures in winter. Most trout were less approachable by the snorkeler in winter than in summer. Bustard and Narver (1975) found a pronounced fright reaction of coho salmon and steelhead trout to a snorkeler in winter. Other researchers have found that low water temperatures reduce fish swimming performance (Hartman 1963 and Brett et al. 1958). Swimming performance of cutthroat trout in Rattlesnake Creek did not appear to be affected during short fleeing bursts.

Winter cover in Rattlesnake Creek consisted of shelf ice, debris, submerged leaf piles, undercut banks, and occasionally aquatic vegetation. Hillman et al. (1987) found that 90% of juvenile salmon and steelhead trout used submerged sedge and grasses overhanging undercut banks. This type of habitat was not available in Rattlesnake Creek in winter although undercut banks were used. Campbell and Neuner (1985) observed fry using submerged leaf piles for cover in winter. Trout up to 150 mm total length used leaf piles for cover in Rattlesnake Creek. Trout observed during my study appeared to prefer overhead ice cover, but I did not collect quantifiable data to verify this observation. The MDFWP (1984) speculated that shelf ice may provide cover from predators, insulate against radiant heat loss, and prevent super cooling of the stream. Maciolek and Needham (1952) found that stream salmonids apparently did not seek substrate shelter in winter when ice cover was available. Areas with anchor ice were avoided.

Only one trout was observed feeding in Rattlesnake Creek during a winter day. Different feeding behavior in winter has been noted in other studies. Maciolek and Needham (1952) observed trout actively feeding during winter (0°C). Bustard and Narver (1985a) observed trout feeding when water temperatures were above 7°C, but steelhead trout and coho salmon varied between being active and inactive at temperatures between 4 and 7°C. No juvenile steelhead were observed feeding at low water temperatures in the Sarita River (Bustard and Narver (1985b).

Winter daytime cutthroat trout counts were always less than summer daytime counts. Winter numbers of cutthroat trout < 300 mm were less than half the numbers observed in summer. The presence of small cutthroat trout at night but not during the day may indicate that these trout hid in the substrate, under aquatic vegetation, or in debris dams. Similar behavior has been reported by Everest et al. (1985) and Chapman and Bjornn (1968).

In conclusion, the size and abundance of trout in Rattlesnake Creek was significantly larger than similar-sized streams. One year of catch and release angling had no measurable affect on the trout population, however, a follow-up study would provide information on the long-term effects of angling. A 68% recapture rate of cutthroat trout < 400 mm indicates the high vulnerability to angling especially compared to smaller size classes and other species. Abundance of cutthroat varied considerably between seasons and diel shifts were noted in the winter.

Seasonal and diel shifts in habitat use have widespread implications in management. High quality pools, cover, and adequate flows are important habitat criteria for winter survival. In Montana, stream carrying capacity may be set by the amount of winter habitat available.

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APPENDICES

APPENDIX A

TABLES

Table 22. Rattlesnake Creek water analysis, 10/28/85 and 12/16/86. Data from Mountain Water Company, Missoula.

Constituent	1985 (mg/L)	1986 (mg/L)
Potassium	<1	<1
Sodium	<1	2
Calcium	3	5
Magnesium	1	2
Sulfate	3	4
Chloride	1	1
Carbonate	0	0
Bicarbonate	26	18
Nitrate as N	<0.05	<0.05
Iron	<0.03	<0.03
Total Solids (Calculated)	22	23
Total Hardness as CaCo3	13	19
pH, standard units	6.9	6.6
Floride	<0.10	<0.10
Arsenic	<0.005	<0.005
Barium	<0.1	<0.1
Cadmium	<0.002	<0.001
Chromium	<0.02	<0.02
Lead	<0.01	<0.01
Mercury	<0.001	<0.001
Selenium	0.005	0.005
Silver	<0.005	<0.005
Specific Conductance @ $25^{o}C$	36 mhos/cm	44mhos/cm

Table 23. Location of study sections and landmarks in the Rattlesnake Creek drainage.

Area	Road Kilometers	Legal Description
Spring Creek	0	
Fraser Creek	5.0	
Bottom of section I	6.6	T14N, R18W, sec 20 ac
Top of section I	7.2	
Old sign hole	8.2	
Bottom of section II	8.5	T14N, R18W, sec 21 aa
Top of section II	9.2	
Beescove Creek	9.5	
Bottom of section III	9.7	T14N, R22W, sec 15 cd
Top of section III	10.3	
Franklin Bridge	12.4	
Bottom of section IV	15.3	T14N, R22W, sec 2 bd
Top of section IV	15.8	

Table 24. Sample creel census form used in the volunteer creel box, 1985 and 1986.

Comments:

Date fished:______ Stay overnight ____yes _____no Hours fished____

Area Fished:	Beeskove-Franklin Br. _____	Franklin Br. Porcupine Cr._____	Above Porcupine Cr._____

	# < 8"	# 8-12"	# 12-16"	# > 16"
Rainbow trout	_____	_____	_____	_____
Cutthroat trout	_____	_____	_____	_____
Hybrid (RB x CT)	_____	_____	_____	_____
Brook trout	_____	_____	_____	_____
Bull trout	_____	_____	_____	_____

Table 25. Allele frequencies at the loci that differentiate westslope cutthroat and rainbow trout in samples collected from Rattlesnake Creek in 1985 and 1986. The allele characteristics of westslope cutthroat trout at each locus is listed first.

Locus	Alleles	1985	1986	d.f.	x^2
Aatl	200	0.922	0.800		
	250	-	0.017		
	100	0.063	0.183	1	4.161*
Ck2	84	0.922	0.800		
	100	0.078	0.200	1	3.943*
Gpi3	92	0.953	0.767		
	100	0.047	0.233	1	9.183**
Idh3,4	86	0.469	0.375		
	100	0.242	0.383		
	114	0.008	0.017		
	71	0.016	-		
	40	0.266	0.208		
	20	-	0.017	3	6.257
Mel	88	0.969	0.767		
	100	0.031	0.233	1	11.409***
Sdh	40	0.922	0.767		
	100	0.078	0.233	1	5.734*
Average westslope		0.938	0.778		
Average rainbow		0.062	0.222		

Notes: d.f. = degrees of freedom, x^2 = contingency table chi-square test for homogeneity of allele frequencies, * = $P<0.05$, ** = $P<0.01$, *** = $P<0.001$. The frequency of the Idh3, 4 86 allele is usually 0.500 in pure populations of westslope cutthroat trout. The proportion of westslope in the samples at these loci, therefore, is estimated to be twice the frequency of this allele. The 1985 sample contains some Yellowstone cutthroat trout genetic material. Thus, the proportion of westslope cutthroat trout genetic material in this sample is likely to be underestimated and the proportion of rainbow trout genetic material to be overestimated.

Table 26. Trout population estimates for section I (0.6 km) of Rattlesnake Creek, 1985.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
Spring Day 4/9/85	CT*	All	4	6	2	10.7	7.9
Summer Day 8/4/85	CT	All	71	348	41	597.0	176.4
		100-200	37	306	22	506.0	194.7
		200-300	18	19	6	53.3	29.8
		300-400	12	19	11	20.7	7.1
		400+	4	4	2	7.3	4.5
	Bull	All	27	25	3	182.0	146.7
	Brook	All	31	20	4	134.4	93.9
Fall Day 10/29/85	CT	All	12	23	6	43.6	25.4
		100-200	1	3	0	7.0	8.4
		200-300	1	9	1	9.0	9.1
		300-400	9	8	4	17.0	8.9
		400+	1	3	1	2.4	1.6
Winter Day 12/10/85	CT	All		28	8		
		100-200		5	0		
		200-300		7	2		
		300-400		13	6		
		400+		2	1		

* cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 27. Trout population estimates for section II (0.6 km) of Rattlesnake Creek, 1985.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
Spring Day 4/9/85	CT*	All	10	23	6	36.7	21.4
Summer Day 7/10/85	CT	All	59	79	30	153.8	37.7
		100-200	16	24	5	69.8	44.6
		200-300	20	22	8	52.7	25.5
		300-400	18	22	12	32.6	13.3
		400+	5	9	5	9.0	4.2
	Brook	All	9	16	2	55.7	49.5
Fall Day 10/17/85	CT	All	26	31	11	71.0	35.5
		100-200	0	0	0	-	-
		200-300	9	5	0	59.0	74.7
		300-400	10	19	7	26.5	13.4
		400+	7	7	4	11.8	5.8
Winter Day 12/11/85	CT	All		59	19		
		100-200		17	0		
		200-300		7	4		
		300-400		25	10		
		400+		10	5		

* cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 28. Trout population estimates for section III (0.6 km) of Rattlesnake Creek, 1985.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
Summer Day 6/20/85	CT*	All	54	54	19	150.3	51.3
		100-200	6	11	3	20.0	14.3
		200-300	19	26	6	76.1	45.4
		300-400	25	13	8	39.4	14.6
		400+	4	4	2	7.3	4.6
Fall Day 10/18/85	CT	All	25	38	15	62.4	22.8
		100-200	0	0	0	-	-
		200-300	11	13	3	41.0	30.4
		300-400	12	21	10	25.0	10.0
		400+	2	4	2	4.0	2.5

*cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 29. Trout population estimates for section IV (0.6 km) of Rattlesnake Creek, 1985.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
Summer Day 8/25/85	CT*	All	150	168	67	374.3	68.3
		100-200	52	80	16	251.5	103.3
		200-300	93	80	45	161.0	29.5
		300-400	5	8	5	8.0	3.5
		400+	0	0	0		
	Bull	All	2	23	2	23.0	21.1
Fall COUNT Day 10/29/85	CT	All		234	39		
		100-200		74	4		
		200-300		147	31		
		300-400		13	1		
		400+		0	0		

* cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 30. Trout population estimates for section I (0.6 km) of Rattlesnake Creek, 1986.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
	CT*	All	106	98	46	221.1	45.3
Summer		100-200	57	55	20	153.7	50.8
Day		200-300	35	29	20	50.4	11.5
7/28/86		300-400	10	11	4	25.4	15.5
		400+	4	3	2	5.7	2.8
	Brook	All	19	25	5	85.7	
	Bull	All	0	11	_	_	
Summer	CT	All	106	94	36	273.7	68.0
Night		100-200	57	45	14	176.9	71.2
7/28/86		200-300	35	31	15	71.0	23.9
		300-400	10	13	5	24.7	13.8
		400+	4	5	2	9.0	6.8
	brook	All	19	4	1	49.0	-
	bull	All	0	8	-	-	-
Fall	CT	All	52	84	20	212.0	76.9
Day		100-200	24	36	8	101.8	54.8
10/29/86		200-300	11	35	3	107.0	88.4
		300-400	14	10	8	17.3	4.6
		400+	3	3	1	7.0	5.6
	brook	All	30	23	2	247.0	226.4
	bull	All	5	5	1	17.0	15.7

* cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 31. Trout population estimates for section II (0.6 km) of Rattlesnake Creek, 1986.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
	CT*	All	104	125	46	275.6	62.4
		100-200	41	73	12	238.1	114.0
		200-300	32	28	15	57.0	18.1
Summer		300-400	26	19	16	30.8	5.5
Day		400+	5	5	3	8.0	4.1
7/12/86							
	brook	All	13	5	0	69.0	95.6
	bull	All	4	6	2	10.7	7.9
Fall	CT	All	92	71	24	266.8	82.9
Day		100-200	55	26	4	290.2	209.6
11/1/86		200-300	18	23	8	49.7	24.4
		300-400	19	16	10	31.0	10.4
		400+	2	6	2	6.0	4.4
	brook	All	14	-	-		
	bull	All	33	11	1	203.0	209.7
Fall	CT	All	92	92	27	307.9	93.7
Night		100-200	55	62	10	319.7	164.3
11/3/86		200-300	18	14	7	34.6	15.4
		300-400	19	15	9	31.0	11.2
		400+	2	1	1	2.0	-
	brook	All	14	3	0	19.0	9.3
	Bull	All	33	12	1	220.0	229.0
Winter	CT	All		97			
Day		100-200		32			
1/9/87		200-300		42			
		300-400		15			
		400+		8			
Night	CT	All		84			
1/9/87		100-200		44			
		200-300		20			
		300-400		18			
		400+		2			

*cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

Table 32. Trout population estimates for section III (0.6 km) of Rattlesnake Creek, 1986.

Date	Species	Size	M[1]	C[2]	R[3]	N[4]	95%CI
Summer Day 7/13/86	CT*	All	108	129	37	369.0	97.4
		100-200	42	75	12	250.4	119.4
		200-300	46	37	17	98.2	32.0
		300-400	16	13	6	33.0	16.2
		400+	4	4	2	7.3	4.5
	brook	All	10	8	2	32.0	25.6
	bull	All	2	9	1	14.0	14.2
Fall Day 10/29/86	CT	All	96	96	34	276.8	69.9
		100-200	50	38	11	164.8	74.5
		200-300	28	31	7	115.0	65.1
		300-400	15	21	13	24.1	7.4
		400+	3	6	3	6.0	3.5
	brook	All	29	12	3	96.5	70.4
	bull	All	17	8	3	39.5	25.8
Fall Night 10/31/86	CT	All	96	67	22	285.8	93.0
		100-200	50	27	8	177.5	90.6
		200-300	28	25	4	149.8	107.7
		300-400	15	12	7	25.0	10.1
		400+	3	3	3	3.0	-
	brook	All	29	6	3	51.5	29.7
	bull	All	17	11	1	-	-
Winter 2/22/87	CT	All		57			
		100-200		30			
		200-300		20			
		300-400		6			
		400+		1			

*cutthroat trout
1=marked; 2=captured; 3=recaptured; 4=number estimated

APPENDIX B

FIGURES

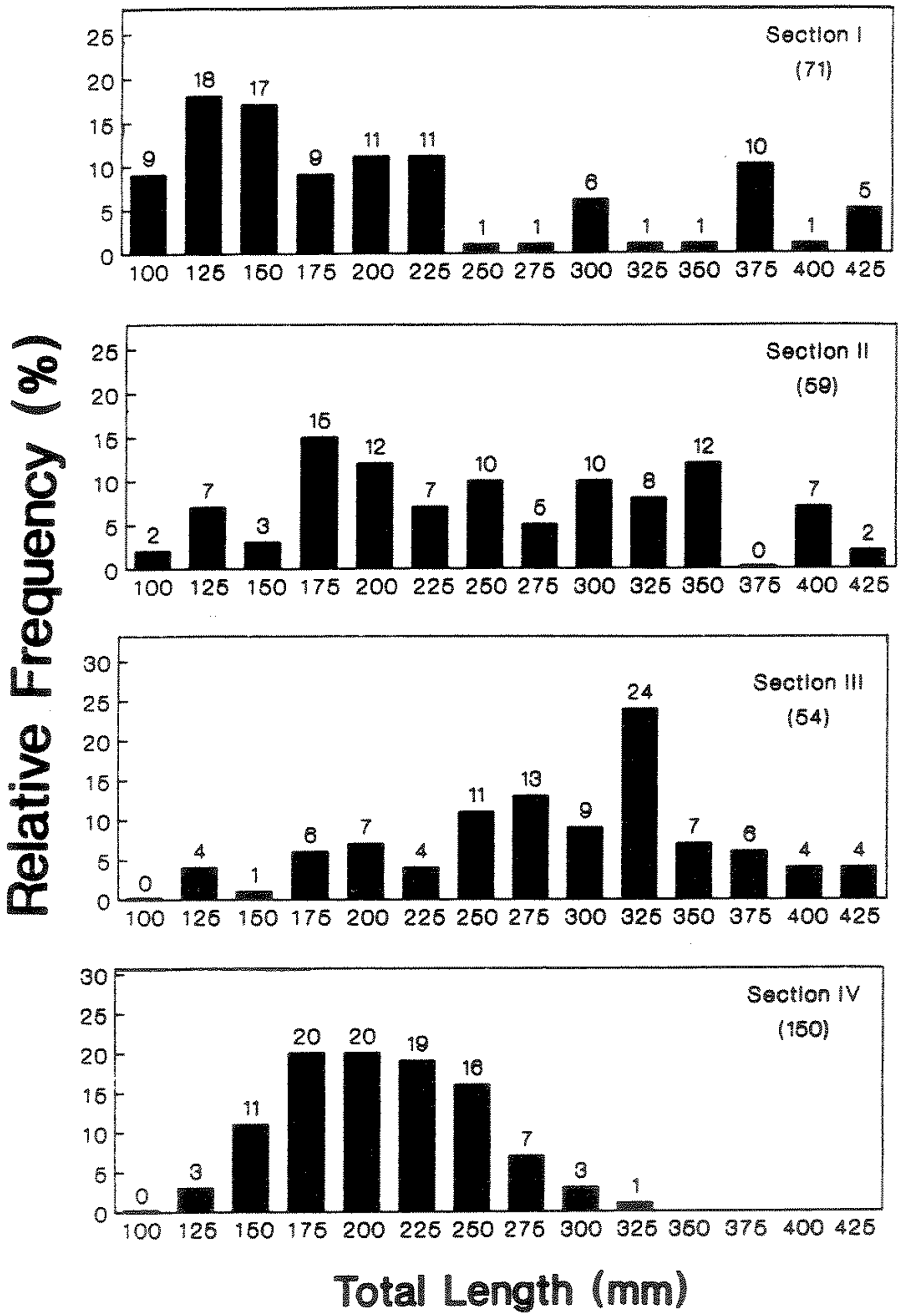


Figure 12. Length frequency distribution of cutthroat trout captured in sections I-IV of Rattlesnake Creek, summer 1985. Sample sizes are shown in parentheses.

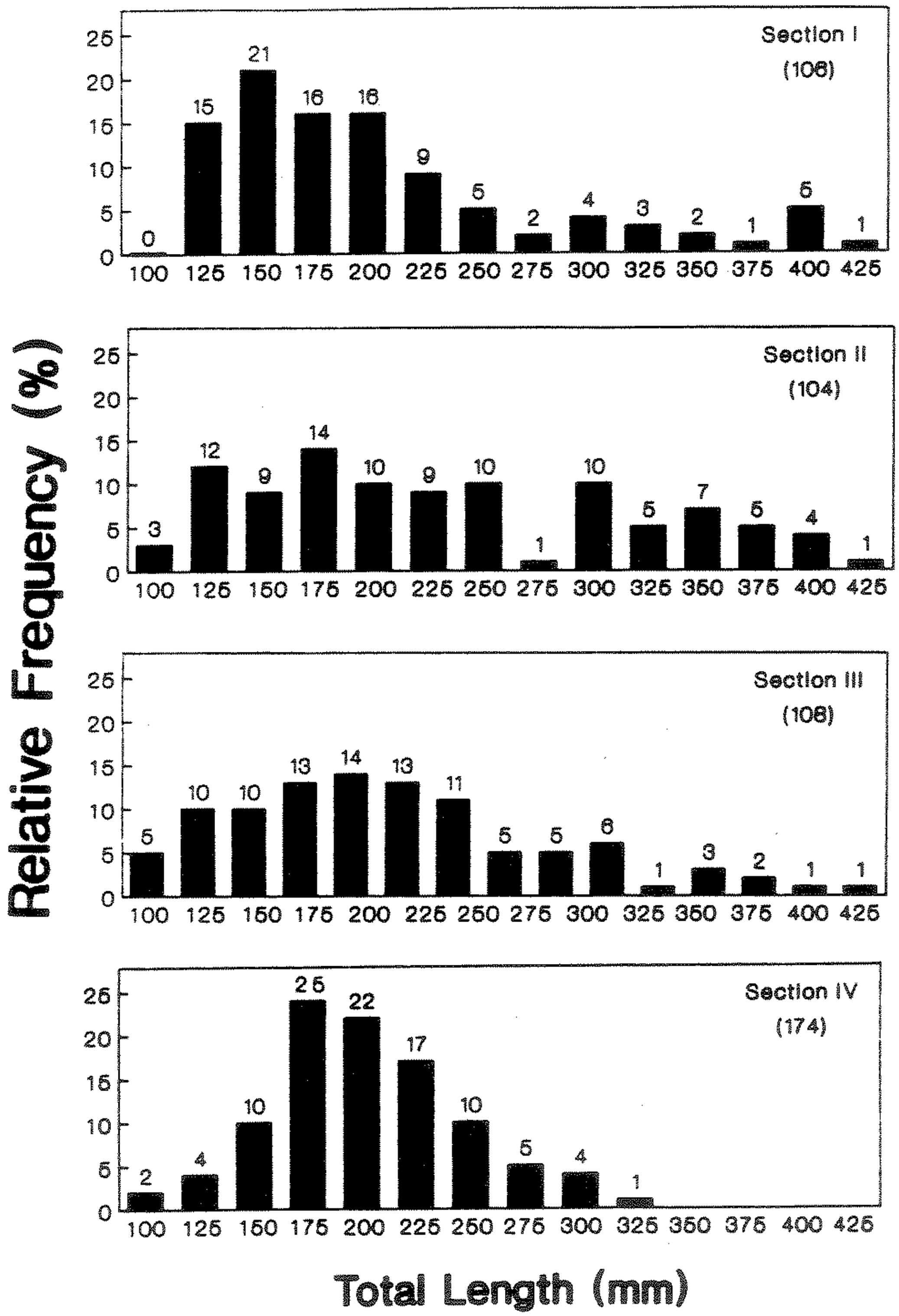
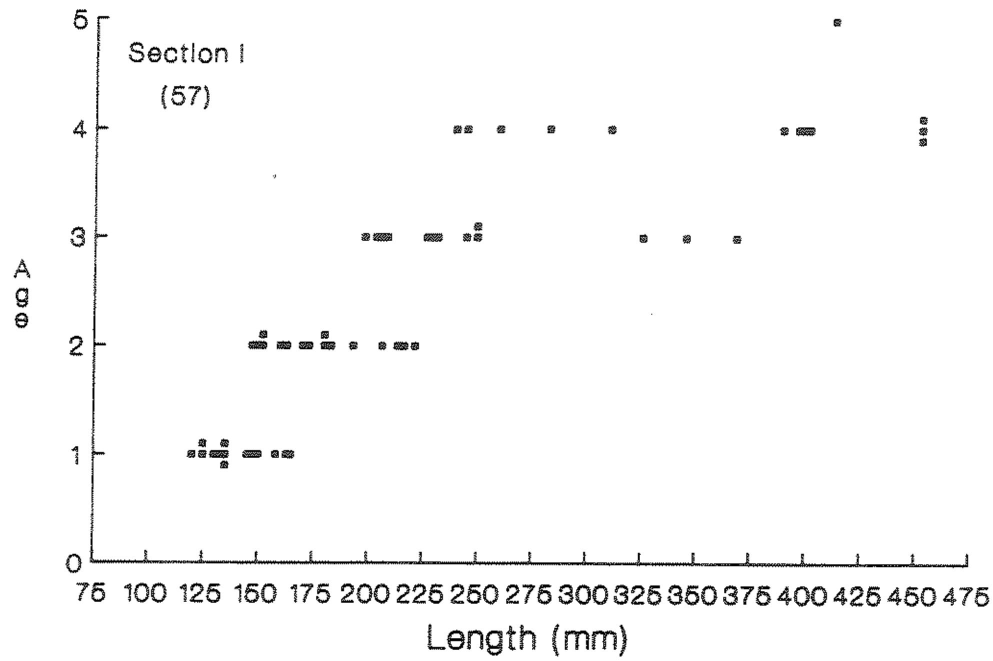


Figure 13. Length frequency distribution of cutthroat trout captured in sections I-IV of Rattlesnake Creek, summer 1986. Sample sizes are shown in parentheses.



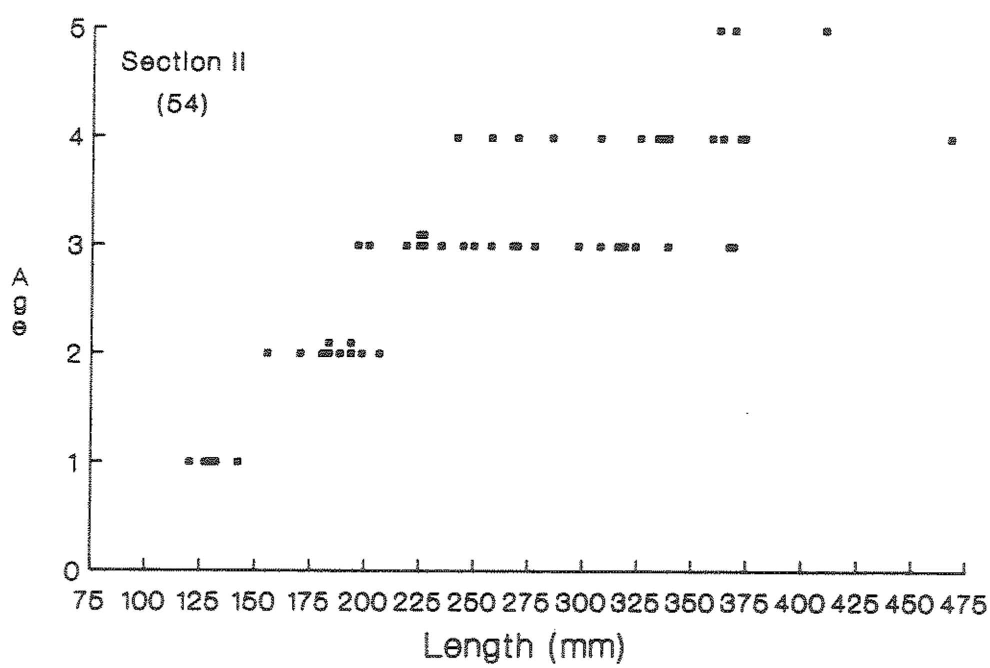


Figure 14. Age and length, determined from scales, of cutthroat trout in sections I and II of Rattlesnake Creek, 1985. Sample sizes are shown in parentheses.