Seasonal distribution and habitat use of westslope cutthroat trout in a sediment-rich basin in Montana
by Susan Comings Ireland

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
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Susan Comings Ireland

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

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ABSTRACT

Several hierarchical scales were used to investigate critical habitat requirements for westslope cutthroat trout in the Taylor Fork drainage. Using a basin scale, high densities (18–33 cutthroat per 100 m^2) were found in only 2 of the 10 surveyed reaches. Elevation, stream order, presence of exotic species, and proximity to spawning grounds were possible reasons for clumped distributions. On a reach scale, slow–water channel unit types (i.e. pools and glides) provided the most important habitat for cutthroat in both summer and winter. Channel unit measurements were analyzed to determine fish–habitat relationships. Using measurements from channel unit types throughout the drainage, significant correlations between cutthroat trout densities and stream–size related variables were found. Using measurements only from areas with high cutthroat densities resulted in significant correlations with habitat variables better describing fish habitat use, such as cover and mean depth. Because the drainage is naturally erosive, sedimentation and disturbance from land use practices did not appear to affect fish density or distribution. Cutthroat movement was generally limited after spawning, and during summer and winter. Upper Wapiti Creek and upper Cache Creek reaches appear to contain two distinct subpopulations of cutthroat. These reaches are important for the maintenance of viable cutthroat populations in the Taylor Fork drainage.

INTRODUCTION

Westslope cutthroat trout *Oncorhynchus clarki lewisi* have drastically declined in abundance and distribution during the last 100 years (Liknes and Graham 1988) and are listed by Montana Fish Wildlife and Parks (MFWP) as a species of special concern (Holton 1990). Protecting remaining populations of westslope cutthroat requires knowledge of their critical habitat requirements.

Critical habitats for westslope cutthroat are likely to differ over a drainage basin depending upon life stage and season. Small tributaries serve as spawning and rearing habitat for young juveniles, providing protection from high flows and bedload movement (Shepard et al. 1984; Rieman and Apperson 1989). Pools are important rearing habitat for juvenile cutthroat in summer (Shepard et al. 1984; Liknes and Graham 1988). Large, deep pools with complex cover, as well as cobble substrate are particularly important as winter habitat for juvenile and adult cutthroat. Peters (1988) found large aggregations of adult and subadult cutthroat in pools during winter. Small cutthroat (< 100 mm) have been found to move into interstitial spaces in the substrate as stream temperatures drop below 4–5° C (Bjornn et al. 1977; Liknes and Graham 1988). The availability of winter habitat may also have a strong influence on seasonal movements of westslope cutthroat. Extensive migrations of westslope cutthroat in the fall have been observed where high quality pools were found downstream of spawning and rearing habitat (Bjornn and Liknes 1986; Liknes and Graham 1988). In contrast, Peters (1988) observed that westslope cutthroat resided the entire year in some streams where high quality pools provided both summer and winter habitat in the same stream section.

Because of their differing seasonal habitat requirements and potentially extensive seasonal movements, defining critical habitat requirements for westslope cutthroat likely requires the use of several different scales. Frissell et al. (1986) developed a hierarchical framework for stream habitat classification emphasizing a stream's relationship to its watershed across a wide range of scales in space and time, from the entire drainage basin, to reaches, channel units, and microhabitat. I investigated the hypothesis that three spatial scales (basin, reach, and channel unit) would be important for identifying critical habitats for westslope cutthroat during summer and winter. The drainage basin scale encompasses all surface waters in the watershed. Reaches are integrated geomorphic units within the basin that lie between breaks in channel slope and possess similar riparian vegetation, bank materials, and a characteristic range of substrate. The channel unit scale is a subsystem of a reach, having a characteristic pattern of flow velocities, depths, and sediment dynamics.

Westslope cutthroat populations appear to be sensitive to changes in habitat due to land use practices. Platts (1974) reported westslope cutthroat trout were common only in undisturbed reaches of streams in the Salmon River drainage of Idaho. In Idaho and Montana, the distribution of remaining strong populations of westslope cutthroat is almost entirely within wilderness and National Parks (Liknes and Graham 1988). Natural and man–caused disturbances have resulted in substantial depositions of fine sediment and loss of bank stability in some stream channels. Bjornn et al. (1977) found carrying capacity of pools for cutthroat was negatively correlated to the degree of gravel embeddedness. Pool filling and reduction of interstitial space in the substrate that occurs with increased sedimentation may have a major impact on availability of winter habitat. The second hypothesis I tested was that fine sediment reduces habitat quality for westslope cutthroat by filling of interstitial spaces and decreasing pool depths.

The Taylor Fork basin was chosen for this study because the naturally erosive geology produces large amounts of silt–like sediment. Most previous investigations involving the effect of sediment deposition on freshwater resident trout have been conducted in the Idaho batholith region where granitic soils produce a sand–like sediment (Bjornn et al. 1977; Hillman et al. 1987). The geology of the region may influence the distribution of habitats, habitat characteristics, and susceptibility to disturbance (Benda et al. 1991).

Specific objectives for this study were to: (1) determine seasonal cutthroat distribution on a basin, reach, and channel unit scale in the Taylor Fork basin; (2) describe seasonal habitat characteristics of cutthroat trout; (3) examine effects of sedimentation on habitat use of cutthroat trout; and (4) determine seasonal movement patterns of cutthroat trout.

STUDY AREA

Located in the Gallatin National Forest, the Taylor Fork drainage in southwest Montana lies 24 km south of Big Sky near the western boundary of Yellowstone Park (Figure 1). The 160 km^2 basin contains approximately 100 stream kilometers and ranges in elevation from 3080 meters in the headwaters to 2032 meters at the confluence of the Taylor Fork and the Gallatin River. Major fish species in the Taylor Fork include westslope cutthroat trout, rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, mountain whitefish *Prosopium williamsoni*, and mottled sculpin *Cottus bairdi*. Hybridization has occurred between rainbow and cutthroat. Hybridization has also occurred between Yellowstone and westslope cutthroat in upper Wapiti Creek (48% Yellowstone, 52% westslope; Bruce May, Gallatin National Forest fishery biologist, personal communication). However, electrophoretic analysis indicates westslope cutthroat have remained more than 85% pure in Cache Creek, one of the highest purities remaining in the Gallatin River drainage (Liknes 1984).

Predominantly classed in the soft sedimentary rock category, the naturally unstable geologic composition in the Taylor Fork drainage is highly erosive and production of large amounts of suspended sediment is common during high flows (Snyder et al. 1978). Indeed, the Taylor Fork is widely known for its 'coloring' of the

Gallatin River many miles downstream during spring runoff and after heavy rainfall. Most of the stream channels throughout the basin were rated in "poor" condition by Snyder et al. (1978).

Channels of the lower, lower-mid, and mid Taylor Fork reaches are low gradient (1% or less) and meander or braid across an extensive floodplain (Figure 1). The upper Taylor Fork reach increases in gradient (> 1.5%) and begins to enter a

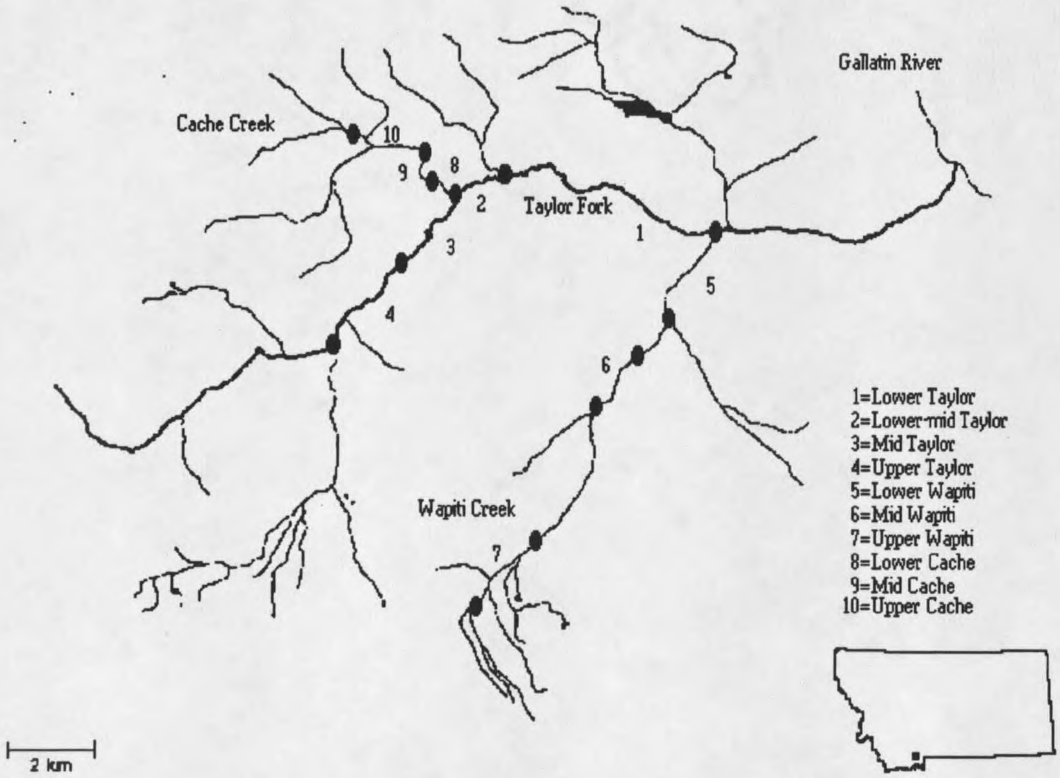

Figure 1. Map of Taylor Fork drainage and study reaches.

coniferous forest. Mid Wapiti and mid Cache Creek channels run through coniferous forest, are moderately steep (> 2.5%) and are composed of coarse substrate. Their channel shape strongly reflects the presence of bedrock outcrops. The high elevation sections of the drainage, upper Wapiti and Cache Creek, meander through alpine meadows.

Land uses in the Taylor Fork drainage have varied over the years. Throughout the drainage, Forest Service land is interspersed with private land belonging to Big Sky Lumber Company and individuals, including owners of a guest ranch on the lower Taylor Fork. Timber harvest and extensive tie cutting occurred between 1868 and 1906 (Snyder et al. 1978). Extreme channel instability below an old splash dam still remains on the middle Taylor Fork today, as evidenced by shallow, braided channels. Recent clearcuts are present in upper Taylor Fork and Cache Creek. Two cattle grazing allotments (220 cow–calf pairs each) exist along Cache Creek, middle Taylor Fork and middle Wapiti Creek. Cattle are brought in to graze during the first week in July and remain in the drainage until mid October. The Taylor Fork basin is an important wintering area for elk. Other land uses include hunting, outfitting, fishing, and backpacking. Overall, upper Wapiti Creek has remained relatively undisturbed, while other parts of the basin have been heavily impacted by past land use practices (Snyder et al. 1978).

METHODS

Reach Measurements

Ten distinct reaches were designated based on differences in gradient and geomorphology and the presence of tributary junctions in order to encompass the variety of stream habitat conditions present in the basin. To help determine reach boundaries, longitudinal stream profiles were constructed to identify breaks in stream gradient (Figure 2). A 1:24,000 scale U.S. Geologic Survey topographic map was used to determine study reach elevations and stream orders (Strahler 1957). UTM coordinates for each reach are listed in Appendix A. To categorize stream channels on the basis of measurable morphological features, stream reaches were classified according to the Rosgen stream classification system (Rosgen 1985). The morphological features used for Rosgen classification include: channel gradient; sinuosity (ratio of channel length to valley length); width/depth ratio; dominant particle size; and entrenchment and confinement of channel. To quantify differences in stream temperatures between study reaches, hourly water temperatures were recorded between October 1991 and November 1992 in four locations throughout the basin using Ryan thermographs. Weekly average temperatures were obtained by summing all readings for the week and dividing by the number of readings.

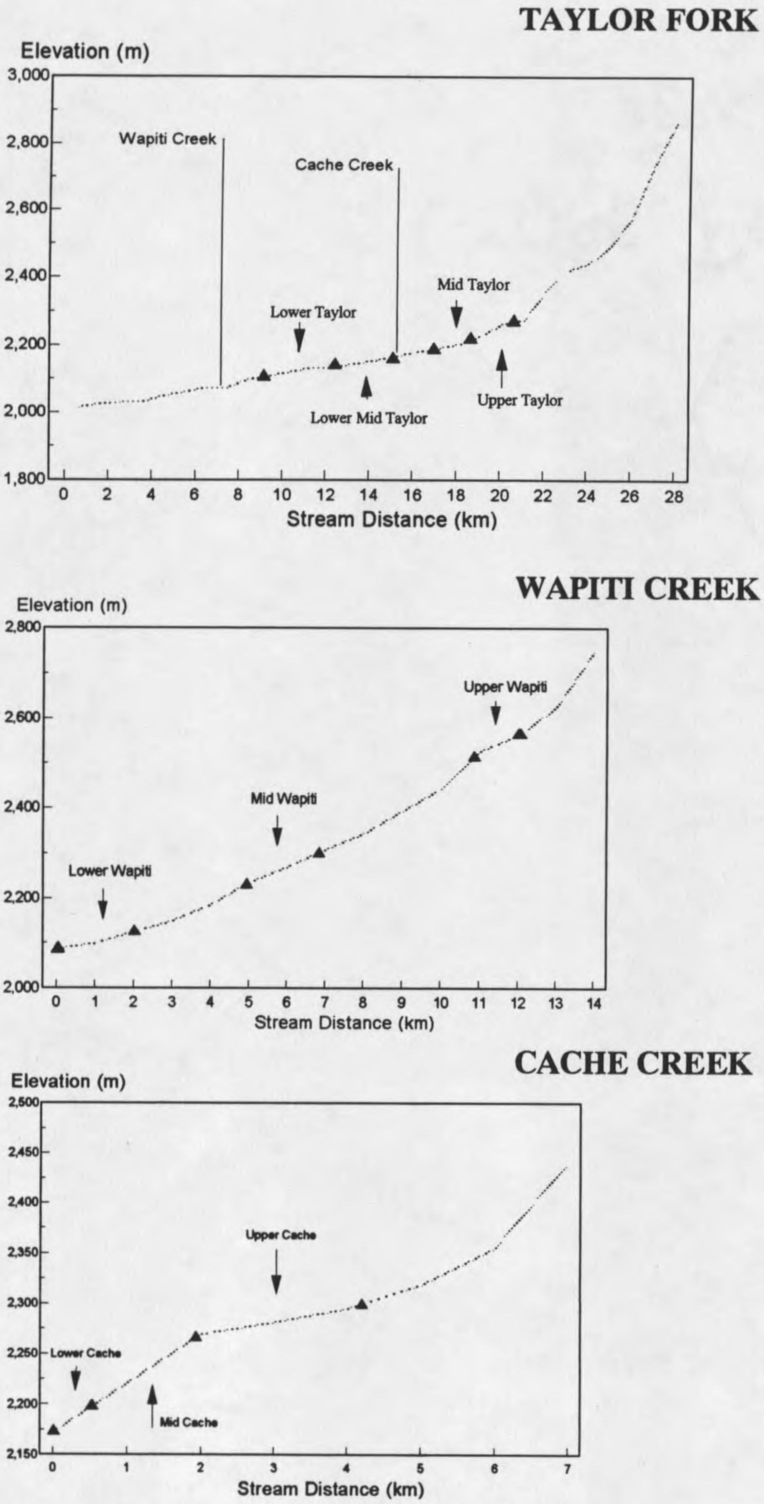

Figure 2. Longitudinal profiles of Taylor Fork, Wapiti Creek, and Cache Creek from mouth to headwaters (km).

Channel Unit Measurements

Nine stream reaches were surveyed during July and August 1992 using the systematic sampling approach outlined by Hankin and Reeves (1988) and following the stream habitat inventory methods developed by the U.S. Forest Service, Region 6 (Overton 1991). Channel units were classified according to Bisson et al. (1982) and modified to describe channel unit types most common in the Taylor Fork basin (Table 1). Habitat variables measured at every channel unit included: length, wetted width, and maximum depth for all pools. Length of each channel unit was measured by walking along the stream bank with a hipchain. Wetted width was measured with a meter tape perpendicular to the flow across the channel at a point representative of the average width of the unit. Maximum pool depth was measured with a meter stick at the deepest point in the pool.

Additional habitat measurements were performed at every 10th channel unit (with a random start). Measurements included channel width, mean depth, cover, pool quality, dominant substrate, embeddedness, substrate composition, percent surface fines, bank height and stability, riparian composition, and gradient. These units were marked with flagging for later fish sampling. Channel width was measured bank to bank from the point at which bankfull flow occurred. Depth was measured in three

Table 1. Classification of channel unit types used in the Taylor Fork stream habitat survey (modified from Bisson et al. 1982).

Fast–water channel unit types:

Riffle–Stream units with moderate current velocity (20–50 cm/sec) and moderate turbulence. Substrate was usually composed of gravel, pebble, and cobble–size particles (2–256 mm).

Step run – a sequence of runs separated by short riffle steps, generally found in high gradient, confined streams dominated by cobble and boulder. Distinguished from step pools by shallower depth (< 0.2 m) between riffle steps.

Step pool – a series of pools separated by short riffles, generally found in high gradient, confined streams dominated by cobble and boulder.

Slow–water channel unit types:

Glide – Stream unit possessing both attributes of riffles and pools, characterized by moderately shallow water with an even flow that lacked pronounced turbulence. Glides were most frequently located at the transition between a pool and the head of a riffle, but were also occasionally found in long, low gradient stream reaches with no major flow obstructions. Substrate was typically silt, peagravel, gravel, and cobble.

Corner pool – unit formed by flow impinging against one streambank because of sharp bend in channel, causing scouring of one bank. Corner pools are most common in low gradient meadows in streams with high sinuosity. Stream banks usually consist of alluvium and lack hard obstructions.

Mid–channel pool – large pool formed by mid–channel scour. The scour hole encompasses more than 60% of the wetted channel. Water velocity is slow and substrate is highly variable. Because of their low occurrence, channel confluence pools, plunge and dammed pools were also included in this category.

Lateral scour pool – pool formed by flow directed to one part of the stream by a partial channel obstruction, usually a large boulder or rootwad. Not common in the Taylor Fork drainage because of lack of large woody debris and boulders in stream.

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places along a transect representing the average width of the unit. To compute mean depth, the three depth measurements were summed and divided by four to account for edge effects (Overton 1991).

For pools, cover was measured according to four categories: large substrate (> 30 cm), overhead cover (vegetation and large woody debris overhanging within 1 m of water surface), submerged cover (vegetation and large woody debris), and undercut bank (90° angle or less). Surface area measurements were recorded for each cover category. Pool quality was rated based on depth, cover, and size (Platts 1979; Table 2). Pool quality ratings ranged from 1 to 5, with a score of 5 representing highest quality.

Substrate composition was characterized using Wolman pebble counts (Wolman 1954) and percent surface fines measurements (Kramer and Swanson 1990) at riffles and pool tail–outs. Wolman pebble counts consisted of categorizing substrate particles by size via the Wentworth scale at 100 points across each site. Surface fines were measured with a 49–point grid by counting the number of intersections that had substrate < 2 mm. The grid was tossed 10 times to determine the average percent fines per site. Dominant substrate was visually estimated in all channel units using the substrate size classification modified from the Wentworth scale in Welch (1948) (Table 3). Embeddedness was visually estimated by rating the degree to which the larger particles were covered with fine sediment (Table 4). An embeddedness rating of 1 indicated the highest degree of embeddedness.

Table 2: Definition of pool quality ratings used in stream habitat survey methodology (adapted from Platts 1979).

SIZE		Rating
Pool longer or wider than mean width of stream.		3
Pool as wide or long as mean width of stream.		2
Pool shorter or narrower than mean width of stream.		1
COVER		
Abundant	> 30% of pool bottom obscured by depth, surface turbulence, or structures (LWD, boulders, vegetation).	3
Partial	10–30% of pool bottom obscured by depth, surface turbulence, or structures.	2
Exposed	< 10% of pool bottom obscured by depth, surface turbulence, or structures.	1
DEPTH		
Deepest part of pool	> 0.9 m	3
Deepest part of pool	0.6–0.9 m	2
Deepest part of pool	< 0.6 m	1

Numerical scores are summed and a rating value assigned:

Total Score	Pool Quality Rating
8 or 9	5
7	4
6	3
5	2
3 or 4	1

Table 3. Definition of substrate size classification used in stream habitat survey methodology (modified from the Wentworth Classification in Welch 1948).

Classification	Particle Diameter (mm)
Sand/silt	< 2
Peagravel	2–6
Gravel	6–7.5
Rubble	7.5–15
Cobble	15–30
Boulder	> 30
Bedrock	

Table 4. Definitions of embeddedness ratings used in stream habitat survey methodology (adapted from Platts et. al. 1983).

Rating	Description
5	Gravel, rubble, and boulder particles have < 5% of their surface covered by fine sediment.
4	Gravel, rubble, and boulder particles have 5–25% of their surfaces covered by fine sediment.
3	Gravel, rubble, and boulder particles have 25–50% of their surfaces covered by fine sediment.
2	Gravel, rubble, and boulder particles have 50–75% of their surfaces covered by fine sediment.
1	Gravel, rubble, and boulder particles have > 75% of their surfaces covered by fine sediment.

Bank height was measured from the wetted perimeter to the top of the bank. Bank stability ratings ranged from 1 to 4, with a score of 4 indicating the highest stability (Table 5). Riparian composition was classified as the percentage of bank comprised of soil/rock, grass, shrubs, sage, willow, or conifer. Gradient was measured with a hand–held clinometer.

Table 5. Definition of streambank stability ratings used in stream habitat survey methodology (adapted from Platts et. al. 1983).

Rating	Percent	Description
4 (Excellent)	75–100	> 75% of the streambank surfaces are covered by vigorous vegetation or by boulders and rubble. If not covered by vegetation the streambank is protected by materials that do not allow bank erosion.
3 (Good)	50–74	50–74% of the streambank surface are covered by vegetation or by gravel or larger material. Those areas not covered by vegetation are protected by materials that allow only minor erosion.
2 (Fair)	25–49	25–49% of the streambank surfaces are covered by vegetation or gravel or larger material. Those areas not covered by vegetation are covered by materials that give limited protection.
1 (Poor)	0–24	< 25% of the streambank surfaces are covered by vegetation or gravel or larger material. That area not covered by vegetation provides little or no control over erosion and the banks are usually eroded each year by high water flows.

Habitat measurements for the tenth reach, the lower Taylor Fork (Figure 1), were based on 3–300 m long 'representative' reaches. The systematic survey approach could not be used since this reach was wide (> 10 m) and thus contained several distinct channel unit types across its width. Habitat measurements were thus conducted at every channel unit within each representative reach rather than at systematically sampled units as above.

Fish Distribution

To compare seasonal distribution and abundance of westslope cutthroat trout and other fishes across the entire basin, fish population estimates were conducted in 8 reaches in the summer (lower and lower–mid Taylor Fork; lower, mid, and upper Wapiti Creek; and lower, mid, and upper Cache Creek) and 7 reaches in the winter (lower, lower–mid, mid, and upper Taylor Fork; upper Wapiti; and lower and upper Cache Creek). Fish sampling during summer took place during low flow (31 July–07 October 1992). Winter fish sampling occurred after average daily stream temperatures had dropped below 4°C (10 October–08 November 1992; Figure 3). All streams iced over after November 8, precluding additional winter sampling.

Fish populations were sampled by electrofishing. In Wapiti Creek and Cache Creek reaches, a Coffelt–10 backpack shocker with CPS pulse was used. Because of the large size of mainstem Taylor Fork reaches, backpack shocking was ineffective.

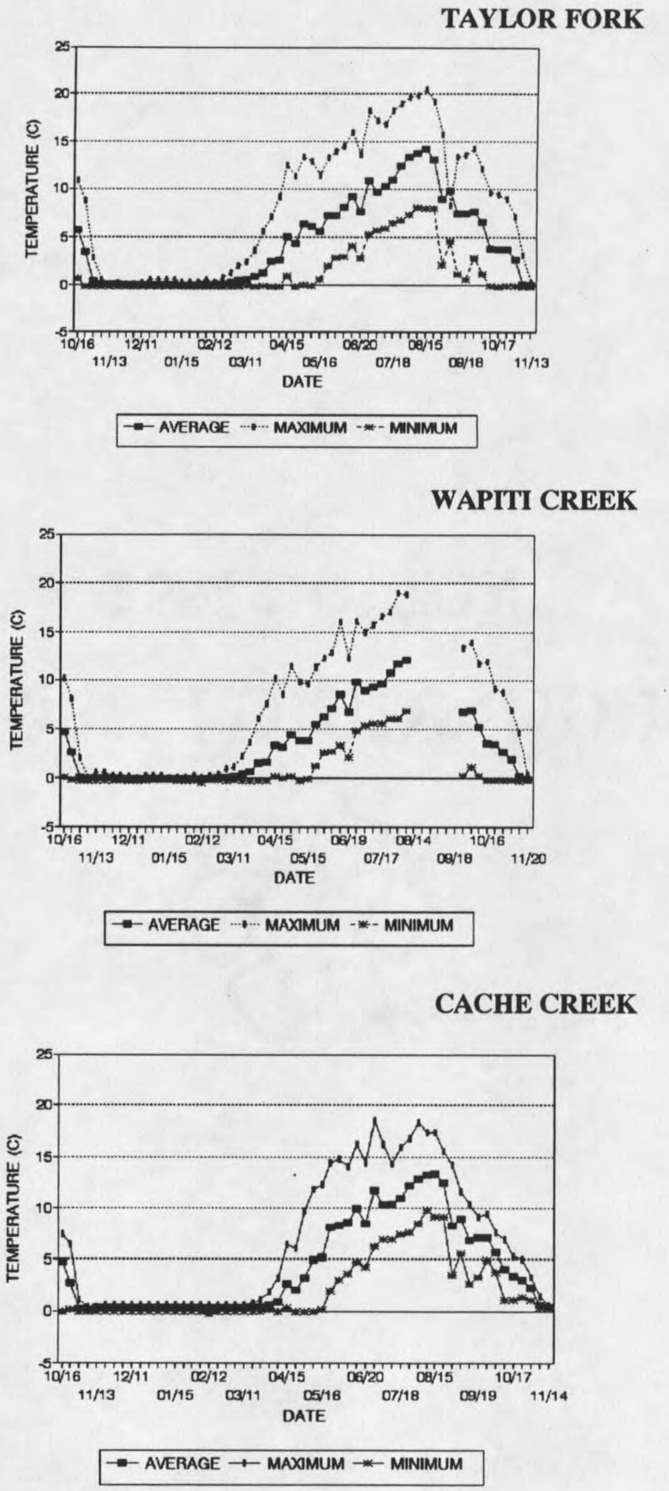

Figure 3. Mean, maximum, and minimum weekly temperatures for lower Taylor Fork, lower Wapiti Creek, and lower Cache Creek between October 1991–November 1992.

Therefore, a bank shocking unit with straight direct–current was used for fish sampling. Fish populations were sampled in channel units measured during the stream habitat inventory. Individual channel units were blocked at each end with nets, except in the lower Taylor Fork reach, where the entire 300 m representative reaches were sampled. Fish were weighed to the nearest gram and fork length was measured to the nearest millimeter. Fish > 130 mm were tagged with a visual implant tag in the adipose tissue behind the left eye. Only salmonids were netted and enumerated. Sculpins were present in all reaches except upper Wapiti and upper Cache, but were not included in fish abundance estimates.

Population estimates were obtained using a multiple depletion method (Zippin 1958) and estimates were computed using the program MICROFISH (Van Deventer and Platts 1986). Fish densities were calculated by dividing the population estimate for each channel unit or subreach by the surface area. Total number of cutthroat trout for each reach was computed by extrapolating the average density for each channel unit type to the total percentage of surface area of that channel unit type present in the reach.

Data Analysis

Differences in density by season for each channel unit type were analyzed by a Kruskal–Wallis nonparametric analysis of variance. In this analysis, I used data only from reaches containing greater than 30% of the total fish density (upper Wapiti and upper Cache Creek). I did not include other reaches due to low occupancy of suitable habitat. Using only high density reaches for analysis enabled me to better understand cutthroat habitat use on a channel unit scale. A nonparametric multiple comparison test for unequal sample sizes was then used to determine differences in density by habitat type (Zar 1984). A Mann–Whitney test was used to compare mean density within each channel type between summer and winter. Lateral scour pools, step runs, and step pools were excluded from the analysis of seasonal habitat type preferences because lateral scour pools occurred in low frequency throughout the basin, while step runs and step pools occurred only in mid Wapiti and mid Cache Creek reaches where densities of cutthroat were low.

Habitat variables measured within channel units were tested for normality and equal variances. Because both assumptions were violated, multiple regression analysis was deemed inappropriate to identify relationships between fish abundance and specific habitat features. Associations between individual habitat variables and fish density and biomass were analyzed using Spearman's rank correlation (Zar 1984). In all statistical analyses, $P \leq 0.05$ was considered statistically significant. STATGRAPHICS statistical package (1989) was used to perform all statistical computations.

Habitat utilization by season was also determined by the equation (Bisson et al. 1982):

$$\text{Utilization} = \frac{\text{channel unit density} - \text{average total density}}{\text{average total density}}$$