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Summer and fall microhabitat utilization of juvenile bull trout and cutthroat trout in a wilderness stream, Idaho

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Abstract

Microhabitat use and availability were evaluated and compared between different size classes of juvenile resident bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*) in a small wilderness stream within the South Fork Clearwater River basin, Idaho. The objective was to determine if utilization of measured habitat characteristics changed from summer to late fall. Sampling of fish was conducted with night snorkeling. During the summer, smaller juvenile bull trout (<66 mm) total length (TL) were associated with shallow stream margins over coarse substrates. In the fall, they moved to significantly deeper, lower velocity water, and closer to cover ($p<0.05$), but maintained their association with coarse substrates. During the summer, larger juvenile bull trout and larger juvenile cutthroat trout (66–130 mm TL) occupied significantly deeper water than smaller juvenile bull trout ($p<0.05$). Generally, larger juvenile bull trout were found closer to the bottom and in lower velocity water than larger juvenile cutthroat trout ($p<0.05$). In the fall, larger juvenile bull trout and larger juvenile cutthroat trout were associated with significantly deeper, lower velocity water located closer to cover than in summer ($p<0.05$). However, cutthroat trout occupied slightly deeper water over finer substrates than bull trout. Deep water with low velocities evidently provide important rearing areas for large bull trout and large cutthroat trout in the fall. Land management practices that maintain such environments will benefit these species.

Introduction

The bull trout (*Salvelinus confluentus*), a native char of the Pacific Northwest, USA, has declined in both abundance and distribution in the last 30 years, especially in the western and southern portions of its range (Goetz, 1989; Ratliff & Howell, 1992). This decline prompted listing of the Klamath River and Columbia River distinct population segments of bull trout as threatened in 1998 under the Endangered Species Act of 1973 (U.S. Fish and Wildlife Service, 1998). Similarly, the westslope cutthroat trout (*Oncorhynchus clarki lewisi*) has experienced significant reductions in abundance and distribution throughout its historic range (Liknes & Graham, 1988).

Factors responsible for declines in both species include loss of habitat, hybridization and competition with exotic fishes, and over-exploitation (Leary et al., 1983; Likens & Graham, 1988; Rode, 1989; Fraley & Shepard, 1989, Goetz, 1989). Within Idaho, many of the last viable and healthy populations of bull trout and westslope cutthroat trout are found in wilderness areas minimally impacted by humans (Rieman & McIntyre, 1993). Such is the case in the South Fork Clearwater River basin, Idaho, where stronger populations of bull trout and cutthroat trout are mainly restricted to wilderness and other minimally impacted areas of two small watersheds.

As conservation of these declining species becomes increasingly important, biologists need to understand how habitat requirements change throughout their entire life cycle. Variables such as depth, velocity and substrate are important habitat characteristics of salmonid habitat (Everest & Chapman, 1972) and

vary by season (Baltz et al., 1991) and as fish grow (Chapman & Bjornn, 1969).

For bull trout and cutthroat trout, species-specific changes in habitat type utilization by season and fish size have been reported in only a few studies. During the summer, age-0 bull trout and cutthroat trout in northern Idaho streams have been shown to inhabit shallow, low-velocity stream margin areas (Saffel & Scarnecchia, 1995; Bonneau & Scarnecchia, 1998). Similar findings have been reported in Montana (Pratt, 1984; Shepard et al., 1984a) and Oregon (Moore & Gregory, 1988; Goetz, 1994). As the fish grow, both species retain their association with deeper areas, but bull trout often inhabit low-velocity areas near the bottom and close to cover (Pratt,1984; Shepard et al., 1984a; Thurow, 1997; Bonneau & Scarnecchia, 1998), whereas cutthroat are typically found in higher velocity areas and higher in the water column (Pratt, 1984; Bonneau & Scarnecchia, 1998).

Changes in utilization of available habitat types from summer to fall are less understood, but have been observed in other salmonids. Johnson & Kucera (1985) reported fall transitions to larger substrates for age-0 steelhead (*Oncorhynchus mykiss*), but found no differences in the utilization of depths and velocities between summer and fall. Autumnal shifts to larger substrate, deeper water, and lower velocities were observed for rainbow trout (Baltz et al., 1991) and for Atlantic salmon, *Salmo salar* (Rimmer et al., 1984). When comparing summer and fall to winter, habitat utilization of bull trout and cutthroat trout in winter shifted towards deeper water with less velocity (Jakober, 1995; Bonneau & Scarnecchia, 1998).

Geomorphology and climate of the surrounding landscape affect the availability of habitat through influences on stream gradient, channel types, substrate, cover and stream productivity. Streams in the Idaho Batholith, such as exist in the South Fork Clearwater basin, are susceptible to impacts from large amounts of sand, which can fill interstitial spaces important for rearing and food production (Megahan, 1974; Bjornn, 1977).

In this study, the objectives were to (1) compare microhabitat use to availability of habitat for juvenile bull trout and cutthroat trout in the summer and fall, and (2) compare microhabitat use by fish size, species and season in a small stream within the Idaho Batholith geologic type.

Study area

Bull trout and cutthroat trout were studied in Tenmile Creek, a tributary of the South Fork Clearwater. Tenmile Creek is a fourth order stream (watershed area, 13 993 hectares) and the studied portion is located entirely within the Gospel Hump Wilderness Area. Elevation ranged from 1365 to 1645 m above sea level. Peak run off usually occurs from late April to early June with base flows occurring during the winter. Tenmile Creek is relatively sterile with conductivities ranging from 40 to 120 mMhos cm^{-1}annually. Bull trout, cutthroat trout, resident rainbow and steelhead trout (*Oncorhynchus mykiss*) and torrent sculpin (*Cottus rotheus*) occur in Tenmile Creek although rainbow trout were not observed within the studied portions.

Methods

Sampling occurred in four stream reaches during the summer and fall of 1994. The four reaches sampled had a mean length of 250 m, mean width of 6.5 m and gradients that ranged from 0.5 to 7%. Conductivities ranged from 50 to 80 mMhos cm^{-1}. Microhabitat availability and use for bull trout and cutthroat trout were characterized in summer and fall. Summer samples were taken from 28 July to 15 August and fall samples from 13 to 20 October.

Available habitat

Perpendicular transects to stream flow were established at 25 m intervals for all reaches. Physical characteristics of the habitat were measured every 0.5 m across each transect, starting at the wetted edge. At each point, we measured water depth and mean water column velocity at 0.6 of the water depth. Water velocities were measured using a Pygmy^{TM} current meter. Dominant substrates were characterized visually within a 0.25 m radius into organic or granular types. Organics were considered one category comprised of vegetative materials ranging in size from fine particulate matter to small sticks and needles. Granular substrates were classified further using the following modified Wentworth scale: silt; sand (<0.6 cm); small gravel (0.6–2.5 cm); large gravel (2.6–7.6 cm); small rubble (7.7–15.2 cm); large rubble (15.3–30.5 cm); boulder (>30.5 cm); and bedrock (large masses of rock).

Utilized habitat

Reaches were snorkeled between 2200 h and 0230 h in the summer and between 2030 h and 0100 h in the fall. During the summer sampling period, nighttime water temperatures ranged from 9.0 to 12.0 °C, whereas during the fall sampling period, nighttime water temperatures ranged from 0.5 to 3.5 °C.

All observations were made by snorkeling at night when these species have been shown to be most visible (Goetz, 1994; Jakober, 1995; Bonneau et al., 1995; Spangler, 1997) and, therefore, only indicate night habitat preferences. Too few bull trout were seen during the day for diel comparisons.

A snorkeler and bank observer worked slowly upstream, aided by low intensity lights to avoid scaring fish. The bank observer searched in water too shallow for the snorkeler as described by Bonneau et al. (1995). When a fish was encountered, the species, total length and focal point elevation (height above stream bottom) were recorded. Length was estimated to the nearest 5 mm using a transparent ruler held within a few centimeters of the fish. A numbered, bright colored washer was then placed at the focal point of the fish. The day after snorkeling, the following physical habitat characteristics were measured or characterized: total depth, focal point velocity, distance to nearest cover (nearest location capable of hiding entire fish from view) and dominant substrate type.

Analyses

All data on juvenile fish use were summarized for each tributary by species for fish under 66 mm TL (hereafter called small fish) and for fish between 66 and 130 mm TL (hereafter called large fish). Habitat availability and use were compared for each fish group, between groups and between seasons for each group. Pearson correlation coefficients were also calculated between variables. Continuous variables (total depth, focal point elevation, velocity and distance to nearest cover) were compared using a Mann-Whitney U-test (Zar, 1984). Where significance was found, values of habitat selection (D) were calculated from Jacob's formula (1974):

$$D = r - p/[(r + p) - 2rp],$$

where r is proportion of a habitat type used by fish and p is the proportion of that habitat type available in each stream. Values of D between 0 and −0.5 indicated avoidance, −0.5 and −1.0 strong avoidance, 0 no avoidance or selection, 0 and 0.5 selection, and 0.5 and 1.0 strong selection. Categorical data such as substrate types contained too many categories with few observations within size group and season for meaningful statistical comparisons.

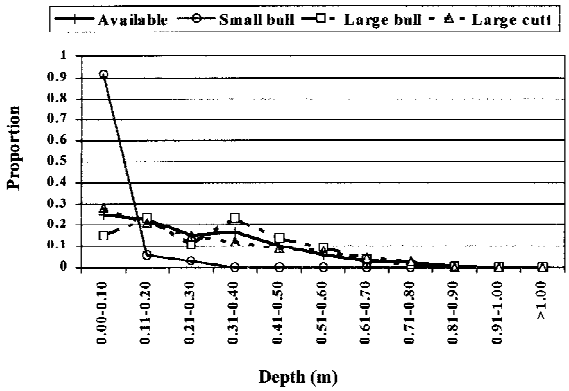

Figure 1. Available and used depths (m) by bull trout and cutthroat trout in Tenmile Creek during the summer.

Results

Both bull trout and cutthroat trout were found in all four reaches of Tenmile Creek during the summer and fall. However, no small cutthroat trout were observed in the survey reaches. Microhabitat measurements were made for 388 fish (321 bull trout and 67 cutthroat trout) during the summer and for 343 fish (284 bull trout and 59 cutthroat trout) during the fall (see Tables 1 and 2). There was little correlation between continuous habitat availability variables (depth vs. velocity, −0.05 summer, 0.01, fall). Similarly, for utilized habitat, variables were generally independent, with the exception of total depth and focal point elevation for small bull trout (see Table 3).

Total Depth

Summer

Small bull trout utilized significantly shallower water (mean, 0.05 m) than expected based on availability (mean, 0.25; $p<0.05$), strongly selected water less than 0.10 m deep and strongly avoided deeper water (see Fig. 1, Table 4). Conversely, large bull trout and large cutthroat trout utilized significantly deeper water (mean, 0.30 m) than expected based on availability (mean, 0.25; $p<0.05$). Large fish generally selected depths between 0.30 and 0.70 m and avoided shallow

Table 1. Summary of microhabitat variables for bull trout and cutthroat trout in Tenmile Creek during the summer. Total depth (TD), focal point elevation (FE), focal point velocity (FV), distance to nearest cover (DC)

Variable	Statistic	Habitat availability *n*=703	Small bull trout *n*=72	Large bull trout *n*=249	Large cutthroat trout *n*=67
TD (m)	Mean	0.25	0.05	0.30	0.39
	Range	0.00–1.04	0.03–0.27	0.03–0.82	0.03–0.70
	St. Error	0.01	0.01	0.01	0.02
FE (m)	Mean	n/a	0.02	0.06	0.07
	Range	n/a	0.01–0.08	0.00–0.52	0.00–0.61
	St. Error	n/a	0.00	0.00	0.01
FV (m/s)	Mean	0.15	0.03	0.02	0.05
	Range	0.00–1.50	0.00–0.23	0.00–0.19	0.00–0.21
	St. Error	0.01	0.01	0.00	0.01
DC (m)	Mean	n/a	0.19	0.38	0.33
	Range	n/a	0.00–1.70	0.00–2.00	0.00–2.00
	St. Error	n/a	0.04	0.03	0.04

Table 2. Summary of microhabitat variables for bull trout and cutthroat trout in Tenmile Creek during the fall. Total depth (TD), focal point elevation (FE), focal point velocity (FV), distance to nearest cover (DC)

Variable	Statistic	Habitat availability *n*=667	Small bull trout *n*=114	Large bull trout *n*=170	Large cutthroat trout *n*=59
TD (m)	Mean	0.20	0.19	0.44	0.49
	Range	0.00–0.82	0.03–0.61	0.03–1.26	0.03–0.98
	St. Error	0.01	0.01	0.02	0.02
FE (m)	Mean	n/a	0.00	0.00	0.04
	Range	n/a	0.00	0.00–0.01	0.00–0.70
	St. Error	n/a	0.00	0.00	0.10
FV (m/s)	Mean	0.08	0.08	0.01	0.01
	Range	0.00–0.69	0.00–0.05	0.00–0.08	0.00–0.09
	St. Error	0.00	0.00	0.00	0.00
DC (m)	Mean	n/a	0.09	0.21	0.23
	Range	n/a	0.00–2.00	0.00–2.00	0.00–1.50
	St. Error	n/a	0.02	0.03	0.04

Table 3. Pearson correlation coefficients for microhabitat variables used by bull trout and cutthroat trout during the summer and the fall. Fall values indicated by (). Total depth (TD), focal point elevation (FE), focal point velocity (FV), and distance to nearest cover (DC)

Fish Group	Variable	TD	FE	FV	DC
Small bull trout	TD	1.00 (1.00)			
	FE	1.00 (0.00)	1.00 (1.00)		
	FV	0.27 (−0.06)	0.27 (0.00)	1.00 (1.00)	
	DC	0.68 (0.09)	0.68 (0.00)	0.39 (0.35)	1.00 (1.00)
Large bull trout	TD	1.00 (1.00)			
	FE	0.25 (0.00)	1.00 (1.00)		
	FV	−0.12 (−0.03)	0.04 (−0.04)	1.00 (1.00)	
	DC	0.20 (0.41)	0.19 (−0.04)	0.28 (−0.02)	1.00 (1.00)
Large cutthroat trout	TD	1.00 (1.00)			
	FE	−0.18 (−0.06)	1.00 (1.00)		
	FV	0.03 (−0.06)	0.03 (0.01)	1.00 (1.00)	
	DC	−0.11 (0.34)	0.15 (−0.13)	0.27 (−0.05)	1.00 (1.00)

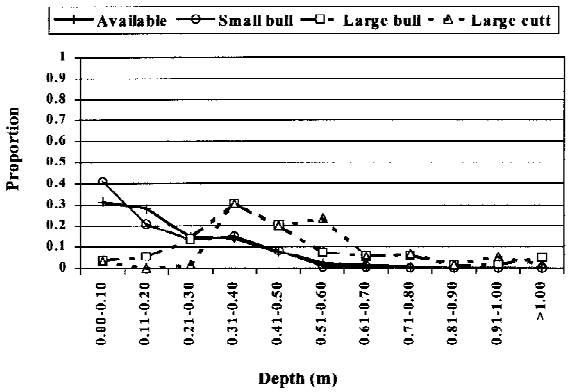

Figure 2. Available and used depths (m) by bull trout and cutthroat trout in Tenmile Creek during the fall.

water. When comparisons were made between each fish group, utilized depths were significantly different among all three groups ($p<0.05$).

Fall

Small bull trout utilized water significantly shallower (mean, 0.19 m) than expected based on availability (mean, 0.25; $p<0.05$), selected water between 0.01 and 0.50 m and avoided the deepest areas (see Fig. 2, Table 4). Large bull trout (mean, 0.44 m) and large cutthroat trout (mean, 0.49 m) utilized water significantly deeper than expected based on availability (mean, 0.20 m; $p<0.05$). Large fish selected depths over 0.30 m, and strongly selected for depths over 0.40 m. As in summer, when comparisons were made between each fish group, utilized depths were significantly different among all three groups ($p<0.05$).

Summer vs. fall

All three groups of fish utilized significantly deeper water in the fall than in the summer ($p<0.05$). This use of deeper water occurred even though the available mean depth was 0.05 m less in fall than in summer.

Focal point elevation

Summer

Small bull trout (mean, 0.02 m) occupied focal point elevations significantly closer to the bottom than both large bull trout (mean, 0.06 m) and large cutthroat trout (mean, 0.07 m; $p<0.05$). However, no significant difference was found between large bull trout and large cutthroat trout ($p>0.05$).

Fall

Both small and large bull trout occupied positions directly on the bottom, but large cutthroat occupied focal point elevations significantly higher than small and large bull trout (mean, 0.04 m;$p<0.05$).

Summer vs. fall

All three groups of fish selected focal point elevations that were significantly lower in fall than in summer ($p<0.05$).

Table 4. Selection by depth category for bull trout and cutthroat trout in the summer and fall. (−− strongly avoided, − avoided, 0 no preference, + selected, ++ strongly selected)

Fish group	Season	Depth (m)										
		0.00–0.10	0.11–0.20	0.21–0.30	0.31–0.40	0.41–0.50	0.51–0.60	0.61–0.70	0.71–0.80	0.81–0.90	0.91–1.0	>1.0
Small bull trout	summer	++	−−	−−	−−	−−	−−	−−	−−	−−	−−	−−
	fall	+	−	−	+	+	−	−	−−	−−	−−	−−
Large bull trout	summer	−	+	−	+	+	+	+	−	−	−−	−−
	fall	−−	−−	−	+	++	++	++	++	++	++	++
Large cutthroat trout	summer	−	+	−	+	+	+	+	−	−	−	−
	fall	−−	−−	−−	+	++	++	++	++	++	++	++

Table 5. Selection by velocity category for bull trout and cutthroat trout in the summer and fall. (−− strongly avoided, − avoided, 0 no preference, + selected, ++ strongly selected)

Fish group	Season	Velocity (m/s)										
		0.00–0.05	0.06–0.10	0.11–0.15	0.16–0.20	0.21–0.25	0.26–0.30	0.31–0.35	0.36–0.40	0.41–0.45	0.46–0.50	>0.51
Small bull trout	summer	++	−	+	−	−−	−−	−−	−−	−−	−−	−−
	fall	++	−−	−−	−−	−−	−−	−−	−−	−−	−−	−−
Large bull trout	summer	++	+	−	−−	−−	−−	−−	−	−	−−	−−
	fall	++	−−	−−	−−	−−	−−	−−	−−	−−	−−	−−
Large cutthroat trout	summer	+	+	−	−	−	−−	−−	−−	−−	−−	−−
	fall	++	−−	−−	−−	−−	−−	−−	−−	−−	−−	−−

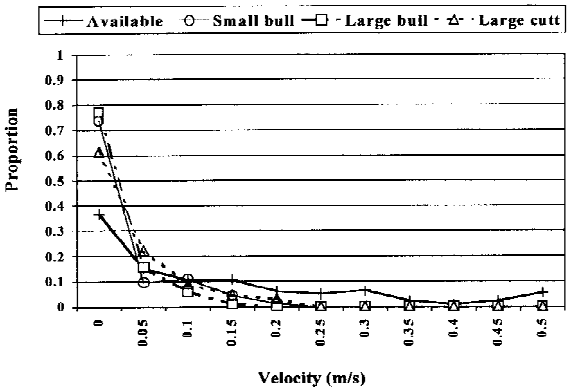

Figure 3. Available and used velocities (m/s) by bull trout and cutthroat trout in Tenmile Creek during the summer.

Focal point velocities

Summer

During the summer, focal point velocities for small bull trout (mean, 0.03 m/s), large bull trout (mean, 0.02 m/s), and large cutthroat trout (mean, 0.05 m/s) were significantly lower than expected based on availability (mean, 0.15 m/s; $p<0.05$; see Fig. 3). All three fish groups selected for velocities under 0.15 m/s, and even more strongly for velocities under 0.05 m/s (see Table 5). Focal point velocities utilized by small bull trout and large bull trout were not significantly different from each other ($p>0.05$). However, both groups of bull trout utilized velocities significantly lower than large cutthroat trout ($p<0.05$).

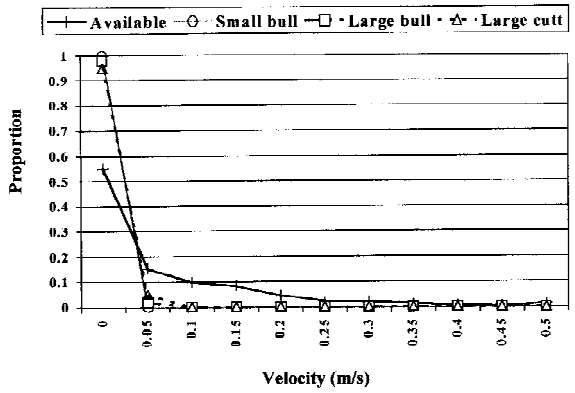

Figure 4. Available and used velocities (m/s) by bull trout and cutthroat trout in Tenmile Creek during the fall.

Fall

During the fall, all three fish groups utilized focal point velocities near zero. Small bull trout (mean, 0.00 m/s), large bull trout (mean, 0.01 m/s), and large cutthroat trout (mean, 0.02 m/s) utilized significantly lower velocities than expected based on availability (mean, 0.08 m/s; $p<0.05$; see Fig. 4). All three fish groups selected strongly for velocities less than 0.05 m/s (see Table 5). When comparisons between focal point velocities were made among the three groups, no significant differences were found ($p>0.05$).

Summer vs. fall

Available velocities were significantly lower in the fall (mean, 0.08 m/s) than in the summer (mean, 0.15 m/s; $p<0.05$). All three groups of fish also utilized focal point velocities significantly lower in the fall than in the summer ($p<0.05$).

Distance to nearest cover

Summer

All three fish groups differed significantly from each other ($p<0.05$) in distance to nearest cover. Small bull trout occupied positions closest to cover (mean, 0.19 m) followed by large cutthroat trout (mean, 0.33 m) and large bull trout (mean, 0.38 m).

Fall

Small bull trout (mean, 0.09 m) were significantly closer to cover than either large bull trout (mean, 0.21 m), or large cutthroat (mean, 0.23 m; $p<0.05$). However, no significant difference in distance to cover was found between large cutthroat trout and large bull trout ($p>0.05$).

Summer vs. fall

All three groups of fish were located significantly closer to cover during the fall than during the summer ($p<0.05$).

Substrate

Summer

Small bull trout selected strongly for large gravel and small gravel substrates and strongly avoided all other substrate types (see Table 6). Large bull trout selected for a wider range of coarse substrate types, including large and small cobble and gravel, but avoided boulders and silt. Large cutthroat trout selected for large and small gravel, but avoided boulders, large and small cobble, and silt. High electivity values for organic matter by large bull trout and bedrock by large cutthroat trout may have been an artifact of low availability, i.e., very few observations of each substrate type.

Fall

In fall, small bull trout strongly selected for small and large gravel, whereas large bull trout strongly selected for large cobble and large gravel (see Table 6). Selection for organics by large bull trout may have been an artifact of low availability (only 2 observations). Generally, large cutthroat trout selected finer substrates than bull trout, ranging from large gravel to silt.

Summer vs. fall

In the fall, both small and large bull trout expanded their selection to include larger substrates such as large and small cobble. However, large cutthroat selected finer substrates (sand and silt) in the fall than in the summer.

Discussion

The use of shallow water along stream margins by small (age-0) juvenile bull trout is consistent with results of other studies. Dolloff & Reeves (1990) reported that age-0 Dolly Varden (*Salvelinus malma*) utilized shallow areas with low velocities in simulated stream experiments. Similarly, age-0 bull trout and cutthroat trout utilized this these sites almost exclusively in small high gradient streams of northern Idaho (Saffel & Scarnecchia, 1995; Bonneau & Scarnecchia, 1998) and Montana (Pratt, 1984). Goetz (1994) also observed a strong affinity for stream edge areas by age-0

Table 6. Selection by substrate category for bull trout and cutthroat trout in the summer and fall. (−− strongly avoided, − avoided, 0 no preference, + selected, ++ strongly selected). Bedrock (BD), boulder, (BO), large cobble (LC), small cobble (SC), large gravel (LG), small gravel (SG), sand (SA), silt (SI), organics (OR)

Fish group	Season	Substrate type								
		BD	BO	LC	SC	LG	SG	SA	SI	OR
Small bull trout	summer	−−	−−	−−	−−	++	++	−−	−−	−−
	fall	−−	−−	+	−	++	++	−−	−−	0
Large bull trout	summer	−	−	+	+	+	+	−	−	++
	fall	+	−	++	+	++	+	−	−−	++
Large cutthroat trout	summer	++	−	−	−	+	+	−	−−	0
	fall	−−	−−	−−	−−	+	−	+	+	0

bull trout in spring-fed tributaries of the Metolius River, Oregon. Moore & Gregory (1988) reported the abundance of age-0 cutthroat trout was proportional to the area of shallow, edge sites in a small stream of the Cascade Mountains, Oregon.

The use of shallow, low velocity areas by age-0 fish may have several advantages. One advantage would be avoidance deeper water where large bull trout and other aquatic predators are found. Bull trout longer than approximately 100 mm TL are primarily piscivorous and are also known to be cannibalistic (Cavender, 1978; Allan, 1980; Armstrong & Morrow, 1980; Shepard et al., 1984b; Bonneau, 1994). Adult bull trout have been observed feeding on juvenile cutthroat trout and bull trout after digging for them in the substrate (Horner, 1978).

A second advantage of occupying low-velocity areas in stream margins would be a reduction in the chance of being displaced by swift water (Moore & Gregory, 1988). The fast currents found in the main channel often exceed the swimming ability of age-0 fish. Hence, fish swept downstream are easily preyed upon by other fish.

A third advantage of occupying low-velocity water may be energetic. Salmonids are known to occupy positions that maximize energy consumption and growth (Everest & Chapman, 1972). Low-velocity areas adjacent to faster water are thought to give fish the greatest net energy gain (Fausch, 1984). Such focal positions are common at the interface between stream margins and main channels (Moore & Gregory, 1988).

Occupancy of shallow, near edge sites not only maximizes feeding opportunities due to its proximity to the main channel, but also can increase growth due to higher stream temperature. In Moores Creek, a stream very similar to and near Tenmile Creek, we found water temperatures in occupied backwater areas exposed to direct sunlight were warmer (12.0 °C) than the main channel (10.0 °C). Warmer water is known to increase growth in salmonids (Brett et al., 1969; Jobling, 1981). Preliminary results from a recent study indicate maximum growth of bull trout occurred at 12.0 °C in a laboratory (T. McMahon, pers. comm., 1999).

Age-0 and larger juvenile bull trout were found associated with larger substrates during the fall than in the summer. This seasonal change in substrate selection has been documented for other salmonids. Johnson & Kucera (1985) reported that age-0 steelhead used gravel and cobble in the summer and shifted to cobble and boulders in the fall. Similar shifts were observed by Rimmer et al. (1984) in age-0, age-1 and age-2 Atlantic salmon. Bonneau & Scarnecchia (1998) observed bull trout and cutthroat trout utilizing coarser unembedded substrates in the winter than in summer. Use of coarse substrates in fall and winter months helps prevent injury due to ice and reduces the likelihood of displacement during high flow events (Chapman & Bjornn, 1969; Bustard & Narver, 1975).

The results of this study further emphasize the importance of deep, low-velocity areas for fall rearing of both species. Both bull trout and cutthroat trout used significantly deeper, lower velocity water when temperatures shifted from 9.0 to 12.0 °C in the summer to 0.5 to 3.5 °C in the fall. Similar shifts in habitat use were reported by Jakober (1995) who reported

stronger preference for slower, deeper areas in the winter than in the fall for both bull trout and cutthroat trout. Bonneau & Scarnecchia (1998) found a comparable shift in the use of habitat types during the day between summer and winter for both species. Other researchers studying salmonids have also observed shifts in habitat type selection toward deeper, slower water in the fall and winter (Bustard & Narver, 1975; Campbell & Neuner, 1985; Cunjak & Power, 1986; Baltz et al., 1991).

Selection of deeper, low-velocity water in the fall may reflect avoidance of both unprofitable energy loss and mammalian predators (Bachman, 1984; Fausch, 1984). As temperatures decline, the metabolic rates of salmonids decrease (Riemers, 1957), their swimming ability is reduced and they are less able to feed or avoid terrestrial and avian predators (Webb, 1978; Rimmer et al., 1983, 1984). In the fall, we observed cutthroat trout resting on or near the bottom well away from typical foraging positions. When temperatures in the fall were as low as 0.5–3.0 °C, cutthroat trout were sluggish and did not move unless prodded repeatedly. However, bull trout were more responsive than cutthroat trout and darted for cover when disturbed.

The shift to deeper, lower-velocity water in the fall by both large and small fish indicates the importance of these habitat characteristics for survival. Logging and other management activities that increase fine sediment or water yield can adversely affect these habitat attributes by filling pools and interstitial spaces between coarse substrate (Chamberlin et al., 1991; Hicks et al., 1991). Intrusion of fine sediment is known to be detrimental to salmonids consequently limiting the rearing capacity of streams (Bjornn, et al., 1977).

Although the results of this study indicate the importance of these habitat types in the fall, future research is needed to quantify specific habitat needs throughout the winter. Habitat availability and use could be limited further by presence of anchor ice and ice scour. A full understanding of the habitat requirements throughout the daily, annual and life history cycles is essential for managers to sustainably manage these sensitive species.

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