

Microhabitat Use by Juvenile Bull Trout in Four Streams Located in the Eastern Cascades, Washington

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Abstract. - The bull trout, *Salvelinus confluentus*, is a stream and lake dwelling salmonid native to western North America. Four streams were studied in the Yakima and Wenatchee River drainages in central Washington to estimate densities and assess habitat use by juvenile bull trout. These streams have been recommended by the Washington Department of Fish and Wildlife for long term monitoring. Night-snorkeling techniques were used to determine bull trout densities and habitat use. Six hundred and fifty six juvenile bull trout were found in the 12.4 stream km that were snorkeled during the summer 1992. Sixty-eight juveniles were found in the 3 stream km surveyed during winter and spring 1992. Density estimates of juvenile bull trout ranged from 0.03 to 4.06 fish/100 m². During winter and spring, the density of juveniles in Indian Creek was 0.23 fish/100 m². The total length of juvenile bull trout ranged from 60 mm to 300 mm. However, some of the fish smaller or equal to 300 mm may have been sexually mature. Microhabitat data were collected on 589 juveniles. Shallow channel margins and backwater areas of riffles were generally used. The water depth and substrate occupied by the juveniles varied between and within each stream during winter, spring, and summer. Juvenile bull trout occupied slow-moving water usually less than 0.05 m/sec with no significant difference detected between streams or seasons. Less than 20% of the fish were found utilizing overhead cover at night but the fish were usually less than 72 cm from cover. Even though juveniles were not often found immediately under cover during the nighttime, areas without cover supported fewer juvenile bull trout. This study examined nighttime habitat use only and the results should not be extrapolated to describe habitat use during the daylight hours.

The bull trout, *Salvelinus confluentus*, is a stream and lake dwelling salmonid native to western North America. Within the Yakima and Wenatchee river basins in eastern Washington, bull trout are located in lakes and streams. Populations have been declining throughout their historical range due to many numerous and interrelated factors (Carl 1985; Fraley and Shepard 1989; Goetz 1989) such as habitat degradation, over-fishing, interspecific competition, and predation. Bull trout populations in the eastern Cascade Mountains of Washington have declined in distribution and abundance in the past 50 years (Brown 1992). The Washington Department of Fish and Wildlife have recommended long-term monitoring for several streams in the Wenatchee National Forest to include: 1) habitat use by juveniles; 2) juvenile bull trout abundance; and 3) adult bull trout populations.

Identification of microhabitat use by salmonid species is necessary to understand the ecology of a species and to ensure the success of future stream habitat restoration projects. Stream habitat availability data is also important to assess any natural or management related environmental changes within streams. Juvenile bull trout have specific rearing habitat requirements and the biology of the species in the eastern Cascade Mountains in Washington is not well known. The majority of published data regarding bull trout habitat use are based on studies of populations in Montana and Oregon (Fraley and Shepard 1989; Goetz 1991; Graham et al. 1980; Pratt 1984).

Habitat use by juvenile bull trout during the summer has been more thoroughly studied than winter habitat. Winter

habitat components have been recognized as an important part of the life history for salmonid species (Chisholm et al. 1987). The purpose of this study was: 1) to determine juvenile bull trout densities; 2) to describe and quantify the habitat use by juvenile bull trout during winter, spring, and summer; 3) to describe and quantify instream habitat characteristics of each study stream.

Study Site

In order to acquire baseline data on bull trout habitat use in Washington, four streams were chosen that were known to contain self-sustaining bull trout populations. South Fork Tieton River, Indian, Chikamin, and Rock creeks have been recommended by the Washington Department of Fish and Wildlife for long-term monitoring. The streams are located in the Wenatchee National Forest in Central Washington and are relatively accessible (Fig. 1).

South Fork Tieton River and Indian Creek, Yakima River drainage, are tributaries of Rimrock Reservoir (Fig. 2). Rimrock Reservoir supports an adfluvial population of bull trout. South Fork Tieton River, a 4th order stream, was surveyed from Corral Creek (T12N R13E Sec 6) to approximately 1.0 stream km downstream of the barrier falls (T12N R12E Sec 12). This is a fairly low gradient river. Indian Creek, a 3rd order stream, was surveyed from its confluence at Rimrock Reservoir (T13N R13E Sec 6) to a possible barrier falls (T14N R12E Sec 20). Indian Creek is a low gradient

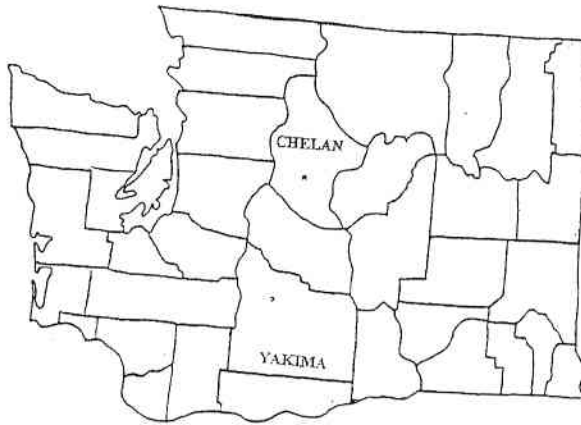


Figure 1. Map of county and location of streams surveyed in the Wenatchee National Forest.

stream with an approximate 2,300 feet elevation gain in the 8.2 river miles. The headwaters of this stream are Pear and Apple lakes. This drainage basin is 9,168 acres and the entire area is located on National Forest land (Hoefler 1990). The last 1.5 stream km surveyed in reach 6 is located in the William O. Douglas Wilderness. Chikamin and Rock creeks, Wenatchee River drainage, are tributaries to the Chiwawa River located in the Entiat Mountain Range and may support adfluvial and fluvial populations of bull trout (Fig. 3). Chikamin Creek, a 2nd order stream, was surveyed from its confluence with Marble Creek (T28N R17E Sec 21) to its lower Forks (T29N R17E Sec 33). Rock Creek, a 3rd order stream, was surveyed from the bridge crossing of the Chiwawa River road (T29N R16E Sec 36) to a potential log jam barrier (T29N R17E Sec 7). The headwaters of Rock and Chikamin creeks are approximately 6,930 and 6,300 feet respectively.

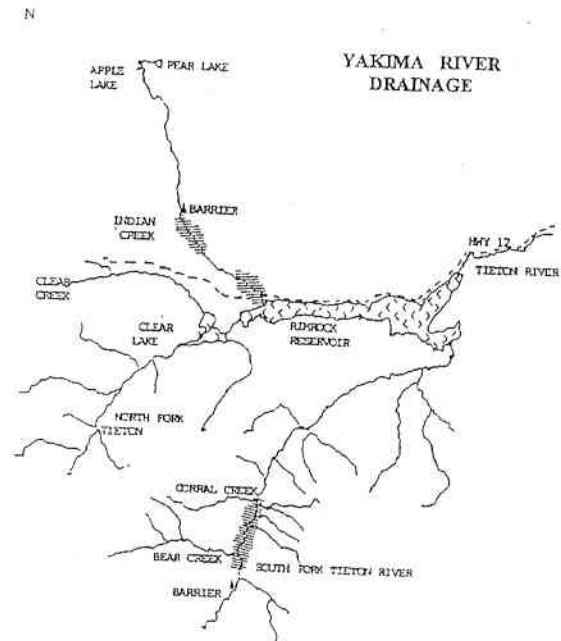
Methods

Density estimates and microhabitat

An approximately 3.0 km reach was surveyed in Indian Creek from February through April, 1992 to assess the habitat use of juvenile bull trout during winter and spring. A 12.4 km area was surveyed from 6 July 1992 to 3 September 1992 to assess habitat use in South Fork Tieton, Indian, Chikamin and Rock creeks during the summer (Table 1). Two 1.5 km reaches were surveyed within each stream by night snorkeling three adjacent 500 m sections in both the lower and upper reaches. An extra 500 m was surveyed in the lower reach of Indian

Table 1. Snorkelling periods for each stream during summer 1992.

Stream	Sampling period
South Fork Tieton	7/6 - 7/16
Indian Creek	7/20 - 8/4
Chikamin Creek	8/5 - 8/20
Rock Creek	8/24 - 9/2



1 cm = 1.4 miles

Figure 2. Map of the study streams in the Yakima River Drainage, Washington 1992. (shaded areas designate sample sites, ---=roads, <<>>=water)

Creek and only 1.4 km surveyed in the upper reach. The lower reach of Indian and Chikamin creeks had three alternating 500 m sections surveyed in each stream. Sampling in each stream was usually completed within a two week period.

Initially, sampling was attempted by snorkeling during daylight hours and using a back-pack electroshocker. Experiments during the winter and summer indicated that snorkeling at night was the most effective method for estimating juvenile bull trout densities. For example, a 700 m reach of Indian Creek snorkeled during the day resulted in no juvenile bull trout being found while the reach snorkeled at night resulted in locating seven juvenile bull trout.

Daytime electroshocking had similar results. A 500 meter section of the South Fork Tieton River was electroshocked and only one juvenile bull trout was found. However, nighttime snorkeling in the same reach yielded 22 juvenile bull trout. Consequently, night snorkeling techniques were used to assess microhabitat and density estimates of juvenile bull trout because they were believed to provide a more accurate assessment of actual bull trout numbers.

Typically, a 500 m reach was snorkeled each night by two divers moving upstream while searching for fish in all habitats encountered. When a diver located a fish identified as a bull trout, a colored metal washer was placed on the substrate directly beneath the focal point of the fish. Each fish site was flagged and numbered. The bull trout observed at night were usually extremely docile; consequently, snorkelers using underwater flashlight were able to measure the total length (TL) of each fish to the nearest 10 mm. This was done by placing a hand-held plastic ruler above, or beside, each fish.

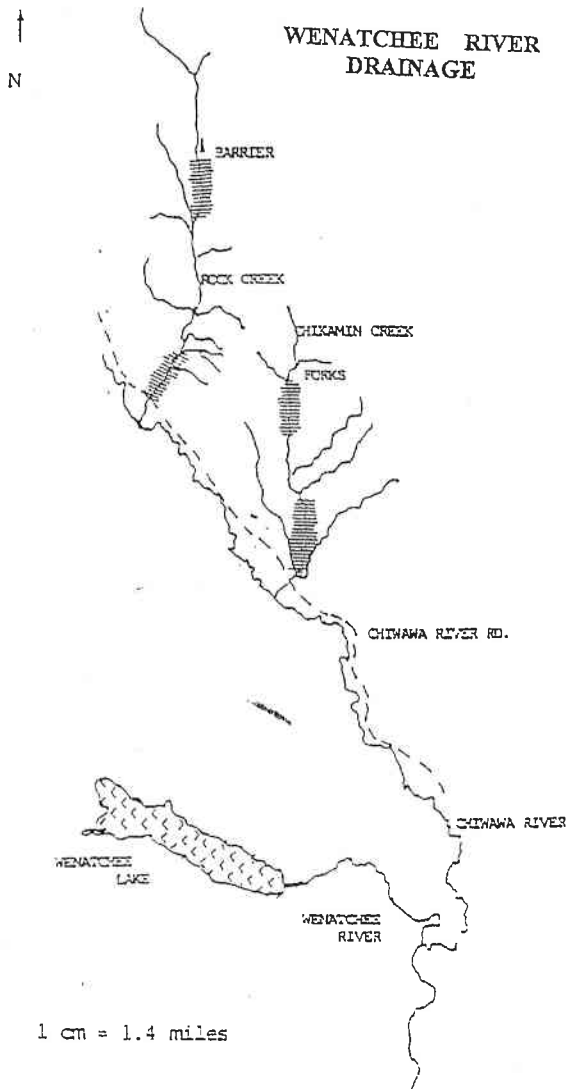


Figure 3. Map of the study streams in the Wenatchee River Drainage, Washington 1992. (shaded areas designate sample site, ---=roads, <<=>=water)

Microhabitat was quantified within a 1 m² area around the fish by measuring water depth, current velocity, substrate, and cover at each fish focal point. An additional eight measurements were collected of the water depth, substrate and cover located along an imaginary X-Y axis at 25 and 50 cm from the focal point (Fig. 4). Data presented on water depths, substrate and cover at fish locations are average values within the 1 m² measured area. The current velocities at each fish focal point were measured at 60 and 100 (bottom) percent of the water column with a Marsh-McBirney electronic flow meter. A modified Wentworth Particle Size scale was used for coding the substrate (Table 2). Cover types were classified using an alphabetical code (Table 3).

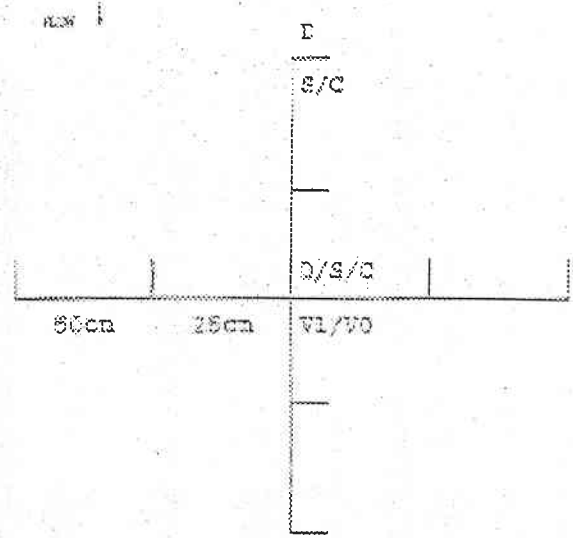


Figure 4. Diagram of microhabitat measurement points at each bull trout location during summer and winter/spring 1992. (D=water depth, S=substrate, C=cover, V1=current velocity at 60% depth, V0=current velocity at 100% depth)

Stream Characteristics

Habitat characteristics for each of these streams were determined by measuring the physical habitat within each study reach. Water depth, current velocity and substrate were measured at six points across the width of the stream at 100 m intervals. Current velocities were measured at 60 and 100 (bottom) percent of the water column with a Marsh-McBirney electronic flow meter.

Each 500 m transect was divided into riffles, pools and glides using a modified Hankin-Reeves method (Hankin and Reeves 1988). The length and width of all riffles, pools and glides were visually estimated with each 5th riffle, 3rd pool and 2nd glide being estimated and measured. Riffles were identified as shallow reaches of the stream with moderate to high current velocities and a stream substrate dominated by pebble and cobble sized particles. In high gradient riffle areas,

Table 2. Modified Wentworth Particle Size scale used to classify substrate in the study streams.

Code	Substrate	Classification
1	Detritus	----
2	Silt	----
3	Sand	----
4	Gravel	2-16 mm
5	Pebble	17-64 mm
6	Cobble	65-255 mm
7	Boulder	256+ mm
8	Bedrock	----

Table 3. Alphabetical code used to classify habitat cover types.

Code	Cover-type
A	Submerged vegetation
B	Small wood <30 cm
C	Large wood >30 cm
D	Overhanging vegetation
E	Rootwad
F	Boulder
G	Turbulence
H	Undercut bank
I	None
J	Log jam

substrates were generally coarser. Pools were described as scoured out depressions which were longer than wide and had small substrate and variable depths. Depressions were usually caused by woody debris or boulder. Glides were shallow areas with gravel/pebble substrate, low current velocity and no major flow obstructions. Large woody debris (>30 cm diameter), small woody debris (<30 cm diameter), rootwads, and log jams were enumerated. The decline in elevation for each 1.5 km reach was determined in meters and then converted to a percent grade to determine gradient.

Results

Density estimates

During summer 1992, 656 juveniles were found in the 12.4 km surveyed in the study streams. Juvenile bull trout found in each 3 km surveyed during the summer ranged from 101 to 242 individuals; the highest number of juveniles was observed in Chikamin Creek. The densities of juvenile bull trout within 500 m sections ranged from 0.03 fish/100 m² in Indian Creek to 4.06 fish/100 m² in Chikamin Creek (Table 4). The average density of juvenile bull trout for all four study streams during the summer was 0.94 fish/100 m². In contrast, the total of 68 juveniles found in the three km reach surveyed in Indian Creek during winter and spring resulted in a density estimate of 0.23 fish/100 m².

Length-frequency histograms (Fig. 5) for juveniles from

Table 4. Densities of juvenile bull trout during the summer (#/m²) and winter/spring (#/m) sampling periods 1992.

Stream	Area surveyed (m)	Total #	Mean no. (range)
South Fork Tieton	3000	101	0.34 (0.08 - 0.70)
Indian Creek (summer)	3400	157	0.84 (0.03 - 2.0)
Indian Creek (win/spr)	3000	68	0.23
Chikamin Creek	3000	242	1.85 (0.15 - 4.06)
Rock Creek	3000	156	0.74 (0.05 - 1.15)

each stream suggest that the size distribution was similar among streams and between seasons ($t=0.72$, $P<0.47$) except for the South Fork Tieton River (ANOVA, $F=5.46$, $P<0.001$). Average length (TL) ranged from 122 mm in Chikamin Creek to 138 mm in South Fork Tieton River during the summer sampling period. During the winter and spring, the average total length of juvenile bull trout was 121 mm.

Juvenile microhabitat use (summer)

Microhabitat data were collected from 589 juvenile bull trout. The habitat data collected only pertains to nighttime and does not necessarily reflect daytime habitat use. Juvenile bull trout occupied pools, glides, and riffles. However, the majority of fish were found along channel margins and backwaters of riffles (Table 5). Juvenile bull trout usually occupied areas of shallow, low velocity water. Over 80% of the juveniles were found without overhead cover (Table 6), and with a mean distance of 72 cm to the nearest cover. The mean distance to cover was similar in all streams except South Fork Tieton River (ANOVA, $F=11.73$, $P<0.001$). The assessment of cover use includes fish seen using immediate cover and those found away from cover. Juvenile bull trout were usually found using boulders as cover except in South Fork Tieton River (Fig. 6). The majority of juveniles in Chikamin, Indian and Rock creeks were found in the mainstem of each stream. However, the South Fork Tieton River juvenile bull trout were most frequently within braided side channels and using large woody debris for hiding. Three-dimensional graphs showing the water depth, substrate, and current velocity at fish focal point were constructed to analyze juvenile bull trout microhabitat graphically (Fig. 7a-d). The water depths that juvenile bull trout used varied among the four streams (ANOVA, $F=11.73$, $P<0.001$). Juveniles were found using deeper water in the South Fork Tieton River. Bull trout were found either resting on, or moving slowly over, the substrate. The stream substrate used varied among the four streams (Kruskal-Wallis, $H=87.98$, $P<0.001$), and ranged from detritus to bedrock (Fig. 8). Juvenile bull trout located in the braided side channels of the South Fork Tieton were generally associated with small-sized substrate particles such as sand. In contrast, the substrates used by juveniles in the other three study streams were generally coarser (gravel to boulder). Juveniles occupied slow-moving water with mean flow rates less than 0.05 m/sec for each stream. No significant differences were found in the mean velocities at fish location between the four study streams (Kruskal-Wallis, $H=2.31$, $P>0.50$).

Table 5. Number of juvenile bull trout using various macrohabitat types during the summer 1992. (bwpr=backwater, pools, or riffles)

Stream	Pools	Riffles	Glides	Bwpr
South Fork Tieton	29	14	13	22
Indian Creek	8	89	3	45
Chikamin Creek	33	67	10	89
Rock Creek	8	63	0	56

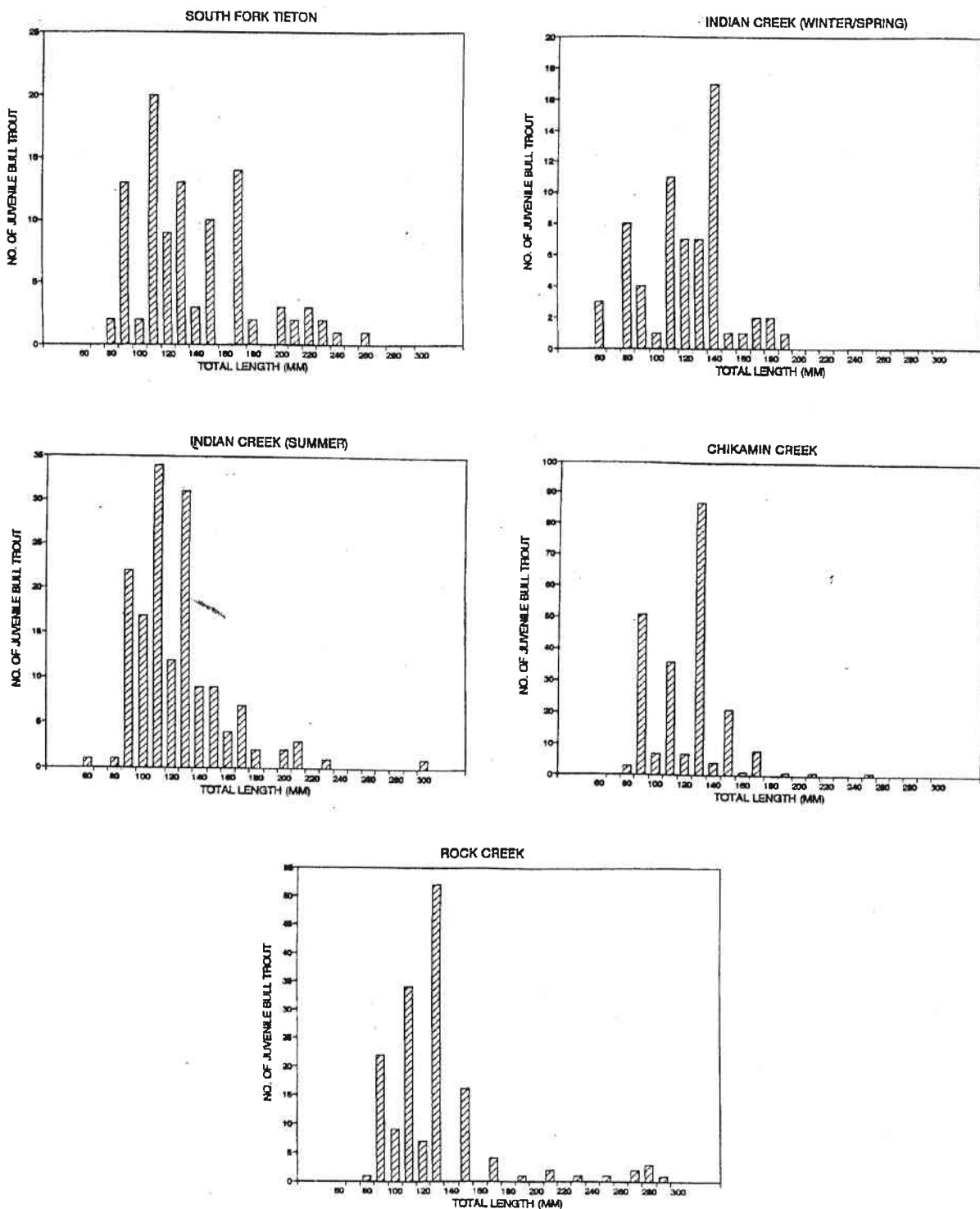


Figure 5. Length-frequency histograms for juvenile bull trout sampled in the four streams during the winter, spring and summer 1992.

Table 6. Number of juvenile bull trout found associated with cover during summer 1992.

Stream	# juveniles	# using cover	%
South Fork Tieton	101	19	18.8
Indian Creek	153	28	17.8
Chikamin Creek	176	23	13.1
Rock Creek	156	24	15.4

Juvenile microhabitat use (winter and spring)

Winter and spring habitat use by juvenile bull trout was studied from February through April, 1992 in Indian Creek. However, habitat availability was not measured. The approximate amount of snow water equivalent for Indian Creek for February through April was 2.08, 1.64, and 1.78 inches respectively with an annual sum of 21.71 inches. The stream temperatures during February through April ranged from 2 to 6°C.

Juveniles were found occupying the same stream reaches and similar habitats during winter, spring, and summer. Microhabitat measurements revealed that juveniles were occupying areas with similar velocities between seasons ($t=0.79$, $P>0.25$). But during the summer juveniles were found in areas with significantly deeper water ($t=7.06$, $P<0.001$). Juveniles rested on a wide variety of substrates and significant differences were found between the seasons ($t=5.51$, $P<0.001$). The majority of the bull trout juveniles were found with small woody debris as the nearest available cover during the winter and spring, whereas boulders were the nearest available cover found during the summer. Juveniles were significantly closer to cover during the winter and spring than the summer ($t=2.23$, $P<0.025$). Juvenile bull trout occupied microhabitats in low velocity pocket pools and backwater eddies during the winter and spring that were very similar to the microhabitats used during the summer.

Habitat availability

The water depths measured along the habitat transects differed between study streams ($F=53.83$, $P<0.001$). Juveniles in South Fork Tieton River and Rock Creek occupied mean depths similar to the mean water depths found along habitat transects. In contrast, juveniles in Chikamin and Indian creeks were occupying significantly deeper water than measured along habitat transects (Fig. 9a-b).

The mean current velocities along habitat transects varied between the study streams ($H=22.69$, $P<0.001$). Indian Creek had the highest mean velocity. The mean velocity from habitat transects among the streams was greater than 0.16 m/sec, suggesting that water selected by fish was significantly slower than the mean stream velocity (Fig. 9a-b).

Riffles accounted for over 90% and pools less than 7% of each stream. Except for the South Fork Tieton River, the streams were narrower in the upper reaches. However, the lower reach of South Fork Tieton River contained numerous

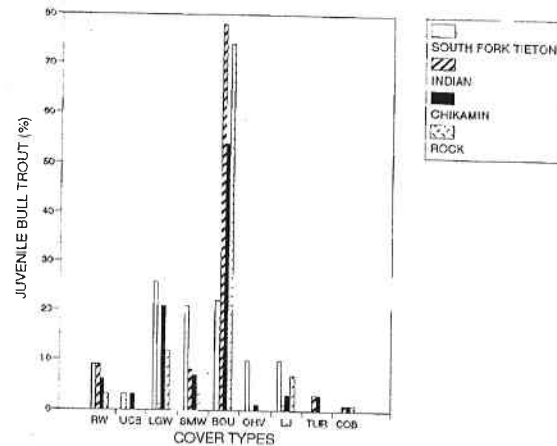


Figure 6. Bar graph representation of nearest cover types used by juvenile bull trout (% of total individuals) in the four study streams during the summer 1992. (RW = rootwad, UCB = undercut bank, LGW = large wood, SMW = small wood, BOU = boulder, OHV = overhanging vegetation, LJ = log jam, TUR = turbulence, COB = cobble)

side channels that were not included in the stream width measurements.

The amount of woody debris present varied between upper and lower reaches of individual streams, and between streams. Total woody debris present in each stream was greater in the lower reach except in Rock Creek. A higher occurrence of large wood was found in Chikamin and Rock creeks than in the other study sites (Table 7).

The percent gradient among study reaches ranged from 2% in South Fork Tieton River to 6% in Chikamin Creek. In general, higher gradients were found in the upper reaches of each stream, where the highest densities of juvenile bull trout were found. Maximum temperature between study streams during the summer sampling periods ranged from 9.5°C in Indian Creek to 12.5°C in South Fork Tieton River.

A stepwise multiple regression was used to determine the relationship between the physical habitat characteristics of streams and juvenile bull trout densities. Bull trout density in each 500 m section was assessed as either low (<12 individuals) or high (>12 individuals). This analysis attempts to determine whether certain instream habitat characteristics

Table 7. Total and percent composition of woody debris found in each study stream during summer 1992.

Stream	Total	Rootwad	<30 cm	>30 cm	Log Jam
South Fork Tieton	230	18	38	33	11
Indian Creek	121	36	26	35	3
Chikamin Creek	251	16	23	50	11
Rock Creek	119	13	16	42	29

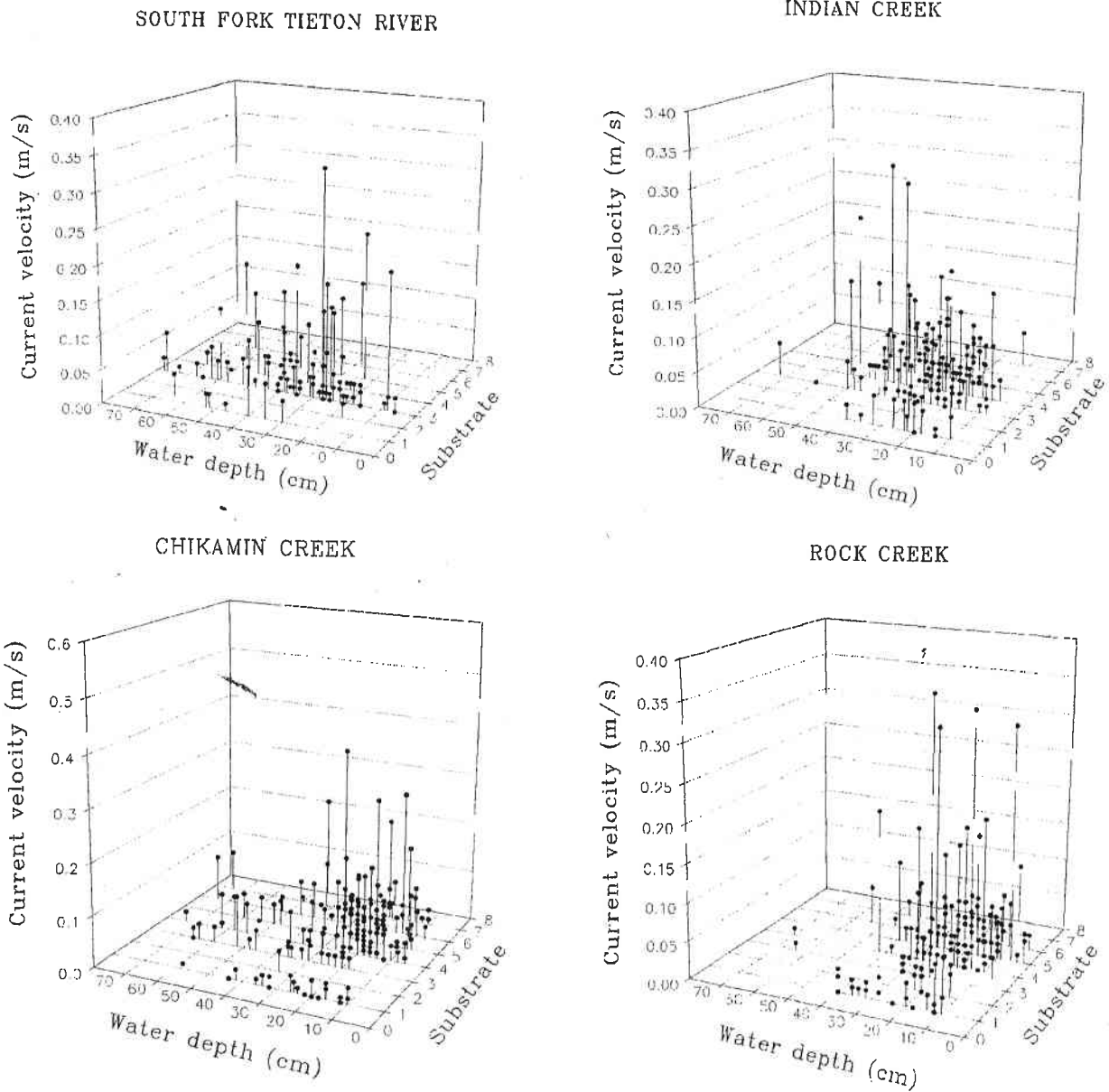


Figure 7. Graphical representation of juvenile bull trout microhabitat in the four study streams sampled during the summer 1992.

either singularly or in combination are correlated with bull trout densities. A total of 19 physical habitat variables were used in the analysis (Table 8). From this analysis, the combination of habitat variables that best explained differences in juvenile density were gradient, mean and standard deviation of current velocity at 100 percent of the water column, and the amount of large woody debris ($r^2=0.61$).

Discussion

Density Estimates

Juvenile bull trout densities varied greatly among study streams. The average density for all the streams was 0.94 fish/100 m². Density of juvenile bull trout present in the upper reach of Rock Creek may be underestimated because of the large number of adult bull trout that had moved into the tributary to spawn. The presence of pre-spawning adult bull trout may induce juveniles to remain under cover. Most streams surveyed during this study had relatively low densities of juveniles compared to those reported by other researchers. For example, age 1 bull trout in the South Fork of Coal Creek following a habitat enhancement project ranged from 12.8 to 14.2 fish per 100 m² area (Weaver 1991) and densities reported

Table 8. Instream habitat variables used in multiple regression analysis. (Std. = standard deviation)

Variables
Depth
Substrate
Velocity (60%)
Velocity (100%)
Stream. width
Std. depth
Std. substrate
Std. velocity (60%)
Std. velocity (100%)
Std. stream width
Total wood
Rootwad
Small wood
Large wood
Log jam
Gradient
Riffle (%)
Pool (%)
Glide (%)

by Pratt (1984) in the Flathead River, Montana were higher. However, densities reported in this study are similar to bull trout densities found in Sun Creek, Oregon (Dambacher et al. 1992).

The streams chosen during this study had a high number of redds prior to this study and were assumed to have high densities of juvenile bull trout (E. Anderson and L. Brown, Washington Department of Fish and Wildlife, pers. com.) Juvenile bull trout population densities are generally suspected to be an indication of the reproductive success of adults and of the overall condition of the population. However, high counts of spawning adults and redds do not always result in high juvenile populations. The Mad River in the Wenatchee National Forest had fewer adults and redds than the streams surveyed during this study but had higher densities of juveniles than any of my study streams (L. Brown, Washington Department of Fish and Wildlife, pers. com.).

The size and age of juveniles can vary between streams due to the stream temperature and productivity (Brown 1992; Pratt 1984). The sampling method employed in this study was found to be accurate for determining densities of juveniles greater than age 0. However, this method does not produce an accurate representation of age 0 juveniles. Goetz (1991) also suggested night snorkeling may not be suitable for determining age 0 juvenile bull trout densities.

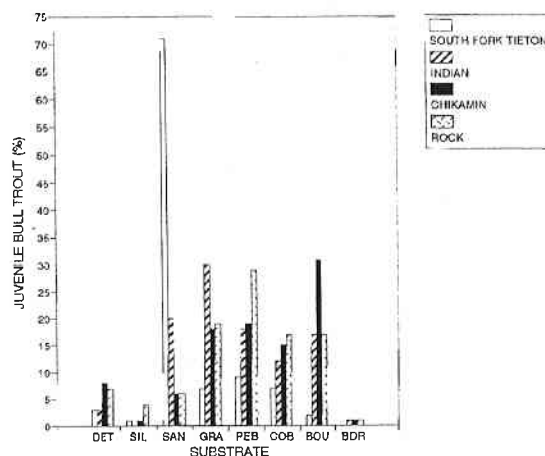


Figure 8. Bar graph representation of substrate used by juvenile bull trout (% of total individuals) for each stream surveyed during the summer 1992. (DET = detritus, SIL = silt, SAN = sand, GRA = gravel, PEB = pebble, COB = cobble, BOU = boulder, BDR = bedrock)

Juvenile habitat

Juvenile bull trout found at night were typically occupying slow, shallow, open water along stream margins. Slow water adjacent to riffles was usually formed by woody debris or complex boulder structures. These areas may be an important factor in the microhabitat of juvenile bull trout. Juvenile bull trout were frequently found occupying slow moving water adjacent to swifter water which allowed them to expend little energy. This type of microhabitat apparently results in the accumulation of drifting macroinvertebrates (Fausch 1984). Bull trout juveniles were found in similar microhabitats in Montana streams (Shepard et al 1984). Juvenile bull trout were predominately found in the channel margins of pools in Sun Creek, Oregon (Dambacher 1992). During the summer, less than 20 percent of juvenile bull trout were observed using overhead cover. Juvenile bull trout were found associated with large submerged wood or interstitial space between boulders during this study. Juveniles in the Metolius River Basin during the summer night sampling period were more closely associated with fine woody debris (Goetz 1991). Woody debris and unembedded substrate were also common cover for the juveniles in the Flathead River system (Pratt 1992). Juvenile bull trout found during this study were generally using similar cover as juveniles in the Metolius and Flathead river basins but were usually further from cover. Possibly the streams studied in Washington had less cover available. Generally, the juveniles were found foraging and resting over substrates ranging from detritus to bedrock at depths ranging from 5 - 75 cm. Juvenile bull trout in this study were observed to be mainly benthic foragers. The highest percentage of juvenile bull trout were found slightly above, or on the streambed which was generally dominated by substrate larger than gravel. Similarly, juvenile bull trout in the Flathead River Basin are usually near the substrate and considered benthic foragers

(Nakano et al. 1992). This was similar to findings in the Metolius (Goetz 1991) and Flathead river basins (Pratt 1992; Shepard et al. 1984).

Juveniles in South Fork Tieton River were usually found in side channels. These areas were shallow, had small substrate particles, and very little detectable flow. Such side channels may provide refuge from predation by larger adult bull trout and other large salmonids.

The pocket pool areas formed by woody debris or boulders provided areas of slow moving water (mean=0.05 m/sec) for juvenile bull trout. In contrast, the stream velocities at fish focal points were slightly greater in the Metolius (Goetz 1991) and Flathead (Shepard et al. 1984) river basins.

Areas occupied by juvenile bull trout were significantly slower than were available at the habitat transects suggesting fish were selecting areas with low current velocities. Therefore, it appears that juvenile bull trout select areas with little detectable flow regardless of the water depth or substrate available.

Winter and spring habitat use by juvenile bull trout in Indian Creek was very similar to that used during summer. Areas of Indian Creek that supported populations of juveniles during winter also had juveniles during the summer. However, Indian Creek has numerous ground water upwellings and above ground springs that provide a relatively constant water temperature throughout the year. The main differences in microhabitat use was that juveniles during winter and spring were found at shallower depths and usually closer to cover. However, the difference in water depth use was probably an artifact of increased water levels during the July sample period rather than an actual shift in habitat preference.

Complex channel structures that contained abundant woody debris may be an important factor in the abundance of bull trout juveniles. Even though the multiple regression analysis failed to detect any relationship between the physical characteristics of the streams and bull trout densities, stream reaches that supported low amounts of woody debris usually had lower densities. The habitat transects within each stream may have been measured on a scale too coarse to detect fine-scale microhabitat that is important to juvenile bull trout. Juvenile bull trout during the winter, spring, and summer consistently occupied areas with a slow current velocity. Since water depth and substrate varied between streams, this suggests that microhabitat components were not selected, but were used in proportion to availability. There is however, strong evidence to suggest that most fish actively select specific microhabitats rather than randomly choosing areas (Gosse 1981). Larkin (1956) stated that freshwater fish are versatile and plastic with respect to their adaptations to a wide range of environmental conditions. However, the results from this study show at night the fish are relatively consistent with respect to current velocity.

Incidental data was collected on other fish species observed during this study. Brook trout (*Salvelinus fontinalis*) were observed in Indian Creek using habitats similar to bull trout. However, young chinook salmon (*Oncorhynchus tshawytscha*), rainbow/steelhead trout (*Oncorhynchus mykiss*) and mountain whitefish (*Prosopium williamsoni*) were generally observed higher in the water column and further from shore than bull

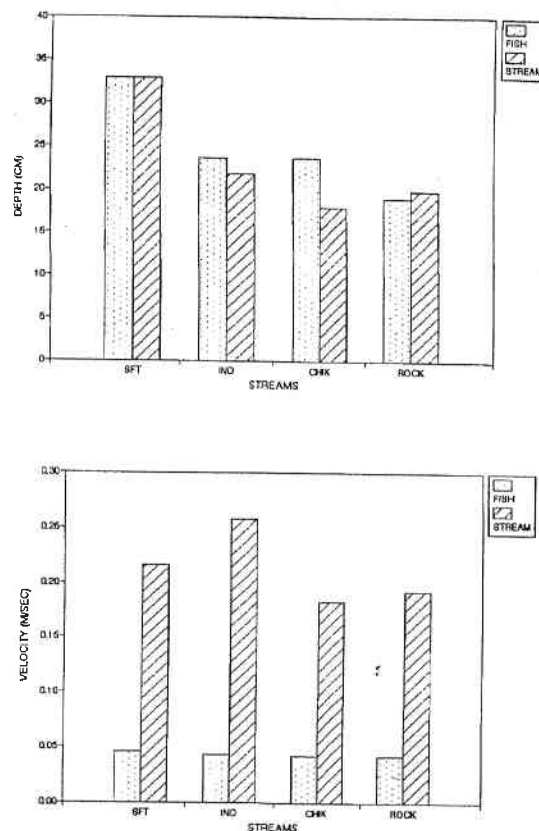


Figure 9a-b. Comparison of fish use and habitat availability for microhabitat variables of water depth (top) and velocity (bottom). (SFT = South Fork Tieton, IND = Indian Creek, CHIK = Chikamin Creek, Rock = Rock Creek)

trout suggesting they utilize faster moving water at night. Chinook salmon and rainbow/steelhead consistently selected areas inshore, which were shallow and slow moving, for nighttime habitat in the Wenatchee River (Hillman et al. 1989). This was similar to habitat used by bull trout during this study. Possible factors influencing nighttime habitat selection are reduced predation, reduction in energy expenditure, and feeding. The net energy gain and fitness might be maximized in these areas of low velocity (Fausch 1984).

Since this study only pertains to nighttime habitat use by juvenile bull trout, there is a need to study daytime habitat use for this species. During the daytime, juveniles appear to be using dense cover. This cover may be an important factor in the survival of this species and should be studied more intensively. This study only briefly describes the overwintering habitat use by juvenile bull trout. Winter habitat requirements are an important factor in the survival of bull trout in many streams located east of the Cascades. The available literature on this subject is extremely limited and consequently more studies to describe the overwintering requirements of bull trout are needed.

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References

- Brown, L. G. 1992. Draft management guide for the bull trout *Salvelinus confluentus* (Suckley) on the Wenatchee National Forest. Washington Department of Wildlife, Wenatchee.
- Carl, L. 1985. Management plan for bull trout in Alberta. Pages 71-80 in D. D. MacDonald, editor. Proceedings of the Flathead River Basin bull trout biology and population dynamics modelling information exchange. Fisheries Branch, B. C. Ministry of Environment, Cranbrook.
- Chisholm, I. M., W. A. Hubert, and T. A. Wesche. 1987. Winter stream conditions and use of habitat by brook trout in high-elevation Wyoming streams. Transactions of the American Fisheries Society 116:176-184.
- Dambacher, J. M., M. W. Buktenica, and G. L. Larson. 1992. Distribution, abundance, and habitat utilization of bull trout and brook trout in Sun Creek. Crater Lake National Park, Oregon. Pages 5-9 in P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.
- Fausch, K. D. 1984. Profitable stream positions for salmonids: relating specific growth rate to net energy gain. Canadian Journal of Zoology. 62:441-451.
- Fraleigh, J., and B. Shepard. 1989. Life history, ecology and population status of migratory bull trout, (*Salvelinus confluentus*) in the Flathead Lake and River system. Montana. Northwest Science 63(4):133-143.
- Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, a literature review. Willamette National Forest, Eugene, OR.
- Goetz, F. 1991. Bull trout life history and habitat study. Final report USFS, Deschutes National Forest, Department of Fisheries and Wildlife, Oregon State University, Corvallis.
- Gosse, J. C., and W. T. Helm. 1981. A method of measuring components for lotic fishes and its application with regard to brown trout. Pages 138-149 in N. B. Armantrout, editor. Acquisition and utilization of aquatic inventory information. Portland, OR.
- Graham, P. J., D. Read, S. Leathe, J. Miller, and K. Pratt. 1980. Flathead River Basin fishery study. Montana Department of Fish, Wildlife and Parks, Kalispell, MT.
- Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Science 43:883-884.
- Hillman, T. W., D. W. Chapman, and J. S. Griffith. 1989. Seasonal habitat use and behavioral interaction of juvenile chinook salmon and steelhead. Daytime and nighttime habitat selection. Pages 43-138 in D. Chapman, editor. Summer and winter ecology of juvenile chinook salmon and steelhead in the Wenatchee River, Washington. Final Report to Chelan County Public Utility District, WA.
- Hoefler, S. 1990. Indian Creek stream survey report. Wenatchee National Forest, Naches Ranger District, Yakima County, Naches, WA.
- Larkin, P. A. 1956. Interspecific competition and population control in freshwater fish. Journal of the Fisheries Research Board of Canada. 13:327-342.
- Nakano, S., K. D. Fausch, T. Furukawa-Tanaka, K. Maekawa, and H. Kawanabe. 1992. Resource utilization of bull char and cutthroat trout in a mountain stream in Montana. Japanese Journal of Ichthyology 39:211-217.
- Pratt, K. L. 1984. Habitat use and species interactions of juvenile cutthroat (*Salmo clarki lewisi*) and bull trout (*Salvelinus confluentus*) in the upper Flathead River Basin. M.S. Thesis, University of Idaho, Moscow.
- Pratt, K. L. 1985. Habitat preferences of juvenile bull trout in the Flathead River Basin. Pages 16-17 in D. D. MacDonald, editor. Proceedings of the Flathead River Basin bull trout biology and population dynamics modeling information exchange. Fisheries Branch, British Columbia Ministry of Environment, Cranbrook, B.C.
- Pratt, K. L. 1992. A review of bull trout life history. Pages 5-9 in P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.
- Ratliff, D. E., and P. J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.
- Shepard, B. B., K. L. Pratt, and P. J. Graham. 1984. Life history of westslope cutthroat and bull trout in the upper Flathead River Basin, Montana. Report to the Environmental Protection Agency Contract R008224-01-5. Montana Department of Fish Wildlife and Parks, Helena.
- Weaver, T. M. 1991. Coal Creek monitoring study no. IX and forest-wide fisheries monitoring-1990. Contract no. P.O. 43-0385-004-08, Montana Dept. of Fish, Wildlife and Parks, Kalispell.