Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*) in a mountain stream

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Abstract: Habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*) in Trestle Creek, Idaho, changed seasonally and dielly. Both cutthroat and bull trout selected pools over riffles in both summer and winter. Both species used a wide range of depths at night but were absent from shallow water (<15 cm) during the day in summer and winter. During summer, juveniles of both species occupied areas of lower velocity water at night than during the day. Both species also occupied lower velocity water during winter days than summer days. During winter days, juvenile bull trout were located below or directly on cobble substrate, whereas cutthroat trout often formed aggregations suspended in the water column of large pools. Both species were more closely associated with cover during the day, and made the greatest use of cover during winter days. Land management activities resulting in decreased pool habitat, instream cover, and stream-bed stability may be especially detrimental to bull trout and cutthroat trout in winter.

Résumé : L'utilisation de l'habitat fluctue en fonction de la saison e1l TJı˝49.64 0 TDı˝( )Tjı˝-49.64 -1.213 TDı˝0.003 Tcı˝0 Twı˝[(é)7(g)10
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Introduction

Bull trout (*Salvelinus confluentus*) and west-slope cutthroat trout (*Oncorhynchus clarki*) have sustained significant reductions in distribution and abundance in this century. Several factors have contributed to the decline of both species, including loss of essential habitats and competition and hybridization with introduced species (Liknes and Graham 1988; Goetz 1989).

Bull trout, a recently recognized species of charr closely related to Dolly Varden (*Salvelinus malma*; Cavender 1978), was historically distributed mainly in interior streams and rivers from the upper Sacramento River in California (Goetz 1989) northward to the upper Yukon River in Canada (Haas and McPhail 1991). The most serious population declines have occurred in southern portions of its range (Goetz 1989), including California, where it has been extirpated, Oregon, where two-thirds of the 65 populations are at risk of extincrequirements of juvenile bull trout are not well understood. In many streams, bull trout and cutthroat trout coexist, which complicates evaluations of the habitat preferences of both species. Pratt (1984), Martin et al. (1992), Adams (1994), Goetz (1994), Jakober (1995), and Saffel and Scarnecchia (1995) reported on habitat use of bull trout or bull trout and cutthroat trout in Montana, Washington, Oregon, and Idaho. All of these studies except Jakober (1995) were conducted during summer; all studies except Goetz (1994), Jakober (1995), and Saffel and Scarnecchia (1995) were conducted by sampling only during the day. Because macro- and micro-habitat use by salmon and trout varies seasonally (Baltz et al. 1991) and dielly (Campbell and Neuner 1985), however, knowledge of both seasonal and diel variation in habitat use is necessary to adequately characterize a species' habitat requirements. Habitat use during summer may not, for example, reveal limitations on carrying capacity resulting from insufficient winter habitat. Habitat use may also differ between day and night. Bonneau et al. (1995) reported that bull trout were more easily enumerated by snorkelers at night; such day and night differences in observability may indicate diel shifts in habitat use.

Comprehensive knowledge of the habitat requirements of both species is essential because in many cases adults spawn and juveniles are reared in streams influenced by timber harvest and associated road construction. The objective of this study was to identify and characterize seasonal and diel changes in stream macrohabitat (pool and riffle) and micro-habitat use by sympatric juvenile bull trout and cutthroat trout.

Study area

Trestle Creek is a small (0.25 m ? s^{-1} discharge in January and July 1992) high-gradient (3–8%), low-conductivity (<50 µmhos ? cm^{-1}

observed in only two pools and were not considered. When a fish was located, a numbered marker was placed on the substrate directly below it and the focal elevation was recorded.

Five microhabitat characteristics were measured at each focal point: (1) vertical distance of the fish above the substrate (focal-point elevation; cm), (2) total water depth (cm), (3) water velocity at the focal point (m ? s^{-1}), (4) distance (cm) to nearest cover (within 1 m of the fish), and (5) type of cover. Velocity at the focal point was measured with a Marsh–McBirney flowmeter to the nearest 0.01 m ? s^{-1}. Cover was classified as cobble/boulder, woody debris, turbulence, or rootwad/undercut bank. Rootwads and undercut banks were combined because they always occurred together in the study reaches. Depth was not considered cover because determination of depths suitable for cover would be arbitrary and the study area was shallow (maximum depth 0.9 m). For fish uncovered in the substrate, depth within the substrate was estimated and focal-point velocity and distance to nearest cover were recorded as zero. The assumption that water velocity was very near zero at focal points within the substrate was supported by frequent observations of fine organic matter under the cobbles, which was washed away when cobbles were lifted.

Data on fish and habitat characteristics were collected in summer and winter during periods of similar stream discharge. We assumed that habitat availability was similar between summer and winter. No noticeable change in discharge occurred between day and night in either season.

Discriminant function analysis was used to evaluate diel and seasonal segregation between and within species. This multivariate approach allows determination of the relative contribution of each a nents (i.e., contributed the most to the separation among groups) of the first discriminant axis (root 1) and distance to cover was the primary component of the second discriminant axis (root 2). Depth contributed the least to discrimination among groups. All groups in each of the four comparisons were significantly different (*P*

Focal-point velocity

Bull trout

In summer, bull trout occupied significantly faster water during the day (mean velocity 0.21 m ? s^{-1}) than at night (mean velocity 0.07 m ? s^{-1}, $P < 0.001$), but in winter they occupied significantly slower water during the day (mean velocity 0 m ? s^{-1}) than at night (mean velocity 0.06 m ? s^{-1}, P

a wide range of cover types was used during summer days, but during winter days, unembedded cobbles served as the main cover.

Discussion

Our finding that juvenile bull trout and cutthroat trout used pools more than riffles is in agreement with other reports (McPhail and Murray 1979; Liknes and Graham 1988; Saffel and Scarnecchia 1995). Both species, especially cutthroat trout, made greater use of pools in winter. An increase in use of pools during winter was reported for brook trout (*S. fontinalis*) and brown trout (*Salmo trutta*) by Cunjak and Power (1986), for coho salmon (*O. kisutch*), Dolly Varden, and steelhead trout by Heifetz et al. (1986), and for coho salmon by Tschaplinski and Hartman (1983). In our study, increased winter use of pools by cutthroat trout was associated with their tendency to spend winter nights suspended midwater in the pools. Bull trout, which used pools less frequently than cutthroat trout in summer and winter, used areas on or near the substrate, often behind cobbles or boulders, which allowed them to inhabit low-velocity areas, even riffles.

Species that select pools over riffles, such as cutthroat trout and bull trout, may be especially affected by loss of pool habitat. Removal of vegetation in watersheds has been shown to result in increased peak discharges, destabilization of slopes, widened and braided channels, and loss of pools (Everest et al. 1985; Lyons and Beschta 1983). In the Belt geology of Trestle Creek and other portions of northern Idaho, rain on snow events on excessively logged watersheds can lead to slope failure and input of cobble/boulder-sized material into streams (Etienne 1987; Cacek 1989), resulting in the filling of pools and the creation of long stretches of unbroken, braided riffle habitat. The loss of pools (and overall habitat complexity) would decrease the amount of living space available for these species.

During summer, both species occupied slower moving water at night than during the day. Campbell and Neuner (1985) reported a shift to slower water at night for rainbow trout and attributed it to movement from feeding positions during the day to resting positions at night. Their conclusion is supported by Schutz and Northcote (1972), who reported that cutthroat trout fed much less efficiently as available light decreased. By night, cutthroat trout in Trestle Creek did not occupy feeding positions near current shear lines, but often rested in slack water away from the drift.

In contrast to cutthroat trout, bull trout did not occupy feeding positions during summer days, but were often observed roaming slack-water areas and picking prey items from the bottom. Many other bull trout were found beneath the substrate or resting on the bottom, evidently not feeding. By means of retinal and behavioral studies, Henderson and Northcote (1985, 1988) determined that the Dolly Varden (a close relative of the bull trout) is better adapted for feeding under low-light conditions than is the cutthroat trout. Although ours was not a study of feeding ecology, we did observe caudal fins protruding from the mouths of bull trout several hours after dark, indicating that they were feeding, at least to some extent, at dusk or at night. Bull trout are often piscivorous (Shepard et al. 1984; Boag 1987), and juvenile bull trout and young-of-the-year cutthroat trout, a potential prey, often occupy similar habitats (shallow stream margins) in Trestle Creek as well as other locations (e.g., Pratt 1984).

During winter days, we observed little feeding activity by juveniles of either species; fish were usually hidden beneath the substrate or in low-velocity areas above the substrate. Other researchers have reported an affinity of salmonids for residing in the interstices of unembedded substrate or resting in low-velocity areas in winter (Bustard and Narver 1975; Campbell and Neuner 1985; Cunjak and Power 1986; Hillman et al. 1987). Habitat use is often a compromise between potential profits (food abundance) and the risks of predation, depletion of energy, and injury (Bustard and Narver 1975; Bachman 1984; Fausch 1984; Cunjak and Power 1986). Our results support this idea. In winter, when salmonids' demand for food is lower (Reimers 1957), we found that fish were seldom in locations where energy expenditure or risk of predation was high. Those cutthroat trout not seeking cover during winter days peas e Frvper 1985˝T*-nj20.001 Tfı 1c03Tcı˝0.012 T13(us)8-1.0tro13(6(s ing unstable substrates may result in low survival rates of eggs and fry (Elwood and Waters 1969; Seegrist and Gard 1972; Erman et al. 1988), washouts of fish from sections of streams (Pearsons et al. 1992), and direct crushing of fish (Erman et al. 1988). Similarly, in some areas the abundance of Dolly Varden has been positively linked to channel stability (Murphy et al. 1986).

Trestle Creek, like many streams containing bull trout, is groundwater fed and does not experience frazil and anchor ice formation. Fish in streams with less groundwater influence may behave differently, especially in winter (Brown and Mackay 1995). The main biases we are aware of in this study are associated with our inability to see fish during the day. Because juvenile fish, especially bull trout, often hid below the substrate by day, it was necessary to carefully lift cobbles and look for fish. Still, fewer fish were found during the day.

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