# HABITAT USE OF YOUNG-OF-YEAR BROWN TROUT AND EFFECTS ON WEIGHTED USABLE AREA

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# Habitat Use by Young-of-Year Brown Trout and Effects on Weighted Usable Area

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***ABSTRACT:*** Water depth, water velocity, and substrate were measured at the observed locations of young-of-year brown trout (*Salmo trutta*) in Douglas Creek, Wyoming, in 1989 and 1990. Sampling was conducted in June and July during both the day and night. Fish used deeper water with higher velocities during day compared to night in both June and July, and used higher velocities and larger substrates in July than in June. These variations in habitat use resulted in different habitat suitability curves for day and night in both June and July. When the various curves were applied with the Physical Habitat Simulation system, differences in computations of weighted usable area of young-of-year brown trout were obtained. The analysis indicated that habitat may be more limiting during June than July, and habitat suitability curves computed from measurements made in June may provide the better assessment of instream flow needs for young-of-year fish.

***KEY WORDS:*** Brown trout, habitat, instream flow, *Salmo trutta*, suitability curves, young-of-year fish.

## INTRODUCTION

The Instream Flow Incremental Methodology (IFIM) was developed by the U.S. Fish and Wildlife Service to evaluate the effects of altered stream flows on fish habitat (Bovee 1982). An integral part of the IFIM is the Physical Habitat Simulation system (PHABSIM), a collection of computer programs that calculates the weighted usable area (WUA) of habitat for a specific life stage of a species as a function of discharge (Milhous et al. 1984; Gore and Nestler 1988). The IFIM and the PHABSIM are being used increasingly as the basis for making recommendations on instream flow requirements for fish. Since their development, one criticism of the IFIM and the PHABSIM has been the use of suitability curves to represent habitat preferences of fish (Mathur et al. 1986; Conder and Annear 1987; Shirvell 1989; Gan and McMahon 1990). Habitat suitability curves describing water depth, water velocity, and

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substrate use are developed for spawning, fry or young-of-year (YOY), juvenile, and adult life stages of target species. Variation in habitat suitability curves can occur within a species as a result of the specific sizes of fish that are sampled, the time when sampling occurs, and the nature of the habitat where the curves are developed.

Instream flow studies often employ habitat suitability curves that were developed from data collected during daylight hours in the summer of a single year (Campbell and Neuner 1985). Mathur et al. (1986) noted that such suitability curves may not be sufficient to describe microhabitat use by fish, especially when seasonal or diel shifts in behavior occur. Bain et al. (1982) noted that seasonal variation in habitat use by some life stages of fish produces the need for season-specific habitat suitability curves, and this is especially true for rapidly growing YOY. Irvine et al. (1987) suggested that for best results, habitat preference criteria should be developed for different times of the year with measurements made during both day and night. However, Campbell and Neuner (1985) pointed out that the extent of segregation of habitat criteria for use in the PHABSIM (i.e., species, life stages, size, season, and diel) can become overwhelming. They recommended that the habitat features limiting populations be identified and focused upon when conducting instream flow studies and making recommendations.

MacCrimmon et al. (1990) recognized that the environmental requirements of YOY brown trout are poorly defined. Helm et al. (1981) found there are greater limitations on the habitat used by YOY than on the habitat of juvenile and adult brown trout. The specific habitat requirements of YOY brown trout include short distances between feeding and resting areas, shallow water where predaceous fish cannot venture (Gosse and Helm 1981), and low water velocities to avoid displacement downstream (Ottaway and Forrest 1983; Heggenes 1988; Heggenes and Traaen 1988). Campbell and Neuner (1985) suggested that YOY move closer to the stream edge at night in response to feeding behavior of larger trout. Gosse and Helm (1981) indicated that with increasing age and size, YOY brown trout select for habitats containing higher water velocities, deeper water, and larger substrate sizes.

Variation in habitat use related to size and diel behavior of YOY brown trout is not well defined. Such variation requires attention when developing habitat suitability curves and using the PHABSIM for YOY brown trout. Our objectives were to determine if diel or seasonal shifts in habitat use by YOY brown trout occurred during the summer and to evaluate the influence of such shifts on habitat suitability curves and resultant WUA predictions by the PHABSIM. We also wished to gain insight as to the time during the summer when habitat availability may be most limiting to YOY brown trout in streams.

## STUDY AREA AND SITES

Douglas Creek is located in the Medicine Bow National Forest in southeastern Wyoming (Figure 1). From its headwaters at 3,170 m above mean sea level (MSL), Douglas Creek flows southwesterly for 46 km where it empties into the North Platte River at 2,290 m MSL. The upper portion of the watershed is primarily coniferous forest. At lower elevations sagebrush and grasslands are common. Fish species inhabiting the drainage include brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), longnose sucker (*Catostomus catostomus*), longnose dace (*Rhinichthys cataractae*), and creek chub (*Semotilus atromaculatus*). The most abundant sport fish is brown trout (Wesche 1973).

Douglas Creek has been altered by tie drives and gold dredging (Thybony et al. 1985), resulting in an unusually wide and shallow channel. The creek is influenced by Rob Roy Reservoir, completed in 1963. The reservoir, at an elevation of 2,840 m MSL, is part of a system to store and convey water to Cheyenne, Wyoming. Water released from the reservoir flows in the stream channel for 1.6 km to the Cheyenne Diversion Structure where it is diverted into a pipeline. The U.S. Forest Service required a minimum instream flow of 0.16 $m^3/sec$ in Douglas Creek immediately

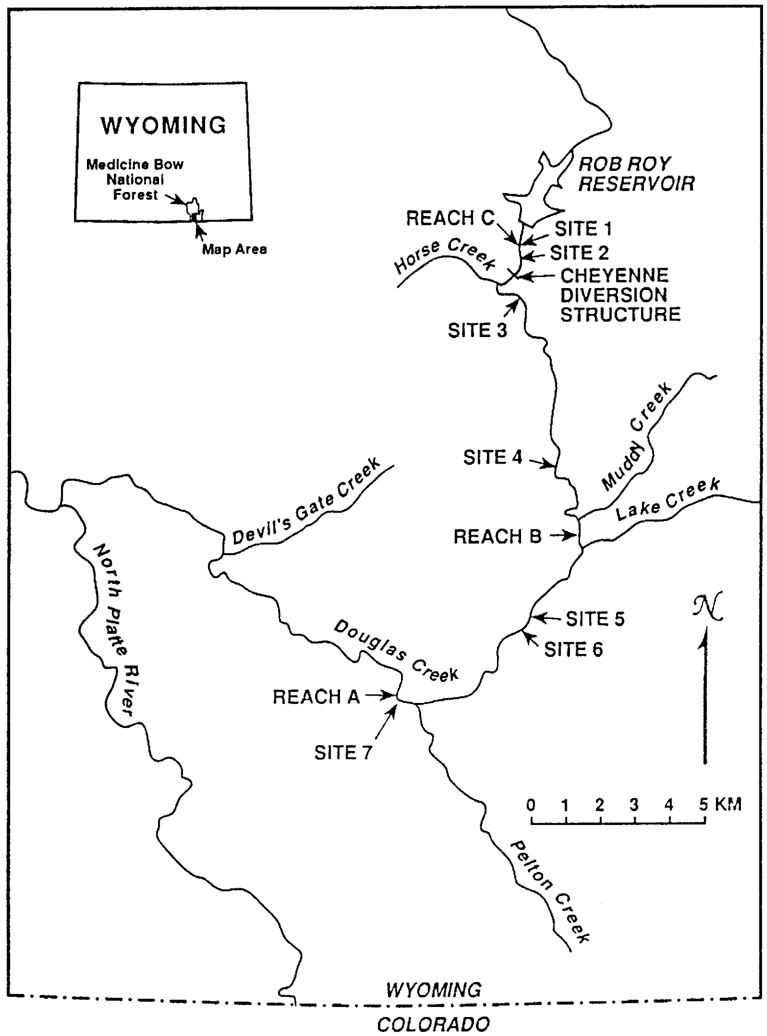


**FIGURE 1.** ***Locations of the study area and the three study reaches (A-C) where young-of-year brown trout habitat use was measured and of the seven sites (1-7) at which weighted usable area for young-of-year brown trout was computed using the Physical Habitat Simulation system in Douglas Creek, Wyoming.***

downstream from the Cheyenne Diversion Structure, beginning in 1986.

Three 800-m-long reaches were selected for study in low-gradient (channel slope <1.0%) meadow areas of the stream at elevations of 2,835 (Reach A), 2,596 (Reach B), and 2,220 (Reach C) m MSL (Figure 1). Late summer low flows were 0.14, 0.23, and 0.28 $m^3$/sec and mean wetted widths were 7.0, 11.6, and 8.2 m in Reaches A, B, and C, respectively. Riparian vegetation was predominantly willow (*Salix*), sedges (*Carex*), and grasses. Past experience demonstrated that YOY brown trout were concentrated in low-gradient meadow reaches of Douglas Creek.

## METHODS

Habitat use by YOY brown trout in Reaches A, B, and C was described during two time periods, 22-26 June and 16-23 July, in both 1989 and 1990 when Douglas Creek was at or near late summer flows. Diel stratification was accomplished by sampling both during daylight (0900-1500 hr) and at night (beginning 1 hr after sunset for 2–3 hr). During each sampling period, 25 YOY were located during day and 25 during night in each reach.

Observations of YOY brown trout locations were made visually from the stream bank. Electrofishing confirmed that the only YOY trout present in the study reaches were brown trout. The low-gradient wide channel with little instream cover and very clear water during both study years made visual observation the most efficient method to locate YOY (Heggenes et al. 1990). The YOY were located by approaching the channel on land and observing the entire stream channel within a reach until 25 YOY had been located. Nighttime sampling was accomplished in the same manner with the aid of a halogen flashlight. The flashlight had no apparent effect on the behavior of the fish. Only stationary YOY were used for habitat assessment. The location of each fish was marked with a numbered flag by wading into the stream.

Following the identification of fish locations, water depth, water velocity, and substrate were measured at the location of each flag. Water depth was determined to the nearest 6.1-cm interval. Mean water column velocity (cm/sec) was measured using a digital electromagnetic current meter. The predominant substrate size at each location was visually estimated and coded numerically following the categorization system from Bovee (1982): fines (silt or sand <0.5 cm diameter), small gravel (0.5–2 cm), medium gravel (3–5 cm), large gravel (6–7 cm), small cobble (8–15 cm), medium cobble (16–23 cm), large cobble (24–30 cm), small boulder (31–58 cm), and large boulder (>58 cm).

Habitat availability was measured for PHABSIM analysis within each of seven sites (Figure 1) during low flows in August and September 1991 when discharge at the point of the diversion structure was a consistent 0.14 $m^3$/sec. The sites were 76–227 m long following the thalweg. Water depth, water velocity, and substrate size were measured at 10–20 points along each of 4–16 transects. Transects established within each site were selected to represent segments having similar hydraulic and morphologic characteristics following Bovee (1982).

The frequency of habitat use measurements of both water depth and water velocity in 6.1-cm increments and the frequency of use of each substrate type were computed for day and night of each sampling month. We used the Kolmogorov-Smirnov test to determine if differences occurred in the frequency distributions of depth, velocity, and substrate used by YOY between the two sampling months and between day and night (SPSSX 1986). If significant differences were not detected, the data were combined. Habitat suitability curves were constructed from the frequency distributions following Bovee and Cochnauer (1977) using the frequency analysis method. The number of observations in each category of a frequency distribution was transformed into a suitability index score by first assigning a score of 1.0 to the category with the highest frequency of use. Each other category was assigned an index score by dividing the number of observations in that category by the number of observations in the category with the highest frequency of use.

The PHABSIM analyses were performed for each of the seven sites according to Bovee (1982) and Milhous et al. (1984) with different suitability curves to yield computations of WUA, or the area suitable for YOY brown trout expressed as square meters per 1,000 m of stream length. The PHABSIM analysis was conducted at the discharge that occurred when habitat availability measurements were made. We used paired $t$-tests to determine significant differences in WUA estimates between sampling times and months. Significance was determined at $P \leq 0.05$.

## RESULTS

The water depths used by YOY brown trout ranged from 1 to 32 cm, whereas water velocities ranged from 0 to 18 cm/sec. Data from Reaches A, B, and C were pooled in the assessment of differences between sampling months and between day and night. Significant differences in the distributions of water depths and water velocities used by YOY brown trout were observed between June and July ($P < 0.0001$),

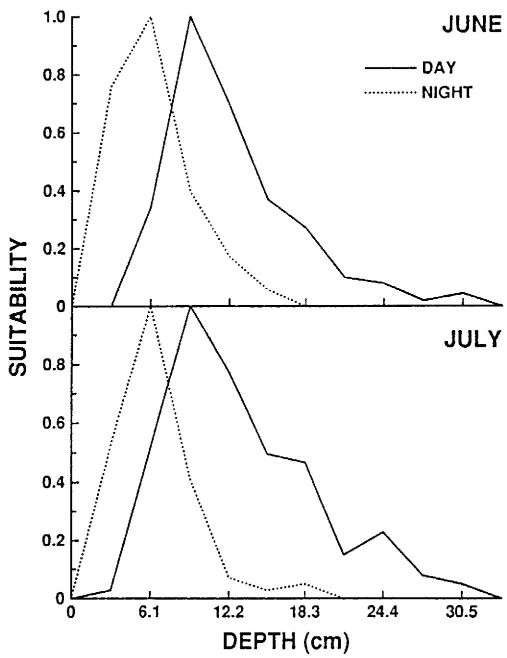


FIGURE 2. *Water depth suitability curves for young-of-year brown trout for June and July in Douglas Creek, Wyoming.*

as well as between day and night within each month ($P$ < 0.0001). The differences are reflected in the resulting habitat suitability curves (Figures 2 and 3).

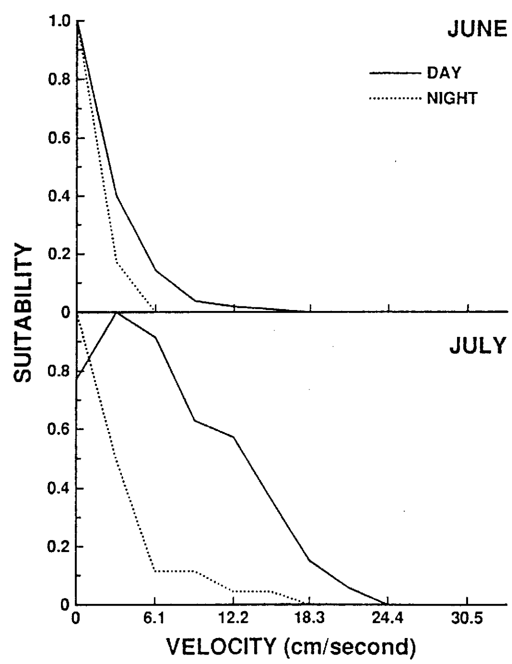


FIGURE 3. *Water velocity suitability curves for young-of-year brown trout for June and July in Douglas Creek, Wyoming.*

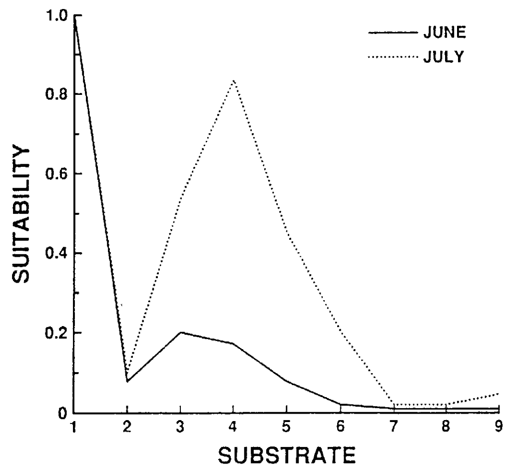


FIGURE 4. *Substrate suitability curves for young-of-year brown trout for June and July in Douglas Creek, Wyoming. Substrate codes are 1 = fines (< 0.5 cm diameter), 2 = small gravel (0.5-2 cm), 3 = medium gravel (3-5 cm), 4 = large gravel (6-7 cm), 5 = small cobble (8-15 cm), 6 = medium cobble (16-23 cm), 7 = large cobble (24-30 cm), 8 = small boulder (31-58 cm), and 9 = large boulder (> 58 cm).*

Substrate used by YOY brown trout did not differ significantly between day and night, but did differ between June and July. Therefore, substrate suitability curves combining day and night were developed for June and July (Figure 4). Larger substrate particles were used more frequently in July.

Four combinations of habitat suitability curves were used in individual PHABSIM analyses (Table 1). Significantly more WUA was predicted at all seven sites using curves

**TABLE 1**
*Weighted usable area ($m^2/1{,}000$ m) for young-of-year brown trout at low flow in Douglas Creek using four combinations of depth, velocity, and substrate suitability curves*

| | Weighted usable area | | | |
|---|---|---|---|---|
| Site | June—day | June—night | July—day | July—night |
| 1 | 24 | 23 | 177 | 79 |
| 2 | 3 | 5 | 173 | 29 |
| 3 | 5 | 17 | 319 | 90 |
| 4 | 15 | 17 | 169 | 56 |
| 5 | 12 | 16 | 211 | 51 |
| 6 | 8 | 7 | 119 | 14 |
| 7 | 16 | 14 | 232 | 50 |

developed from data gathered in July than by curves developed in June or at night in July ($P \leq 0.05$). No significant difference was observed in WUA between day and night in June, but in July the nighttime WUA was significantly less than the daytime WUA ($P = 0.0013$). The WUA computations indicated greater habitat availability in July than in June during both the day ($P = 0.0013$) and night ($P = 0.0030$).

## DISCUSSION

The YOY brown trout in Douglas Creek moved closer to the stream edge at night where water depth and water velocity were less than in midchannel. This movement may be a means of avoiding nocturnal predation by larger brown trout (Campbell and Neuner 1985).

The mean total length of YOY brown trout sampled from Reaches A, B, and C was 26 mm in June and 39 mm in July (Harris 1991). As YOY brown trout grew from June to July, they were found in faster water and over larger substrate particles. This was similar to the observations of Gosse and Helm (1981).

The shifts in habitat use between June and July, as well as between day and night, by YOY brown trout resulted in large variations in habitat suitability curves computed for each month and time (Figures 2–4). Subsequently, the WUA predicted by the PHABSIM varied, dependent upon which curves were used. Significantly more WUA was predicted from curves developed from July data compared to June data. This was due to the higher water velocities and larger substrate particles used in July (Figures 3 and 4). The results indicate that interpretations and recommendations for instream flow requirements could vary greatly (Table 1) depending on when data are obtained for development of habitat suitability curves (Bain et al. 1982; Irvine et al. 1987).

Our findings support Bain et al. (1982), Mathur et al. (1986), and Irvine et al. (1987) in that suitability curves developed without consideration of the size of YOY fish or the time of day when sampling is conducted may not be sufficient. Our results indicate that habitat availability for YOY brown trout in Douglas Creek is most limiting during early summer when the fish are smallest. Following Campbell and Neuner (1985), the habitat suitability curves computed from our observations in June are probably more appropriate than the ones from July for instream flow analysis.

Application of the PHABSIM requires an understanding of the variation in habitat used by fish as they increase in size and between day and night, as well as through the seasons. Our results provide a warning to users of the PHABSIM that computations of WUA based on a single set of habitat suitability curves for each life stage may not be adequate due to variation in habitat use within each live stage. The most appropriate habitat suitability curves for PHABSIM analyses are probably those that represent the most limiting habitat conditions during a particular life stage. When developing habitat suitability curves, users of the PHABSIM should attempt to identify when habitat is most limiting and to develop curves during that period for more accurate determination of instream flow requirements.

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