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# Use of Winter Concealment Cover by Juvenile Cutthroat and Brown Trout in the South Fork of the Snake River, Idaho

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*Abstract.* — During February–April 1990 the number of age-0 cutthroat trout *Oncorhynchus clarki* and brown trout *Salmo trutta* concealed during the day in several types of cover was assessed in a large river, the South Fork of the Snake River in southeastern Idaho. Fish typically were concealed along the edge of the wetted perimeter at water depths shallower than 0.5 m. Population estimates for age-0 cutthroat trout ranged from 0 in rounded cobble (<20 cm in diameter) to 4.56 fish per meter of bank in clean boulder substrate. Abundance of age-0 brown trout varied with substrate in a similar manner but ranged from 0 to 0.50 fish per meter of bank. Cobble and boulder habitat that was heavily embedded with fine sediment contained fewer juvenile trout of either species. The first electrofishing pass extracted 78% of the age-0 cutthroat trout and 76% of the age-0 brown trout estimated to be present in concealment cover. The fraction of fish emerging from concealment to swim in the water column at night was 61–66% of the numbers estimated to be in concealment during the day.

Winter may be a stressful period for stream-dwelling salmonid fishes. Their ability to escape endothermic predators is impaired by reduced swimming performance, and they are susceptible to physical damage resulting from ice formation (Needham and Jones 1959). Furthermore, they may suffer a metabolic deficit during acclimation to rapidly declining water temperatures in early winter (Cunjak 1988a).

At the onset of winter, as midday water temperatures drop below about 8°C, juvenile salmonids may undergo several behavioral changes. Territoriality dissolves, and the fish may aggregate with other members of their cohort (Hillman et al. 1987; Riehle and Griffith, in press). Aggregation may persist as fish move into specific areas, such as thermal refuges (Cunjak and Power 1986), or it may be brief, with fish moving singly or in small groups into interstices in the substrate (Hartman 1963), sometimes as deep as 15–30 cm beneath the substrate surface (Everest 1969). We use the term "concealment" to describe that movement into interstitial space and the term "concealment cover" to describe the substrate surrounding that space. Recent studies in large Idaho rivers (Contor 1989; Smith 1992; Riehle and Griffith, in press) suggest that the concealment cover used most heavily by age-0 rainbow trout *Oncorhynchus mykiss* is located along stream margins. In the Henry's Fork of the Snake River, 96% of the juvenile rainbow trout observed at night during the winter of 1986–1987 were associated with 20% of the habitat; that habitat consisted of boulder clusters and submerged willows, both only along stream margins, and of undercut bank habitat (Contor 1989). One purpose of the work reported here was to evaluate what winter concealment cover, if any, was used by juveniles of wild cutthroat trout *O. clarki* and brown trout *Salmo trutta* during the day in the South Fork of the Snake River in southeastern Idaho.

Stream-dwelling salmonids concealed during the day in winter may emerge from cover at night (Campbell and Neuner 1985). Juvenile rainbow trout in the Henry's Fork of the Snake River were observed by Contor (1989) to emerge within 30–60 min after sunset. In stream areas not covered by surface ice nocturnal feeding by juvenile Atlantic salmon *Salmo salar* (Cunjak 1988b) and juvenile rainbow trout (Riehle and Griffith, in press) has been observed when water temperatures were below 4°C. Based on the slowness of digestion at such temperatures (24 h to evacuate 15% of stomach contents at 4°C; Elliott 1972), we hypothesized that fish might emerge from concealment only every second or third night to feed. Our second objective was to assess the proportion of day-concealed fish that emerged at night in the South Fork of the Snake River.

## Methods

We examined a portion of the South Fork of the Snake River approximately 20 km downstream from Palisades Dam in Bonneville County, Idaho. The study area was at an elevation of 1,615 m and extended from a point 1 km above the U.S. Highway 26 bridge downstream 3 km to the Conant Valley anglers' access (Figure 1). Channel width

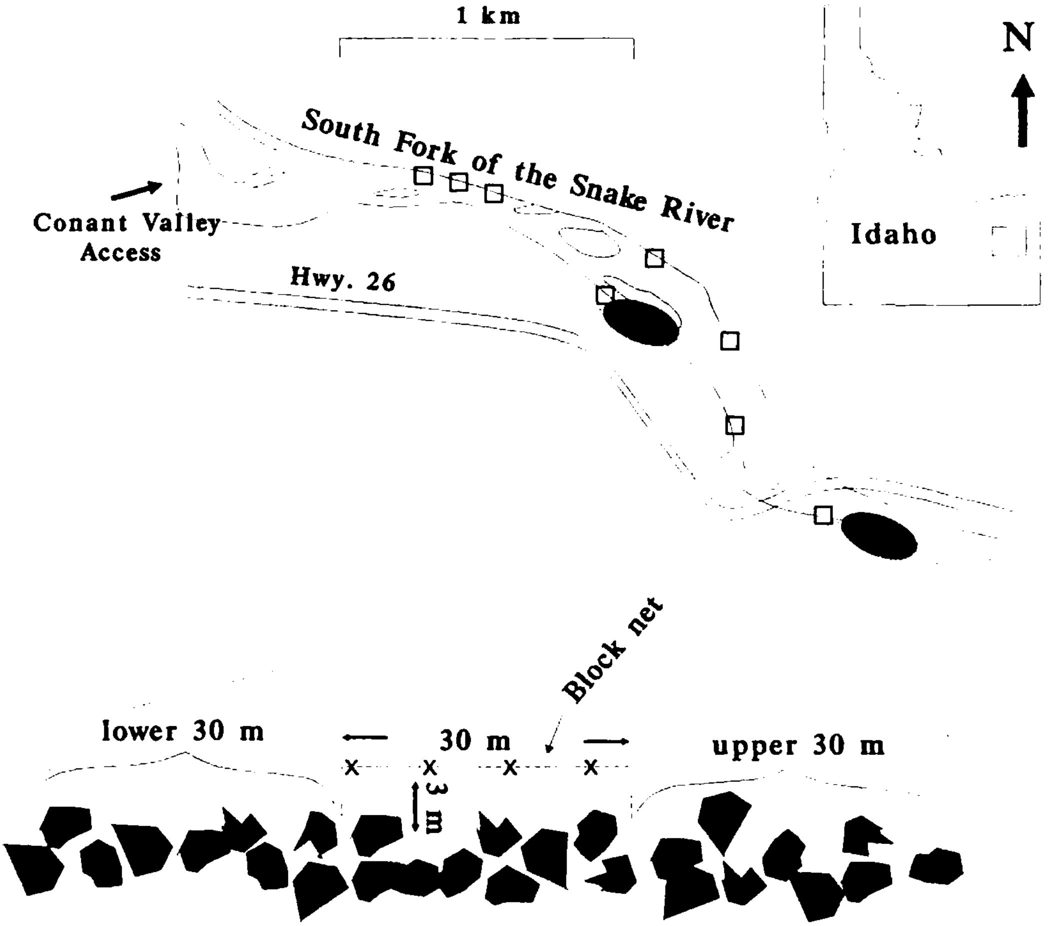

FIGURE 1.—Location of study sites sampled to assess trout density in February and March 1990 (open squares) and sites used to assess trout emergence from concealment (shaded ovals), South Fork of the Snake River, Idaho.

ranged from 100 m to as much as 210 m in a braided section, and gradient through the study area was 0.21%. An 800-m-long side channel that was about 8 m wide and a maximum of 1.2 m deep comprised one study site. Substrate in the study area was typically rounded quartzite cobble; angular basalt boulders and rounded cobble were found at the base of talus slopes along much of the banks. As a result of low flow, the stream margin had pulled away 1–2 m from brushy riparian community. A small amount of large woody debris and no aquatic macrophytes were present within the stream channel.

Winter flow was held below normal at the time of study, which followed several years of below average precipitation, to store water for summer irrigation. During our study in February, March, and early April 1990, discharge gradually increased from 31.4 to 37.1 $m^3/s$ (USGS 1991). Peak flow during the 1990 water-year of 391 $m^3/s$ occurred in July. Average discharge for the period 1950–1990 was 189 $m^3/s$ (USGS 1991). Conductivity was approximately 250 $\mu S/cm$ during sampling, and midday water temperatures were 4°C on 10 February, 5.1°C on 10 March, 7°C on 30 March, and 6.8°C on 2 April 1990.

Electrofishing was conducted with either a backpack or boat-mounted unit. The boat-mounted unit consisted of a 5,000-W generator and Coffelt VVP-15 control unit, which produced 6 A of 600-V pulsed-DC at 84 Hz with a 33% duty cycle. Average strength of the electrical field 1 m from the handheld anode was 0.13 V/cm as measured with a field strength meter (M.T.I., Inc., model FS/C II). The backpack unit (Coffelt model BP 1C) was operated at 340-V pulsed DC to produce 1 A at

TABLE 1.—Population estimates (upper 95% confidence limit in parentheses) of cutthroat trout and brown trout from three passes of electrofishing during the day in portions of the South Fork of the Snake River, Idaho, in 1990. Embeddedness ratings: <5% fines (5), 5–25% fines (4), 25–50% (3), and 50–75% (2).

| | Study site | | Trout | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Number per pass | | | | |
| Habitat | Embeddedness | Length (m) | Species and age | 1 | 2 | 3 | Total number, $N$ | $N$/m of bank |
| | | | **10 Feb 1990** | | | | | |
| Boulder, main channel | 5 | 50 | Cutthroat, age 0 | 42 | 5 | 0 | 47 (47) | 0.96 |
| | | | Cutthroat, age 1 | 2 | 0 | 0 | 2 | 0.04 |
| | | | Brown, age 0 | 4 | 0 | 0 | 4 | 0.08 |
| Boulder, side channel | 5 | 60 | Cutthroat, age 0 | 52 | 13 | 0 | 65 (66) | 1.08 |
| | | | Cutthroat, age 1 | 2 | 0 | 0 | 2 | 0.03 |
| | | | Brown, age 0 | 3 | 0 | 0 | 3 | 0.05 |
| Cobble, >20 cm | 5 | 30 | Cutthroat, age 0 | 8 | 2 | 0 | 10 (11) | 0.37 |
| | | | Cutthroat, age 1 | 0 | 0 | 0 | 0 | 0 |
| | | | Brown, age 0 | 3 | 0 | 0 | 3 | 0.10 |
| Cobble, <20 cm | 5 | 40 | All trout | 0 | 0 | 0 | 0 | 0 |
| | | | **10 Mar 1990** | | | | | |
| Boulder | 5 | 50 | Cutthroat, age 0 | 176 | 35 | 14 | 228 (232) | 4.56 |
| | | | Cutthroat, age 1 | 2 | 0 | 0 | 2 | 0.04 |
| | | | Brown, age 0 | 13 | 7 | 3 | 25 (31) | 0.50 |
| Boulder | 4 | 35 | Cutthroat, age 0 | 75 | 19 | 8 | 104 (108) | 2.97 |
| | | | Cutthroat, age 1 | 3 | 0 | 0 | 3 | 0.09 |
| | | | Brown, age 0 | 15 | 2 | 1 | 18 (19) | 0.51 |
| Boulder | 3 | 40 | Cutthroat, age 0 | 28 | 6 | 1 | 35 (36) | 0.88 |
| | | | Cutthroat, age 1 | 0 | 1 | 0 | 1 | 0.03 |
| | | | Brown, age 0 | 12 | 0 | 0 | 12 | 0.30 |
| Cobble, >20 cm | 2 | 35 | Cutthroat, age 0 | 2 | 0 | 0 | 2 | 0.06 |
| | | | Cutthroat, age 1 | 0 | 0 | 0 | 0 | 0 |
| | | | Brown, age 0 | 0 | 0 | 0 | 0 | 0 |

75 Hz and an 80% duty cycle. Average field strength 1 m from the anode was 1.0 V/cm. These settings most effectively captured known numbers of trout from concealment cover at low temperatures in laboratory experiments.

*Daytime trout density.*—We assessed fish density in four streambank substrate sites (boulder in both side channel and main channel, and two sizes of rounded cobble) on 10 February 1990. The sites were unembedded by fine sediments and ranged from 30 to 50 m in length (Table 1). Substrate particle size was assessed by measuring 60 pieces of substrate (20 pieces at the head, middle, and tail of each site) that were mostly or completely submerged along the bank edge. Average boulder diameter was 52 cm (range 31–80 cm) in the main channel site and 49 cm (range 32–79 cm) in the side channel, both ranges within the small boulder category of Helm (1985). Average cobble diameter was 25 cm (range 19–28 cm) at one site and 14 cm (range 10–21 cm) at the other, both within the large cobble category of Helm (1985). Three successive passes with electrofishing gear were made. The boat-mounted unit was used at main river sites and the backpack unit was used in the side channel. Fish were measured to the nearest millimeter (total length) and weighed to the nearest 0.1 g; Fulton's condition factor ($K$) was calculated by dividing fish weight by the cube of the length and multiplying by $10^5$. Brown trout and cutthroat trout were identified as either age-0 or age-1 and older from their length, and scales were taken from a sample to validate age classification. Population estimates and 95% confidence intervals were calculated using depletion method procedures with MicroFish softwear (Van Deventer and Platts 1989).

On 10 March 1990, fish abundance was assessed in four 35–50-m-long main channel sites (Table 1) of cobble or boulder bank habitat that varied in embeddedness. Particle size in the cobble site averaged 26 cm (range 21–31 cm), similar to one site sampled in February, but fine sediment partially occluded interstitial spaces. We did not attempt to quantitatively measure embeddedness but used the relative scale of Platts et al. (1983) that assigns ratings of 1 (highest embeddedness) to 5 (lowest) to describe the percentage of large particle surface covered by fine sediment. The cobble site was rated 2 (50–75% of surface covered by fines).

At the other three sites, boulder diameter was not measured but appeared similar to that of sites examined in February. Embeddedness at one boulder site was rated as 3 (25–50% of surface covered), at another as 4 (5–25%), and at the third site as 5 (less than 5%). Three passes were made through the four sites with the boat-mounted electrofishing unit. Fish were not weighed, and lengths and scales were checked for only those few fish for which age validation was felt to be needed.

We also searched for age-0 trout that might have been concealed in the substrate in midchannel locations by electrofishing the length of the study area on 10 February and 10 March with the boat-mounted gear. Approximately 3 h was spent each day on a single pass, zigzagging through habitat that included a range of water depths and velocities. We did not attempt to comprehensively sample from bank to bank.

*Emergence from concealment.*—The proportion of juvenile trout that concealed themselves during the day but emerged at night was evaluated by comparing the number of trout visible to a snorkeler at night with electrofishing estimates made during the day. We used two sites, each encompassing 90 m of streambank on one side of the river (Figure 1). One site contained unembedded boulder habitat along the south bank of the side channel that had been sampled on 10 February, and the other was similar boulder habitat along the south bank of the main channel immediately upstream from the Highway 26 bridge (Figure 1). The side channel site was sampled on 30–31 March, and the main river site was sampled on 2–3 April 1990.

Each site was divided into three 30-m-long segments. The upper segment of each was initially not disturbed. At 0800 hours of the first day of the experiment, the middle third of a site was enclosed with a block net (6.4-mm mesh, 1.3 m deep) to isolate a 3-m-wide strip of habitat along the bank. At midday, habitat within the block net was electrofished using the backpack unit described above; fish were removed in three passes and held without returning them. The same procedure, but without the block net, was then carried out in the lower segment of a site within 3 m of the stream bank.

That night, beginning 2 h after sunset, age-0 trout in each of the three segments were enumerated by a snorkeler experienced in winter night-viewing procedures. The snorkeler moved slowly upstream, counting trout observed in the beam of a dive light that were within 3 m of the bank. Underwater visibility was approximately 2.0–2.2 m. Midday on the second day, all segments (with the block net still in place in the middle segment) were electrofished in three passes. Because trout could not always be identified to species by the snorkeler, population estimates were made for age-0 brown and cutthroat trout combined, and we ignored the few age-1 cutthroat trout that were encountered.

## Results

### *Daytime Trout Density*

Although we initially electrofished in a number of locations throughout the study area, age-0 trout were seen and collected only along the banks. Adult trout and juvenile and adult mountain whitefish *Prosopium williamsoni* were abundant in nonbank locations. The juvenile cutthroat and brown trout we captured typically were concealed along the streambank in water depths shallower than 0.5 m. It was difficult to identify the exact locations that some fish occupied prior to their disturbance by the electrical field, but all were within 1 m of the edge of the wetted perimeter. Individuals of both species were shaded pitch-black when they emerged from concealment.

Eighty-seven percent of the fish captured at the seven sites were age-0 cutthroat trout. Age-1 and older cutthroat trout constituted 2% of the total, and age-0 brown trout 11% (Table 1). No older brown trout were captured. The first electrofishing pass through a site captured an average of 78% of the number of age-0 cutthroat trout and 76% of the brown trout estimated to be present in concealment cover (Table 1).

The density of age-0 trout in unembedded concealment cover increased as substrate particle size increased. Population estimates of age-0 cutthroat trout ranged from 0 in cobble less than 20 cm in average diameter to 4.56 fish per meter of bank in boulder substrate (Table 1). Abundance of age-0 brown trout varied with substrate in a similar manner, ranging from 0 to 0.50 fish per meter of bank. Heavily embedded cobble and boulder habitat contained fewer juvenile trout; the boulder site that was 25–50% embedded held less than one-third the cutthroat trout density of adjacent boulder sites that were moderately or slightly embedded (Table 1).

Length of age-0 cutthroat trout captured on 10 February averaged 91.0 mm, and age-0 brown trout averaged 124.9 mm (Table 2). Body condition was greater for age-0 cutthroat trout in the side channel

TABLE 2.—Size and condition factor ($K$) of age-0 cutthroat and brown trout captured by electrofishing on 10 February 1990 in the South Fork of the Snake River, Idaho.

| Habitat | Trout species | $N$ | Mean (range) Length, mm | Mean (range) Weight, g | Mean (range) $K$ |
|---|---|---|---|---|---|
| Boulder, main river | Cutthroat | 46 | 88.7 (64–120) | 5.7 (2.1–13.9) | 0.78 (0.54–1.11) |
| | Brown | 4 | 123.0 (120–128) | 15.1 (13.9–17.5) | 0.81 (0.78–0.83) |
| Boulder, side channel | Cutthroat | 52 | 94.3 (72–117) | 7.4 (2.9–14.9) | 0.84 (0.68–0.99) |
| | Brown | 3 | 116.3 (110–126) | 14.0 (10.1–20.9) | 0.85 (0.75–1.04) |
| Cobble (>20 cm), main river | Cutthroat | 10 | 84.7 (76–110) | 5.1 (3.0–9.5) | 0.81 (0.68–0.87) |
| | Brown | 3 | 136.0 (130–150) | 21.0 (16.2–28.5) | 0.82 (0.77–0.84) |

than in the same type of concealment cover in the main channel. The difference was significant (Kolmogorov–Smirnov test, $P < 0.040$) for condition but not significant for either weight ($P < 0.055$) or length ($P < 0.086$). Condition values ranged from 0.54 to 1.11 in the main channel site, and values at the other sites fell within this range. Age-0 cutthroat trout collected in the large cobble (>20 cm) site were smaller than those collected in boulder sites, but small sample size precluded statistical analysis. Age-1 and older cutthroat trout ranged from 136 to 245 mm.

### *Emergence from Concealment*

In the middle and lower segments of each site, an average of 64 (range 27–95) age-0 cutthroat and brown trout, combined, were captured by the initial set of three electrofishing passes and were not returned to the sites (Table 3). The first electrofishing pass captured an average of 78% (range 74–82%) of the age-0 trout present, based on the first-day estimates. That night, eight trout were observed swimming within the middle segment (enclosed by the block net) at the side channel site and five trout at the main river site. In the upper segment of each site, from which no trout had been removed, 38 and 62 trout were counted in the side channel and main river sites, respectively. Fish were actively maintaining position in low water velocities, and most were within 1 m of the bank. Repeat electrofishing the following day in the middle and lower segments of each site captured an average of 11 (range 5–16) age-0 trout from concealment.

The fraction of fish observed at night for each segment ranged from 50% of the estimated population in the middle side channel to 100% in the middle main river (Table 3). In the upper segment of each site where fish were not electrofished during the first day, 66% (side channel) and 62% (main river) of the population estimated from electrofishing the second day had been observed at night.

We believe the best estimate of age-0 trout density combines the first day electrofishing population estimate with the second day electrofishing estimate. First-day population estimates averaged 87% of the "best" estimates for the middle segments enclosed by block netting and 83% for the lower segments. "Best" estimates ranged from 1.13

TABLE 3.—Numbers of age-0 cutthroat and brown trout (combined) captured by daytime electrofishing and counted by snorkeling in side-channel boulder substrate on 30–31 March 1990 and in similar habitat on the main river on 2–3 April 1990, South Fork of the Snake River, Idaho. Estimated population size ($N$) is followed by the upper 95% confidence limit in parentheses.

| Site and segment | First day of electrofishing Pass 1 | Pass 2 | Pass 3 | Total $N$ | Snorkel count | Second day of electrofishing Pass 1 | Pass 2 | Pass 3 | Total $N$ | Estimate of total number of fish | $N$/m of bank | Percent of daytime total observed at night |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Side channel | | | | | | | | | | | | |
| Upper | | | | | 38 | 47 | 10 | 1 | 58 (59) | | | 66 |
| Middle | 78 | 13 | 4 | 95 (97) | 8 | 16 | 0 | 0 | 16 (16) | 111 | 3.70 | 50 |
| Lower | 20 | 5 | 2 | 27 (29) | 5 | 7 | 0 | 0 | 7 (7) | 34 | 1.13 | 71 |
| Main river | | | | | | | | | | | | |
| Upper | | | | | 62 | 81 | 16 | 4 | 101 (103) | | | 61 |
| Middle | 39 | 9 | 3 | 51 (53) | 5 | 5 | 0 | 0 | 5 (5) | 56 | 1.90 | 100 |
| Lower | 62 | 18 | 2 | 82 (84) | 11 | 15 | 1 | 0 | 16 (16) | 98 | 3.33 | 69 |

to 3.70 fish per meter of bank for four sites (Table 3).

## Discussion

In our sampling of the South Fork of the Snake River, we captured juvenile cutthroat trout and brown trout only within a narrow band along the stream margin in shallow water during the day, although substrate that appeared to provide adequate interstitial space for concealment was abundant across the stream width throughout much of the study area. Observations by Schrader and Griswold (1992) during the winter of 1990–1991 support our findings. Schrader and Griswold made 149 day and night dives (56 h total) using snorkeling gear and scuba to search the range of habitat present in 105 South Fork sites, including some in our study area. They observed age-0 cutthroat and brown trout only at night and only along the stream margin, generally within 30 cm of concealment cover. An exception was one backwater location where two cutthroat trout and one brown trout were found at night and one brown trout in the day, all at a depth of 4 m. Similarly, Contor (1989) found that 96% of the age-0 rainbow trout observed by snorkeling at night in the Henry's Fork of the Snake River were along the stream margins in winter, although in Contor's study area quality concealment cover was lacking in midchannel. Age-0 steelhead (anadromous rainbow trout) in Fish Creek, Oregon, were typically concealed in winter along stream margins, whereas age-1 steelhead appeared to select larger (>1-m diameter) substrate in deeper water (Everest et al. 1985).

We believe that concentration of juvenile salmonids along the stream margin in winter is an adaption to survival in stream reaches characterized by low gradient and a lack of surface and anchor ice. In those situations, fish benefit from interstitial water temperature that may be about 0.5°C warmer than in the adjacent water column (Smith 1992), and they can emerge from concealment at night, move less than a meter, and be positioned in slow water to feed on invertebrate drift.

On the other hand, other behavior patterns would be better adapted to different winter environments. In a Nova Scotia river with prolonged surface and anchor ice formation, age-0 Atlantic salmon were found by Rimmer et al. (1984) and Cunjak (1988b) to overwinter in riffle-run habitats, an environment that was absent from our study area. Atlantic salmon hid beneath rocks that were closer to midstream than to riverbanks, and high water velocity there minimized fine particle deposition (Cunjak 1988b). Feeding by age-0 Atlantic salmon continued through winter, presumably at night, although it was not directly observed (Cunjak 1988b). A variation on this behavior is that of juvenile steelhead in a high gradient, high elevation tributary of the Clearwater River in Idaho where fish remained in small boulder concealment cover under 10 cm of anchor ice, apparently without feeding for extended periods (Everest 1969). Other basic patterns, such as use of side pools and off-channel ponds to survive winter freshets in western coastal streams (Bustard 1986), have also been identified.

The density of juvenile trout in clean-boulder bank habitat in our study area was much higher than in that of other stream systems with which we are familiar. Assuming a width of 1 m for the strip along the stream margin in which fish were found, maximum density in South Fork sites approached 500 trout/100 $m^2$. These densities are especially high because they represent numbers of fish alive near the conclusion, rather than the onset, of winter. Although we did not sample woody debris, age-0 trout density would be expected to be even higher there than in boulder concealment. During winter South Fork night dives, Schrader and Griswold (1992) observed densities of cutthroat trout and brown trout in small woody debris that were two to four times higher than those near boulders. Further research is needed to assess the maximum holding capacities of woody debris, boulder, and other winter habitat components.

The smallest clean substrate that age-0 trout used for late winter concealment in our study area was cobble about 20 cm in diameter. Because they are smaller than brown trout of the same age-group, cutthroat trout might be able to use interstitial spaces unavailable to brown trout, although we did not have adequate data to evaluate that possibility. Rimmer et al. (1984) and Cunjak (1988b) found a similar particle size threshold for juvenile (most 60–100-mm-long) Atlantic salmon in New Brunswick and Nova Scotia streams, as did Everest et al. (1985) for 40–70-mm-long juvenile steelhead in Oregon. Bustard and Narver (1975a) found more than half of the age-0 steelhead in a British Columbia stream under rock less than 15 cm in diameter, and some in rock of 10 cm, but Bustard and Narver pointed out that larger rock was not available.

We found lower densities of juvenile trout in substrates in which interstitial spaces were filled by fine particles. In experimental channels at temperatures below 5°C, Bjornn et al. (1977) introduced groups of age-0 steelhead trout and chinook salmon *O. tshawytscha* to conditions of 50% and 100% embeddedness. After 5 d, about one-fourth as many fish remained in test as in control (zero embeddedness) channels. After patches of cobble were added under banks and in riffles and glides in a tributary of the South Fork of the Clearwater River in Idaho, numbers of overwintering juvenile chinook salmon increased eightfold over numbers from the previous winter, although numbers at the onset of the two winters were comparable (Hillman et al. 1987). Simulating winter conditions before and after stream disturbance, such as might result from logging, Bustard and Narver (1975b) found that at 2–5°C, 88% of 40–90 mm age-0 coastal cutthroat trout selected clean rubble 15–30 cm in diameter over the same material that was completely embedded with fine sediment. In the Henry's Fork of the Snake River, in habitat in which interstices of boulders and cobble were occluded with fine sediment, juvenile rainbow trout were not observed or collected (Contor 1989).

Condition factors of the juvenile cutthroat trout we collected at the end of winter were highly variable, and some were unexpectedly low. Thirty-eight percent of the fish we collected in February and March were at or below a *K* of 0.80. Condition factors of age-0 salmonids in streams consistently have been observed to drop in early winter to minima of 0.84–0.90 and then increase through late winter (brook trout *Salvelinus fontinalis*: Hunt 1969; Cunjak and Power 1987; Cunjak et al. 1987; brown trout: Cunjak and Power 1987; Atlantic salmon: Cunjak 1988b; rainbow trout: Smith 1992). Age-0 rainbow trout did not survive the winter of 1989–1990 in cages in the Henry's Fork of the Snake River if their late fall condition was less than 0.77 (Smith 1992). The possibility that cutthroat trout might be capable of surviving with unusually low body condition needs further evaluation.

The initial electrofishing pass through South Fork sites consistently captured approximately three-fourths of the age-0 trout that were present in concealment cover, according to our estimates. The effectiveness of such sampling would be expected to vary with fish size and species and the depth to which individual trout are concealed in the substrate.

The hypothesis that juvenile trout do not emerge from concealment each night was borne out by our limited data. The best estimates, in our estimation, were those for which fish were counted the night before electrofishing; these indicated 61–66% emergence. In our other tests, disturbance from repeated electrofishing prior to emergence might have biased results. With water temperature at about 7°C, trout activity and digestive rate would have been greater during our work than during midwinter and might have led to more frequent emergence. Additional study throughout the winter with marked fish of a number of species is needed.

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## References

Bjornn, T. C., and six coauthors. 1977. Transport of granitic sediment in streams and its effects on insects and fish. University of Idaho, College of Forestry, Wildlife, and Range Sciences, Bulletin 17, Moscow.

Bustard, D. R. 1986. Some differences between coastal and interior stream ecosystems and the implications to juvenile fish production. Canadian Technical Report of Fisheries and Aquatic Sciences 1483:117–126.

Bustard, D. R., and D. W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 32:667–680.

Bustard, D. R., and D. W. Narver. 1975b. Preferences of juvenile coho salmon (*Oncorhynchus kisutch*) and cutthroat trout (*Salmo clarki*) relative to simulated alteration of winter habitat. Journal of the Fisheries Research Board of Canada 32:681–687.

Campbell, R. F., and J. H. Neuner. 1985. Seasonal and diurnal shifts in habitat utilized by resident rainbow trout in western Washington Cascade Mountain streams. Pages 39–48 *in* F. W. Olson, R. G. White, and R. H. Hamre, editors. Symposium on small hydropower and fisheries. American Fisheries Society, Western Division and Bioengineering Section, Bethesda, Maryland.

Contor, C. R. 1989. Winter day and night habitat utilization and behavior of juvenile rainbow trout in the Henry's Fork of the Snake River, Idaho. Master's thesis. Idaho State University, Pocatello.

Cunjak, R. A. 1988a. Physiological consequences of overwintering in streams; the cost of acclimatization? Canadian Journal of Fisheries and Aquatic Sciences 45:443–452.

Cunjak, R. A. 1988b. Behavior and microhabitat of young Atlantic salmon (*Salmo salar*) during winter. Canadian Journal of Fisheries and Aquatic Sciences 45:2156–2160.

Cunjak, R. A., R. A. Curry, and G. Power. 1987. Seasonal energy budget of brook trout in streams: implications of a possible deficit in early winter. Transactions of the American Fisheries Society 116:817–828.

Cunjak, R. A., and G. Power. 1986. Winter habitat utilization by stream resident brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*). Canadian Journal of Fisheries and Aquatic Sciences 43:1970–1981.

Cunjak, R. A., and G. Power. 1987. The feeding and energetics of stream-resident trout in winter. Journal of Fish Biology 31:493–511.

Elliott, J. M. 1972. Rates of gastric evacuation in brown trout, *Salmo trutta* L. Freshwater Biology 2:1–18.

Everest, F. H. 1969. Habitat selection and spatial interaction of juvenile chinook salmon and steelhead trout in two Idaho streams. Doctoral dissertation. University of Idaho, Moscow.

Everest, F. H., G. H. Reeves, J. R. Sedell, J. Wolfe, D. Hohler, and D. A. Heller. 1985. Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement. Report to Bonneville Power Administration, Division of Fish and Wildlife, Project 84-11, Portland, Oregon.

Hartman, G. F. 1963. Observations of behavior of juvenile brown trout in a stream aquarium during winter and spring. Journal of the Fisheries Research Board of Canada 20:769–787.

Helm, W. T., editor. 1985. Aquatic habitat inventory: glossary of stream habitat terms. American Fisheries Society, Western Division, Habitat Inventory Committee. (Available through the Department of Fish and Wildlife, Utah State University, Logan.)

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. The effects of sediment on summer and winter habitat selection by juvenile chinook salmon in an Idaho stream. Transactions of the American Fisheries Society 116:185–195.

Hunt, R. L. 1969. Overwinter survival of wild fingerling brook trout in Lawrence Creek, Wisconsin. Journal of the Fisheries Research Board of Canada 26:1473–1483.

Needham, P. R., and A. C. Jones. 1959. Flow, temperature, solar radiation, and ice in relation to activities of fish in Sagehen Creek, California. Ecology 40:465–474.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service General Technical Bulletin INT-138.

Riehle, M. D., and J. S. Griffith. In press. Changes in habitat utilization and feeding chronology of juvenile rainbow trout in fall and at the onset of winter in Silver Creek, Idaho. Canadian Journal of Fisheries and Aquatic Sciences 50.

Rimmer, D. M., U. Paim, and R. L. Saunders. 1984. Changes in the selection of microhabitat by juvenile Atlantic salmon (*Salmo salar*) at the summer–autumn transition in a small river. Canadian Journal of Fisheries and Aquatic Sciences 41:469–475.

Schrader, W. C., and R. G. Griswold. 1992. Winter habitat availability and utilization by juvenile cutthroat trout, brown trout, and mountain whitefish in the South Fork Snake River, Idaho. Idaho Department of Fish and Game, Final Project Report, Boise.

Smith, R. W. 1992. Effects of concealment cover availability and water temperature on overwinter survival of juvenile rainbow trout in the Henry's Fork of the Snake River, Idaho. Master's thesis. Idaho State University, Pocatello.

USGS (United States Geological Survey). 1991. Water resources data for Idaho. USGS, Water-Data Report ID-91, Boise, Idaho.

Van Deventer, J. S., and W. S. Platts. 1989. Microcomputer software system for generating population statistics from electrofishing data—user's guide for MicroFish 3.0. U.S. Forest Service General Technical Report INT-254.