SEASONAL USE OF HABITAT BY JUVENILE STEELHEAD TROUT IN HURDYGURDY CREEK, CALIFORNIA, AND IMPLICATIONS FOR STREAM ENHANCEMENT

by

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A Thesis
Presented to
The Faculty of Humboldt State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

July, 1989
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IN HURDY GURDY CREEK, CALIFORNIA
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ABSTRACT

Seasonal shifts in macro- and microhabitats chosen by age 0+ steelhead (*Oncorhynchus mykiss*) were used to assess the effects of boulder structures placed in a fourth-order, coastal stream to increase rearing capacity for juvenile steelhead. Microhabitats identified by direct observation by divers were used to quantify microhabitat used during summer 1985 and the following winter. Macroinvertebrate drift was also monitored with monthly, 24-hour collections to determine if there were seasonal limitations in food supply. Microhabitat data were collected for totals of 227 and 24 age 0+ steelhead in summer and winter, respectively. Microhabitat characteristics for 0+ steelhead (with respect to water depth, average water column velocity and substrate type) were found to be similar to previously reported values. An attempt to discriminate seasonal groups of age 0+ steelhead via multivariate analysis of these and additional variables (maximum water velocity within average foraging distance from focal points, and focal height) was inconclusive. During winter, age 1+ steelhead virtually disappeared while age 0+ steelhead were numerous only in secondary channel pools. Invertebrate drift was at its low-point from late October to mid-December. Winter is the season most likely to limit the production of juvenile steelhead. Because secondary channel pools, which appeared to offer the most preferred winter habitat are extremely limited in this stream, enhancement of this habitat type is recommended.
ACKNOWLEDGEMENTS

I thank Dave Fuller, Mike McCain, and Yvonne Woodard for their able assistance in the field and laboratory. L. Decker provided valuable direction throughout the design and implementation of this project as well as commenting, along with Tom Lisle on early drafts of this manuscript. Joe Moreau and Kerry Overton contributed crucial background information regarding Forest Service stream enhancement projects.

Forrest Reynolds of California Department of Fish and Game, as well as Kerry Overton and Tom Lisle of U.S. Forest Service were instrumental in developing the funding which enabled this project.
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INTRODUCTION

Throughout the Pacific Northwest, the production of anadromous salmonids has decreased dramatically over the past several decades. The economic importance of anadromous salmonids has prompted research on rehabilitation techniques. Early rehabilitation efforts concentrated on propagating fish in hatcheries. Problems with disease, increasing operational costs and concerns over the possibility of genetic pollution of native stocks have created interest in enhancing habitat to mitigate losses (Leidy 1983).

Increasing amounts of money are being spent to enhance salmonid habitat in the Pacific Northwest and throughout North America. More than $100 million will be invested during the next decade to increase production of Pacific salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) smolts. However, project evaluations have rarely been funded (Hall and Baker, 1982).

A project conducted by the United States Forest Service on Hurdygurdy Creek, a tributary to the South Fork of the Smith River in California, has altered several riffles by placing boulder clusters and deflectors in the stream. Project managers had concluded that production of steelhead smolts might be limited by the availability of suitable habitat during low flows of late summer. Boulder structures were intended to narrow and deepen the channel, thereby increasing the amount of useable habitat for juvenile steelhead during periods of low water.

Riffles and shallow, near-shore areas have been found to be critical winter habitats for juvenile salmonids (Bustard and Narver 1975a, Mason 1976, Everest et al. 1984) as well as primary food-producing areas (Pennak and Van Gerpen 1947, Chapman 1962). The density of juvenile anadromous salmonids may be regulated by food abundance in some streams (Chapman 1966). Concerns that the availability of over-wintering habitat and/or food could be limiting steelhead production in Hurdygurdy Creek prompted this research.

The objectives of this paper were: (1) to document microhabitat use by juvenile steelhead within the study sites during both summer and winter, (2) to describe commonly-used habitats located outside the study sites that were used by age 0+ steelhead during the winter, (3) to quantify the biomass of aquatic macroinvertebrates passing through each of the two study sites.
STUDY SITE

Hurdygurdy Creek is a fourth-order stream which drains 78 square kilometers of steep, densely forested land in the Siskiyou Mountains of northern California (Figure 1). Watershed elevations range from 1200m in headwater areas to 180m at the confluence with the South Fork Smith River, located 40 river-kilometers from the Pacific Ocean. The stream supports runs of steelhead trout, chinook salmon (*O. tshawytscha*), coastal cutthroat trout (*O. clarki*), and Pacific lamprey (*Lampetra tridentata*). Rainfall in this area averages nearly 300 cm annually and stream discharge ranges from lows near 0.5 cubic meters per second (cms) to peaks approximating 140 cms (Moreau 1982). The watershed is largely within Six Rivers National Forest boundaries. Primary land uses include timber harvest with associated road construction, suction dredge mining, and recreational activities including angling and camping.

A 112-meter-long section of stream known as Chimney Flat (CF), where stream enhancement structures had been placed in 1984, was selected for study along with an 83-meter-long control section, which I named Salamander Creek (SC), located two kilometers upstream (Figure 1). The SC site was thought to be similar to the CF site prior to treatment because the channel was wide and shallow and had a cobble-dominated substrate (Joe Moreau, Fish Biologist, Six Rivers National Forest Gasquet District, personal communication). These so-called "flood riffles" are believed to have been created by debris torrents that coursed down the lower 10 km of Hurdygurdy Creek during a large storm in the winter of 1964/1965 (Moreau 1982).

MATERIALS AND METHODS

**Mapping and selection of sampling grids**

Major features of the channel and banks were mapped using an alidade and plane table (scale 1in = 2m). Maps incorporated major velocity threads, substrates and major structural features such as channel banks, logs, bedrock outcrops and overhanging vegetation (Platts et al., 1983).
Figure 1. Map of study sites on Hurdygurdy Creek, California. Dots on stream indicate approximate locations of Chimney Flat (CF) and Salamander Creek (SC) sites.
Following the completion of the habitat maps, simple random sampling was used to select a total of twelve stations from within the two sections. Each station included blocks of 1.0-square-meter sampling units which extended from one meter below the station center to one meter above and across the full width of the stream, thus including a two-meter-wide swath of channel from bank to bank. This yielded: (1) a sample of microhabitats available within the two study sites, and (2) a sample of territories occupied by juvenile salmonids. A grid of squares measuring 1m x 1m, suspended approximately 0.5m above the water surface was constructed by anchoring a 2cm-diameter rope along both banks and then suspending cross-lines of monofilament fishing line at the upstream and downstream limits of each swath to be sampled (Figure 2). Wire paper clips were positioned along the monofilament at one meter intervals. Maps depicting substrates, velocity threads, objects protruding above the water surface, the position of low-overhanging (<2m) vegetation, and instream structures were drawn freehand on 10x10 squares to the inch graph paper.

Direct observations

Observations were made by divers equipped with mask and snorkel from approximately 1000 to 1400 hours on twenty days during the summer of 1985 (July 23-September 20) and ten days during the following winter (January 9-March 20). Preliminary observations in June 1985 indicated that some fish, especially larger individuals, would flee or hide upon the approach of a diver. These fish would return after a period of up to 10-12 minutes, reoccupy their positions and commence feeding. Therefore, on each occasion when fish were to be observed, divers entered the stream quietly from downstream locations, and once in place, held their positions for 20 minutes prior to marking the positions of fish in the section with color-coded metal washers and collecting data. These precautions minimized disturbances and allowed the fish to adjust to the presence of divers prior to data collection.

Divers recorded the focal point (Everest and Chapman 1972), distance above the substrate (mm), species and approximate size (total length in mm) of each fish. Total lengths were estimated to the nearest 5mm using a scale drawn on 20x40cm clear acrylic slates. In areas of shallow water along banks where divers were unable to see fish, fish were observed from the bank. Any fish that did not appear to be focusing on a particular point for at least half of the observation period
Figure 2. Portable grid employed during summer microhabitat work.
was excluded from the sample except to note any aggressive interactions with other fish.

During summer data collection, fish were numerous in both study sections, and sample sizes believed adequate for statistical analyses (i.e. n>30 for univariate analyses and n>60 for multivariate analyses using six variates) were easily located within the selected sampling grids. However, fish were much less numerous during the winter and observations were made throughout the entire area of both study sections in an attempt to obtain required sample sizes.

Electrofishing and off-site habitat monitoring

The CF site was electrofished on February 12, 1986, in order to find fish located within boulder interstices not visible to divers. The upstream half of the site was first observed by divers, and then thoroughly electrofished with a Smith-Root model VII backpack electroshocker. All fish collected were tallied and released.

Off-site habitats within the lower five kilometers of Hurdygurdy Creek were surveyed periodically in January through March. Following dramatic decreases in their numbers of juvenile steelhead in both the CF and SC sites, all types of available habitat, including cascades, riffles, runs, main channel and secondary channel pools were investigated by divers in an attempt to find off-site concentrations of fish.

Microhabitat data collection

Following the collection of data on fish within a sampling section, the team immediately re-entered the stream, located all color-coded markers, and measured focal point velocity (cm per second), average velocity of the water column as measured at a depth equal to 0.6 times the total depth at that point, substrate size category (Dunne and Leopold, 1978), depth of water (mm), and the maximum velocity within a distance from the focus of each fish equal to 3 times the total length of the fish. This final datum was intended to measure the maximum current velocity exploited by an individual fish foraging for drifting invertebrates and was adapted from Fausch (1984). A Marsh-McBurney model 201 current meter was used for all velocity readings (estimated to the nearest centimeter per second). Data on water depth, average velocity and substrate were then collected at randomly selected points.
in the same section. Points were sampled until sample sizes for both the fish and random point sets were equal. The data collected at random points were used to characterize microhabitat availability in each section. The total number of fish encountered during winter was very small (n=27). Therefore, I decided to double the number of random points to 54 in an effort to more completely sample available microhabitat.

**Invertebrate drift**

Drifting invertebrates were sampled on July 3, July 30, September 4, September 20, October 30, December 17, 1985, and on February 7 and March 19, 1986. Sample dates were generally selected to coincide with trips to the study site when fish observations were taking place, and were spread out over the fish microhabitat sampling period in approximately thirty day intervals.

On each sample date, invertebrate drift was collected at dawn, dusk, and at the mid-points of the daylight and dark periods. The intervals between collection times on any given date varied from four to seven hours. One-meter-long, square-mouthed drift nets constructed of 0.5 mm synthetic mesh with openings measuring 30cm x 50cm x 100cm were mounted on rebar posts driven into the streambed at each of the two sampling sites. Nets were placed with top edges slightly submerged to exclude surface drift that could obstruct the net mouth. Velocities at 0.2 and 0.8 times the height of the net opening were measured with a current meter at the onset and at the end of each sampling period. Discharge through each net during each collection was computed by averaging the two velocity readings and multiplying by the cross-sectional area, and the density of invertebrate drift was estimated as total biomass of invertebrates per cubic meter of water discharged.

Collections were rough sorted in the field: At each collection time, any large leaves (area >5cm) trapped in the nets were each given a single shake in a bucket of water collected from the stream immediately upstream from the site. The nets were then rinsed in the same bucket and the sample was poured back through the net to trap organisms and detritus. A wash bottle containing 70% ethanol was used to flush the sample into a collecting jar.
In the laboratory, the samples were poured into a glass tray which had a grid scribed on its bottom to facilitate searching the tray. All aquatic invertebrates were retrieved and wet-weighed to the nearest 0.01mg following Greeson (1979).

Statistical analyses

Analysis of microhabitat data was conducted using BMDP (Dixon et al. 1983) and MINITAB (Ryan et al. 1985) statistical software. A discriminant function was generated to classify fish into either a summer or winter group. The null hypothesis, that each of the estimates for sample means was estimating the same parameter, was tested for each of the variables.

Analysis of microhabitat preferences of fish other than 0+ steelhead was not done. Other fish were so rare (i.e., fewer than three of any species) that estimates of their associated microhabitat preferences would be highly uncertain.

Invertebrate drift data for each sampling date were separated into daylight and dark categories and means for each category were computed. Data from collections obtained at the SC and CF sites were pooled for analysis after it was found that there were no significant differences in median values (Wilcoxon rank sum test, alpha=0.05). Mean densities for both light and dark periods were then plotted as a time series to describe fluctuations in invertebrate drift density throughout the study period.

RESULTS

Microhabitat use

Statistical analysis of the microhabitat data via multivariate methods proved inconclusive. The discriminant function was able to correctly classify no more than 70.5% of the fish into the summer and winter groups. Results of univariate analyses are depicted in Table 1 and Figures 3-8. The most powerful single variable for distinguishing groups was depth of the water column in which the fish were found. The seasonal sample means for summer and winter depths were 0.25m and 0.38m, respectively, and these were found to differ significantly at the 95% confidence level.
Table 1. Seasonal microhabitat preferences of age 0+ steelhead in Hurdygurdy Creek, California. Values varying significantly (t-test, P < 0.05%) are marked with asterisks. Sample sizes were 227 and 24 in summer and winter, respectively.

<table>
<thead>
<tr>
<th>Microhabitat variable</th>
<th>Summer mean</th>
<th>Winter mean</th>
</tr>
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<tbody>
<tr>
<td>Depth of water</td>
<td>0.25m*</td>
<td>0.38m*</td>
</tr>
<tr>
<td>Focal velocity</td>
<td>0.07m/s</td>
<td>0.05m/s</td>
</tr>
<tr>
<td>Average velocity</td>
<td>0.15m/s</td>
<td>0.13m/s</td>
</tr>
<tr>
<td>Maximum velocity</td>
<td>0.20m/s</td>
<td>0.16m/s</td>
</tr>
<tr>
<td>Focal height</td>
<td>0.05m</td>
<td>0.06m</td>
</tr>
<tr>
<td>Substrate type</td>
<td>Rubble</td>
<td>Rubble</td>
</tr>
</tbody>
</table>
Figure 3. Seasonal shifts in microhabitat use by age 0+ steelhead in Hurdygurky Creek, California. Boxes indicate limits of first and third quartiles, lines across boxes indicate data means, whiskers extending above and below boxes indicate data range.
Figure 4. Frequency distribution of water depths available in summer, and those used by age 0+ steelhead in Hurdygurdy Creek, California.
Figure 5. Frequency distribution of water depths available in winter, and those used by age 0+ steelhead in Hurdygurdy Creek, California.
Figure 6. Frequency distribution of substrates available in both summer and winter, and those used by age 0+ steelhead in Hurdyurdy Creek, California.
Figure 7. Frequency distribution of average water column velocities available in summer, and those used by age 0+ steelhead in Hurdygurdy Creek, California.
Figure 8. Frequency distribution of average water column velocities available in winter, and those used by age 0+ steelhead in Hurdygurdy Creek, California.
The next most powerful variable was focal point velocity. Sample means for summer and winter, respectively, were 0.07 m/s and 0.05 m/s. However, these were not found to differ significantly ($P = 0.05$). The remaining variables were of little value in describing differences between microhabitats used by age 0+ steelhead.

**Winter habitats**

Age 0+ steelhead overwintering in the CF site appeared closely associated with artificial cover: 22 of the 26 fish observed (85%) were located within 1 m of a boulder structure. Nine of the 10 age 0+ steelhead overwintering in the SC site were found within 2 m of a partially submerged log (diameter approximately 0.75 m) wedged along one bank.

The use of substrate interstices by juvenile steelhead varied dramatically by season. During the summer observations a single juvenile out of 245 (<0.5%) was observed using this microhabitat, while during the winter, 26 out of 67 juveniles (39%) were observed using interstices in main channel habitats. Evidence of common use of substrate interstices was provided by electrofishing within the CF site on February 12, 1986. Habitats which had been surveyed by divers a few minutes prior revealed twice as many (15 vs 7) juveniles as counted by direct observation.

During winter monitoring of off-site habitats, fish were found only in low densities (5-10 per each 100 m of channel searched) until a small, ephemeral, channel braid, separated from the main channel by a broad cobble bar was investigated. This habitat type corresponds to "secondary channel pools" as described by Bisson et al. (1982). Juvenile steelhead were abundant in the shallow pools of the secondary channel; more than 100 were counted in a single pool measuring 30 m x 2 m with a maximum depth of 0.3 m and virtually no flow. All fish observed in this and similar pools were 0+ steelhead, many of which were feeding in the water column. First discovered in early March, these fish remained in the pools through April but had virtually disappeared by mid-May.

Juvenile steelhead using secondary channel pool habitats during winter were associated with overhead cover in the form of debris jams. In the absence of such cover, these fish tended to hold near the bottom in the deeper sections of the pools. Fish in the secondary channel pool habitats appeared less skittish and brighter in color than those in the main channel. Water temperatures in the main channel
ranged from 7.5 to 11.5 °C during the winter of 1985-86. Water temperatures were not measured in the secondary channel pools.

**Food availability**

Invertebrate drift density (IDD) fluctuated considerably during the study period with peaks in early July and again in February and March. A low-point in IDD was reached during the period of late October to mid December (Figure 9). Nighttime densities exceeded daytime densities by a factor of five to seven (Table 2). Night IDD also fluctuated more than did day IDD. Daytime and nighttime IDD were found to be poorly correlated overall (r=0.367).

**DISCUSSION**

Age 0+ steelhead exhibited seasonal shifts in habitat utilization during the study period. As winter approached, the fish appeared less active, more skittish and more closely associated with large cover elements in the study sections. Age 0+ fish tended to use deeper and slower water more in winter than during summer. Fish found outside the study sections during winter were especially common in the slow-moving pools of secondary channels, a habitat type that accounts for <0.4% by area of fish habitat in the Hurdygurdy watershed (L. Decker, personal communication).

Mean values for water velocities and substrates associated with microhabitats utilized in winter by age 0+ steelhead in Hurdygurdy Creek are generally similar to published information (Everest and Chapman 1972, Bustard and Narver 1975a, Everest et al. 1984). Age 0+ steelhead overwintering in the study sites used deeper water on average than reported by Everest and Chapman (1972), and Bustard and Narver (1975a). However, research by Everest et al. (1984) reports juveniles overwintering in Fish Creek, Oregon, used water of similar depth.

Previous work has revealed that the habitat used by juvenile salmonids varies with time of year (Hartman 1965, Chapman and Bjornn 1969, Mason 1976, Everest et al. 1984, Heifetz et al. 1986). Bustard and Narver (1975a) reported that age 1+ steelhead in a small Vancouver Island stream overwinter mainly in locations affording cover and low water velocity, such as areas close to logs, root wads and
Figure 9. Invertebrate drift density expressed as milligrams wet weight per cubic meter of water in Hurdygurdy Creek, California. Data points are represented by circles (day collections) or dots (night collections). Sample dates range from July 1985 through March 1986.
Table 2. Invertebrate drift densities (IDD) at Salamander Creek and Chimney Flat sampling sites. IDD expressed in milligrams, wet weight, per cubic meter of water.

<table>
<thead>
<tr>
<th>Sampling dates</th>
<th>Locations and collection times</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Salamander Ck.</td>
</tr>
<tr>
<td></td>
<td>Day</td>
</tr>
<tr>
<td>July 2, 1985</td>
<td>0.031</td>
</tr>
<tr>
<td>July 30, 1985</td>
<td>0.019</td>
</tr>
<tr>
<td>Sep. 3, 1985</td>
<td>0.022</td>
</tr>
<tr>
<td>Sep. 19, 1985</td>
<td>0.018</td>
</tr>
<tr>
<td>Oct. 30, 1985</td>
<td>0.002</td>
</tr>
<tr>
<td>Dec. 17, 1985</td>
<td>0.009</td>
</tr>
<tr>
<td>Feb. 7, 1986</td>
<td>0.027</td>
</tr>
<tr>
<td>Mar. 19, 1986</td>
<td>0.064</td>
</tr>
</tbody>
</table>
debris in main channels. The authors found most age 0+ steelhead either very close to or under rubble and cobble. Edmundson et al. (1968) found juvenile steelhead in two Idaho streams using substrate interstices during the winter, while Everest et al. (1984) reported that most age 0+ and 1+ steelhead overwintering in two Oregon streams occupied the interstitial spaces of a boulder-cobble substrate.

During this study, fish occupied substrate interstices to a greater extent in winter than in the summer. Nearly half of all fish observed during winter dives were found in these habitats. Also, I believe that the additional fish tallied during electrofishing of the CF site in February, 1986, represented individuals which were present during the preceding dive but were using interstices not visible to the divers.

My findings that large numbers of overwintering age 0+ steelhead relied on small, shallow pools in secondary channels contrasts with published information indicating that only juvenile coho salmon (Oncorhynchus kisutch) or cutthroat trout commonly use this habitat during winter (Bustard and Narver 1975a, 1975b). Spring-fed side channels were used as winter habitat by age 0+ steelhead in Oregon streams studied by Everest et al. (1984), although this habitat type was not so heavily used as either alcoves or riffle margins. Hartman (1965) and Heifetz et al. (1986) report the extensive winter use of pool habitats by juvenile steelhead, although both studies refer to deeper, main channel pools with substantial cover. It is possible that the relative importance of secondary channel habitats in Hurdygurdy Creek has been exaggerated following the loss of large woody debris in the main channel subsequent to the catastrophic events of winter 1964/1965. Also, it may be that steelhead are more likely to use these habitats in the absence of coho.

The majority of discharge into the secondary channels during winter base flow came from small springs and percolation through river bars. If water temperature in the secondary channels (not measured during study) was raised by groundwater inflow, fish may have remained in these habitats because of warmer temperatures. This behavior was described for downstream-migrating juvenile steelhead by Chapman and Bjornn (1969). The temperature of near-surface groundwater frequently approximates the local mean annual air temperature (Freeze and Cherry 1979), and is therefore warmer than surface water during winter. Therefore, I have speculated that water temperatures in the spring-fed secondary channels at Hurdygurdy Creek were relatively warm during winter and age 0+ steelhead benefitted from the less stressful environmental conditions in these habitats.
Age 0+ steelhead were rare in all main channel habitats during winter; few were discovered during several carefully conducted snorkel surveys. However, an exhaustive search of substrate interstices not directly observable by divers was not done. We were able to capture three 1+ steelhead while electrofishing around mid-stream boulder clusters in the CF site on March 5, and this, along with the experience of others (Edmundson et al. 1968, Everest et al. 1984), suggests that interstices within cobble-to-boulder size substrates constitute important winter refuges for older juvenile steelhead.

Age 1+ steelhead were conspicuously absent during the winter and must either make extensive use of substrate chambers or emigrate into smaller tributaries or down to the South Fork Smith River. Juvenile steelhead in Idaho are known to migrate downstream into larger streams for overwintering (Chapman and Bjornn 1969) although this appears to be an uncommon behavior in coastal streams (Shapovalov and Taft 1954, Chapman 1962). A two-hour-long investigatory dive on February 7 in a 300-meter-long section of the South Fork Smith River near the confluence of Hurdygurdy Creek turned up only a few 0+ steelhead (< 10) hiding in root wads and no 1+ steelhead. This suggests that juveniles did not migrate into the larger stream.

Some juveniles found in the secondary channel habitats may have been cutthroat trout and not steelhead. Cutthroat trout have been described as favoring habitats similar to these during winter (Bustard and Narver 1975b), and there are no suitable criteria for distinguishing free-swimming steelhead from cutthroat at total lengths less than approximately 80 mm (personal experience). However, cutthroat trout did not otherwise appear to be numerous in Hurdygurdy Creek, and the assumption was made that all juvenile salmonids of less than 80mm total length were steelhead.

The boulder structures placed in Hurdygurdy Creek have increased habitat diversity in these sections. The large interstitial spaces within the structures appear to provide additional overwintering habitat. Winter habitat for 0+ steelhead, as represented by the quiet pools of secondary channels, is limited in Hurdygurdy Creek. This presents an enhancement opportunity with great potential in stream sections where the valley floor is wide enough for secondary channels to persist, especially in locations where winter-warm groundwater is discharged.
It is my impression that the most significant reduction in numbers of 0+ steelhead took place during the winter, as their density appeared stable throughout the summer but had decreased noticeably by spring when they emerged from interstices. There are several reasons to suspect that winter may be the most difficult time of year for juvenile salmonids in Hurdygurdy Creek: (1) the physical environment is at its harshest during winter storms with low temperatures, rapid fluctuations in stream discharge and periodic mobilization of substrates; (2) the metabolism of fishes is slowed at low temperatures, reducing their ability to maintain positions and feed in flowing water; and (3) the availability of food may be reduced during late fall and early winter, as suggested by the IDD portion of this study. Late summer is, in some streams, a time when the density of salmonids may be limited due to critically high water temperatures and decreased habitat availability (Jim Hopelain, personal communication). Maximum temperatures in Hurdygurdy Creek, however, never exceeded 19.0 C and the amount of useable habitat did not appear to decrease dramatically from June to September.

Food availability decreased late in the year, and was lowest from late October to mid-December. Studies of aquatic invertebrate drift commonly express density as numbers of individuals per unit volume (Elliott 1967, Kreuger and Cook 1981, Stewart and Szczytko 1983, Allan and Russek 1985) rather than as biomass per unit volume. It seems reasonable to use IDD, if the intention of drift sampling is to describe food availability for salmonids. Conversions of biomass to numbers of individuals and vice versa are not generally feasible, however, and because of this I am not able to make a comparison of food availability in Hurdygurdy Creek to published data on other anadromous salmonid streams.

Minute organisms such as larval chironomids (Diptera) and the early instars of many baetids (Ephemeroptera) are frequently abundant in the drift of salmonid streams, yet their small size may often result in their being ignored by drift-feeding salmonids (Allan 1978). In this study, the major component of the total weight of any given drift sample consisted of a small number of relatively large-bodied individuals. I believe, in view of this, that the biomass of drifting invertebrates estimated here is a reasonable measure of the food available to fish.

Juveniles in the study sections appeared to feed almost exclusively on drift during this study. The only possible bottom foraging occurred on two occasions when 0+ steelhead were observed pecking at the surface of boulders where larval simulids
(Diptera) were visible. Mason and Chapman (1966) suggested that the amount of incoming invertebrate drift is a factor in determining the carrying capacity for fish. Although I do not know for certain that juvenile steelhead in Hurdygurdy Creek depend primarily upon drift for food, the decrease in IDD in November and December 1985 may indicate limited food and a consequent drop in carrying capacity at that time of year.

In view of my findings that (1) winter seemed likely to be the most stressful time of year for age 0+ steelhead, and (2) in winter, age 0+ steelhead were most numerous in spring-fed secondary channel pools which appeared to offer benefits of abundant cover, low water velocities, and warmer water temperatures, I believe enhancing winter habitat, rather than summer habitat, would have been a more effective strategy for increasing numbers of steelhead smolts produced from Hurdygurdy Creek. Biologists originally planning the enhancement project lacked complete information on the availability of lifestage- and season-specific habitats; based on information collected in what they believed were similar systems, spawning habitat and summer rearing habitat were incorrectly identified as limiting factors.

One strategy for increasing the production of stream salmonids is to deepen portions of shallow riffles, providing more summer, low-water habitat. While this approach may often be appropriate, serious problems can arise if all season- and lifestage-specific habitat requirements of fishes are not considered. The task of accurately identifying factors which limit production of anadromous salmonids in streams is a crucial first step in the design of effective projects.


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