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# Capture, Marking, and Enumeration of Juvenile Bull Trout and Cutthroat Trout in Small, Low-Conductivity Streams

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*Abstract.*—Relative efficiencies of sampling methods were evaluated for bull trout *Salvelinus confluentus* and cutthroat trout *Oncorhynchus clarki* in small, high-gradient streams with low conductivities. We compared day and nighttime observations by snorkelers to enumerate bull trout and cutthroat trout, and at night we also used a bank observer. Methods were developed for capturing juvenile bull trout in areas where traditional methods such as electrofishing were ineffective. Juvenile salmonids were counted during the day and night in two reaches (200 m) of Trestle Creek, Idaho, in August 1991. In July 1992, juvenile salmonids were counted during the day and night in 10 reaches (75 m) of three Idaho streams: Trestle, Rattle, and Granite creeks. Night counts of juvenile bull trout exceeded day counts in all reach comparisons; differences were significant ($P < 0.05$) in 1992 but not in 1991. In contrast, summer day counts of cutthroat trout were significantly higher ($P < 0.05$) than night counts when reaches were pooled in 1991, but no differences were found in 1992. Observations from the bank sometimes improved the accuracy of the population estimates; more than one-third of the juvenile bull trout observed in Trestle Creek in 1992 were observed from the bank, whereas bank observers saw fewer fish (both species) than snorklers in Granite Creek. Both snorkelers and bank observers effectively captured juvenile bull trout with specially designed nets at night. The snorkeler captured 71% of the juvenile bull trout observed, whereas the bank observer captured 86%. Visible polymer implants allowed us to identify marked fish at night without the need for recapture.

Bull trout *Salvelinus confluentus,* the only native char in the intermountain West, has sustained reductions in distribution and abundance in this century. Ratliff and Howell (1992) estimated that two-thirds of 65 bull trout populations they studied in Oregon had at least a moderate risk of extinction. Factors responsible for the decline include habitat degradation, interactions with introduced salmonids, overharvest, and climatic change (Goetz 1989).

The American Fisheries Society has classified bull trout as a species of special concern (Williams et al. 1989), and the species is listed as a Category 2 candidate under the U.S. Endangered Species Act. In October 1992, the U.S. Fish and Wildlife Service was petitioned to assess the status of bull trout.

The inventory of bull trout in small, high-gradient streams poses problems. In Idaho, juvenile bull trout are typically found in cold (<15°C) streams with low conductivity (<100 μS/cm), generally in close association with the substrate and woody debris in the channel (Pratt 1984). Methods such as electrofishing and day snorkeling may be ineffective or impractical for sampling juvenile bull trout (Fraley and Shepard 1988).

Preliminary attempts to enumerate and capture juvenile bull trout with electrofishing gear were unsuccessful. Water conductivities in our study streams were too low (<50 μS/cm), and juvenile bull trout were too elusive for effective sampling with a backpack electrofisher. Fish were observed avoiding the electrical field. Moreover, we had to be careful not to injure the large (>400 mm) adfluvial adult bull trout in the study streams (Sharber and Carothers 1988).

The primary objective of our study was to develop an effective sampling method for bull trout and cutthroat trout *Oncorhynchus clarki.* We evaluated underwater counts of both species during the day and night and also compared summer and winter counts. Additionally, we developed a technique for capturing juvenile bull trout with specially designed dip nets and for marking them with an implanted but visible fluorescent polymer. The polymer implants were used as part of another study but are described here because of their applicability to fish enumeration.

## Study Area

Trestle and Granite creeks flow directly into Lake Pend Oreille. Rattle Creek is a tributary to Lightning Creek and the Clark Fork River, the principal inlet to Lake Pend Oreille. The streams drain steep watersheds vegetated by coniferous forest. Stream gradients ranged from 1–8% and canopy coverage from 0 to nearly 100%. No aquatic vegetation was observed within sampled reaches. Water clarity did not limit underwater observations in summer or winter. Highest flows are in the winter and spring when rain on snow is common. Fish species present were bull trout, westslope cutthroat trout *O. c. lewisi,* rainbow trout *Oncorhynchus mykiss,* mountain whitefish *Prosopium williamsoni,* and one or more species of sculpins *Cottus* spp.

## Methods

*Fish capture.*—Many methods of underwater capture such as the zap gun or spear gun (Ivanovic 1955) kill the target fish, which may be unacceptable for rare or endangered species. Other methods such as the slurp gun, which captures fish alive, were used effectively for fry of Atlantic salmon *Salmo salar* but were less effective on larger fish (Morantz et al. 1987). Small dip nets have shown promise for sampling juvenile salmonids. DeGraaf and Bain (1986) used a small net to capture more than half of the juvenile Atlantic salmon they observed, but larger fish were more difficult to capture. Morantz et al. (1987) used a similar net to capture small Atlantic salmon parr but found that larger parr avoided the net.

We constructed two nets, one used by a snorkeler and the other by a bank observer. The snorkeler used a small dome-shaped net of 3-mm-mesh nylon equipped with a drawstring closing mechanism. The narrow, rectangular frame of this net was no longer than the longest fish to be captured (12 × 27 cm) and could be placed over a fish lying on an irregular substrate without leaving escape routes beneath the net. The snorkeler proceeded upstream until a trout was observed. The snorkeler approached the fish (without shining the light directly on it during night sampling), slowly moved the net until it was directly above the fish, then swiftly lowered the net over the fish and pressed it firmly against the substrate. The drawstring was then pulled, which closed the bottom of the net under the fish. The fish was then easily transferred to a container for temporary retention.

Bank observers used a small dip net with an attached encircling net to capture fish. We constructed the encircling net by attaching a 16 × 60-cm piece of 3-mm-mesh nylon to a 13 × 16-cm dip-net frame. The bottom of the encircling net was weighted with lead. When a fish was observed, the encircling net was lowered around it with the dip net on the downstream end. Once the fish was surrounded, it was chased into the dip net and removed from the stream. The observers wore a head-mounted light to free both hands for netting.

Efficiencies of both types of nets were evaluated during both day and night sampling. We attempted to capture every age-1 and older bull trout and cutthroat trout observed. For each attempt, we recorded fish species and success or failure of the capture attempt.

*Marking.*—We sought a method of marking that would enable us to identify bull trout at night, preferably without the need of recapture and without increasing mortality of the fish. We used fluorescent polymer implants, developed by Northwest Marine Technology, Inc.[1], Shaw Island, Washington. The implant appears as a small fluorescent line visible to the naked eye.

The implant consisted of a two-component polymer that we combined immediately before use. The polymer was injected beneath the skin or between fin rays with a 28-gauge syringe. Fish were marked in one of the following locations: top of head, adipose tissue behind the eye, adipose fin, dorsal fin, pectoral fin, or caudal fin. We used different marking locations to distinguish fish from different stream sections as part of another study. Tagged fish were relocated at night by a diver or bank observer using a fluorescent light.

To test tag retention times, we tagged 85 juvenile bull trout once at the Sandpoint Hatchery operated by the Idaho Department of Fish and Game in Sandpoint, Idaho. Fish were checked for tag retention after 2 month and again after 4 months.

*Enumeration test 1, underwater counts.*—We compared underwater counts of fish during day and night within two reaches of Trestle Creek in late summer. The two reaches (A and B) were about 200 m long and contained 6 pocket-water habitats, 9 pools, and 10 riffles. Water temperatures, recorded continuously on a thermograph,

[1] The use of trade or firm names in this paper is for reader information and does not imply endorsement by the U.S. Forest Service of any product or service.

ranged from 11 to 12.5°C during the snorkeling period, with minimal diel fluctuation.

Two snorkelers completed night counts on August 19 and 20, 1991, between 2300 and 0230 hours. Each snorkeler, equipped with a wetsuit, mask, snorkel, recording sleeve, and underwater light, counted in one reach. The snorkeler entered the water downstream from the lowermost habitat unit and proceeded slowly upstream through each unit, counting all salmonids and recording them in 100-mm size-classes. An assistant on shore followed the snorkeler and transferred counts to a data sheet but did not attempt to count fish. Day counts were completed on August 20 between 1100 and 1400 hours in the same reaches with identical procedures.

We categorized bull trout as small juveniles (<100 mm total length), large juveniles (100–400 mm), and adults (>400 mm), and westslope cutthroat trout as juveniles (≤200 mm) and adults (>200 mm). Day and night counts of each species in each reach were compared. We examined the effect of fish size on day versus night counts by pooling fish by species and size-class for each reach. We used a test for the difference in two proportions to examine differences in day versus night counts (Zar 1974).

*Enumeration test 2, underwater plus bank counts.*—We compared day and night snorkeling counts during winter in 2 reaches in Trestle Creek and during summer in 10 reaches of Trestle, Rattle, and Granite creeks. Reaches of each stream were selected between the mouth and the uppermost limit to bull trout migration and were about 75 m long with a wide range of temperatures and gradients. Each reach contained several pools and riffles. We measured water temperatures at the time of snorkeling with a hand-held thermometer. Fish counts in winter were completed from January 15 to February 10, 1991; in summer counts were made July 10–25, 1992. Fish were counted during winter days between 1000 and 1300 hours and during winter nights between 1700 and 2000 hours. We completed counts during summer days between 1000 and 1500 hours and during summer nights between 2300 and 0200 hours.

Two observers, one snorkeling and one on shore, counted fish during the day and again that night. The snorkeler entered the stream at the lower end of the reach and proceeded slowly upstream. Numbers of bull trout and cutthroat trout were recorded and periodically reported to the bank observer. Age-0 fish were not counted. The bank observer walked upstream parallel to the snorkeler and counted fish in shallow stream margins and backwater areas inaccessible to the snorkeler. The bank observer counted fish along both banks. Communication between the bank observer and the snorkeler ensured that fish were counted only once.

We plotted day and night counts by species for each reach. Counts were pooled for the 2 reaches in winter and 10 reaches in summer, and differences were tested with a paired $t$-test (Dowdy and Wearden 1983). Percentages of fish counted with each method (bank observer and snorkeler) were compared between day and night.

TABLE 1.—Capture frequencies for juvenile bull trout and cutthroat trout by snorkelers and bank observers using dip nets at night. Capture frequencies during daylight hours were less than 10%.

| Technique and species | Number of Attempts | Number of Captures | Capture frequency (%) |
|---|---|---|---|
| Snorkelers | | | |
| Bull trout | 91 | 65 | 71 |
| Cutthrout trout | 60 | 13 | 22 |
| Bank observers | | | |
| Bull trout | 50 | 43 | 86 |
| Cutthrout trout | 40 | 12 | 30 |

## Results

### Fish Capture

Both snorkelers and bank observers successfully captured juvenile bull trout with dip nets at night. Capture frequencies were 71% for snorkelers and 86% for bank observers (Table 1). Success was lower for cutthroat trout: 22% for snorkelers and 30% for bank observers. Capture efficiencies did not exceed 10% for either species during the day.

### Marking

After 2 months, all 85 fish had retained their injected fluorescent tags. By the end of 4 months, only one fish had lost its tag, and all fish survived. Marks on the head, dorsal fin, adipose fin, and caudal fin were easily observed by snorkelers without recapturing the fish. Marks on the pectoral fins or behind the eyes were more difficult to locate because the diver had to see both sides of the fish.

### Enumeration

*Test 1, underwater counts.*—When counts in individual habitat units were pooled into two reaches (A and B), night counts were greater than or equal to day counts for all three size-classes of bull trout in both reaches (Figure 1), but night–day differences were not significant ($P > 0.08$). In contrast,

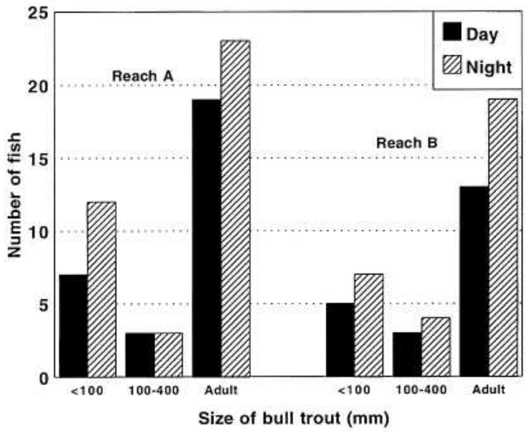


FIGURE 1.—Day and night counts of juvenile and adult bull trout pooled by size-class in two reaches of Trestle Creek, August 1991.

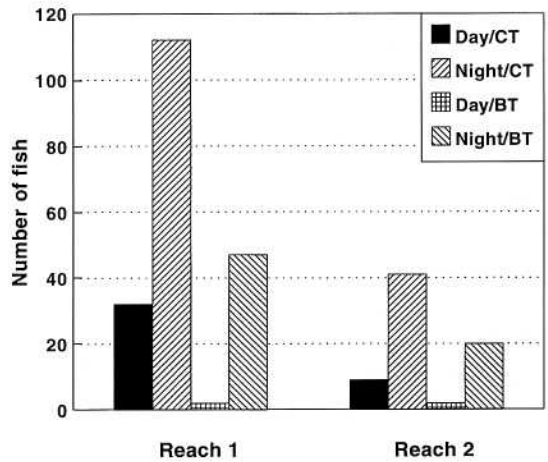


FIGURE 3.—Day and night counts of bull trout (BT) and cutthroat trout (CT) in two reaches of Trestle Creek in winter (January–February), 1991.

day counts were greater than or equal to night counts for both size-classes of cutthroat trout in both reaches (Figure 2). Day counts of juvenile cutthroat trout were significantly larger than night counts in reaches A ($P < 0.001$) and B ($P < 0.025$).

*Test 2, underwater plus bank counts.*—Juvenile bull and cutthroat trout were observed in the 2 reaches sampled in winter and all 10 reaches sampled in summer. The numbers of juvenile bull trout counted at night were significantly greater than the numbers counted during the day for the combined reaches in both winter ($P < 0.001$) and summer ($P < 0.001$). Night counts exceeded day counts within each reach (Figures 3, 4).

During summer, in contrast, the number of juvenile cutthroat trout counted at night did not differ significantly from the number counted during the day (Figure 5). During winter, however, night counts of cutthroat trout were significantly larger than day counts ($P < 0.01$; Figure 3).

During night surveys, two observers, one snorkeling and one on the bank, were necessary to observe fish in stream margins and backwater areas. A large percentage of the fish were located by the bank observer in Trestle Creek, whereas few fish were located by the bank observer in Granite Creek (Figure 6). A bank observer was also used during the day but never counted age-1 or older bull trout or cutthroat trout.

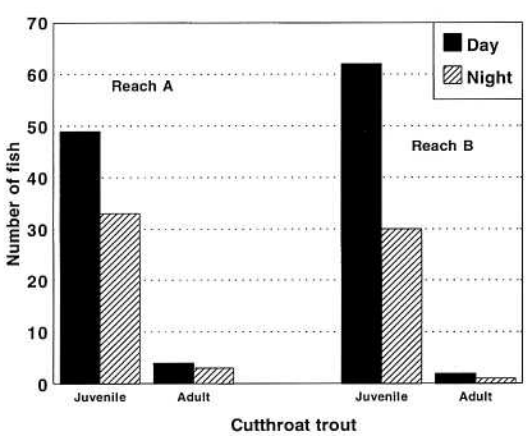


FIGURE 2.—Day and night counts of juvenile and adult cutthroat trout (pooled) in two reaches of Trestle Creek, August 1991.

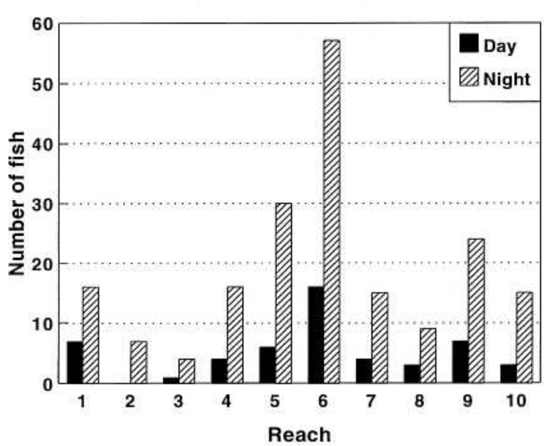


FIGURE 4.—Day and night counts of bull trout in 10 reaches of three streams in summer, 1992.

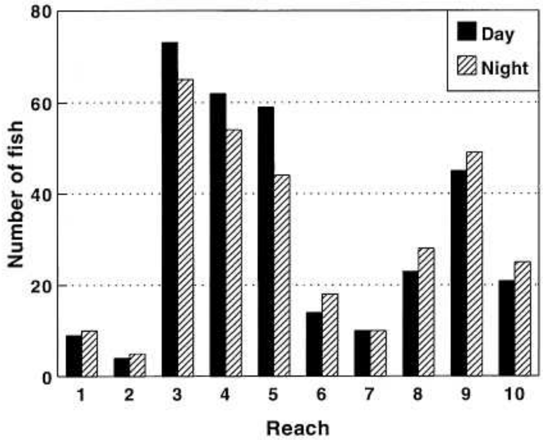


FIGURE 5.—Day and night counts of cutthroat trout in 10 reaches of three streams in summer, 1992.

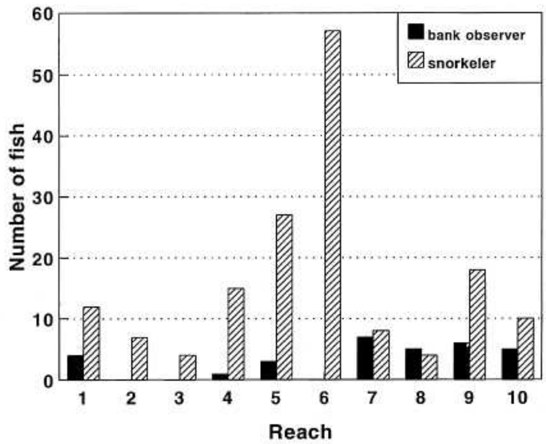


FIGURE 6.—Numbers of bull trout and cutthroat trout observed by the snorkeler and bank observer in 10 reaches of three streams.

## Discussion

The ease of capturing juvenile bull trout at night with nets allowed us to collect fish without relying on electrofishing. In areas where juvenile bull trout are scarce or access is poor, a diver may find capturing bull trout with nets at night is easier and more efficient than electrofishing. We captured all sizes of juvenile bull trout effectively because their resting behavior at night made them susceptible to capture with nets. Attempts to net bull trout and cutthroat trout during the day were unsuccessful. Use of nets at night may also have application when injury to fish such as adult bull trout must be avoided. If fish are to be captured in winter, snorkeling and netting fish at night may be effective. Although capture efficiencies were not quantified, bull trout were more sluggish in winter than in summer and were easily captured.

The use of fluorescent polymer implant tags permitted us to identify marked bull trout at night without recapturing them. This is an important attribute because bull trout were most effectively observed at night. Because some salmonids overwinter in the substrate during the day but leave cover at night (Campbell and Neuner 1985), a tag that is easily identifiable at night would allow marked fish to be relocated. Fluorescent implants would be especially useful for mark–recapture population estimates of bull trout in summer and winter. Tag retention in the hatchery was nearly 100% after 4 months. Retention time in a natural environment might be longer because raceway rearing imposes the stresses of unnaturally high fish densities as well as abrasive physical constraints.

Although we found visual counts by a snorkeler and bank observer to be superior to electrofishing for sampling and enumerating bull trout, other researchers have found the opposite. In the Flathead River drainage, electrofishing estimates of juvenile bull trout consistently exceeded estimates derived from day snorkeling (Fraley and Shepard 1988). In our study streams, we found electrofishing gear ineffective for capture and enumeration, and fish were observed avoiding the electrical field. Low water conductivities (<50 μS/cm) and low water temperatures (<11°C) likely made electrofishing ineffective. The cover-seeking nature of bull trout may render them especially difficult to sample in streams with abundant cover.

Our comparisons of day and night underwater counts of bull trout suggest that day counts underestimate the actual population. When counts were pooled by reach and compared, night counts consistently exceeded day counts in all 12 sampled reaches of both tests. Goetz (1991) similarly reported that night snorkeling was superior to day snorkeling.

Larger differences between day and night counts in 1992 than in 1991 are partly due to the addition of a bank observer in 1992. More than one-third of the bull trout counted in Trestle Creek at night in 1992 were counted by the bank observer. Higher densities of juvenile bull trout in 1992 may also be partly responsible for the observed differences. Approximately the lower half of both reaches A and B, which were sampled in 1991, were also sampled in 1992. Although the sampled sections in 1992 were only half as long, total numbers of bull trout counted in 1992 (63) were higher than in 1991 (32). The actual difference was probably even greater because age-0 bull trout were included in the 1991 count but not in the 1992 count.

The differential day–night observability of juvenile bull trout appeared to be greater for smaller fish than for larger ones, perhaps because smaller fish hide more effectively than large fish during the day. If large bull trout are less susceptible to predation than smaller bull trout, they may not seek cover as often.

Compared to bull trout, cutthroat trout were less readily observed at night than during the day. When counts were pooled by reach and compared, day counts were significantly higher than night counts in the two summer 1991 reaches of Trestle Creek, and did not differ in the 10 reaches of three creeks in 1992. We often found it difficult to obtain accurate counts of cutthroat trout at night because the dive lights usually caused aggregations of fish to scatter, thus lowering our counts. In comparison, cutthroat trout typically faced upstream and could be approached by a diver in daytime.

If cutthroat trout shift from the water column to cover, the shift may be influenced by predators (Bugert and Bjornn 1991; Tabor and Wurtsbaugh 1991). Within Trestle Creek, the presence of large (>400 mm) bull trout may have influenced the cover-seeking behavior of cutthroat trout at night.

## Acknowledgments

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