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Evaluation of Batch Marking Small Rainbow Trout with Coded Wire Tags

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Abstract.—We conducted a laboratory and field study to assess the feasibility and effects of tagging small (<80-mm) rainbow trout *Oncorhynchus mykiss* with coded wire tags in five body locations. In the laboratory, 8-week retention rates ranged from 95.0% to 100% for coded wire tags implanted in the snout, nape, and base of the caudal, dorsal, and anal fins and from 97.0% to 100% among tagged fish in the following length-classes: 40–49, 50–59, 60–69, and 70–79 mm. Tagged and untagged control fish had similar growth ($P > 0.2$) and total mortality rates (8.4% versus 7.5%; $P = 0.33$). However, mortality was significantly higher among fish tagged in the nape (16.9%; $P < 0.01$) and those in the 40–49-mm length-class (16.1%; $P < 0.01$). In the field, 90% (126 of 140) of fish recaptured 5 months to 3 years after tagging retained the coded wire tag. Tag location was correctly identified in 100% of tagged fish. Batch marking with coded wire tags in different body locations appears to be an effective tagging method for small salmonids, although care must be exercised when tagging in the nape and at lengths less than 50 mm.

Coded wire tags have been used extensively since the 1960s to mark large numbers of fish efficiently and inexpensively (Jefferts et al. 1963; Blankenship 1990; Dunning et al. 1990). Coded wire tags have several desirable characteristics, including small size, high retention rate, and minimal side effects (Bergman et al. 1992; Guy et al. 1996). An additional advantage is that they can be inserted into small juvenile fish and recovered years later in adults (Thrower and Smoker 1984). However, a limitation of coded wire tags is that their use typically involves sacrificing the fish to remove the tag and read the code. To circumvent this limitation, several investigators have implanted coded wire tags in multiple body locations as a batch mark. Batch mark information is then retrieved using a coded wire tag detector to pinpoint the location of the magnetic tag (Heidinger and Cook 1988; Bergstedt et al. 1993; Tipping and Heinricher 1993; Pitman and Isaac 1995; Hale and Gray 1998).

We sought to determine the efficacy of coded wire tags as a batch mark to estimate the relative contribution of juvenile rainbow trout *Oncorhynchus mykiss* from several tributaries to adult recruitment. Juvenile salmonids emigrate from natal tributaries either soon after emergence or after a period of extended rearing. Length at migration ranges from about 25 mm soon after emergence to 100 mm or more after tributary growth (e.g., Rosenau 1991; Knight et al. 1999). Coded wire tags have been used successfully to batch mark large juvenile and adult brown trout *Salmo trutta* (142–254 mm, 28–196 g) and rainbow trout (80–314 mm, 14–348 g) in the snout, the base of fins, and the cheek (Hale and Gray 1998), but their use for batch marking salmonids less than 80 mm (a typical size for age-0 salmonids) has not been evaluated extensively. Bergman et al. (1968) evaluated the effects of coded wire tags implanted in the snouts and backs of small (50-mm) chinook salmon *O. tshawytscha*, but we found no other published reports of tagging small salmonids in locations other than the snout. Here we report on a laboratory and field investigation of the tag retention by and biological effects on small (<80-mm) rainbow trout tagged with coded wire tags in five body locations.

Methods

Laboratory.—Juvenile hatchery-reared rainbow trout (30–79 mm total length, 0.15–5.64 g) were obtained from the Bozeman Fish Technology Center, Bozeman, Montana, and sorted into five 10-mm length-classes: 30–39, 40–49, 50–59, 60–69,

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and 70–79 mm. Fish were randomly selected from each length-class and placed into six aluminum flow-through tanks supplied with spring water (10–12°C). The number of fish placed into each tank was about 30 from the 30–39-mm and 40–49-mm length-classes, 20 from the 50–59-mm and 60–69-mm length-classes, and 12 from the 70–79-mm length-class. Fish from the 30–39-mm length-class were later omitted from our analysis because of high loss rates (>50%) in both the control and test tanks due to cannibalism by larger fish.

Tanks were randomly assigned one of the five tag location treatments or the untagged control. Limitations on tank availability prevented replication of each tagging treatment. Mixing fish of different tag types in the same tank to allow replication among tanks (e.g., Mourning et al. 1994) was not feasible because of the difficulty of assigning tag location to fish that lost tags. Therefore, tank and treatment effects could not be separated in our study. Before tagging, fish were allowed to acclimate for 24–48 h.

Test fish were tagged over 2 d in April 1998. Before tagging, control and tagged fish were anesthetized with tricaine methanesulfonate (MS-222), weighed, and measured. Fish in each length-class were given a common tattoo mark by injecting Alcian Blue dye (Hart and Pitcher 1969) into the skin with a 22-gauge hypodermic needle in different body locations. A handheld Multishot tag injector (Northwest Marine Technology, Inc., Shaw Island, Washington) was used to implant standard-length (1.1-mm) coded wire tags into one of five body locations: the snout, the nape, or the musculature at the base of the dorsal, anal, or caudal fin. A sleeve placed over the injection needle ensured a uniform insertion depth of 2 mm. Tags in the nape were injected just posterior to the head and slightly off center. Tags implanted in the bases of fins were inserted with the long axis parallel to muscle striations (Dunning et al. 1990). Tagged fish were passed over a handheld coded wire tag detector (Northwest Marine Technology) to ensure tag insertion. Before this study, 100 rainbow trout (70–120 mm) were tagged to provide tagging experience and identify suitable tagging locations.

Fish were fed daily to satiation with commercial trout feed. Tag retention, survival, and growth were measured over 8 weeks. Tag retention was checked at 24 h and then once or twice weekly. Mortalities were removed and counted daily. Total mortality was compared among treatment and control groups within each length-class and among length-classes within each treatment by means of Fisher's exact test. Growth in length and weight were measured at 4 and 8 weeks posttagging. The effect of tagging location on growth was analyzed within each length-class with one-way analysis of variance (ANOVA). Data were analyzed using SAS/STAT statistical software (SAS Institute 2000). The level of significance for statistical testing was 0.05.

Field.—Wild age-0 and age-1 rainbow trout were captured using screw or weir traps as they migrated downstream to the Missouri River near Craig, Montana. The traps were located at the mouths of three spawning tributaries (Sheep Creek, Little Prickly Pear Creek, and the Dearborn River) and were run from March to October 1998–2000. Outmigrating rainbow trout (40–200 mm) were tagged with coded wire tags at least 2 d per week; when possible, a minimum of 200 fish were tagged. Tag location was unique for each tributary (Sheep Creek, snout; Little Prickly Pear Creek, base of anal or caudal fin; Dearborn River, base of dorsal fin). In 1999, tag location was switched to the caudal fin for Little Prickly Pear fish after an inadvertent tagging mistake necessitated changing tag location. Tags also contained a unique code so that the year of tagging could be determined at recapture. The adipose fin was removed from all tagged fish to assess tag retention. Tagged fish were recaptured in the main-stem Missouri River from 1998 to 2000 during the annual fall population estimates. Fish with an adipose fin clip were checked with a handheld coded wire tag detector for the presence of a tag, and the tag location was noted. Fish with deformed fins, which are characteristic of hatchery rainbow trout that originated from the stocking of upriver reservoirs, were omitted from the analysis (3 of 143 fin-clipped recaptures). All adipose-fin-clipped fish were sacrificed to recover the tag and verify the tag location determined with the tag detector; the tag code was also identified to determine the year of tagging. To assess the effects on growth, all tagged fish and a sample of untagged fish were aged using scales, and *t*-tests were used to compare the mean length at capture between tagged and untagged fish within the same age-group.

Results

Laboratory

Tag retention was 95.0–100% among the five tag locations and 97.0–100% among the four length-classes over the 8-week experiment (Table 1). Only six tags were lost among the 430 fish

TABLE 1.—Coded wire tag retention and mortality at 8 weeks after tagging for rainbow trout in four length-classes tagged in five body locations.

Retention or mortality variable	Tag location					Overall retention by length-class (%)	Overall mortality %	
	Anal fin	Caudal fin	Dorsal fin	Nape	Snout		Tagged	Untagged
40–49 mm								
Tags lost	1	0	0	1	2	97.0		
Mortality (%)	18.2	9.7	8.6	34.6	13.9		16.1	11.9
50–59 mm								
Tags lost	0	0	0	0	1	98.8		
Mortality (%)	0.0	6.7	4.8	15.0	17.6		8.8	5.9
60–69 mm								
Tags lost	0	0	0	0	1	99.1		
Mortality (%)	0.0	0.0	0.0	4.8	0.0		0.9	4.8
70–79 mm								
Tags lost	0	0	0	0	0	100.0		
Mortality (%)	0.0	0.0	0.0	6.2	0.0		1.6	0.0
Overall retention by location (%)	98.8	100.0	100.0	98.6	95.0			
Overall mortality by location (%)	6.9	4.8	4.5	16.9	9.1		8.4	7.5

tagged (98.6% retention). Of these, four tags had been inserted into the snout and one each into the nape and anal fin. Also, four of the lost tags were from fish in the 40–49-mm length-class and one each from the 50–59-mm and 60–69-mm length-classes. All of the tag loss occurred within the first 4 weeks after tagging, and no tag loss was observed in the 4–8 weeks after tagging. Total mortality was similar among tagged and untagged fish (8.4% versus 7.5%; $P = 0.33$; Table 1). Mortality did not differ among treatments and the control within each length-class ($P = 0.09$–1.00). Within treatments, mortality among length-classes was also similar ($P = 0.08$–0.56) except for fish tagged in the nape and anal fin locations ($P = 0.03$ and 0.02, respectively). In both treatments, the mortality rates of the 40–49-mm fish were higher than those of the other length-classes (Tukey-type multiple comparison [Zar 1984]; $P < 0.05$). Overall, mortality was significantly higher among fish tagged in the nape than among those tagged elsewhere (16.9%; $P < 0.01$) and among fish in the 40–49-mm length-class (16.1%; $P < 0.01$). Fish 40–49 mm in length that were tagged in the nape had the highest mortality among all length-class × tag location groups (34.6%). Microscopic examination revealed that the mortality of nape-tagged fish resulted from penetration of the cranium or spinal cord. Growth in length and weight did not differ between control and tagged fish at 4 and 8 weeks posttagging among any length-class × tag location group ($F = 0.30$–1.50; $P = 0.2$–0.9).

TABLE 2.—Comparison of mean length at capture between tagged and untagged rainbow trout captured in the Missouri River.

Age (years)	Group	*N*	Length (mm)		*P*
			Mean	SD	
1	Tagged	89	254	27	0.07
	Untagged	116	246	35	
2	Tagged	27	375	29	0.03
	Untagged	19	355	30	
3	Tagged	6	431	19	0.24
	Untagged	5	413	27	

Field

From 1998 to 2000, 12,304 juvenile rainbow trout were tagged as they migrated from their natal tributaries. Tag retention was 90.0% in the 140 adipose-fin-clipped wild rainbow trout recaptured in the Missouri River. Tag location, which was determined with a handheld tag detector, was correctly identified in 100% of recaptured tagged fish (178–450 mm). Tagged fish were recaptured from 5 months to 3 years after being tagged. The survival of tagged fish with different batch marks did not differ considerably among the four tagging locations (0.4–1.2%), though the recovery rate was low for all groups. Length at capture was similar between tagged and untagged age-1 and age-3 rainbow trout (Table 2). Tagged age-2 fish were significantly larger than untagged fish.

Discussion

The tagging of juvenile fish is often desired to assess recruitment and movement and to identify and monitor stocks. However, tagging options for fish smaller than 100 mm are often limited because many external and internal tags have poor reten-

tion or significant biological effects (Buckley and Blankenship 1990; Bergman et al. 1992; Mourning et al. 1994; McMahon et al. 1996). Coded wire tags have been successfully applied to larval fishes (e.g., Thrower and Smoker 1984; Bergstedt et al. 1993), but traditional use requires sacrificing the fish to remove and read the tag. Batch marking of fish with coded wire tags in different body locations offers an alternative to sacrificing fish to obtain tag information (Heidinger and Cook 1988; Tipping and Heinricher 1993; Hale and Gray 1998).

Our laboratory and field results demonstrate that it is feasible to insert coded wire tags into the snout and the base of the anal, caudal, and dorsal fins of small rainbow trout and recover tag information up to 3 years later without tag removal. The retention of tags in different locations was greater than 95% over 8 weeks in the laboratory and 90% in the field. This high tag retention rate was similar to the 95% mean retention rate reported over 19–30 d for larger brown trout and rainbow trout tagged with coded wire tags in the cheek, snout, and base of the pectoral, pelvic, dorsal, adipose, and caudal fins (Hale and Gray 1998).

As in previous evaluations of inserting coded wire tags into the snouts and backs of small (50-mm) chinook salmon (Bergman et al. 1968), we found few side effects to tagging small rainbow trout in five particular body locations. We observed no lesions at tag locations and no adverse effects on survival or growth among most of the tag locations and length-groups in the laboratory or field. However, further examination of long-term effects in wild populations is warranted given the low number of tagged fish that we recovered (1%), which limited the power to detect statistically significant differences in mortality among fish tagged in different body locations.

Our examination of tag location and fish size demonstrated that care must be exercised when fish are tagged in the nape and at lengths less than 50 mm. In contrast to our findings, previous investigators reported few adverse effects from tagging small centrarchids (<50 mm) in the nape (Heidinger and Cook 1988; Buckmeier 2001). The deeper body of centrarchids likely reduces the possibility of injury from piercing the spinal column. We were unable to evaluate the long-term survival of coded-wire-tagged rainbow trout less than 40 mm long, but initial 24-h results showed high tag retention and low mortality in all locations except the nape, indicating that tagging fish of this size is feasible.

Correct identification of batch marks was 100% among the four body locations we tested in the field (the snout and the caudal, anal, and dorsal fins). Additional testing is needed to identify other suitable sites. Other tag locations used successfully for larger salmonids include the cheek and the base of the pelvic, pectoral, and adipose fins (Hale and Gray 1998). The number of suitable tag locations will be limited by how well the detector can correctly identify tags that are in close proximity (Hale and Gray 1998).

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