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Evaluation of coded wire tag retention in brown trout (*Salmo trutta*) fingerlings tagged at three anatomical locations

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ABSTRACT

The North Carolina Wildlife Resources Commission has used coded wire tags to mark fish. We evaluated coded wire tags placed at three different anatomical locations (left cheek, right cheek and snout) in brown trout (*Salmo trutta*) fingerlings (range of mean annual total lengths = 81.31 – 101.89 mm) prior to stockings (10,000 fish per tagging location). We determined the probability of tag retention at zero, 87 and 176 days posttagging across mean fish lengths. Anatomical tagging location influenced the probability of a fish being tagged. At all evaluation periods and for all mean sizes, brown trout fingerlings tagged in the left cheek had higher probabilities of being tagged than other positions of tags, with snout tags performing the worst. Intra-location comparisons revealed a decline in tag retention across temporal scales. Days posttagging had a negative effect on probability of tag retention, while length had a positive effect on the probability of tag retention. Our results indicated that the likelihood of a tag being present at 176 days was influenced by position of tag and initial tagging success more so than length or days posttagging. Although tag retention was generally high across all tag positions, differences in retention revealed the need to refine the tagging procedure. In addition, the underperformance of coded wire tags placed in the snout suggested that alternative marking locations should be explored.

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Introduction

Utilization of marks to identify groups of fish has been a valuable tool for fisheries biologists for decades, and as such, there is considerable variation in mark type and data gathered (Bergman et al. 1992; Guy et al. 1996). Given their size and effectiveness, coded wire tags (CWT) have been used commonly in marking small fishes (Ostergaard 1982; Thrower and Smoker 1984; Klar and Parker 1986; Heidinger and Cook 1988; Bumguardner et al. 1992; Collins et al. 1994; Wallin and Van Den Avyle 1994; Dussault and Rodriquez 1997; Wallin et al. 1997; Isely and Fontenot 2000; Fries 2001; Munro et al.

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2003; Dorsey 2004; Simon and Dörner 2010). As the name implies, CWT are equipped with a binary code; however, tags must be extracted from fish before this information can be recovered. Invasiveness of extraction procedures depends upon the location of the tag, and in some instances, recovery may not be possible without sacrificing fish.

Although binary codes imprinted on the CWT may provide useful information, the small size and ease of application allow the CWT to function as a batch mark without relying upon recovery of the code (Bergman et al. 1992). By assigning specific anatomical positions of tags for groups of fishes (e.g. cohorts), handheld detection devices can be used to locate the CWT and by default, determine group assignment (Bergman et al. 1992; Tipping and Heinricher 1993; Hale and Gray 1998). This approach was used by the North Carolina Wildlife Resources Commission (NCWRC) to evaluate brown trout (*Salmo trutta*) fingerlings stocked into Bridgewater Tailrace, North Carolina (Wood et al. 2017). Performance evaluation of these fish required live individuals. Thus, the NCWRC relied upon external detection of the CWT at alternating anatomical tag locations to distinguish among cohorts.

Confidence in cohort analyses was critical for NCWRC fisheries staff and evaluation of Brown trout in the Bridgewater Tailrace. As such, it was important to understand tag retention rates and develop associated correction factors for tag loss (if needed) at conclusion of the Bridgewater Tailrace project. Long-term evaluation of tag retention was possible due to the duration fingerlings remained within NCWRC hatcheries from time of tagging (May) to stocking (November) each year. This study examined CWT retention at three anatomical locations in Brown trout fingerlings from 2011 to 2013.

Methods

Tagging

Ten-thousand Brown trout fingerlings were tagged annually at Marion State Fish Hatchery, Marion, NC, in May 2011, 2012 and 2013. Mean total lengths (TLs) at time of tagging ranged from 81.31 mm TL (SE = 0.43; 2011) to 101.89 mm TL (SE = 0.62; 2013). Fish were anesthetized via a concentration of 25.0 mg/L of AQUIS-20E (AQUI-S New Zealand, Ltd., Lower Hutt, New Zealand) and subsequently marked with a 0.1×1.0-mm CWT. Tags were administered via a Mark IV CWT injector (Northwest Marine Technology, Inc., Shaw Island, Washington). Positions of tags varied by year to differentiate cohorts: left cheek (2011), right cheek (2012) and snout (2013). All individuals were scanned via a Northwest Marine Technology CWT detector to verify tag insertion; individuals failing examination were retagged and scanned. All verified fish were placed in a NCWRC raceway to recover and await transfer to long-term rearing units.

Fish were reared in concrete raceways that ranged in size from 6,359 to 9,945 L. Rearing conditions remained consistent throughout the study. Temperature averaged 19.89 °C (SE = 0.28) and dissolved oxygen levels varied on a longitudinal gradient of 10.00 mg/L upon raceway entry to 6.00 mg/L at exit. Additionally, fish across all years were fed to satiation daily as an attempt to achieve maximum growth.

Evaluating tag retention

Three hundred fish were selected, weighed (g), measured (mm TL) and evaluated for tag presence once an annual tagging event concluded and approximately every 30 days thereafter. We ran a generalized linear model based on a binomial distribution to test for the probability of tag retention at zero, 87 and 176 days posttagging across mean fish lengths ($\alpha < 0.05$). In addition, a Monte Carlo simulation was developed using experiment results to demonstrate the influence of tag position, days posttagging and fish length. Populations of 100,000 individuals were simulated. Fish length was assumed to have a Weibull distribution ($\alpha = 5$, $\beta =$ mean TL for the days posttagging). Days posttagging were held constant at 87 or 176, and a population was then simulated for each tag location.

Results

Position of tag (df = 2; $\chi^2 = 117.51$; $p < 0.0001$), days posttagging (df = 1; $\chi^2 = 8.82$; $p = 0.0030$) and an individual's TL ([cohorts exhibited consistent growth rates among years, but larger fish had a higher probability of being tagged] df = 1; $\chi^2 = 8.12$; $p = 0.0044$) had significant effects on tag retention within the study. Tag retention differed among all positions of tags at each time and length increment evaluated (Table 1). Retention rates declined slightly through time for each position of tag, but these differences only varied slightly from initial tagging probabilities. Evaluations conducted on the day of tagging found varying levels of tag retention. Immediately after tagging events, probabilities of being tagged ranged from 0.9848 (95% confidence intervals [CIs] = 0.9776, 0.9899) for the left cheek to 0.9069 (CI = 0.8856, 0.9251) for individuals tagged in the snout. This hierarchy of tagging probability (highest to lowest: left cheek, right cheek. and snout) remained constant throughout the study (Table 1) and was further demonstrated in Monte Carlo population simulations (Figure 1). Final evaluations at 176 days posttagging and 225 mm TL found probabilities of being tagged that ranged from 0.9821 (left cheek; CI = 0.9742, 0.9879) to 0.8955 (snout; CI = 0.8730, 0.9150).

Discussion

Coded wire tags have been a useful tool in the NCWRC's evaluation of stocked Brown trout within the Bridgewater Tailrace; however, long-term assessment of tag retention had not been conducted by the NCWRC prior to this study. Although we were unable to evaluate multiple positions of tags concurrently over consecutive years due to guidelines of the Bridgewater Tailrace project (one anatomical location per cohort), our findings provided insight into CWT tagging success and retention. Overall, results supported anecdotal observations of NCWRC staff: placement of CWT in the snout of brown trout fingerlings is not as effective as placement in either cheek.

Length had a positive influence on tag retention, and snout-tagged fish were on average larger at time of tagging than fish tagged at the other two locations. This size discrepancy is likely due to differences in numbers of fish within initial production lots (numbers of brown trout fingerlings produced and reared prior to extraction of 10,000

Table 1. Probabilities of fingerling brown trout being tagged at mean total lengths (TL) during three evaluation periods for each position of tag.

Period posttagging (days)	Mean TL (mm)	Probability of being tagged (%)		
		LC	RC	S
0	93.0	0.9848 (0.9776, 0.9899)	0.9474 (0.9329, 0.9593)	0.9069 (0.8856, 0.9251)
87	157.9	0.9834 (0.9771, 0.9882)	0.9436 (0.9319, 0.9536)	0.9009 (0.8856, 0.9147)
176	225.0	0.9821 (0.9742, 0.9879)	0.9400 (0.9231, 0.9539)	0.8955 (0.8730, 0.9150)

Values in parenthesis are 95% confidence intervals.
LC, left cheek; RC, right cheek; S, snout.

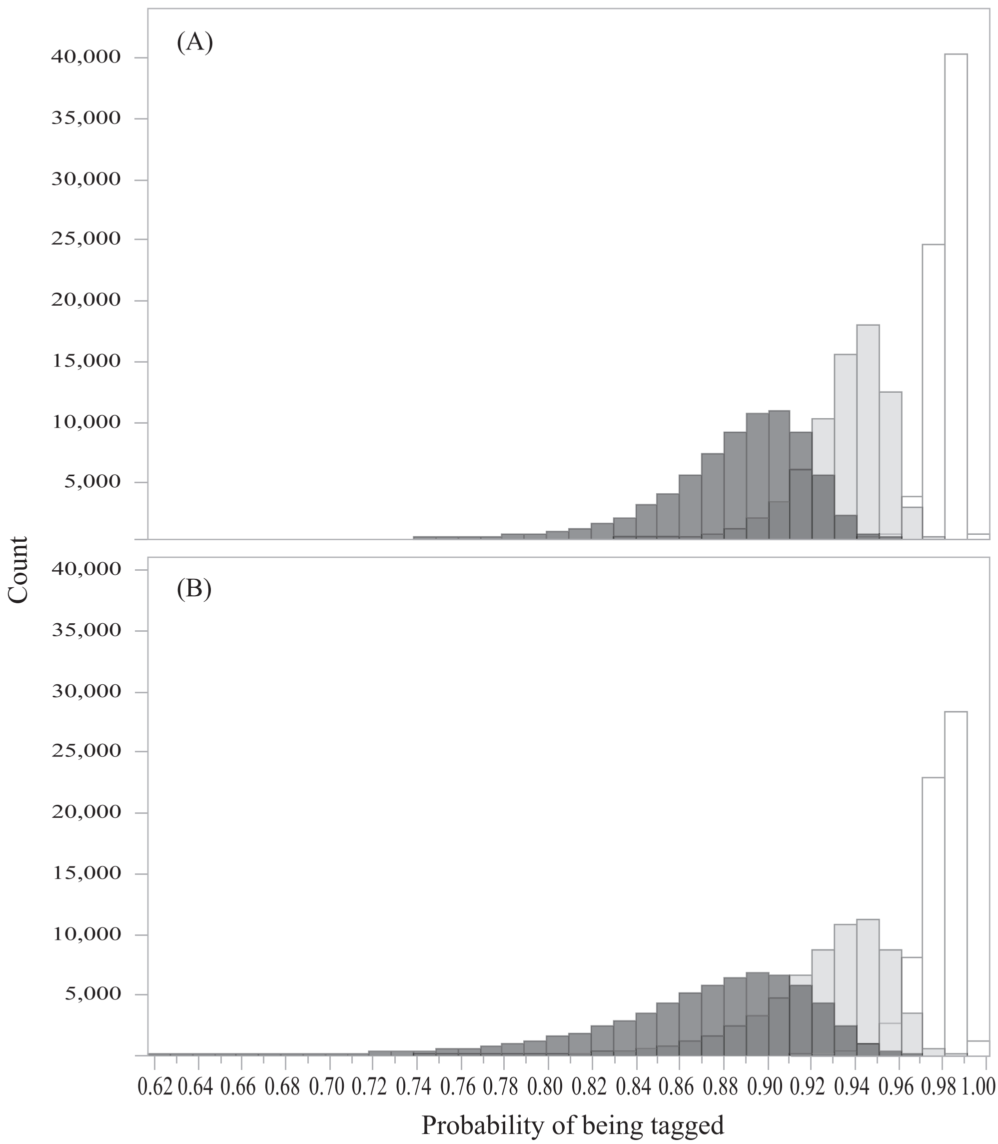

Figure 1. Probability of tag retention simulations for left cheek (hollow bars), right cheek (light-grey bars) and snout (dark-grey bars) tagged fish at 87 (panel A) and 176 (panel B) days posttagging.

annually for the Bridgewater Tailrace project) and associated density-dependent influences. Consequently, fingerling sizes at the time of tagging were inversely related to initial lot sizes. However, despite the observed positive relationship between an individual's size and its probability of being tagged, the larger, snout-tagged fish had poorer initial tag retention than fish tagged in either cheek. Differences among CWT tagging success at different anatomical locations has been found in other studies (see Bergman et al. 1992; Bergstedt et al. 1993; Pitman and Isaac 1995), with specific differences noted for snout *versus* cheek implantations (Klar and Parker 1986; Fletcher et al. 1987; Williamson 1987; Bumguardner et al. 1992). As with these other studies, lack of musculature and reduced tagging area on snouts of brown trout fingerlings within our study likely contributed to the disparity between the probabilities (and associated variance) of snout and either cheek tags being present. However, the differences between observed left and right cheek probabilities were more puzzling.

Positioning of the tagging device and improper alignment can influence tagging success (Kolari and Hirvonen 2006). Variation of positioning may be reflected in the differences between left and right cheek observations. Many of NCWRC staff that assisted with CWT applications held the body of fingerling trout consistently with the same hand and rotated the fish to insert tags into the cheek either from a dorsal or ventral position (J. Rash, personal observation). This rotation meant that depending on the cheek, tags would be inserted into the narrower, dorsal portion or the wider, ventral area of a cheek. It is possible that individuals consistently inserted tags into the right cheek via the narrower, dorsal musculature, which requires more precision to ensure adequate tag placement. Determining how significant of a role dorsal *versus* ventral insertion was in the success of cheek tags in this study is difficult and speculative; however, observed differences between the two cheek locations does highlight the importance of consistency across tagging efforts.

Tag retention for each position of tag was influenced highly by initial tagging efforts. As such, it is important that personnel are as efficient as possible, and variation in tagger experience has also been noted as an influence on tagging success (Niva 1995). The majority of staff used in tagging events during this study had previous experience with CWT, and those unfamiliar were trained and supervised until they demonstrated proficiency in the tagging process. As a result, prowess of personnel across tagging events should have been comparable throughout the study. Furthermore, each tag was verified with a CWT detector to ensure each brown trout fingerling was tagged properly, but it should be noted that improperly placed tags (even those that exit the fish immediately after insertion) would have elicited a positive reading if scanned. Such inaccurate verifications could result in overinflated estimates of initial tagging success. Regardless of tagger experience, it would be beneficial to discuss proper tag placement and verification with individuals as CWT-based projects are initiated.

Given the immediate verification process and the lower probabilities of fish being tagged on day zero, it is also possible that tagged fish (in particular, those tagged in the snout) lost their tags soon after tagging. Fletcher et al. (1987) noted a similar tag loss pattern in their observations of CWT-marked Largemouth Bass (*Micropterus salmoides*). During our study, brown trout fingerlings were tagged indoors, transported to outdoor raceways and then evaluated for tag presence once tagging was completed. This transportation and timeframe may allow improperly tagged fish to shed CWT prior to our initial evaluations.

This study allowed us to consider brown trout recaptures within the NCWRC Bridgewater Tailrace project with greater certainty. These data suggested that brown trout fingerlings were generally retaining CWT well regardless of position; however, lower retention by snout-tagged fish suggested we may be better served by eliminating the snout as a CWT tagging location and replacing it with another batch-mark option that is readily identifiable (e.g. different CWT location, removal of adipose fin, visible implant elastomer tags). Furthermore, the observed differences in tag retention demonstrated that the tagging procedure itself can be refined to improve retention. As a result, it will remain important that all staff understand the nature of CWT tagging and continue to receive proper training and oversight.

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Disclosure Statement

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