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Comparison of Large and Small Visible Implant Tags: Retention and Readability in Hatchery Brook Trout

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Abstract.—Retention and readability of small (2.5 × 1.0 × 0.1-mm) and large (3.0 × 1.5 × 0.1-mm) visible implant (VI) tags were compared among different size-classes (211–470 mm total length, TL) of hatchery brook trout *Salvelinus fontinalis.* Among smaller size-groups (<400 mm TL), retention of large tags (63–86%) 100 d after tagging was less than retention of small tags (89–97%). Overall retention of large tags was much better among larger size-groups (≥400 mm TL) than among smaller sizes (97% versus 74%). Insufficient postorbital adipose tissue in smaller size-groups probably caused the poor retention of large VI tags. Retention was different between the two workers who inserted large VI tags. Readability of large and small tags was not affected by fish size at tagging. We recommend that large VI tags be used to mark brook trout longer than 400 mm TL because they are retained better. Fish with small tags from a previous study were subsequently monitored (and reported here) to assess retention and readability between 354 and 454 d after tag insertion. Over this period less than 3% of small VI tags were lost, but readability declined from 95% to 74%. In studies that extend beyond a year, small VI tags may have to be extracted to be read.

Introduction

Visible implant (VI) tagging is an advantageous and reliable method for marking salmonids. Typically, VI tags do not affect fish growth, condition, or survival (Blankenship and Tipping 1993; Bryan and Ney 1994; Frenette and Bryant 1996; Zerrenner et al. 1997). Retention and readability for small, standard-size VI tags (2.5 × 1.0 × 0.1 mm) have been adequate for short-term field and hatchery studies. For example, Bryan and Ney (1994) reported tag retention of 100% in a stream population of brook trout *Salvelinus fontinalis,* 200 mm total length (TL) and larger, for 1 year. Niva (1995) observed 96–98% retention 69 d after tagging in three- and four-summer brown trout *Salmo trutta* (mean TL of 164–270 mm).

Lack of postorbital adipose tissue in small fish often limits the size of fish suitable for tag insertion. Salmonids less than 160 mm have too little tissue for standard-sized VI tags, which causes poor retention (Bryan and Ney 1994; Niva 1995). Large VI tags (3.0 × 1.5 × 0.1 mm) were developed by Northwest Marine Technology, Shaw Island, Washington, to improve readability over small tags. However, large VI tags could exacerbate the problem of retention in small fish and may only be suitable for larger fish. Retention and readability are also affected by variables such as species, size, growth, and environmental conditions (Kincaid and Calkins 1992; Bryan and Ney 1994; McMahon et al. 1996; Shepard et al. 1996).

The purpose of this study was (1) to compare the short-term (100-d) retention and readability of small and large VI tags among different sizes of brook trout, and (2) to examine the long-term (354–454-d) retention and readability of small VI tags in brook trout tagged as yearlings.

Methods

Short-term study.—In this 100-d study, brook trout were held in three 5.3-m^3 circular (3.3-m diameter) concrete tanks at the Little Moose Field Station near Old Forge, New York. Water (6–11°C) from nearby Little Moose Lake was supplied to the tanks, and fish were fed daily on dry commercial food. During periods of furunculosis, food was treated with a tetramycin antibiotic. A decline in growth and some mortality occurred due to the disease.

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Each of 238 brook trout of varying size (range 211–470 mm TL, mean = 324 mm) received two visible implant tags: (1) small (standard) VI tag (2.5 × 1.0 × 0.1 mm) inserted into the left adipose eye tissue, and (2) large VI tag (3.0 × 1.5 × 0.1 mm) inserted into the right adipose eye tissue. Large and small tags were inserted on the same day (18 June 1996). Fish were anesthetized (MS-222, tricaine methanosulfonate) before tag insertion. Tags were injected into the fish using a syringe needle (Haw et al. 1990; Kincaid and Calkins 1992). Fish were selected without known bias out of each tank. Two workers inserted tags (applicator 1 tagged 108 fish; applicator 2 tagged 130 fish) into the clear postorbital eye tissue at a slight angle, with placement just below the surface. Total length (mm), wet weight (g), and tag code were recorded for each fish. All tags were checked for retention (tag presence or absence) and readability approximately once a month (i.e., at 29 d, 63 d and 100 d after tagging).

We segregated the data into six size-classes: 211–249, 250–299, 300–349, 350–399, 400–449, and 450–470 mm. Retention was calculated as the percent of fish with tags present at the end of each month (100 × tags present/total number of fish). Tag readability was calculated as the percent of VI tag codes that could be read by the naked eye or with the aid of a magnifying glass (100 × tags readable/total number of fish with tags). Tags were classified as readable only if the entire tag could be seen and all characters could be read accurately; otherwise, the tag was classified as unreadable. Because of mortality, sample sizes declined over the study. The sample size at the end of each period was used to calculate percent retention (100 × tags present/[total number of fish tagged − number that died]), and readability.

To examine the effects of fish length and applicator on the probability of tag retention and readability, a logistic regression was applied to the data using a generalized additive model (Hastie and Tibshirani 1990):

$$\log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 \text{Applicator} + S(\text{Length}),$$

where π is the probability of retention or readability, β_0 is the intercept, β_1 is the coefficient associated with the factor Applicator, and S(Length) denotes a generalized function of length, specifically a scatterplot smoother with effectively 4 df.

Long-term study.—We also examined long-term retention and readability of small VI tags using 40 brook trout (range = 260–355 mm TL, mean = 325 mm) previously tagged in another study (Zerrenner et al. 1997). Small tags were injected into these fish in June 1995 (at age 1), and we examined them 354–454 d after tagging.

Results

Retention

Fish length and applicator significantly affected the retention probability of large tags ($P < 0.05$; Tables 1, 2). However, for small tags the effects of applicator and length were only marginally significant ($P \approx 0.05$; Table 2).

Smaller brook trout size-classes (<400 mm TL) had lower retention of large tags (63–77%) than of small tags (89–97%) 100 d after tagging (Table 1). Larger size-classes (≥400 mm) retained large tags (97%) better than the smaller sizes (74%) after 100 d. In the smaller size-classes, retention differences between small (91–95%) and large (74–87%) tags were evident 63 d after tagging; most tags were lost within the first 63 d after tagging. Predicted retention probability of large tags exceeded 90% for fish larger than 400 mm (Figure 1). Retention probability of small tags never fell below 90% at any length (Figure 2).

Retention varied between the two applicators, the greatest difference (>30%) observed in fish 300–349 mm (Table 1). This difference was apparent by day 29 (54% for applicator 1 and 92% for applicator 2) and continued through day 100 (46% and 78%).

Readability

Readability of large tags was variable over the first 63 d (73–100%) but after 100 d improved to 96% or more for all size-classes except the largest, where one of six fish was unreadable (Table 3). Some tissue clouding was noted immediately after large tags had been inserted. Readability of small tags was greater than 90% for all size-classes during the entire study and was 100% after 100 d for all size-classes, except 350–399 mm (94%). Length did not have an effect on readability of either size tag, although a marginal applicator effect ($P \approx 0.04$) occurred for the smaller tags.

Long-Term Study

Retention of small tags at 354 d to 454 d after tagging remained high (≥97%; Table 4). Readability declined from 95% at 354 d to 74% at 454 d. During this period, the postorbital tissue became cloudy and pigmented in several fish as water temperatures

TABLE 1.—Percent retention and sample size (*N*) of small and large visible implant tags in six size-classes of hatchery brook trout at 29, 63, and 100 d after tagging. Two workers (applicators) performed the tagging of the fish.

Size range (mm)	Applicator	Retention and sample size at 29 d %	29 d *N*	63 d %	63 d *N*	100 d %	100 d *N*
Large tags							
211–249	1	94	33	73	33	71	31
	2	92	37	84	37	83	35
	1 and 2	93	70	78	70	77	66
250–299	1	94	17	88	17	88	17
	2	100	14	86	14	83	12
	1 and 2	97	31	87	31	86	29
300–349	1	54	13	46	13	46	13
	2	92	25	88	25	78	23
	1 and 2	79	38	74	38	67	36
350–399	1	88	16	83	12	50	10
	2	83	12	80	10	78	9
	1 and 2	86	28	82	22	63	19
400–449	1	100	21	95	20	100	16
	2	100	31	100	31	100	20
	1 and 2	100	52	98	51	100	36
450–470	1	83	6	83	6	67	3
	2	100	4	100	4	100	4
	1 and 2	90	10	90	10	86	7
Small tags							
211–249	1	97	33	82	33	81	31
	2	100	37	100	37	97	35
	1 and 2	98	70	91	70	89	66
250–299	1	94	17	94	17	94	17
	2	93	14	93	14	100	12
	1 and 2	94	31	94	31	97	29
300–349	1	100	13	100	13	92	13
	2	96	25	92	25	96	23
	1 and 2	97	38	95	38	94	36
350–399	1	94	16	100	12	100	10
	2	92	12	90	10	89	9
	1 and 2	93	28	95	22	95	19
400–449	1	95	21	95	20	100	16
	2	100	31	100	31	100	20
	1 and 2	98	52	98	51	100	36
450–470	1	83	6	83	6	100	3
	2	100	4	100	4	100	4
	1 and 2	90	10	90	10	100	7

TABLE 2.—Results of the logistic regression of the effects of applicator and fish length on tag retention. The *F*-statistics and resulting *P*-values indicate the significance of the added component conditioned on the fit to the reduced model shown in the previous line. Significance based on $\alpha = 0.05$.

Tag type, factor	df	Residual df	Residual sum of squares	*F*	*P*
Large tags					
Intercept	1	192	194		
Applicator	1	191	190	4.8	0.03
S(Length)	4	187	169	5.7	0.0002
Small tags					
Intercept	1	192	84		
Applicator	1	191	81	4.0	0.05
S(Length)	4	187	73	2.6	0.04

warmed from 6°C to 11°C and the study fish grew in length (+15 mm) and in weight (+92 g).

Discussion

Large tags were difficult to insert in small brook trout (<400 mm) and exhibited poor retention (74%) because of insufficient postorbital adipose tissue. Larger fish (≥400 mm) had adequate tissue for inserting large tags. Retention of small tags was high (≥89%) in all sizes of fish (211–470 mm) over the 100-d evaluation period. Northwest Marine Technology (personal communication) has reported that right-handed individuals tend to have a more difficult time tagging on the right side of the fish. Some bias against proper placement of large tags in our study may have existed because

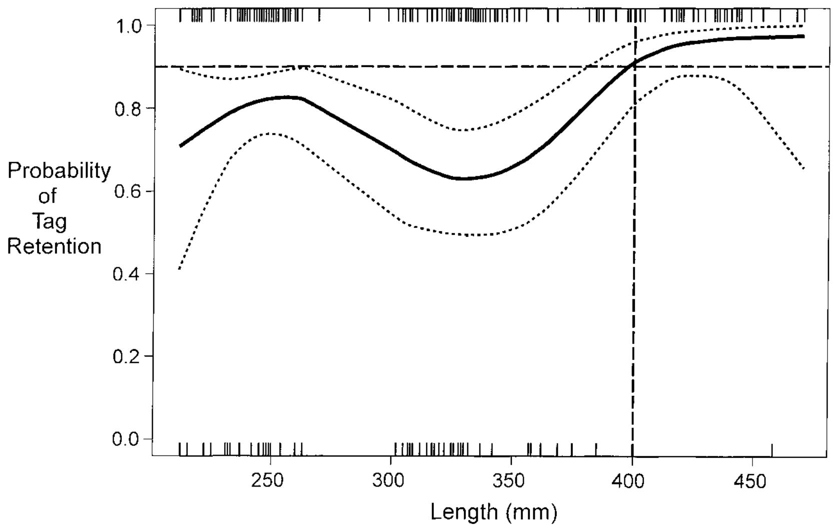

FIGURE 1.—Retention probability (solid line) of large tags 100 d after tagging in hatchery brook trout; dashed curved lines indicate 95% confidence bounds. The dashed vertical line marks 400 mm total length; the dashed horizontal line highlights 90% probability for tag retention. Hatch marks along the top (1 = tag retained) and bottom (0 = tag lost) of the figure represent the observed data.

both applicators were right handed and inserted large tags into the right side of the fish. Bryan and Ney (1994) reported size-related retention differences associated with small VI tags in brook trout. In their study, tag retention was 50–80% in fish less than 200 mm and 100% in fish greater than 200 mm. As adipose eye tissue thickness and size increase with fish size (Niva 1995), brook trout become better suited to retain visible implant tags (Haw et al. 1990; Kincaid and Calkins 1992; Bryan and Ney 1994).

The retention differences between the two applicators for large VI tags (e.g., 46% and 78% in 300–349-mm size-class after 100 d; Table 1) may

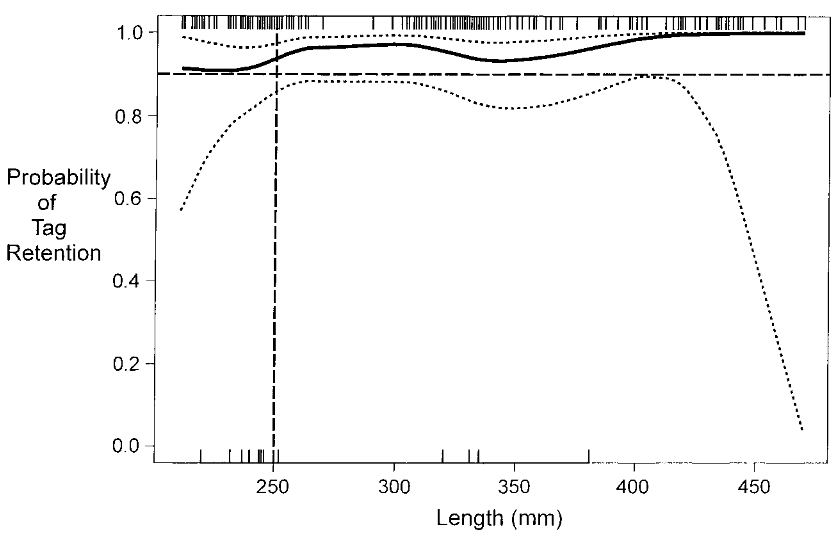

FIGURE 2.—Retention probability (solid line) of small tags 100 d after tagging in hatchery brook trout; dashed curved lines indicate 95% confidence bounds. The dashed vertical line marks 250 mm total length; the dashed horizontal line highlights 90% probability for tag retention. Hatch marks along the top (1 = tag retained) and bottom (0 = tag lost) of the figure represent the observed data.

TABLE 3.—Percent readability and sample size (*N*) of small and large visible implant tags in six size-classes of hatchery brook trout at 29, 63, and 100 d after tagging.

Tag type and size range (mm)	Readability					
	29 d		63 d		100 d	
	%	*N*	%	*N*	%	*N*
Large tags						
211–249	97	64	100	55	96	55
250–299	96	29	100	27	96	25
300–349	73	30	82	28	96	24
350–399	100	24	82	17	100	12
400–449	98	52	96	50	100	36
450–470	100	9	89	9	83	6
Small tags						
211–249	100	68	100	64	100	59
250–299	100	28	100	29	100	28
300–349	100	37	92	36	100	34
350–399	92	26	90	21	94	18
400–449	100	51	96	50	100	36
450–470	100	9	100	9	100	7

be attributed to individual technique, specifically as related to using limited amounts of tissue. Lack of sufficient tissue allowed less margin of error when inserting the large tags. Although applicator 1 had more tagging experience, he had difficulty inserting large tags into this particular group of fish. Thus, tag retention can be highly dependent on applicator and more experience does not always ensure greater tag retention success.

The greater loss of large versus small tags was probably caused by differences in size of the insertion wound and on subsequent tag erosion. The injector needle for large tags inflicted a wider, more damaging wound than small tag needle, and that wound may have taken more time to heal. Erosion of tissue caused by movement of large tags after insertion, combined with incompletely healed insertion wounds, may have exacerbated loss of large tags. Kincaid and Calkins (1992) similarly reported that small tags were too large for the available adipose tissue in small fish, which resulted in tissue rupture and tag loss. New soft VI tags are now being offered by Northwest Marine Technologies as an alternative to the original VI tags used in this study. The soft texture may reduce the retention problems associated with the sharp edges of the original hard tags.

Interspecific differences in adipose tissue would influence tag retention; thus, our observations with brook trout may not be valid for other salmonid species. Differences in periocular tissue among wild populations of coastal cutthroat trout *Oncorhynchus clarki* were reported by Wenburg and George (1995). McMahon et al. (1996) noted that

TABLE 4.—Percent retention and readability of small visible implant tags in hatchery brook trout at 354 to 454 d after tagging. Fish were originally marked in a 1995 study (Zerrenner et al. 1997).

Days after tagging	Percent retention (sample size)	Percent readability (sample size)
354	100 (40)	95 (40)
383	100 (38)	76 (38)
417	97 (37)	78 (36)
454	97 (36)	74 (35)

Arctic grayling *Thymallus arcticus* had more adipose tissue than brook trout, which allowed easier tag insertion. Differences between species were also reported by Kincaid and Calkins (1992) who observed thicker adipose and higher tag retention in landlocked Atlantic salmon *Salmo salar* than lake trout *Salvelinus namaycush.* These studies demonstrate that new investigations should determine, as a first step, whether VI tag retention is adequate for the size of fish and species to be studied.

Readability of small and large tags was generally high (>94%) among all fish sizes over the 100-d period (Table 3). In some fish, however, large tags exhibited reduced readability 29 d after tagging. Tissue damaged when inserting large tags often became clouded and resulted in low readability early in this study. However, as insertion wounds healed over time, readability improved to 96% or more by 100 d.

Retention of small tags was excellent (≥97%) over the 354–454-d period; however, tag readability declined from 95% to 74%. Our study, as well as those of others, indicate that growth causes the adipose tissue to become thicker, resulting in the development of pigmented cells that can cover tags over time (Kincaid and Calkins 1992; Crook and White 1995; Frenette and Bryant 1996; Treasurer 1996). Kincaid and Calkins (1992) found that increased pigmentation, tag migration, and thicker adipose tissue reduced readability of VI tags to zero in yearling lake trout 294 d after tagging. Consequently, long-term studies may require special efforts to read VI tags. Crook and White (1995) overcame the problems of reduced readability by using torchlight illumination and by removing tags, reading them, and reinjecting tags in a different location. Visible implant tagging should be combined with a benign secondary mark (e.g., fin clip) so that fish with lost or unreadable tags can be identified.

We recommend the use of large VI tags for brook trout longer than 400 mm TL. These tags have the advantage of being easier to read and should lead to fewer tag reading errors than with small tags. If reading ease is not important to a study, then small tags are preferred because they provide good retention in all brook trout sizes greater than 200 mm.

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