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# Growth, Mortality, and Mark Retention of Hatchery Brook Trout Marked with Visible Implant Tags, Jaw Tags, and Adipose Fin Clips

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*Abstract.*—Growth, mortality, mark retention, and mark readability were compared among control and treatment groups of 197–265-mm hatchery brook trout *Salvelinus fontinalis* marked with visible implant (VI) tags, adipose fin (AD) clips, or stainless steel circular-strap jaw tags. Based on growth rates calculated for individual fish after 90 d, brook trout marked with VI tags grew faster than those with jaw tags ($P < 0.03$). Mortality was higher after 251 d for jaw-tagged fish (45%) than the cumulative mortality (8.3%) observed among VI-tagged, AD clipped, and control fish. Mark retention was 75% for VI tags, 99% for jaw tags, and 100% for AD clips. Visible implant tag loss was greatest within 7 d after insertion. After 251 d, 37% of the VI tags were unreadable, but 92% of the "unreadable" tags were readable if magnification and light were used. Unreadability could limit the usefulness of VI tags in multiyear studies unless problem tags can be removed from the fish to read tag codes.



Marked fish are used to investigate at least five characteristics of fish and fisheries: stock contribution or use, fish growth, fish movement, fish survival, and population estimation (Hilborn et al. 1990). Basic considerations for the use of marks in fishery management or research are the effect of the tag on fish survival, behavior, growth, permanency or recognition, and the cost of the marking technique (McFarlane et al. 1990). External fish tags are useful for determining patterns of fish movement and growth (Everhart and Youngs 1981); however, most of these tags (e.g., anchor, disk) are attached by percutaneous punctures between muscles or bones and can be inappropriate for stream-dwelling salmonids (Bryan and Ney 1994). The mandible jaw tag is an external tag that is labeled with an alphanumeric code for individual fish identification (Shetter 1936; Youngs 1958). However, several authors have reported that jaw tags have adverse effects on fish growth (e.g., Warner 1971), probably because the tag physically interferes with feeding. Jaw tags are also known to cause lesions in the mouths of fish (Ricker 1942), although increased mortality has not been reported.

Visible implant (VI) tags provide a simple tagging method for marking fish for later individual identification (Haw et al. 1990). The tag is an alphanumerically labeled strip of plastic that is implanted under transparent skin tissue, such as the postorbital adipose eyelid tissue of salmonids. Though the tag is internal, it is readable externally. The VI tag provides many advantages over external tags, including the absence of wounds associated with jaw tagged fish (Ricker 1942). Bryan and Ney (1994) reported 65% tag retention and no effect from VI tags on condition of brook trout *Salvelinus fontinalis* in a Virginia stream over a 1-year period. Their study, however, did not measure survival. Mourning et al. (1994) compared growth, survival, tag retention, and tag readability between fish marked with external T-bar anchor and VI tags. Fish marked with VI tags had higher survival and growth rates than fish marked with anchor tags; however, the two tags showed no differences in retention. Anchor tags had a higher readability than VI tags.

This study compared growth, mortality, mark retention, and readability over a 251-d period among control and three treatment groups of hatchery yearling brook trout marked with either VI tags, jaw tags, or adipose fin clips.

## Methods

The experiment involved three mark treatments, each with two replicate lots of 40 yearling domestic brook trout (mean total length 235 mm, range 197–265 mm; mean wet weight 160 g, range 79–254 g). In addition, two lots of 40 control fish were handled identically as the treatment fish, except that no marks were applied. The three mark treatments were visible implant tag (VI tag) and adipose fin (AD) clip, jaw tag, and AD clip) only. A small portion (1–2 mm) of the upper (VI-tagged fish) and lower (jaw-tagged fish) caudal fin was also excised to square off the tip of the fin and to

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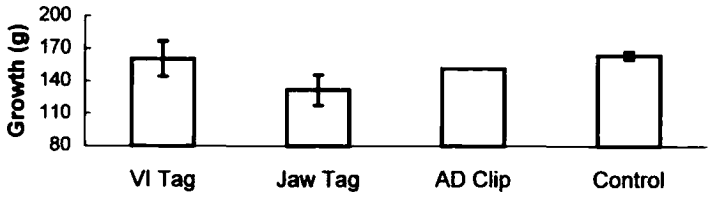


FIGURE 1.–Mean growth rate (weight) and 95% confidence intervals for brook trout 93 d after being marked with visible implant (VI) tags, jaw tags, or adipose fin (AD) clips and for controls; AD-clipped fish exhibited no variation in growth between tanks.

identify the tag type if fish lost tags during the experiment. Adipose clips in combination with VI tags simulated typical field conditions, in which AD clips are used to alert investigators to the presence of VI tags. Visible implant tags were the standard version (2.5 × 1.0 × 0.1 mm) with white lettering on a black background and were applied with a hand-held injector according to the methods of Haw et al. (1990) and Kincaid and Calkins (1992). Jaw tags were a circular strap, made from stainless steel (1.27 cm long) that contained an alphanumeric code. Jaw tags were applied according to methods described by Shetter (1936). Both jaw and VI tags were placed on the left side of the fish.

The application of marks to treatment fish and handling of control fish occurred on 29 June 1995. All fish were anesthetized in MS-222 (tricaine methanesulfonate; concentration, 100 mg/L). One person measured the fish and applied marks to one-half of each lot of fish (40 fish). The second person then marked the second half of each lot. Each fish was randomly assigned to one of the three treatments or control. The first lot of each treatment and control were then placed in one tank; the second lot of treatment and control fish were held in another tank. Thus, each applicator had marked one-half of the fish in each tank. Fish were held in two 5.3-$m^3$(3.3-m-diameter) indoor, circular concrete tanks. Lake water supplied the tanks, and water temperature ranged from 2.2 to 18.0°C (mean ± SD, 9.6 ± 14°C). The fish were fed daily to satiation on dry commercial food throughout the study.

Weights and retention of marks were determined at 7, 21, 35, 49, 63, 93, 123, 153, and 251 d; VI tag readability and movement within the adipose eyelid tissue were also recorded. During the fall while fish were maturing, sex of each fish was determined and examined for stage of maturity. Mortality was noted daily in each tank. Weight and marks were recorded from dead fish. Mark retention data recorded from dead fish were used to calculate percent retention up to the date that a fish died but were not used in the calculations afterwards.

Growth rate was calculated as the mean difference in weight from marking to day 93 for each treatment and control. After this time (in the fall), many fish became mature and lost body weight due to the shedding of gametes. The effects of the treatments and control and the two tanks on growth rate were analyzed with a 2 × 4 factorial design analysis of variance (ANOVA). Growth rates of individual fish were calculated as the mean individual growth rate in weight from time of marking to day 93 for VI tag and jaw tag treatments only because these marks identified individual fish. The effects of these two marks, the two tanks, and two applicators were analyzed with a 2 × 2 × 2 factorial design ANOVA. Mortality and mark retention are multinomial variables and were analyzed for the effects of treatments and control and for differences between tanks and applicators by a chi-square test (Snedecor and Cochran 1989). Critical level used for rejection of the null hypothesis was $P < 0.05$.

## Results and Discussion

No differences in growth were observed among treatment and control fish averaged by lot after 93 d (Figure 1). Over the period, each group of brook trout gained an average of 152 g (range, 132–165 g). Growth of fish was not different between tanks. However, based on growth rates calculated for individual fish, brook trout marked with VI tags grew faster than those with jaw tags ($P < 0.03$).

Brook trout mortality 251 d after marking was different among mark treatments and controls ($P < 0.0001$; Figure 2). The large difference was due to a much higher mortality (45%) of the jaw-tagged fish than the cumulative mortality (8.3%) of the VI-tagged AD-clipped, and the control fish ($P < 0.0001$). No differences in mortality were found among VI tag and AD clip treatments or the control. Mortality of all mark treatments and con-

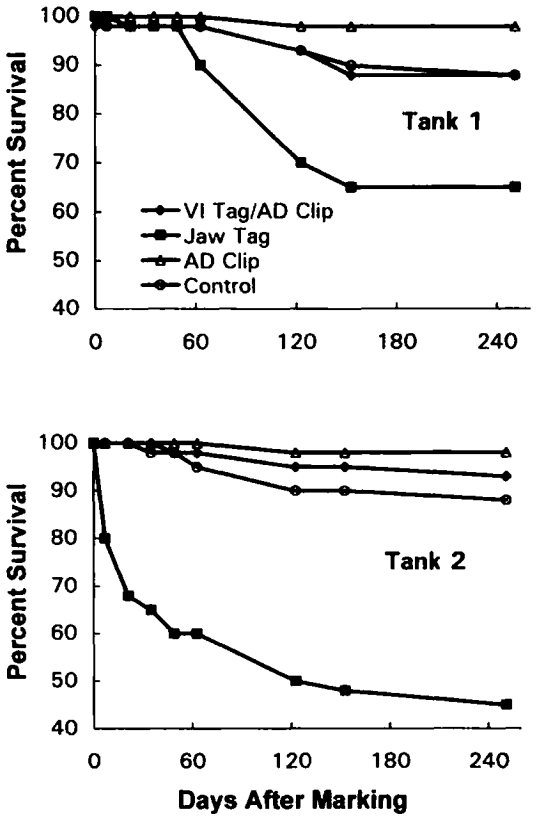


FIGURE 2.—Percent survival of brook trout in two rearing tanks 251 d after marking with either visible implant (VI) tags, jaw tags, or adipose fin (AD) clips and for controls.

trol fish was not different between tanks. Mortality of jaw tagged fish in tank 2 was greatest during July and August due to a furunculosis infection in the hatchery. Mortality of jaw-tagged fish in both tanks also was high from October through December after fish matured (50% of total jaw tag mortality). Mortality of jaw-tagged fish was sex related; fish that remained at the end of the experiment, consisted of 82% males and 18% females.

At 251 d, mark retention differed among treatments ($P < 0.0001$); it was 75% for VI tags, 99% for jaw tags, and 100% for of AD clips. Visible implant tag loss was greatest (85% of all tags lost) over the first 7 d after tagging; most of the remaining losses occurred over the next 28 d (Table 1). Only one jaw tag was lost. Visible implant tag retention did not differ between tanks or applicators. Retention of VI tags was 73% for 207–234-mm fish and 77% for 235–261-mm fish, but the difference was not statistically significant.

Visible implant tags were the only marks that became unreadable. At 123 d, 2% of the VI tags were unreadable (Table 1). At 153 d, 2% of the total VI tags were unreadable, and 4% were only readable with light and a magnifier. At 251 d, 6% of the tags were unreadable due to cloudiness in the adipose eyelid tissue, 29% were only readable under light and magnification, and 2% were unreadable due to tag movement within the tissue.

Mark retention in VI-tagged fish was less than for jaw-tagged and AD-clipped fish. The greatest loss of VI tags occurred in the first 7 d of the study; tag loss essentially stopped 35 d after tagging. We may have inadvertently increased tag loss by handling the fish for inspection before the insertion wound healed. Haw et al. (1990) reported that wounds from tag injection usually healed in 15 d. Our VI tag retention (75%) was lower than reported by Bryan and Ney (1994) for 158–289-mm wild brook trout (89%) based on recaptures over a 1-year period (Table 2). In other species, retention rates have been reported as high as 86–99% at 49–97 d for brown trout *Salmo trutta* and 94% in cutthroat trout *Oncorhynchus clarki* at 19–21 months (Blankenship and Tipping 1993). In contrast, much lower VI tag retention (41–45%) was reported for lake trout *Salvelinus namaycush* at 294 d (Kincaid and Calkins 1992). Similar to our study, Mourning et al. (1994) reported 82% retention of tags in rainbow trout *O. mykiss* and that most VI tag loss occurred within 10 d of tagging. Haw et

TABLE 1.—Loss and readability of visible implant tags from two lots of 40 brook trout from 7 to 251 d after marking. Percentage of tags lost was calculated for live fish on each date. Tags present (%) is based on the original number of marked fish and combines the effect of tag loss and mortality.

| Variable | Days after tagging | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7 | 21 | 35 | 49 | 63 | 93 | 123 | 153 | 251 |
| Number of survivors | 79 | 79 | 79 | 79 | 78 | 78 | 75 | 73 | 72 |
| Tags lost (% of survivors) | 19 | 22 | 25 | 25 | 26 | 26 | 27 | 26 | 25 |
| Tags present (% out of 80 fish) | 80 | 77 | 74 | 74 | 72 | 72 | 69 | 67 | 67 |
| Tags unreadable (% of tags present) | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 6 |
| Tags readable only with light and magnification (% of tags present) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 |

TABLE 2.—Tag loss and readability for visible implant tags reported in studies of salmonids.

| Species and reference | Age or size | Tag retention | | Tag readability | |
|---|---|---|---|---|---|
| | | Retained (%) | Time after tagging | Unreadable (%) | Time after tagging |
| Atlantic salmon | | | | | |
| Kincaid and Calkins (1992) | Adults | 84 | 294 d | 18 | 294 d |
| | Yearlings | 49 | 294 d | 0 | 294 d |
| Brown trout | | | | | |
| Niva (1995) | 164–168 mm | 58–64 | 77–84 d | 3–9 | 77–84 d |
| | 215–270 mm | 86–99 | 49–97 d | 2–13 | 49–97 d |
| Brook trout | | | | | |
| Bryan and Ney (1994) | 130–170 mm | 58 | 1 year[a] | 0 | 365 d |
| | 158–289 mm | 89 | 1 year[a] | 0 | 365 d |
| Present study | 207–261 mm | 75 | 251 d | 8<br>29[b] | 251 d |
| Lake trout | | | | | |
| Kincaid and Calkins (1992) | Adults | 45 | 294 d | 23 | 294 d |
| | Yearlings | 41 | 294 d | 100 | 294 d |
| Cutthroat trout | | | | | |
| Blankenship and Tipping (1993) | 207–307 mm | 94 | 19–21 months | 1 | 7–21 months |
| Rainbow trout | | | | | |
| Mourning et al. (1994) | 142–239 mm | 82 | 120 d | 3<br>11[c] | 120 d |

[a] Recaptured over a 1-year period.
[b] Without light and magnification.
[c] Without light.



al. (1990) reported that VI tag loss in hatchery rainbow trout ceased 28–49 d after tagging.

Retention of VI tags was 10% greater for fish in tank 1 than in tank 2. Slightly better tag retention in tank 2 may reflect improved skill in inserting VI tags as the two taggers gained experience by first tagging fish for tank 1. Niva (1995) reported that VI tag retention in brown trout improved with applicator experience from 58 to 64% in age-2 fish and from 86 to 96% in age-3 fish.

Visible implant tag retention was not size dependent for yearling brook trout over the 197–265-mm size range. Blankenship and Tipping (1993) found no relationship between size at tagging and VI tag retention for sea-run cutthroat trout smolts (207–307 mm). Often VI tag loss from salmonids has been reported as greater in small fish than in larger fish. Bryan and Ney (1994) reported that only 58% of wild brook trout 130–170 mm retained VI tags, in contrast to 89% of 158–289 mm fish (Table 2). Similarly, Kincaid and Calkins (1992) reported that tag retention in Atlantic salmon juveniles was much lower (49%) than in adults (84%) at 294 d. Size-dependent VI tag loss has also been shown in brown trout (Niva 1995) and rainbow trout (Mourning et al. 1994; Table 2). The increasing VI tag retention with larger fish reported in these studies probably was a result of the thickness of adipose eyelid tissue, which increased with fish size (Niva 1995). Our study did not examine a large variation in size of brook trout, and thus was less likely to detect size-dependent VI tag retention.

At the end of our study, 8% of VI tags had become unreadable, and 29% were only readable with light and magnification either because an increase in adipose eyelid tissue reduced transparency or because of movement of the tag (Table 1). Tags considered unreadable would have been readable if excised from the fish. Mourning et al. (1994) noted that at 120 d, 3% of VI tags were unreadable in rainbow trout and that 11% were only readable with light (Table 2). The lowest VI tag readability in any salmonid study was reported by Kincaid and Calkins (1992) for yearling lake trout; 100% of VI tags were unreadable at 294 d.

Choice of a mark to use in a particular study must take into account a variety of issues, including project duration and the length of time the mark must remain readable. When VI tags were placed in the adipose eyelid tissue of brook trout, 25% were lost and 8% of the tags were unreadable after 251 d. Tag loss is the most serious problem; however, most losses happen soon after tagging and can be estimated. Brook trout studies that use VI tags should recapture fish within a few months after tagging while tag readability is high. Unreadability could limit the usefulness of VI tags in multiyear studies unless problem tags can be removed from the fish to read tag codes.

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