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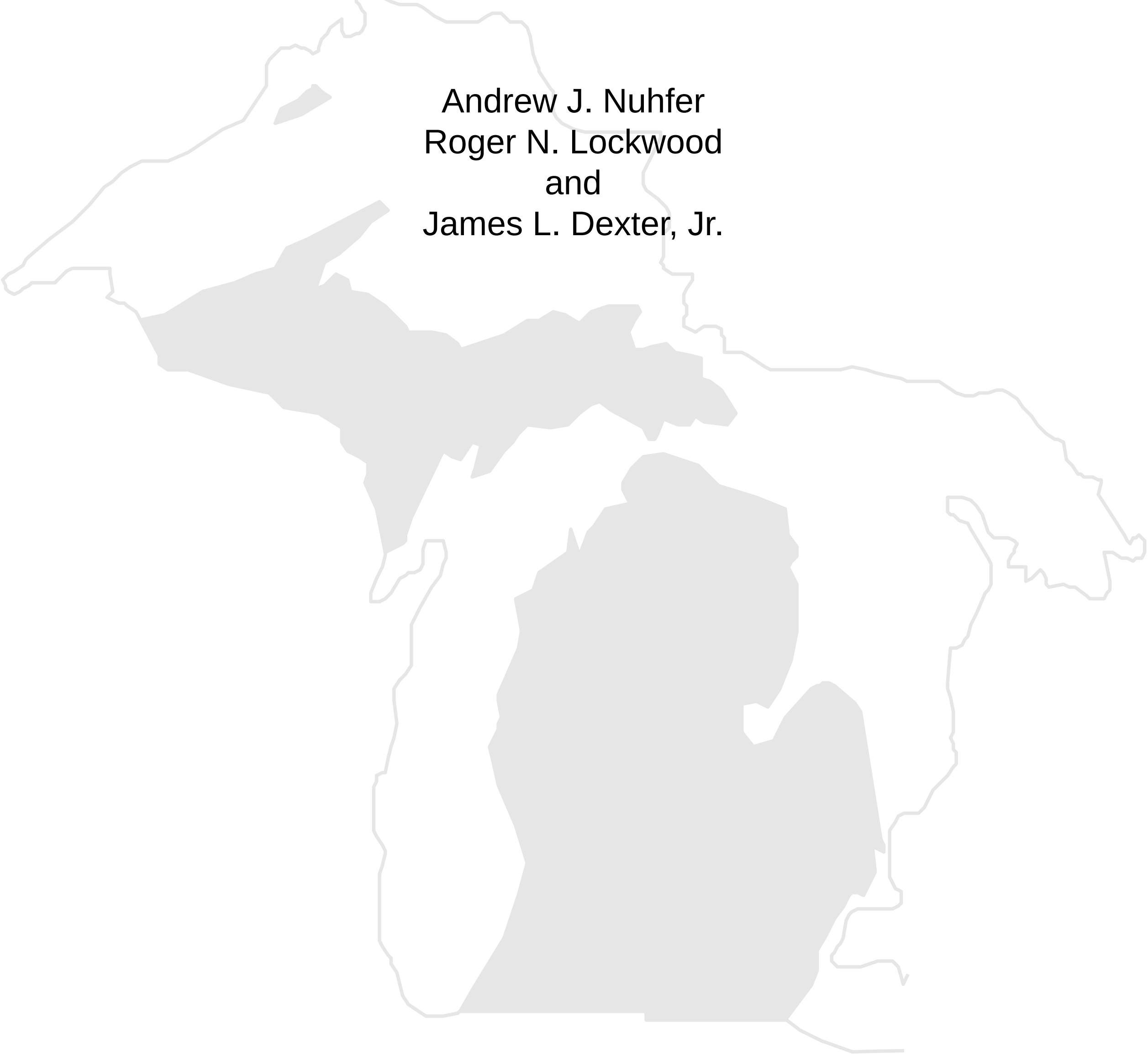

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MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

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Selected Factors Affecting Rate of Loss of Fine-Fabric Floy Tags when Applied to Yearling Brown and Rainbow Trout

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Abstract.–We tested the potential suitability of FD-68B fine-fabric Floy tags for determining relative survival or angler recovery of different strains of small yearling rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta.* We determined tag loss in small inland lakes for up to 37 months after tagging. We determined effects of Floy tagging, fin clipping, and tag color on brown trout mortality and effect of tag color on tag loss rates for up to 7 months. Rainbow trout lost tags at a rate of approximately 1% per month over 37 months. Brown trout lost tags at a rate of 1.6% per month over 37 months. Relative survival of three rainbow trout strains through 30 months was accurately ranked based on tag recovery. However, due to tag loss, relative survival through 30 months of three brown trout strains was not accurately ranked based on tag recovery. Significant differences in survival among brown trout strains were detected based on fin clip recoveries but no differences could be detected when survival was estimated from tag recoveries. Inverse relationships between tag loss and trout total length (TL) at tagging appeared to be a major cause of variation in tag loss between different trout strains. Small brown trout (<16.5 cm mean total length) tagged and stocked into a shallow, weedy spring pond lost 54% of their tags within 101 d after stocking during 1990 and 57% within 210 d after stocking during 1991. High tag loss by these trout was attributed primarily to their small size at tagging and anatomical location of tag insertion. Our data suggested that insertion of tags beneath the posterior half of the dorsal fin, where pterygiophores are smaller than the anterior half, contributed to poor tag retention. Brown trout tagged with orange or brown tags, lost tags at the same rate over a 210 d period. Daily mortality rates of four groups of brown trout: fin clipped and tagged with orange tags, fin clipped with brown tags, fin clipped only, and unmarked fish, were not significantly different through 210 d of residence in the spring pond.

Our findings suggested that fine-fabric Floy tags were poorly suited for evaluations of relative survival or return to creel of different trout strains or species when tagged trout were < 17-cm long at tagging. Tag loss varied by species and strain of trout, size of fish, and anatomical location of tag insertion. Because of this variability, differences in the numbers of tags returned from different strains or species could not be readily attributed to performance differences between groups. Fine-fabric Floy tags may be suitable for short-term evaluations of angler harvest of rainbow trout (≥ 17 cm TL) in lakes where most fish are caught within the first six months after stocking.

Introduction

Michigan Department of Natural Resources (MDNR) has annually stocked approximately 2.7 million trout into inland lakes and streams in recent years (Anonymous 1993, 1994). Over 90% of these trout are yearlings with rearing and stocking costs of about 75 cents per fish. Fishery managers must choose between an array of species and strains of trout and attempt to stock those that will best satisfy specific management objectives, which usually center around providing or increasing angler harvest. Managers frequently have little quantitative data available to guide these decisions. Access-site catch surveys are often used to help measure the success of stocking programs, but may be labor intensive and expensive.

Some managers use voluntary angler returns of Floy anchor tags (Floy Tag and Manufacturing Co., Seattle) as an economical alternative to access-site catch surveys to assess angler catches of stocked trout (Dexter 1991). However, to use this method it is necessary to know the rate at which tagged fish lose tags. Rate of tag loss depends upon factors such as species tagged and tagging technique (Dunning et al. 1987, Ebener and Copes 1982, Keller 1971, Mourning et al. 1994, Muoneke 1992). Because yearling trout stocked in Michigan are often quite small, we elected to test fine fabric rather than conventional (regular diameter monofilament) FD-68B Floy anchor tags. Fine fabric tags have a shorter maximum length (3.8 cm) and smaller diameter monofilament. Hence, they are injected with a smaller diameter needle than conventional tags and should cause less tissue damage when injected. They also should produce less hydraulic drag than conventional tags.

Tag color might also affect tag loss rates and mortality if brightly colored tags promoted attacks by fish or avian predators. Tag loss attributed to attacks directed at tags by brown trout *Salmo trutta,* rainbow trout *Oncorhynchus mykiss*, and Pacific salmon *Oncorhynchus sp.* has been previously reported (Lister and Harvey 1969, Smith and McPherson 1981, McAllister et al. 1992, Brewin et al. 1995). Such attacks have also been reported to cause injury, and in some instances mortality, to individuals tagged with brightly colored (red) tags (German and LaFaunce 1955). Other investigators have concluded that yellow external tags attract piscivorous fish resulting in increased mortality of tagged fish (Lawler and Smith 1963, Armstrong and Blackett 1966). Many anglers who observed orange tags applied to trout, for an evaluation of their performance in a stream (Dexter 1991), hypothesized that the tags would induce higher predation mortality by avian predators.

Our primary objective in this study was to measure tag loss rates for FD-68B fine-fabric Floy tags to help assess their suitability for evaluations of trout survival or harvest rates. We used different strains of small yearling rainbow and brown trout. We also evaluated whether or not tag loss was affected by fish size at tagging, tagging technique (insertion of tag between either anterior or posterior pterygiophores), or tag color.

Study Area

Brown trout were tagged in 1990 and 1991 for a short-term tag study and were stocked into a 0.2-ha drainable spring pond at the Wolf Lake State Fish Hatchery located in the southern portion of Michigan's lower peninsula. Maximum and mean water depths in the pond were approximately 2 m and 1 m, respectively. Aquatic vegetation was dense throughout two thirds of the pond and extended to the water surface over approximately 50% of the pond surface. Trout stocked into this pond were preyed upon heavily by belted kingfishers *Megaceryle alcyon*, great blue herons *Ardea herodias*, and green herons *Butorides virescens*.

Six inland lakes located in the northern portion of Michigan's lower peninsula were used to assess long-term (approximately 3 years) tag retention. These lakes have surface areas ranging from 1.2-6.5 ha. Five of the lakes are classified as limestone sinks and have limited littoral area. Maximum water depths in these lakes range from 8.8-18.0 m, and mean depths from 4.2-5.9 m. Lake bottom substrates are primarily sand, marl, and organic detritus. The lakes were all landlocked and oligotrophic with sparse aquatic vegetation. The sixth lake (East Fish Lake) was a kettle lake with more littoral area and aquatic vegetation than the 5 other lakes. In some areas of East Fish Lake, rooted aquatic vegetation extended approximately 30 m from the shoreline. Maximum and mean water depths in East Fish Lake are 12.2 and 6.1 m, respectively. Fallen trees were common along the shorelines of all six lakes. Thus, some materials that might be expected to abrade Floy tags were present in all lakes, but were confined to limited shoreline areas. Trout were tagged and stocked into these six lakes during April 1992.

Methods

Short-Term Tag Loss

On April 12, 1990, 500 Soda Lake (SL) strain brown trout (mean total length = 15.5 cm) were tagged with FD-68B fine-fabric Floy anchor tags and then temporarily returned to the hatchery raceways. The fish were anaesthetized with MS-222 (tricaine) before being tagged and each fish received an adipose fin clip. Mean total length (TL) of tagged trout was determined from a subsample of 97 fish. Tags were injected into fish between pterygiophores located beneath the posterior half of the dorsal fin. Tagging was done by two MDNR employees. Tagged trout were held for 3 days to determine if any tags would be lost before stocking into the drainable spring pond, but no tags were lost. Percentage tag loss was determined at 41, 76, and 101 d after stocking by completely draining the spring pond to recover all surviving fish. Following each draining, trout were held in a fish stocking unit for 2-4 h and returned to the pond as soon as it was one half refilled.

To determine if tagging, tag color, or fin clipping affected trout mortality, in 1990 we also stocked 500 brown trout that received an adipose clip and a tag, 250 trout that were given a right ventral fin clip and 250 control fish that were neither tagged nor clipped. Half of the tagged trout were tagged with brown tags and half with orange tags.

On March 26, 1991, 500 Plymouth Rock (PR) brown trout (mean TL = 16.3 cm) were tagged and measured using methods similar to those described for the April 12, 1990 experiment. Adipose fins were clipped on 250 fish tagged with brown tags, and both adipose and right pectoral fins were clipped on 250 fish tagged with orange tags. An additional 500 untagged PR brown trout were stocked into the pond at the same time, half of which were marked with a left ventral fin clip and half were not marked. We assumed no differences in mortality occurred due to differences in which fins were clipped. Thus, when the pond was drained it was possible to estimate mortality of trout for four groups of trout—unmarked control fish, fish with fin clips only, fin-clipped fish with orange tags, and fin-clipped fish with brown tags. Because there was no tag loss during the first 3 days of the April 12, 1990 experiment, trout tagged in 1991 were stocked into the drainable pond on the same day that they were tagged. During 1991, tag loss was evaluated at 35, 85, 122, 167, and 210 d after tagging.

Data on tag loss from the 1990 and 1991 tagging experiments were analyzed using regression procedures similar to those described below for the long-term data analyses. We analyzed data for both individual years and data pooled for 1990-91. We did not pool data for the short- and long-term tag retention studies for the following reasons. First, the drainable pond contained dense aquatic macrophyte beds and we did not think tag loss in such an environment was comparable to data obtained from fish in lakes with little plant growth. Second, during 1990-91 tags were inserted between pterygiophores located beneath the posterior half of the dorsal fin, whereas in 1992 all tags were injected between pterygiophores located within a few millimeters of the anterior insertion point of the dorsal fin.

Mortality rates for each short-term experiment were calculated for the control group and each treatment method group, and were based on the number of fish present at final draw down. No fish were added to the pond after initial plantings. Analysis of variance was used to test the hypothesis that no differences in mortality rates existed between groups.

After examining tag loss data from the 1990-91 experiments we hypothesized that high tag loss rates had occurred in part because tags were inserted beneath the posterior half of the dorsal fin. We suspected that pterygiophores located in this region were smaller than those located anteriorly. To test our hypothesis, we used a micrometer caliper to measure anterior and posterior pterygiophore lengths of three strains of rainbow trout (n = 46) and two strains of brown trout (n = 29) obtained from MDNR hatcheries in 1995. Rainbow trout strains tested were Eagle Lake (EL), Arlee (AR), and Michigan steelhead (STT). Brown trout strains were Wild Rose (WR) and Seeforellen (SF). After dissecting out the dorsal fin, we carefully removed soft tissues and measured the length of the second anterior pterygiophore and the second from the last posterior pterygiophore. Length measurements of these two pterygiophores were representative of the mean length of pterygiophores in the anterior and posterior zones. We used regression analysis to determine relationships between trout length and pterygiophore length in each zone.

Long-Term Tag Loss

During April 1992, a total of 1,953 rainbow trout and 2,184 brown trout collected from hatchery raceways were tagged with green FD-68B fine-fabric Floy anchor tags. Three strains of rainbow trout (Michigan steelhead, Eagle Lake, and Shasta (SH)) and three strains of brown trout (Plymouth Rock, Seeforellen, and Wild Rose) were used. Trout were anaesthetized with MS-222, then tagged and given a single fin clip. All tags were injected within a few millimeters behind and below the anterior margin of the dorsal fin. Fin clips were administered to allow identification of trout strains if they lost their Floy Tags. For rainbow trout, STT received an adipose clip, SH a left pectoral clip, and EL a left ventral clip. For brown trout, WR received a left ventral clip, SF a right ventral clip, and PR an adipose clip. If a gentle tug on a newly inserted tag suggested that the T-bar did not lock behind the trout's pterygiophores, the tag was removed and both tag and fish were discarded. Total length, weight, and tag number of all individual trout were recorded. Three MDNR personnel conducted all tagging. Immediately after tagging, five of the trout strains were transferred to a fish carrier unit, transported and stocked into the lakes. Steelhead-strain rainbow trout were held over night in a fish transport unit and stocked the following day. Before stocking, tag retention by the six strains was virtually 100% as only one loose tag was found in the transport unit.

At the time of tagging, EL were significantly longer (approximately 0.6 cm) than either SH or STT, but mean weights did not differ significantly between strains (ANOVA, Tukey's honestly significant difference test). Mean weights of the three rainbow trout strains differed by less than 1.5 grams. When tagged, SF and WR brown trout were each significantly longer and heavier than PR. Wild Rose brown trout were significantly longer and heavier than SF when tagged and stocked.

Four experimental lakes were stocked with brown trout (Ford, North Twin, South Twin and Section 4 lakes) and two with rainbow trout (West Lost and East Fish lakes). Equal numbers of each trout strain were stocked into each study lake. Stocking density for each species was 246 trout per hectare.

Tag loss percentages for rainbow trout stocked in West Lost Lake were determined from electrofishing samples collected November 1992, May 1993, and November 1993. Rainbow trout in East Fish Lake were collected by ice angling during February 1993, and by electrofishing during May 1993. During April and May 1994, samples used to determine tag loss were collected from a fish trap located at the lake outlet. Trout collected by these non-lethal methods were released back into the lakes following data collection. Gill nets were used to collect and remove virtually all trout from both lakes during October 1994 and May 1995. We assumed that any natural mortality occurring between October 1994 and May 1995 was similar between strains of trout. This allowed us to compare the survival rank of each strain (based on a direct count of survivors) with the survival rank determined from trout that retained tags. Survival ranks based on fish retaining tags were considered to be analogous to relative number of tags recovered for different species or strains from an unbiased sampling method. Tag returns from netting or angler surveys are often used to determine survival. However, due to catchability differences between species or strains, results from angler surveys may not be indicative of survival.

Brown trout tag loss was determined from samples of trout collected by electrofishing during October 1992, May 1993, and November 1993. Brown trout were collected with gill nets and removed from the study lakes in October 1994 and May 1995. As with rainbow trout, this allowed comparisons of survival ranks based on fin clips with those determined from tag recoveries.

Each fish collected was examined for tag presence and tag wounds. If characteristics of the tag wound (bleeding or no sign of healing) on a fish without a tag suggested the tag had been recently torn out by a gill or dip net, we did not record the tag as missing. Loss of tags attributable to collection and handling were very rare.

Tag loss was plotted against time for each strain of brown and rainbow trout. To increase precision, data were pooled across lakes by strains. While pooling data across lakes may not be justified from a statistical standpoint, we pooled data across lakes on biological grounds. We wanted to better reflect variability occurring within management evaluations utilizing tagging information. Moreover, we expected pooled data to be a more accurate measure of tag loss for management experiments which are often conducted in small oligotrophic lakes with sparse aquatic vegetation. We used analysis of variance to test the null hypotheses that regression slopes did not deviate significantly from zero. To determine if tag loss rates were significantly different between strains, we looked for overlap of descriptive 95% limits from linear regression lines relating percentage of tags lost to months after tagging. These descriptive limits were calculated using (Neter et al. 1990):

$$t_{n-2df} \bullet SE \sqrt{\frac{1}{n} + \frac{(X_o - \overline{X})^2}{\left[\sum_{i=1}^{n} x^2 - \left(\sum_{i=1}^{n} x\right) \Big/ n\right]}}\,, \qquad (1)$$

where,

t_{n-2df} = t value for n-2 degrees of freedom and ∝ = 0.05
SE = standard error of the estimate,
n = sample size,
X_o = months after tagging,
$\overline{X}$ = mean of months.

We compared tag retention rates by size group of fish. Because all fish were measured in April 1992, lengths at tagging of fish that retained tags upon recovery were known.

Relative tag retention (RTR_j) then for 1-cm size classes (j) was calculated by:

$$RTR_j = \frac{R_j / TR}{O_j / TO}, \qquad (2)$$

where,

R_j = recovered number from tagged cm size class *j*,
TR = total number recovered,
O_j = original number in cm size class j,
TO = total number tagged.

Thus, RTR_j compares tag retention rate for a given size group to tag retention rate for all sizes combined. If RTR_j <1.0, then retention rate for a size group is below average and if $RTR_j \geq 1.0$, retention rate for a size group is at or above average.

Results

Short-Term Tag Loss

Both SL- and PR-strain brown trout lost tags at relatively high rates in the shallow, weedy spring pond. For SL, percentage tag loss increased with days after tagging and release, reaching 54% by 101 d during the 1990 test. However, a regression of percent tag loss versus days after tagging and release was not significant.

For PR, we found no significant difference in tag loss relating to color of tag. After 210 d, fish with brown tags lost 65.1%±10.3 of tags and fish tagged with orange tags lost 46.5%±10.5 of tags. Therefore, we pooled data for both colors to calculate the following linear regression describing percent tag loss (y) over days after tag and release (x) time ($r^2 = 0.89$, $P_{\propto} = 0.0001$)::

$$y = -8.39 + 0.31x. \qquad (3)$$

By the end of the 1991 experiment (210 d), 57% of PR brown trout had lost their tags.

Poor tag retention during the short-trials appeared to be partially related to the small size of trout at the time they were tagged. Mean length of SL-strain brown trout tagged in 1990 was 15.5 cm and 54% of these fish had lost their tags within approximately 3 months. Plymouth Rock-strain brown trout tagged in 1991 averaged 16.3 cm long and lost approximately 20% of their tags after the same period (estimated tag loss in 1991 after 90 d is derived from equation 3). Corresponding mean lengths at time of tagging in the long-term experiment were 15.8 cm for PR, 16.9 cm for SF, 17.7 cm for WR, 17.58 cm for STT, 17.6 cm for SH and 18.3 cm for EL.

Higher tag loss rates during the short-term experiments also appeared related to differences in the anatomical location where tags were injected into the fish. Tags were injected between pterygiophores beneath the posterior half of the dorsal fin in the short-term experiments. Our pterygiophore length evaluation showed that pterygiophores in the anterior zone were uniformly longer than those in the posterior zone. Thus, fish in the long-term study were tagged within a few millimeters behind the anterior insertion point of the dorsal fin.

Anterior and posterior pterygiophore lengths were positively and significantly correlated with trout total length (Figures 1 and 2). For SF and WR strains of brown trout combined, the linear equation for anterior pterygiophore lengths (Y_a) regressed on fish length (X) was ($r^2 = 0.64$, $P_{\propto} < 0.0001$):

$$Y_a = 0.41 + 0.52X, \qquad (4)$$

and posterior pterygiophore lengths (Y_p) regressed on fish length was ($r^2 = 0.35$, $P_{\propto} = 0.0007$):

$$Y_p = 2.14 + 0.27X. \qquad (5)$$

Brown trout greater than 12.7 cm long had significantly longer anterior pterygiophores than posterior pterygiophores ($P_{\propto} = 0.05$), Figure 1.

We made a similar evaluation of pterygiophore lengths versus fish total length for three strains of rainbow trout and again found highly significant regression relationships (Figure 2). Regression equations for anterior pterygiophore lengths regressed on fish length was ($r^2 = 0.88$, $P_\propto < 0.0001$):

$$Y_a = -1.33 + 0.68X, \tag{6}$$

and posterior pterygiophore lengths regressed on fish length was ($r^2 = 0.68$, $P_\propto < 0.0001$):

$$Y_p = 0.37 + 0.42X. \tag{7}$$

Posterior pterygiophores were significantly shorter than anterior pterygiophores ($P_\propto = 0.05$) for the size range of rainbow trout examined.

Visual inspection of pterygiophores indicated that their lengths were positively correlated to their diameters. Hence, better retention of tags inserted between anterior pterygiophores was probably related to better locking of the T-bar behind stronger pterygiophores.

During the short-term experiments there were no significant differences in mortality rates between tagged and untagged groups of fish or between treatment groups which received combinations of fin clips and tags (ANOVA, $P_\propto > 0.05$). In 1990, mean daily mortality (proportion) of clipped-and-tagged trout with orange and brown tags was 0.015. Estimates of mean daily mortality for clipped-and-untagged trout and unclipped-and-untagged trout were 0.019 and 0.016, respectively. In 1990, experimental fish with orange or brown tags received the same fin clip and differences in mortality between groups of trout bearing different colored tags could not be assessed. Therefore, these two groups were combined for determining mortality at pond draining. In 1991, mean daily mortality rates for clipped fish with orange or brown tags did not appear to be different and were 0.0094 and 0.0087, respectively. Mean daily mortality rate for fish that were only clipped was 0.0100 while mortality rate of unclipped fish was 0.0088.

Similarities in mortality of fish with orange or brown tags also indicates that application of multiple fin clips and a tag did not influence mortality in 1991. Fish tagged with orange tags received an adipose and right pectoral clip, whereas only the adipose fin was clipped on fish tagged with brown tags.

Long-Term Tag Loss

Rainbow Trout—Rainbow trout lost 35% of their tags after 37 months, or approximately 1% per month and rates of tag loss were not significantly different between rainbow trout strains (Figure 3). Mean monthly percentages of tags lost were 1.24 ±0.73 for SH, 0.73 ±0.56 for EL, and 0.75 ±0.48 for STT. Coefficients of determination for tag loss rate relationships were 0.66 ($P_\propto = 0.004$) for SH, 0.53 ($P_\propto = 0.017$) for EL, and 0.66 ($P_\propto = 0.007$) for STT. The tag loss estimate of 50.0% for West Lost Lake STT from the November 1993 sample was considered an outlier and removed from the data set prior to creation of the final STT model. This data point was based on a very small sample ($N = 4$), fell outside the 95% confidence limit of the original regression line (which was determined using this data point), and did not follow the trend observed for either of the other strains nor for the East Fish Lake steelhead.

Brown Trout–Percentage of tags lost by brown trout over 37 months was 59% or 1.6% per month. Rates of tag loss for PR were significantly greater than for WR throughout our study period (Figure 4). Near the regression midpoint of 21 months, tag loss was significantly greater for PR than for SF. However, considering the whole 37-month period, tag loss rates were not different for SF and PR. During this time, rate of tag loss per month was 1.04%±0.39 for WR, 1.33%±0.51 for SF, and 1.33%±0.57 for PR. Three data points were not included in development of these regression models, WR from Ford Lake on May 1995, and SF from Ford Lake on May 1995 and from Section 4 Lake on October 1992. Each of these data points was based on a single fish and could not provide an approximation of both tagged and tagless fish. Our models provided good fits to our data, coefficients of determination were 0.72 ($P = 0.0001$) for WR, 0.73 (P = 0.0001) for SF, and 0.64 (P = 0.0002) for PR.

Tag loss rates in the short-term experiments conducted in the weedy spring pond were substantially higher than those in long-term experiments conducted in oligotrophic lakes. Tag loss for the short-term experiment was 47.4 ±7.2% after 6 months (180 d) for PR brown trout. This was significantly greater than tag loss for WR (16.7 ±7.5%) and SF (18.8 ±10.1%) at 6 months in the long-term experiment. However, tag loss at 6 months for PR brown trout in the long-term experiment was not significantly different than PR brown trout after 6 months in the short-term experiment. At 7 months (210 d) after tagging, brown trout from the 1991 short-term study lost 56.7%±9.2 of their tags, which was significantly greater than 17.8%±7.2 for WR, 20.1%±9.7 for SF and 35.7%±10.3 for PR (all from the long-term study).

Fish Size Effects on Tag Loss-Trout that were smaller when tagged tended to lose a higher percentage of their Floy tags (Figures 5 and 6). Significant positive linear relationships between RTR_j and cm size group at tagging (X_{sg}) were detected for rainbow trout ($r^2 = 0.91$, $P_{\propto} < 0.0001$):

$$RTR_j = -0.92 + 0.11\ X_{sg}, \tag{8}$$

and for brown trout ($r^2 = 0.49$, $P_{\propto} = 0.0237$):

$$RTR_j = -0.22 + 0.07\ X_{sg}. \tag{9}$$

Survival-Survival of brown trout strains through 30 months residence was not accurately ranked based on fin clips (Table 1). Survival of the PR strain was highest based on fin clips whereas survival of WR was highest based on tag recoveries. Survival ranks for brown trout strains determined from fin clips were different than those based on tags because of variable tag loss among strains. By contrast, rainbow trout strain survival ranks based on recoveries of either clipped or tagged fish were the same (Table 1).

When data from all four study lakes were analyzed no significant differences were detected in survival among brown trout strains through 30 months after stocking (ANOVA $P_{\propto}>0.05$) when survival was estimated from fin clips (Nuhfer, in press). Similarly, we found no significant difference in survival based on tag recovery. Nuhfer (in press), showed that mean survival of brown trout (pooled strains) in Ford Lake was significantly lower ($P_{\propto} = 0.05$) than in each of the other three lakes. A second analysis of strain survival was performed with data from Ford Lake excluded. The Tukey multiple comparison test of fin-clip-based survival data from North Twin, South Twin, and Section 4 lakes showed that PR survival was significantly higher than survival of either WR or SF. WR survival was significantly higher than for SF. An identical analysis performed on tag-recovery-based survival estimates failed to detect significant differences among strains.

No significant differences in survival of rainbow trout strains were detected by Nuhfer (in press) based on fin clips. Likewise, we detected no significant differences based on tag recovery.

Survival estimates determined from recoveries of fin clipped fish were uniformly higher than estimates based on tag recoveries. Because of tag loss, surviving fractions of brown trout strains estimated from recoveries of fin clipped fish were 1.8-3.3 times higher than tag-based estimates. Analogous survival estimates for each rainbow trout strain were all approximately 1.5 times higher when based on fin clips.

Discussion

The large differences in tag loss rates that we observed between strains of yearling trout made interpretation of relative return rates of fine-fabric Floy tags from different strains and species difficult. Interpretation of tag returns was further confounded by high rates of tag loss from 7 to 12 months following tagging. Greatest tag loss within the first year was exhibited by PR brown trout, 35.66%±10.37 by 7 months and 42.33%±8.39 by 12 months. The least tag loss within the first 12 months was observed for EL rainbow trout, 6.84%±10.38 by 7 months and 10.49%±8.24 by 12 months. Regression equations from this study could be used to correct for potential tag loss, but may not accurately portray tag loss for other strains or fish species, other sizes of fish, or for alternate tag insertion locations.

In general, use of fine-fabric Floy anchor tags to quantitatively evaluate relative survival between trout strains for periods of 7 months or more appeared inappropriate. We suggest that evaluations of trout strains, relying on recoveries of tagged fish, are more likely to be meaningful if at least 95% of trout retain tags during the evaluation period. Because the sampling method used to evaluate trout plants also adds variability, tag losses greater than 5% over the course of a study make differences difficult to detect. No aspect of our work indicated that a 95% tag retention rate for a multiple year study was attainable with fine-fabric Floy tags. Strains are often evaluated over a period of years. Hence, to adequately compare two or more strains or species of fish, identifying marks must remain detectable over multiple years. High tag loss, which occurred over the course of our study, due in part to effects of trout size on tag loss, and inherent variability due to sampling suggest that that conclusions regarding long-term relative strain performance ranks could not be made with confidence based on fine-fabric Floy tag recoveries. Our results suggest that fine-fabric Floy tags are unsuitable for evaluations of relative angler harvest of most yearling brown trout strains stocked into Michigan inland lakes, particularly when they are small at the time tagged. Minimum size limits for trout in Michigan inland lakes where brown trout are stocked are often set at 38.1-40.6 cm. High and variable tag loss rates such as those we observed for brown trout would most likely result in insufficient tag recoveries several years after stocking to permit any meaningful evaluation. In our long-term study, strain-survival ranks based on brown trout that retained tags were different than the true survival ranks based on fish identified by fin clips. Survival ranks for rainbow trout strains were the same based on either tags or clips. However, mean weights at tagging of the rainbow trout strains we tested were virtually identical, so size-at-tagging effects on tag loss were presumably less important for rainbow trout strains than for strains of brown trout tested.

Differences in relative tag retention by different sizes of trout (Figures 5 and 6) confounded interpretation of observed fine-fabric Floy tag returns from different trout strains or species. Size-related relative tag retention varied among the species of trout we tested and probably varied among strains. Although the range of sizes of each trout strain tagged were similar, length frequency distributions at tagging varied. Mean weights at tagging for three rainbow trout strains tested were virtually identical, as were mean lengths of SH and STT strains. PR-strain brown trout lost significantly more tags than WR brown trout throughout our long term study and had a greater proportion of small fish tagged than did WR. Franzin and McFarlane (1987) reported that Floy FD-67 anchor tags worked well for white suckers *Catostomus commersoni* over 20 cm fork length, but were generally unsatisfactory for smaller fish. Four months after tagging, Mourning et al. (1994) found no size-related difference in percentage of FD-68B fine-fabric Floy tags lost by rainbow trout that ranged from 14.2-23.9 cm TL (mean TL 18.2 cm). Eames and Hino (1983) reported that 9.4%±10.7 of Floy anchor tags were missing from chinook salmon *Oncorhynchus tshawytscha* (20.2 cm FL at tagging) recovered over a 28-month period after they were stocked into a landlocked lake. Brewin et al. (1995) found that when tagged as adults, length distributions of brown trout which lost Floy tags were not different from those that retained tags.

Fine-fabric Floy tags appeared most suitable for short-term evaluations of angler harvest from single-strain stockings of relatively large rainbow trout in trout lakes where most trout are caught within the first few months after stocking. Approximately 1% of fine fabric Floy tags were lost per month by all strains of trout in the first year of our long-term study. This rate of tag loss should provide sufficient opportunities for anglers to report catches of tagged trout in fisheries where exploitation rates are fairly high shortly after fish are stocked.

Alexander (1975) reported that from mid-April to mid-October 76% of available rainbow trout and 80% of available brook trout, in a small-lake fishery maintained by stocking, were harvested by anglers. Thus, fine-fabric Floy tags should be suitable for short-term (6-month) evaluations of large yearling rainbow trout stocked into lakes, provided that anglers cooperate by reporting tag recoveries. The relatively higher and more variable tag loss rates exhibited by brown trout strains in our short- and long-term tests, coupled with lower expected angler exploitation rates, indicates that fine-fabric Floy tags would be a poor method for evaluating even short-term returns from brown trout stocking programs.

Shorter pterygiophores of brown trout, which help lock the tag in place, may have contributed to the higher tag loss rates we observed for brown trout. Regression analysis of rainbow and brown trout total length, and length of their anterior pterygiophores showed that rainbow trout 16.1-21.6 cm TL had larger anterior pterygiophores than brown trout of the same size (Figures 1 and 2). Regression equations 4 and 6 indicate that on average, 17.8-cm rainbow trout have anterior pterygiophores as long as those of 19.9-cm brown trout.

Effects of Tagging Technique

Our results suggest that fine-fabric Floy tags should be injected between anterior, rather than posterior, pterygiophores to reduce tag loss rates. This was particularly important when tagged trout were small. During the short-term tag retention study conducted in 1990, over half of 15.5-cm brown trout tagged between posterior pterygiophores shed their tags within about 3 months, whereas only 34% of 15.8-cm brown trout tagged between anterior pterygiophores in 1992 had lost tags more than a year after they were stocked. The 16.3-cm brown trout tagged posteriorly in 1991 lost 47% of their tags within 6 months compared with 19% tag loss for 16.6-cm SF brown trout tagged anteriorly in 1992. Many investigators have emphasized the importance of locking T-bar anchor tags behind interneural spines (pterygiophores) to enhance retention (Carline and Brynildson 1972, Eames and Hino 1983, Keller 1971, Mourning et al. 1994, Muoneke 1992). We took great care to assure that T-bars were locked on fish we tagged. However, even with careful placement of anchor tags, gradual loosening and loss of tags similar to what we observed in both our long- and short-term tag loss studies has been reported (Mourning et al. 1994; Muoneke 1992).

Anterior placement may only be important if tagged fish are small. Carline and Brynildson (1972) reported that from 2.0-5.7% of FD-67 Floy anchor tags inserted at the posterior base of the dorsal fin were lost by brook trout recovered over a 7-month period. These trout ranged from 16.5-19.0 cm TL and averaged 17.8 cm. Keller (1971) reported that brook trout (9.9-16.5 cm TL) stocked in the fall lost 58% of FD-67 #20 Floy tags over winter and 90% within less than 1 year. He postulated that these high losses were due to placement of tags low on the back where they did not engage interneural spines (we suspect that he was actually referring to pterygiophores). In a subsequent experiment, when tags were placed higher on the backs of 13.2-24.4 cm brook trout, tag loss was only 2% after 2 months. The picture presented in his paper suggests that T-bars were locked behind the posterior pterygiophores. Based on our findings regarding posterior placement of fine-fabric Floy tags on small brown trout, we postulate that disparity in tag loss rates observed in Keller's (1971) experiments were related to both posterior placement of tags and fish size at tagging.

Effect of Habitat Type

Fine-fabric Floy tag loss rates may be higher in shallow lakes with heavy plant growth than in deep oligotrophic lakes having few macrophytes. We could not directly assess this hypothesis because trout that lost tags at extremely high rates in the shallow spring pond were tagged in a different anatomical location. Relatively large growths of filamentous algae were present on most tags from trout recovered from the shallow pond but rarely observed on tags from trout recovered from the oligotrophic lakes. It has been proposed that hydraulic drag created by such growths may increase tag loss (Carline and Brynildson 1972, Ebener and Copes 1982). Snagging and loosening of tags by contact with aquatic vegetation may have contributed to higher tag loss rates observed in the shallow lake. The lower tag loss rates and reduced tag wound severity we observed for rainbow trout strains, compared to those of brown trout strains of similar size in the oligotrophic lakes, may also have been due to reduced contact with vegetation. Trout collections from these lakes indicated that rainbow trout were more pelagic and less cover oriented than brown trout and hence may have been less likely to loosen tags on vegetation or woody debris. It is also possible that high stocking densities (5,000 trout per hectare) and the low volume of living space in the spring pond increased the likelihood of fish striking tags, thereby causing them to be loosened and lost.

Effect of Tag Color on Tag Loss and Mortality

We rejected the hypothesis that brown trout tagged with orange tags would suffer greater tag loss and mortality than those tagged with less visible brown tags. Lack of significant differences in tag loss rates related to tag color are consistent with those of McAllister et al. (1992) who found no significant differences in tag loss for groups of rainbow trout tagged with nine colors of FD-67 anchor tags and reared in raceways for over nine months. As in McAllister et al.'s (1992) study, trout tagged with brown tags actually lost more tags than fish tagged with orange tags. Neither our data nor our observations of avian predation attempts on trout in the spring pond supported the hypothesis that these predators caused tag loss by striking at tags. Because there were no piscivores present in the spring pond, selective predation by fish provoked by tag color, as reported by Lawler and Smith (1963) and Armstrong and Blackett (1966), was not possible.

Management Implications

In general, fine-fabric Floy tags did not appear to provide a good alternative to angler survey methods for evaluations of survival or catches of yearling trout that were less than approximately 17 cm TL at the time they are tagged. Tag loss due to fish size at tagging, tag placement and species were crucial factors affecting tag loss. Rainbow trout ≥ 17.6 cm mean TL retained 65% of their tags through three years, which should provide reasonable opportunities for anglers to report tag recoveries. However, accurate determination of significant differences in relative catches of different strains of rainbow trout of this size, based on fine-fabric Floy tag returns, would be difficult. Numbers of tags returned must be quite large and differences in catch substantial before one could conclude that observed differences were meaningful. Because of the wide variability in tag loss we observed among brown trout strains, we recommend using alternate marking techniques for brown trout strain evaluations.

To promote better tag retention, Floy tags should be injected beneath the anterior half of the dorsal fin on all yearling trout that are presently stocked in Michigan. Although tag color did not affect mortality or tag loss in this study, less visible tags could possibly reduce mortality in many Michigan waters if predatory fish are attracted to the tags as reported in other studies. In addition, this may alleviate angler perceptions that brightly colored tags harm the fish.

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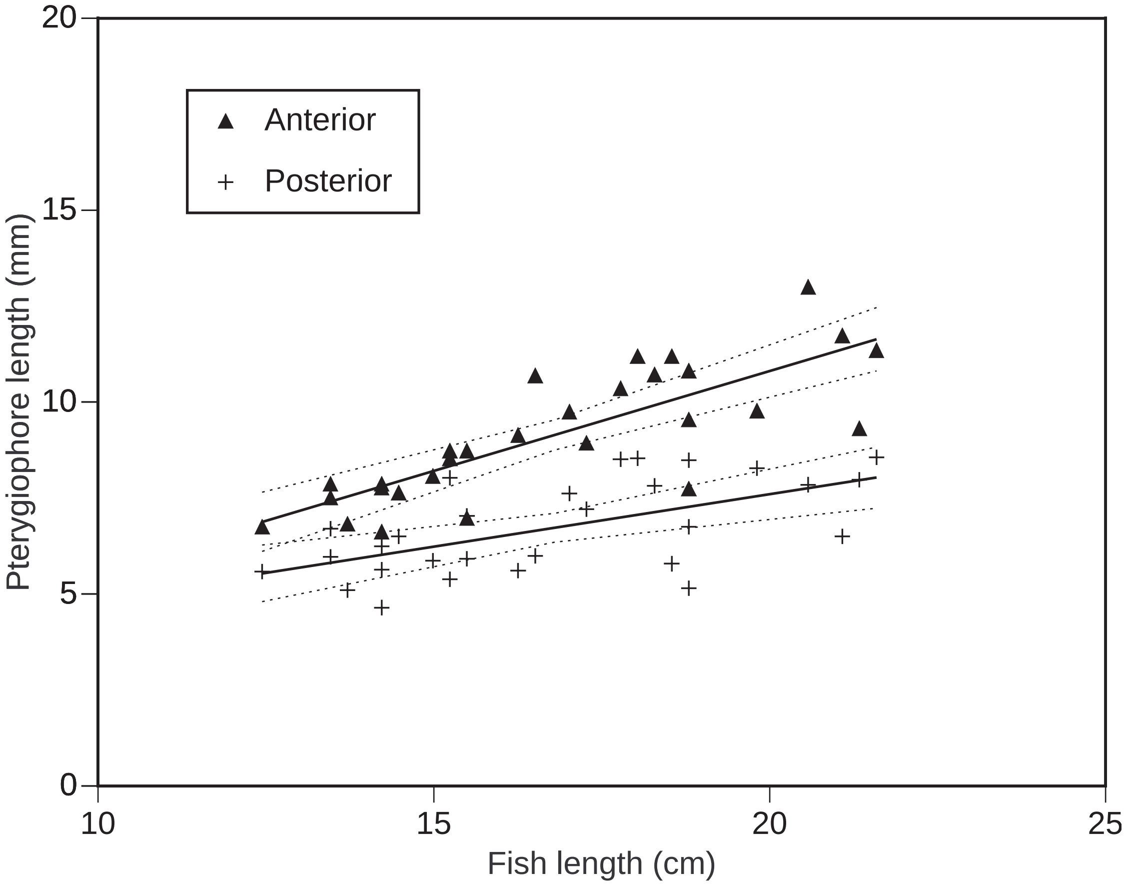

Figure 1.—Anterior and posterior pterygiophore lengths versus total length of SF- and WR-strains of brown trout. Solid thick lines represent model prediction and dotted lines represent 95% descriptive confidence limits.

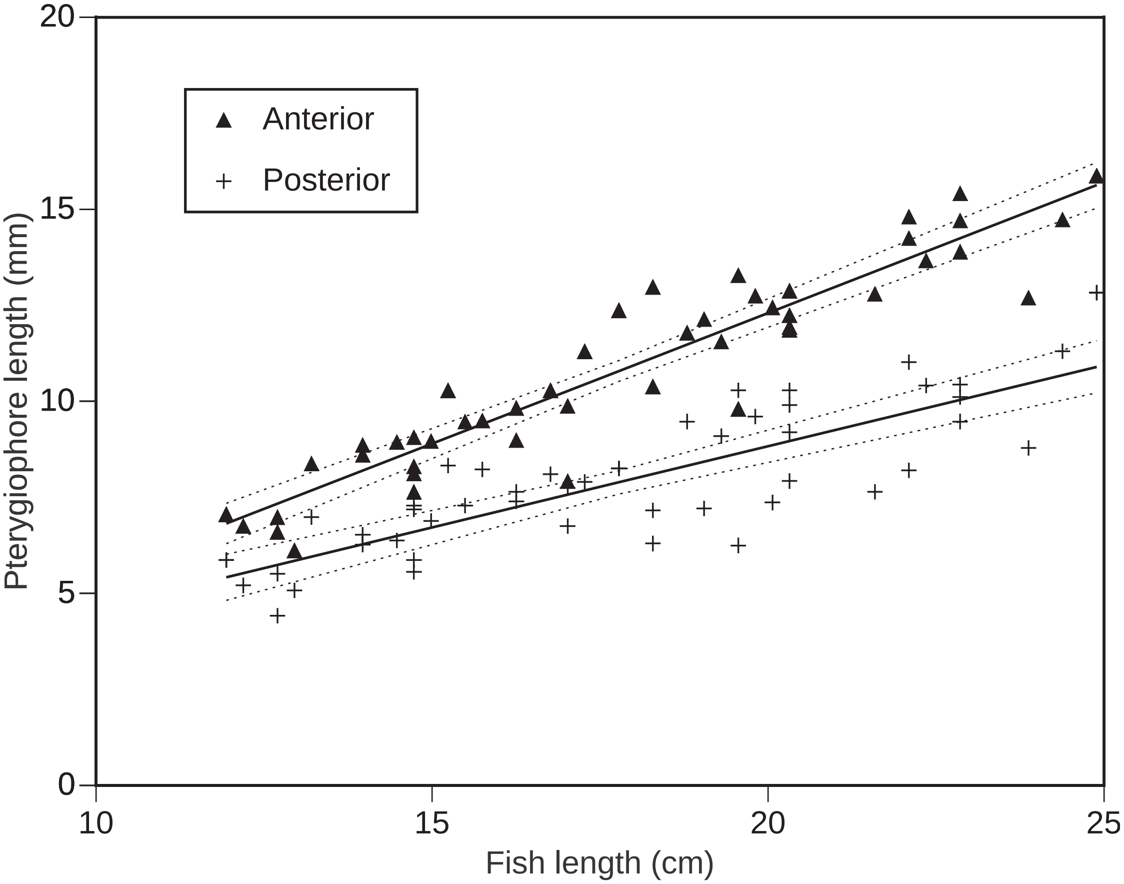

Figure 2.—Anterior and posterior pterygiophore lengths versus total length of EL-, AR-, and SST-strains of rainbow trout. Solid thick lines represent model prediction and dotted lines represent 95% descriptive confidence limits.

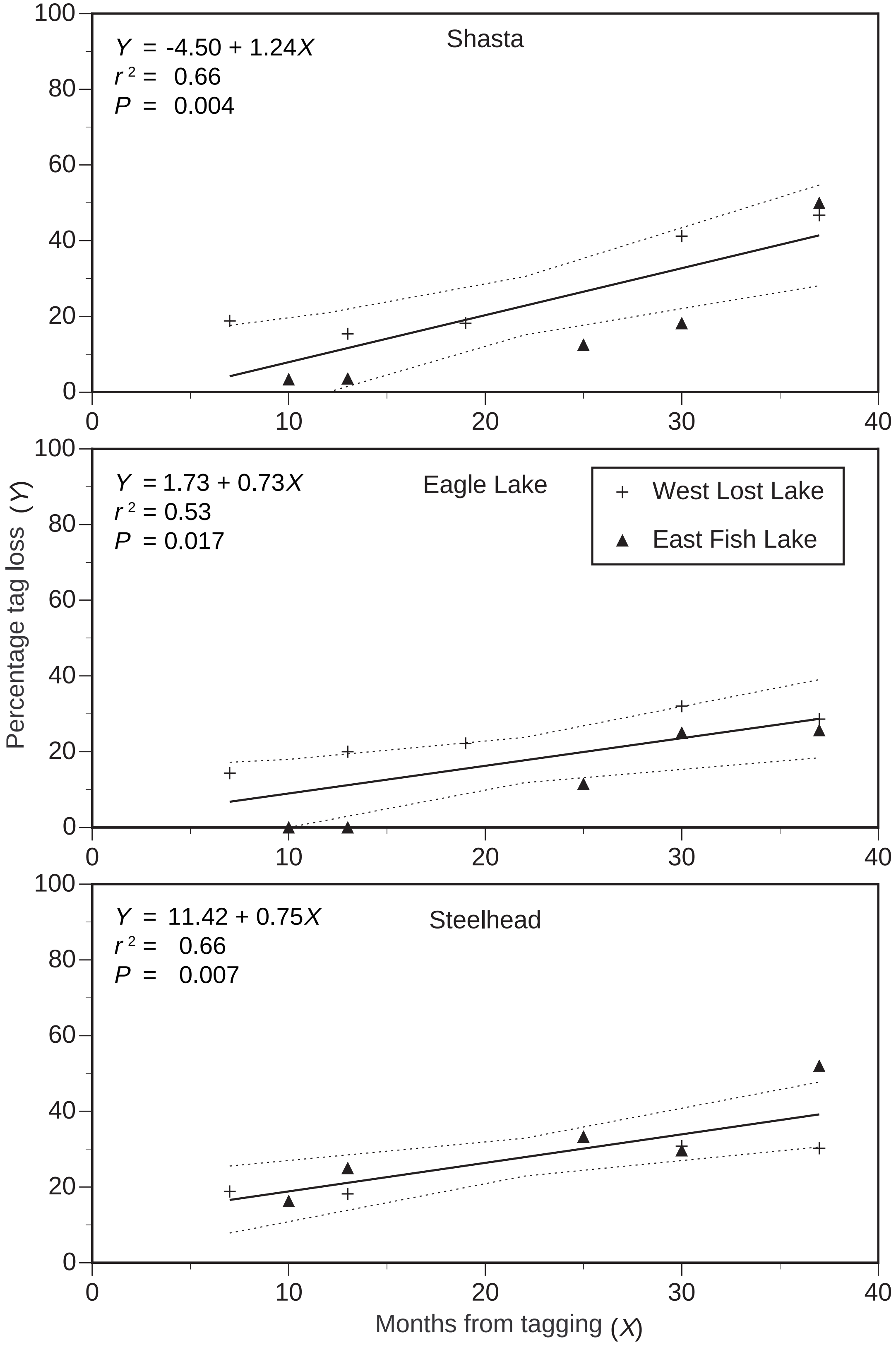

Figure 3.—Relationships between percent tag loss and months after tagging for three strains of rainbow trout over a 30-month sampling period. Fish were tagged in April 1992 and resided in West Lost Lake and East Fish Lake during study. Curved lines are 95% descriptive confidence limits. The regression models and coefficients of determination are shown for each strain.

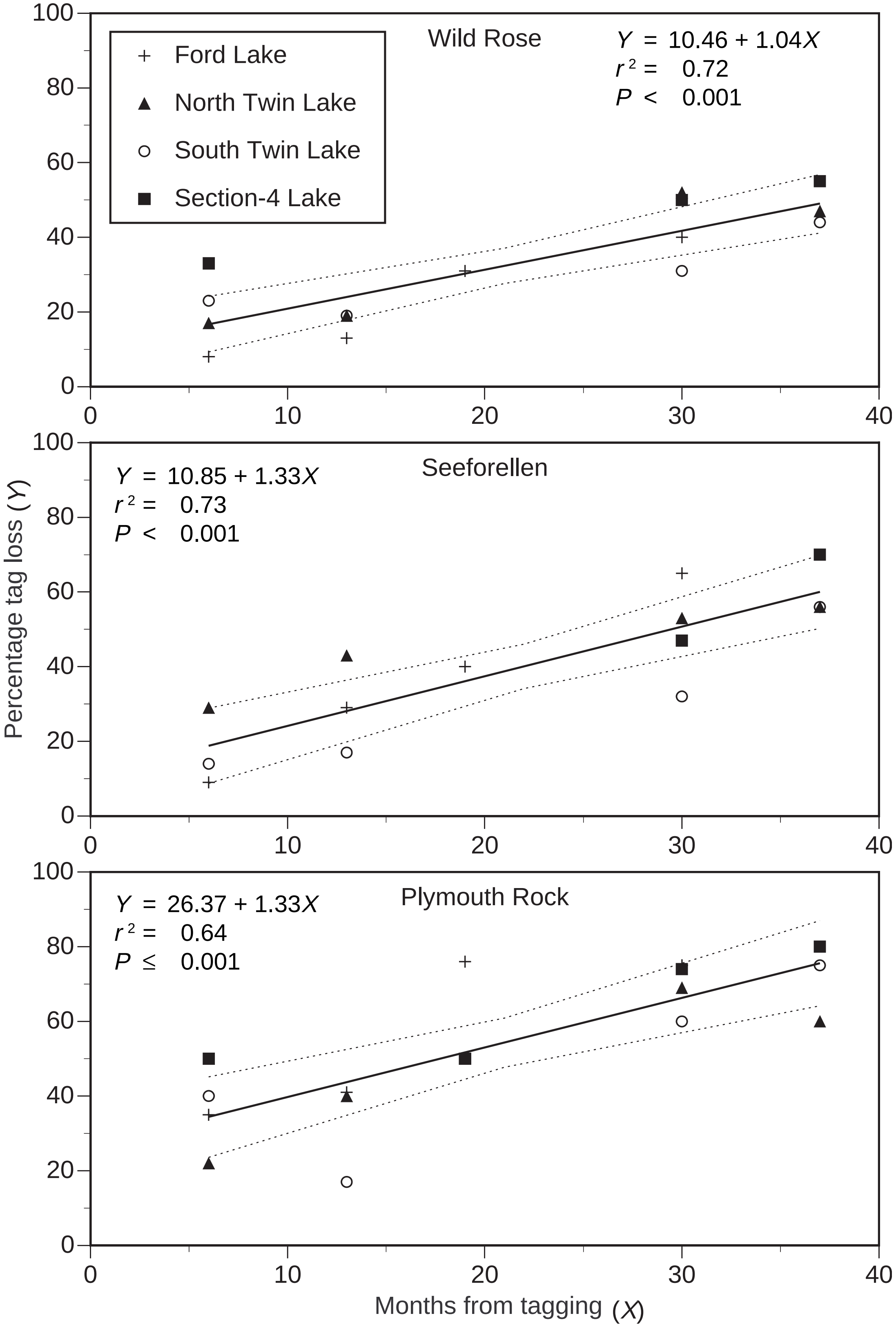

Figure 4.—Relationships between percent tag loss and months after tagging for three strains of brown trout over a 31-month sampling period. Fish were tagged in April 1992 and resided in Ford Lake, North Twin Lake, South Twin Lake, and Section-4 Lake during study. Curved lines are 95% descriptive confidence limits. The regression models and coefficients of determination are shown for each strain.

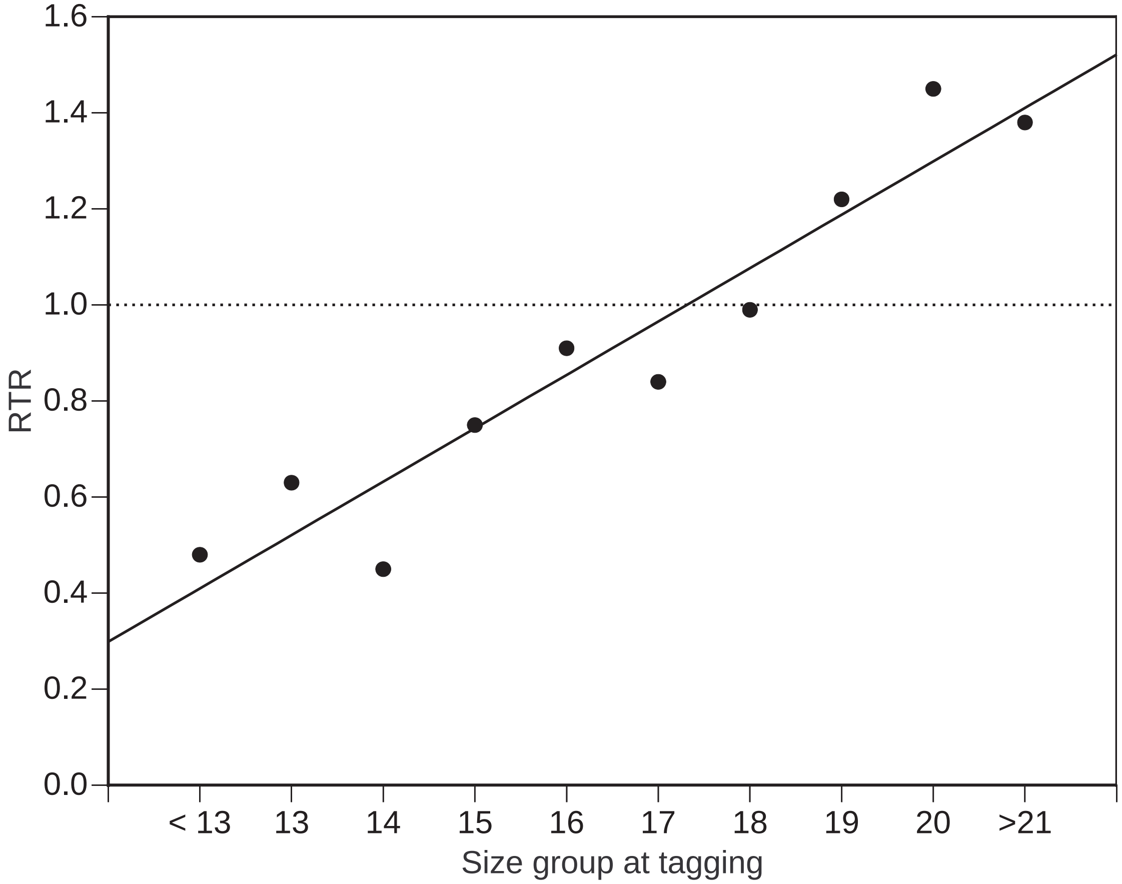

Figure 5.—Relative tag retention (RTR) by tagging size group for rainbow trout. Fish were tagged in April 1992 and final tag loss was determined from pooled samples collected and removed during October 1994 and May 1995. Size groups such as 14 represent fish from 14.0-14.9 cm TL.

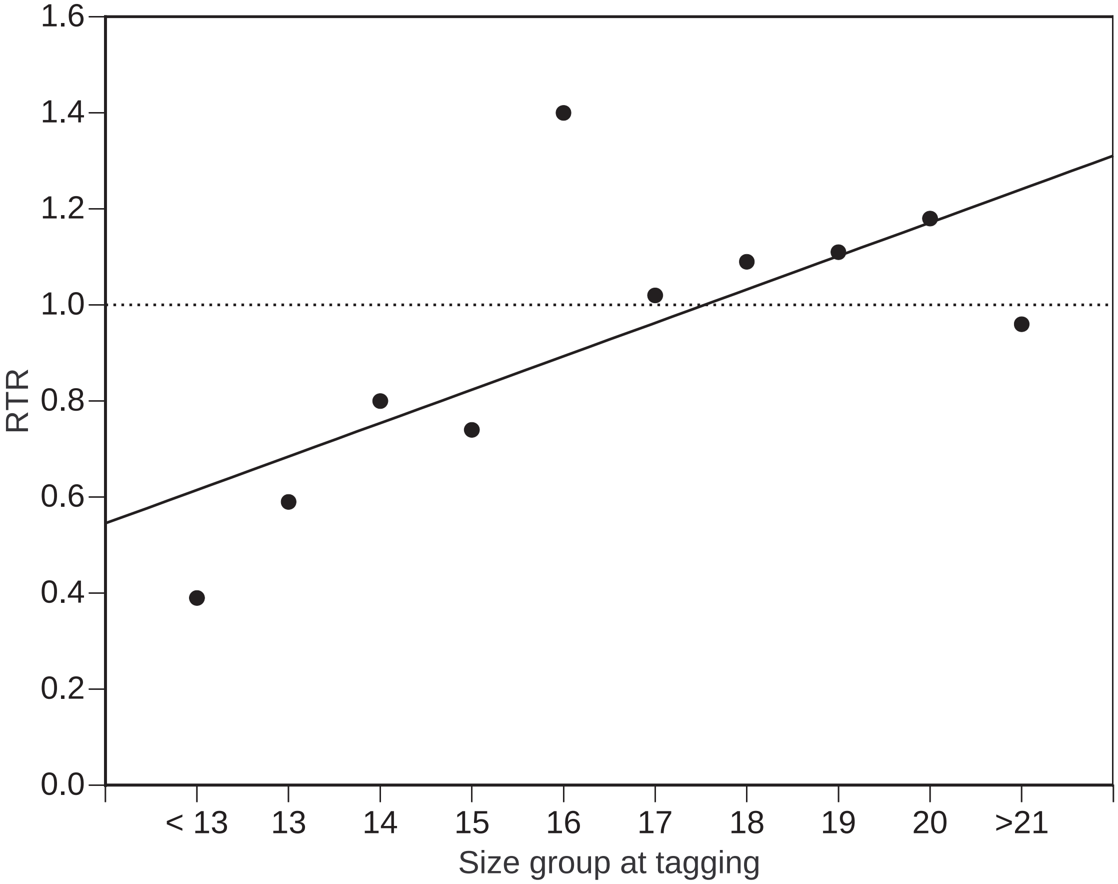

Figure 6.—Relative tag retention (RTR) by tagging size group for brown trout. Fish were tagged in April 1992 and final tag loss was determined from pooled samples collected and removed during October 1994 and May 1995. Size groups such as 14 represent fish from 14.0-14.9 cm TL.

Table 1.–Surviving fraction and survival rank (1 = highest, 3 = lowest) of three strains of brown trout and three strains of rainbow trout based on fin clip and tag recovery data. All fish were collected with gill nets.

	Surviving fraction based on		Survival rank based on	
Species/strain	Fin clip	Floy tag	Fin clip	Floy tag
Brown Trout				
WR	0.266	0.148	2	1
SF	0.225	0.103	3	2
PR	0.331	0.100	1	3
Rainbow Trout				
STT	0.356	0.241	1	1
SH	0.124	0.088	3	3
EL	0.246	0.180	2	2

References

Alexander, G.R. 1975. Growth, survival, production and diet of hatchery-reared rainbow and brook trout stocked in East Fish Lake, under different stock densities, cropping regimes, and competition levels. Michigan Department of Natural Resources Fisheries Research Report No. 1828, Ann Arbor.

Anonymous. 1993. Michigan fish stocking record. Michigan Department of Natural Resources, Fisheries Division Lansing.

Anonymous. 1994. Michigan fish stocking record. Michigan Department of Natural Resources, Fisheries Division Lansing.

Armstrong, R.H., and R.F. Blackett. 1966. Use and evaluation of dart tags to study the migration habits of Dolly Varden, *Salvelinus malma* (Walbaum). Transactions of the American Fisheries Society 95:320-323.

Brewin, M.K., L.L. Stebbins, and J.S. Nelson. 1995. Differential losses of Floy anchor tags between male and female brown trout. North American Journal of Fisheries Management 15:881-884.

Carline, R.F., and O.M. Brynildson. 1972. Effects of the Floy anchor tag on the growth and survival of brook trout (*Salvelinus fontinalis*). Journal of the Fisheries Research Board of Canada 29:458-460.

Dexter, J.L. 1991. Angler catch and densities of stocked and wild brown trout in Augusta Creek, Michigan. Michigan Department of Natural Resources Fisheries Technical Report No. 91-9, Ann Arbor.

Dunning, D.J., Q.E. Ross, J.R. Waldman, and M.T. Mattson. 1987. Tag retention by, and tagging mortality of, Hudson River striped bass. North American Journal of Fisheries Management 7:535-538.

Eames, M.J., and M.K. Hino. 1983. An evaluation of four tags suitable for marking juvenile chinook salmon. Transactions of the American Fisheries Society 112:464-468.

Ebener, M.P., and F.A. Copes. 1982. Loss of Floy anchor tags from lake whitefish. North American Journal of Fisheries Management 2:90-93.

Franzin, W.G., and G.A. McFarlane. 1987. Comparison of Floy anchor tags and fingerling tags for tagging white suckers. North American Journal of Fisheries Management 7:307-309.

German, E.R., and D.A. LaFaunce. 1955. A comment on the use of red tags on fish. California Fish and Game 41:119-120.

Keller, W.T. 1971. Floy tag retention by small brook trout. New York Fish and Game Journal 18:142-143.

Lawler, G.H. and G.F.M. Smith. 1963. Use of coloured tags in fish population estimates. Journal of the Fisheries Research Board of Canada 20:1431-1435.

Lister, D.B., and R.A.L. Harvey. 1969. Loss of Petersen disc tags from spawning chum salmon (*Oncorhynchus keta*). Canadian Fish Culturist 40:33-40.

McAllister, K.W., P.E. McAllister, R.C. Simon, and J.K. Werner. 1992. Performance of nine external tags on hatchery-reared rainbow trout. Transactions of the American Fisheries Society 121:192-198.

Mourning, T.E., K.D. Fausch, and C. Gowan. 1994. Comparison of visible implant tags and Floy anchor tags on hatchery rainbow trout. North American Journal of Fisheries Management 14:636-642.

Muoneke, M.I. 1992. Loss of Floy anchor tags from white bass. North American Journal of Fisheries Management 12:819-824.

Neter, J. A., W. Wasserman, and M. H. Kutner. 1990. Applied linear statistical models. Richard D. Irwin, Inc., Burr Ridge, Illinois.

Nuhfer, A. J. In Press. Relative survival and growth of three strains of brown and rainbow trout stocked into small Michigan inland lakes. Michigan Department of Natural Resources Fisheries Research Report No. 2026, Ann Arbor.

Smith, A.K., and B.P. McPherson. 1981. Comparison of T-bar and Petersen disc tag loss from chinook salmon (*Oncorhynchus tshawytscha*) in the Rogue River, Oregon. Oregon Department of Fish and Wildlife Report 80-8, Portland.

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