Evaluation of Hand-Tagging Juvenile Walleyes with
Binary-Coded Wire Microtags

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Abstract.—We evaluated survivorship, tag retention, and growth of juvenile walleyes Stizostedion vitreum hand-tagged with binary-coded wire microtags (BCWMTs) or cold-branded with liquid nitrogen. A single BCWMT could be injected via the hand-tagging technique every 5–10 s and tagging with BCWMTs was superior to cold-branding. Fish with dorsally injected BCWMTs had significantly greater mean survival than the caudally injected group but not greater survival than the cold-branded group. There was no difference (P > 0.05) in survival among any of the three control groups. Microtags were retained equally well in dorsal and caudal locations, and significantly better than cold brands. Fish grew significantly in standard length during the 66-d evaluation period (P < 0.05) and increased (though not significantly) in wet weight. Treatment and control groups were not significantly different in attained size, suggesting no differential growth depression due to marking method or location.

Fishery biologists have developed numerous ways to mark fish for studies of migration, mortality, growth, habitat use, and other aspects of life history (Wydoski and Emery 1983; Parker et al. 1990). One marking technique that does not mutilate fish or affect their behavior and growth is injection of binary-coded wire microtags (BCWMTs), which were first described by Jefferts et al. (1963).

Coded wire microtags (1-mm-long x 0.25-mm-diameter stainless steel wires) have been used successfully in many fish studies, although there have been mixed results in terms of survival and tag retention. For example, when BCWMTs were used on anchovies Stolephorus purpureus smaller than 57 mm (standard length), mean survival was 80.5% and tag retention was 85.3% (Leary and Murphy 1975). Heidinger and Cook (1988) successfully tagged largemouth bass Micropterus salmoides, channel catfish Ictalurus punctatus, golden shiner Notemigonus crysoleucas, bluegill Lepomis macrochirus, and walleye Stizostedion vitreum with BCWMTs; percent survival ranged between 58 and 100% and tag retention was 91–100%. In contrast, Crumpton (1985) documented a 75.9% survival but only a 10% BCWMT retention after 69 d among 50–71-mm (total length) largemouth bass tagged in the forebrain area; fish tagged in the nasal area had 70.5% survival and 25% tag retention. These studies indicated that tag placement is important but that behavior, swimming, and feeding are not affected by the BCWMTs.

Injection of the BCWMT can be accomplished either with an expensive (about US$12,000) automatic tag injector and quality control device (automatic tagging system) or with a low-cost ($75) hand-held injector and field detector ($2,700). The automatic tagging system is more uniform in terms of operation and allows the tagging of many individuals per unit of time. The hand-held tagging syringe is more difficult to use and tagging quantity per unit of time is reduced. With this in mind, we addressed the following questions. What is the effect on survival, tag retention, and growth of juvenile walleyes hand-tagged with BCWMTs? Are these response variables affected by the tag injection location? We compared BCWMT data with survival of and mark retention by walleyes that were cold-branded with liquid nitrogen.

Methods

Source of walleyes.—Walleyes were provided by the Iowa Department of Natural Resources' Rathbun Fish Hatchery in Moravia, Iowa. Twenty walleyes were sacrificed upon arrival to determine initial values of standard length and blotted wet weight. These individuals represented the size range of fish in the entire sample and are collectively called the initial group.

Laboratory facility and experimental protocol.—Fish were held in a flow-through laboratory facility. Water from a holding tank was pumped to a polyvinyl chloride (PVC) manifold that fed water to each experimental aquarium (volume, about 144 L). The water volume was exchanged about three times per day at the flow rate used. Water temperature was maintained at 21.0 ± 2.0°C and the photoperiod was adjusted to match ambient...
photoperiod during the year. Each experimental unit of three aquaria had two 1.2-m fluorescent light fixtures mounted 1 m above the water. Each unit had a PVC frame covered with fiberglass screening, and about 40% of the unit was covered with black plastic that provided dark areas where the fish could hide. Light striking the water surface under the screening ranged (in einsteins, E) from 4.5 to 9.0 μE·m$^{-2}$·s$^{-1}$ (mean ± SD, 6.8 ± 1.3 μE·m$^{-2}$·s$^{-1}$).

Fish were fed Biokyowa prepared diets (Kindschi and MacConnell 1989; Loadman et al. 1989) ad libitum three to five times per day for 66 d; the excess feed was siphoned away every third day. Fish were fed the C-1700 diet initially and were switched to the C-2700 diet as they grew larger. Dead fish were removed daily, examined for tag retention, measured, and weighed. Water temperature and dissolved oxygen were monitored weekly, and chlorine and ammonium were monitored occasionally.

All pertinent equipment used to inject and detect the BCWMTs was purchased from Northwest Marine Technology, Shaw Island, Washington. The BCWMTs were precut, magnetized, and mounted in a silicone block by the manufacturer for easy removal with the hand injector. The BCWMTs were injected under the skin from the posterior direction in either of two locations: (1) immediately below the anterior portion of the dorsal fin; and (2) in the caudal peduncle immediately above the lateral line. The tag was injected 1 mm longitudinally into the musculature on the right side of the fish.

Liquid nitrogen cold-branding was accomplished with a 3-mm-wide flat piece of metal. The cooled metal was placed on the right side of the fish immediately under the anterior portion of the dorsal fin for 3–4 s.

Experimental design and statistical analyses.—Two experiments were simultaneously conducted (Table 1). The first evaluated the effect of handling on walleye survival and provided control data. Control fish were (1) netted and handled only; (2) netted, handled, and sham-injected (the syringe needle was inserted under the skin without a tag) in the caudal location; or (3) netted, handled, and sham-injected in the dorsal location. The second experiment evaluated the influence of the tagging or branding technique on survival, tag or brand retention, and mean growth. These treatments were (1) caudal tagging with a BCWMT; (2) dorsal tagging with a BCWMT; and (3) cold-branding.

An analysis of variance (ANOVA) and a Student–Newman–Keuls (SNK) test were used to examine mean differences in standard length and blotted wet weight among the initial, dorsally tagged, caudally tagged, cold-branded, and control groups. We used SPSS statistical software for this purpose (SPSS, Inc., 1989, SPSS PC+ Users Guide, V.3., Chicago). All values are reported as means ± SDs.

A randomized complete block ANOVA and an SNK test (SAS, Inc., 1985, SAS Users Guide, Gary, North Carolina) were used to discern treatment differences in survival of and tag or brand retention by juvenile walleyes in the tagging experiment as well as survival in control groups. For the tagging experiment, blocks were the 10 replicate tanks and treatments were the three tag or brand applications. For the controls, blocks were the three replicate tanks and treatments were the three types of handling. All percentage data were arcsine-transformed prior to analysis (Sokal and Rohlf 1969).

Results

Survival

There were no significant differences in mean percent survival of walleyes among the netted and handled (85.7 ± 14.3%), the netted, handled, and dorsally sham-injected (80.9 ± 21.8%), and the netted, handled, and caudally sham-injected (90.4...
FIGURE 1.—Mean percent survival (three replicates) among the three walleye control groups. N/H = netted and handled; N/H+dorsal = netted, handled, and sham-injected dorsally; N/H+caudal = netted, handled, and sham-injected caudally.

N/H and N/H+dorsal control groups (Figure 1; \( P > 0.05 \)). Caudally tagged walleyes had significantly lower mean percent survival (57.8 ± 23.9%; \( P < 0.05 \)) than both the dorsally tagged fish (78.9 ± 16.1%) and the cold-branded fish (82.5 ± 16.9%), which survived about equally well (Figure 2A).

Tag and Brand Retention

Microtag retention rates of dorsally tagged (92.3 ± 18.5%) and caudally tagged (93.5 ± 14.1%) walleyes were indistinguishable \((P > 0.05; \text{Figure } 2B)\). Cold-branded individuals did not retain any visible brands after 66 d.

Growth

Walleyes grew significantly in standard length in the dorsally tagged (99.5 ± 12.3 mm), caudally tagged (101.4 ± 10.7 mm), cold-branded (103.2 ± 10.4 mm), and control (103.9 ± 6.6 mm) groups when compared to the mean initial length (84.9 ± 9.2 mm; \( P < 0.05 \)), but there were no significant differences among treatment groups (Figure 3A). There were no significant differences in mean wet weight among the initial (8.7 ± 2.6 g), dorsally tagged (10.6 ± 4.3% g), caudally tagged (11.4 ± 3.9 g), cold-branded (11.0 ± 3.4 g) or control (10.1 ± 0.9 g) groups \((P > 0.05; \text{Figure } 3B)\).

Discussion

The BCWMT methodology is a simple means of tagging juvenile walleyes, and the use of the tagging syringe makes it cost-effective if many individuals do not have to be tagged in a very short period of time. Survival and tag retention are as good with the hand-tagging method as with the automatic tagging system (see discussion below). Survivorship (but not tag retention), however, depends on the tag location for either technique. Mortality in our study apparently was not due simply to handling because all three control groups had high survival. Mortality seems to be attributable to something associated with the actual presence of the tag. The lower survival of fish with caudal tags might have been caused by damage to arteries, veins, or nerves concentrated in the narrow caudal peduncle.

Survival percentages in our experiments (means, 58–90%) are comparable to those in other studies on juvenile fishes. For example, percent survival ranged between 58 and 100% and tag retention ranged between 91 and 100% in studies of five species by Heidinger and Cook (1988). One of those species was walleye. Heidinger and Cook (1988) injected BCWMTs into either the nasal or
Hand-tagging walleyes with microtags (51–73 mm total length) using the more expensive automatic tagging system and documented survival and tag retention similar to our results.

Although various methods of cold-branding have been successful with some fishes (Raleigh et al. 1973; Brock and Farrell 1977; Berge 1990), the method used in this study was inappropriate because no marks could be seen after 66 d. Coutant (1972), Raleigh et al. (1973), and Wydoski and Emery (1983) have indicated that cold-branding has variable results with fish with large scales. We could see only deformed scales and some minor discoloration with a dissecting microscope. Our technique obviously would not be valuable under most conditions. Recently, LaJeone and Bergerhouse (1991) developed a liquid nitrogen branding system to mark juvenile walleyes by means of a brass brand bearing either a circle, a triangle, or a vertical bar. Brands persisted over several growing seasons. Their technique is much better than ours mainly because their brands were brass and larger than our brand, and they cooled their brands for 0.5 h prior to marking.

Walleyes grew significantly in length and somewhat (though not significantly) in weight during our 66-d study, so they must have been feeding. Microtag location and cold-branding did not influence growth significantly, indicating that no differential growth depression was associated with marking technique. However, tagging location seems to have affected growth of fish in other studies. For example, Crumpton (1985) indicated that largemouth bass tagged in the forebrain area grew significantly less than both controls and fish tagged in the nasal cartilage. Heidinger and Cook (1988) found that small walleyes (mean total length, 51 mm) tagged in the nasal capsule grew as well as controls but that larger walleyes (73 mm) were smaller than controls after 6 months. Cheek-tagged walleyes of both size-groups were similar in length to their respective controls. Walleyes used in our experiments were initially about the same size as Heidinger and Cook’s large size-group, suggesting that the hand-tagging technique has less influence on growth than the automatic tagging system. These data suggest that combinations of fish size, tag location, and duration of an experiment influence interpretations of growth of tagged fish.

The results of this study suggest that BCWMTs can be individually coded (within limits), they can be used in laboratory and field experiments when data on individual fish are required. For example, one could address individual growth, temperature tolerance, behavior, genetics, or any other life history trait with the identification provided by such tags. They could also be used to distinguish stocked from naturally spawned, untagged individuals and determine if

The results of this study suggest that BCWMTs can be effectively used via the hand-tagging methodology. This approach is much less costly than the automatic tagging system, though less efficient in terms of time and personnel. Tag location is vitally important and the dorsal musculature is a better tagging area than the caudal musculature. Heidinger and Cook’s (1988) data on walleye also indicate that the cheek and nasal areas are good BCWMT injection sites. Time required to tag juvenile walleyes with the syringe is between 5 and 10 s per fish when taggers are fresh, but it increases as taggers become fatigued. Cold-branding as used in this study was not a good marking technique for walleye.

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Figure 3.—(A) Mean standard lengths and (B) mean wet weights of the initial group of juvenile walleyes prior to treatments and of those treated for 66 d. I = initial group (N = 20); DT = dorsally tagged group (N = 20); CT = caudally tagged group (N = 16); CB = cold-branded group (N = 14); C = control group (N = 17). Lengths with similar symbols are not significantly different from each other (P > 0.05); weights did not differ significantly among treatments.
there is any difference in growth between the two groups. These distinctions can be made without killing the fish simply by examining all captured fish with a field magnetic detector.

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