Western North American Naturalist 70(2), © 2010, pp. 218–223

EFFICACY OF USING PASSIVE INTEGRATED TRANSPONDER TECHNOLOGY TO TRACK INDIVIDUAL SHORTHEAD SCULPINS

Donald W. Zaroban[1] and Steven M. Anglea[2]

ABSTRACT.—We evaluated the feasibility of using passive integrated transponder (PIT) tags to mark and track individual shorthead sculpins (*Cottus confusus*). We implanted PIT tags in 80 shorthead sculpins in 2 size categories (60–80 mm and 81–106 mm total length) and in 1 of 2 locations (subcutaneous along the spinous dorsal fin or in the body cavity). We evaluated tag retention, sculpin survival, and net-avoidance behavior for 29 days. We observed no mortality directly attributable to PIT-tag injection at either tagging location. We observed a 38.8% loss rate of dorsal tags and a 2.5% loss rate of body-cavity tags. No change in net-avoidance behavior was observed. We released 97 PIT-tagged sculpins into an artificial stream and monitored them with 3 stationary and 1 portable antenna. Sixty sculpins were detected at least once, and 18 sculpins were detected multiple times with the portable antenna. These results indicate that PIT-tagging within the body cavity is a feasible method for marking and tracking individual shorthead sculpins.

Key words: Cottus confusus, *Cottidae, PIT tags, detectability, tag retention, survival.*

Space and resource use are important considerations in ecology, management, and conservation of stream fish (Lucas and Baras 2000, Riley et al. 2003, Albanese et al. 2004). Data on space and resource use is best obtained through direct observation of individual movement (Kernohan et al. 2001). Studies of sculpin (*Cottus* spp.) movements have historically been hampered by the necessity of rehandling the fish in order to positively identify individuals (Bailey 1952, McCleave 1964, Brown and Downhower 1982, Hill and Grossman 1987, Petty and Grossman 2004). Recent evaluations of passive integrated transponder (PIT) tags and their use on sculpins have been conducted on the European bullhead (*Cottus gobio;* Bruyndoncx et al. 2002, Knaepkens et al. 2007), slimy sculpin (*Cottus cognatus;* Cucherousset et al. 2005, Keeler et al. 2007) and mottled sculpin (*Cottus bairdii;* Ruetz et al. 2006, Breen et al. 2009). The use of PIT tags to identify individual sculpins is advantageous since the tag is small, and once individuals are tagged, they need not be rehandled to be redetected (Prentice et al. 1990a, Lucas and Baras 2000). To obtain reliable observations from a tagging study, the tagging method must not affect the survival, growth, reproduction, behavior, or mobility of the tagged animal (Wydoski and Emery 1983, Prentice et al. 1990a, Silvy et al. 2005, Ruetz et al. 2006).

Our general purpose was to evaluate the feasibility of using PIT tags to mark individual shorthead sculpins (*Cottus confusus*) because we know of no reports on the use of this technology to mark and redetect this species. Our specific objectives were to evaluate survival of tagged fish, effects of fish size and tagging location on tag retention, mobility of tagged fish, and our ability to redetect PIT-tagged shorthead sculpins.

METHODS

Survival, Tag Retention, and Mobility

Shorthead sculpins were collected from a side channel of the Boise River, Idaho, on 6 and 7 March 2006 using a backpack electrofisher (Smith Root LR-24). The fish were transported to a wet lab at Biomark in Boise, Idaho, and not fed for 48 hours prior to tagging. Twenty-two 19-L buckets with six 1.5-cm holes approximately 30 mm from the top (to allow water to circulate from the bucket without overtopping) were placed into a 1211-L live well. Water from the live well overflowed into an 80-L tank containing activated carbon filter material and was then recirculated to the buckets.

Total length (mm) was recorded for each fish (63–106 mm). Two tagging locations (body cavity

[1]University of Idaho, College of Natural Resources and Idaho Department of Environmental Quality, 1410 N. Hilton Street, Boise, ID 83706. E-mail: don.zaroban@deq.idaho.gov
[2]Biomark, Inc., 703 South Americana Boulevard, Suite 150, Boise, ID 83702.

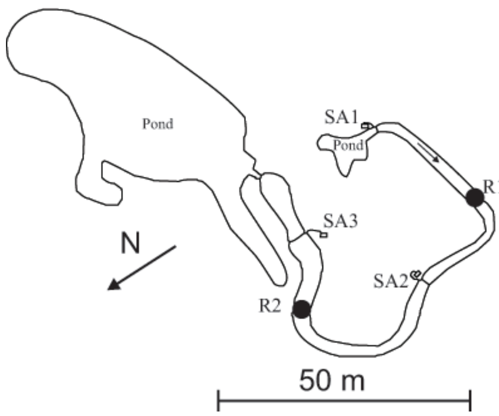

Fig. 1. Schematic of the Morrison Knudsen Nature Center stream channel (not to scale) and location of the stationary antennas (SA1, SA2, and SA3) and release locations (R1 and R2).

or dorsal) and 2 length classes (small, <80 mm total length; or large, ≥80 mm total length) were evaluated during the study, resulting in 4 treatment groups: large/body cavity, large/dorsal, small/body cavity, and small/dorsal. Treatment groups were randomly assigned to each bucket.

We PIT-tagged 80 shorthead sculpins (20 individuals per treatment), leaving 4 fish of each length class untagged as controls. Tagging location was randomly assigned to each fish. The fish were tagged with standard FDX-B PIT tags (Digital Angel Corporation; 12.5 × 2.0 mm in diameter; approximately 0.1 g in air) following the protocols described in Prentice et al. (1990b). All fish were anesthetized to lethargy (operculum movement maintained) with 45 mg · L^{-1} tricaine methanesulfonate (MS-222). PIT tags were inserted using a 12-gauge hypodermic needle fitted onto a syringe modified with a plunger. To insert body-cavity tags, a 1.5–2-mm incision was made posterior to the pelvic fins using the hypodermic needle. The tag was then inserted in a posterior direction into the body cavity. To insert dorsal tags, a 1.5–2-mm incision was made slightly ventral to the anterior base of the dorsal fin, and the needle was inserted beneath the skin approximately 14 mm toward the tail. The plunger was depressed as the needle was removed, leaving the PIT tag along the base of the spinous dorsal fin. No sutures were used to close body-cavity or dorsal incisions. Four fish were placed into each of the treatment buckets.

The sculpins were held for 29 days. Buckets were checked daily for lost tags, fish mortality, and water quality. Lost tags (retrieved with a magnet) and dead fish were removed when observed, and the tag code and treatment group were noted. Net-avoidance of the sculpins was assessed weekly by netting the fish from each bucket and observing their behavior. The sculpins were fed a diet of chopped earthworms. Each bucket received approximately eight 1-cm earthworm segments every 1–2 days. Uneaten worm segments were removed when they were observed.

Instream Detection

We installed 3 Biomark stationary pass-through antennas in the upper, middle, and lower reaches of the artificial stream (Gebhards Creek; approximately 120 m long, 1 m wide, and 0.25 m deep) at the Morrison Knudsen Nature Center, Idaho Department of Fish and Game, Boise, Idaho (Fig. 1). The antenna openings measured 30.5 × 80 cm, 51 × 51 cm, and 61 × 61 cm at the lower, middle, and upper locations, respectively. The TX1400ST PIT tags were detectable within 30 cm of either side of the antennas. Stationary antennas were placed in shallow trenches and secured in an upright orientation requiring fish to swim through the antenna opening. Digital Angel FS2001F-ISO readers were used to control the antennas and to store tag codes. Each stationary system was powered by a 12-V deep-cycle battery (47 A · h^{-1}). The reader, antenna tuning box, and battery for each stationary system were stored in lockable, weatherproof boxes located on the stream bank adjacent to the antennas. The stationary antenna system was operated from 1 November 2006, just prior to the release of PIT-tagged fish, until 8 December 2006.

Ninety-seven shorthead sculpins were collected from the Boise River, Idaho, on 30 October 2006 by using a backpack electrofisher. Total length of these sculpins ranged between 72 and 115 mm. These fish were PIT-tagged in the body cavity and were held in a 360-L aerated container for approximately 24 hours prior to release at 2 points into the artificial stream. Forty-eight PIT-tagged sculpins were released at location R1, and 49 were released at location R2 (Fig. 1). Instream mobility of detected fish was documented by calculating distances between the stationary antenna where the fish was detected and its original release point.

TABLE 1. Summary of shorthead sculpin mortalities and lost tags by treatment. BC = body cavity.

Treatment	n	Mortalities (%)	Lost tags (%)
Large dorsal	20	0 (0)	13[c] (65)
Small dorsal	20	4[a] (25)	18[c] (90)
Large BC	20	0 (0)	2[c] (10)
Small BC	20	0 (0)	0[c] (0)
Large control	4	0 (0)	—
Small control	4	4[b] (100)	—

[a]Bucket no. 22, day 14 of the study
[b]Bucket no. 19, day 3 of the study
[c]Tagging location statistically significant: $P < 0.0001$

We conducted 10 tracking surveys with a Biomark portable antenna in the artificial stream. The portable antenna was triangular, each side measuring 30.3 cm long, and was connected to a 1.2-m pole. The portable antenna detected tags within a range of 30 cm. The portable antenna was powered by an internal 12-V NiMH battery (6-hour battery life with continuous operation). The reader and antenna tuning box for the portable system was carried in a waist belt worn by the operator.

Surveys with the portable antenna were conducted semiweekly over the study period. The stream was scanned for PIT tags with the portable antenna while the researcher walked upstream. When a PIT tag was detected but the fish not observed, the substrate was disturbed with a magnet on a handle to determine whether the tag was present in a living fish or a dead fish or if it had been lost. The fish was recorded as living if the PIT tag was not detected following disruption of the substrate.

Data Analyses

Survival and tag retention are binary variables. Comparisons between treatment groups were made using the chi-square statistic. For small sample comparisons (expected cell counts <5), Fisher's exact test was used (Agresti 1996).

RESULTS

Survival, Tag Loss, and Mobility

Patterns in mortality and tag loss were evident (Table 1, Fig. 2). Eight sculpins from 2 buckets died during this study. The 4 small control sculpins died on day 3 of the study. Four small sculpins from a single bucket that had received and lost dorsal tags died on day 14 of the study.

Thirty-one (78%) of the 40 sculpins that received dorsal tags lost their tags. Twenty (65%) of these tags were lost within the first 7 days following tagging (Fig. 2). Two (5%) of the 40 sculpins that received body-cavity tags lost their tags. Both of these tags were from the large/body cavity treatment; these tags were lost on study days 3 and 7 (Fig. 2). Tag loss was significantly lower from the body cavity than from the dorsal tagging location when compared across all fish ($\chi^2 = 43.378$, df = 1, $P < 0.001$) as well as when compared for small fish alone ($\chi^2 = 32.727$, df = 1, $P = 0.001$) and for large fish alone ($\chi^2 = 12.907$, df = 1, $P = 0.001$). Tag loss was independent of fish size ($\chi^2 = 0.465$, df = 1, $P = 0.495$). Fish mortality was independent of tag location (Fisher's exact test: $P = 0.116$) and fish size (Fisher's exact test: $P = 0.116$). We were unable to test whether a conditional association (Agresti 1996) existed between mortality and tagging location due to size.

Net-avoidance behavior was assessed on study days 7, 11, 14, 19, 25, and 28. We observed no change in net-avoidance behavior in any of these fish.

Instream Detection

We detected 60 (62%) of the 97 sculpins one or more times. Sixteen (16%) sculpins were detected by both stationary and portable antennas, and 22 (23%) were unique to each system. Thirty-seven (38%) sculpins were not detected with either system. With the portable antenna, we detected 20 (21%) individuals once, 8 (8%) individuals twice, 6 (6%) individuals 3 times, 3 (3%) individuals 4 times, and 1 (1%) individual 7 times. We observed no statistical association between redetected fish and fish size.

Based on known release locations and detections at stationary antennas, we were able to document continued mobility by calculating distances and directions moved by 38 individuals. These fish moved 16–99 m, and the median distance moved was 91 m. We observed upstream movement in 14 individuals, downstream movement in 19 individuals, and movement in both directions in 5 individuals. We retrieved no PIT tags with the magnet and observed no instances where a detected tag did not move once the substrate was disturbed.

DISCUSSION

Shorthead sculpins tagged in the body cavity demonstrated high survival, tag retention, and mobility. We do not attribute the observed

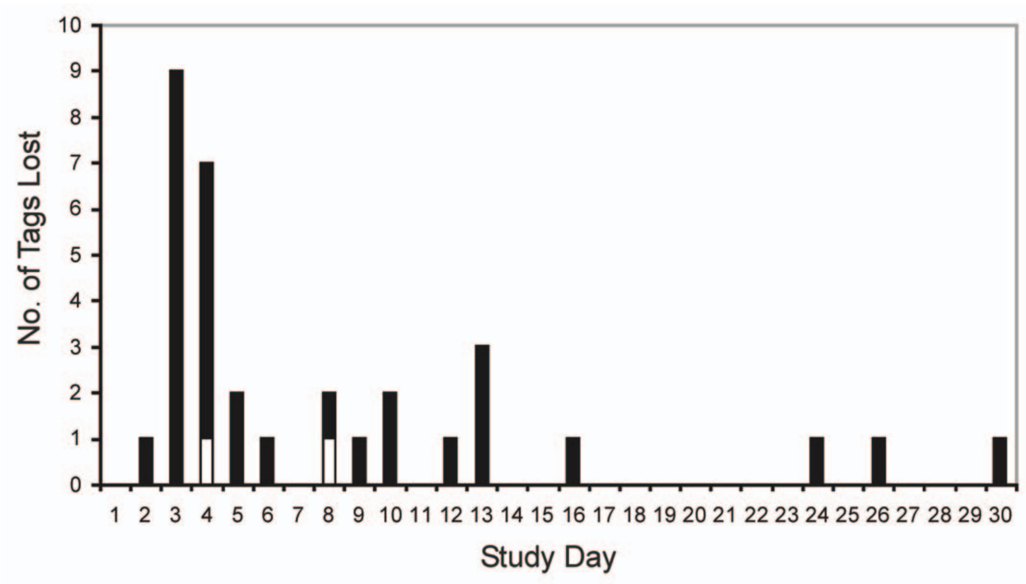

Fig. 2. Count of PIT tags lost by study day. Black bars are dorsal tags, and white bars are body-cavity tags.

mortalities to tagging effects during the 29-day study period, and our results are comparable to other PIT-tagging studies on cottids. Ruetz et al. (2006) reported a 96% survival rate for mottled sculpin (56–85 mm total length) tagged with 12.0 × 2.1-mm PIT tags and held in a laboratory for 28 days. In a sample of European bullheads (>70 mm total length) tagged with PIT tags in the body cavity, Bruyndoncx et al. (2002) reported no tag loss or mortalities after 4 weeks, and only one tag loss after 7 weeks. Knaepkens et al. (2007) reported European bullhead survival rates of 90%–100% and 95% tag retention over a 7-week study period. Keeler et al. (2007) reported survival rates over 99% and no tag loss in the first 24 hours after tagging slimy sculpins (*C. cognatus*) averaging 75 mm total length. We attribute the mortalities we observed to unexplained bucket effects. In both buckets where mortalities occurred, we observed reduced water circulation, likely resulting in low dissolved oxygen concentrations and subsequent mortalities. Our experimental design does not allow us to distinguish a bucket effect from a size effect. The combined survival and retention results indicate the body-cavity tagging location is preferred. The majority of PIT-tag losses occurred within 7 days of tagging. Body-cavity injection of tags through a hypodermic needle in a posterior direction appears useful for tagging individual shorthead sculpins down to 60 mm total length.

PIT-tagged sculpins were detected in the artificial stream using stationary and portable antennas. Stationary antennas allowed us to continuously detect sculpins passing a fixed location, indicating these sculpins were mobile following tagging. The portable antenna allowed us to relocate sculpins in the artificial stream. We observed no avoidance of the portable antenna, in contrast to Cookingham and Reutz 2008 who observed net-avoidance for round gobies (*Neogobius melanostomus*). Using the portable antenna, we detected 39% of the sculpins released. With the stationary antennas, we detected an additional 23% of our tagged sculpins. Using both portable and stationary antennas, we detected 62% of our tagged fish. In comparison, Cucherousset et al. (2005) detected 82% of the slimy sculpin they released into tributaries of the Kennebecasis River in New Brunswick, Canada, and Breen et al. (2009) detected 99% of the mottled sculpin they tagged in Seven Mile Creek in Michigan. The reach of Seven Mile Creek used by Breen et al. (2009) was not blocked by barrier nets; however, the stream segments sampled by Cucherousset et al. (2005) had barrier nets at each end, hindering fish movement out of the study area. Our artificial stream was an open system, with ponds at upstream and downstream ends (Fig. 1). The distances moved by tagged sculpins suggest that it is possible that some fish we did not detect emigrated from the sample reach. The ability to relocate sculpins is essential to describing space and habitat use over time. We caution readers not to infer movement distance (displacement) from our results since these sculpins were relocated to an artificial stream.

We found that PIT tags and PIT-tag antennas are useful for monitoring movement of individual shorthead sculpins and likely other small-bodied organisms. We suggest using stationary and portable antennas in combination when monitoring cryptic, benthic taxa, such as sculpins or crayfish. The continuous monitoring of the stationary antennas provides information concerning movement of individuals into or out of the survey area, and this information is useful for detecting wider-ranging individuals. Detections made using the portable antenna provide information useful in evaluating habitat use, connectivity, and degradation issues.

ACKNOWLEDGMENTS

This project was funded and supported by the USDI Bureau of Land Management (Assistance Agreement No. DLF0505532, Mod #1), the U.S. Environmental Protection Agency (Assistance Agreement No. DLA040219, Task Order No. DLF040649), the Idaho Department of Environmental Quality, the Nature Conservancy, the Lava Lake Foundation for Science and Conservation, and Biomark Incorporated. Project development support was provided through the Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, by J. Michael Scott, James L. Congleton, Timothy G. Cochnauer, and Robert M. Hughes. Our Animal Care and Use Protocol (No. 2004-74) was developed with assistance from Brad Williams of the University of Idaho. Citation in this document does not imply endorsement by the organizations involved. Special thanks go to Bonnie J. Zaroban as well as Barry Burnell and Balthasar Buhidar of the Idaho Department of Environmental Quality for their encouragement and support throughout this project. This manuscript was greatly improved by the comments received from 3 anonymous reviewers.

LITERATURE CITED

AGRESTI, A. 1996. An introduction to categorical data analysis. John Wiley & Sons, Inc. New York, NY.

ALBANESE, B., P.L. ANGERMEIER, AND S. DORAI-RAI. 2004. Ecological correlates of fish movement in a network of Virginia streams. Canadian Journal of Fisheries and Aquatic Sciences 61:857–869.

BAILEY, J.E. 1952. Life history and ecology of the sculpin *Cottus bairdi punctulatus* in southwestern Montana. Copeia 1952:243–255.

BREEN, M.J., C.R. RUETZ III, K.J. THOMPSON, AND S.L. KOHLER. 2009. Movements of mottled sculpins (*Cottus bairdii*) in a Michigan stream: how restricted are they? Canadian Journal of Fisheries and Aquatic Sciences 66:31–41.

BROWN, L., AND J.F. DOWNHOWER. 1982. Summer movements of mottled sculpins, *Cottus bairdi* (Pisces: Cottidae). Copeia 1982:450–453.

BRUYNDONCX, L., G. KNAEPKENS, W. MEEUS, L. BERVOETS, AND M. EENS. 2002. The evaluation of passive integrated transponder (PIT) tags and visible implant elastomer (VIE) marks as new marking techniques for the bullhead. Journal of Fish Biology 60:260–262.

COOKINGHAM, M.N., AND C.R. REUTZ III. 2008. Evaluating passive integrated transponder tags for tracking movements of round gobies. Ecology of Freshwater Fish 17:303–311.

CUCHEROUSSET, J., J.M. ROUSELL, R. KEELER, R.A. CUNJAK, AND R. STUMP. 2005. The use of two new portable 12-mm PIT tag detectors to track small fish in shallow streams. North American Journal of Fisheries Management 25:270–274.

HILL, J., AND G.D. GROSSMAN. 1987. Home range estimates for three North American stream fishes. Copeia 1987:376–380.

KEELER, R.A., A.R. BRETON, D.P. PETERSON, AND R.A. CUNJAK. 2007. Apparent survival and detection estimates for PIT-tagged slimy sculpin in five small New Brunswick streams. Transactions of the American Fisheries Society 136:281–292.

KERNOHAN, B.J., R.A. GITZEN, AND J.J. MILLSPAUGH. 2001. Analysis of animal space use and movements. Pages 125–166 *in* J.J. Millspaugh and J.M. Marzluff, editors, Radio tracking and animal populations. Academic Press, San Diego, CA.

KNAEPKENS, G., E. MAERTEN, C. TUDORACHE, G. DE BOECK, AND M. EENS. 2007. Evaluation of passive integrated transponder tags for marking the bullhead (*Cottus gobio*), a small benthic freshwater fish: effects on survival, growth and swimming capacity. Ecology of Freshwater Fish 16:404–409.

LUCAS, M.C., AND E. BARAS. 2000. Methods for studying spatial behaviour of freshwater fishes in the natural environment. Fish and Fisheries 1:283–316.

MCCLEAVE, J.D. 1964. Movement and population of the mottled sculpin (*Cottus bairdi* Girard) in a small Montana stream. Copeia 1964:506–513.

PETTY, J.T., AND G.D. GROSSMAN. 2004. Restricted movement by mottled sculpin (Pisces: Cottidae) in a southern Appalachian stream. Freshwater Biology 49:631–645.

PRENTICE, E.F., T.A. FLAGG, AND C.S. MCCUTCHEON. 1990a. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Pages 317–322 *in* N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester Jr., E.D. Prince, and G.A. Winans, editors, Fish-marking techniques. American Fisheries Society Symposium 7, Bethesda, MD.

PRENTICE, E.F., T.A. FLAGG, C.S. MCCUTCHEON, D.F. BARSTOW, AND D.C. FLAGG. 1990b. Equipment, methods, and an automated data-entry station for PIT tagging. Pages 335–340 *in* N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester Jr., E.D. Prince, and G.A. Winans, editors, Fish-marking techniques. American Fisheries Society Symposium 7, Bethesda, MD.

RILEY, W.D., M.O. EAGLE, M.J. IVES, P. RYCROFT, AND A. WILKINSON. 2003. A portable passive integrated transponder multi-point decoder system for monitoring habitat use and behaviour of freshwater fish in small streams. Fisheries Management and Ecology 10:265–268.

RUETZ, C.R., III, B.M. EARL, AND S.L. KOHLER. 2006. Evaluating passive integrated transponder tags for marking mottled sculpins: effects on growth and mortality. Transactions of the American Fisheries Society 135: 1456–1461.

SILVY, N.J., R.R. LOPEZ, AND M.J. PETERSON. 2005. Wildlife marking techniques. Pages 339–376 *in* C.E. Braun, editor, Techniques for wildlife investigations and management. The Wildlife Society, Bethesda, MD.

WYDOSKI, R.S., AND L. EMERY. 1983. Tagging and marking. Pages 215–237 *in* L.A. Nielsen and D.L. Johnson, editors, Fisheries techniques. American Fisheries Society, Bethesda, MD.

Received 26 February 2009
Accepted 4 November 2009