Taylor & Francis
Taylor & Francis Group

North American Journal of Fisheries Management

ISSN: 0275-5947 (Print) 1548-8675 (Online) Journal homepage: http://www.tandfonline.com/loi/ujfm20

Do Tags Exceeding 2% of Total Body Weight Impair Lake Sturgeon Movement?

Zachary R. Snobl, Ryan P. Koenigs, Ronald M. Bruch & Fredrick P. Binkowski

To cite this article: Zachary R. Snobl, Ryan P. Koenigs, Ronald M. Bruch & Fredrick P. Binkowski (2015) Do Tags Exceeding 2% of Total Body Weight Impair Lake Sturgeon Movement?, North American Journal of Fisheries Management, 35:5, 880-884, DOI: 10.1080/02755947.2015.1069425

To link to this article: http://dx.doi.org/10.1080/02755947.2015.1069425

Published online: 11 Sep 2015.

Submit your article to this journal

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=ujfm20

Download by: [Wisconsin Dept of Natural Resources] **Date:** 14 September 2015, At: 12:41

North American Journal of Fisheries Management 35:880–884, 2015
© American Fisheries Society 2015
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2015.1069425

MANAGEMENT BRIEF

Do Tags Exceeding 2% of Total Body Weight Impair Lake Sturgeon Movement?

Zachary R. Snobl* and Ryan P. Koenigs
Wisconsin Department of Natural Resources, Bureau of Fisheries Management, 625 East County Road Y, Suite 700, Oshkosh, Wisconsin 54901, USA

Ronald M. Bruch
Wisconsin Department of Natural Resources, Bureau of Fisheries Management, 101 South Webster Street, Madison, Wisconsin 53703, USA

Fredrick P. Binkowski
School of Freshwater Sciences, University of Wisconsin–Milwaukee, 600 East Greenfield Avenue, Milwaukee, Wisconsin 53204, USA

Downloaded by [Wisconsin Dept of Natural Resources] at 12:41 14 September 2015

Abstract

A common guideline for attaching or imbedding transmitters for fish is that the transmitter weight should not exceed 2% of the total weight in air of a fish. This guideline is thought to limit the negative effects of tagging, but little research supports it. Our objectives were to compare the postrelease dispersal rates of 48 hatchery-reared fingerling Lake Sturgeon *Acipenser fulvescens* (265–305 mm, 80–100 g) surgically implanted with sonic transmitters equating to 2% and 4% of fish body weight, and to compare the dispersal rates between fish stocked in two river systems in Wisconsin. Downstream dispersal rates of the 2% and 4% treatments were not significantly different within the individual rivers but were significantly different between rivers. We recommend that transmitters weighing up to 4% of total body weight can be used without effects on the movement of fingerling Lake Sturgeon.

Radiotelemetry and acoustic telemetry provide many advantages for quantifying fish movements (Gowan et al. 1994; Barth et al. 2011), survival (Pollock et al. 2004; Young and Isely 2006; Johnson et al. 2010), and habitat use and preferences (Tyus et al. 1984; Kynard et al. 2000). However, a major concern with telemetry studies is whether the stress associated with handling and tagging causes differences in behavior relative to unmarked individuals (Jepsen and Aarestrup 1999). Documented negative effects of handling and tagging include increased mortality (Knights and Lasee 1996), decreased swimming capacity (Adams et al. 1998), reduced growth (Zale et al. 2005), and tag expulsion (Lacroix et al. 2004). To limit these effects, a common guideline is that transmitter weight should not exceed 2% of the total weight of a fish in air and 1.25% of the weight in water (Winter 1983). However, limited research supports these weight percentages (Brown et al. 1999).

Past studies that examined the effects of transmitter burdens exceeding 2% of total body weight have been limited to mostly laboratory settings and have produced variable results. Small (95–160 mm FL) Chinook Salmon *Oncorhynchus tshawytscha* with tag burdens ranging from 2.2% to 10.0% displayed decreased swimming capacity by up to 20%. Further, decreased swimming capacity resulted in the test fish being preyed upon three times more than the control fish (Adams et al. 1998). However, increased transmitter burdens (6–12% of total body weight) had no effect on the swimming performance of Rainbow Trout *O. mykiss* (Brown et al. 1999). Another laboratory study showed that increasing the transmitter burden from 2.0% to 2.8% in Rainbow Trout and White Perch *Morone americana* had no effect on swimming performance (Mellas and Haynes 1985). These variable results demonstrate that tag burden thresholds need to be further assessed for each species. Additionally, few studies have tested the

*Corresponding author: zachary.snobl@wisconsin.gov
Received January 6, 2015; accepted June 29, 2015

Downloaded by [Wisconsin Dept of Natural Resources] at 12:41 14 September 2015

transmitter weight guideline in the field, and thus it is unknown if laboratory results can be applied to field studies.

Limiting transmitter size to 2% of body weight can be especially challenging when studying small fish, as smaller, lighter tags may have an insufficient battery life to answer desired research questions (Zale et al. 2005). For example, transmitters with a battery life sufficient (e.g., 365 d) to successfully examine habitat use and movement patterns of age-0 and juvenile Lake Sturgeon *Acipenser fulvescens* will typically exceed 2% of the fish's total body weight. Therefore, our primary objective was to compare the postrelease dispersal rates of large fingerling (265–305 mm TL, 80–100 g in weight) Lake Sturgeon surgically implanted with sonic transmitters equating to either 2% or 4% of the body weight of a fish. This objective was tested in two river systems to also compare the downstream dispersal rates between the two rivers.

METHODS

Study area.—The Winnebago System is a large, shallow, eutrophic system in east-central Wisconsin, including Lake Winnebago and three upriver lakes (Butte des Morts, Winneconne, and Poygan), that collectively covers 668 km^2 of surface water (Figure 1). The Upper Fox River and the Wolf River (along with their major tributaries) flow into Lake Winnebago and collectively drain a 15,540-km^2 watershed. The Upper Fox River also flows through Lake Puckaway, a 2,029-ha lake, and the river has a discharge of 32.8 cms. The Wolf River has almost twice the discharge of the Upper Fox River at 62.8 cms. Adult Lake Sturgeon migrate up both river systems to spawn each spring (Bruch and Binkowski 2002). Following spawning, larvae and young of year Lake Sturgeon remain in the upper portions of the rivers before making perceived downstream migrations in their first fall (Kempinger 1996).

Lake Sturgeon rearing, transmitter implantation, and release.—All Lake Sturgeon used in this study were reared at the University of Wisconsin Milwaukee School of Freshwater Sciences. Gametes were collected from wild broodstock captured from the Wolf River during April 2010. Using standard techniques, fish were reared at 20–22°C from the post-sac-fry to post-fingerling stages. Before stocking, the temperature was decreased 1°C every 3 d until the temperature matched the river temperature (6°C).

In October 2010, 48 fingerling Lake Sturgeon weighing 90 ± 10 g were surgically implanted with two different-sized acoustic transmitters. Smaller transmitters (1.8 g in air, 1.0 g in water, volume of 865.9 mm^3; Vemco V7-4 L, dB 136, variable 40–80-s ping rate, 171-d battery life) equated to 2% of total body weight (2% treatment), whereas larger transmitters (3.6 g in air, 2.2 g in water, volume of 1,526.81 mm^3; Vemco V9-1 L, dB 142, variable 40–80-s ping rate, 192-d battery life) equated to 4% of total body weight (4% treatment). The mean transmitter burden for the 2% treatment group was 2.03% (range = 1.82–2.25%, $n = 24$), while the mean transmitter burden for the 4% treatment group was 3.94% (range = 3.69–4.29%, $n = 24$). All fish in this study carried transmitters and were not compared with untagged fish. Acoustic tags were surgically implanted into the abdomen (halfway between the midline and ventral scutes, six to seven ventral scutes posterior to the head) through a 1–2-cm incision. Incisions were closed using a 2/0 needle with monofilament sutures (typically two or three sutures were required) and then flushed with oxytetracycline antibiotic.

Tagged fish were held in rearing tanks for 3 weeks following surgery to assess survival and potential transmitter expulsion. All tags were programmed with a 3-week delay following activation to prolong battery life.

Forty-eight tagged Lake Sturgeon were released on November 9, 2010, at two locations within the Lake Winnebago system (Figure 1). Release locations were at the Montello River 1 km upstream of the confluence with the Upper Fox River (121 km upstream of Lake Winnebago), and the Wolf River 50 m downstream of the Shawano Paper Mill Dam in Shawano (200 km upstream of Lake Winnebago). Both locations were just downstream of a dam that prevented upstream movement. Twelve 2% treatment fish and twelve 4% treatment fish were released at each location. The Winnebago System has a passive acoustic receiver array consisting of 26 Vemco acoustic receivers (VR2s and VR2Ws, 69-kHz receiving frequency) covering both river systems as well as the inlets into the upriver lakes (Lakes Butte des Morts, Winneconne, and Poygan) and Lake Winnebago (Figure 1).

Data analysis.—Movement data downloaded from acoustic receivers were analyzed for potential differences between the 2% and 4% treatments, within and between rivers. A two-way ANOVA using type III sum of squares (to account for uneven groups), alpha level set at 0.05, was used to compare the average downstream dispersal rates (km/d) between release locations and receivers 40.8 km downstream on the Upper Fox River and 31.2 km downstream on the Wolf River as well as differences between the two rivers. These receiver locations provided the most comparable distances between the two rivers while also having contacts with most fish (Montello–Upper Fox River 2% treatment $n = 12$, 4% treatment $n = 10$, Wolf River $n = 24$). Significant interactions in the ANOVA were then analyzed with a *t*-test.

Differences in the locations where fish within each treatment were last contacted before transmitter expiration (171 d after release) was analyzed using chi-square analyses ($\alpha = 0.05$). Fish were categorized as being in a river or lake environment depending on their last contact location. The two release location groups were analyzed separately.

RESULTS

No mortality or tag expulsion was observed over the 3-week holding period following surgery. Transmitter detections indicated that fish traveled long distances or through

Downloaded by [Wisconsin Dept of Natural Resources] at 12:41 14 September 2015

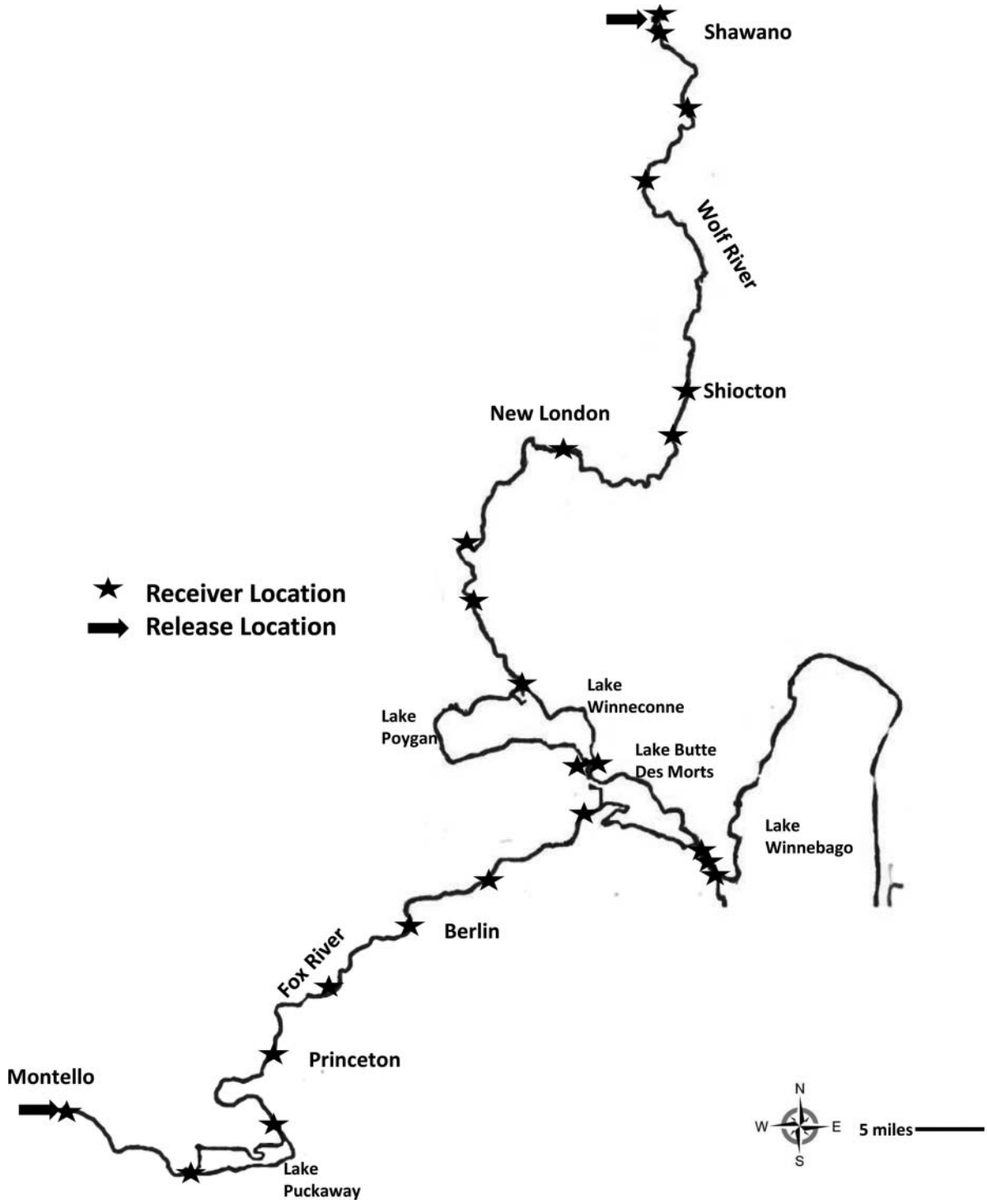

FIGURE 1. The Winnebago System, depicting all receiver locations as stars. Shawano was the release location for the Wolf River, whereas fish were released at Montello on the Upper Fox River. Fish could not travel upstream at either location because of dams just upstream of the release location.

large lentic environments; thus, we assumed that all fish survived until the end of the study.

Mean downstream dispersal rates between both treatments were not significantly different for either release location ($F = 0.48$, $P = 0.49$; Wolf River dispersal rates: 2% treatment $= 28.64 \pm 8.94$ km/d, 4% treatment $= 26.25 \pm 9.52$ km/d; Upper Fox River 2% treatment $= 8.45 \pm 4.57$ km/d, 4% treatment $= 7.65 \pm 5.75$ km/d). When comparing dispersal rates

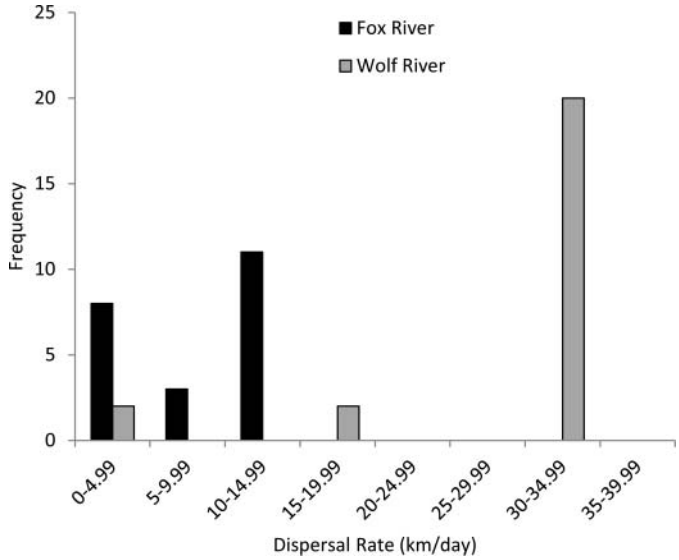

FIGURE 2. Age-0 hatchery-reared Lake Sturgeon dispersal rates in the Wolf ($n = 24$) and Upper Fox rivers ($n = 22$). Half of the fish released into each river were implanted with transmitters weighing 2% of total body weight, and the rest of the fish were implanted with transmitters weighing 4% of total body weight. All fish were released on November 9, 2010, and were released at locations in Montello and Shawano, Wisconsin.

between rivers, fish in both treatments dispersed downstream significantly faster in the Wolf River than in the Upper Fox River (Figure 2; ANOVA: $F = 116.46$, $P < 0.0001$; t-test: $t = -8.81$, df = 44, $P < 0.0001$).

Fish within the 4% treatment group were more likely than the 2% treatment fish to disperse out of the Wolf River during the battery life of the tag, specifically 67% of 4% treatment fish compared with only 25% of the 2% treatment fish ($\chi^2 = 4.196$, $P = 0.04$). The opposite trend was observed in the Upper Fox River, where all of the 2% treatment fish left the river by the end of the transmitter battery life, while only 42% of the 4% treatment fish had left the river ($\chi^2 = 6.316$, $P = 0.02$).

DISCUSSION

Although there has been little field research justifying Winter's (1983) guidance of not exceeding 2% transmitter burdens, this guidance has been almost universally accepted and applied. Our study is the first field evaluation of exceeding the 2% tag weight guideline for a sturgeon species. The results indicate that tag burdens up to at least 4% did not impact the survival or dispersal rates of age-0 Lake Sturgeon and thus are acceptable. These results are also consistent with those of other laboratory studies conducted on other species of fish, including Rainbow Trout and White Perch (Mellas and Haynes 1985; Brown et al. 1999). However, more field studies are desired to better evaluate the impacts of higher tag burdens in the natural environment for a multitude of fish species.

In both treatments, fish dispersed downstream significantly faster in the Wolf River than in the Upper Fox River. Many factors may have influenced this trend. One of the most likely factors is the lentic environment of Lake Puckaway on the downstream route through the Upper Fox River. Lake Puckaway is located 18 km downstream of the release location, and fish have to move through the lake before reaching the upriver lakes or Lake Winnebago. In comparison, the Wolf River contains 160 km of uninterrupted river from the release location downstream to the upriver lakes. The reduced current associated with the lentic environment of Lake Puckaway could considerably slow down fish. Lake Puckaway is also a shallow, eutrophic lake with abundant chironomids, a staple in Winnebago System Lake Sturgeon diets (Stelzer et al. 2008), which could have contributed to the sturgeon remaining in the lake for longer durations. The increased discharge of the Wolf River, almost double that of the Upper Fox River, could have also contributed to the faster dispersal rates following stocking.

All Lake Sturgeon in this study were hatchery reared and may have displayed different behavioral patterns than wild fish. For example, age-0 hatchery reared Striped Bass *M. saxatilis* have been shown to disperse significantly slower than wild Striped Bass (Wells et al. 1991). However, the capture of wild age-0 Lake Sturgeon can be difficult, which was the main reason for utilizing stocked fish in this study. Hatchery-reared fish also sufficiently met our primary study objective of evaluating the impacts of tag burdens higher than 2% on fish movement. With that said, we recommend that the dispersal rates of wild age-0 Lake Sturgeon be further evaluated and compared with the dispersal rates of hatchery-reared fish.

Although these findings demonstrate Lake Sturgeon, and potentially other species of fish, can handle heavier tags with little or no effect on dispersal or survival, we still recommend using the smallest tag possible to accomplish study objectives. The results observed in this study do not automatically merit the use of larger, longer-lived tags. However, there are scenarios where the application of smaller tags to satisfy the 2% guidance will not result in a sufficient battery life to evaluate study objectives. In these scenarios, we recommend utilizing larger tags, up to 4% of the fish body weight, to provide sufficient battery duration to carry out the study. We also recommend that further field evaluations be conducted with multiple species of wild fish to further study the impacts of increased tag burdens on fish movement, growth, and survival.

ACKNOWLEDGMENTS

We thank Joshua Raabe for his helpful comments on this manuscript. We also thank Sturgeon for Tomorrow for funding costs associated with rearing. Acoustic tags were purchased with revenue generated from the sale of Winnebago System sturgeon spearing licenses. Lastly, we thank Doug Rinzel for compiling all acoustic data from the study fish into a useable format.

Downloaded by [Wisconsin Dept of Natural Resources] at 12:41 14 September 2015

REFERENCES

Adams, N. S., D. W. Rondorf, S. D. Evans, J. E. Kelly, and R. W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 55:781–787.

Barth, C. C., W. G. Anderson, L. M. Henderson, and S. J. Peake. 2011. Home range size and seasonal movement of juvenile Lake Sturgeon in a large river in the Hudson Bay drainage basin. Transactions of the American Fisheries Society 140:1629–1641.

Brown, R. S., S. J. Cooke, W. G. Anderson, and R. S. McKinley. 1999. Evidence to challenge the "2% rule" for biotelemetry. North American Journal of Fisheries Management 19:867–871.

Bruch, R. M., and F. P. Binkowski. 2002. Spawning behavior of Lake Sturgeon (*Acipenser fulvescens*). Journal of Applied Ichthyology 18:570–579.

Gowan, C., M. K. Young, K. D. Fausch, and S. C. Riley. 1994. Restricted movement in resident stream salmonids: a paradigm lost? Canadian Journal of Fisheries and Aquatic Sciences 51:2626–2637.

Jepsen, N., and K. Aarestrup. 1999. A comparison of the growth of radio-tagged and dye- marked pike. Journal of Fish Biology 55:880–883.

Johnson, S. L., J. H. Power, D. R. Wilson, and J. Ray. 2010. A comparison of the survival and migratory behavior of hatchery-reared and naturally reared steelhead smolts in the Alsea River and Estuary, Oregon, using acoustic telemetry. North American Journal of Fisheries Management 30:55–71.

Kempinger, J. J. 1996. Habitat, growth, and food of young Lake Sturgeons in the Lake Winnebago system, Wisconsin. North American Journal of Fisheries Management 16:102–114.

Knights, B. C., and B. A. Lasee. 1996. Effects of implanted transmitters on adult Bluegills at two temperatures. Transactions of the American Fisheries Society 3:440–449.

Kynard, B., M. Horgan, M. Kieffer, and D. Seibel. 2000. Habitats used by Shortnose Sturgeon in two Massachusetts Rivers, with notes on estuarian Atlantic Sturgeon: a hierarchical approach. Transactions of the American Fisheries Society 129:487–503.

Lacroix, G. L., D. Knox, and P. McCurdy. 2004. Effects of implanted dummy acoustic transmitters on juvenile Atlantic Salmon. Transactions of the American Fisheries Society 133:211–220.

Mellas, E. J., and J. M. Haynes. 1985. Swimming performance and behavior of Rainbow Trout (*Salmo gairdneri*) and White Perch (*Morone Americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488–493.

Pollock, K. H., H. Jiang, and J. E. Hightower. 2004. Combining telemetry and fisheries tagging models to estimate fishing and natural mortality rates. Transactions of the American Fisheries Society 133:639–648.

Stelzer, R. S., H. G. Drecktrah, M. P. Shupryt, and R. M. Bruch. 2008. Carbon sources for Lake Sturgeon in Lake Winnebago, Wisconsin. Transactions of the American Fisheries Society 137:1018–1028.

Tyus, H. M., B. D. Burdick, and C. W. McAda. 1984. Use of radiotelemetry for obtaining preference data on Colorado Squawfish. North American Journal of Fisheries Management 4:177–180.

Wells, A. W., D. M. Randall, D. J. Dunning, and J. R. Young. 1991. Dispersal of young-or-the-year hatchery Striped Bass in the Hudson River. North American Journal of Fisheries Management 11:381–392.

Winter, J. D. 1983. Underwater biotelemetry. Pages 371–395 *in* L. A. Nielson and D. L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Young, S. P., and J. J. Isely. 2006. Posttournament survival and dispersal of adult Striped Bass. North American Journal of Fisheries Management 26:1030–1033.

Zale, A. V., C. Brooke, and W. C. Fraser. 2005. Effects of surgically implanted transmitter weights on growth and swimming stamina of small adult Westslope Cutthroat Trout. Transactions of the American Fisheries Society 134:653–660.

Downloaded by [Wisconsin Dept of Natural Resources] at 12:41 14 September 2015