Variation in Trotline Catfish Catch and Bycatch Rates by Hook and Bait Type in the New River, Virginia

Benjamin. D. Dickinson[1], *Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061*

Steve L. McMullin, *Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061*

Donald J. Orth, *Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061*

John R. Copeland, *Virginia Department of Game and Inland Fisheries, Blacksburg, VA 24060*

Abstract: The New River, Virginia, supports a trotline fishery for catfish (Ictaluridae) that coexists with popular recreational fisheries for smallmouth bass (*Micropterus dolomieu*), muskellunge (*Esox masquinongy*), and walleye (*Sander vitreus*), yet no studies have examined trotline catches or bycatch of these game fish. Trotline effort was estimated by conducting off-site interviews of trotline fishers and field counts of active trotlines. Catch of catfish and bycatch were estimated with experimental trotline sets that used circle or J hooks and two bait types (i.e., live or cut bait). Catch averaged 12.1 catfish 100 hook nights^{-1}. Experimental trotline sets baited with live baitfish captured predominantly channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*) but caught few smallmouth bass, muskellunge, or walleye. Cutbait caught fewer catfish, particularly flathead catfish, and fewer non-catfish species than live bait. Circle hooks were more effective for catching channel catfish compared to J hooks. Although game fish were caught at nearly equal rates by both hook types, 67% of J hooks were embedded in the stomach or esophagus compared to only 18% of those caught with circle hooks. Based on our standardized trotline surveys, a catfish angler caught 1 game fish for every 32 catfish that were caught. Overall, our findings suggest that trotline fishing for catfish would likely have a small influence on the abundant smallmouth bass population in the New River, compared to the smaller, developing walleye population.

Keywords: Bycatch, catfish, trotline baits, hook type

Journal of the Southeastern Association of Fish and Wildlife Agencies 5:46–52

Few studies have examined the catch composition and catch rate of trotlines, particularly recreational trotlines (Steffensen et al. 2011, Eder et al. 2016). Trotlines are passive fishing gears consisting of an unattended line with one or more hooks that are often used to target catfish (Ictaluridae) in freshwater fisheries. Catfish anglers and scientists may use the terms setline, layline, throw line, limb line, drop line, and trotline interchangeably, and definitions may vary locally or regionally (Hubert et al. 2012). Here, we are specifically concerned with trotlines, which are generally horizontally deployed mainlines with multiple dropper lines, each with a hook.

Creel surveyors seldom encounter trotline anglers because they usually operate for brief periods while setting gear or retrieving catch (Michaletz and Dillard 1999, Arterburn et al. 2002, Kuklinski and Boxrucker 2008, Eder et al. 2016 or fish at night and/or from private shore locations (Michaletz and Dillard 1999, Eder et al. 2016). Lists of trotline-specific licensed fishers are often unavailable for mail or telephone surveys (Arterburn et al. 2002). Catfish anglers in general are less responsive to mail surveys (Schramm et al. 1999) and angler diary programs (Bray 1997) than other types of anglers, and we assume trotline fishers to be no different. While trotline fishers often represent a small percentage of the entire angler population, ranging from 6% to 13% of licensed individuals in a few limited studies (Arterburn et al. 2002, Fisher et al. 2002, Reitz and Travnichek 2004, Virginia Department of Game and Inland Fisheries [VDGIF] unpublished data), high numbers of hooks and lines gives rise to the potential for illegal overharvest or conflict with other river users.

Commercial trotline catches generally consist of ≥90% of catfish (Sanderson 1961, White 1961, Johnson and Timmons 1989, Timmons et al. 1989). Such selectivity for catfish is not unexpected because commercial trotline hooks are usually baited with cut baits unlikely to attract piscivorous game fish and effects on them may be negligible (Johnson and Timmons 1989). However, trotline bycatch and mortality of piscivorous fish, turtles, and other animals are largely undocumented (Moll and Moll 2004, Cartabiano et al. 2015).

1. Present address: Indiana Department of Natural Resources, 100 W. Water Street, Michigan City, IN 46360

Recreational trotlines have received less attention than commercial trotlines, and concerns persist regarding illegal fishing (Quinn 1993). Examining catch rates of recreational trotlines with different baits and hook types for both catfish and bycatch may inform anglers and managers regarding preferred hook type on trotlines as well as the potential for overharvest. Circle hooks, first used by commercial trotline fishers (Ott and Storey 1991), are increasingly popular with all types of catfish anglers and may increase catch rates of catfish in some cases (Schmitt and Shoup 2013). One study found no difference in catch rates of channel catfish (*Ictalurus punctatus*) and flathead catfish (*Pylodictis olivaris*) caught on trotlines with either circle or J hooks (Arterburn and Berry 2002). Circle hooks may reduce bycatch mortality of hooked fish, but their effectiveness is species dependent, and whether or not they reduce deep hooking, organ damage, or accidental self-hooking when fished on trotlines is equivocal (Cooke and Suski 2004, Schmitt and Shoup 2013).

Trotlines baited with live fish may catch more flathead catfish whereas cut bait may be more likely to catch channel catfish and fewer game fish (White 1961, Johnson and Timmons 1989, Quinn 1993, Arterburn and Berry 2002). Anglers, guides, scuba divers, and outfitters have voiced concerns about the prevalence, safety hazards, and/or bycatch of trotlines in rivers (Dickinson et al. 2015). Because of these perceived conflicts, knowledge of bycatch in trotline fisheries for catfish is needed (Bodine et al. 2013, Dickinson et al. 2015).

The New River, Virginia, supports a recreational trotline fishery that coexists with a recreational fishery for trophy smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), and muskellunge (*Esox masquinongy*; Palmer et al. 2005, Copeland et al. 2006, Brenden et al. 2007, Palmer 2013) as well as panfish such as redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*). New River anglers in Virginia have become increasingly catch-and-release oriented in the past 30 years with the implementation of slot limits and the emergence of trophy fisheries for smallmouth bass and muskellunge (Austen and Orth 1984, Copeland et al. 2006, Brenden et al. 2007). Trotline fishing is often perceived to conflict with traditional hook-and-line angling (Bodine et al. 2013, Dickinson et al. 2015). Considering that trotline fishers are permitted to use live bait in the New River, potential bycatch of piscivorous game fish is a reasonable concern among managers and some stakeholders. Consequently, our study objectives were to (1) estimate the catch rate and catch composition (catfish and bycatch) with experimental trotlines, and (2) compare catch rates and hook locations for two hook types and two bait types.

Study Area

The study was conducted on the New River in Virginia. The New River originates in North Carolina and flows in a northeasterly direction until the region of Claytor Lake and Dam where it then meanders in a northerly directly into West Virginia. The New River has a unique native fish community with eight endemic species and high percentage of non-native fishes (Jenkins and Burkhead 1993, Hilling et al. in press). Management efforts have historically focused on smallmouth bass, muskellunge, and walleye, while native channel catfish and flathead catfish are seldom considered in management decisions. There are no restrictions to the number of lines or hooks that trotline fishers may deploy in Virginia, and the bag limit is 20 catfish per day (species in aggregate) with no length restrictions. Four study reaches between 6 and 10 km long known to be used by trotline anglers were selected for the purposes of this study using expert knowledge from VDGIF biologists, angling guides, and local river users and based on verifiable trotline use during a pilot survey in 2010. They are referenced by their nearest public boat launches: Ivanhoe, Foster Falls, Allisonia, and Eggleston.

Methods

Experimental Trotline Catch Rates

Trotline fishing deployment and effort followed the procedures described by Arterburn and Berry (2002) but with 26 hooks per trotline instead of 10 because most New River trotline fishers used trotlines with at least 20 hooks per line (Dickinson et al. 2015). Experimental fishing events were conducted monthly at each study reach from May to October 2011.

Six trotlines were set in each reach for each sampling event, defined as an overnight set. Three live bait lines were fished with assorted fishes, such as bullheads, *Ameiurus* spp., and minnows (Cyprinidae), approximately 8–15 cm total length, and three cut bait lines were fished with 3-cm pieces of cut gizzard shad, *Dorosoma cepedianum*, in a randomized manner. Trotlines were constructed with approximately 30 m of #18 tarred nylon mainline, with #9 or #18 twisted nylon droppers approximately 40 cm long spaced 1.2 m apart. Each trotline had 13 circle hooks (Size 3/0 Eagle Claw Lazer Sharp offset circle, large eye for trotline; Eagle Claw, Denver, Colorado) and 13 J hooks (Size 2/0 Eagle Claw Lazer Sharp, O'Shaughnessy sea guard, non-offset, trotline and trailer hook, ringed eye), which were attached one hook per dropper line; hook type was alternated every other dropper. Although hook sizes differed, the gap (the distance from the hook point to shank) was equal for both hook types.

Trotlines were set at the upstream and downstream ends of pools, in current breaks, and near large woody debris by tying one end of

the line to a secure object such as an exposed root and stretching the line between 45° and 90° relative to current direction. Trotlines were anchored to the bottom by three weights spaced equally along the length of the line. They were set in late afternoon or early evening and retrieved early the following morning. We recorded the date, location, species, length, weight, hook type, hooking location on the body, and bait type for each fish caught. Catch per unit effort (CPUE) was calculated for each trotline sampling event by location and standardized as the number of fish caught per 100 hook nights.

We used backwards-stepwise logistic regression in SPSS to estimate the odds ratios (Lemeshow and Hosmer 1984) for the presence or absence of fish on trotlines with month (May–October), hook type (circle hook, J hook), and bait type (live, cut) as predictors. Regressions were run independently for channel catfish, flathead catfish, and aggregated game fish (i.e., smallmouth bass, walleye, muskellunge, and rock bass). Logistic regression provided estimates of an odds ratio, a simple-to-interpret effect that can be more easily generalized to other studies.

Trotline Effort and Catch

Trotline fishing effort was estimated by counting lines set by recreational catfish anglers in the same four study reaches. This systematic, random trotline survey was conducted three times a month from June–October 2011. Creel clerks navigated the study reaches with kayaks due to the navigational hazards of rapids, rock ledges, and shallow water. No trotline fishing effort surveys were done in May due to high water and unsafe conditions. The shoreline and near-shore water of each riverbank was scanned for evidence of trotlines, which were then identified with Global Positioning System (GPS) coordinates to avoid double counting. Monthly trotline effort (E) in hook nights was estimated following the equation of Winkelman (2011):

$$E = \frac{L}{D} \times H \times F$$

where L = number of trotlines found in a given river reach, D = detection probability, H = number of hooks per line, and F = days fished per month. Detection probability was used to correct for missed trotlines and was determined on six randomly selected survey dates. Prior to the scheduled survey on these dates, assistants placed between 4 and 11 mock trotlines (similar in construction and placement to methods used by New River trotline fishers) for the surveyors to encounter during their survey. Mock trotlines were hidden and tied to woody debris, rootwads, or tree trunks underwater and close to the bank. Detection probability was calculated by the number of mock lines that were found divided by the number of lines set (Eder et al. 2016) and 95% confidence limits were calculated with the Clopper-Pearson exact method (Clopper and Pearson 1934).

Data from interviews with 63 trotline users from a concurrent study (Dickinson et al. 2015) provided additional estimates of trotline catch and effort that was used to calculate H and F. Interviewees were asked how many hooks they used on their trotlines, how frequently they fished their trotlines per month, and how many catfish they caught per trotline. This approach assumed that hooks per trotline and frequency of trotline fishing did not differ spatially or temporally, as some of the interviewees fished in the New River but not in the study reaches or during all months the creel survey was conducted. Therefore, H and F calculated from the survey were used to estimate E and total catch per reach per month. Catch was standardized to number of fish caught per 100 hook nights.

Results

Experimental Trotline Catch Rates

Total fishing effort from experimental trotlines was 1853 hook nights with live bait and 1820 hook nights with cut bait. Hook and bait numbers fished were equal, but numbers retrieved differed slightly because several dropper lines broke during retrieval. Experimental trotlines collected 338 fish, 86% of which were catfish. Bycatch totaled 12 common snapping turtles (*Chelydra serpentina*) and 46 game fish which included 14 smallmouth bass, 18 walleye, and 2 muskellunge. Approximately 80% of all fish were caught on live bait, including 45 of 46 game fish and 91 of 93 flathead catfish. Experimental trotlines with live bait caught 12.1 catfish 100 hook nights^{-1}. Catch rates with live bait were highest for channel catfish (7.2 fish 100 hook nights^{-1}) and flathead catfish (4.9 fish 100 hook nights^{-1}; Table 1). Live-baited trotlines caught 0.76 smallmouth bass and 0.97 walleye 100 hook nights^{-1}. Cut bait caught only channel catfish (3.5 fish 100 hook nights^{-1}).

Flathead catfish and other game fish were approximately 45 times more likely to be caught with live bait than cut bait (odds

Table 1. New River experimental trotline catch rates (fish 100 hook nights^{-1}), May–October 2011, of flathead catfish, channel catfish, and game fishes (walleye, smallmouth bass, muskellunge, rock bass) by hook type and bait type. Numbers in parentheses (*n*) are total hooks fished per category.

	Catch 100 hook nights^{-1}				
Species	Total (*n* = 3673)	Cut bait (*n* = 1820)	Live bait (*n* = 1853)	Circle hook (*n* = 1837)	J hook (*n* = 1836)
Flathead catfish	2.5	0.1	4.9	2.8	2.2
Channel catfish	5.4	3.5	7.2	7.1	3.7
All catfish	7.9	3.6	12.1	9.9	5.9
Walleye	0.5	0.0	0.5	0.2	0.2
Smallmouth bass	0.4	0.0	0.4	0.2	0.2
Muskellunge	0.1	0.0	0.1	0.0	0.1
Rock bass	0.3	0.1	0.3	0.2	0.2
Combined game	1.3	0.1	2.4	1.2	1.3
All fish	9.1	3.7	14.5	11.1	7.2

Table 2. Location of hook penetration for fish caught on circle and J hooks during 2011 experimental trotline fishing in the New River, Virginia. Numbers in parentheses are percent of all hooked fish.

	Eye	Lip	Stomach/ esophagus	External	*n*
Circle hooks					
Channel catfish	22 (17%)	105 (81%)	1 (1%)	2 (2%)	130
Flathead catfish	3 (6%)	46 (88%)	3 (6%)	0 (0%)	52
Gamefish	1 (5%)	17 (77%)	4 (18%)	0 (0%)	22
All fish	26 (13%)	168 (82%)	8 (4%)	2 (1%)	204
J hooks					
Channel catfish	4 (6%)	58 (87%)	1 (1%)	4 (6%)	67
Flathead catfish	1 (2%)	30 (73%)	0 (0%)	10 (24%)	41
Gamefish	1 (4%)	7 (29%)	16 (67%)	0 (0%)	24
All fish	6 (4%)	95 (72%)	17 (13%)	14 (11%)	132

ratios = 44.37 and 45.84, respectively, $P < 0.001$). Channel catfish were approximately twice as likely to be caught with live bait as with cut bait (odds ratio = 2.03, $P < 0.001$). Trotline catches of channel catfish remained fairly consistent by month, but flathead catfish were approximately two times more likely to be caught in August than other months. Game fish were almost three and four times more likely to be caught in June and October, respectively, than other months.

Circle hook catch rates were 1.5 times higher than J-hook catch for all fishes, but only channel catfish were significantly more likely to be caught on circle hooks compared to J hooks. Flathead catfish and game fish were almost equally likely to be caught with either hook type. Location of hook penetration on the bodies of captured fish was influenced by hook type and fish species (Table 2). More game fish (20 of 46, 44%) were hooked in the stomach or esophagus than flathead catfish (4 of 94, 3%) or channel catfish (2 of 197, 1%). Most fish that were hooked in the eye were channel catfish, and this was especially true for circle hooks (Table 2). Game fish were more likely to be hooked in the stomach or esophagus with J hooks (67%) than circle hooks (18%; Table 2). Half of the walleye and 36% of the smallmouth bass caught by experimental trotlines were dead at the time of retrieval.

Trotline Effort and Catch

Field surveys of trotlines documented a total of 32 unique active trotlines in the four study reaches. The trotline users ($n = 24$) interviewed by Dickinson et al. (2015) reported fishing with trotlines averaging 30 hooks per line, but hooks per line ranged from 1 to 105. Trotline users fished their lines an average 8.9 trips mo^{-1} (range = 1–25 trips mo^{-1}). Interview data were pooled for hooks per line and frequency of fishing. Detection probability was 0.9 (39 of 44 dummy trotlines detected) and the 95% confidence interval was 0.75 to 0.96. The Allisonia (4429 hook nights) and Foster Falls (3391) reaches had highest total mean effort, followed by Eggleston (1879) and Ivanhoe (767). Mean hook nights per km varied from 110 to 591 and averaged 324 hook nights km^{-1}.

Mean CPUE provided from interviews of active trotline users was 13.2 catfish 100 hook $nights^{-1}$ (range = 7.7–22.2 fish 100 hook $nights^{-1}$). Most trotline users interviewed preferred to use live bait, which was in line with field observations from our trotline effort surveys. Consequently, the trotline catch rates with live bait were used to generate catch estimates. Trotline users caught an estimated 1400 catfish, which was 41.6 catfish km^{-1}. Catfish catch was 14.1 km^{-1} at Ivanhoe, 30.1 km^{-1} at Eggleson, 51.0 km^{-1} at Foster Falls, and 75.0 km^{-1} at Allisonia. Only 160 game fish were caught with trotlines, conferring a catch rate of 1.3 fish 100 hook $nights^{-1}$. Therefore, on average, a catfish angler caught 1 game fish for every 32 catfish that were caught.

Discussion

This study demonstrated an approach to estimating trotline effort, catfish harvest per effort, and gamefish and turtle bycatch that can be used to guide fisheries management. We concluded that trotlines effectively targeted catfish in a harvest-oriented recreational fishery. A combination of experimental trotline fishing and trotline effort surveys provided a repeatable method for estimating catch and bycatch rates of trotlines. Most game fish captured with trotlines, with the exception of walleye, were fish that were abundant and widely distributed in the study area (Copeland et al. 2006). Trotline bycatch of walleye, however, remains a concern as this unique fish depends on annual stocking to support management objectives to increase angler catches (Palmer 2013).

New River trotline fishing appears to be primarily a summer pursuit. Many New River trotline fishers reported ceasing trotline activity when the water temperature cooled (Dickinson et al. 2015). Trotline fishing effort showed a similar seasonal decline in Oklahoma; only 168 individuals fished with trotlines from 1 November to 15 May, compared to 942 individuals fishing with trotlines from 16 May to 31 October (Kuklinski and Boxrucker 2008). Cold air and water temperatures likely prompt all but the most dedicated trotline fishers to stop fishing with trotlines in the fall and winter, particularly those fishing for flathead catfish, which often become sedentary during winter months (Stauffer et al. 1996, Weller and Winter 2001, Daugherty and Sutton 2005) and cease feeding when water temperatures fall below 11 °C (Bourret et al. 2008).

Trotlines caught larger size flathead catfish than observed in standardized boat-electrofishing samples (Copeland et al. 2006). The mean total length of flathead catfish caught in trotlines was 62 cm TL (range = 40–100 cm) and 15% of flathead catfish caught

were over 80 cm TL (Dickinson 2012). Catfish were poorly represented in boat elecrofishing samples and mean length of flathead catfish from boat electrofishing samples pooled over thirteen years (1996–2010) was 38 cm TL (range = 50–85). Channel catfish caught on trotlines were smaller and average total length was 56 cm TL (range = 40–66 cm).

The trotlines used in this study proved to be effective for catching catfish. Trotline bait type and hook type influenced catch rate and composition, and catch rate was much greater with live bait for all species. Cut bait caught mostly channel catfish whereas flathead catfish were almost exclusively caught with live bait, which is consistent with their piscivorous feeding habits (Roell and Orth 1993, Jackson 1999) and that reported in previous field studies (White 1961, Quinn 1993, Arterburn and Berry 2002). Circle hooks caught more channel catfish than did J hooks. When hooked, many channel catfish rolled and twisted around the main line. It is possible that due to their design, circle hooks simply retained hooked channel catfish better than J hooks (Cooke and Suski 2004).

Trotlines offer recreational anglers the potential to catch and harvest large numbers of catfish. Therefore, trotlines should be used for routine sampling of catfishes (Vokoun and Rabeni 1999, Arterburn and Berry 2002). Trotline catch rates and composition are influenced by technique, fish populations, and fish assemblages, which vary among regions (Quinn 1993, Kuklinski and Boxrucker 2008). We documented catch rates of approximately 12 catfish 100 hook-nights^{-1} with live bait, similar to ranges reported in the literature for commercial and recreational trotlines which ranged from 1 to 18 catfish 100 hook night^{-1}, averaging approximately 10 catfish 100 hook night^{-1} (White 1961; Timmons et al. 1989; Stauffer and Koenen 1999; Arterburn and Berry 2002; Stewig 2006a, 2006b; Stewig and Chapman 2009; Barada 2009; Eder et al. 2016). Trotliners in other fisheries harvested 1.5–3 times more catfish than rod-and-reel anglers (Quinn 1993; Kuklinski and Boxrucker 2008). However, catch rate comparisons are problematic because disparate units of effort are used to measure active versus passive fishing techniques.

Experimental trotline fishing to quantify catch rates was useful in several ways. Although catfish catch rates by interviewed trotline fishers (13.2 catfish 100 hook-nights^{-1}) were very close to our experimental trotline fishing catch rates (12.1 catfish 100 hook-nights^{-1}), we were concerned about recall bias. Additionally, given that harvest of game fish caught by trotlines is illegal in Virginia, and given the potential conflict between smallmouth bass and walleye guides and trotline fishers, we were concerned that trotline fishers might be inclined to report low-biased game fish catch rates. Experimental fishing appeared to be a standardized approach to quantify catfish catch, bycatch, and bycatch mortality because it was subject to the least recall and biases. Trotline anglers were rarely in direct attendance of their lines and were therefore difficult to successfully survey using traditional access-point or roving creel methods (Michaletz and Dillard 1999). Experimental fishing combined with angler surveys offered the first estimate of trotline fishing effort, an important recreational activity in the New River.

It appeared that circle hook use on trotlines could offer decreased hooking mortality of game fish and increased catch rates for catfish. Game fish were caught at nearly equal rates by both hook types, but 67% of game fish caught by J hooks were hooked in the stomach or esophagus compared to 18% caught with circle hooks, suggesting that hooking mortality might be lower with circle hooks. Circle hooks were also significantly more effective for catching channel catfish compared to J hooks.

Many trotline fishers interviewed by Dickinson et al. (2015) believed that trotline fishing effort was declining. Although few investigators have reported on reliable estimates of trotline effort, the decline in trotline fishing along with low estimates of trotline bycatch and effort suggest that trotline fishing is not in major conflict with the trophy fisheries. Trotline fishers might be receptive to increasing their use of circle hooks because of increased catch rates, and smallmouth bass and walleye anglers would likely be pleased with potentially lower hooking mortalities of game fish caught by trotline fishers with circle hooks.

Acknowledgments

This work was supported via a grant from the Department of Game and Inland Fisheries from Federal Aid in Sportfish Restoration Program in the U.S. Fish and Wildlife Service. We thank Dylan Hann, George Palmer, Tyler Young, and Jason Emmel for assistance during all stages of collecting field data. We thank Bill Kittrell and local conservation police officers with the Department of Game and Inland Fisheries for sharing their knowledge and providing input in the development of the scope for work. Jason Emmel, Michael Moore, Zach Moran, and Joseph Schmitt provided editorial reviews on the manuscript. The final version benefitted from careful editorial comments and questions by Steve Sammons, Hal Schramm, and Vince Travnichek.

Literature Cited

Arterburn J. and C. Berry. 2002. Effect of hook style, bait type, and river location on trotline catches of flathead and channel catfish. North American Journal of Fisheries Management 22: 573–578.

———, D. Kirby, and C. Berry. 2002. A survey of angler attitudes and biologist opinions regarding trophy catfish and their management. Fisheries 27:10–21.

Austen D. J. and D. J. Orth. 1984. Angler catches in the New River, Virginia and West Virginia, in relation to minimum length limits. Proceedings of

the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 38:520–531.

Barada, T. J. 2009. Catfish population dynamics in the Platte River, Nebraska. Master's Thesis, University of Nebraska, Lincoln.

Bodine, K. A., D. E. Shoup, J. Olive, Z. L. Ford, R. Krogman, and T. J. Stubbs. 2013. Catfish sampling techniques: where we are now and where we should go. Fisheries 38:529–546.

Bourret, S., R. Tingley, Y. Kanno, and J. Vokoun. 2008. Maximum daily consumption and specific daily metabolic demand of juvenile flathead catfish (*Pylodictis olivaris*). Journal of Freshwater Ecology 23:413–419.

Bray, G. S. 1997. Evaluating angler diaries as a tool for assessing catch rates of freshwater sportfish in Mississippi. Master's Thesis, Mississippi State University.

Brenden, T. O., E. M. Hallerman, B. R. Murphy, J. R. Copeland, and J. A. Williams. 2007. The New River, Virginia, muskellunge fishery: population dynamics, harvest regulation modeling, and angler attitudes. Environmental Biology of Fishes 79:11–25.

Cartabiano, E. C., D. R. Stewart, and J. M. Long. 2015. Effect of bait and gear type on channel catfish catch and turtle bycatch in a reservoir. Journal of Freshwater Ecology 30:407–415.

Clopper, C. and E. S. Pearson.1934. The use of confidence or fiducial limits illustrated in the case of the binomial. Biometrika 26:404–413.

Cooke, S. and C. Suski. 2004. Are circle hooks an effective tool for conserving marine and freshwater recreational catch-and-release fisheries? Aquatic Conservation: Marine and Freshwater Ecosystems 14:299–326.

Copeland J. R., D. J. Orth, and G. C. Palmer. 2006. Smallmouth bass management in the New River, Virginia: a case study of population trends with lessons learned. Proceedings of the Annual Conference of the Southeastern Association of the Fish and Wildlife Agencies 60:180–187.

Daugherty, D. and T. M. Sutton. 2005. Seasonal movement patterns, habitat use, and home range of flathead catfish in the lower St. Joseph River, Michigan. North American Journal of Fisheries Management 25:256–269.

Dickinson, B. D. 2012. Characterizing a hidden fishery: setline fishing in the New River, Virginia. Master's Thesis, Virginia Tech University, Blacksburg.

———, D. J. Orth, and S. L. McMullin. 2015. Characterizing the human dimension of a hidden fishery: riverine trotline fishers. Fisheries 40:386–394.

Eder, B. L., M. A. Pegg, and G. E. Mestl. 2016. A new approach to quantifying trotline angler effort and catch. Journal of Applied Ichthyology 32:491–494.

Fisher, W. L., D. F. Schreiner, C. D. Martin, Y. A. Negash, and E. Kessler. 2002. Recreational fishing and socioeconomic characteristics of eastern Oklahoma stream anglers. Proceedings of the Oklahoma Academy of Science 82:79–87.

Hilling, C. D., S. L. Wolf, J. R. Copeland, D. J. Orth, and E. M. Hallerman. in press. Occurrence of two non-indigenous catostomid fishes in the New River, Virginia. Northeastern Naturalist.

Hubert W. A., K. L. Pope, and J. M. Dettmers. 2012. Passive capture techniques. Pages 223–265 *in* A. V. Zale, D. L. Parrish, and T. M. Sutton, editors, Fisheries techniques, 3rd edition. American Fisheries Society. Bethesda, Maryland.

Jackson, D. C. 1999. Flathead catfish: biology, fisheries and management. Pages 23–35 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: Proceedings of the International Ictalurid Symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Jenkins, R. E. and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Johnson, R. J. and T. J. Timmons. 1989. Multiple survey evaluation of a Kentucky commercial trotline fishery. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 43:56–65.

Lemeshow, S. and D. W. Hosmer, Jr. 1984. Estimating the odds ratios with categorically scaled covariates in multiple logistic regression analysis. American Journal of Epidemiology 119:147–151.

Kuklinski, K. E. and J. Boxrucker. 2008. Catfish angling and harvest statistics with emphasis on trophy blue catfish management in Oklahoma. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 62: 149–153.

Michaletz, P. and J. Dillard. 1999. A survey of catfish management in the United States and Canada. Fisheries 24:6–11.

Moll, D. and E. O. Moll. 2004. The ecology, exploitation, and conservation of river turtles. Oxford University Press, New York.

Ott, R. A. and K. W. Storey. 1991. Hooking mortality of channel catfish caught by trotline. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 45:399–406.

Palmer, G. C. 2013. New River walleye tagging study. 2008–2012 Popular Report: Virginia Department of Game and Inland Fisheries, Richmond.

———, B. R. Murphy, and E. M. Hallerman. 2005. Movements of walleyes in Claytor Lake and the upper New River, Virginia, indicate distinct lake and river populations. North American Journal of Fisheries Management 25:1448–1455.

Quinn, S. 1993. Description of a multiuse fishery for flathead catfish. North American Journal of Fisheries Management 13:594–599.

Reitz, R. A. and V. H. Travnichek. 2004. Analysis of Missouri catfish angler demographics and opinions for fisheries management alternatives. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 58:66–81.

Roell, M. J. and D. J. Orth. 1993. Trophic basis of production of stream-dwelling smallmouth bass, rock bass, and flathead catfish in relation to invertebrate bait harvest. Transactions of the American Fisheries Society 122:46–62.

Sanderson, A. E., Jr. 1961. Evaluation of effect of trotline use on the Potomac River fishery. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 15:314–319.

Schmitt, J. and D. Shoup. 2013. Delayed hooking mortality of blue catfish caught on juglines. North American Journal of Fisheries Management 33:245–252.

Schramm, H. L., Jr., J. T. Forbes, D. A. Gill, and W. D. Hubbard. 1999. Fishing environment preferences and attitudes toward overharvest: are catfish anglers unique? Pages 417–425 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm Jr. and T. Coon, editors. Catfish 2000: Proceedings of the International Ictalurid Symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Stauffer, K. W., R. C. Binder, B. C. Chapman, and B. D. Koenen. 1996. Population characteristics and sampling methods of flathead catfish *Pylodictis olivaris* in the Minnesota River. Minnesota Department of Natural Resources, St. Paul.

——— and B. D. Koenen. 1999. Comparison of methods for sampling flathead catfish in the Minnesota River. Pages 329–339 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: Proceedings of the International Ictalurid Symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Steffensen, K. D., B. L. Eder, and M. A. Pegg. Using Lindgren-Pitman hook timers to understand the dynamics of trotline catches in a large river. North American Journal of Fisheries Management 31:980–985.

Stewig, J. D. 2006a. Red River of the North fisheries population assessment summer 2005: reach 3 report river mile 49.5 to 144.6. Project F-29-R(P)-25. Minnesota Department of Natural Resources, St. Paul.

———. 2006b. Red River of the North fisheries population assessment sum-

mer 2005: reach 4 report river mile 0 to 49.5. Project F-29-R(P)-25. Minnesota Department of Natural Resources, St. Paul.

——— and B. Chapman. 2009. Fisheries asssessment of the Mississippi River in Wright, Stearns and Sherburne Counties 2007, river miles 879 to 926. Project F-29-R(P)-25. Minnesota Department of Natural Resources, St. Paul.

Timmons, T., T. Hoffnagle, R. Hale, and J. Soldo. 1989. Incidence of sport fishes in the commercial fish catch from Kentucky Lake, Kentucky and Tennessee. North American Journal of Fisheries Management 9:209–212.

Vokoun, J. C. and C. F. Rabeni. 1999. Catfish sampling in rivers and streams: a review of strategies, gears, and methods. Pages 329–33 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: Proceedings of the International Ictalurid Symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Weller, R. and J. Winter. 2001. Seasonal variation in home range size and habitat use of flathead catfish in Buffalo Springs Lake, Texas. North American Journal of Fisheries Management 21:792–800.

White, C. E. 1961. The selectivity and effectiveness of bait and snag lines fished in the TVA lakes of Alabama. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Commissioners 15:359–367.

Winkelman, D. L. 2011. Evaluation of the flathead catfish population and fishery on Lake Carl Blackwell, Oklahoma, with emphasis on effects of noodling. Pages 209–217 *in* P. H. Michaletz and V. H. Travnichek, editors. Conservation, Ecology, and Management of Catfish: The Second International Symposium. American Fisheries Society Bethesda, Maryland.