North American Journal of Fisheries Management 22:573–578, 2002

357-F

Effect of Hook Style, Bait Type, and River Location on Trotline Catches of Flathead and Channel Catfish

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Abstract.—Trotlines can be used to provide data on catfish populations, but better understanding of trotline selectivity is needed. We compared differences in the presence or absence of channel catfish *Ictalurus punctatus* and flathead catfish *Pylodictis olivaris* caught on trotlines among hook types, bait types, substrate types, channel types, water depths, and woody debris complexities in two South Dakota rivers. Channel catfish were 3.5 times more likely to be caught on hooks baited with cut common carp *Cyprinus carpio*, and flathead catfish were 28 times more likely to be caught on hooks baited with live black bullheads *Ameiurus melas*. Sea-circle hooks caught fewer catfish of either species than O'Shaughnessy or modified circle hooks. Channel type, water depth, and substrate type affected catches of flathead and channel catfish from the Big Sioux River, but did not influence catches of either species on the James River. The Big Sioux River had greater habitat variability, thereby increasing our chances of finding differences in trotline catches between habitat types. Our research highlights some of the biases associated with using trotlines to collect flathead and channel catfish, but it suggests that trotlines can be used to supplement data on size structure and the total catch of flathead catfish longer than 450 mm and to sample flathead and channel catfish in places where habitat characteristics render other gear types ineffective.

Relatively little is known about types of gear used for sampling riverine catfish populations (Vanderford 1984; Marshall 1991; Michaletz and Dillard 1999). Trotlines, which have been used by commercial fishers for many years (White 1956), are sometimes used to assess catfish populations, but information on specific protocols is lacking (White 1961; Stauffer et al. 1996; Michaletz and Dillard 1999). Trotlines are sometimes used to complement other gear types, such as hoop nets or electrofishers, when sampling channel catfish *Ictalurus punctatus* and flathead catfish *Pylodictis olivaris* (Topp et al. 1994; Stauffer et al. 1996). Trotlines can be constructed in many different ways, but few guidelines have been suggested (Johnson 1987). Hooking mortality for channel catfish caught on trotlines is less than 20% (Ott and Storey 1993). Baits affect hoop net catches (Pierce et al. 1981; Holland and Peters 1992; Tillma et al. 1997), but little information is available on the selectivity of baits for sampling catfish with trotlines. Our objectives were to compare flathead and channel catfish catches on trotlines for the James and Big Sioux rivers among three hook styles, two bait types, and four macrohabitats.

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Received January 2, 2001; accepted August 13, 2001

Study Area

We sampled catfish from the James and Big Sioux rivers in eastern South Dakota. These turbid rivers meander through mostly private land used for agriculture before emptying into the Missouri River. Riparian woodlands occur in many areas along both rivers, especially river reaches from the Missouri River confluence to the first dam on each river where our study was conducted. The first major dam on the James River is located at Milltown (river km 117) and on the Big Sioux River at Klondike (river km 189). In both rivers, temperatures range from 0°C to 28°C, average stream widths are less than 50 m, and average conductivities range from 800 to 1,400 μS (Burr et al. 2000). James River instream habitat is more homogeneous than that of the Big Sioux River, which has more woody debris and pool–riffle complexes (for habitat details, see Berry et al. 1993; Dieterman and Berry 1998). Fish communities of both rivers are composed of 40–50 species, most of which are cyprinids. Popular recreational species are walleye *Stizostedion vitreum*, black bullhead *Ameiurus melas*, northern pike *Esox lucius*, channel catfish, and flathead catfish (Berry et al. 1993; Doorenbos et al. 1996).

Methods

Trotlines were constructed with 13.2-m-long main lines, 136.0-kg-test twine, and 2.0-m-long tie-off lines (used to attach trotlines to bank vegetation or large woody debris). Ten dropper lines, each 30.5-cm long and made of 81.6-kg-test twine spaced 1.2 m apart, were attached to each trotline with 3/0 barrel swivels at both ends. Droppers were attached to the main line by one swivel that slid freely between knots tied 5 cm apart on the main line. Hooks were attached to the other swivel by opening and closing the eye of the hook with pliers. In 2000, the hooks on each trotline alternated between O'Shaughnessy (Mustad #34009, stainless steel) and modified circle hooks (Pierce #AA-11-5040, cadmium steel; Johnson 1987) but in 1999, hook type (sea-circle hooks [Eagle claw #190, carbon steel] and O'Shaughnessy hooks) alternated by trotline. O'Shaughnessy hooks and sea-circle hooks are similar in design to those used by commercial fishers and biologists (Ott and Storey 1993; Stauffer et al. 1996). We also used modified circle hooks because popular articles tout these hooks as being superior to others (Hoffman 1999). We believed that using a standard hook gap distance (hook point to shank) would minimize differences in catch rates between hook styles.Therefore, we used 3/0 O'Shaughnessy and modified circle hooks, and 6/0 sea-circle hooks. We used live black bullheads (100–200 mm TL) and cut pieces (2.5 cm^2) of common carp *Cyprinus carpio* for bait.

Catfish were sampled in July and August 1999 and 2000 on the Big Sioux River and in July and August 2000 on the James River. Catfish were collected from thirteen 4.8-km-long reaches on each river. Eight trotlines per reach were set at approximately equal distances apart at locations with a secure tie-off (large woody debris or rooted vegetation) and few obstructions to minimize entanglement. Four trotlines were baited with live black bullheads and four with pieces of common carp. Baiting each trotline was determined randomly by flipping a coin. Trotlines were set in the early evening and fished through morning and evening crepuscular periods, in reaches classified as either a run or a bend. Woody debris complexity, meaning the density of woody debris visible above the surface within 50 m of each trotline, was categorized as ''simple'' (less than 2 logs, randomly distributed) or complex (2 or more logs with branches, in a patchy distribution). We used a rod to classify water depths as shallow (less than 1.5 m) or deep (1.5 m orgreater) and to classify substrate as soft (sand or silt) or hard (rock or clay).

We used logistic regression (LOGIT module in SYSTAT version 10.0) to compare the presence or absence of a flathead or channel catfish on each trotline hook as a function of river (Big Sioux River, James River), bait type (live black bullheads, cut common carp), hook type (O'Shaughnessy, sea-circle, modified circle), channel type (bend, straight), water depth (shallow, deep), substrate type (soft, hard) and woody debris complexity (simple, complex). All variables were categorical and, except for hook type, were binomial, so differences between categories could be assessed without additional analysis. Backward stepwise binary logistic regression was used to determine variables that explained most of the variation, with alpha for removal set at 0.15. Regressions were run independently for (1) channel and flathead catfish, (2) the Big Sioux River and James River, (3) trotline-related variables (hook types, bait types), and (4) habitat variables (channel type, water depth, substrate type and woody debris complexity). The three hook types were tested only on the Big Sioux River, because sea-circle hooks were not used during sampling on the James River. The hook type variable had three categories, and by coding O'Shaughnessy hooks as the reference, only analysis of differences in catch between O'Shaughnessy and sea-circle hooks or modified circle hooks was appropriate (SYSTAT 2000). Our habitat analysis did not include fish caught on sea-circle hooks, because they were only used in one river for one year.

Results and Discussion

We caught more channel catfish (N = 243) than flathead catfish (N = 86), probably because the abundance of channel catfish was greater than that of flathead catfish in both rivers (Arterburn 2001; Kirby 2001; Shearer 2001). We collected 98 channel catfish and 36 flathead catfish from the Big Sioux River with 1,120 hooks of effort, for a mean catch per unit effort (CPUE) of 0.0875 fish per hook-night for channel catfish and a mean CPUE of 0.0321 fish per hook-night for flathead catfish. We collected 145 channel catfish and 50 flathead catfish from the James River with 960 hooks of effort, for a mean CPUE of 0.151 fish per hook-night for channel catfish and a mean CPUE of 0.0521 fish per hook-night for flathead catfish. Flathead catfish ranged in length from 461 mm to

TABLE 1.—Results of logistic regression analysis for flathead and channel catfish collected from the Big Sioux River, South Dakota, during the summers of 1999 and 2000. Odds ratios (±95% confidence intervals), *t*-ratios, and *P*-values are presented for trotline functions that compared bait type (cut common carp, live black bullhead) and hook type (O'Shaughnessy hooks versus sea-circle and modified circle hooks) and habitat functions that compared channel type (straight, bend), water depth (<1.5 m, ≥1.5 m), predominate substrate (soft, hard), and woody debris complexity (simple, complex); N/A indicates variables removed from the model during stepwise regression.

Variable	Odds ratio[a]	*t*-ratio	*P*-value
Channel catfish			
Trotline functions			
Cut-carp baited	3.48 ± 1.33	−5.055	<0.0001
Sea-circle[b]	0.46 ± 0.17	−3.247	0.001
Modified circle[b]	0.50 ± 0.28	−1.668	0.095
Habitat functions[c]			
Straight channel	1.88 ± 0.74	−2.459	0.014
Depth < 1.5 m	1.67 ± 0.66	1.982	0.048
Soft substrates	3.44 ± 2.62	1.684	0.092
Woody debris complexity	N/A	N/A	0.663
Flathead catfish			
Trotline functions			
Live-bullhead baited	18.83 ± 14.33	−4.019	<0.0001
Sea-circle[b]	0.494 ± 0.26	−1.825	0.068
Modified circle[b]	0.412 ± 0.32	−1.181	0.237
Habitat functions			
Channel bends	3.60 ± 2.38	2.324	0.020
Depth ≥ 1.5 m	2.57 ± 1.56	−1.984	0.047
Hard substrates	2.34 ± 1.45	−1.733	0.083
Woody debris complexity	N/A	N/A	0.173

[a] Odds ratios were calculated as the highest catch over the lower catches, except for hook type variables.
[b] Hooks listed were tested against O'Shaughnessy hooks, and odds ratios less than 1 signify the inverse of the number of times that an O'Shaughnessy hook was more likely to catch a catfish than the listed hook type.
[c] Habitat functions exclude catfish caught on sea-circle hooks.

917 mm, and channel catfish ranged from 230 mm to 796 mm.

We found that bait types and certain hook types influenced trotline catches of catfish. For channel catfish, bait and hook types significantly influenced catches of channel catfish on the Big Sioux River (likelihood ratio = 44.166, df = 3, $P < 0.0001$), but on the James River only bait significantly affected catches (likelihood ratio = 28.125, df = 1, $P < 0.0001$) because only modified circle and O'Shaughnessy hooks were used (Tables 1 and 2). For flathead catfish, bait and hook types affected catches from the Big Sioux River (likelihood ratio = 41.436, df = 3, $P < 0.0001$) and James River (likelihood ratio = 56.895, df = 1, $P < 0.0001$). When using trotlines to collect catfish, bait type had the greatest influence on number and species of fish caught (Tables 1, 2). Trotlines baited with live black bullheads were up to 28 times more likely to catch flathead catfish than channel catfish, but trotlines baited with cut common carp were up to 3.5 times more likely to catch channel catfish, probably because flathead catfish are more piscivorous than channel catfish (Jackson 1999).

Sea-circle hooks negatively affected catches of both catfish species from the Big Sioux River (t-ratio = −3.247, df = 2, $P = 0.001$) when compared with catches of channel catfish on O'Shaughnessy hooks (Table 1). However, no significant differences between O'Shaughnessy hooks and modified circle hooks were found for channel or flathead catfish from either river (Tables 1, 2). Our results were similar to those of Orsi et al. (1993) for trolling gear, which showed that sea-circle hooks caught significantly fewer salmon than did O'Shaughnessy hooks. Based on our results, O'Shaughnessy or modified circle hooks should be used when sampling flathead and channel catfish with trotlines.

Similar sizes of catfish were collected on all hook types, which suggests that gape width may provide a better measure for standardizing between hook types than hook size. Lengths of channel catfish ranged from 230 mm to 781 mm on 3/0 O'Shaughnessy, from 252 mm to 796 mm on 3/0 modified circle hooks, and from 309 mm to 700 mm on 6/0 sea-circle hooks. Lengths of flathead catfish ranged from 572 mm to 917 mm on 3/0

TABLE 2.—Results of logistic regression analysis for flathead and channel catfish collected from the James River, South Dakota, during the summer of 2000. Odds ratios (±95% confidence interval), *t*.-ratios, and *P*-values are presented for trotline functions that compared bait type (cut common carp, live black bullhead) and hook type (O'Shaughnessy hooks versus sea-circle and modified circle hooks) and habitat functions that compared channel type (straight, bend), water depth (<1.5 m, ≥1.5 m), predominate substrate (soft, hard), and woody debris complexity (simple, complex); N/A indicates variables removed from the model during stepwise regression.

Variable	Odds ratio[a]	*t*-ratio	*P*-value
Channel catfish			
Trotline functions			
Cut-carp baited	2.71 ± 0.86	−5.089	<0.0001
O'Shaughnessy[b]	N/A	N/A	0.412
Habitat functions			
Channel type	N/A	N/A	0.783
Water depth	N/A	N/A	0.604
Substrate type	N/A	N/A	0.194
Woody debris complexity	N/A	N/A	0.201
Flathead catfish			
Trotline functions			
Live-bullhead baited	27.75 ± 21.05	4.589	<0.0001
O'Shaughnessy[b]	N/A	N/A	0.234
Habitat functions			
Channel type	N/A	N/A	0.420
Water depth	N/A	N/A	0.201
Substrate type	N/A	N/A	0.793
Woody debris complexity	N/A	N/A	0.795

[a] Odds ratios were calculated as the highest catch over the lower catch(es), except for hook type variables.
[b] Only modified circle and O'Shaughnessy hooks were used on the James River.

O'Shaughnessy hooks, from 470 mm to 893 mm on 3/0 modified circle hooks, and from 461 mm to 728 mm on 6/0 sea-circle hooks.

Habitat functions affected catfish catches on the Big Sioux River but not on the James River. On the Big Sioux River, habitat variables explained significant amounts of the variability associated with differences in trotline catches for channel catfish (likelihood ratio = 17.258, df = 3, P = 0.001) and flathead catfish (likelihood ratio = 15.530, df = 3, P = 0.001). However, when differences in trotline catches among macrohabitats on the James River were tested for flathead and channel catfish, all variables had a P-value greater than 0.15 during our step-wise regression, so the model contained no variables.

Catches of catfish were influenced by channel type, water depth, and substrate type but not woody debris complexity. On the Big Sioux River, channel catfish were collected 1.9 times more often in straight river sections (50 m) than in river sections containing bends, but flathead catfish were caught 3.6 times more often in river sections with bends (Table 1). Channel catfish were 1.7 times more likely to be collected from shallow water (<1.5 m) and flathead catfish were 2.6 times more likely to be collected from deep water (≥1.5 m). Channel catfish were collected 3.4 times more often where the substrate was soft, but flathead catfish were 2.3 times more likely to be collected in areas with hard substrates. Trotline catches did not differ with woody debris complexity (low, high) within 50 m of where the trotline was set. Perhaps testing for differences in proximity to woody debris or a finer scale approach to complexity would have provided different results. Our habitat evaluation was on a coarse scale that might be used to select sites in routine surveys. Our results suggest differences in habitats and rivers can affect catfish vulnerability. The Big Sioux River has a higher velocity and more pool-riffle complexes that create greater heterogeneity of habitats. The greater heterogeneity found in the Big Sioux River likely increased differences in trotline catches for different habitats, whereas in the more homogeneous James River trotline placement had little influence on catch rates. Our results show that trotline catch of either channel or flathead catfish can be improved by selecting appropriate bait types, hook types, and trotline locations.

Our research should help biologists use trotlines to collect channel and flathead catfish more effectively. Channel catfish are most commonly collected using hoop nets (Vokoun and Rabeni 1999), but habitats with shifting woody debris or counter currents (e.g., eddies, low-head dams) can be difficult to sample with hoop nets. Trotlines provide an alternative in structurally complex habitats where other gear types can be ineffective. Trotlines were more efficient than hoop nets for collecting flathead catfish from the Minnesota River (Stauffer and Koenen 1999).

Trotlines were briefly mentioned in a recent review of catfish sampling protocols for riverine environments, but the authors favored pulsed-DC electrofishing for sampling flathead catfish (Vokoun and Rabeni 1999). Pulsed-DC electrofishing may be biased toward small flathead catfish (Robinson 1994; Stauffer and Koenen 1999; Vokoun and Rabeni 1999). Our data suggest that trotlines should be considered for collecting flathead catfish if pulsed-DC electrofishing is ineffective or if fish larger than 450 mm are needed. A combination of DC electrofishing and trotlines might yield better population data than either method alone (Stauffer and Koenen 1999).

Stauffer and Koenen (1999) reported higher trotline CPUE (0.09 fish per hook-night) for flathead catfish than we reported, and they caught flathead catfish from a wider range of lengths (436 mm to 1225 mm) than we did (461 mm to 917 mm). The results of the two studies may have differed because of population differences or differences in hook or bait sizes. Larger hooks (7/0, 8/0) and larger baits (150–400 mm) were used in the Minnesota River study (Stauffer and Koenen 1999). Comparing our data with those from other studies is difficult because trotline designs differ among studies. For comparisons among rivers, trotline use and design protocols should be standardized, especially hook type and size, bait type and size, and habitats where trotlines are set, because these factors can influence catch, as we have shown. Rigid sampling protocols can reduce variability (Hubert 1996). We agree with other researchers (Stauffer and Koenen 1999; Vokoun and Rabeni 1999) that biologists should consider using trotlines for sampling catfish, especially if large fish are required to fulfill study objectives (e.g., trophy fish management), or when other gear types prove ineffective. This study should prove useful to biologists who are interested in using trotlines to collect channel and flathead catfish from Midwestern streams and rivers.

Acknowledgments

This study was funded by the South Dakota Department of Game, Fish, and Parks through Federal Aid in Sport Fish Restoration Project Number F-15-R, Study Number 1580. The South Dakota Department of Game, Fish, and Parks, U. S. Geological Survey, Wildlife Management Institute, South Dakota State University, and the U. S. Fish and Wildlife Service jointly support the South Dakota Cooperative Research Unit. We would like to thank D. Kirby, N. Morey, and M. Schaetzke, who helped collect data, C. Paukert and M. Brown for their statistical advice, and D. Willis, S. Chipps, K. Stauffer, D. Iserman, D. Hansen, and V. Travnichek for editing drafts.

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