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[Article]

Efficacy of a Benthic Trawl for Sampling Small-Bodied Fishes in Large River Systems

DAVID P. HERZOG* AND VALERIE A. BARKO

Missouri Department of Conservation, Open Rivers and Wetlands Field Station, 3815 East Jackson Boulevard, Jackson, Missouri 63755, USA

JOHN S. SCHEIBE

Department of Biology, Southeast Missouri State University, Cape Girardeau, Missouri 63701, USA

ROBERT A. HRABIK AND DAVID E. OSTENDORF

Missouri Department of Conservation, Open Rivers and Wetlands Field Station, 3815 East Jackson Boulevard, Jackson, Missouri 63755, USA

Abstract.—We conducted a study from 1998 to 2001 to determine the efficacy of a benthic trawl designed to increase species detection and reduce the incidence of zero catches of small-bodied fishes. We modified a standard two-seam slingshot balloon trawl by covering the entire trawl with a small-mesh cover. After completing 281 hauls with the modified (Missouri) trawl, we discovered that most fish passed through the body of the standard trawl and were captured in the cover. Logistic regression indicated no noticeable effect of the cover on the catch entering the standard portion of the modified trawl. However, some fishes (e.g., larval sturgeons *Scaphirhynchus* spp. and pallid sturgeon *S. albus*) were exclusively captured in the small-mesh cover, while the catch of small-bodied adult fish (e.g., chubs *Macrhybopsis* spp.) was significantly improved by use of the small-mesh cover design. The Missouri trawl significantly increased the number and species of small-bodied fishes captured over previously used designs and is a useful method for sampling the benthic fish community in moderate- to large-size river systems.

Trawling has been used to sample aquatic organisms in coastal marine systems (Matsushita and Shida 2001), reservoirs (Michaletz et al. 1995), and rivers (Dettmers et al. 2001). Trawl size and design vary depending on the intended use. For example, researchers often target an individual species and use a trawl that is known to capture that group (Van Den Avyle et al. 1995; Pine 2000; Madsen and Holst 2002). During many trawl surveys, the loss of other species is unimportant and at times, because of catch regulations, is considered beneficial (Kelley 1994). Therefore, many trawl surveys use large-mesh trawls because they tend to capture larger fish and reduce bycatch. Large-mesh trawls also reduce drag while in tow and are noted for fuel efficiency (Dickson 1962; Naidu et al. 1987; Mous et al. 2002). In addition, shape, configuration, and environmental factors can also influence trawl catch (Glass and Wardle 1989; Kunjipalu et al. 1992; Chopin and Arimoto 1994; Kim and Wardle 1997; Godo and Walsh 1998; Dahm 2000; Ryer and Olla 2000; Matsushita and Shida 2001). Furthermore, catch is affected by trawl design components. For example, the cod end (i.e., distal end) is where most of the trawl catch is collected. Millar (1992) modeled trawl selectivity based on total catch, which he determined was influenced by size and shape of the mesh openings in the cod end. Therefore, the cod end is often modified to capture a particular size of organism (Lowry and Robertson 1996), although many factors can affect catch entering the cod end. For example, the escape of organisms through the body of a trawl may result in variable cod end retention (Dremiere et al. 1999; Polet 2000). The covered cod end method has been used to determine efficacy of mesh cod ends (Madsen and Holst 2002). However, the body of the trawl also determines total catch. Therefore, the whole catch of a trawl is determined by the sum of catches made in the trawl components.

Trawl gear are probably the most commonly used sampling gear in oceanic and estuarine habitats but are only occasionally used in large rivers (Hayes et al. 1996). Trawl gear have been used to sample the Mississippi River, but techniques var-

* Corresponding author: david.herzog@mdc.mo.gov

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ied among researchers (Pitlo 1992; Dettmers et al. 2001). From 1991 to 1997, we used a standard two-seam balloon trawl to sample benthic fishes for the Long Term Resource Monitoring Program (LTRMP; Gutreuter et al. 1995). However, total catch was often zero (D. Herzog, unpublished data), and small benthic fishes (e.g., chubs *Macrhybopsis* spp.) and larval or juvenile fishes (e.g., sturgeons *Scaphirhynchus* spp.) were not well represented in the total catch. Therefore, the objective of this study was to design a trawl to increase species detection while reducing the incidence of zero catch and improving catch of small-bodied fishes. To accomplish this, we modified a two-seam slingshot balloon trawl—both the body and the cod end—by use of a dual-mesh design (i.e., pass-through technique). We covered the entire standard trawl with small mesh to determine capture probability.

Study Site

This study was conducted in the unimpounded section of the upper Mississippi River between river kilometers (RK) 48.3 and 128.7 (see Herzog 2004). This reach is located between the Missouri (RK314) and Ohio River (RK0) confluences, contains few side channels, and has been channelized for commercial navigation. Water surface elevations in this reach rise and fall annually by approximately 8 m. Channel maintenance structures (e.g., wing dikes) occur throughout this reach, and vast expanses of limestone rock (i.e., revetment) cover much of the riverbank.

Methods

Sample sites were selected by use of a stratified random design developed for the LTRMP (Gutreuter 1993; Gutreuter et al. 1995); subjectively chosen fixed sites were also used. The study reach was stratified into four physical habitat classes (e.g., wing dike, main-channel border, side channel, and tributary; see Barko et al. 2004 for habitat descriptions), which were delineated in a geographical information systems database (Owens and Ruhser 1996). Each potential study site was represented on a 50 × 50-m grid indexed by universal transverse mercator coordinates on 1989 infrared photos (e.g., basemap). Annual site locations (e.g., primary sites) were randomly chosen within each physical habitat. If a stratified random site was deemed unsafe due to snags or other conditions, then a stratified random alternate site was chosen. These sites were randomly chosen from the 50 × 50-m grids and were located within 1 km^2 of the center of the primary site. Subjectively chosen sites were selected based on unique habitat features within the study area (e.g., island tips and gravel bars). Site selection for this study (1998–2001) and for previous work that used another trawl design (1991–1997) remained consistent over time.

The modified trawl (hereafter referred to as the Missouri trawl; Figure 1) was made of a two-seam (i.e., standard) slingshot balloon trawl (Gutreuter et al. 1995) completely covered with 4.76-mm, heavy, delta-style mesh. Experiments involving covered cod ends address the effect of capture in the cod end of the net (Madsen and Holst 2002). However, we were also interested in the effect of capture by the trawl body. Therefore, we modified the standard approach to covering the cod end by instead covering the entire net. The standard trawl body was made of 1-mm-diameter nylon twine with 19.05-mm bar mesh. Bar measure was the length measured from the beginning of a knot to the beginning of an adjacent knot (Hayes et al. 1996). The headrope was 4.87 m long; four floats (3.81 cm wide × 6.35 cm high) were spaced every 0.91 m along the headrope. The quoted approximate buoyancy of each float was 124.7 g. The width of the standard trawl narrowed from 4.87 m at the headrope to 0.91 m at the mid-section to 0.38 m at the cod end (Figure 2a). The standard trawl's cod end was made of 1.67-m-long, 1.5-mm-diameter nylon twine with 19.05-mm bar mesh and was lined with 3.18-mm ace-style mesh. Therefore, we added the same 3.18-mm mesh size to the cover's cod end, which was 2.14 m long and 1.52 m wide. The footrope was 5.48 m long, and a 4.76-mm-diameter chain was attached to it. The chain helped the footrope maintain contact with the substrate during conditions of heavy current, fast tow speeds, or undulating bottom surfaces (e.g., sand waves). The 4.76-mm-delta-mesh cover was attached directly to the headrope of the standard trawl by use of 1-mm-diameter nylon twine. The cover was large enough to keep space between the cover and the standard trawl, minimize influence on the mesh of the standard trawl, and allow ballooning of the standard trawl (Figure 2b). The Missouri trawl was attached to the boat with 30.48–60.96-m towlines. Towline length was dependent on water depth (i.e., deeper water required longer towlines; Brabant and Nedelec 1979). In water depths of 5 m or less, 30.48-m towlines were used, whereas 60.96-m towlines were used in water depths over 5 m and up to 10 m. Water depth during each tow varied by less than 2 m and was moni-

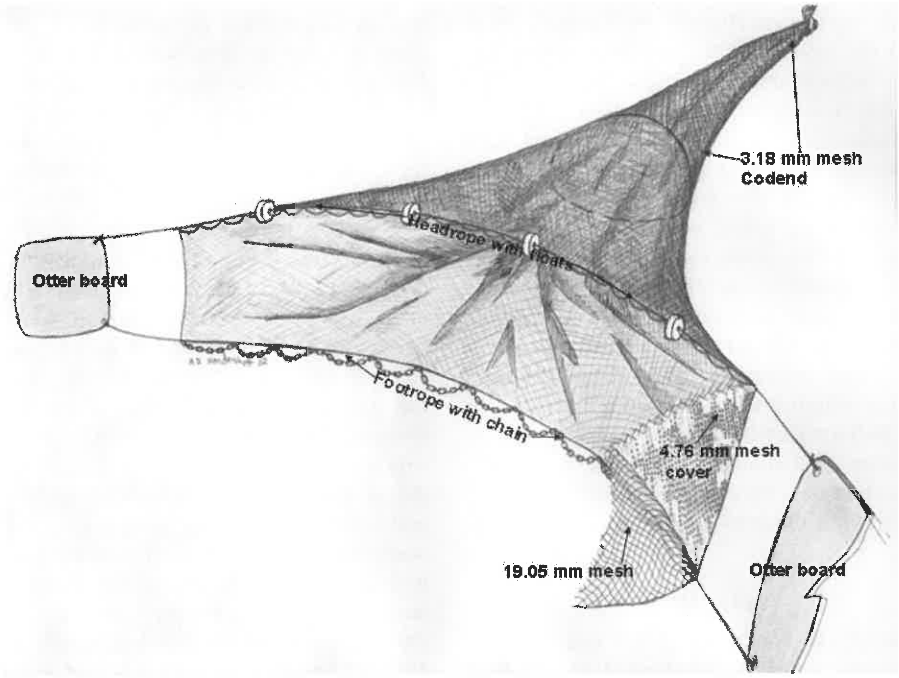

FIGURE 1.—Sketch of a modified two-seam balloon trawl (Missouri trawl), illustrating the individual components (illustration is not to scale).

tored so that the maximum water depth for the length of extended towline was not exceeded. The towlines were 15.87-mm-diameter twisted nylon ropes that were attached to the bow of the boat. The otter boards were 38.10 cm high, 76.20 cm long, and weighed 13.6 kg each. A buoy was attached to a single 22.86–30.78-m rope line that was fastened to the cod end of the trawl to assist in retrieval if the trawl became snagged.

The trawl was manually deployed and retrieved. We began by powering the boat in reverse (bow upstream) with continued movement downstream. Reverse-direction trawling is safer than forward trawling with small johnboats in large rivers. For example, when a snag is encountered, the towlines pull downward at the attachment point. Use of stern-mounted towlines in rivers may cause small johnboats to take on water or capsize, whereas bow-mounted towlines utilize the buoyancy of the bow and dampen downward pull. In addition, the power from outboard motor propellers is generated in forward gear. When a trawl is snagged during reverse trawling, forward gear allows the driver more power to reduce the downward pull of the towlines. We continued a trawl haul by tossing the buoy line off the bow of the boat, followed by the cod end of the net. The trawl and otter boards were deployed into the water while the boat operated in reverse downstream. Tension was kept on the towlines so that the otter boards did not twist while the towlines were being deployed. A standard haul was approximately 350 m and lasted approximately 6 min (Gutreuter et al. 1995). The Missouri trawl was towed by a 7.32-m johnboat equipped with a 90-hp outboard motor. Trawling speed (km/h) and distance (m) were monitored by use of a Garmin GPSMAP 168 Sounder Global Positioning System with differential correction. Effort was recorded in time trawled and distance traveled (i.e., from the point at which towlines were taut to the point when the net was retrieved into the boat). Trawling location and duration were limited by water depth less than 0.5 m and bottom snags. Methods of deployment for the Missouri trawl (1998–2001) and standard trawl (1991–1997) remained consistent.

Catch in each portion (e.g., standard trawl and cover) of the Missouri trawl was kept separate to determine separate probabilities of capture. Fish were identified to species, measured, and enumerated. Total length (TL) was measured for fish of all species except adult paddlefish *Polyodon spa-*

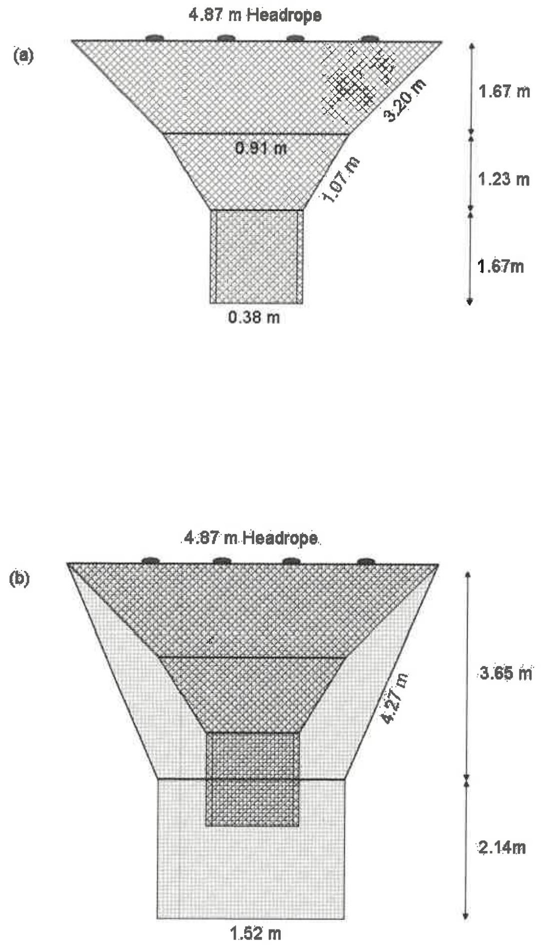

FIGURE 2.—Trawl designs for (a) a standard two-seam balloon trawl (used to sample the upper Mississippi River in 1991–1997) and (b) a modified (Missouri) trawl (used for sampling in 1998–2001).

thula and sturgeons, which were measured to fork length (FL). All common and scientific names follow Nelson et al. (2004). To compare abundances of species captured in the standard portion and cover of the Missouri trawl, we used chi-square tests for equal proportions (Steel and Torrie 1980; SAS Institute. 1988; $P \leq 0.05$) because we assumed that the cod end of the standard trawl was nonselective for size.

Trawl effect on capture probability for fish of a given length was assessed by use of logistic regression (SAS Institute. 1988). Logistic regression was used to characterize catch response of the standard trawl versus the cover rather than as a selectivity prediction tool. The cumulative probability of capturing a fish was linearized with the logit transformation

$$p' = \log_e\left(\frac{p}{1-p}\right) \quad (1)$$

where p is the cumulative probability of capturing a fish of a given length or shorter. Thus, the linear regression model had the form

$$p' = \beta_0 + \beta_1 X. \quad (2)$$

where X represents fish length. Transforming the linearized cumulative probabilities back to their original form resulted in the logistic regression model

$$E(Y) = \frac{e^{(\beta_0+\beta_1 X)}}{1 + e^{(\beta_0+\beta_1 X)}}, \quad (3)$$

With this formulation, the dependent axis was the expected cumulative probability of capturing a fish with a length of at least X cm, and varied from 0 to 1. The regression was performed four times. Cumulative probability of capture was regressed against length based on the 1998–2001 data, first for the standard trawl portion and second for the cover of the Missouri trawl. The maximum fish length that passed through the trawl body to the cover was 28 cm, and therefore this length was used in the models. Hence, fish larger than 28 cm were not represented and subsequently were not used in the comparison between the cover and the standard trawl portion. To determine the effect of the cover, the cumulative probability of capture was regressed against all fish lengths for the unmodified standard trawl (1991–1997 data) and for the standard trawl portion of the Missouri trawl (1998–2001).

Species data from the standard trawl without the cover (1991–1997) were compared to the Missouri trawl data set (1998–2001). We estimated the rate of species capture by randomly selecting 100 observations from both the 1991–1997 and 1998–2001 data sets. The data were randomized by assigning a random number to each sample. The data were then sorted by random number. The first sample listed was plotted by the number of species captured in that sample or haul. We continued plotting samples until 100 observations were reached. A logarithmic trend line was used to plot each "sample" for both trawls.

Results

Two-hundred eighty-one Missouri trawl hauls were completed over the 4-year period from 1998 to 2001. We sampled at depths that ranged from 0.6 to 10 m; mean depth was 3.2 m. Water surface velocity ranged from 0.02 to 1.94 m/s, and the mean was 0.81 m/s. Secchi disk transparency averaged 28 cm and ranged from 2 to 61 cm. Sample area substrates varied but were mostly comprised of sand. We captured 3,217 fish (32 species) in the standard trawl portion of the Missouri trawl and 10,549 fish (43 species; 77% of the total catch) in the 4.76-mm-mesh cover. Chi-square tests indicated that abundances of 18 of the 45 species captured were significantly higher (df = 1, $P \leq 0.05$) in the cover than in the standard trawl portion. However, shovelnose sturgeon *S. platorynchus* had significantly higher abundance in the standard trawl portion than in the cover (Table 1). Five percent of the hauls (15/281) had zero catch in both the standard trawl portion and the cover. The standard trawl portion of the Missouri trawl had zero catch in 21% (60/281) of the hauls, whereas the cover had zero catch in 6% (18/281) of the hauls.

Larval sturgeons and pallid sturgeon were captured only in the cover of the Missouri trawl. Several additional species were captured exclusively in the cover (e.g., bullhead minnow, inland silverside, Mississippi silvery minnow) or exclusively in the standard trawl portion (e.g., shortnose gar) and were represented by more than one occurrence (Table 1). The remaining species did not have significantly different abundance in the standard trawl portion versus the cover of the Missouri trawl. Sturgeon chub and larval sturgeons were captured in the Missouri trawl but had not been captured by Missouri Department of Conservation Open Rivers Field Station researchers during 1991–1997, when the unmodified standard trawl was used. Two-hundred eighteen standard trawl hauls were completed over the 7-year period, 1991–1997. During 1991–1997, 2,966 fish representing 30 species were captured in the standard trawl. Twenty-four percent of the hauls (52/218) had zero catch.

All four logistic regression models were significant at the 0.05 level ($P \leq 0.0001$) and explained 82.33% (standard trawl portion of Missouri trawl: $p = 0.5 + 0.08 \cdot \text{Length}$; $F_{1,77} = 266.20$), 90.27% (standard trawl without cover: $p = 0.34 + 0.09 \cdot \text{Length}$; $F_{1,77} = 677.14$), 91.51% (cover of Missouri trawl, fish lengths up to 28 cm: $p = -0.82 + 0.41 \cdot \text{Length}$; $F_{1,25} = 269.57$), and 87.8% (standard trawl portion of Missouri trawl, fish lengths up to 28 cm: $p = -1.36 + 0.28 \cdot \text{Length}$; $F_{1,25} = 180.56$) of the variance in cumulative capture probability (Figures 3, 4). Fish larger than 28 cm were not captured in the cover because they did not pass through the body of the standard trawl portion. Therefore, regressions for the cover and the standard trawl portion were based only on fish lengths up to 28 cm (Figure 3). The slopes of the regression models for fish up to 28 cm differed markedly between the standard trawl portion and cover; the regression for the cover had a steeper slope (Figure 3). Use of the cover resulted in greater probability of capture for fish lengths up to 23 cm, and for fish longer than 15 cm the cumulative probability of capture approached 1.0 (Figure 3). The standard trawl portion of the Missouri trawl accumulated captures at a slower rate, and the cumulative probability of capture approached 1.0 for fish longer than 26 cm.

The slopes of the regression models were similar between the standard trawl portion of the Missouri trawl (1998–2001) and the standard trawl without the cover (1991–1997). Use of the cover did not affect the cumulative capture probability of fish in the standard trawl portion of the Missouri trawl (Figure 4). Therefore, the cumulative probability of capturing fish in the standard trawl portion of the Missouri trawl was the same as that of the standard trawl without the cover.

Species detection was higher in the Missouri trawl than in the unmodified standard trawl. Random sampling of the data indicated quicker response time of species detection by use of the Missouri trawl (Figure 5). After eight samples, the Missouri trawl captured 50% of the overall detected species, whereas it took the standard trawl 56 samples to reach the same level of species detection.

Discussion

Our data show that many small fishes passed through the trawl body. Previous negligible catch of small benthic fishes in the standard trawl (1991–1997) was because of the trawl body. We used a small-mesh cod end in the standard trawl for 7 years before implementing the Missouri trawl. We detected fewer individuals and species in the standard trawl than in the Missouri trawl. Seventy-seven percent of the total fish captured passed through the standard trawl's mesh and failed to reach the cod end of the standard trawl, including young and larval fish (e.g., sturgeons) and smaller-bodied adult species (e.g., chubs). The lack of several historically common species (e.g., sturgeon chub, sicklefin chub) in community samples during 1991–1997 was previously troublesome. Both fish species were candidates for federal endangered status during this study.

The standard trawl design did not effectively

TABLE 1.—Fish species captured by use of a modified two-seam balloon trawl (i.e., Missouri trawl) in the upper Mississippi River during 1998–2001. Species abundances in the standard (std.) trawl portion and cover were compared by use of the chi-square statistic. Species with significantly different abundances ($P \leq 0.05$) are denoted by asterisks.

Family and species	Total catch		χ^2	*P*
	Cover	Std. trawl		
Acipenseridae				
Pallid sturgeon *Scaphirhynchus albus*	2	0	0	
Shovelnose sturgeon *S. platorynchus*	22	83	35.44	<0.001*
Larval sturgeon *Scaphirhynchus* spp.	26	0	0	
Polyodontidae				
Paddlefish *Polyodon spathula*	181	24	120.24	<0.001*
Lepisosteidae				
Shortnose gar *Lepisosteus platostomus*	0	4	0	
Clupeidae				
Goldeye *Hiodon alosoides*	22	8	6.53	<0.001*
Mooneye *H. tergisus*	11	3	4.57	0.033*
Skipjack herring *Alosa chrysochloris*	1	2	0.33	0.564
Gizzard shad *Dorosoma cepedianum*	40	39	0.01	0.91
Threadfin shad *D. petenense*	3	3	0	1.0
Cyprinidae				
Grass carp *Ctenopharyngodon idella*	7	1	4.5	0.033*
Red shiner *Cyprinella lutrensis*	1	0	0	
Blacktail shiner *C. venusta*	1	0	0	
Common carp *Cyprinus carpio*	35	19	4.74	0.029*
Mississippi silvery minnow *Hybognathus nuchalis*	2	0	0	
Bighead carp *Hypophthalmichthys nobilis*	39	6	24.2	<0.001*
Shoal chub *Macrhybopsis hyostoma*	3,070	396	2,062.98	<0.001*
Sturgeon chub *M. gelida*	198	36	112.15	<0.001*
Sicklefin chub *M. meeki*	144	40	58.78	<0.001*
Silver chub *M. storeriana*	28	5	16.03	<0.001*
Emerald shiner *Notropis atherinoides*	26	1	23.15	<0.001*
River shiner *N. blennius*	1	0	0	
Bigeye shiner *N. boops*	1	0	0	
Silverband shiner *N. shumardi*	36	1	33.11	<0.001*
Channel shiner *N. wickliffi*	893	91	653.66	<0.001*
Bluntnose minnow *Pimephales notatus*	1	0	0	
Bullhead minnow *P. vigilax*	2	0	0	
Catostomidae				
River carpsucker *Carpiodes carpio*	5	10	1.67	0.197
Blue sucker *Cycleptus elongatus*	1	1	0	1.0
Black buffalo *Ictiobus niger*		1	0	
Shorthead redhorse *Moxostoma macrolepidotum*	1	1	0	1.0
Ictaluridae				
Yellow bullhead *Ameiurus natalis*	1	0	0	
Blue catfish *Ictalurus furcatus*	602	347	68.52	<0.001*
Channel catfish *I. punctatus*	4,376	1,762	1,113.23	<0.001*
Stonecat *Noturus flavus*	12	3	5.4	<0.02*
Freckled madtom *N. nocturnus*	4	2	0.67	0.414
Flathead catfish *Pylodictis olivaris*	2	5	1.29	0.257
Atherinopsidae				
Inland silverside *Menidia beryllina*	2	0	0	
Moronidae				
White bass *Morone chrysops*	5	4	0.111	0.739
Striped bass *M. saxatilis*	1	0	0	
Centrarchidae				
Bluegill *Lepomis macrochirus*	2	2	0	1.0
Percidae				
Logperch *Percina caprodes*	1	0	0	
River darter *P. shumardi*	9	2	4.46	0.035*
Sauger *Sander canadensis*	4	9	1.92	0.166
Sciaenidae				
Freshwater drum *Aplodinotus grunniens*	728	306	172.23	<0.001*
All species	10,549	3,217	5,938.65	<0.001*

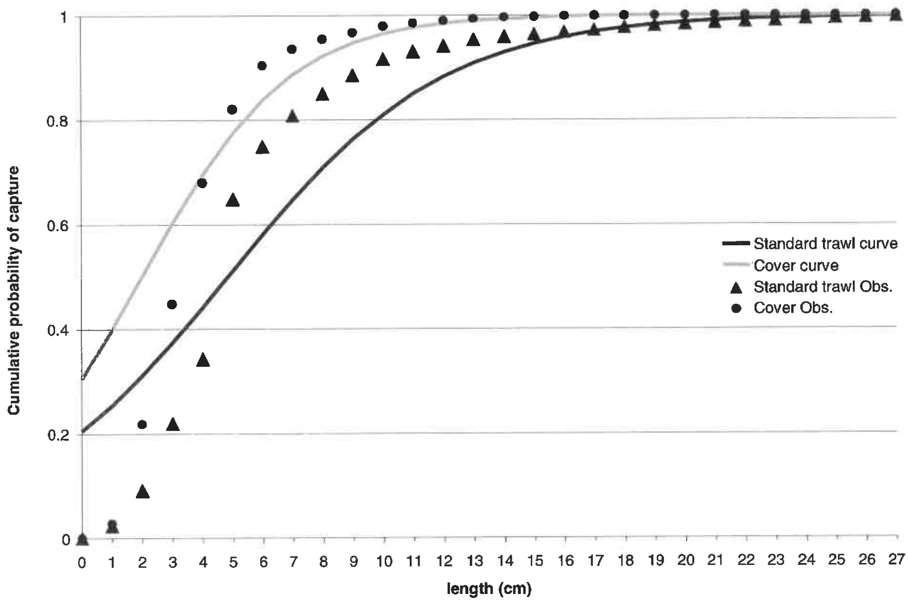

FIGURE 3.—Results of the logistic regression plotting the cumulative probability of capture against fish length for the standard trawl portion and cover of the Missouri trawl (triangle = standard trawl, observed; circle = cover, observed). Standard trawl and cover curves are indicated by solid lines.

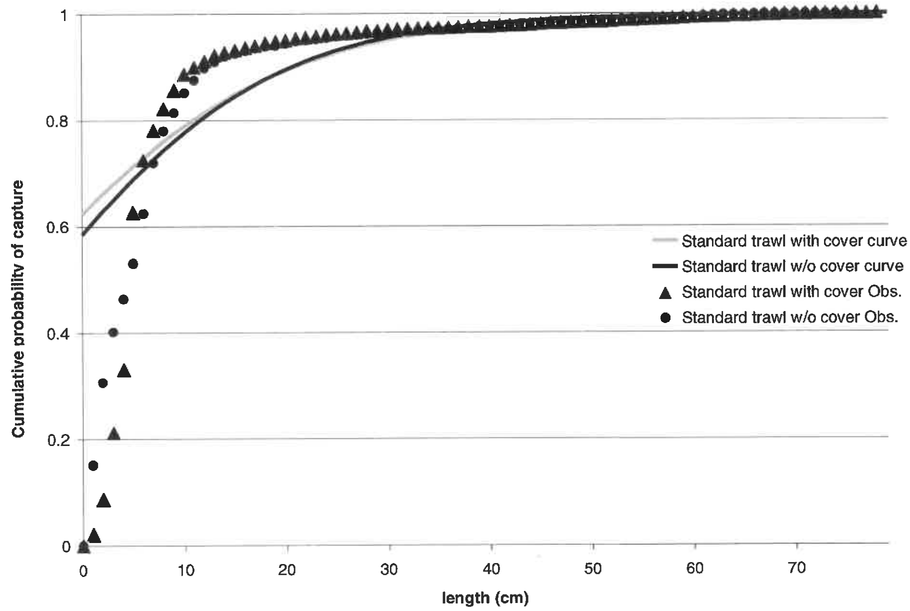

FIGURE 4.—Results of the logistic regression plotting the cumulative probability of capture against fish length for the standard trawl without a cover (used to sample the upper Mississippi River in 1991–1997) and the standard trawl portion of the Missouri trawl (used for sampling in 1998–2001) (triangle = standard trawl with cover, observed; circle = standard trawl without cover, observed). Curves for standard trawls with and without a cover are indicated by solid lines.

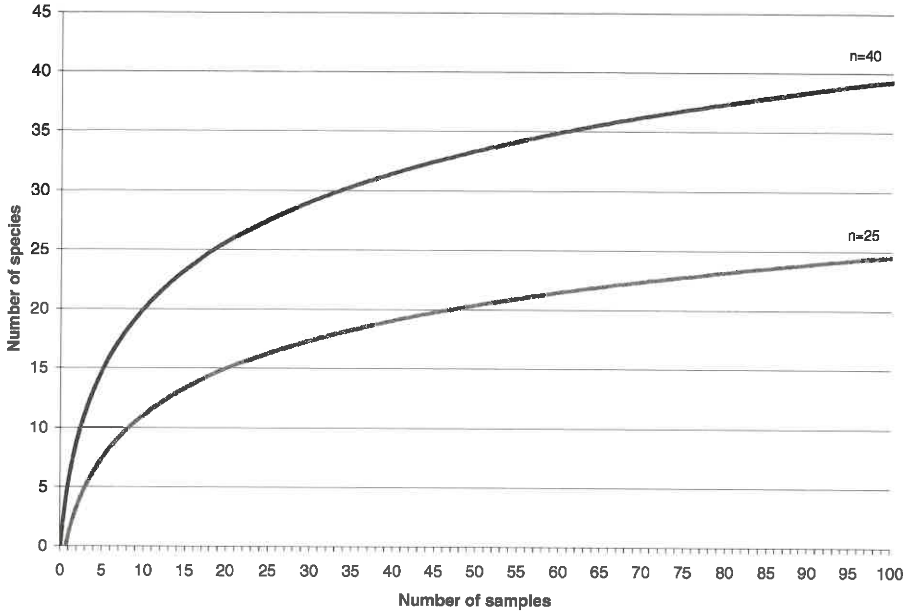

FIGURE 5.—Comparison of the rate of fish species captured after 100 samples by use of the unmodified standard trawl (gray line) and the Missouri trawl (black line) in the unimpounded reach of the upper Mississippi River. Solid lines represent cumulative numbers of fish species captured at selected sampling intervals.

capture small fish, and the design could have contributed to escape through the trawl body because the fish may have impinged against the mesh prior to entering the cod end. Although the standard trawl is generally funnel-shaped, the attack angle of the trawl body may have caused the trawl to act more like a sieve rather than as a funnel for directing fish to the cod end. We speculate that fish have a higher tendency to pass through the netting when the attack angle is abrupt than when the angle is gradual. Unfortunately, no studies on this subject have been published for freshwater systems, and additional research should be conducted to clarify this issue. However, trawling procedures were consistent throughout the study for both trawls (i.e., Missouri and standard). Therefore, any changes to catch composition that occur through use of the Missouri trawl should be attributed to the cover.

When a trawl with a cover is used, mesh interactions may affect the catch. Cover effects were not identified when the cumulative capture probabilities from the standard trawl portion of the Missouri trawl (1998–2001) and the standard trawl without the cover (1991–1997) were compared. Cumulative capture probabilities were nearly identical across all length ranges. These results are similar to findings of Madsen and Holst (2002), who found no obvious masking effects caused by a covered cod end on catch of a single species. However, fish larger than the mesh cannot pass through to the small mesh. This explains the significantly higher abundance of shovelnose sturgeon in the standard portion of the Missouri trawl. A fish's shape, texture, behavioral response (e.g., predator avoidance), and size are important factors in determining its susceptibility to fishing gear (Pope et al. 1975). Shovelnose sturgeon are not strong swimmers and use substrate appression to maintain themselves in the current (Adams et al. 1997). Thus, this species is less likely to escape an encounter with a bottom trawl. Conversely, larval sturgeons pass through large mesh because of their size and shape. Gunderson (1993) addressed differences in trawl capture based on fish size and ability to out-swim the trawl. Also, because of habitats they occupy, some fish (e.g., pelagic species) will not be captured by bottom trawling. All 18 species that were significantly more abundant in the small-mesh cover than in the standard portion of the Missouri trawl were either small or had streamlined bodies.

Although there was no apparent effect of the cover on cumulative probability of catch, there was an effect on drag. The small-mesh cover of the Missouri trawl increases the power required by the motor to pull the trawl and requires substantially more manpower to retrieve than does an unmodified standard trawl. In addition, the small-mesh cover is susceptible to damage because it is on the outside of the trawl. However, the utility of the cover for community sampling outweighs any negative aspects like higher drag or maintenance, and the cover may reduce catch mortality of small fish. For example, although large-mesh trawls capture larger fish, reduce drag, and allow for reduced bycatch (Dickson 1962; Naidu et al. 1987), they may injure or kill fish. Fish escapement through large-mesh trawls may cause delayed mortality because of the trauma of pass-through or impingement on the trawl body (Chopin and Arimoto 1994). However, because there were two mesh sizes in the Missouri trawl, smaller fish that passed through the standard trawl portion remained separate from large debris and larger fish. This design prevented unnecessary damage to smaller fish by impingement on larger fish or debris. Matsushita and Shida (2001) noted that separation of marine debris by selective gear (i.e., bycatch exclusion window) avoided much damage to the catch. This is extremely important when there is potential for encountering a federally endangered species (e.g., pallid sturgeon) while trawling. The Missouri trawl design improves small fish capture and decreases the likelihood of delayed mortality caused by capture stress.

When a single gear is used to sample a fish community, it is important to address how many species are being captured as well as the total number of individuals of each species. Many sampling protocols are designed to capture species-specific information by use of best methods and are effective tools for resource managers. However, a sampling gear that is effective for multiple species and diverse areas provides more utility per unit effort. We have shown that the Missouri trawl is a practical method for sampling fish communities in different-size river systems. The advantages of this trawl include low equipment cost, simple operation, and improved capture of fish species and abundance in comparison to that of a two-seam slingshot balloon trawl with a 19.05-mm-mesh body and a 3.18-mm-mesh cod end. Researchers continue to modify cod end specifications to study and capture specific sizes of fish (Mous et al. 2002). The modifications are usually not associated with community sampling, but rather are used to increase catch of large fish and reduce catch of small or unwanted fish. Our study supports the idea that the body of the trawl can affect capture as much as or more than the cod end. This methodology will improve the effectiveness of benthic fish community sampling in moderate to large river systems.

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