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A comparison of four types of sampling gear used to collect shovelnose sturgeon in the Lower Missouri River

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Summary

We compared variability in catch per unit effort (CPUE) and size structure of shovelnose sturgeon *Scaphirhynchus platorynchus* collected in 2003 and 2004 with stationary winter gill nets, drifted trammel nets, hoop nets, and otter trawls in the Lower Missouri River, USA to determine the most precise types of gear to collect all sizes of sturgeon so that refinements of long-term monitoring protocols can be made. A total of 1947 net sets or trawls collected 8743 shovelnose sturgeon, with 67% of the fish collected during winter gill netting (16% of total samples). Mean coefficient of variation (CV) among all months for juvenile (age 3 and younger; <250 mm fork length) sturgeon was highest for gill nets and lowest for otter trawls ($P = 0.0008$). Mean CV of subadult and adult shovelnose sturgeon (≥250 mm) was highest in hoop nets compared to other gear types ($P = 0.0002$). All gear and mesh sizes collected the most common sizes of shovelnose sturgeon (500–600 mm), but only otter trawls and trammel nets collected fish <150 mm. The higher precision of winter gill nets and summer otter trawls led to fewer samples needed to detect changes in CPUE as compared to hoop and trammel nets. Sampling only with types of gear that do not collect younger shovelnose sturgeon may hinder management decisions that rely on recruitment trends to determine the effects of management actions (e.g. channel modifications).

Introduction

Many major river systems throughout North America have been modified for flood control, irrigation, navigation, hydropower, and other human uses and there is increased concern as to how these activities have affected the biota (Benke and Cushing, 2005). In the channelized Lower Missouri River (Sioux City, Iowa USA to the mouth of the Mississippi River near St. Louis, Missouri, USA), many main channel big river fishes have declined in abundance (Keenlyne, 1997; Galat et al., 2005a) and monitoring programs to detect possible changes in fish populations have recently been implemented. However, less attention has been given to the evaluation of these monitoring programs and their ability to detect changes in population abundance and size structure. Because of the concerns with declines in large river fishes of the Missouri River, a monitoring program was established to determine the status and trends of fishes in the mainstem Missouri River (Drobish, 2006; Wanner et al., 2007). Until recently, no long-term monitoring program was established for the mainstem Missouri River (Galat et al., 2005b). Although substantial sampling with various sampling gear types has occurred with this monitoring program, there has been little attention given to the evaluation of the program to detect trends in the abundance and size structure of the fish population monitored (but see Wanner et al., 2007).

One of the target species of the monitoring program is the shovelnose sturgeon *Scaphirhynchus platorynchus*, which are native to the Missouri River and sympatric with the federally-endangered pallid sturgeon *Scaphirhynchus albus* (Keenlyne, 1997; Bramblett and White, 2001). There is concern over the status of shovelnose sturgeon because of presumed declines in the species over the last 50 years caused by loss of habitat, channelization, and harvest (Keenlyne, 1997; Quist et al., 2002; Colombo et al., 2007). Detection of trends in recruitment and abundance of these slow growing, long-lived fish (>17 years in the Lower Missouri River; Quist et al., 2002) is needed to determine the effect of various management actions such as habitat and channel modifications. Therefore, sampling all sizes of these fish to detect status and trends is needed to determine if management actions are necessary to protect and conserve this species for the future. The objectives of this study were to compare the variability of four sampling gear types used to collect shovelnose sturgeon. We wanted specifically to determine if there were gear types and/or times of the year that had the lowest sampling variability with the widest length ranges of shovelnose sturgeon collected.

Materials and methods

Sample site selection and gear deployment

All sampling was conducted on the mainstem Missouri River from river km (rkm) 0 (St. Louis) to river kilometers (rkm 367 (Glasgow, Missouri) across all seasons as part of an ongoing long-term monitoring effort of fishes in the river using sampling protocols described by Drobish (2006) and Wanner et al. (2007). River bends, defined as a curvature in the river where the river changes direction (Armantrout, 1998) and is the distance from thalweg crossover to thalweg crossover ($n = 8$–10, depending on year and river segment), were randomly selected from all river bends identified within each of two river segments (e.g. rkm 0–209 and rkm 210–367) from the U.S. Army Corps of Engineers (Drobish, 2006). Once a river bend was selected, an attempt was made to sample all macrohabitats (inside bends, outside bends, and channel crossovers) within that river bend (Wanner et al., 2007).

Sampling consisted of numerous types of gear in each bend, however gear deployment on specific dates was based on water temperature and season (USFWS, 2002; Drobish, 2006). For example, gill nets were used only in winter when water temperature was below 12°C to minimize mortality (USFWS, 2002), whereas otter trawls, trammel nets, and hoop nets were primarily sampled only in March through October.

Gear types were fished in a manner similar to Wanner et al. (2007). Mulitfilament gill nets used were 61 m long and 2.4 m in depth and consisted of 8–7.6 m panels of 3.8, 5.1, 7.6, and 10.2 cm bar measure mesh; panels were organized in ascending sizes and then repeated twice within one net. Gill nets were set overnight for a min. of 12 h in depths of at least 1.2 m, primarily in pools off dike structures when water temperatures were < 12°C (December-April). Catch per unit effort (CPUE) was calculated as the number of fish collected per 30.5 m of gill net set overnight; therefore each 61 m net set overnight was two units of effort. Trammel nets were 38.1 m multifilament nets with a 2.4 m inner wall of 2.5 cm bar mesh and a 1.8 m outer wall of 20.3 cm mesh. Nets were actively fished from March to October by drifting with the current for a min. of 75 m with a target drift of 300 m. CPUE was expressed as the number of fish collected per 100 m drifted. Otter trawls were 4.9 m wide, 0.91 m high and 7.6 m long with 0.63 cm stretch inner mesh and 3.8 cm outer chafing mesh. Nets were deployed from March to October downstream just faster than the current for a target of 300 m trawled (min. 75 m). CPUE was expressed as the number of fish collected per 100 m trawled. Hoop nets were double throated, 1.2 m dia. with seven hoops and 3.8-cm bar mesh. Hoop nets were set March to October, parallel with the current and with the opening on the downstream end. Each net was fished overnight and not baited (Wanner et al., 2007). CPUE was expressed as the number of fish collected per overnight set. All shovelnose sturgeon collected were measured for fork length and released near the capture site.

Data analysis

Coefficient of variation of CPUE (CV; Zar, 1996) was calculated for each type of gear, month, and shovelnose sturgeon size class (juvenile: < 250 mm fork length) and subadult and adult (≥250 mm). Fish < 250 mm were typically age 3 and younger, whereas ages of larger fish were typically age 4 and older (Quist et al., 2002). The CV provides a relative measure of variability that can be compared among gear types. Coefficient of variation was plotted by month for each gear and size class to determine temporal trends in sampling variability. Because effort was calculated differently for each gear, (e.g. we could not compare CPUE of actively fished otter trawls with CPUE of passively fished gill nets), we made no attempt to compare CPUE among gear types. However, we did determine whether the number of samples that could be completed per day varied for each gear type in order to determine if more samples of one gear type could be collected on a typical sampling day.

An analysis of variance was used to determine if mean monthly CV differed among gear types and size classes of shovelnose sturgeon. Sample sizes needed to detect a 25% change in CPUE were calculated by methods described in Allen et al. (1999) and Paukert (2004). In these analyses we combined all samples for each gear type to estimate the number of samples (at a power of 0.8) needed to detect a 25% change in CPUE for each type of gear. The mean CPUE and standard deviation of the CPUE was calculated separately for each gear type and size class of shovelnose sturgeon.

Logistic regression was used to determine if the probability of collecting at least one juvenile shovelnose sturgeon was related to the gear sampled. In this analysis we coded each net set or trawl as either 1 (juvenile shovelnose sturgeon present) or 0 (juvenile shovelnose sturgeon absent). Odds ratios were used to determine the likelihood of a juvenile shovelnose sturgeon being collected by a specific type of gear (Stokes et al., 1995).

Results

Totals of 1947 net sets or trawls were used to collect 8743 shovelnose sturgeon in the Missouri River from 5 January 2003 to 21 October 2004. The number of samples varied by month, with gill nets primarily used in winter, whereas hoop nets, trammel nets, and otter trawls were more often used from April to October (Fig. 1). There was a total of 310 winter gill net sets, 535 hoop net sets, 558 otter trawls, and 544 trammel net drifts. The mean number of samples per gear type in each macrohabitat (inside bend, outside bend, channel crossover) was 162 (range: 17–462). Although winter gill netting consisted of 15.9% of the total samples of all types of gear (310 ⁄ 1947), it collected 66.9% of the shovelnose sturgeon (5853 ⁄ 8743). In contrast, hoop nets collected 1.7% of the fish but accounted for 27.5% of the sampling (Fig. 1).

Juvenile shovelnose sturgeon

Mean CV of juvenile shovelnose sturgeon ranged from 223 to 1179. However, fewer types of gear collected juvenile sturgeon. For example, the only gill nets that collected juvenile shovelnose were in March and December 2003. Across all months, mean CV for juvenile shovelnose sturgeon was highest for gill nets (mean = 947 SE = 106) followed by trammel nets (mean = 469 SE = 57) and otter trawls (mean = 299 SE = 61; $F = 13.88$, d.f. = 2, 12, $P = 0.0008$). When

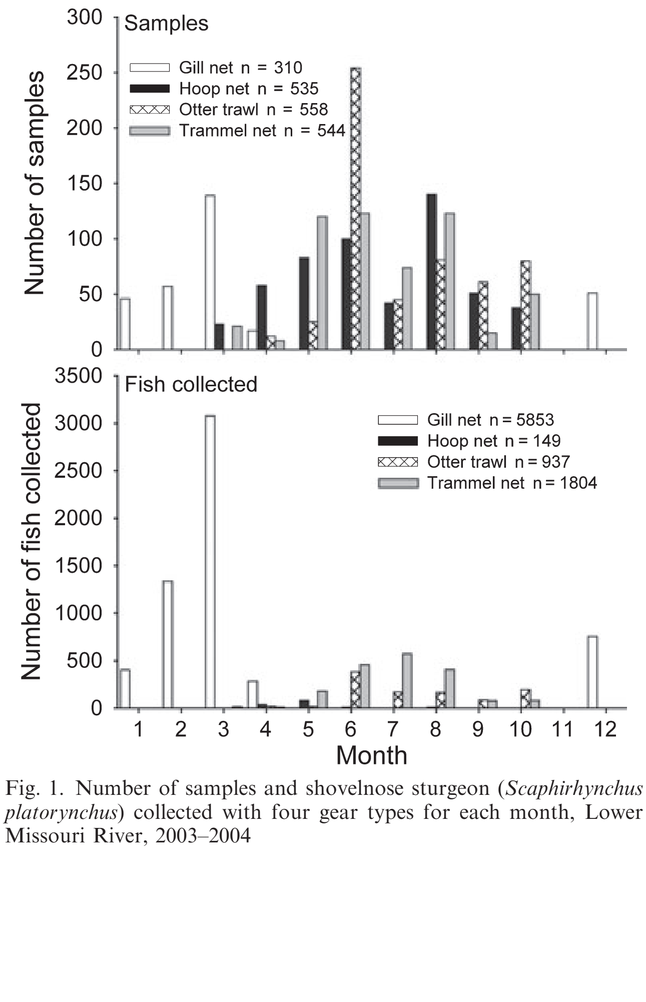

Fig. 1. Number of samples and shovelnose sturgeon (*Scaphirhynchus platorynchus*) collected with four gear types for each month, Lower Missouri River, 2003–2004

comparing just April through October, mean CV for otter trawls was lower (315 SE = 29) than for trammel nets (mean = 520 SE = 58; F = 10.15, d.f. = 1, 8, P = 0.013). No juvenile shovelnose sturgeon were collected in hoop nets, and no gill nets were set other than in winter months. The lowest CV for juvenile shovelnose sturgeon was in otter trawls in summer (Fig. 2). Of the 4 months when both otter trawls and trammel nets were used (June–August, October), the lowest CV for both types of gear was in July and October.

The number of samples needed to detect changes in juvenile shovelnose sturgeon CPUE ranged from 1675 to 51776 samples (Table 1). Otter trawls needed the lowest number of samples but were still very high (range 1675–3598). Sample size could not be conducted using hoop nets because no shovelnose sturgeon < 50 mm were collected with this gear.

Subadult and adult shovelnose sturgeon

Subadult and adult shovelnose sturgeon CV was typically lower than sturgeon < 250 mm, ranging from 107 to 616. For all months combined, hoop nets had the highest mean CV for subadult and adult shovelnose sturgeon (mean = 372 SE = 31), but mean CV for winter gill nets (mean = 133 SE = 40), trammel nets (mean = 203 SE = 31) and otter trawls (mean = 172 SE = 33) did not differ from each other (F = 10.05, d.f. = 3, 24, P = 0.0002). For sampling from only April through October (when otter trawls, hoop nets, and trammel nets were all used), mean CV was still highest for hoop nets (mean = 418 SE = 56) but did not differ between otter trawls (mean = 179 SE = 16) or trammel nets (mean = 210 SE = 29)(F = 12.13, d.f. = 2, 15, P = 0.0007). Subadult and adult shovelnose sturgeon catch rate variability was consistent for all gear except hoop nets. With increased CV in May and June (Fig. 2), the lowest CV for subadult and adult shovelnose sturgeon was in July for otter trawls and also low in July for trammel nets. In contrast, hoop nets had the highest CV and increased throughout the months. However, CV of subadult and adult shovelnose was consistently low for winter gill nets (Fig. 2).

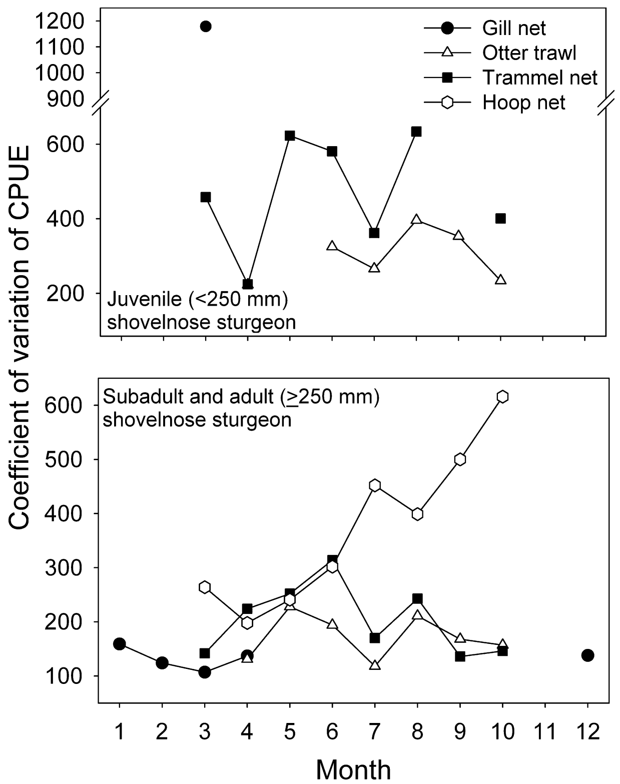

Fig. 2. Coefficient of variation (CV) of catch per unit effort of gill nets, trammel nets, otter trawls, and hoop nets among months for shovelnose sturgeon (*Scaphirhynchus platorynchus*), Lower Missouri River, 2003–2004

Table 1
Mean catch per unit effort and sample sizes for juvenile (< 250 mm) and subadult and adult (≥250 mm) shovelnose sturgeon (*Scaphirhynchus platorynchus*) collected with four gear types, Lower Missouri River, 2003–2004

				No. samples needed to detect 25% change in CPUE			
	Mean CPUE	SD	N	Power of 0.6	Power of 0.7	Power of 0.8	Power of 0.9
Juvenile							
Gill net	0.003	0.040	310	24103	30346	38814	51776
Hoop net	0.000	0.000	535				
Otter trawl	0.069	0.224	558	1675	2109	2698	3598
Trammel net	0.036	0.231	544	6372	8022	10261	13687
Subadult ⁄ adult							
Gill net	9.460	11.77	310	234	306	391	521
Hoop net	0.279	1.106	535	2461	3098	3963	5286
Otter trawl	0.644	1.253	558	593	747	955	1274
Trammel net	1.510	4.290	544	1264	1592	2036	2715

CPUE, catch per unit effort; SD, standard deviation. Sample size calculations based on number of samples to detect 25% annual change in CPUE at 5% level.

The number of samples needed to detect a 25% change in subadult and adult shovelnose CPUE was much lower than for juvenile fish (Table 1), ranging from 234 to 5286. Gill nets had the lowest CV and thus the fewest number of samples to detect changes in CPUE. At a power of 0.8, about 391 samples would be needed to detect changes on large shovelnose sturgeon relative abundance in gill nets.

The number of samples that could be obtained per day depended on the type of gear used. The median number of net sets was lowest for gill nets (median = 7, range: 1–11), followed by trammel nets (median = 8, range: 1–26), hoop nets (median = 9, range: 1–23), and otter trawls (median = 11, range: 1–24). Also, hoop nets and gill nets were passive types of gear set overnight and therefore required an additional day of sampling. Otter trawls and trammel nets were active gear and thus required only one sampling day.

Sizes structure

Mean length of shovelnose sturgeon collected in the four mesh sizes of gill nets varied from 559 to 591 mm, whereas other gear types collected similar mean lengths (Table 2; Fig. 3). Mean lengths for all mesh sizes of gill nets, trammel nets, otter trawls, and hoop nets were statistically different (F = 143.53, d.f. = 6, 8736, P < 0.001) except that hoop nets collected similar mean lengths as mesh gill nets of 5.1, 7.6, and 10.2 cm. However, the size range of fish collected varied substantially. Only trammel nets and otter trawls collected fish < 150 mm, but all types of gear collected fish to at least 700 mm (Fig. 3). For gill nets, the larger mesh size did not necessarily collect larger fish. The widest range of fish sizes for gill nets was collected in 7.6-cm mesh, collecting both the smallest and largest shovelnose of all gill-net mesh

Table 2
Mean length (SE = standard error) of shovelnose sturgeon (*Scaphirhynchus platorynchus*) collected with four gear types, km 0–367, Lower Missouri River, 2003 and 2004

Gear or mesh	Mean fork length (mm)	SE	Range	IQR	N
Gill net (cm)					
3.8	559	1.5	260–740	575–610	2220
5.1	589	1.2	204–800	562–623	2146
7.6	591	2.1	168–786	562–628	876
10.2	570	3.0	272–780	529–620	611
Trammel net	541	2.5	90–760	490–614	1804
Otter trawl	502	4.9	5–748	456–605	937
Hoop net	584	5.2	423–703	548–635	149

N, number of fish; IQR, interquartile range (middle 50% of observations).

sizes. However, otter trawls collected the smallest fish of all gear types.

The probability of collecting a shovelnose sturgeon <250 mm was influenced by the gear and mesh sizes used. Only two of 310 gill nets (0.65%) collected fish under 250 mm (one fish each in 5.1 and 7.6 cm mesh), whereas no shovelnose sturgeon <250 mm were collected in hoop nets. A higher proportion of trammel nets (28 nets; 5%) and otter trawls (68 trawls; 12%) collected juvenile shovelnose sturgeon. Logistic regression revealed that otter trawls were 2.5 times more likely to collect a small shovelnose sturgeon compared to trammel nets, and gill nets were 8.3 times less likely compared to trammel nets ($\chi^2 = 53.47$, d.f. = 2, $P < 0.001$).

Discussion

Winter gill net sets and summer otter trawls had more precise estimates of CPUE for both sizes of shovelnose sturgeon when compared to hoop nets and trammel nets. The higher precision of these CPUE estimates led to fewer otter trawls and gill-net samples needed to detect changes in relative abundance compared to hoop nets and trammel nets. Juvenile shovelnose sturgeon collected in otter trawls had the lowest variability and the fewest samples to detect trends in relative abundance compared to other gear types. Winter gill nets had the lowest variability in subadult and adult shovelnose sturgeon CPUE and collected a majority of the fish. However, no other gear was used during winter so further direct gear comparisons could not be made.

The detection of changes in abundance and size structure of fish populations is critical in a long-term monitoring program.

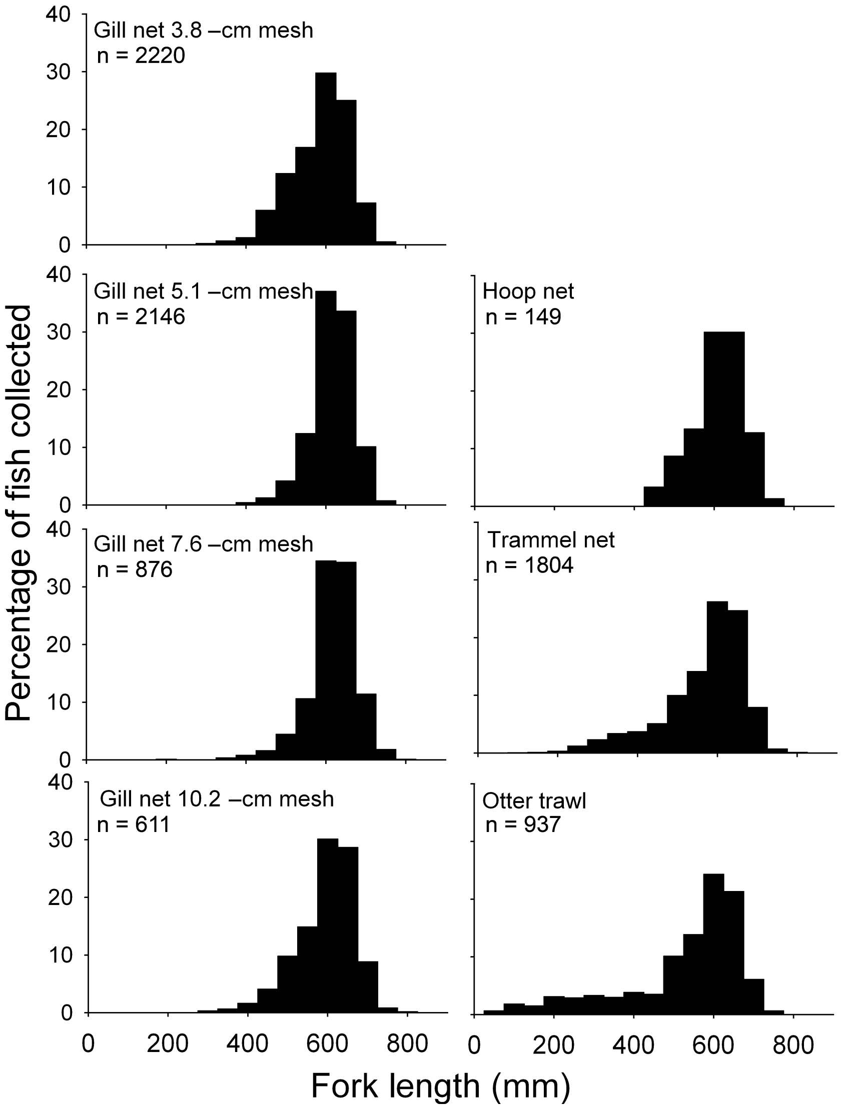

Fig. 3. Length frequency of shovelnose sturgeon (*Scaphirhynchus platorynchus*) collected in four mesh sizes of gill nets, trammel nets, otter trawls, and hoop nets, Lower Missouri River, 2003–2004

However, high variability of CPUE estimates may mask actual changes in abundance (Allen et al., 1999). In addition, biases associated with different gear types make it difficult to assess population status and trends (Beamesderfer and Reiman, 1988). Although all gear types (and mesh sizes) collected the most common sizes of shovelnose sturgeon (500–600 mm), trends in these sizes of fish may be less suitable to determine management actions compared to trends in smaller (and younger) fish. In the Lower Missouri River, shovelnose sturgeon >500 mm are at least 6 years old (Quist et al., 2002) and thus the effects of management actions that may have affected recruitment are not known for several years. Shovelnose sturgeon do not typically become vulnerable to many standardized gear types until older, thus the impacts of various management actions on recruitment has a considerable lag time (Colombo et al., 2007). Therefore, the establishment of a long-term monitoring program with adequate gear and sample sizes to detect trends of juvenile fish is necessary to make informed management decisions. Gill nets, trammel nets, and trawls are commonly used to collect benthic fishes in riverine environments (Wildhaber et al., 2003; Herzog et al., 2005; Wanner et al., 2007). However, researchers need to maximize their field efforts as budgets and time constraints increase. Our results indicate that winter gill nets collected a majority of the subadult and adult shovelnose sturgeon, whereas otter trawls may be the most effective to detect recruitment of juvenile fish. Wanner et al. (2007) also suggested that cold water (<12°C) gill nets were effective at collecting juvenile pallid sturgeon (which still may be up to 700 mm) in the Missouri River upstream 1500 rkm from our study site, suggesting that this gear may be suitable with *Scaphirhynchus* species. Gill nets are passive and need to be deployed 1 day and retrieved the next day. Although smaller mesh sizes of gill nets collected smaller fish than did larger mesh gill nets, juvenile (<250 mm) shovelnose sturgeon were still rarely collected in gill nets. However, the smallest gill net mesh was 3.8 cm and smaller mesh sizes (e.g. 2.5 cm, which is the same mesh as trammel nets) may allow for the collection of juvenile shovelnose sturgeon. Otter trawls and trammel nets collect juvenile shovelnose sturgeon, allowing resource managers to minimize the time in the field as these active gear types can be fished during 1 day. During one set date, about 20 otter trawls and/or trammel net sets can be conducted, whereas fewer (e.g. 10) gill net sets are possible. Therefore, resource managers will need to balance the ability to collect high numbers of subadult and adult shovelnose sturgeon in gill nets with the additional day in the field needed to retrieve these nets. Using gear types that maximize catch and minimize variability and size bias, coupled with minimizing time needed for each sampling event, will provide resource managers with the information needed to make informed decisions about fish populations. For shovelnose sturgeon these may be otter trawls in summer and winter gill net sets.

One assumption in sampling to assess population status and trends is that the gear used actually reflects the actual abundance and size structure of the population of interest (Paukert, 2004; Wanner et al., 2007). In our study, only gill nets were used in winter in deepwater habitats. The assumption is that the low velocity pool habitats where gill net sampling occurred are representative of the entire shovelnose sturgeon population. Although we believe this is likely, we suggest using at least two gear types in two seasons (winter gill nets and otter trawls) that when combined will provide the ability to collect all size classes of shovelnose sturgeon in various habitats and seasons. Although otter trawls collected a wider size range of shovelnose sturgeon, its slightly higher variability of subadult and adult catches compared to winter gill nets suggest that this gear alone is not the best choice to detect trends in abundance. We agree with Wanner et al. (2007) that multiple types of gear may be most suitable in a standardized sampling program to determine responses of fishes to management actions in the Missouri River and, likely, other rivers.

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