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A Standardized Sampling Protocol for Channel Catfish in Prairie Streams

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Abstract.—Three alternative gears—an AC electrofishing raft, bankpoles, and a 15-hoop-net set—were used in a standardized manner to sample channel catfish *Ictalurus punctatus* in three prairie streams of varying size in three seasons. We compared these gears as to time required per sample, size selectivity, mean catch per unit effort (CPUE) among months, mean CPUE within months, effect of fluctuating stream stage, and sensitivity to population size. According to these comparisons, the 15-hoop-net set used during stable water levels in October had the most desirable characteristics. Using our catch data, we estimated the precision of CPUE and size structure by varying sample sizes for the 15-hoop-net set. We recommend that 11–15 repetitions of the 15-hoop-net set be used for most management activities. This standardized basic unit of effort will increase the precision of estimates and allow better comparisons among samples as well as increased confidence in management decisions.

Channel catfish *Ictalurus punctatus* is an important recreational species in the middle-latitude prairie states of the United States. However, according to a 1999 survey of state resource management agencies, management of populations in streams and rivers is hindered by a lack of suitable sampling methodology (Michaletz and Dillard 1999). To date, a standardized unit of sampling effort has not been developed specifically for small to medium-size prairie streams. Sampling that results in abundance estimates and length-frequency distributions with known quantitative attributes would lead to more efficient use of management tools, such as creel limits, length restrictions, habitat protection, and habitat restoration, that aim to maintain and enhance highly utilized channel catfish populations.

Our objective was to develop a sampling protocol to monitor the abundance and size structure of channel catfish in prairie streams. We sampled channel catfish with three gears during three months (June, August, and October) in three prairie streams of varying size. We evaluated the gears based on four questions fisheries biologists have recently asked (Irwin and Hubert 1999): (1) how much personnel effort is required? (2) does the gear catch more channel catfish in a particular season? (3) does the gear appear sensitive to population differences? and (4) does the performance of the gear vary within a short time period or under different stream flow conditions? We also provide estimates of (1) the number of replicate samples of the recommended gear that are required for the desired level of precision in the mean estimate of abundance (based on catch per unit effort, CPUE) and (2) the number of channel catfish needed to produce a repeatable size structure histogram.

Study Sites

Channel catfish were sampled in three streams in the Grand River basin of northern Missouri (Figure 1). A 10-km reach of each stream was selected, within which three 200-m sampling sites were designated. Yellow Creek, near Mendon, Missouri, represented the smaller tributary streams. At the study reach, Yellow Creek was a fifth-order stream with a base flow of 1.9 m^3/s and a wetted width of approximately 5 m. The streambed was incised, with sand and silt substrates and a glide−pool habitat sequence. Big Creek, near Pattonsburg, Missouri, characterized the mid-reach or major tributaries. This creek was also fifth order but had a base flow of 3.4 m^3/s and a wetted width of approximately 11 m. The streambed was composed

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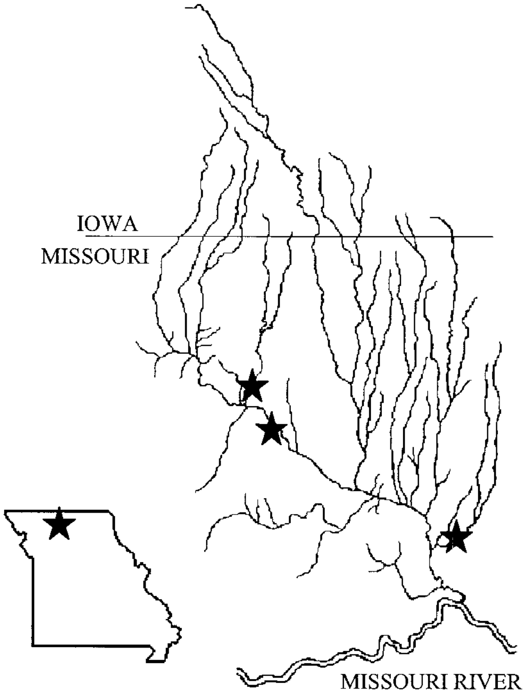

FIGURE 1.—Map of the Grand River basin, Missouri, showing the locations of the three 10-km study reaches, Big Creek, the Grand River, and Yellow Creek (stars, left to right).

of sand, silt, and gravel, as bedrock outcrops associated with localized riffle–pool complexes occurred along Big Creek. A reach of the Grand River near Gallatin, Missouri, was used to characterize the main stem of medium-size prairie streams. At the study reach, the Grand River was seventh order, had a base flow of 7.1 m^3/s and a wetted width of approximately 19 m. Sand and silt, with locally abundant gravel and clay patches, dominated the substrate. Boulder (>256 mm) and cobble (64–255 mm) substrate were also present from the riprap used for bank stabilization. The Grand River study reach included both unchannelized and channelized portions.

Methods

Field sampling.—Channel catfish were collected from a wide range of stream conditions to assess the effects of season, abiotic conditions, and gear type on abundance and size structure data. Sampling was conducted during 3 months in the growing season in 1997 and 1998, namely, June (late spring), August (summer), and October (fall). Sampling was conducted during all river conditions that allowed safe operation of the gear, ranging from extremely low flows to bankfull discharges.

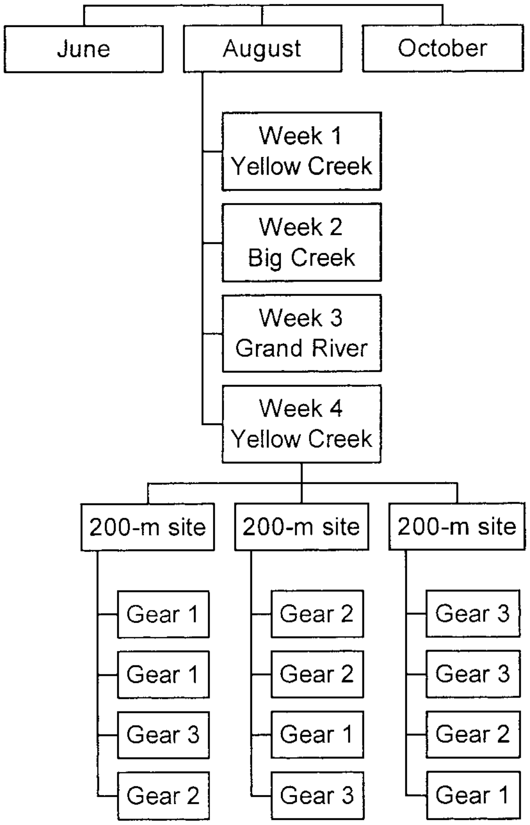

FIGURE 2.—Diagram of sampling activities within a month. Three 200-m sites were sampled each week (only shown for August and week 4). Gears were randomly assigned a starting position each week.

During each sampling period, the same series of events took place over a 4-week time span. The three streams were sampled one at a time, with one stream being visited again during the fourth week to estimate within-season variance. Yellow Creek was sampled a second time in June, Big Creek in August, and the Grand River in October each year. Three gears were used concurrently to sample three 200-m sites (one gear per site) in each stream. Gears were rotated among the three sites (from randomly assigned starting locations) at 24-h intervals. Sampling included four 24-h intervals (Figure 2).

Gears.—Based on pilot study experimentation and a literature review (Vokoun and Rabeni 1999), we chose to evaluate hoop nets, bankpoles, and an AC electrofishing raft. We deployed hoop nets at a density of 15 nets/200 m of stream. This density was viewed as an intermediate one that would transfer well along the range of stream sizes evaluated in the project while maintaining a desired level of saturation sampling within each 200-m site. Each hoop net saturation set (HNSS) was composed of ten 25.4-mm-bar-mesh nets and five 13-mm-bar-mesh nets. All 15 hoop nets were 0.6 m in diameter and 3 m in overall length, with seven fiberglass hoops. Two fingered throats trapped the catfish. Each net was baited with approximately 2 kg of cheese trimmings; additional cheese was added as sampling progressed to replace the lost cheese. The five 13-mm-mesh nets were distributed evenly among the ten 25.4-mm-mesh nets. The hoop nets were evenly distributed in each 200-m site (1 net/13.3 m of stream) according to the following directives: (1) if woody debris was present, the net was placed immediately upstream of the debris; (2) if no woody debris was present, the net was placed nearer to the cut bank (the outside bend); and (3) if the immediate upstream net was placed near the cut bank, then the cheese scent trail was offset by placing the net in midchannel, on the shallow flat of the sandbar (inside bend). With these directives, two individuals were able to approach a 200-m site and deploy the 15-hoop-net set in a consistent manner. We attempted to place all nets in water deep enough to completely submerge them, but this was occasionally impossible. Surprisingly, as long as interior throats were submerged, partially submerged nets captured catfish. The 24-h HNSS is considered a single unit of effort (i.e., catch is the total number of channel catfish captured by all 15 nets). This differs from the traditional treatment of hoop net CPUE data, which considers each net an individual unit of effort.

We used small-diameter (19-mm) polyvinyl chloride pipe for bankpoles, as these poles were durable and provided flex. The poles were 1.5–2.1 m long and equipped with braided nylon twine, a 3-oz lead sinker, and a single stainless steel 5/0 hook. Bankpoles were used in groups of 30, with two-pole pairs set throughout a 200-m site in the same manner as the hoop nets. Within a two-pole pair, one pole was baited with a live leech and the other with a live goldfish *Carassius auratus,*76–127 mm long. The 24-h bankpole effort was considered a single unit of effort.

The AC electrofishing raft used two electrodes, each with a circular terminal end that was 25.4 cm in diameter. The electrodes delivered AC from a Smith−Root model 1.5 KVA-83 electrofisher. Electrical output was maintained at 200 V and 5–6 A. The electrofisher received power from a 2,500-W Homelite gas-powered generator. A holding tank was placed on the raft. A four-person crew waded the stream with the electrofishing raft; each of the first two people held an electrode and a small dip net and captured fish that surfaced near them, while each of the other two held a large D–frame dip net directly downstream of each probe, shadowing its path. Sampling began at the downstream boundary of each 200-m study site and continued upstream through all wadeable habitat in an exaggerated ‘‘S’’ pattern. The unit of effort was one coverage of the 200-m site, with no time limit.

The total length of each channel catfish that we captured was recorded before its release. Fluctuations in stream stage were monitored during all 24-h sampling periods by means of a staff gauge located in each 200-m site. Water temperatures were recorded at the end of each 24-h sampling period or at the conclusion of the electrofishing raft effort.

Analysis.—We analyzed the data in two phases, first by comparing the performance of the three gears and then by estimating the sampling effort and precision of the HNSS. In the first phase we evaluated two qualitative criteria (effort required per set and gear-associated size selectivity) and four quantitative criteria (mean CPUE among months, sensitivity to population size, mean CPUE within months, and the effect of stream stage fluctuation on mean CPUE). The effort required per set was recorded as the total person-hours required for completion of a unit of effort, including the time required to deploy and retrieve gear and remove fish. Travel time to and from sites and fish processing time were not included. Gear-associated size selectivity was evaluated by comparing length-frequency distributions.

The four quantitative criteria were analyzed by means of analysis of variance (ANOVA). Evaluating the mean CPUE among months entailed a comparison of the number of channel catfish collected by each gear during June, August, and October. Comparison of the mean CPUE of a gear among study streams was used to assess whether the gears could detect population size differences. In making the latter comparison, we assumed that within the Grand River basin, which is a watershed without any major dams or reservoirs and one that is confined to a single ecoregion, a linear length of a larger stream would hold more channel catfish than a comparable length of a substantially smaller stream. This assumption was generally supported by studies in Iowa and Kansas streams (Paragamian 1990; Layher and Maughan 1985). Mean CPUE among months and sensitivity to population size were investigated using three-way ANOVA with main effects of year, stream, and month. Data were transformed ($\log_e$[CPUE + 1]) to meet the assumption of normality. Normality was assessed using normal probability plots, stem−leaf plots, and the Shapiro−Wilk statistic. Bartlett's test was used to assess the assumption of homogeneous variance. We considered all 200-m sites within a stream to be representative of the stream. One replicate sample was a 200-m site sampled with a particular gear within a 24-h period. Replicates were considered to be independent because channel catfish are mobile in streams (Hubert 1999), with reported linear ranges that average 2,978–8,464 m and that can be as great as 44,456 m for some individuals (Wendel and Kelsch 1999). Because the Grand River basin lacks barriers to movement, we believe that substantial mixing of individuals (i.e., immigration and emigration) occurred daily at our small sampling scale (i.e., 200 m), which would argue for the independence of the samples and against the use of a repeated-measures design.

Evaluating mean CPUE within months entailed comparing the performance of a gear during the first and fourth weeks of the same month by means of a one-way ANOVA. Significance was evaluated at $\alpha = 0.01$ to control for possible increases in the type I error associated with multiple testing (Neter et al. 1990).

The effect of stage fluctuation was evaluated by comparing the mean CPUE of gears for samples taken during 24-h periods in which the stage changed more than 30 cm with that of samples taken when the stage varied less than 30 cm; this comparison was also made by means of a one-way ANOVA. Samples taken during stage fluctuations were removed from the data set and not used in other analyses. The literature offered no definition as to what constitutes a stable or fluctuating stream stage; however, our choice of the 30-cm criterion was made before data analysis and was based on field observations.

The results from the first phase of analysis were used to determine the most efficient gear (the HNSS) and the best time of year to sample (October). In the second phase, we predicted the required effort and associated level of precision when using the HNSS in stable water levels in October. To generate CPUE trend data, we used an equation that conveys the number of samples needed as precision increases. This approach allows fisheries managers to choose the level of precision they desire based on the corresponding effort required (Neumann et al. 1995). The equation is

$$\text{Required effort} = [(100 \times \text{SD/mean}) \div (100 \times \text{SE/mean})]^2,$$

where SD is the standard deviation of the sample data, SE is the standard error of the mean, and mean is the sample mean. The coefficient of variation of the mean (100 × SE/mean) was fixed at values of 10, 15, 20, 25,. . ., 50.

To estimate the number of fish required to build a repeatable length-frequency histogram, we used a method that randomly sampled a set number of fish from a reference length frequency and then quantitatively compared the sample length frequency to the reference length frequency (Vokoun et al., in press). Specifically, we calculated the percent difference of each length category in the sample length frequency from that of the reference length frequency and then squared the percent differences to eliminate negative values. We then calculated a mean of these percent differences (the mean squared difference, MSD) 100 times and generated an empirical distribution from which a mean and 90% inclusive interval were derived. We chose to evaluate the sampling effort for population size structure using 25-mm-increment length categories for the calculation of all MSD values. Because we sampled a large number of fish at multiple sites in both October 1997 ($N = 2{,}761$) and 1998 ($N = 1{,}537$), we assumed that these length frequencies combined represented a stabilized length frequency for the 15-hoop-net saturation set in October. As such, it was used as the reference length frequency. We use the term stabilized to mean that the addition of more samples (collected in the same standardized manner as the previous samples) will not cause meaningful changes in the percent frequency of particular length categories.

Results

Gear Performance

We captured 6,906 channel catfish in 1997 and 1998, 204 with the electrofishing raft, 109 with bankpoles, and 6,593 with the HNSS.

Electrofishing raft.—The electrofishing raft required a mean of 8 person-hours for a single unit of effort involving a four-person crew; 0.5 h was required for setup, 1 h to cover all wadeable habitat, and 0.5 h to break down and remove the gear. The length-frequency histogram produced by this

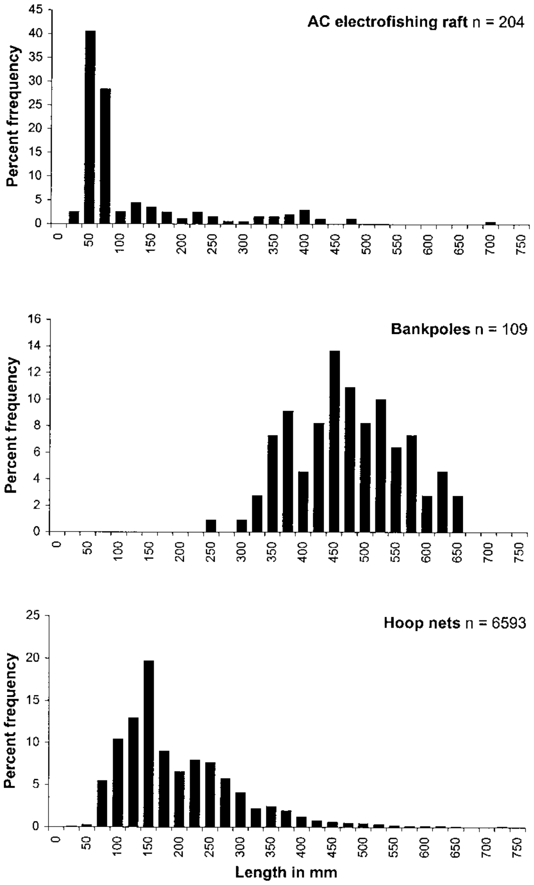

FIGURE 3.—Length-frequency histograms by gear type, including the total catch of channel catfish for 1997 and 1998.

TABLE 1.—Mean catch per unit effort (CPUE) of channel catfish for sampled months in the Grand River basin, Missouri, for 1997 and 1998 combined. Mean CPUE is the mean number of channel catfish captured by each of three types of gear: an AC electrofishing raft (AC-EF), a 30-bankpole set (BPS), and a 15-hoop-net saturation set (HNSS). Mean CPUE (SE) is presented untransformed; however, Tukey's honestly significant difference test was performed on log-transformed CPUE data when analysis of variance indicated significant ($P < 0.05$) differences. Different small letters indicate significant ($P < 0.05$) differences among samples; N is the number of samples.

Gear	Month	N	Mean CPUE	SE	Tukey's test
AC-EF	Jun	5	3.4	2.46	
	Aug	15	9.93	2.25	
	Oct	4	9.75	5.06	
BPS	Jun	26	1.65	0.23	
	Aug	29	1.45	0.24	
	Oct	25	1.24	0.29	
HNSS	Jun	20	23.85	5.9	y
	Aug	25	35.16	10.41	y
	Oct	20	107.25	23.51	z

gear was dominated by the length categories of 26–50 mm and 51–75 mm and included 19 length categories ranging from 26−50 mm up to 676–700 mm total length (Figure 3). Mean CPUE among months was 3.4–9.9 (Table 1) and did not vary significantly ($F = 0.46$; df = 2, 16; $P = 0.64$). Mean CPUE between streams was 0.5–11.13 (Table 2) and did not vary significantly ($F = 3.34$; df = 2, 16; $P = 0.06$), indicating that electrofishing raft sampling as described here was not sensitive to population size. The probability of each interaction term exceeded 0.05 (Table 3). Only two of six possible within-month mean CPUE comparisons were completed, because of high flows (Table 4). Mean CPUE within August 1997 and August 1998 did not differ ($F = 0.16$; df = 1, 4; $P = 0.71$; and $F = 0.02$; df = 1, 2; $P = 0.89$, respectively). The effect of stream stage fluctuation was not evaluated for this sampling gear because fluctuations greater than 30 cm in 24 h were associated with the high flows that precluded sampling.

Bankpoles.—A mean of 3.5 person-hours was required for bankpole sampling, approximately 0.75 h for the two–person crew to set up and bait the bankpoles and another 1 h to pick them up and collect catfish. The size selectivity of this sampling gear was for fish ranging from 226–250 mm up to 626–650 mm (Figure 3). The length frequency included 16 length categories and was not dominated by specific categories. Mean CPUE among months was 1.24–1.65 (Table 1) and did not vary significantly ($F = 0.14$; df = 2, 62; $P = 0.87$). Mean CPUE among streams was 1.23–1.75 (Table 2) and did not vary significantly ($F = 0.85$; df = 2, 62;

TABLE 2.—Mean catch per unit effort (CPUE) of channel catfish by stream in the Grand River basin, Missouri, for 1997 and 1998 combined. Stream abbreviations are as follows: Y is Yellow Creek, B is Big Creek, and G is the Grand River. See the caption to Table 1 for additional explanations.

Gear	Stream	N	Mean CPUE	SE	Tukey's test
AC-EF	Y	4	0.5	0.28	
	B	12	9.5	2.08	
	G	8	11.13	3.7	
BPS	Y	24	1.75	0.27	
	B	30	1.23	0.2	
	G	26	1.42	0.29	
HNSS	Y	18	23.0	6.62	y
	B	24	23.79	5.28	y
	G	23	109.39	21.48	z

TABLE 3.—Summary of results from three-way analysis of variance for standardized AC raft electrofishing (AC-EF), 30-bankpole sets (BPS), and 15-hoop-net saturation sets (HNSS) evaluating the effects of year, stream, and month on catch per unit effort. Catch per unit effort data were log-transformed to better approximate a normal distribution. Lack of data precluded analysis of all interaction terms for the electrofishing raft samples.

Gear	Effect	F	df	P
AC-EF	Year	1.0	1, 16	0.33
	Stream	3.34	2, 16	0.06
	Month	0.46	2, 16	0.64
	Year × stream	0.0	1, 16	0.95
	Year × month		0, 16	
	Stream × month		0, 16	
	Year × stream × month		0, 16	
BPS	Year	0.75	1, 62	0.39
	Stream	0.85	2, 62	0.43
	Month	0.14	2, 62	0.87
	Year × stream	0.29	2, 62	0.75
	Year × month	0.08	2, 62	0.93
	Stream × month	0.61	4, 62	0.66
	Year × stream × month	0.66	4, 62	0.62
HNSS	Year	5.63	1, 50	0.02
	Stream	10.08	2, 50	0.0002
	Month	3.46	2, 50	0.04
	Year × stream	0.16	2, 50	0.85
	Year × month	0.5	2, 50	0.61
	Stream × month	2.19	4, 50	0.08
	Year × stream × month	0.32	1, 50	0.57

$P = 0.43$), indicating that bankpole sampling as described here was not sensitive to population size. The probability of each interaction term exceeded 0.05 (Table 3). All six possible within-month mean CPUE comparisons were made (Table 4). Mean CPUE differed between the 1st (2.75) and 4th (0.75) weeks in August 1997 ($F = 17.93$; df = 1, 6; $P = 0.006$); mean CPUE did not differ between the first and fourth weeks in other comparisons. Stream stage fluctuation affected the mean CPUE of bankpole sampling more than that of the other gears. As study streams rose and fell, individual bankpoles were either completely submerged (making them difficult to retrieve) or left with the hooks out of the water. Because our unit of effort was based on 30 poles per sampling effort, no formal comparison of mean CPUE could be performed.

Hoop net saturation set.—A mean of 6.0 person-hours were required for the HNSS, 1.5 h for the two-person crew to bait and deploy the nets into a 200-m site and 1.5 h to collect the nets and fish. The HNSS sampled the broadest range of length categories (27) of the three gears evaluated, ranging from fish 0–25 mm to those 626–650 mm in length. Mean CPUE among months was 23.9–107.3 (Table 1) and varied among seasons ($F = 3.46$; df = 2, 50; $P = 0.04$), with highest catch rates in October (Tukey's procedure; $P < 0.05$). Mean CPUE among streams was 23–109.39 (Table 2) and did vary significantly ($F = 10.08$; df = 2, 50; $P = 0.0002$), indicating that HNSS sampling as described here was sensitive to population size. Mean CPUE was greatest in Grand River and differed from that in Big Creek and Yellow Creek (Tukey's procedure; $P < 0.05$). The probability of each interaction term exceeded 0.05 (Table 3). Five of six possible within-month mean CPUE comparisons were made (Table 4). Mean CPUE did not differ between the first and fourth weeks in any month investigated. Stream stage fluctuations affected the mean CPUE of the HNSS. In samples where stage changed less than 30 cm, CPUE ranged from 0 to 432, with a mean and standard error of 57.74 ± 16.86. This differed significantly ($F = 10.94$; df = 1, 83; $P = 0.001$) from the CPUE of samples where stage varied more than 30 cm, which ranged from 2 to 802, with a mean and standard error of 147.8 ± 42.14.

Predicting Effort and Precision

When used in stable water levels in October, HNSS combined the qualities that best addressed project objectives. Accordingly, this sampling method was used to estimate the effort required to achieve particular levels of precision for CPUE and length frequencies.

CPUE.—With HNSS sampling, 96 samples are required to produce a coefficient of variation of 10%, whereas only 4 samples are required for a

TABLE 4.—Mean catch per unit effort (CPUE) of within-month channel catfish sampling in the Grand River basin, Missouri. Sampling occurred Monday–Friday during the first and fourth weeks of a calendar month. Mean CPUE is the mean of the total number of channel catfish captured by each gear: AC electrofishing raft (AC-EF), 30 bankpole sets (BPS), and 15-hoop-net saturation sets (HNSS). Mean CPUE (SE) is presented untransformed; however, analysis-of-variance tests of significance were performed on log-transformed data; *N* is the number of samples.

Gear	Month and year	Week	*N*	Mean CPUE	SE	*F*	df	*P*
AC-EF	Jun 1997	1						
		4						
	Jun 1998	1	3	0.33	0.33			
		4						
	Aug 1997	1	4	6.25	1.49	0.16	1, 4	0.71
		4	2	8	4			
	Aug 1998	1	3	14.67	7.26	0.02	1, 2	0.89
		4	1	13				
	Oct 1997	1	3	12.67	5.84			
		4						
	Oct 1998	1						
		4						
BPS	Jun 1997	1	3	2	0	0.43	1, 5	0.54
		4	4	1.75	0.48			
	Jun 1998	1	4	2.25	0.95	0.94	1, 4	0.39
		4	2	1	0			
	Aug 1997	1	4	2.75	0.25	17.93	1, 6	0.006
		4	4	0.75	0.25			
	Aug 1998	1	3	1.33	0.33	7.83	1, 5	0.04
		4	4	0.25	0.25			
	Oct 1997	1	4	0.5	0.5	4.57	1, 6	0.08
		4	4	2	0.71			
	Oct 1998	1	3	0.33	0.33	1.62	1, 4	0.27
		4	3	2	1.15			
HNSS	Jun 1997	1	1	4		0.76	1, 3	0.45
		4	4	2	0.71			
	Jun 1998	1	4	23.25	19.99			
		4						
	Aug 1997	1	4	4.5	1.5	3.31	1, 6	0.12
		4	4	25.25	17.26			
	Aug 1998	1	4	20.25	6.61	2.2	1, 6	0.19
		4	4	10.75	2.29			
	Oct 1997	1	4	55.75	36.54	2.64	1, 6	0.16
		4	4	228	85.71			
	Oct 1998	1	2	108.5	70.5	0.3	1, 4	0.61
		4	4	116.25	21.77			

coefficient of variation of 50% (Figure 4). Substantial improvements in precision occur as effort increases from 1 sample to about 20.

Size structure.—As sample size increased, the median value of the MSD decreased. This indicates that the simulated length frequencies became more similar to the observed length frequencies as sample size increased. The relationship between sample size and MSD was nonlinear (Figure 5); the first several increases in the number of fish sampled (up to 400) reduced the MSD more than subsequent increases.

Discussion

Too few channel catfish were produced by bankpole sampling for it to be used as the sole sampling method. However, because setlines are a legal method and represent the expected creel of a setline angler, managers may wish to use them in a standardized fashion to contribute larger fish to HNSS-based data sets. That bankpole sampling selected for larger channel catfish was consistent with previous studies (Santucci et al. 1999; Gale et al. 1999). The electrofishing raft was not well suited to sampling channel catfish because the abiotic conditions required for its use were often limiting and it also exhibited a strong bias toward age-0 fish, almost to the exclusion of the adult population.

The use of hoop nets to sample riverine catfishes has been widespread (Pierce et al. 1981; Hesse et al. 1982; Hubert and Schmitt 1982; Gerhardt and Hubert 1989; Holland and Peters 1992; Peters et al. 1992; Robinson 1994). However, evaluation of

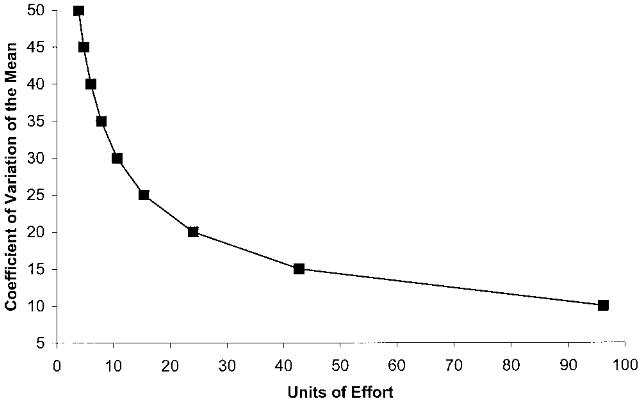

FIGURE 4.—Relationship between the units of effort (number of hoop net saturation sets (HNSS) and the precision of the resulting data expressed as the coefficient of variation of the mean. Coefficients of variation were calculated from HNSS catch data collected during stable water levels in October 1997 and 1998.

their precision and efficiency has been rare. Comparison of studies has been limited by differences in methodology (i.e., baits, mesh sizes, seasons, and net placement). Robinson (1994) reported that 25-mm-mesh hoop nets provided a representative sample of channel catfish populations in the Missouri River, Missouri. However, 25-mm-mesh hoop nets typically catch relatively few age-0 and age-1 channel catfish (Holland and Peters 1992). We recommend integrating smaller-mesh nets as our 13-mm-mesh nets readily captured age-0 and age-1 channel catfish and thus may provide important management insight into the area-specific reproductive potential of small to medium-size prairie watersheds.

Our results for the HNSS during October stable water levels were used to estimate the effort needed to gain a desired level of precision. While managers may choose any precision level that they feel to be appropriate, we offer a few recommendations. A 20% coefficient of variation of the mean is often desirable (Peterson and Rabeni 1995; Neumann et al. 1995), which would require 24 units of effort. This level of effort could be achieved by running the HNSS concurrently at different sites. However, the loss of confidence entailed in accepting a 25% or 30% coefficient of variation is probably offset by the reduction in required effort (15 and 11 repetitions, respectively), and such a level of confidence may be sufficient for many management considerations. Guidelines for determining the number of fish needed to build a re-

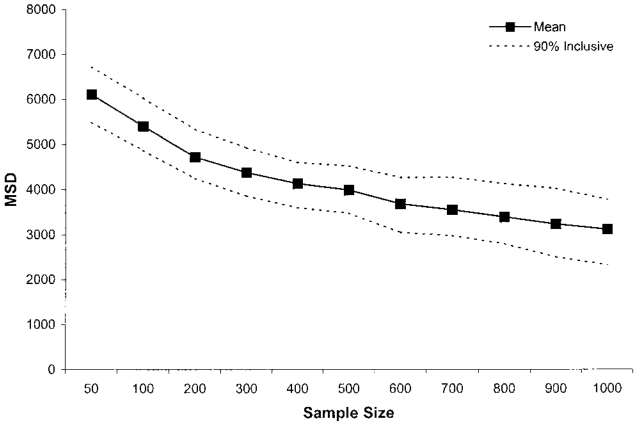

FIGURE 5.—Relationship between the mean-squared difference between sample and reference length frequencies and sample size (number of channel catfish). Differences were calculated by bootstrap sampling from and then comparison with the length frequencies of catch data from hoop net saturation sets deployed during stable water levels in October 1997 and 1998.

peatable length-frequency histogram are lacking (Vokoun et al., in press). However, our results suggest that sampling at least 400 channel catfish will reduce much of the difference between sample length frequencies and a stabilized length frequency based on an unusually large sample size. A sampling effort of 11−15 d in the Grand River basin would conservatively produce a length frequency based on more than 750 channel catfish, which would allow both size structure and abundance data to be collected simultaneously.

The HNSS as a unit of sampling effort can be used in small to medium-size streams across a wide range of physical conditions. The predicted effort and precision provided by this study are applicable to a limited geographical area. Biologists in other systems can derive area-specific effort and precision estimates as they accumulate samples. Our estimates are, however, based on data encompassing both channelized and unchannelized reaches, varying levels of natural riffle−pool development and woody debris, and a range of stream sizes; as a consequence, we feel that our estimates are an acceptable starting point for biologists working in other systems. Biologists in northern climates may need to adjust the seasonal timing of sampling. The channel catfish population in the lower Wisconsin River has been reported to begin downstream migration to the upper Mississippi River in mid-October (Pellett et al. 1998). Tag returns in the Grand River basin indicated that downstream migration was occurring in mid-November (Vokoun 1999). In ecological terms, the targeted sampling period is during fall when stream temperatures have cooled to 14–19°C and before the onset of migration toward overwintering habitats. The protocol we described for the HNSS will increase the comparability of samples and allow biologists to begin to monitor trends in abundance and size structure more confidently. This will allow evaluation of management objectives and actions, such as harvest limitations or size restrictions.

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