2-2008

Gear-Specific Population Demographics of Channel Catfish in a Large Midwestern River

Robert E. Colombo
Southern Illinois University Carbondale

Quinton E. Phelps
Southern Illinois University Carbondale

James E. Garvey
Southern Illinois University Carbondale

Roy C. Heidinger
Southern Illinois University Carbondale

Tom Stefanavage
Indiana Department of Natural Resources

Published in *North American Journal of Fisheries Management*, Vol. 28, Issue 1 (February 2008) at doi: 10.1577/M06-200.1

Recommended Citation

Colombo, Robert E., Phelps, Quinton E., Garvey, James E., Heidinger, Roy C. and Stefanavage, Tom. "Gear-Specific Population Demographics of Channel Catfish in a Large Midwestern River." (Feb 2008).

North American Journal of Fisheries Management 28:241–246, 2008

DOI: 10.1577/M06-200.1

[Management Brief]

Gear-Specific Population Demographics of Channel Catfish in a Large Midwestern River

ROBERT E. COLOMBO,* QUINTON E. PHELPS, JAMES E. GARVEY, AND ROY C. HEIDINGER
Fisheries and Illinois Aquaculture Center, Department of Zoology,
Southern Illinois University, Carbondale, Illinois 62901-6511, USA

TOM STEFANAVAGE
Indiana Department of Natural Resources, Division of Fish and Wildlife, Winslow, Indiana 47598, USA

Abstract.—Various gear types have been used to sample populations of channel catfish *Ictalurus punctatus* in lotic systems. However, these gears produce different population characteristics (i.e., recruitment, growth, and mortality). We compared the population demographics of channel catfish in the Wabash River, Indiana, sampled with baited 25- and 32-mm-bar mesh hoop nets and three-phase alternating current (AC) electrofishing. Based on catch per unit effort, the relative abundance of channel catfish sampled with 32-mm hoop nets was lower than that of fish sampled with 25-mm hoop nets and AC electrofishing. Each gear type also resulted in a different length frequency, mean length increasing progressively in sampling with 25-mm hoop nets, 32-mm hoop nets, and AC electrofishing. Similarly, age-frequency distributions differed among gears. The 25-mm hoop nets biased the age structure toward younger individuals (mean age = 2.5), whereas both 32-mm hoop nets (mean age = 4.0) and AC electrofishing (mean age = 5.8) included older fish. Catch-curve analysis generated different mortality rates for the three gear types, the mortality rate being highest (50%) in fish sampled with 25-mm hoop nets. Gear-specific size and age structures led to differences in von Bertalanffy statistics among the 25-mm hoop nets and AC electrofishing, while the results for 32-mm hoop nets were uninterpretable. Because the different gears led to conflicting parameter estimates, management practices based on sampling with single gears may be contradictory. Given the differences in gear selectivity, biologists need to approach management cautiously until calibration to the true size and age structure is conducted.

Populations of channel catfish *Ictalurus punctatus* provide important recreational and commercial fisheries throughout the United States. Catfish are considered moderately or highly important to anglers in 32 states and are managed in 34 states (Michaletz and Dillard 1999), leading to high stocking rates of channel catfish by both federal and state agencies (Heidinger 1999). Although harvest of these fisheries has declined since the early 1980s (Heidinger 2000; FAO 2003), 28 states still have commercial catfish fisheries (Michaletz and Dillard 1999). In the Midwestern United States, commercial catfish fisheries are particularly important. For example in Illinois, catfish account for 25% of the fish biomass harvested annually from rivers by commercial fishers (Maher 2002). Because commercial exploitation of catfish populations in the Mississippi River has led to recruitment overfishing (Pitlo 1997; Slipke et al. 2002), it is essential to monitor these populations, which requires an understanding of the ability for sampling gears to assess population demographics. Numerous studies have documented that an individual gear type may bias simple populations metrics such as age structure (Essington et al. 2002), growth (Lucena and O'Brien 2001), size structure (Sullivan and Gale 1999; Robinson 1999), and mortality (Beamesderfer and Rieman 1988).

Several gear types are used to assess the demographics of channel catfish populations. Hoop nets are commonly used to sample catfish populations in lentic and lotic environments (Gerhardt and Hubert 1989; Pugibet and Jackson 1991; Holland and Peters 1992; Stopha 1994; Robinson 1999; Sullivan and Gale 1999; Vokoun and Rabeni 1999; Jackson 2004). However, these gears vary in size selectivity and catch rates. Different mesh sizes produce different length-frequency distributions (Holland and Peters 1992), which may result in incorrect estimates of population metrics. Therefore, adequately describing the characteristics of a population sampled with hoop nets requires using a large complement of mesh sizes, which is often impractical. Alternating current (AC) and direct current (DC) electrofishing also have been used to sample catfish (Jacobs and Swink 1982; Santucci et al. 1999; Vokoun and Rabeni 1999). These gears have been shown to produce conflicting measures of efficiency (Heidinger et al. 1983) and size selectivity (Reynolds 1996; Santucci et al. 1999). Therefore, one must take care when using such methods to determine the size and age structure of the population. Because of the bias in any one particular gear type, a multi-gear approach for assessing populations may be beneficial.

We determined the size and age selectivity of two

---

* Corresponding author: rcolombo@siu.edu

Received August 9, 2006; accepted June 27, 2007

different hoop net mesh sizes and AC electrofishing on channel catfish populations in a large Midwestern river. This approach forms the basis for developing a standardized sampling protocol for managing channel catfish in lotic systems.

Methods

We sampled catfish in the Wabash River, Indiana, from river kilometer (rkm) 550 through rkm 9.6 (measuring from its confluence with the Ohio River) during fall (September through November) from 2001 through 2004. Nineteen 1.6-km sites were sampled with baited 25- and 32-mm-bar mesh hoop nets and three-phase AC electrofishing (Honda 4,000-W, 220-V generator). We used AC electrofishing because it is more efficient than DC (Heidinger et al. 1983). Hoop nets were 1 m in diameter, 3 m long, and double-throated with six fiberglass hoops. A 457-mm polyvinyl chloride tube drilled with 12.5-mm-diameter holes was filled with 2 kg of rancid cheese and attached with a clip to the innermost hoop. Baiting increases catch during nonspawning periods (Gerhardt and Hubert 1989). All hoop nets were set in the afternoon (1300–1500 hours) and retrieved the next morning (0800–1000 hours); therefore, we calculated catch per unit effort (CPUE) as number of fish per net-night. Nets were deployed parallel to the flow with an anchor attached to the most upstream portion of the net. Five 25-mm hoop nets and five 32-mm hoop nets were set randomly at each site during each sampling trip ($N = 10$ per site).

Shoreline electrofishing was conducted twice each fall (at intervals of at least 2 weeks) at each site in all 4 years except in fall 2002 and 2004, when only 14 and 18 sites, respectively, could be sampled owing to low water. Electrofishing commenced on one bank and continued downstream until 1.6 km had been covered; this process was then repeated on the opposite bank. To standardize effort, we kept voltage and amperage constant with the same wattage generator. Care was given to maintain a constant speed of 1.6 km/h so that the entire site was sampled in approximately 1 h. For electrofishing, the CPUE was determined as the number of channel catfish sampled per hour.

All channel catfish were identified and measured to the nearest millimeter total length. The proportional stock density (PSD; [number of fish $\geq$ quality length/number of fish $\geq$ stock length] $\times$ 100) and relative stock density (RSD-P; [number of fish $\geq$ preferred length/number of fish $\geq$ stock length] $\times$ 100) indices were calculated by using the length-classes (sub–stock length, <280 mm; stock length, 280 mm; quality length, 410 mm; and preferred length, 610 mm) given by Gabelhouse (1984). The 95% confidence intervals (CIs) for PSD values were calculated from the method described by Gustafson (1988) to estimate statistical precision of the index.

For analysis of age structure, the left spine was disarticulated from each catfish and a 700-μm-thick section of the articulating process was removed with a Beuhler low-speed Isomet saw. Spines were analyzed under a dissecting microscope (10–45×) using reflected light and aged independently by two readers. Any disagreements between readers were resolved by consensus. If consensus could not be reached, then the fish was removed from the sample. Instantaneous mortality (Z) was estimated from the slope of the catch curve, which was converted to annual percent mortality ($\text{APM} = [1 - e^{-Z}] \times 100$; Ricker 1975). To dampen the effects of variable year-class strength, we combined data across the 4 years (Ricker 1975). For each gear type, we removed the age-classes that contained fewer than five individuals to reduce the variation caused by ages and sizes less susceptible to that gear (Van Den Avyle and Hayward 1999). For all gears, growth was assessed with a von Bertalanffy model, using length at capture to estimate length at age. The von Bertalanffy model assumes the form $L_t = L_\infty(1 - e^{-K[t-t_0]}$, where L_∞ is the theoretical maximum length, K is the growth constant, and t_0 is the age at which length is zero.

Mean CPUE between hoop nets was compared by using a t-test. Catch per unit effort data were $\log_{10}(x + 1)$ transformed to meet the assumptions of homogeneity of variance and normality (Sokal and Rohlf 1995). To compare length- and age-frequency distributions, we used Kolmogorov–Smirnov nonparametric tests (KS). To compensate for experimentwise error rate, we applied the Bonferroni correction to the P-values for multiple comparisons (i.e., $\alpha = 0.05/3 = 0.017$; Sokal and Rohlf 1995). To determine whether stock density indices differed between gears, we used a chi-square test (Conover 1980). Further, we assessed age-frequency distributions for skewness and kurtosis to determine differences from normality. In determining whether the slopes of the catch curves differed among gear types, a test for homogeneity of slopes was conducted (test for interaction in analysis of covariance [ANCOVA]). To determine whether growth curves differed among gears, we analyzed the residual sums of squares of the different curves (Chen et al. 1992). Unless otherwise stated, the a priori level of significance was 0.05.

Results and Discussion

Catch Efficiency

A total of 2,655 channel catfish were sampled during the 4 years of this study. Of these, 1,335 (50.3%) were sampled with 143.5 h of electrofishing. Hoop netting accounted for 49.7% of the catfish sampled, the 25-mm

TABLE 1.—Catch per unit effort (CPUE) for channel catfish sampled in the Wabash River during 2001–2004. Values are fish/net-night for hoop net sampling and fish/hour for electrofishing; *N* = number of fish.

	25-mm hoop nets			32-mm hoop nets			AC electrofishing		
Year	Net-nights	*N*	Mean CPUE (SE)	Net-nights	*N*	Mean CPUE (SE)	Hours	*N*	Mean CPUE (SE)
2001	140	256	1.8 (0.6)	140	66	0.5 (0.1)	37.9	247	6.4 (0.7)
2002	120	75	0.6 (0.2)	120	22	0.2 (0.1)	33.1	271	8.2 (1.0)
2003	197	649	3.3 (0.6)	197	105	0.5 (0.1)	36.9	471	12.5 (2.0)
2004	172	107	0.6 (0.2)	167	26	0.2 (0.1)	35.6	346	9.6 (1.5)
Total	629	1087	1.7 (0.3)	624	219	0.3 (0.1)	143.5	1335	9.2 (0.7)

hoop nets sampling 1,087 channel catfish during 629 net-nights and the 32-mm hoop nets sampling 219 channel catfish during 624 net-nights (Table 1). Overall, the mean CPUE of 25-mm hoop nets was higher than that of the 32-mm hoop nets ($t = 7.137$, df $= 246$, $P < 0.001$).

Size Selectivity

Electrofishing sampled larger fish than either the 25- or 32-mm hoop nets (Figure 1). Length-frequency distribution of catfish sampled with electrofishing differed from those determined with the 25-mm (KS $= 17.42$, $P < 0.001$) and the 32-mm hoop nets (KS $=$ 5.64, $P < 0.001$). Further, the length-frequency distribution of catfish sampled with the 25-mm hoop nets differed from that for those sampled with the 32-mm hoop nets (KS $= 7.63$, $P < 0.001$). The 25-mm hoop nets sampled more small channel catfish and may have contributed to the higher catch rates relative to the 32-mm hoop nets. However, this gear failed to sample as many channel catfish larger than 350 mm as the 32-mm hoop nets did (Figure 1). Similarly, other studies have shown that hoop net mesh size may influence length-frequency distributions, such that smaller mesh nets sample smaller catfish (Holland and Peters 1992; Vokoun and Rabeni 1999). Alternating current electrofishing sampled the largest channel catfish most efficiently but may have underestimated the relative abundance of channel catfish smaller than 300 mm. These results differ markedly from previous research, which suggested that small channel catfish were more susceptible to electrofishing than large catfish (Santucci et al. 1999).

Corresponding to the differing length-frequency distributions, the stock density indices differed among gear types. The PSD and RSD-P values for electrofishing exceeded those for 25-mm hoop nets (PSD: $\chi^2 = 316$, $P < 0.001$; RSD: $\chi^2 = 9.4$, $P < 0.01$; Figure 1). Similarly, the PSD value for electrofishing was greater than that of 32-mm hoop net (χ^2 = 124, $P < 0.01$; Figure 1). There was, however, no difference in RSD-P between these gears (χ^2 = 0.19, $P > 0.017$). In addition, the PSD value for the 32-mm hoop net was

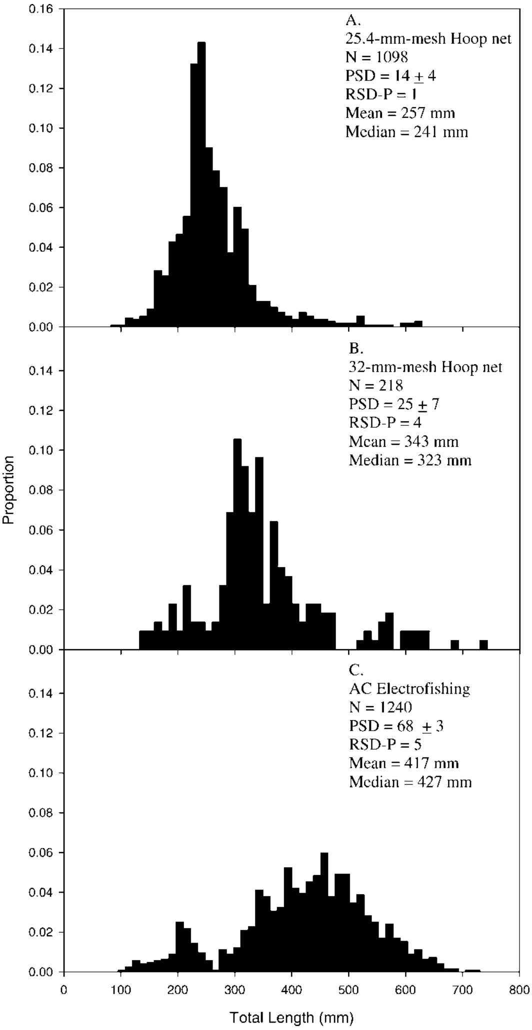

FIGURE 1.—Length-frequency distributions for channel catfish sampled with **(A)** 25-mm hoop nets, **(B)** 32-mm hoop nets, and **(C)** AC electrofishing in the Wabash River during fall 2001–2004. Ninety-five-percent confidence intervals are given for PSD (the proportional stock density), means for RSD-P (the relative stock density of preferred-length fish).

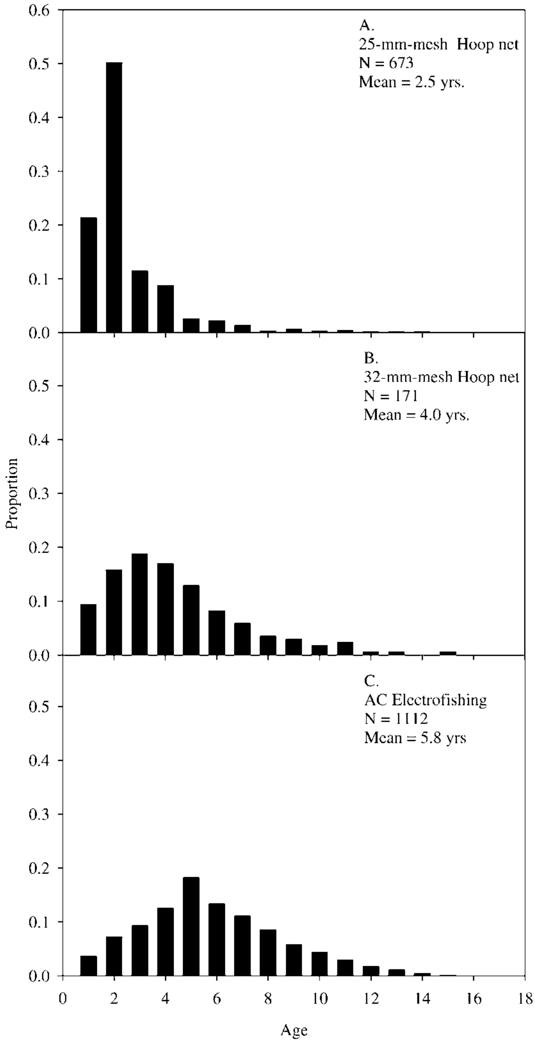

FIGURE 2.—Age-frequency distributions for channel catfish sampled with **(A)** 25-mm hoop nets, **(B)** 32-mm hoop nets, and **(C)** AC electrofishing in the Wabash River during fall 2001–2004.

greater than that of the 25-mm hoop net ($\chi^2 = 9.3$, $P < 0.01$; Figure 1), but there was no difference in RSD-P between these gears ($\chi^2 = 9.3$, $P > 0.017$; Figure 1). Sub–stock length fish made up 64.6% of the channel catfish sampled with the 25-mm hoop nets but only 17.9% with 32-mm hoop nets and 12.6% with AC electrofishing.

Age Selectivity

Differences in the size selectivity of the gears led to differences in age distributions. Channel catfish fully recruited at age 2 in the 25-mm hoop nets, at age 3 in the 32-mm hoop nets, and at age 5 in AC electrofishing (Figure 2). Fish age 1–4 dominated the 25-mm hoop net age-frequency distribution leading to a strongly positively skewed, leptokurtic distribution (skewness = 2.8 ± 0.09 [mean ± SE], kurtosis = 11.1 ± 0.19; Figure 2). Catfish sampled with the 32-mm hoop nets displayed a slightly positively skewed, platykurtic distribution (skewness = 1.2 ± 0.19, kurtosis = 1.5 ± 0.37; Figure 2). The age-frequency distribution of catfish sampled with electrofishing showed a weakly positively skewed platykurtic distribution (skewness = 0.5 ± 0.1, kurtosis = –0.02 ± 0.15). Thus, age-frequency distributions differed among gears (all comparisons: KS = 3.44–12.90, $P < 0.001$). Coinciding with size structure, an individual gear may provide biased measures of age structure.

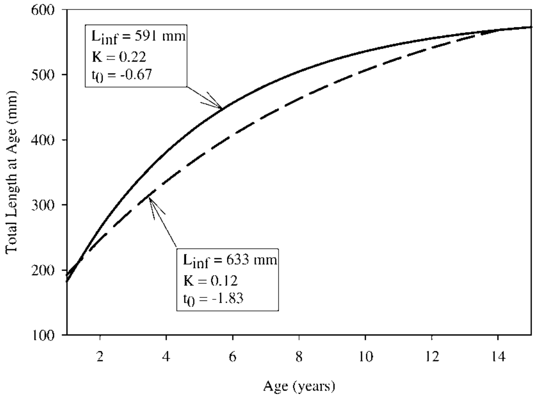

FIGURE 3.—Graphs of the von Bertalanffy models ($P < 0.01$) for channel catfish sampled with electrofishing and 25-mm hoop nets in the Wabash River during fall 2001–2004; see text for parameter descriptions.

Different age distributions caused mortality rate estimates to differ among gear types (all comparisons, ANCOVA, $P < 0.001$). Annual percent mortality (APM) was lowest for the 32-mm hoop net ($r^2 = 0.97$, $P < 0.01$, APM = 28%), highest for the 25-mm hoop nets ($r^2 = 0.93$, $P < 0.01$, APM = 50%), and intermediate for the electrofishing sample ($r^2 = 0.96$, $P < 0.01$, APM = 31%). Growth estimated by the von Bertalanffy models differed between the 25-mm hoop nets and electrofishing ($F = 4.75$, df = 3, 22, $P < 0.01$), such that the catfish sampled with the former grew more slowly but reached a larger size (Figure 3). Similarly, Lucena and O'Brien (2001) noted unusable parameters (i.e., L_∞ and K) of growth based on a single gear. Unfortunately, we were unable to compare growth derived from the 32-mm hoop net catches because of nonsensical results for L_∞ (930 mm) and K (0.06).

In summary, 25-mm hoop nets sampled more small, young channel catfish but few large or old individuals. This reduced PSD values, strongly skewed age structure, increased mortality rates, and reduced growth in comparison with the other two gears. The 32-mm bar mesh hoop nets sampled large catfish; however, the catch rate of all sizes of catfish was low, resulting in similar mortality estimates generated by electrofishing and unintepretable growth patterns. Electrofishing sampled many large channel catfish, but failed to sample young, small catfish. Electrofishing may have best estimated adult mortality (age > 5 years), because the gear produced the largest number of adult age-classes. Therefore, developing sound sampling designs for river catfish must take into account the apparent size- and age-related biases associated with each gear.

Management Implications

Because each of the three gear types led to different estimates of the population characteristics of channel catfish, use of a single gear type may result in incorrect management decisions. However, these issues could be resolved by obtaining multiple years of data and knowing the limitations of the gears. Care must be taken to use multiple gear types that will provide the best estimates of size and age structure. For example, we suggest using 25-mm hoop nets for indexing relative abundance and mortality of young catfish and using AC electrofishing to determine growth, mortality, and an index of adult density. This multiple-gear approach differs from previous research on channel catfish, which suggested using hoop nets to assess population demographics (Vokoun and Rabeni 1999). Using multiple gears will allow managers to make informed management decisions and gather accurate and precise measures of population metrics. However, we caution that the use of AC electrofishing may provide results that differ from those obtained with DC electrofishing, and using different complements of hoop-net mesh sizes may alter results. With the contradictory estimated population metrics among gears, we recommend that future researchers "ground truth" accuracy of each gear by comparisons with rotenone samples or some other technique that provides an unbiased estimate of population structure.

References

Beamesderfer, R. C., and B. E. Rieman. 1988. Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505–510.

Chen, Y., D. A. Jackson, and H. H. Harvey. 1992. A comparison of von Bertalanffy and polynomial functions in modeling fish growth data. Canadian Journal of Fisheries and Aquatic Sciences 49:1228–1235.

Conover, W. J. 1980. Practical nonparametric statistics, 2nd edition. Wiley, New York.

Essington, T. E., D. E. Schindler, R. J. Olson, J. F. Kitchell, C. Boggs, and R. Hilborn. 2002. Alternative fisheries and the predation rate of yellowfin tuna in the eastern Pacific Ocean. Ecological Applications 12:724–734.

FAO (Food and Agriculture Organization of the United Nations). 2003. Yearbook of fisheries statistics: capture and production, volume 9611. FAO, Rome.

Gabelhouse, D. W., Jr. 1984. A length categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Gerhardt, D. R., and W. A. Hubert. 1989. Effect of cheese bait on seasonal catches of channel catfish in hoop nets. North American Journal of Fisheries Management 9:377–379.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139–141.

Heidinger, R. C. 1999. Stocking for sport fisheries enhancement. Pages 375–401 *in* C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Heidinger, R. C. 2000. Commercial harvest and history of major freshwater finfish species. Page 209–252 *in* R. E. Martin, E. P. Carter, G. J. Fhik, and L. M. Davis, editors. Marine and freshwater products handbook. Technomic Publishing, Lancaster, Pennsylvania.

Heidinger, R. C., D. R. Helms, T. I. Hiebert, and P. H. Howe. 1983. Operational comparison of three electrofishing systems. North American Journal of Fisheries Management 3:254–257.

Holland, R. S., and E. J. Peters. 1992. Differential catch by hoop nets of three mesh sizes in the lower Platte River. North American Journal of Fisheries Management 12:237–243.

Jackson, D. C. 2004. Natural history and fisheries. Pages 15–35 *in* C. S. Tucker and J. A. Hargreaves, editors. Biology and culture of channel catfish. Elsevier, Amsterdam.

Jacobs, K. E., and W. D. Swink. 1982. Estimations of fish population size and sampling efficiency of electrofishing and rotenone in two Kentucky tailwaters. North American Journal of Fisheries Management 2:239–248.

Lucena, F. M., and C. M. O'Brien. 2001. Effects of gear selectivity and different calculation methods on estimating parameters of bluefish, *Pomatomus saltarix* (Pisces: Pomatomidae), from southern Brazil. U.S. National Marine Fisheries Service Fishery Bulletin 99:432–442.

Maher, R. 2002. 2001 Commercial catch report exclusive of Lake Michigan. Illinois Department of Natural Resources, Brighton.

Michaletz, P. H., and J. G. Dillard. 1999. A survey of catfish management in the United States and Canada. Fisheries 24(8):6–11.

Pitlo, J. 1997. Response of upper Mississippi River channel catfish populations to changes in commercial harvest regulations. North American Journal of Fisheries Management 17:848–859.

Pugibet, E. E., and D. C. Jackson. 1991. Sampling flathead catfish in small streams. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 43(1989):133–137.

Reynolds, J. B. 1996. Electrofishing. Pages 221–254 *in* B. R.

Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Ottawa.

Robinson, M. S. 1999. Evaluation of three gear types for sampling channel catfish in small impoundments. Pages 260–271 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: proceedings of the international ictalurid symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Santucci, V. J., Jr., D. H. Wahl, and D. F. Clapp. 1999. Efficiency and selectivity of sampling methods used to collect channel catfish in impoundments. Pages 317–328 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: proceedings of the international ictalurid symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Slipke, J. W., A. D. Martin, J. Pitlo, Jr., and M. J. Maceina. 2002. Use of the spawning potential ratio for the upper Mississippi River channel catfish fishery. North American Journal of Fisheries Management 22:1295–1300.

Sokal, R. R., and F. J. Rohlf. 1995. Biometry, 3rd edition. Freeman, New York.

Stopha, M. E. 1994. Hoop and mesh size influences on hoop net catches of buffalofishes (Catostomidae) and catfishes (Ictaluridae) in the upper Yazoo River basin of north-central Mississippi. Master's thesis. Mississippi State University, Mississippi State.

Sullivan, K. P., and C. M. Gale. 1999. A comparison of channel catfish catch rates, size distributions, and mortalities using three different gears in a Missouri impoundment. Pages 293–300 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: proceedings of the international ictalurid symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.

Van Den Avyle, M. J., and R. S. Hayward. 1999. Dynamics of exploited fish populations. Pages 127–163 *in* C. C. Kohler and W. A. Hubert, editors. Inland fisheries management in North America, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Vokoun, J. C., and C. F. Rabeni. 1999. Catfish sampling in rivers: a review of strategies. Pages 271–286 *in* E. R. Irwin, W. A. Hubert, C. F. Rabeni, H. L. Schramm, Jr., and T. Coon, editors. Catfish 2000: proceedings of the international ictalurid symposium. American Fisheries Society, Symposium 24, Bethesda, Maryland.