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# Comparison of Electrofishing and Experimental Gill Nets for Sampling Size Structure and Relative Abundance of Blue Catfish in Reservoirs

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*Abstract*.—Despite increasing popularity of blue catfish *Ictalurus furcatus* with anglers, effective management of blue catfish has been hindered by limited information on appropriate sampling methods. We compared the efficiency, precision, and accuracy of low-frequency pulsed-DC electrofishing and experimental gill nets for use in estimating relative population abundance and size structure in 12 reservoirs. Electrofishing yielded greater catch rates and lower mean relative standard error (RSE) than gill nets. Similarly, the number of samples necessary to achieve a RSE = 0.25 was lower with electrofishing in most reservoirs. Gill-net catch per unit effort (CPUE) and electrofishing CPUE were strongly correlated ($P < 0.01$), and length-frequency distributions were also similar between gear types in many reservoirs examined. Where they differed, there was no consistent pattern, suggesting that differences were due to low precision (caused by low numbers of fish captured) rather than gear bias. Our analysis indicated that both low-frequency pulsed-DC electrofishing and gill netting effectively measured relative abundance of blue catfish. In most cases, electrofishing was more efficient at estimating CPUE and size structure (requiring fewer samples to achieve comparable precision); thus, we recommend using this gear when estimating these parameters for reservoir blue catfish populations.

## Introduction

The wide U.S. distribution of blue catfish *Ictalurus furcatus*, as well as the ability of the species to attain large sizes (International Game Fish Association 2010), has, in recent years, heightened the species' popularity with anglers (Michaletz and Dillard 1999; Arterburn et al. 2002). This, in turn, has prompted fisheries managers to more actively manage this species (Graham 1999; Michaletz and Dillard 1999; Arterburn et al. 2002). However, effectiveness of blue catfish management and research efforts has been limited by a lack of information on appropriate sampling methods (Brown 2007). Consequently, there is little information concerning the biology of blue catfish population dynamics. This lack of knowledge has been suggested as one of the major constraints to the effective management of this species (Graham 1999; Michaletz and Dillard 1999).

Many sampling gears have been tested for possible use in sampling blue catfish, but many are ineffective or result in size-biased samples (Gale et al. 1999; Vokoun and Rabeni 1999). Slat traps and hoop nets are selective for channel catfish *I. punctatus* and rarely catch blue catfish (Posey and Schafer 1964; Holland and Peters 1992). Trotlines are effective but are biased towards large fish (Hale 1987; Vokoun and Rabeni 1999). In riverine environments, both low-frequency pulsed-DC electrofishing (Justus 1994; Rachels and Ashley 2002) and gill nets (Jackson 1995; Gale et al. 1999) effectively capture blue catfish, but the potential size bias of these gears has not been evaluated in this environment. Low-frequency pulsed-DC electrofishing in reservoir habitats appears to be both effective and unbiased with respect

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to size (Buckmeier and Schlechte 2009; Bodine and Shoup 2010) while electrofishing at higher frequencies (i.e., ≥ 60 pulses/s) is ineffective (Justus 1994). Blue catfish cannot, therefore, be effectively collected with standardized higher-frequency electrofishing samples commonly used by fisheries biologists to collect other sport fish. Little is known about the potential size bias of gill nets in reservoir habitats, but data from a single reservoir suggest potential size bias (Buckmeier and Schlechte 2009). Furthermore, the ability to obtain adequate samples of blue catfish utilizing gill nets has only been demonstrated in tailwater environments (e.g., Vokoun and Rabeni 1999) where fish were much more heavily concentrated than what is likely of reservoir blue catfish fisheries. However, gill nets are commonly used by fisheries biologists to sample other open-water sport fish in reservoirs, so the ability to use blue catfish data from this gear would be convenient if catch rates and size structure are unbiased. The purpose of this research was to compare efficiency, precision, and relative accuracy of low-frequency pulsed-DC electrofishing- and experimental gill net-derived estimates of relative abundance and size structure of blue catfish in reservoirs. Specifically, we had three objectives: (1) to compare number of samples required to estimate catch per unit effort (CPUE) at a target relative sampling error (RSE) of 25% using both gear types, (2) compare CPUE and size-structure indices between the two gear types, and (3) compare size-structure estimates derived from each gear type.

## Methods

Low-frequency pulsed-DC electrofishing (summer) and experimental gill nets (fall) were used to sample blue catfish once in each of 12 Oklahoma reservoirs from 2004 to 2008 in accordance with Oklahoma Department of Wildlife Conservation (ODWC) standardized sampling protocol. Electrofishing was conducted in 3–5 m water depth with a boat-mounted Smith-Root 5.0 Generator Powered Pulsator operated at 15 pulses/s and the high voltage setting (50–1,000 V). Percent of range was adjusted to standardize output at 4 A. Each station was sampled for 900 s with one electrofisher using two chase boats ($N$ = 8 stations per lake) with the electrofisher slowly moving towards surfacing fish. Each boat, including the electrofisher, was operated by a driver and two dip netters. Electrofishing stations were selected randomly with stratification by lower and upper reservoir habitat with equal representation of shoreline and pelagic habitat. Chase boats were necessary to collect fish that surfaced away from the electrofisher (Boxrucker and Kuklinski 2006). Total length (TL, mm) was recorded for all blue catfish collected.

Gill net samples were conducted with monofilament experimental gill nets constructed of eight 2-m-deep × 7.62-m-long panels with mesh sizes of 12.7, 15.9, 19.1, 25.4, 38.1, 50.8, 63.5, 76.2-mm bar mesh. Gill nets were set in the morning, fished overnight (18–24 h), and retrieved the following day. Gill-net sites were ODWC's historic sampling locations with stratification by lower and upper reservoir habitat with equal representation of shoreline and pelagic habitat. Gill nets were set on the bottom, in water 2–5 m deep in accordance with the ODWC's standardized sampling protocol, and sampling efforts ranged from 5 to 25 net-sets per gill-net survey based on reservoir size (Table 1).

To compare efficiency and precision of electrofishing and gill nets at measuring relative abundance, mean CPUE (number per hour for both gear types) and RSE (SE/mean; a measure of sampling precision equivalent to coefficient of variation of the mean) were calculated for both gear types. Mean CPUEs were formulated by calculating catch rates from individual samples and then averaging sample CPUEs and calculating associated SEs for each lake. The number of samples needed to achieve a desired precision of RSE = 0.25 was estimated based on the empirical 80th percentile of 500 randomly sampled and equally probable catch distributions obtained by resampling the observed data with replacement, as described in Dumont and Schlechte (2004). Resampling was done with a Visual Basic program in Microsoft Excel. Resulting estimates were compared to evaluate sampling precision and do not represent recommended sampling regimes. Linear regression was used to test for relationships between electrofishing CPUE and gill-net CPUE to determine if both gears provide similar information about relative abundance (suggesting equal accuracy of both gears).

To compare size structure of blue catfish sampled from electrofishing and gill nets, proportional size distributions were calculated from each gear (pooling all replicate samples for each lake within year) and compared via equivalency testing as described in Miranda (2007). Electrofishing- and gill-net-derived length-frequency distributions from each lake were also compared via Kolmogorov-Smirnov analysis. Neither gear had high enough proportional

TABLE 1. Summary of environmental data and mean blue catfish catch per unit effort (CPUE) from low-frequency pulsed-DC electrofishing (number/h from replicated 900-s samples) and experimental gill nets (number/h from replicate overnight [18–24h] sets) in 12 Oklahoma reservoirs. Relative sampling error (RSE) and number (*N*) of samples needed to achieve RSE < 0.25 are given as estimates of sample precision.

| Reservoir | Surface area (ha) | Mean depth (m) | Mean secchi (cm) | Conductivity range (μS/cm) | Electrofishing CPUE (# fish/h) | Electrofishing *N* of stations | Electrofishing RSE | Electrofishing *N* needed for RSE = 0.25 | Gill netting CPUE (# fish/h) | Gill netting *N* of nets | Gill netting RSE | Gill netting *N* needed for RSE = 0.25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arcadia | 1,546 | 4.6 | 67 | 210–422 | 118.50 | 8 | 0.18 | 6 | 0.12 | 10 | 0.26 | 12 |
| Ellsworth | 2,266 | 5.2 | 35 | 416–529 | 693.50 | 8 | 0.24 | 10 | 0.49 | 5 | 0.37 | 12 |
| Eufaula | 41,359 | 6.7 | 37 | 296–403 | 390.00 | 8 | 0.15 | 4 | 0.48 | 25 | 0.27 | 37 |
| Ft. Cobb | 1,659 | 5.9 | 58 | 445–547 | 113.00 | 8 | 0.29 | 13 | 0.10 | 5 | 0.21 | 5 |
| Ft. Gibson | 7,689 | 7.3 | 86 | 169–304 | 174.00 | 8 | 0.10 | 3 | 0.14 | 15 | 0.24 | 19 |
| Hugo | 5,362 | 3.2 | 33 | 55–78 | 633.50 | 8 | 0.11 | 3 | 0.31 | 15 | 0.38 | 47 |
| Kaw | 6,896 | 7.7 | 35 | 332–1,233 | 294.00 | 8 | 0.15 | 5 | 0.25 | 15 | 0.27 | 20 |
| Keystone | 10,530 | 7.2 | 43 | 592–5,688 | 224.00 | 8 | 0.28 | 12 | 0.19 | 15 | 0.30 | 25 |
| Oologah | 11,922 | 5.7 | 68 | 161–452 | 848.00 | 8 | 0.22 | 8 | 0.88 | 15 | 0.26 | 19 |
| Robert S. Kerr | 16,997 | 3.6 | 26 | 58–1,148 | 294.00 | 8 | 0.31 | 14 | 0.37 | 18 | 0.30 | 32 |
| Sardis | 5,811 | 5.0 | 72 | 47–81 | 61.00 | 8 | 0.23 | 9 | 0.07 | 15 | 0.31 | 29 |
| Waurika | 4,087 | 5.9 | 63 | 389–353 | 490.50 | 8 | 0.09 | 2 | 0.57 | 5 | 0.33 | 10 |
| | | | | Mean | 318.79 | 8 | 0.20 | 7 | 0.33 | 13 | 0.29 | 22 |

size distributions of preferred-length fish (PSD-*P*) to warrant analysis of larger proportional size distribution metrics (i.e., gill-net PSD-*P* ranged from 0 to 3 with a mean of 1.1, and electrofishing PSD-*P* ranged from 0 to 5 with a mean of 0.68).

## Results

Electrofishing produced greater catch rates and lower mean RSE than gill nets, providing more data with better precision (Table 1) using similar effort (i.e., both gears required approximately three boat-days of effort to sample one lake with the number of sites used in this study). Similarly, the number of samples necessary to achieve a RSE = 0.25 was lower with electrofishing (mean = 7, SE = 1.2, range = 2–14) than with gill nets (mean = 22, SE = 3.5, range 5–47) in all reservoirs except Ft. Cobb Reservoir. Estimates of relative abundance (i.e., CPUE) from gill nets and electrofishing were strongly correlated ($r^2 = 0.781$; $P < 0.01$; Figure 1), suggesting that both gears would produce similar estimates of relative population density. Thirty-three percent of the study reservoirs had PSD values from gill nets and electrofishing that were ±5 units of each other (Miranda 2007), and 50% of the reservoirs were within ±10 PSD units (Bodine et al. 2011, this volume), suggesting no strong bias in either gear type in many cases (Table 2). For reservoirs where gill-net and electrofishing PSD differed, gill nets consistently had the larger value. Length-frequency distributions were similar between gear types in some, but not all, of the study reservoirs. However, where they differed, no size-classes were consistently over- or underrepresented (Figure 2). Therefore, we found no consistent evidence of systematic bias in the sampled length distributions for either gear considering their respective precision at moderate sampling effort (i.e., sampling effort used in this study), but gill-net catches were skewed toward larger fish in some reservoirs. However, a need for high gill-net catch rates (and/or high levels of replication) when investigating population size metrics is clearly illustrated.

## Discussion

Low-frequency pulsed-DC electrofishing and gill nets effectively measured relative abundance for

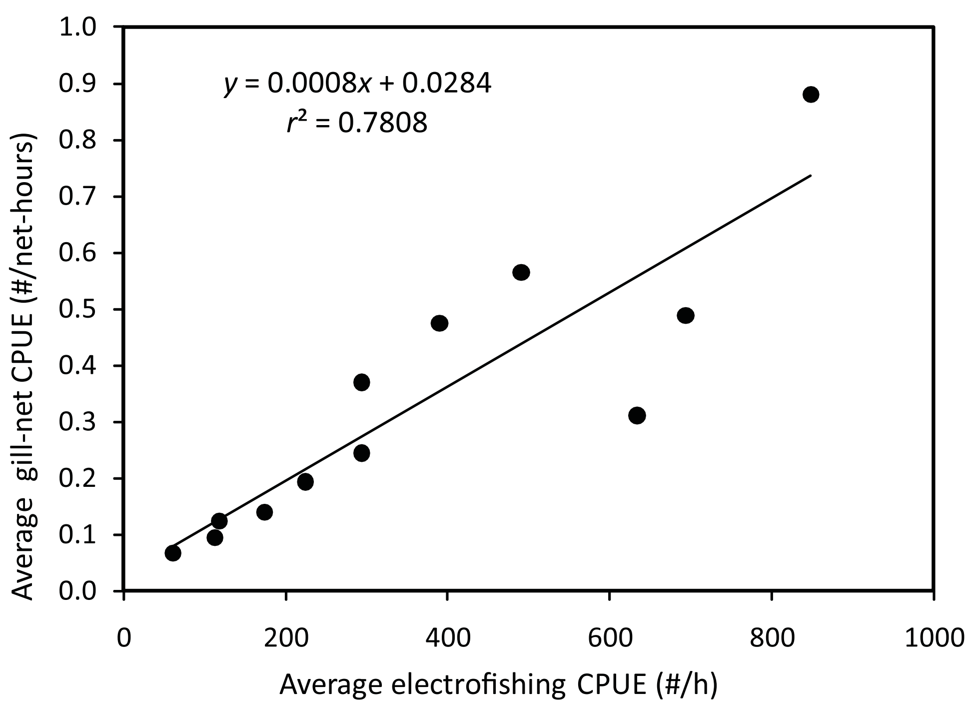


FIGURE 1. Relationship between low-frequency pulsed-DC electrofishing catch per unit effort (CPUE; number/h from replicated 900-s samples) and experimental gill-net CPUE (number/h from replicate overnight [18–24 h] sets) for blue catfish in 12 Oklahoma reservoirs (2004–2008).

TABLE 2. Electrofishing- and gill-net-derived proportional size distribution (PSD) for blue catfish in 12 Oklahoma reservoirs. Bolded line and double asterisk indicate electrofishing and gill net values that differ by > 10 units; a single asterisk indicates differences > 5 units.

| | PSD | |
|---|---|---|
| Reservoir | Electrofishing | Gill net |
| **Arcadia**** | **19.86** | **71.43** |
| Ellsworth | 0.95 | 5.00 |
| Eufaula* | 8.75 | 18.64 |
| **Ft. Cobb**** | **29.17** | **55.56** |
| **Ft. Gibson**** | **3.39** | **43.33** |
| **Hugo**** | **1.16** | **35.29** |
| **Kaw**** | **21.57** | **34.00** |
| Keystone* | 49.83 | 44.44 |
| Oologah | 41.70 | 40.00 |
| Robert S. Kerr | 16.67 | 15.25 |
| Sardis | 2.83 | 0.00 |
| **Waurika**** | **16.03** | **0.00** |

blue catfish. However, CPUE was greater for electrofishing than for gill nets, indicating that electrofishing will provide more fish for length, weight, or age measurements given a similar amount of effort (approximately three boat-days of effort were required for each lake for both gears in this study). Low-frequency electrofishing is often an effective method of sampling blue catfish (Justus 1994; Rachels and Ashley 2002; Mauck and Boxrucker 2004; Bodine and Shoup 2010) as catch rates are typically high. Electrofishing enables blue catfish to be collected immediately, thereby reducing mortality and avoiding potential bias to study objectives (e.g., when collecting diet data or tissue samples that must come from live individuals). Results of our RSE analysis illustrate that electrofishing provides precise population abundance and size-structure estimation with less sampling effort than gill nets. Electrofishing also allows for efficient sampling of a larger area due to the mobile nature of boat-mounted electrofishing units that can provide increased spatial distribution of sampling with less sampling effort than would be required with gill nets. Previous blue catfish electrofishing studies have demonstrated that low-frequency DC electrofishing has no apparent length bias for fish greater than 250 mm TL (Buckmeier and Schlechte 2009; Bodine and Shoup 2010). This suggests that in the cases where our length-frequency distributions from electrofishing and gill-net samples differed, the electrofishing distribution may be more accurate. This is further supported by the fact that differences were usually associated with gill net samples with small numbers of fish captured (due to lower CPUE).

Previous studies have shown that gill nets are capable of capturing blue catfish (Gido and Matthews 2000; Goeckler et al. 2003; Dumont and Schlechte 2004). However, Buckmeier and Schlechte (2009) is the only study prior to ours to consider the relative effectiveness of gill nets for sampling this species. Using marked fish with a known length-frequency distribution, they found that gill-net catch rates were low and somewhat size-selective in the Trinity River/Lake Livingston system. Our multi-lake study is consistent with these conclusions, but we found that differences in length-frequency distribution between electrofishing and gill nets were not consistent from lake to lake. This, in combination with the lack of any consistent strong pattern between electrofishing and gill-net PSD, suggests that gill nets may simply have lower precision for size-structure data rather than a true bias as suggested by Buckmeier and Schlechte (2009) when sufficient sample sizes are collected. However, additional research with known population sizes is needed to adequately address the potential size bias of gill nets. Additionally, much of the divergence between electrofishing and gill-net length-frequency distributions is likely due to the low catch rates of gill nets. In our study, reservoirs with low gill-net catch rates relative to electrofishing catch rates typically illustrated the greatest divergence in length frequency. This is consistent with previous research with other species, suggesting that several hundred fish are often required to accurately estimate length distributions (Miranda 2007). While Buckmeier and Schlechte (2009) collected hundreds of fish, their experimental gill nets did not include three of the smaller mesh sizes (12.7-, 15.9-, or 19.1-mm bar mesh) used in our study. This difference may account for why our study did not find strong bias against small fish identified by Buckmeier and Schlechte (2009).

While gill nets may provide unbiased data when sufficient sample sizes exist, they have lower catch rates, have lower precision, and frequently kill captured fish. Therefore, they should not be used in studies that require large numbers of fish (e.g., age and growth studies), when many samples cannot be made, or where releasing fish unharmed is desired. Gill nets also require relatively long net-set times

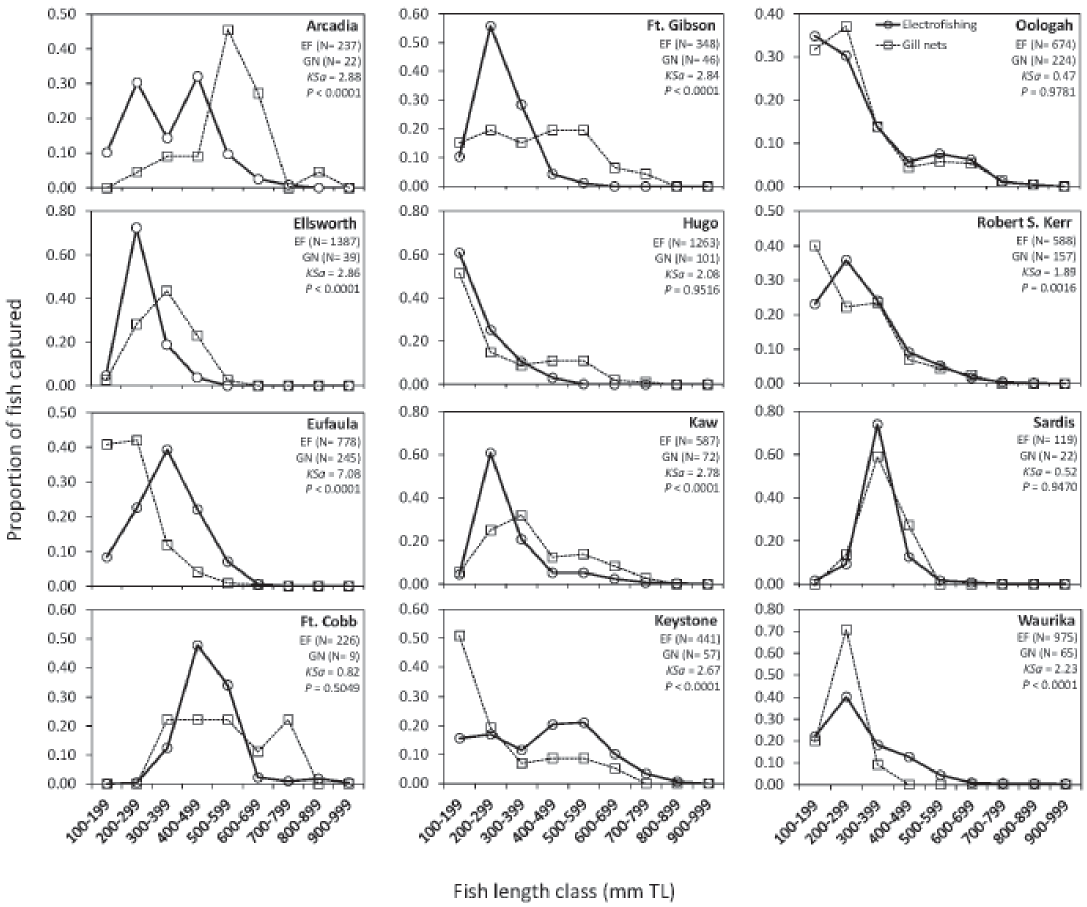


FIGURE 2. Length-frequency histograms of blue catfish captured by low-frequency pulsed-DC electrofishing (EF; solid line with circles) and experimental gill nets (GN; dashed line with squares) from 12 Oklahoma reservoirs (2004–2008).

that can result in higher regurgitation rates than other gears (Bowen 1996; Sutton et al. 2004), limiting their usefulness as a method to collect diet data. However, they could be an effective gear for measuring relative abundance, especially in situations where gill nets are already being used to evaluate abundance of other species, catch rates for blue catfish are high (e.g., in reservoirs with large blue catfish populations), and reduced precision is acceptable.

Our results suggest low-frequency DC electrofishing is preferable to gill netting for collection of blue catfish population data in most cases. However, in some cases, it may be more convenient or cost effective to use gill nets (e.g., when standard gill-net samples are being used for other management objectives anyhow) in the situations where they adequately sample the population (i.e., when catch rates and the number of nets used ensures enough fish are caught for adequate precision). The correlation between CPUE from electrofishing and gill net samples, and the lack of systematic deviation of their length-frequency distributions, suggest that both gears provide similar accuracy when gill-net samples are large enough to overcome their inherently lower precision. Effort required to collect the necessary large sample sizes using gill nets, however, limits their usefulness for many fisheries objectives, and this should be considered before deciding to use gill nets to monitor blue catfish populations. Ultimately, the gear type selected for sampling blue catfish needs to be individualized to specific research objectives. Attempts should be made to minimize biases that may affect the integrity of research.

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