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MANAGEMENT BRIEF

Diel Influences on Silver Carp Catch Rates Using an Electrified Paupier in Lentic Habitats

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Abstract

The CPUE (fish/6,000 m^3) of Silver Carp *Hypophthalmichthys molitrix* obtained by using an electrified butterfly trawl (paupier) was evaluated among various temporal (time of day and season) and spatial (location, habitat [shoreline and open water], and water depth) factors that are likely to be influential in large lentic habitats. The paupier sampled the upper water column (1.5 m) in three locations (Kentucky Lake, Kentucky [two embayments]; Lake Barkley, Kentucky [forebay]; and upper Illinois River, Illinois [two backwaters]). Sampling commenced 2 h prior to sunset and continued into the night, not exceeding 5 h beyond sunset. Model selection showed that all temporal and spatial factors were important. Post hoc analysis revealed that Silver Carp CPUE was higher at night (beyond 1 h after sunset), in shoreline habitat, and in water generally no deeper than 5 m. Seasonal variation in CPUE occurred, but in general the CPUE was high in the fall for all locations. Considering these results for management application, we estimated the sampling effort required to reach precise CPUE and adequately assess size structure (125 stock-length fish) in shoreline habitat at night. These sampling objectives were attainable in the spring and fall seasons for all locations (4–31 deployments) but were more variable in summer. We recommend consideration of the paupier as a standard method to sample Silver Carp in large lentic habitats by using the guidelines provided herein (i.e., sampling of the shoreline beyond 1 h after sunset during the fall season). An important next step to strengthen this method is to validate CPUE as an index of density.

The Silver Carp *Hypophthalmichthys molitrix* is an invasive species from Asia and has proliferated throughout much of the Mississippi River basin (Chick and Pegg 2001; Kolar et al. 2007; Irons et al. 2011; Hayer et al. 2014; Ridgway and Bettoli 2017). Silver Carp often occur at high density and can negatively impact food web dynamics, ecosystem function (Irons et al. 2007; Kolar et al. 2007; Sampson et al. 2009; Phelps et al. 2017; DeBoer et al. 2018), and economies that are dependent on sport fish and commercial fishing resources (Stokstad 2003; Cooke and Hill 2010; Tsehaye et al. 2013). Their extraordinary leaping and evasive behaviors pose a potential hazard to recreational users (Kolar et al. 2007) and are also problematic for researchers attempting to capture Silver Carp. Several studies have reported difficulty in sampling these fish with conventional methods (Williamson and Garvey 2005; Wanner and Klumb 2009; Hayer et al. 2014), which can give rise to uncertainty when informing management decisions (Sass et al. 2010; Irons et al. 2011; Seibert et al. 2015).

Standardized sampling is defined as sampling with identical gear during the same season (or same set of environmental conditions) in the same manner over time or among fish populations (Pope et al. 2010). Standard sampling does not eliminate bias but theoretically holds the

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bias constant, allowing differences in indices computed from samples among years or fish populations to be attributed to relative changes in a population or relative differences among populations. Daytime electrofishing is typically used in conjunction with other conventional methods to assess Silver Carp demographics (Williamson and Garvey 2005; Hayer et al. 2014; Stuck et al. 2015; Ridgway and Bettoli 2017), but more effective capture approaches (Bouska et al. 2017) are difficult to standardize. Recently, novel electrified trawls were developed to take advantage of electrofishing performance but also to reduce bias among operators, increase CPUE, reduce the occurrence of gear saturation, and potentially index fish density with volume sampled (ACRCC 2016, 2018; Hammen et al. 2019). Three key components in developing a standard method include (1) low sampling variability, (2) high CPUE, and (3) an estimate of sampling effort needed to meet sampling objectives (Bonar and Hubert 2002; Bonar et al. 2009; Quist et al. 2009). Sampling variance is often reduced by sample stratification (e.g., season, day or night, habitat, and river stage thresholds; Reynolds and Kolz 2012). For example, electrofishing at night often yields more individuals and larger individuals compared to daytime electrofishing (Sanders 1992; McInerny and Cross 2000; Pierce et al. 2001; Reynolds and Kolz 2012); therefore, standardized sampling of Smallmouth Bass *Micropterus dolomieu* and Largemouth Bass *M. salmoides* is typically performed at night to achieve an increased catch rate and greater sampling precision (Paragamian 1989; Dumont and Dennis 1997; Bonar et al. 2009; Blackwell et al. 2017). Improved sampling at night with electrofishing has also been documented for Gizzard Shad *Dorosoma cepedianum* (Dumont and Dennis 1997), Common Carp *Cyprinus carpio* (Smith 2017), and Grass Carp *Ctenopharyngodon idella* (Smith 2017). Kaller et al. (2017) collected more Silver Carp at night than during the daytime when conducting electrofishing community sampling in the Atchafalaya River basin, Louisiana. However, we are unaware of any studies assessing diel influences on Silver Carp catch rate. A better understanding of this relationship could reduce the amount of effort required to conduct population assessments and could improve sampling programs in North America.

In this study, we sought to determine when (diel and season) and where (habitat and depth) Silver Carp CPUE was highest in two Kentucky reservoirs and two Illinois River backwaters using an electrified butterfly trawl (paupier). This evaluation also examines the effort required to meet sampling objectives as recommended by Bonar et al. (2009) for developing standardized methods. Therefore, we estimated the number of gear deployments that were necessary to achieve precise CPUE and to evaluate size structure using sampling data.

METHODS

Study area.— Sample locations included lentic habitats in two sites on Kentucky Lake, lower Tennessee River, Kentucky (Big Bear embayment: area = 540 ha, sampled depth range = 0.6–4.8 m; Sledd Creek embayment: area = 298 ha, sampled depth range = 1.4–5.3 m); one site on Lake Barkley, lower Cumberland River, Kentucky (forebay; area = 732 ha, sampled depth range = 1.5–20.0 m); and two sites on Marseilles Pool, upper Illinois River, Illinois (Hanson Material Services, East Pit backwater: area = 192 ha, sampled depth range = 1.8–4.8 m; West Pit backwater: area = 137 ha, sampled depth range = 1.8–3.7 m; Figure 1). The West Pit backwater is indirectly connected to the Illinois River channel through a culvert connection with the East Pit backwater. All sample locations have robust densities of adult Silver Carp.

Sampling gear.— The paupier was modeled after skimmer or butterfly trawls used in coastal waters to harvest shrimp (Hines et al. 1999) but with an electrofishing component. Paupier frames were 3.7 m wide × 1.5 m high positioned on both the port and starboard sides of the boat (total coverage area = 11.1 m^2; ACRCC 2016). Conical nets composed of 38-mm stretched-mesh body reduced to 4-mm stretched mesh in the cod end were attached to each frame and extended back 7 m. Three 3-m cable dropper anodes were affixed to booms approximately 1.5 m forward of the cathodic frames. An 18-cm hemisphere anode was suspended in each frame approximately 1 m back from the net opening. Electrofishing settings were 30 Hz and a 15% duty cycle using an 82-A ETS pulsator (ETS Electrofishing Systems). A standard power table was developed for the paupier, and peak amperage was adjusted according to ambient water conductivity to transfer consistent power to fish and achieve the desired fish reaction based on guidance from Miranda (2009).

Data collection.— Sampling was conducted over three seasons (spring, summer, and fall) in 2017. Sampling commenced 2 h prior to sunset and continued into the night, not exceeding 5 h beyond sunset. We attempted a target of 16 transect samples for each site in a season. Paupier frames were fixed at the surface to sample the upper 1.5 m of the water column. The speed of the boat was set to 4.5 km/h, transect distance was set to 500 m, and CPUE was standardized to fish per 6,000 m^3 sampled. Transects were stratified by habitat as either open water (>10 m from shore) or shoreline (≤10 m from shore). Transects did not cross or repeat during a sampling event. Transect starting direction was randomly chosen from eight cardinal directions (e.g., northwest) but was redirected to follow the depth contour when a change in depth was encountered using GPS plot charts (Navionics, New Bedford, Massachusetts). Time of day was recorded at the start of each transect; water depth (m) was recorded at the beginning and end of each transect and then averaged. Total length

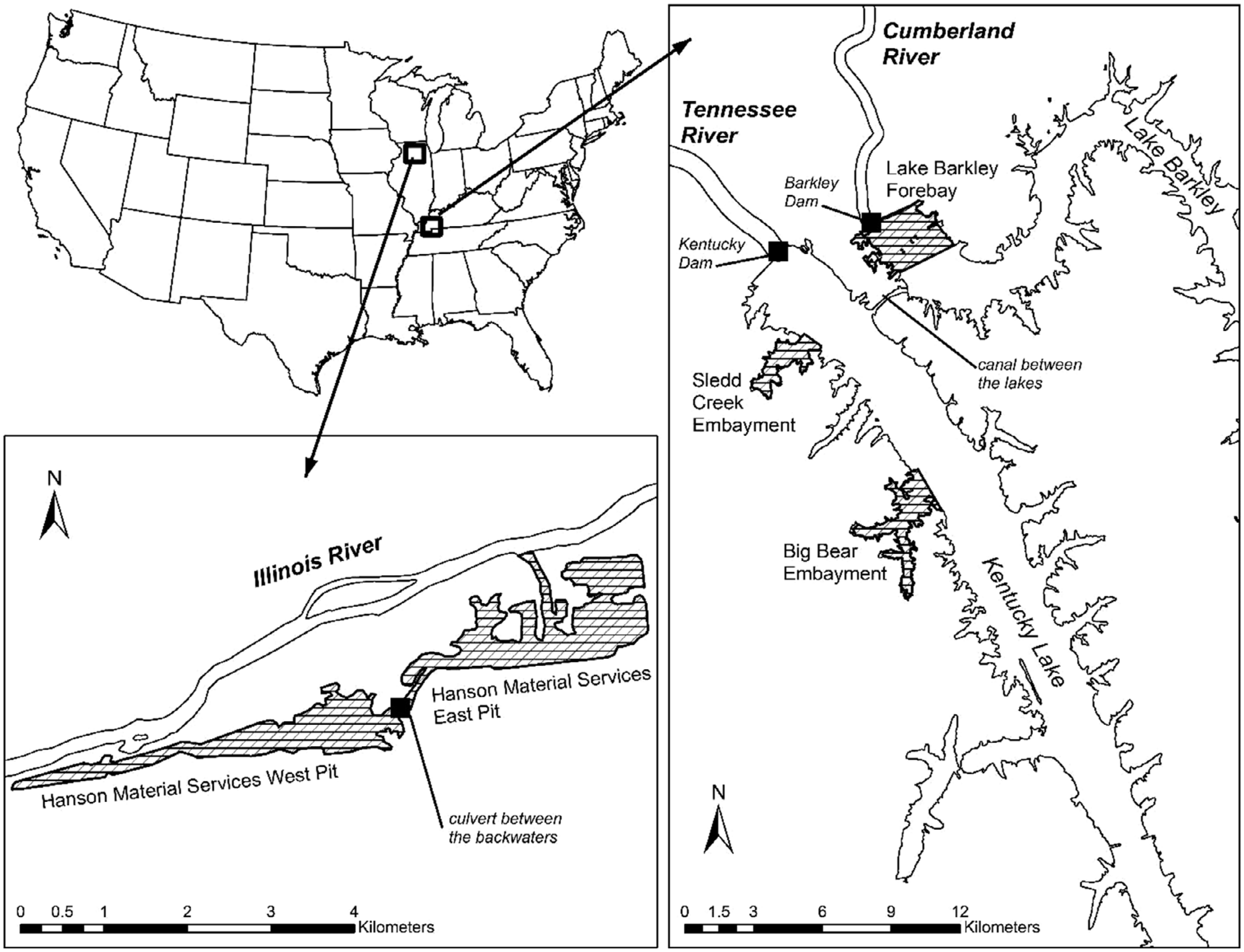

FIGURE 1. Sample locations (hash marks) in two Kentucky reservoirs (Kentucky Lake [Big Bear and Sledd Creek embayments] and Lake Barkley [forebay]) and two Illinois River backwaters of the Marseilles Pool (Hanson Material Services, East Pit and West Pit backwaters), where Silver Carp were collected in 2017.

(mm) and weight (g) were recorded for all captured Silver Carp.

Data analysis.— Due to overdispersion in the data (overdispersion test: $Z = 2.89$, $P < 0.01$; Kleiber and Zeileis 2008; Table 1), a negative binomial generalized linear mixed model was used to examine the nature and strength of the relationship between variables and Silver Carp CPUE. Sample site was the random variable and was nested within location. Transect average water depth was a continuous variable. Categorical variables included time of day, location, habitat, and season. Sampling time of day was categorized as follows: 1–2 h prior to sunset, 1 h prior to sunset, 1 h after sunset, 1–2 h after sunset, 2–3 h after sunset, 3–4 h after sunset, and finally 4–5 h after sunset. All variables were tested for correlations by using a polyserial correlation (Drasgow 1986). A second-order Akaike's information criterion corrected for small sample size (AIC$_c$; Burnham and Anderson 2002) was used to select the most parsimonious model out of a set of a priori ($N = 8$) candidate models (Table 1). Candidate models included all variables but with different interaction terms to inform whether time and location effects were dependent on other temporal and spatial variables. The model with the lowest AIC$_c$ value was considered the top model, and the ranking of the remaining models was determined by calculating the AIC$_c$ difference ($\Delta\text{AIC}_c = \text{AIC}_{c,i} - \text{AIC}_{c,min}$). Akaike weights ($w_i$) were calculated to determine the scale of relative support for each model (Burnham and Anderson 2002). Model selection used the packages mgcv (Wood 2017) and MASS (Venables and

Ripley 2002) in R (R Development Core Team 2019). A type III Wald chi-square test was used to determine significant variables within the top model. Post hoc tests were conducted using the emmeans package in R (Length 2018) to obtain least-squares means (Lsmeans) comparisons of categorical variables.

Sample size estimates for monitoring efforts were obtained using two methods. The first method targeted the sampling of 125 stock-size individuals (Silver Carp ≥ 250 mm TL; Phelps and Willis 2013) as suggested by Quist et al. (2009) to appropriately assess the size structure of a population in standard fisheries management applications. Therefore, the sample sizes (with 95% confidence intervals) that were needed to obtain 125 stock-size Silver Carp were calculated. The second method used a resampling procedure to determine the number of transect samples that were needed to achieve a relative standard error (RSE) less than 25% of the mean CPUE (Koch et al. 2014). A sample size was pre-determined, and transect samples were randomly resampled from the data set. After each resampling event, the RSE of CPUE was calculated for the particular sample size, the process was repeated 2,000 times, and a percentage was calculated based on the number of times the RSE was less than 25%. The sample size for resampling was increased until the percentage of RSE was less than 25% in 80% of the resampling events. All statistical analyses were performed in R (R Development Core Team 2019), and statistical significance for all analyses was declared at an α of 0.05.

TABLE 1. Candidate model results (AIC_c = second-order Akaike's information criterion corrected for small sample size; k = number of parameters; ΔAIC = difference in AIC_c between the given model and the best-performing model; w_i = Akaike model weight) used to predict Silver Carp CPUE (fish/6,000 m^3) from 2017. Average depth (Depth; m) was a fixed continuous variable; time of day (Time), location, season, and habitat type (Habitat) were fixed categorical variables; and site was a random variable, which was nested within location.

Model	AIC_c	k	ΔAIC	w_i
CPUE = Depth + Time + Habitat + (Season × Location)	1,679.44	19	0.00	1.00
CPUE = Depth + (Time × Location) + Season + Habitat	1,705.95	27	26.51	0.00
CPUE = Depth + (Time × Season) + Location + Habitat	1,707.71	27	28.27	0.00
CPUE = (Depth × Location) + Time + Season + Habitat	1,709.64	17	30.20	0.00
CPUE = Depth + Time + Season + (Habitat × Location)	1,712.01	17	32.57	0.00
CPUE = Depth + Season + (Time × Habitat) + Location	1,714.23	21	34.78	0.00
CPUE = Depth + Season + Time + Habitat + Location	1,715.00	15	35.56	0.00
CPUE = (Depth × Time) + Season + Habitat + Location	1,717.93	21	38.49	0.00
CPUE = 1	1,749.06	3	69.62	0.00

RESULTS

Overall, 2,948 Silver Carp were captured from 298 transects during this study. Silver Carp mean TL was 511 mm (range = 300–960 mm) in the Kentucky Lake embayments, 587 mm (range = 395–950 mm) in the Lake Barkley forebay, and 669 mm (range = 506–904 mm) in the Illinois River backwaters. No correlations were found between variables; thus, all variables were included in the analysis ($\rho < 0.60$). The top model contained all of the weight ($w_i = 1.00$; $\Delta AIC_c < 2.00$; Burnham and Anderson 2002) relative to all other models. This model contained the effects of time of day, water depth, habitat, and the interaction of location and season (Tables 1, 2). The type III Wald chi-square test found that location, depth, habitat, sample time, and the interaction of season and location were all significant variables ($P \leq 0.05$; Table 3).

Night sampling periods (beyond 1 h after sunset) were similar (Lsmeans test: $P > 0.05$) and had higher Silver Carp CPUE relative to sampling 1 h prior to sunset (mean ± SE = 3.25 ± 1.02 fish/6,000 m^3) and 1 h after sunset (5.10 ± 1.00 fish/6,000 m^3; Lsmeans test: $P \leq 0.05$; Figure 2). Sampling 3–4 h after sunset (21.01 ± 5.32 fish/6,000 m^3) yielded a higher CPUE compared to all daytime sample periods and 1 h after sunset (Lsmeans test: $P \leq 0.05$; Figure 2). No differences in Silver Carp CPUE occurred among sample periods during the day or 1 h after sunset (Lsmeans test: $P > 0.05$; Figure 2). Predicted Silver Carp CPUE increased with decreasing depth in all locations, seasons, sample periods, and habitats ($\beta = -0.13$; Figure 3). Silver Carp CPUE was higher in shoreline samples (16.58 ± 2.36 fish/6,000 m^3) compared to open water (9.74 ± 2.72 fish/6,000 m^3; Lsmeans test: z-ratio = −2.21, df = 1, $P = 0.03$; Figure 4). Seasonal differences in Silver Carp CPUE were found within two of the three sampling locations. Silver Carp CPUEs in Illinois River backwaters were higher in the summer (11.02 ± 2.52 fish/6,000 m^3) compared to the spring (2.73 ± 0.58 fish/6,000 m^3; Lsmeans test: z-ratio = −3.17, df = 1, $P = 0.04$). The CPUE during fall sampling (13.93 ± 4.87 fish/6,000 m^3) was similar that in both spring (Lsmeans test: z-ratio = −2.72, df = 1, $P > 0.05$) and summer (Lsmeans test: z-ratio = 0.48, df = 1, $P = 0.99$; Figure 5). In Kentucky Lake embayments, Silver Carp CPUE was higher in spring (29.05 ± 7.70 fish/6,000 m^3; Lsmeans test: z-ratio = 4.89, df = 1, $P < 0.01$) and fall (36.91 ± 12.44 fish/6,000 m^3; Lsmeans test: z-ratio

TABLE 2. Top model of Silver Carp CPUE, including parameter estimates (coefficients) and associated SDs. For categorical variables, the levels not shown were held constant and set to a parameter estimate of 0.00.

Variable	Coefficient	SD
Intercept	2.75	0.88
Illinois River backwaters	−2.02	0.78
Kentucky Lake embayments	−0.41	0.79
Summer	−1.27	0.58
Fall	−1.02	0.62
Depth	−0.13	0.05
Nearshore	0.43	0.19
1 h prior to sunset	−0.31	0.42
1 h after sunset	−0.16	0.42
1–2 h after sunset	0.86	0.42
2–3 h after sunset	1.01	0.42
3–4 h after sunset	1.46	0.39
4–5 h after sunset	1.12	0.41
Illinois River backwaters × Summer	2.46	0.67
Illinois River backwaters × Fall	−0.52	0.67
Kentucky Lake embayments × Summer	2.03	0.7
Kentucky Lake embayments × Fall	1.51	0.7

= −6.47, df = 1, $P < 0.01$) compared to summer (5.22 ± 1.58 fish/6,000 m^3; Figure 5). The CPUE was similar during spring and fall sampling in Kentucky Lake embayments (Lsmeans test: z-ratio = −1.17, df = 1, $P = 0.96$; Figure 5). No differences in Silver Carp CPUE were detected among seasons in the Lake Barkley forebay (Lsmeans test: $P > 0.05$; Figure 5).

Estimated sample sizes required to obtain representative size structure and precise CPUE varied by location depending on season; therefore, estimates were calculated for each using sampling data in shoreline habitat at night (beyond 1 h after sunset). In the Lake Barkley forebay, spring samples required the lowest sample size for both size structure assessment ($N = 6$; range = 4–13) and precise CPUE ($N = 15$; Table 4). Sample size requirements in Illinois River backwaters were lowest in fall for size structure assessment ($N = 12$; range = 8–22) and were lowest in spring for precise CPUE ($N = 15$; Table 4). The fall season in Kentucky Lake embayments required the lowest sample size for both size structure ($N = 4$; range = 3–7) and precise CPUE ($N = 14$; Table 4).

TABLE 3. Type III Wald chi-square test results for the top model of Silver Carp CPUE.

Variable	Chi-square value	df	P-value
Intercept	10.36	1	<0.01
Location	10.76	2	<0.01
Season	4.67	2	0.10
Depth	4.69	1	0.03
Habitat	4.53	1	0.03
Sample time	48.58	6	<0.01
Location × Season	46.22	4	<0.01

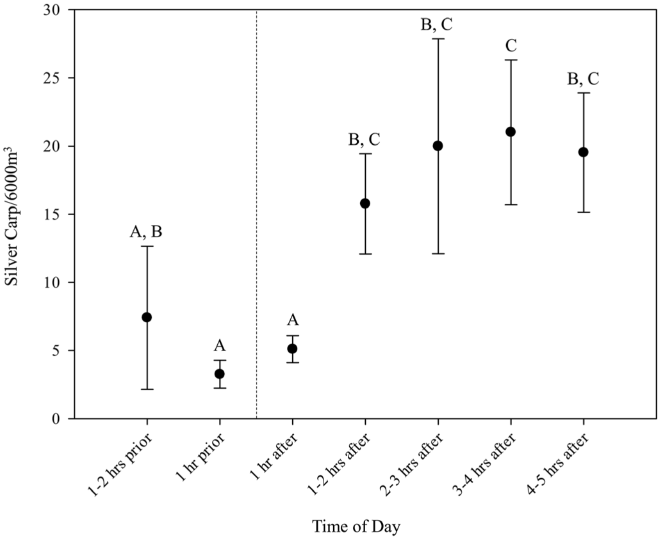

FIGURE 2. Silver Carp CPUE (fish/6,000 m^3) for time of day from sunset in 2017. Periods are categorized into 1-h bins relative to the timing of sunset (dashed line). Error bars represent SE, and letters indicate significant differences.

DISCUSSION

Our results suggest that Silver Carp CPUE increases at night regardless of other environmental factors. Sampling at night to improve CPUE is not a new concept for fisheries management, particularly when using electrified gears (Witt and Campbell 1959; Paragamian 1989; Bonar et al. 2009). Catch rate may improve at night for a variety of reasons, including differences in fish activity, distribution, or vulnerability to capture (Sanders 1992; McInerny and Cross 2000; Pierce et al. 2001; Reynolds and Kolz 2012). Researchers conducting electrofishing surveys have indicated that an increased catch rate at night was attributed to fish movement from deepwater to nearshore habitat for several riverine species (Sanders 1992; Wolter and Freyhof 2003). Silver Carp CPUE in the present study was consistently high in shallow, shoreline habitat and is consistent with telemetry data on the Illinois River, where Silver Carp rarely occupied depths greater than 4 m (DeGrandchamp et al. 2008). Gear efficiency may have influenced the disparity between habitats, as the trawl frames and electrical field sample a larger proportion of the water column in shallow, shoreline habitat. Similarly, Bouska et al. (2017) increased the capture efficiency of Silver Carp through tactical maneuvering along shorelines and

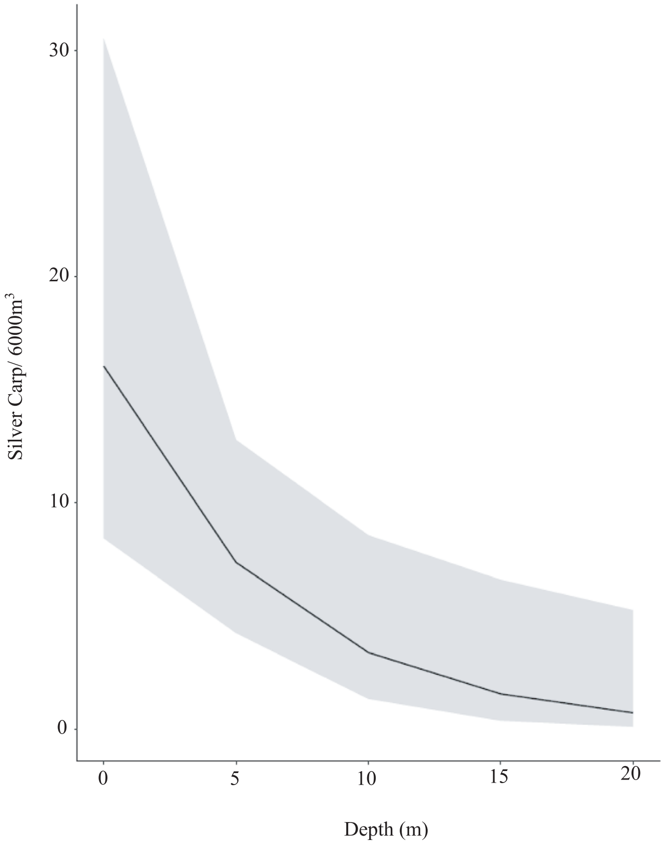

FIGURE 3. Predicted Silver Carp CPUE (fish/6,000 m^3) and 95% confidence intervals (gray shading) for transect average depth across all locations and seasons in 2017. All other variables were held constant.

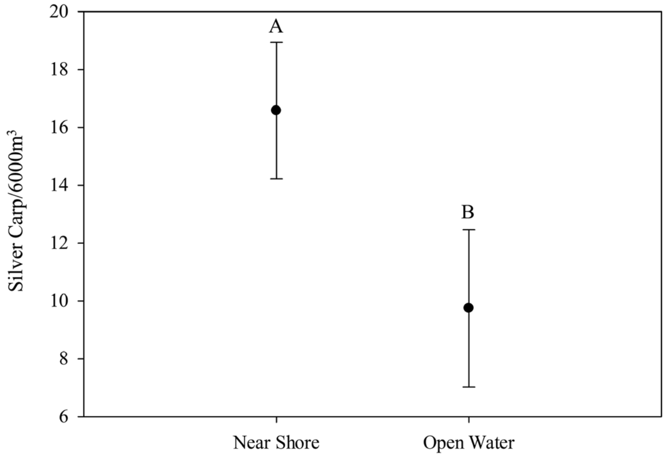

FIGURE 4. Silver Carp mean CPUE (fish/6,000 m^3) in habitats across all sample locations and seasons in 2017. Error bars represent SE, and letters indicate significant differences.

structure/habitat breaks. Regardless of the mechanism, samples should be stratified between shoreline and open-water habitats to reduce variability in Silver Carp CPUE.

According to conventional wisdom, avoidance from electrofishing vessels for many fish species is visual and diminishes at night or during the day in increasing water turbidity (Paragamian 1989; McInerny and Cross 2000; Pierce et al. 2001; Blackwell et al. 2017). Although we did not assess water clarity effects, there is evidence that Silver Carp avoidance could be independent of lighting conditions. Vetter et al. (2017a, 2017b) suggested that auditory and mechanosensory stimuli were more important in eliciting leaping responses than visual stimuli. A study comparing nighttime and daytime jump responses to electrified gears relative to catch rate across a range of water turbidity could provide further insight on the vulnerability of these fish.

Silver Carp CPUE varied by the interaction of season and location. The highest Silver Carp CPUE in the Illinois River backwaters occurred in summer and fall subsequent to conditions that were favorable to spawning. Silver Carp may have moved to the adjacent channel during spring when mean monthly discharge peaked for 2017 (6,612 m/s; U.S. Geological Survey gauge 5543010) and water temperature (18.4°C) was conducive to spawning activity (Verigin et al. 1978; Abdusamadov 1987; Schrank et al. 2001). Silver Carp CPUE was highest in spring and fall for Kentucky Lake embayments, whereas season was nonsignificant in the Lake Barkley forebay. Although it is unknown whether movement in riverine settings is relatable, movement rates of telemetered Silver Carp in Kentucky Lake were positively correlated with water level and temperature in 2017, with fish moving upstream during the first half of the year and then returning downstream during the remainder of the year (Dreves et al. 2018). Silver Carp migration out of Kentucky Lake embayments could be related to lower CPUE in summer. Therefore, standardized sampling in lentic habitats should consider environmental drivers related to large-scale emigration.

Our results suggest that the sample size required for precise CPUE (Koch et al. 2014) and for characterizing size structure (Quist et al. 2009) of Silver Carp was attainable when and where CPUE was highest (shoreline habitat at night [beyond 1 h after sunset]). Frequently, these sampling objectives are logistically difficult to achieve for natural resource managers. For instance, standardized sampling programs in Kansas and Texas reservoirs were statistically insufficient for several sport fish species and reaching the desired level of effort was often not practical (Dumont and Schlechte 2004; Koch et al. 2014). Silver Carp often assemble in dense aggregations and are highly mobile (DeGrandchamp et al. 2008); thus, variable CPUE for this species would be expected. Nevertheless, the sample size required for precise CPUE ranged from 11 to 31 across all locations and seasons—excluding Kentucky Lake embayments during summer sampling (47), when CPUE was statistically lowest. Mean sampling effort

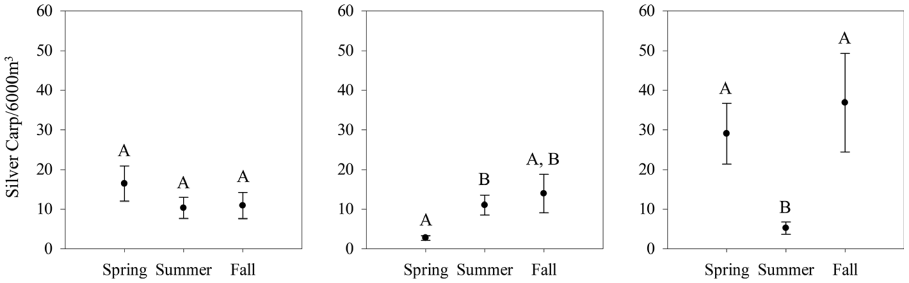

FIGURE 5. Silver Carp mean CPUE (fish/6,000 m^3) among seasons and locations (1 = Lake Barkley forebay; 2 = Illinois River backwaters; 3 = Kentucky Lake embayments) in 2017. Error bars represent SE, and letters indicate significant differences.

TABLE 4. Estimated sample sizes needed to meet Silver Carp sampling objectives (size structure [with range in parentheses]: Quist et al. 2009; precision: Koch et al. 2014). Using sample data (*n*) results from the negative binomial linear mixed model, sample sizes were determined for each season and location when and where CPUE was the highest (samples collected at night [beyond 1 h after sunset] and along shoreline habitat).

Season	*n*	Size structure	Precision
Lake Barkley forebay			
Spring	9	6 (4–13)	15
Summer	8	7 (5–14)	11
Fall	5	9 (4–125)	27
Illinois River backwaters			
Spring	16	29 (20–50)	15
Summer	18	12 (8–22)	21
Fall	11	14 (8–62)	31
Kentucky Lake embayments			
Spring	25	4 (3–6)	23
Summer	21	14 (9–48)	47
Fall	11	4 (3–7)	14

required to conduct size structure assessments ranged from 4 to 29 across all locations and seasons. An experienced paupier crew could feasibly complete 20 transect samples in a single night depending on competing management objectives and time devoted to collecting fisheries data. However, several more deployments can be accomplished when incorporating a tender boat crew to sort catches and collect data. Transect length could be inversely related to variability in CPUE (Miranda et al. 1996). Therefore, future work should help to identify optimal transect length for the paupier to reduce CPUE variability and produce an adequate number of samples for statistical analyses.

Several researchers have expressed difficulty in assessing Silver Carp size structure with daytime electrofishing; thus, additional gear types are incorporated to account for this shortcoming (Williamson and Garvey 2005; Wanner and Klumb 2009; Hayer et al. 2014; Ridgway and Bettoli 2017). Although the results provided herein are specific to the paupier, we believe that conventional electrofishing could likewise improve at night. Currently, paired electrofishing and hydroacoustics are conducted during the daytime to estimate Silver Carp abundance on the Illinois River system (MacNamara et al. 2016, 2018). Ye et al. (2013) conducted hydroacoustic assessments on a fish community dominated by native Silver Carp and Bighead Carp *H. nobilis* in Lake Laojianghe (a 1,840-ha oxbow lake of the Yangtze River), and the biomass estimate was 60% higher at night than during the day. Therefore, hydroacoustic surveys of Silver Carp in large lentic waters of North America (e.g., Kentucky Lake and Lake Barkley) could be advantageous at night. We encourage other researchers assessing Silver Carp with conventional active gears to evaluate the potential benefits of night sampling, particularly when bias in sampling efficiency is suspected.

We propose that the paupier be considered a standard method for assessing Silver Carp in large lentic waters, particularly when deployed at night (beyond 1 h after sunset) in shoreline habitat. We recommend fall sampling with the paupier because CPUE was generally high for all locations and the sampling effort required to meet sampling objectives was achievable. An important next step to strengthen this method will be to confirm whether CPUE can accurately index density (Hangsleben et al. 2013; Tyszko et al. 2017). We are unaware of any standard method of quantifying Silver Carp density. Such a gear could measure spatial and temporal variability and monitor the population response to management actions. However, the variance in catchability and the validity of CPUE for indexing Silver Carp density must first be understood and established for the paupier.

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