A Comparison of Tandem Baited Hoop Net Catch Rates, Size Structures, and Turtle Bycatch by Month and Bait Type in Two East Arkansas Lakes

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Abstract: Tandem baited hoop nets (TBHN) are the most efficient gear used to evaluate channel catfish (*Ictalurus punctatus*) populations in reservoirs. However, sampling month and bait used in TBHN have varied among collections in Arkansas and in published studies. Understanding how catch rates and size structure might change by season or bait type will help inform standard sampling protocols used by management agencies. We evaluated catch rates, size structure, and turtle bycatch of TBHN in two lakes in eastern Arkansas (Lake Greenlee and Lake Des Arc) using Zote™ soap and cheese logs monthly from May to October 2022. Catch per unit effort (CPUE) with cheese logs significantly exceeded CPUE with Zote™ soap (Z = -15.26, $P < 0.001$). Using Zote™ soap, June and July yielded significantly greater CPUE than other months of the study. Cheese log CPUE in July was statistically greater than every month except June (Z = 2.12, P = 0.61), and June CPUE was greater than every month except July and August (Z = 3.13, P = 0.07). Nets baited with Zote™ soap captured channel catfish with significantly longer mean length than nets baited with cheese logs (Z = 14.56, $P < 0.001$) and the length distributions of fish collected varied by bait type in both lakes. Mean turtle bycatch by bait type was significantly different, with Zote™ soap catching significantly fewer turtles than cheese logs (Z = -3.01, P = 0.003). Due to differences in CPUE and size structure of channel catfish collected by the different bait types, TBHN samples collected with Zote™ soap and cheese logs should not be combined for analysis. Because we detected higher CPUE for both bait types during summer months, we recommend sampling during June–July, though variation existed between our lakes suggesting that other months such as August could be considered.

Key words: cheese logs, CPUE, *Ictalurus punctatus*, Zote™ soap

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Tandem baited hoop nets (TBHN) are considered the most efficient gear to evaluate channel catfish (*Ictalurus punctatus*) populations in reservoirs (Bodine et al. 2013). The Arkansas Game and Fish Commission (AGFC) adopted TBHN as the primary sampling gear in all lentic environments in 2015 as a part of the agency's Catfish Standard Sampling Protocol (CSSP; Olive et al. 2015). The CSSP provides specifications for hoop nets used in sampling, amount of bait to use and source, effort for a lake dependent on lake surface area, timing of sampling and water depth, random selection of sample areas, and minimum data analyses required. Information derived from this type of sampling includes relative abundance, size structure, age, growth, and mortality of channel catfish populations, which guides management decisions regarding length and creel limits as well as stocking requests.

The CSSP suggests that lakes should be sampled during May–July; however, TBHN sampling typically occurs during May or June before water temperatures exceed 25 C. This temperature limit is based on Malone (2016) who reported that relative abundance of channel catfish in TBHN in Arkansas was highest in May and June when water temperatures were between 21.4–24.6 C. Other studies that evaluated seasonality of baited hoop net catches have reported reliable results from summer sampling (Flammang and Schultz 2007); Gerhardt and Hubert (1989) found that catch was highest during the post-spawning period in July. Other authors found TBHN sampling was equally efficient or had similar catchability across summer months (Buckmeier and Schlechte 2009, Tyszko et al. 2021b). One study found that CPUE of TBHN was higher in fall than spring (Wallace et al. 2011). Results associated with seasonality of catch is mixed and evaluation of catch by month from spring to fall may help refine standard sampling protocols and provide managers with a wider range of dates to sample fish.

Although the design of TBHN and the configuration of tying them in tandem has become relatively standardized (Sullivan and Gale 1999, Michaletz and Sullivan 2002, Flammang and Schultz 2007, Porath et al. 2011), disagreement remains on the effectiveness of bait types (Bodine et al. 2013). Choice of bait type has varied over time as early studies using baited hoop nets reported using rancid cheese (Gerhardt and Hubert 1989), waste cheese (Michaeltz and Sullivan 2002, Michaeltz 2009), or soybean cake pellets (Richters and Pope 2011). Two studies that compared bait

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types in TBHN found that CPUE was higher with soybean cake when compared to cheese bait (Flammang and Schultz 2007) and sunflower cake (Wallace et al. 2011). More recently researchers have used commercially available cheese logs (Boatcycle Inc., Henderson, Texas; Buckmeier and Schlechte 2009, Stewart and Long 2012, Cartabiano et al. 2015, Long et al. 2017) or a similar commercial cheese log ("Powerbait", Nets and More, Jonesville, Louisiana; Tyszko et al. 2021a).

While researchers have refined TBHN and determined that it is an effective way to capture channel catfish, they have documented high levels of turtle mortality (Sullivan and Gale 1999, Michaletz and Sullivan 2002, Wallace et al. 2011). Therefore, managers have explored Zote™ soap as an alternative bait type that could reduce turtle bycatch. Barabe and Jackson (2011) did not detect a significant difference in turtle bycatch when using Zote™ soap and cut bait on trotlines in research ponds. However, a 3-yr study period in six Mississippi rivers using Zote™ soap as bait resulted in the capture of hundreds of blue catfish (*Ictalurus furcatus*) and channel catfish, with no turtle bycatch (Barabe and Jackson 2011). Cartabiano et al. (2015) compared Zote™ soap and cheese log bait during summer TBHN surveys in an Oklahoma reservoir and observed equal turtle bycatch with both baits and no difference in catch rate, mean length, or size structure of channel catfish. Long et al. (2017) found similar TBHN catch rates between Zote™ soap and cheese logs for 13 Kentucky reservoirs, but observed higher turtle bycatch with cheese logs. In addition, mean total length of channel catfish collected with Zote™ soap was slightly greater than that of channel catfish collected with cheese logs.

The AGFC primarily uses cheese logs (Boatcycle Inc., Henderson, Texas) for sampling channel catfish. However, the yearly composition of cheese logs is often inconsistent, potentially causing high variability in CPUE and size structures from repeated annual samples. Harder, drier cheese logs may not disintegrate in water after 72 h of soak time, diminishing their effectiveness as an attractant. Due to cheese log inconsistency, some biologists switched to using Zote™ soap for bait chiefly because it is more consistent from year to year. However, concerns emerged over the comparability of cheese logs and Zote™ soap as bait. For example, on Storm Creek Lake, Arkansas, catch-per-unit-effort (CPUE) increased from 1 (SE = 1) fish set^{-1} (one set is a three-net tandem set soaked for 72 h) in 2015 using cheese logs that were dry and that did not dissolve in 72 h to 12 (SE = 4) fish set^{-1} in 2016 using Zote™ soap (Homan and Tindall 2017). However, on Lake Greenlee, Arkansas, CPUE was 490 (SE = 36) fish set^{-1} in 2014 using cheese logs that dissolved after 72 h but decreased to 89 (54) fish set^{-1} in 2019 and 23 (2) fish set^{-1} in 2020 using Zote™ soap (Tindall and Homan 2020, Tindall and Homan 2021). Not only did CPUE vary between these samples, but size structures were also inconsistent, which complicates the decision on which bait to use for standardized sampling. Further exacerbating this issue is that contemporary cheese log quality is more consistent, which has promoted a resurgence of its use by some Arkansas fisheries biologists. Using this higher quality bait has resulted in greater catch rates of channel catfish than with Zote™ soap (Brinkman and Hann 2020), causing biologists to question the validity of switching to Zote™ soap as the primary bait for TBHN.

The varying catch rates by bait type and the disagreement in the literature regarding seasonality of catch rates make designing effective TBHN sampling difficult. Therefore, we sought to elucidate the effect of bait type and sampling month on TBHN catch to improve effectiveness of future sampling. The objectives of this study were to determine: 1) if overall TBHN catch rate varied by month (May through October), 2) if TBHN catch rate varied by bait type (Zote™ soap versus cheese logs), 3) if size structure of channel catfish collected using TBHN varied by bait type, and 4) if bycatch of turtles caught in TBHN varied by bait type.

Methods

We set TBHN monthly from May to October 2022 in two different reservoirs located in the Mississippi Alluvial Plain ecoregion of eastern Arkansas (Figure 1). Lake Greenlee is a 111-ha, four-leveed reservoir near Brinkley, Arkansas, that has no watershed and water level maintained with two well pumps. Lake Des Arc is a 113-ha reservoir located near Des Arc, Arkansas. Lake Des Arc is primarily a leveed reservoir with a small watershed and water level maintained with one well pump. In Lake Greenlee, natural reproduction of channel catfish was documented in historic rotenone surveys and hatchery stockings were discontinued in 2006 (Farwick and Holt 2006). Lake Des Arc receives annual stockings of 1650 yearling (~150 mm) channel catfish.

Each month, from May to October 2022, we set TBHN at eight randomly selected sites in each lake following the AGFC CSSP (Olive et al. 2015). The perimeter of each lake was divided into 600-m shoreline segments which were randomly selected for TBHN placement. Nets were set parallel to the shoreline within the randomly selected segment. We measured dissolved oxygen monthly to determine thermocline depth at Lake Des Arc and ensure that nets were set above the thermocline. Lake Greenlee has a maximum depth of 2.1 m and did not stratify. Set depth in Lake Des Arc and Lake Greenlee ranged from 1.1–3.0 m and 0.9–1.8 m, respectively. Bait type for the first set was randomly selected and the subsequent sets alternated between bait types. Nets were set in locations with minimal slope and free of structure to keep the net from rolling and entangling in structure.

Each TBHN set consisted of three hoop nets tied together with rope bridles. The hoop nets consisted of seven fiberglass hoops and measured 3.4 m long with a front hoop diameter of 0.8 m. Webbing of each hoop net was 25 mm mesh of size 15 multifilament. The throats on the hoop nets were crowfoot style throats tied to the second and fourth hoops and the rear throat was constricted with a wire tie about 15 cm from the cod end. Each net had two, 3.2 mm mesh bait bags filled with approximately 600 g of bait. The bags contained either cheese logs (one quarter of a 2721 g cheese log, BoatCycle Inc.) or Zote™ soap Rosa (one 400 g bar and ½ of another 400 g bar) for each net set. We attached the three hoop nets together using a steel ring tied into the bridle of each net and clipped it to the cod end of the next net with a carbineer clip. An anchor with 15.2 m of rope was tied to the cod end of the first net deployed and a large weight was attached with 15.2 m of rope to the ring on the bridle of the third net. A small weight on the ring of the bridle on the second net in the series helped weigh the nets down. We marked set locations with GPS but did not attach buoys to avoid tampering. Net set retrieval occurred 3 days (72 h) after they were set. As each net was retrieved, we measured (total length, mm) all channel catfish collected and released them and we counted the total number of turtles in each net. For catches using cheese logs in Lake Greenlee, only the first 100 channel catfish in each set were measured due to the high number of catches, and the remainder were counted and released. Catch per unit effort was calculated as the number of channel catfish collected in one 72-hr set of three nets tied in tandem and expressed as fish set^{-1}.

We used a Poisson generalized linear mixed model (GLMM) with log link to determine differences in CPUE based on month and bait type, with lake was included as a random effect. Based on visual comparisons using a histogram and a quantile-quantile plot (Q-Q Plot), channel catfish length distributions adequately followed a Gamma distribution. To determine if mean length of channel catfish varied by bait type, we used a GLMM based on a Gamma distribution with log link that included bait type as a fixed effect and lake and month as random effects. A Kolmogorov-Smirnov test was used to examine size structure by comparing the size distribution of all channel catfish caught with cheese logs versus soap bait for each lake. We compared turtle catch between bait types using a GLMM based on a Poisson distribution with log link that included bait as a fixed effect and month and lake as random effects. We performed all statistical tests in R (R Development Core Team 2022) with the glmer function in the lme4 package (Bates et al. 2015) used to run GLMMs. Post-hoc analyses were performed using the emmeans package (Lenth 2024) with pairwise comparisons adjusted for multiple comparisons using a Tukey's adjustment. All statistical tests were considered significant at $P \leq 0.05$. Means are reported ±1 SE.

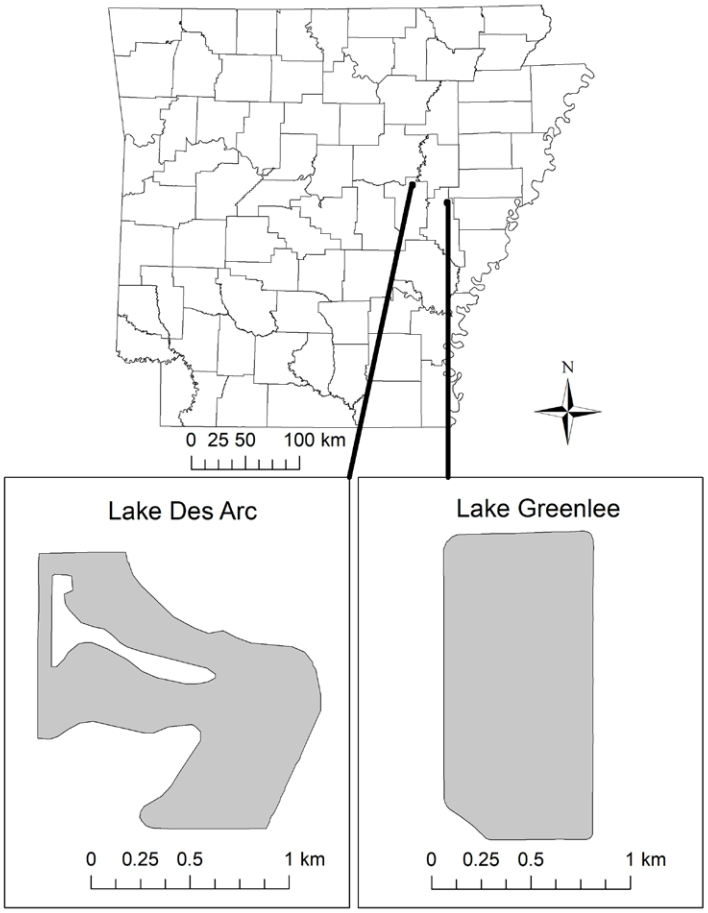

Figure 1. Arkansas study lakes sampled with tandem baited hoop nets during May–October 2022.

Results

In Lake Greenlee, 2857 channel catfish were collected (2336 measured for length) in nets with cheese logs while 1384 (1338 measured for length) were collected with Zote™ soap. Mean CPUE (fish set^{-1}) for nets with cheese logs ranged from 80 ±33 (SE) in October to 167 ±23 in July, while mean CPUE for Zote™ soap nets ranged from 16 ±7 in September to 91 ±32 in July (Figure 2). In Lake Des Arc, 964 channel catfish were collected with cheese logs while 121 channel catfish were collected with Zote™ soap. Mean CPUE for nets with cheese logs ranged from 23 ±4 in June to 65 ±8 in August, while mean CPUE of nets with Zote™ soap ranged from 2 ±1 in May to 7 ±2 in August (Figure 2). In the GLMM for CPUE, bait type had a significant effect with cheese log CPUE significantly exceeding Zote™ soap CPUE (Z = -15.26, P <0.001). Cheese log CPUE was greatest in summer months with July CPUE being significantly greater than all but June CPUE, though August CPUE was not significantly different from June CPUE (Table 1, Figure 3). Similarly, June and July CPUE for Zote™ soap were

significantly greater than CPUE from the other months in the study (Table 1, Figure 3).

Mean length of Lake Greenlee channel catfish collected in nets with cheese logs was 306 ±1 mm while mean length of channel catfish collected in nets baited with Zote™ soap was 333 ±2 mm (Figure 4). In Lake Des Arc, mean length of channel catfish collected with cheese logs was 345 ±4 mm while mean length of channel catfish collected with Zote™ soap was 473 ±13 mm (Figure 4). Mean length was significantly different by bait type (Z = 14.56, P < 0.001); fish captured with Zote™ soap were significantly larger on average than fish captured with cheese logs. The length distributions of channel catfish collected with cheese logs versus channel catfish collected with Zote™ soap also were significantly different in Lake Greenlee (D = 0.18, P < 0.001) and in Lake Des Arc (D = 0.42, P < 0.001; Figure 5).

In Lake Greenlee, mean CPUE (turtles set^{-1}) of turtles for all months in cheese log nets was 2.2 ±0.6 and 1.3 ±0.5 in Zote™ soap nets (Figure 6). In Lake Des Arc, mean CPUE of turtles for all months in cheese log nets was 0.7 ±0.2 and 0.2 ± 0.1 in Zote™ soap nets (Figure 6). Bait type had a significant effect on catch of turtles (Z = -3.01, P = 0.003) with Zote™ soap nets catching significantly fewer turtles than cheese log nets.

Table 1. Statistically significant post hoc tests from the generalized linear mixed model comparing tandem baited hoop net CPUE (fish set^{-1}) of channel catfish by month from sampling in 2022 in Lake Greenlee and Lake Des Arc, Arkansas.

Bait	Month Comparison	Estimate (SE)	*Z*	*P*
Cheese logs	May vs. June	−0.36 (0.06)	−6.33	<0.001
	May vs. July	−0.47 (0.06)	−8.38	<0.001
	May vs. August	−0.19 (0.06)	−3.25	0.053
	June vs. September	0.22 (0.06)	4.04	0.003
	June vs. October	0.37 (0.06)	6.48	<0.001
	July vs. August	0.28 (0.05)	5.23	<0.001
	July vs. September	0.33 (0.05)	6.13	<0.001
	July vs. October	0.48 (0.06)	8.53	<0.001
	August vs. October	0.20 (0.06)	3.40	0.033
Soap	May vs. June	−0.34 (0.08)	−4.28	0.001
	May vs. July	−0.34 (0.08)	−4.35	0.008
	May vs. August	0.50 (0.10)	5.07	<0.001
	May vs. September	1.28 (0.12)	9.83	<0.001
	June vs. August	0.84 (0.09)	9.01	<0.001
	June vs. September	1.61 (0.13)	12.86	<0.001
	June vs. October	0.52 (0.08)	6.26	<0.001
	July vs. August	0.84 (0.09)	9.08	<0.001
	July vs. September	1.62 (0.13)	12.90	<0.001
	July vs. October	0.53 (0.08)	6.32	<0.001
	August vs. September	0.78 (0.14)	5.59	<0.001
	September vs. October	−1.09 (0.13)	−8.22	<0.001

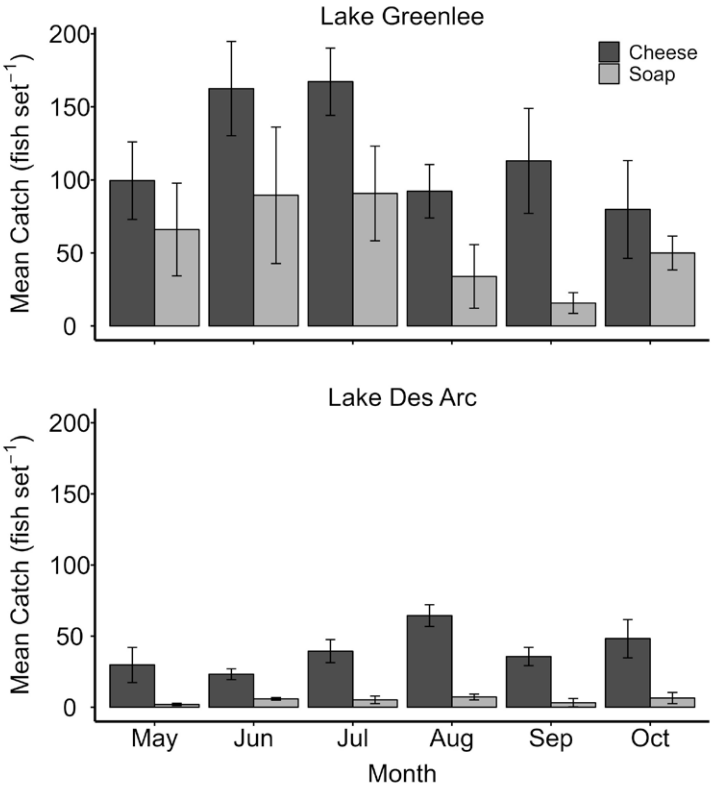

Figure 2. Mean CPUE (±1 SE) of channel catfish collected in tandem baited hoop nets in Lake Greenlee and Lake Des Arc, Arkansas, by month and bait type.

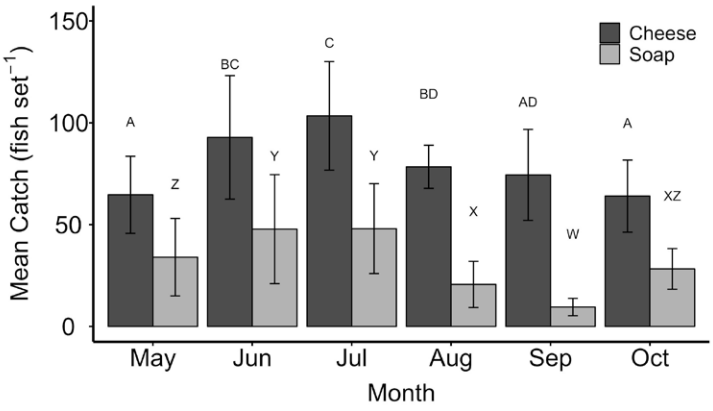

Figure 3. Mean CPUE (±1 SE) of channel catfish collected in tandem baited hoop nets with lakes combined by month and bait type. Letters A–D indicate significant monthly differences for cheese log CPUE. Letters W–Z indicate significant differences in monthly CPUE for Zote™ soap nets.

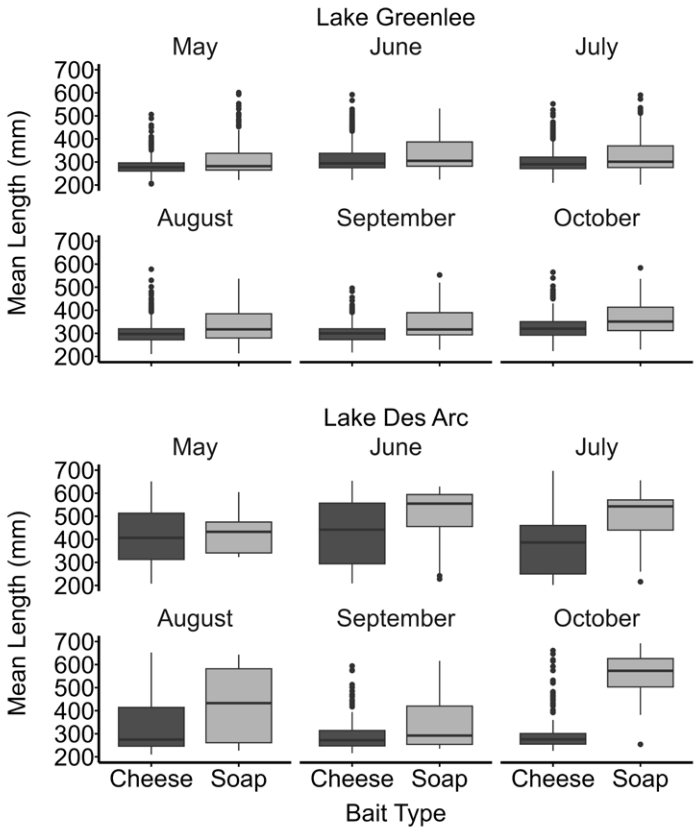

Figure 4. Box plots of total length of channel catfish collected in tandem bait hoop nets from Lake Greenlee and Lake Des Arc, Arkansas, by month and bait type.

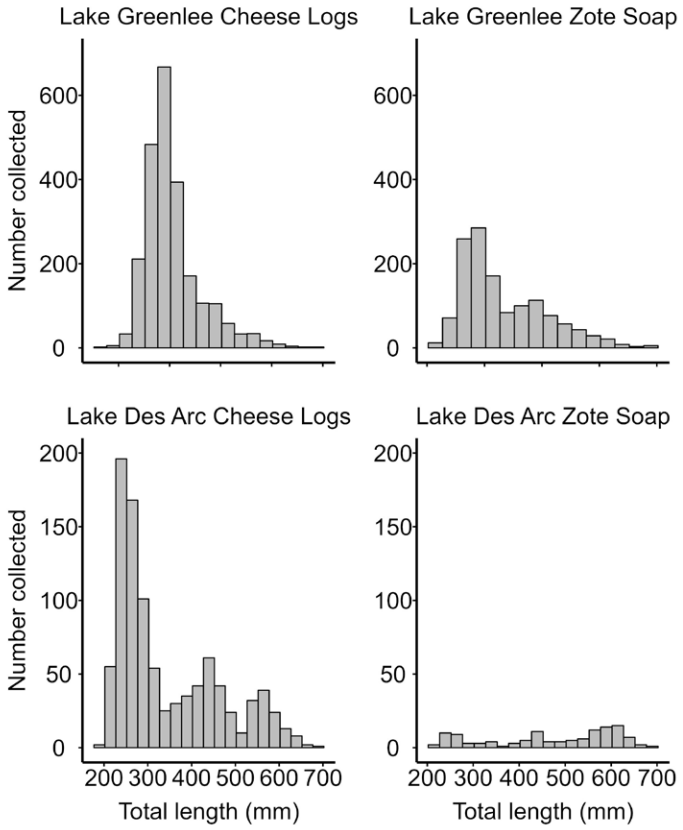

Figure 5. Length frequency distribution of channel catfish collected in tandem baited hoop nets from Lake Greenlee and Lake Des Arc, Arkansas, using cheese logs and Zote™ soap. Note that y-axes are scaled differently between lakes.

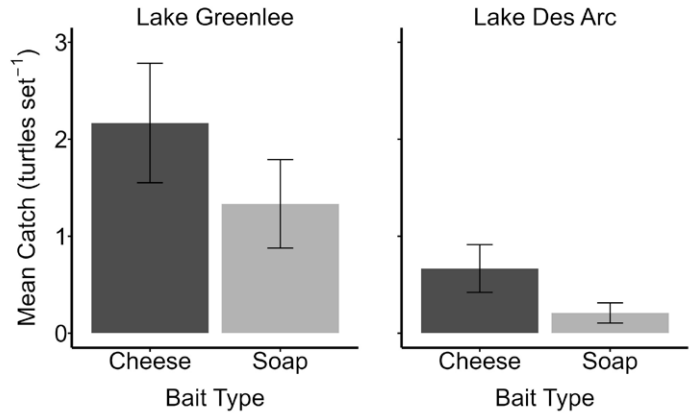

Figure 6. Mean (SE) turtle catch in tandem baited hoop nets from Lake Greenlee and Lake Des Arc, Arkansas, by bait type.

Discussion

Catch per unit effort of channel catfish with Zote™ soap in June and July significantly exceeded CPUE in May, August, September, and October. With cheese logs, CPUE was highest in July, followed by June, August, and September. June and July CPUE at Lake Greenlee was about 15 times greater with Zote™ soap and 5 times greater with cheese logs than CPUE with the same baits at Lake Des Arc during June and July. Based on these results June and July are likely to yield the highest CPUE for TBHN sampling, similar to results from other studies (Flammang and Schultz 2007, Buckmeier and Schlechte 2009, Tyszko et al. 2021b). However, given the patterns we observed, managers should expect temporal variations in CPUE as well as variation between reservoirs. Managers should experiment with sampling during multiple summer months to determine which month is best for each reservoir if a reservoir has never been sampled. Our results indicate that TBHN sampling does not need to be restricted to the narrow water temperature window suggested by Malone (2016). Among our spring and summer samples, only the May sample at Lake Des Arc (mean

= 24.4 C ±0.1) was within the ideal sampling temperature range suggested by Malone (2016).

We documented that TBHN CPUE of channel catfish was greater using cheese logs than using Zote™ soap in the two study lakes. Cartabiano et al. (2015) and Long et al. (2017) reported no difference in TBHN CPUE of channel catfish baited with Zote™ soap and cheese logs. As our results are contrary to these two studies, we provide evidence that ideal bait type may vary between reservoirs. If high quality cheese logs of the same consistency from year to year are available, cheese logs may be the preferred bait for TBHN sampling, given this bait produced the most fish in our study. For example, in Lake Des Arc, catch rates were nine times higher with cheese logs than with Zote™ soap. Because our study indicates bait type can influence catch rate, we suggest that bait type remain consistent if the sampling goal is to precisely track changes in population size or if a long-term dataset using one bait type exists. Biologists are encouraged to experiment with Zote™ soap and cheese logs in reservoirs that have never been sampled with TBHN or if catch rates are low using one bait type.

Mean length of channel catfish collected using Zote™ soap was greater than those collected using cheese logs. Length distributions of channel catfish collected using the two bait types were also significantly different in both lakes. These results are contrary to results reported by Cartabiano et al. (2015) who observed mean lengths of channel catfish caught in TBHN with Zote™ soap were not statistically different than those caught in TBHN with cheese logs. They also found that size structure of channel catfish was not statistically different by bait type (Carabiano et al. 2015). Similar to our study, Long et al. (2017) documented catching larger channel catfish with Zote™ soap than with cheese logs. It is unclear why mean length was greater with Zote™ soap baited nets or which bait type had more consistent efficiency across all size classes. Future studies should examine how accurately each bait type describes the true population of a lake. We urge biologists to use caution when comparing samples collected with different bait types given the difference in size structure of the samples and mean size of fish collected in our study.

Similar to Long et al. (2017), we observed significantly lower bycatch of turtles in TBHN baited with Zote™ soap than in TBHN baited with cheese logs. Although Cartabiano et al. (2015) found that equal numbers of turtles were caught in TBHN baited with cheese logs and Zote™ soap, they found very few turtles were caught on trot lines baited with Zote™ soap. If turtle bycatch is a concern at a particular waterbody, managers should use caution with cheese logs as bait in TBHN as turtle bycatch will likely be higher with cheese logs than with Zote™ soap.

In summary, we found that CPUE was highest during summer, which is similar to findings in other studies (Flammang and Schultz 2007, Buckmeier and Schlechte 2009, Tyszko et al. 2021b). Therefore, TBHN use in Arkansas should not be limited to the narrow spring sampling window suggested by Malone (2016) and should be used from June–July, although additional months such as August could be considered. Both Zote™ soap and cheese logs were effective baits for catching channel catfish in TBHN, though CPUE was lower for Zote™ soap than for cheese logs. Catch rates of channel catfish in TBHN are usually variable and managers may have difficulty detecting actual population changes using CPUE as an index of abundance (Tyszko et al. 2021b). Given the differences in catch rate between baits in this study and the difference in size of fish collected in this study and Long et al. (2017), we recommend that managers analyze data collected from TBHN baited with Zote™ soap separately from cheese logs. We also recommend that if high quality cheese logs (soft and disintegrates in water over 72 h) remain available for purchase, they should be used as the primary bait in TBHN sampling. However, if long term datasets of successful TBHN sampling with Zote™ soap have already been collected in a waterbody, we recommend using the same bait type in future sampling. Finally, if turtle bycatch is a primary concern, managers should use Zote™ soap as bait in TBHN sampling.

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