Assessing Angler Use and Demographics at Three Small Impoundments using Trail Cameras

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Abstract: Trail cameras were deployed from 1 October 2015 through 30 September 2016 to measure angling effort at three lakes on the North Carolina Wildlife Resources Commission Sandhills Game Lands. Images were quantified via computer software and analyses were conducted to assess total angling effort as well as temporal (e.g., AM vs. PM, weekday vs. weekend, and seasonal effort), angling method (boat vs. bank), and demographic (male vs. female, youth vs. adult) calculations. Indian Camp Lake was the most used site by anglers throughout the study (1640.3 ± 32.2 angler-h) followed by Crappie Lake (675.0 ± 14.9 angler-h) and Kinney Cameron Lake (482.3±11.1 angler-h). Mean angler effort was highest in the spring at Kinney Cameron Lake and Crappie Lake but was equally high at Indian Camp Lake in the spring and summer. At all three lakes, anglers expended more effort on average in the afternoons and weekend days. Mean effort of bank anglers was higher than boat anglers at Indian Camp Lake but was similar between the groups at the other two lakes. Most effort on all three lakes was expended by adult and male anglers. Remote cameras yielded quality information about these systems, but camera theft, battery failure, image quality, and image interpretation were limiting factors in the overall utility of trail cameras in this study. The percentage of users that were unable to be categorized demographically varied by waterbody and ranged from 5.3% to 33.0% across age groups and from 8.1% to 36.1% for gender. Despite these limitations, the use of trail cameras in this study provided valuable information without the significant time and costs associated with traditional creel surveys.

Key words: creel survey, camera placement, image interpretation, seasonal use patterns, angler demographics

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Angler use and demographic information are key components of fisheries management (Jones and Pollock 2012). Traditional methods for obtaining these data are creel surveys (Pollock et al. 1994) and human dimensions surveys (Knuth et al. 2012). However, these surveys are conducted under a rigorous statistical design that require significant manpower commitments that often conflict with other agency duties. Further, angling pressure is usually highest on weekends or holidays (Jones and Pollock 2012), meaning that these surveys often must be scheduled outside of normal working hours or additional staff must be hired to conduct them, both of which can require appropriation of additional funding. Fisheries managers often need these data but do not have the resources to conduct fully developed creel or human dimensions surveys.

Whereas remote cameras (i.e., trail cameras, camera traps) have been used commonly for studying terrestrial animals (e.g., Wang et al. 2006, Kays and Slausen 2008, Newey et al. 2015), only recently have fisheries managers begun to use them for studying angler use (Smallwood et al. 2012, Greenberg and Godin 2015, Hining and Rash 2015, Powers and Anson 2016, Askey et al. 2017, Simpson 2018, Stahr and Knudsen 2018). These studies have illustrated that remote cameras can provide useful information without the typical costs and manpower constraints that accompany onsite creel surveys (Pollock et al. 1994, Simpson 2018). Trail cameras have been used to document angler effort successfully in remote British Columbia lakes without expending substantial manpower (Greenberg and Godin 2015, Askey et. al 2017). A similar approach was used in South Dakota to document the use of remote fishing access areas (Simpson 2018). Although cameras have proven useful in fisheries management investigations, they have limitations like all sampling methods, often site specific (Smallwood et al. 2012, Hartill et al. 2016).

The North Carolina Wildlife Resources Commission's (NCWRC) Sandhills Game Lands (SGL) comprise 26,000 ha in south-central North Carolina. Although the SGL are primarily managed for timber and wildlife habitat, they also contain nine impoundments open to public fishing and other types of recreation such as paddling and hunting (NCWRC 2015). These lakes were constructed in the 1930s and 1940s, range in size from 1 to 30 ha, and contain naturally reproducing populations of largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), chain pickerel (*Esox niger*), yellow perch (*Perca flavescens*), and black crappie (*Pomoxis nigromaculatus*). Additionally, Indian Camp Lake is annually stocked with 1,200 channel catfish (*Ictalurus punctatus*) to increase harvest opportunities. Although these lakes represent a significant portion of the impoundments owned by the NCWRC, they are located in rural areas and access can be limiting. Little information exists on angler use patterns on these impoundments.

Despite their rural locations, SGL lakes may function in many ways similar to the community fishing ponds described in Eades and Lang (2012) in that they may require additional amenities and

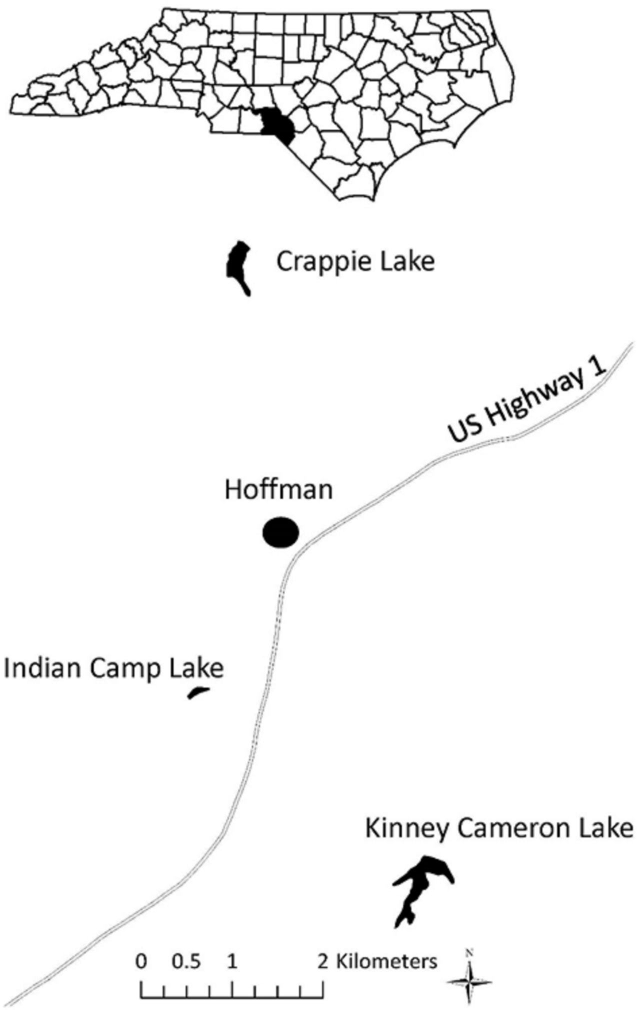

Figure 1. Map of the three lakes on the Sandhills Game Lands in south-central North Carolina where cameras were used to assess angler use and demographics, October 2015 to September 2016.

Table 1. Characteristics of three Sandhills Game Lands lakes used to evaluate angler use with trail cameras from October 2015–September 2016.

Lake	Size (ha)	Amenities	Distance from major road (km)
Indian Camp Lake	2	Two fishing piers in addition to cleared bank area; improved parking area; 1,200 channel catfish stocked annually.	1
Kinney Cameron Lake	14	Gravel boat ramp; unimproved fishing along dam; unimproved parking area.	1
Crappie Lake	8	Gravel boat ramp; unimproved fishing along dam; unimproved parking area.	2.5

multiple types of fisheries management strategies to be successful (Schramm and Edwards 1994, Balsman and Shoup 2008). However, the need for specific management actions or strategies is difficult to determine without a better understanding of angler use and demographics. Therefore, the objectives of this survey were to: 1) quantify the amount and type of use at three SGL lakes and 2) assess the utility of trail cameras for collecting angler use information.

Methods

Study Area

This study was conducted at three lakes located within the SGL: Crappie Lake, Indian Camp Lake, and Kinney Cameron Lake (Figure 1). These three lakes varied in size, distance from a public highway, and amenities offered (Table 1); they were chosen because together they represented most of the range of these attributes across SGL lakes. For example, Indian Camp Lake was the only SGL waterbody which received routine stockings of fish; also, there were two fishing piers at Indian Camp Lake, providing dedicated access to anglers. Kinney Cameron Lake was located close to the main road, whereas Crappie Lake was located farther back on the SGL property; both lakes were larger than Indian Camp Lake.

Data Collection

One Moultrie N990I field camera (Moultrie Feeders, Birmingham, Alabama) was installed at each of the three lakes. All three cameras were secured to trees using screws and were mounted in locked security cases secured with a Masterlock Python locking cable to deter theft. Despite this, the Moultrie camera at Kinney Cameron Lake was stolen in July 2016 and was subsequently replaced with a Bushnell Aggressor camera (Bushnell, Inc., Overland Park, Kansas) because a replacement was needed immediately and a Moultrie camera was unavailable. As suggested in previous studies (Smallwood et al. 2012, Greenburg and Godin 2015), we positioned each camera at the most likely ingress/egress point to each study site, directing it toward onsite amenities such as bank fishing areas, piers, or boat ramps where present and when possible. Cameras therefore captured more than one access point at each of the three lakes; however, the maximum distance that cameras were installed from angler access points was 115 m, 240 m, and 350 m at Indian Camp, Kinney Cameron, and Crappie lakes, respectively. Image resolution was set on all cameras at four megapixels in order to balance image resolution with available storage on memory cards used in the cameras. All cameras were set to record images at 15-min intervals from 0700 to 1800 hours daily. Images were recorded between 1 October 2015 and 30 September 2016. Each camera was visited at 30- to 60-day intervals to check equipment, download images, and replace batteries as needed (per Hining and Rash 2015).

Image Analysis

All captured images were analyzed using TimeLapse2 image enumeration software (Greenberg and Godin 2015). Each person present in an image was examined and if they could be identified as an angler through visual evidence, such as possession of fishing gear or launching a watercraft equipped for fishing, they were counted and first categorized as an angler. If an angler was initially present in a photo, was not present in a succeeding photo or photos but then reappeared in a later photo on the same date, that angler was counted as present during the entire period from the first image until the last image where the angler was present. In almost all cases, this was accomplished by visually linking specific individuals with specific vehicles and counting their presence at a site based on the presence or absence of the specified vehicle. Anglers were then categorized by gender and age category if possible, otherwise they were recorded as unknown for one or both categories as applicable. For the purpose of this study, adults were considered to be anglers who appeared to be 16 years or older; younger anglers were categorized as youths. Both gender and age determinations were subjectively made by the author. Images were also classified as weekday (Monday to Friday) or weekend (Saturday, Sunday, and all federal holidays) and AM (0700 to 1145 hours) or PM (1200 to 1800 hours) for analysis. Finally, images were also classified by season: winter (December to February), spring (March to May), summer (June to August), and fall (September to November).

Statistical Analysis

All summarized data were transferred from TimeLapse2 into the R statistical software package (R Core Team 2013) for additional analysis. Statistical significance was set *a priori* at $P = 0.05$. The angler counts in this survey were considered instantaneous counts for estimation purposes (Pollock et. al 1994) since a single vantage point was used at each site (Malvestuto 1996). In order to calculate daily estimates of effort (angler-h), all instantaneous counts on a given date were summed and a mean was calculated by dividing the total counts per day by the number of images collected on that date. These mean counts were then multiplied by the hours the camera collected images to obtain a daily mean estimate of angler-h. These mean daily values were then summed over all the dates images were collected at each lake to estimate total angler effort (Malvestuto 1996). Standard error values were calculated for each daily estimate and then summed to generate total standard error estimates around each total effort value.

Since the distributions of mean daily estimates of angler effort did not meet normality assumptions, all mean daily estimate values were log transformed $\log_{10}$(mean daily effort+1) for analysis. A one-way ANOVA was used to detect differences between geometric mean daily effort of all anglers combined by waterbody as well to detect differences in seasonal use by all anglers. If a significant difference among values was detected, Tukey's post-hoc test was used to determine specific differences. Two sample *t*-tests were used to determine differences in the geometric means of angler effort by waterbody between bank vs. boat, AM vs. PM, weekdays vs. weekends, adult vs. youth, and male vs. females. Finally, the relationship between the percentage of unassigned estimated total hours of angling effort for age and gender were compared using linear regression for all three lakes combined.

Results

Cameras were operational over the course of the study for 332 days at Indian Camp Lake, 365 days at Crappie Lake, and 312 days at Kinney Cameron Lake. Cameras were not operational over the entire 365 days at Indian Camp and Kinney Cameron lakes because of camera theft, unexpected battery failure, or user error. A total of 41,851 images were collected and analyzed during this survey. Of those images, 14,123 were collected at Indian Camp Lake, 16,445 were collected at Crappie Lake, and 11,283 at Kinney Cameron Lake. Most of the images did not contain angling activity; by percentage, these were 77% at Indian Camp Lake, 91% at Crappie Lake, and 87% at Kinney Cameron Lake. Installation and maintenance of cameras and image downloading totaled 19 person-days of effort, and image analysis and enumeration totaled 27 person-days of effort.

Total estimated angler effort and associated SEs for the three lakes was 1640.3 ± 32.2 angler-h at Indian Camp Lake, 482.3±11.1 angler-h and Kinney Cameron Lake, and 675.0 ± 14.9 angler-h at Crappie Lake. Mean daily estimated angling effort for all anglers combined (Table 2) was higher at Indian Camp Lake than at the other two lakes ($F = 62.55$, df = 2, 1006; $P \leq 0.001$); mean angler effort was similar between Kinney Cameron and Crappie lakes. Mean effort by bank anglers was higher than boat anglers at Indian Camp Lake ($t = 18.10$, df = 662, $P < 0.001$) but was similar between these groups at Kinney Cameron Lake ($t = -0.94$, df = 595, $P = 0.40$) and Crappie Lake ($t = 1.90$, df = 699, $P = 0.06$). Mean angler effort was higher during PM hours than AM hours for all lakes (Table 2; t range -3.87 to -9.58, $P < 0.001$). Mean angler effort was also higher on weekend days than weekdays at all three lakes (t range -3.02 to -4.54, $P < 0.002$). Mean angler effort was highest in the spring than in other seasons at Kinney Cameron Lake and Crappie lakes; mean effort was similarly low among the other seasons at Kinney Cameron Lake, but was higher in summer than in fall and winter at Crappie Lake (Table 3). In contrast, mean angler effort at Indian Camp Lake was highest in the spring and summer than in the fall and winter (Table 3).

Table 2. Mean daily effort of all anglers (angler-h day^{-1}) at three Sandhills Game Lands lakes as well as by user type (bank vs. boat) and temporal effort (AM vs. PM.; weekday vs. weekend). Values in parentheses equal ± 1 SE.

Lake	Camera days	All	Bank	Boat	AM	PM	Weekday	Weekend
Indian Camp Lake	332	4.9 (0.4)	4.9 (0.4)	0.1 (0)	0.8 (0.1)	4.1 (0.3)	3.7 (0.4)	8.3 (0.2)
Kinney Cameron Lake	365	1.5 (0.1)	0.7 (0)	0.9 (0.1)	0.4 (0)	1.1 (0.1)	0.8 (0.1)	3.2 (0.6)
Crappie Lake	312	1.8 (0.2)	0.9 (0.2)	0.9 (0.1)	0.6 (0.1)	1.2 (0.2)	1.3 (0.2)	5.2 (0.5)

Table 3. Mean daily effort of all anglers (angler-h day^{-1}) at three Sandhills Game Lands lakes by season. Values in parentheses equal ± 1 SE. Mean values with the same superscript were similar (Tukey's test, $P > 0.05$).

Lake	Fall	Winter	Spring	Summer
Indian Camp Lake	5.0 (3.5)^{b}	1.2 (0.3)^{a}	8.3 (1.1)^{c}	6.4 (0.7)^{c}
Kinney Cameron Lake	0.8 (0.3)^{a}	0.3 (0.1)^{a}	4.7 (0.7)^{b}	1.0 (0.3)^{a}
Crappie Lake	0.9 (0.2)^{a}	0.1 (0.2)^{a}	3.8 (0.6)^{c}	2.5 (0.4)^{b}

Table 4. Mean daily effort of all anglers (angler-h day^{-1}) at three Sandhills Game Lands lakes as well as by age group (adult, youth, unknown [Unk] age) and gender (male, female, unknown [Unk] gender). Values in parentheses equal ± 1 SE.

Lake	Camera days	All	Adult	Youth	Unk age	Male	Female	Unk gender
Indian Camp Lake	332	4.9 (0.4)	4.2 (0.4)	0.5 (0.1)	0.3 (0.1)	3.8 (0.3)	0.8 (0.1)	0.4 (0.1)
Kinney Cameron Lake	365	1.5 (0.1)	1.2 (0.1)	0.1 (0.0)	0.2 (0.0)	1.1 (0.1)	0.2 (0.0)	0.3 (0.0)
Crappie Lake	312	1.8 (0.1)	1.2 (0.1)	0.1 (0)	0.6 (0.1)	1.2 (0.2)	0.1 (0.0)	0.6 (0.1)

Table 5. Distance to the maximum field of view for cameras placed at three Sandhills Game Lands lakes with the percentage of unknown total user effort (angler-h) by age group and gender.

Lake	Camera distance (m)	Unknown age %	Unknown gender %
Indian Camp Lake	115	5.3	8.1
Kinney Cameron Lake	240	13.2	19.4
Crappie Lake	350	33.0	36.1

Mean angler effort was 8- to 12-fold higher for adults than youths at all three lakes (Table 4; t range 7.73 to 13.13, $P < 0.001$). Likewise, mean effort of male anglers was 5 to 12 times that of female anglers at all three lakes (Table 4; t range 7.02 to 11.37, $P < 0.001$).

Efforts to categorize demographic data were successful for the majority of anglers observed but the percentage of total angler-h that could not be categorized varied by demographic and lake. The percentage of angler effort that could not be categorized by age group or gender was highest at Crappie Lake and lowest at Indian Camp Lake, with Kinney Cameron Lake falling in the middle (Table 5). Problems in categorizing the demographic data appeared to increase with camera distance from angler access features. In each case, gender appeared to be more difficult to assign than age group.

Discussion

This study provided baseline data on the usage of a subset of lakes on the SGL. These initial findings indicate that Indian Camp Lake was the most popular lake for angling of the three lakes surveyed. This is not surprising given that this lake is close to a main highway and is the most recreationally developed of the three lakes featuring two fishing piers and a gravel parking area as well as being the only lake that receives periodic stockings of channel catfish. Fishing effort was equally high in the spring and summer in Indian Camp Lake, but fishing effort on the other two lakes was higher in the spring than in the other three seasons. The channel catfish stocking program is conducted during April to September each year which could have kept fishing effort high during the summer at Indian Camp Lake. In general, total angling effort at all three lakes was lower than expected and less than what Ivasauskas et al. (2016) calculated for a 32-ha urban lake in the Piedmont region of North Carolina.

This survey provided a cost-effective method for collecting angler use data on these three lakes. A typical creel survey conducted by the North Carolina Wildlife Resources Commission is conducted over an entire year period similar to this study (Morgeson and Fisk 2018); however, these traditional creel surveys are scheduled for 240 person-days of survey time on one waterbody and a full-time creel clerk is hired to conduct them. In this study, three lakes were surveyed with a combined total of over 1,000 days of data collection. Given that the total amount of data collection (fieldwork and image processing) in this survey took less than 50 person-days and required only one permanent employee, the amount of funds expended was much less using trail cameras instead of a traditional creel survey.

Additional time, and therefore cost, was saved by the use of image enumeration software instead of manually enumerating each image and entering the data into a spreadsheet. Greenberg and Godin (2015) calculated a 30% to 60% reduction in personnel time by using TimeLapse2 software for image enumeration as well as over a 150% increase in processing speed for image enumeration. While costs and processing time will vary depending on the amount of information being enumerated for each image, it is likely that as more variables are measured, the advantages of image enumeration software will become more pronounced.

Although angler counts were collected on at least 310 days of the year on each lake in this study, angler effort was underestimated in several ways. For example, night angling was not measured in this study, although this also is not commonly conducted in traditional creel surveys due to safety concerns (Jones and Pollock 2012). Anglers who were fishing but not captured in any images were also not accounted for and may have affected accuracy of these estimates. Additionally, equipment failure, user error, and theft all occurred during this survey and limited the results collected. Similar issues, including equipment and technology limitations, unique to the use of remote cameras have been noted by others (Smallwood et al. 2012, Newey et al. 2015, Hartill et al. 2016). As technology advances some of these limitations may be eliminated or reduced, such as the ability to collect higher quality images at night over longer distances.

The variability in determing age and gender across the three lakes was most likely due to the distance the cameras needed to be placed in order to collect data. Hining and Rash (2015) collected demographic data from remote camera images but their cameras were placed much closer (less than 5 m) to the areas anglers used. Camera placement and field of view have been noted in previous studies as limiting factors in collecting needed information with remote cameras (Smallwood et al. 2012, Stahr and Knudsen 2018). In this study, the camera which was placed a little over 100 m from the access area at Indian Camp Lake allowed more than 90% successful identification of demographic variables. A doubling of that distance, at Kinney Cameron Lake, decreased success rate a commensurate amount, and the camera placed 350 m away from angler access, at Crappie Lake, resulted in a 33% or higher unsuccessful identification rate of demographic information. If demographic data such as these are critical, it is advised to consider the best possible camera location that will allow for adequate image resolution at the shortest distance from angler access areas. It is likely that as camera technology evolves and camera resolution capabilities increase, the ability to more accurately collect subjective demographic data at similar distances should increase as well.

This survey yielded valuable information on angler effort and demographics but did not collect information on angler harvest and could not collect angler opinion. Angler catch and harvest are best measured through the use of traditional creel surveys (Pollock et al. 1994, Malvestuto 1996, Jones and Pollock 2012), and angler opinion information is best measured in human dimension surveys (Knuth et. al 2012). Creel surveys utilize spatial and temporal probabilities in order to provide the most accurate estimates of angler effort, catch, and harvest (Pollock et al. 1994, Malvestuto 1996), whereas angler opinion surveys require anglers to be present during survey periods to collect data. Data collected in this study serve as a valuable reference point for future creel and/or human dimension surveys on these lakes or other SGL impoundments. The temporal trends identified in this study, as well as the high percentage of dates where many or all images recorded no angling activity, can be valuable in helping to determine when creel surveys should be attempted as well as helping to identify the most likely times when anglers would be present for angler opinion surveys.

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