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Direct comparison of boat access-based autonomous cameras and roving creel surveys for estimating fishing effort: implications for use in creel surveys with non-uniform probability sampling

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Abstract

The use of remote, automated cameras in monitoring angler activity has increased as the cost of the technology has decreased. Estimating angler effort via creel surveys is a foundational practice in fisheries management. Combined, cameras and creel surveys can provide fishery managers with tools to monitor harvest and assess angler responses to management activities such as stocking and alterations of fishing regulations. However, assessing these responses often occurs over a period of time and with methods that do not include camera use, making comparisons tenuous. This research compares angler effort estimates from remotely deployed autonomous, i.e., trail cameras with a concurrent access-based creel survey. In both study lakes effort as measured by cameras was within the standard error of effort measured by the creel survey. Therefore, managers should be comfortable with making comparisons from previous surveys. Cameras also revealed patterns in fishing effort that were not accounted for in the creel survey. Managers using non-uniform probability creel surveys should consider using cameras to identify angling patterns thereby increasing both the precision and accuracy of the creel survey.

Introduction

Assessing the recreational fishery through creel surveys is an important component of actively managing fisheries. Gathering information regarding angler effort in response to regulation changes (Pierce and Tomcko 1998), success or failure of supplemental stocking on fish populations (Hunt et al. 2017) and angler behavior (Carpenter et al. 1994; and Fayram et al. 2006) are commonly collected through creel surveys. Additionally, exploitation rates and harvest can be calculated through data collected from creel surveys (Pierce et al. 1995; Margenau et al. 2011; and Isermann et al. 2005).

Data for these assessments are commonly collected through roving, access-point creel surveys, or a combination of the two methods. While the information collected through creel surveys is important for fishery managers in making informed decisions, the data collection process is often expensive. For example, the creel survey associated with this work cost more than $20,000 (2015 USD). Consequently, fishery managers have looked to advances in remote camera technology to estimate angler effort and integrate that information into their management actions (Parnell et al. 2010; Smallwood et al. 2012; Greenberg and Godin 2015). Most recently, cameras have been used to collect effort by monitoring boat ramps (Powers and Anson 2016; Stahr and Knudsen 2018; and Dutterer et al. 2020), determining trip length (Stahr and Knudsen 2018) and counting anglers (Hining and Rush 2018). Furthermore, cameras have been used to supplement data collection from other survey methods (Askey et al. 2018). Undoubtedly, though not found in peer reviewed publications, remote cameras have been implemented into many fisheries management programs.

While cameras have been integrated into fisheries management, there are several areas of their use that could be explored more deeply. First, although they have been used successfully to verify fishing patterns to improve precision and accuracy of instantaneous counts from flights (Askey et al. 2018) they have not been used to improve observational error in roving or access-based creels. Additionally, comparisons between cameras and 'on the ground' surveys are lacking from a variety of angling situations. Dutterer et al. (2020) compared methods and found camera-based estimates to be higher than those of a roving creel survey. Comparing methods such as that completed by Dutterer et al. (2020) should not be overlooked because evaluating programs over a longer period is often critical for meaningful measurements of success or failure, particularly if the program being evaluated involves a long-lived species.

The goals of this study were two-fold: to compare fishing effort estimates between autonomous, time-lapse cameras and a concurrent roving creel survey, and determine if cameras can be used to increase the precision and accuracy of roving and access-based creel surveys.

Methods

Study Site

Elk and Mary lakes are both located completely within the boundaries of Lake Itasca State Park, Minnesota. Elk Lake is remote, requiring a 13 km drive on a one-way road from the park entrance. Elk Lake is 123 ha and has a robust fishery for trophy Muskellunge (*Esox masquinongy*) and Northern Pike (*Esox luscious*). Walleye (*Sander vitreus*) are also a common target for anglers. Mary Lake is 22 ha and is typical of a Centrarchid-dominated system, with Largemouth Bass (*Micropterus nigricans*) and Bluegill (*Lepomis macrochirus*) being the primary targets of anglers. At the time of the creel survey, regulations included a 148 cm minimum length limit for Muskellunge, 102 cm for Northern Pike on Elk Lake. Lake Mary had a catch and release regulation for Largemouth Bass and bag limits of 5 Bluegill and 5 crappie (*Pomoxis* spp.).

Access to both lakes is limited to single, state-owned boat landing with limited parking spots for vehicles and boat trailers, nine spots on Elk Lake and three spots on Mary Lake. The shorelines of both lakes are undeveloped and difficult to access for shoreline angling. Both lakes have an 8 kmh speed limit which limits recreational activity to kayaking and canoeing.

Camera Set and Photo Analysis

Moultrie Wingscape Timelapse Pro and Stealthcam GX45NG, were deployed on each boat landing (one of each per boat landing). The Wingscape cameras focused on the parking area for the lake access while the Stealthcam cameras were placed lake-facing, near the access to enable a count of occupants per watercraft. Access pointing cameras were set to take a photo every 10 minutes from 5 a.m. until 10:30 p.m., whereas lake pointing cameras were motion activated. Wingscape cameras featured a flash option so night images could be collected. Stealthcam cameras used an infrared feature that also allowed for night and low visibility image capture. All cameras were set to collect photos at medium quality resolution, 3,008 x 1,692 pixels per picture. Batteries and SD cards were replaced monthly. Images were time stamped with date and time of day. As per State of Minnesota administrative orders, images containing persons or personal information were deleted within 60 days of photo capture or download.

Cameras were located where vegetation did not interfere with image capture and where changes in sun location and angle over the course of the season did not affect picture quality. The access camera on Elk Lake was relocated after a week of use when several trees leafed and partially blocked the parking area. Cameras were hidden from view but were clearly marked as belonging to the Minnesota Department of Natural Resources. At Elk Lake cameras were 20 m and 3 m from the access and lakeside, respectively. Mary Lake cameras were set at 5 m from the access and 5 m from lakeside. These distances allowed full surveillance of entire parking areas for each lake and to obtain regular images of anglers on the lake.

Images were inspected using Windows Photo Gallery and trip details were manually entered into a spreadsheet. For access images, each individual vehicle/boat trailers unit was identified and was monitored beginning with the time each was first captured on the time lapse photos until it was no longer present. For example, if Unit A was first seen at time stamp 0640, start time was 0640 and total fishing time was estimated until the unit was no longer seen in the parking area. If the Unit A no longer appeared in the 1030 photo, total fishing time was estimated at 3 h and 50 minutes and represented a completed trip. This process was repeated for each unit and at both lakes each day. Because the lakes have speed limits, other recreational activities such as water skiing or tubing are not possible on either lake; consequently, each launched trip was assumed to be for fishing. Based on previous creel surveys, canoes and kayak launched on both lakes were assumed to be for non-angling recreation and not included in fishing counts (Moen 2004). Although shore fishing opportunities are available on each of the lakes, they are very limited. Previous creel surveys showed shore fishing effort was negligible (Moen 2004). Consequently, shore anglers were not the focus of the camera census. The mean number of anglers per trip was estimated by summing the total number of anglers per boat per image collected by lakeside cameras and dividing by the number of boats observed. The mean number of anglers per boat was calculated for each month over the course of the study period which lasted from May 13 to September 30, 2016, on Elk Lake and from June 8th to September 30, 2016, on Mary Lake. However, since both techniques yielded similar results, the number of anglers per boat was set at 2 per boat for calculations of effort. Cameras were set to collect photos for 2.5 hours beyond the time the creel clerk was present and conducting counts and interviews. To account for the difference in census length, effort from the cameras was calculated both for the time 0630 to 2230 as well as 0800 to 2000.

Creel Survey

Concurrent to the camera census, a two-stage, stratified random, incomplete trip creel survey was conducted on both lakes from

December 19th, 2015, through September 30th, 2016. Only data collected during the period the remote cameras were deployed were used for this comparison study. A creel clerk conducted instantaneous pressure counts and angler interviews. Two other lakes, Itasca and Ozawindib, were included in the creel survey but not the camera survey. Sampling probabilities of Elk and Mary were set at 15%. The order in which lakes were surveyed was randomly generated for each sampling day, consequently the number of lakes surveyed each day varied from two to all four. To allow comparisons to previous on-the-water-surveys, the 2016 survey was stratified by season, day type (weekday, weekend, or holiday), and angler type (boat or shore). One instantaneous boat and angler count was conducted at each lake during each sampling event, usually when the clerk arrived at the lake. To ensure all parties were counted, the clerk would account for lake users based on the presence of vehicle/trailer units in parking lots and explore the use of MN DNR rental boats which are stored at public access points on each lake. Most anglers were interviewed as they came off the lakes. Anglers remaining on the water as the sampling period was ending were interviewed by boat; those interviews were treated as incomplete trips. Time of contact for each angler/group was recorded by the clerk. The sampling day was randomly assigned as either an early (0730 to 1530 hours) or late 1200 to 2000 hours) shift with 30 minutes on each end allotted for travel time. Each shift consisted of four 1.75-hour sampling blocks. Creel data were analyzed using Creel Application Software (Soupir and Brown, 2002; Moen, 2017).

Results

Elk Lake

Total fishing pressure estimated from cameras was 6,133 hours on Elk Lake during the camera surveillance period of May 13th to September 30th. Pressure estimated from the creel survey during the same period was 4,631 (SE 955) hours, nearly 25% less than camera counts (Figure 1). Monthly pressure was similar from both methods in May and September, but camera pressure counts were higher in June, July, and August (Figure 1). When camera counts were adjusted to include only the same daily time period covered by the creel survey, the results were similar for all months and in total. The number of anglers per boat were both estimated to be 2.0 from cameras and the survey over the entire season. Trip length was 3.6 hours based on camera counts whereas the creel survey estimated trip length to be slightly less than 3 hours (Table 1). Monthly mean number of fishing units and anglers per boat were similar between the camera counts and creel.

Mary Lake

Fishing pressure estimated from cameras was 754 hours on Mary Lake during the camera surveillance period of June 8th to September 30th. Pressure estimated from the creel survey during the same period was 787 hours (S.E. 226.5 hours; Figure 1). Monthly pressure estimates were similar during all months of the study from both methods. The number of anglers per boat was estimated to be 1.95 from camera images and 1.97 from the survey. Trip length averaged 1 hour from both the camera counts and the creel survey (Table 1).

TABLE 1. Comparison of monthly trip length (hours) and number of anglers per boat (group size) from a creel survey and camera counts on Elk and Mary lakes.

	May	June	July	August	Sept	Total
Elk Creel Trip Length	3.2	2.4	3.0	3.8	2.3	3.0
Elk Camera Trip Length	3.4	3.2	3.8	4.2	3.6	3.6
Mary Creel Trip Length	NA	1.0	0.7	0.5	1.3	0.9
Mary Camera Trip Length	NA	1.1	0.6	0.6	.2	0.9
Elk Creel Group Size	1.5	1.9	2.5	2.1	2.0	2.0
Elk Camera Group Size	1.7	2.0	2.3	2.0	2.0	2.0
Mary Creel Group Size	NA	2.0	2.3	2.0	2.0	2.0
Mary Camera Group Size	NA	2.0	2.2	2.0	2.0	2.0

Discussion

Several studies have demonstrated the benefits of autonomous cameras to fisheries managers needing to collect information on fishing pressure (Askey et al. 2018; Stahr and Knudsen 2018; Dutterer et al. 2020). Implementing cameras into program-level evaluations have become commonplace (Dutterer et al. 2020). Results of this work further demonstrate the viability of using remote cameras to assess fishing pressure.

As the use of autonomous cameras for assessing angler effort becomes more prevalent, comparing effort and other angler behavior between current and previously completed creel surveys is inevitable. Furthermore, following trends of anglers in response to management actions such as regulation or stocking changes through angler effort is necessary. However, comparisons using different methods is tenuous and previous side-by-side comparisons have shown pressure estimates can vary widely (Askey et al. 2018; Dutterer et al. 2020). This side-by-side comparison of the two methods further demonstrates the need to be extremely cautious when making comparisons of efforts from two different methods. Understanding the source of those discrepancies may, however, allow for comparisons to be made. For example, the difference between the creel survey and camera pressure estimates on Elk Lake were due to two factors, undercounted night-time fishing during June, July, and August by the creel survey and lower trip length (2.9 hours/trip) estimated by the creel. Night-time angling, mainly for Muskellunge, was popular during the months of July and August. However, the creel survey ended at 2000 hr, often when anglers were just arriving at the lake to begin angling. Differences in trip length were also due in large part to extended night-time fishing. Cameras indicated anglers were often on the lake well into the night and the next day, furthering the discrepancy in the estimates because trip length was underestimated by the creel survey. When these sources were accounted for and camera counts are adjusted to the same time frame as the creel survey, pressure estimates were comparable, and camera counts were well within the standard error associated with the creel-derived estimates. In this case, cameras presented a more accurate count of pressure on Elk Lake than did the creel survey.

Pressure estimates were similar on Mary Lake, where most of the angling effort occurred during the day-time hours when the creel clerk was present. Results demonstrate that camera counts can be used for comparison. However, these comparisons should be under tightly controlled conditions, such as a limited access resource with a well-understood fishery, such that strata can be assigned to maximize angler contact.

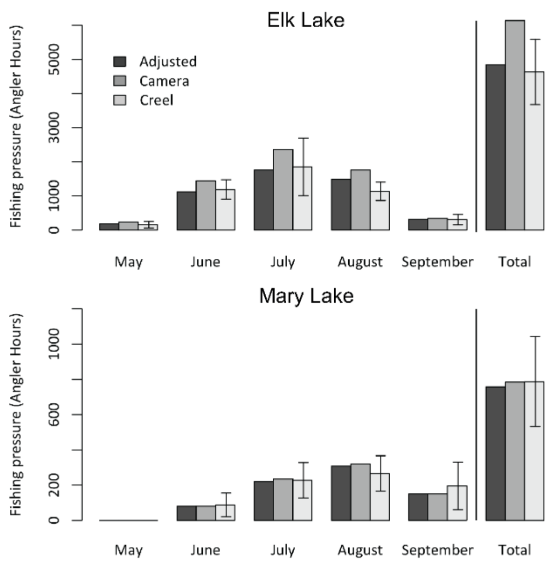

FIGURE 1. Monthly and total fishing pressure (angler hours) as estimated by a creel survey and an autonomous, remote camera on Elk and Mary lakes. Angler hours from cameras include those concurrent to creel survey timing (0800 to 2000 hr) as well as hours outside the creel survey timing (0500 to 2200 hr). Standard errors are included for the creel survey.

As noted, cameras revealed angling patterns on Elk Lake that reduced the probability that the clerk would encounter an angler. Pre-survey surveillance using cameras prior to establishing strata can boost the probability for encounter, a primary goal of non-uniform probability surveys, (Malvestuto et al. 1978; Malvestuto 1996). For example, on Elk Lake increasing the number of strata selected that represented afternoon and evening time periods would have improved the likelihood of encountering anglers as well as gathering completed trip information. Combined, this would increase the accuracy and precision of the survey. On lakes with multiple access points, cameras can be used to identify popular entry points and when combined with time-of-day use, also increase the probability of encountering anglers. As camera technology increases and costs decrease, real-time data collection could also be used to increase encounters with anglers.

Autonomous cameras offer fishery managers the opportunity to collect pressure estimates in a cost-effective manner. Using pressure estimates from cameras to compare with previous creel surveys is possible but caution is needed to ensure that both methods are sampling the same time periods. Additionally, cameras likely provide a more accurate picture of angling pressure, particularly in limited-access fisheries. Applications of camera technology can improve the development of non-uniform probability creel surveys can increase both the accuracy and precision interview-based creel surveys.

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