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Estimating the number of recreational anglers for a given waterbody

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ABSTRACT

Knowing how many anglers use a given body of water is paramount for understanding components of a fishery related to angling pressure and harvest, yet no study has attempted to provide an estimate of the population size of anglers for a given waterbody. Here, we use information from creel surveys in a removal-sampling framework to estimate total numbers of anglers using six reservoirs in Nebraska, USA, and we examine the influence of the duration of sampling period on those estimates. Population estimates (N ± SE) of unique anglers were 2050 ± 45 for Branched Oak Lake, 1992 ± 29 for Calamus Reservoir, 929 ± 10 for Harlan County Reservoir, 985 ± 24 for Lake McConaughy, 1277 ± 24 for Merritt Reservoir, and 916 ± 18 for Pawnee Lake during April–October 2015. Shortening the sampling period by one or more months generally resulted in a greater effect on estimates of precision than on estimates of overall abundance. No relationship existed between abundances of unique anglers and angling pressures across reservoirs and sampling duration, indicative of a decoupling of angler abundance and angling pressure. The approach outlined herein has potential to provide defendable answers to "how many are there?", questions we ask when subjects cannot be marked, which should provide new insights about angler populations and subpopulations.

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1. Introduction

"How many are there?" is an age-old sociological question as well as an age-old ecological question. The need to know population size has spawned numerous analytical techniques that have been used over two centuries to estimate the size of populations as diverse as the 1802 human population of France (Cochran, 1978), the number of illicit drug users in Los Angeles County, California, USA (Hser, 1993), and the number of invasive Chinese mystery snail (*Bellamya chinensis*) in Wild Plum Lake, Nebraska, USA (Chaine et al., 2012). The volume of literature pertaining to this question is immense. Even so, abundance estimation remains an active area of research, particularly because estimating the abundance or density of people within geographic boundaries or animals in wild populations is not a trivial matter. Virtually all techniques for estimation of abundance involve the basic problem of estimating the size of the population from a sample, or subset, of encountered individuals. Many methods have been developed to estimate the probability of detection associated with various kinds of survey count statistics (Powell and Gale, 2015). Techniques include multiple observers (Manly et al., 1996; Nichols et al., 2000), removal methods (Moran, 1951 Zippin, 1958), capture-recapture (Amstrup et al., 2010; Bailey et al., 2004; Nichols, 1992) and repeated counts (Dail and Madsen, 2011; Dodd and Dorazio, 2004; Royle, 2004; Royle et al., 2007).

Recreational fishing (the attempt to capture aquatic animals—mainly fish—that do not constitute the angler's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets [FAO, 2012]), is a multi-billion-dollar industry (Cowx, 2002). During 2011, 33.1 million U.S. residents 16 years old and older participated in recreational fishing (USFWS and USCB, 2011). Understanding fishing pressure and angler composition at the region or waterbody level is important if fishery managers are to serve and satisfy their constituents. Gaining such understanding is complicated because anglers seek different kinds of experiences (Hunt, 2005), which results in potential differences in their spatial and temporal distributions and hence susceptibility to being counted—all of this makes it difficult to estimate the number of anglers for a given waterbody.

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Fishing pressure is important, yet so is fidelity (or frequency of participation). For example, there were 705,236 ± 32,765 h of recreational angling from shore along 250 km of the south and south-west coast of Portugal during August 2006-July 2007, which corresponded to 166,430 ± 9792 trips (Veiga et al., 2010). Even so, it is unknown whether 166,430 unique anglers each fished one day along this coastal stretch during that year, 457 unique anglers each fished every day along this coastal stretch during that year, or likely some combination therein. The implications as to which scenario accurately represents angler behavior have far-reaching effects from a fishery-management perspective in terms of allocating financial, human, and other resources. For example, there might be a priority placed on providing supporting amenities (e.g., shoreline fishing access and ablution facilities) to facilitate a large number of anglers at any one point in time if the former scenario were representative of angler abundance. So the question becomes – how do we estimate angler abundance to ensure sound management of a given system?

One feasible approach to estimate abundance of anglers is to use existing techniques with which managers and policy makers are relatively familiar. We often estimate the number of fish in a waterbody using direct observation, mark-recapture, and removal methods (Hayes et al., 2007). For example, Hankin and Reeves (1988) used direct observation of juvenile Coho salmon (*Oncorhynchus kisutch*) by divers to estimate that there were 4106 ± 886 (95% confidence interval) fish in the pools and riffles of the lower 9.6 km of Cummins Creek, Oregon during 1985. Steffensen et al. (2012) used mark and recapture to estimate annual density of wild pallid sturgeon (*Scaphirhynchus albus*) in an 80.5-rkm of the lower Missouri River varied from 5 to 9 fish/rkm during 2008–2010, while the annual density of hatchery-reared fish varied from 29 to 32 fish/rkm. Milewski and Willis (1989) used removal to estimate that there were 38 ± 13 (90% confidence interval) brown trout (*Salmo trutta*) in a 90-m stretch of Gary Creek, South Dakota during 1988. The same techniques used to estimate the number of fish in a waterbody could potentially be used to estimate the number of anglers fishing that same waterbody. Although people in many countries are provided unique identification numbers (e.g., social security number in the USA, social insurance number in Canada, and personal identity number in Sweden), we cannot typically mark or tag an angler. Thus, the techniques used for estimation of anglers are constrained. However, we do ‘capture’ anglers in an unmarked fashion by conducting creel surveys. Therefore, we propose that removal methods can be used on anglers, just like removal methods can be used on captured fish that do not receive individual marks.

Biologically, we believe that effort-based estimates are the appropriate measure, especially when considering the influence of recreational activities on the fishery resource. Politically, we believe that population estimates are the appropriate measure, especially when considering needs for educational programs or preparing for potentially contentious management actions. Generally, participation estimates at recreational sites or waterbodies are effort-based, such as the number of angler-trips or number of visitor-days. To that end, our goal was to estimate the number of recreational anglers for a reservoir with a simple, non-intrusive process of removal (via a capture-recapture approach) during on-site, in-person interviews that were part of routine (i.e., standard monitoring procedures for management agencies of recreational fisheries) creel surveys. To our knowledge, this is the first reported attempt to estimate the number of recreational participants on this scale—that is, attempt to estimate the population size of unique anglers for a given waterbody and compare estimates of overall abundance to angling effort.

2. Material and methods

We estimated the population sizes of anglers and angling effort during April-October 2015 for six reservoirs located throughout Nebraska, USA (Table 1). Clerks used automobiles to move (rove with the intent of gathering a representative sample proportional to use) among parking areas around the reservoirs, and moved on foot along the shore and in parking lots to contact angler parties. Thus, we interviewed boat anglers at boat ramps (generally completed fishing for the day) and bank anglers at parking areas (generally completed fishing) or on the shoreline (active in fishing) to estimate the reservoir-specific population size of unique anglers. Anglers that fished multiples of these reservoirs were included in the respective multiple population estimates. We used a stratified multi-stage probability-sampling regime (Malvestuto, 1996) to determine days of interviews. We had a target of 16 or 18 interview days each month, stratified into 10 week-days, 6 weekend-days, and 2 holiday-days (holidays occurred during May, July, and September). Each interview day was further stratified into morning (sunrise to 1330) and afternoon (1330 to sunset) periods.

A clerk contacted an angler party (i.e., a group of individuals travelling together for fishing) onsite at the reservoir and interviewed one individual that was designated the party-appointed spokesperson. The spokesperson was asked, “Have you been interviewed at this waterbody, [*reservoir name*], this year?” A binary (i.e., “yes” or “no”) answer was recorded, and that answer was replicated by the number of individuals within that party. We summed within each month for each reservoir the number of responses in which anglers stated that they had not been interviewed at that reservoir during the current year. We modeled our datasets as mark-removal studies in closed systems and analyzed our reservoir-specific data with a full likelihood capture (p) and recapture (c) model in program MARK. We evaluated four capture-probability (given presence and not previously removed) schemes across months and selected the best model using an information-theoretic approach (Anderson, 2008) for each reservoir. The four schemes were (1) capture probability constant across months, (2) capture probability constant across months except for April, (3) capture probability constant across months except for April and May, and (4) capture probability different across all months. During preliminary analysis, we suspected that utilization of each reservoir by most anglers did not occur until either May or June, which is why we included Schemes 2 and 3. We set the probability of recapture (c) at 0, and treated the

Table 1
Characteristics of reservoirs.

Reservoir	Latitude (N)	Longitude (W)	Surface area (ha)	Number of access areas for:	
				Boat anglers	Bank anglers
Branched Oak Lake	40.972539°	−96.863604°	728	4	16
Calamus Reservoir	41.847826°	−99.220834°	2075	5	10
Harlan County Reservoir	40.057313°	−99.272493°	5463	3	9
Lake McConaughy	41.248224°	−101.683402°	12,141	14	21
Merritt Reservoir	42.627675°	−100.871769°	1176	5	19
Pawnee Lake	40.842609°	−96.869964°	299	2	10

analysis as a mark-removal study. Assumptions for our approach were (1) anglers' memories were reliable and answers truthful, (2) dynamics of parties were limited such that any re-organization of angler parties through time only occurs within groups of "removed" and "not previously removed" anglers, (3) a closed population (i.e., no recruitment, immigration, emigration or mortality) of anglers existed within each reservoir for the assessment period, and (4) our sampling period within the seasonality of recreational angling was appropriate for removal sampling (i.e., participation in angling at a waterbody is such that the proportion of uncaptured anglers declined throughout our sampling period). The latter two assumptions are typical of any application of removal methods (Powell and Gale, 2015), and the former two assumptions were necessary additional considerations when applying removal sampling to humans in our angling context.

We desired to understand the methodological approach employed, especially to know if shorter durations of sampling could be employed to estimate the number of anglers for a given waterbody. To assess the effect of shorter sampling seasons on population estimates, we used the top model of capture probability for each reservoir and generated a series of population estimates using consecutively shorter sampling periods. All sample periods began with our initial sampling month (i.e., April); we consecutively eliminated months from the end of our sampling period starting with October and continuing through August, producing four population estimates generated using data from 4-, 5-, 6-, and 7-month sampling periods (4-month: April-July, 7-month: April-October). We compared population estimates with pressure estimates for the associated number of months. Our sampling methodology required subsampling to start with April because we could not correct for anglers that were "removed" in April if we evaluated a sampling scheme beginning with another month.

We completed two instantaneous counts during each survey shift at each reservoir to estimate angling pressure. We began counts at predetermined randomly selected times; all counts were completed in less than an hour from the start time. The mean number of anglers for the two counts on each day at each reservoir was used to calculate a reservoir-specific daily angling effort (Malvestuto, 1996; Pierce and Bindman, 1994). We multiplied the angler count by the number of hours during the survey period adjusted by the probability (0.5 for this study) of the daily period, and calculated the mean and variance of daily effort for each stratum (week-day, weekend-day, and holiday-day) per month, and extrapolated the stratum effort estimates and associated variances by the number of days in each strata per month (Rasmussen et al., 1998). The sum of the stratum effort estimates and variances within month provided a monthly estimate of effort, and the sum of monthly effort estimates and variances provided period (4-month period through 7-month period) estimates of effort.

3. Results

We contacted 1164 angler parties at Branched Oak Lake, 912 at Calamus Reservoir, 1082 at Harlan County Reservoir, 599 at Lake McConaughy, 775 at Merritt Reservoir, and 519 at Pawnee Lake. Refusal rates for participation ranged from 0.0% for Harlan County Reservoir to 7.3% for Pawnee Lake. Angler-party size across reservoirs ranged from 1 to 18 (mean = 2.3; median = 2); angling duration (only interviews of angler parties that had completed fishing) across reservoirs ranged from 13 min to 69.2 h (mean = 4.9 h; median = 4.5 h). Proportion of interviews for angler parties fishing from a boat ranged from 6.1% at Pawnee Lake to 93.5% at Harlan County Reservoir. As expected, "Have not been interviewed before at this waterbody during this year" responses declined throughout the assessment period across all six reservoirs, producing cumulative removal curves with asymptotes (Fig. 1).

The best description, depending on reservoir, of variation in monthly probability of capture (p) in our population-estimation models was either a model with two capture probabilities (constant across months except for April) or a model with three probabilities (constant across months except for April and May). We encountered inestimable parameters in population-estimation models with month-specific capture probabilities, and we thus excluded these models from consideration (Table 2). Population estimates (N ± SE) from top models varied between reservoirs from 916 ± 18 anglers at Pawnee Lake for the 7-month period (April-October 2015) to 2050 ± 45 anglers at Branched Oak Lake for the 7-month period (Table 3).

Shortening the sampling period by one or more months generally resulted in a greater effect on the estimate of precision than on the estimate of abundance. For example, six months of data at Branched Oak Lake produced a standard error 231% greater than the standard error for seven months of data, but only an increase of 9.27% in the overall abundance estimate. Precision of estimates decreased with each consecutive shortening of sampling period for most reservoirs, but remained relatively low (standard error <10% of the estimate) until a sampling period of four months, at which point the standard error increased substantially for many waterbodies (Table 3).

Contrary to expectations, abundance of unique anglers for a given period and reservoir did not predict angling pressure for that given period and reservoir. No significant relationships existed between pressure estimates and population estimates for the four-month (ANOVA: $F_{1,4} = 0.087$, $P = 0.73$, $r^2 = 0.02$), five-month (ANOVA: $F_{1,4} = 0.021$, $P = 0.89$, $r^2 = 0.01$), six-month (ANOVA: $F_{1,4} = 0.012$, $P = 0.91$, $r^2 < 0.01$), or seven-month (ANOVA: $F_{1,4} = 0.002$, $P = 0.97$, $r^2 < 0.01$) sampling periods (Fig. 2). Much of the deviance appeared to be due to the data point for Lake McConaughy (i.e., potential outlier). However, removal of this data point did not lead to a significant relationship for the four-month

Table 2

Competing models used to estimate the population sizes for recreational anglers at six Nebraska reservoirs during April–October 2015, including probability of detection (p), probability of recapture (c, constrained to c = 0), and population size (N). Models are ordered in columns by the number of parameters (*k*); 2, 3, and 4, respectively. We provide the difference between a model's corrected Akaike's information criterion (AICc) value and the AICc value of the highest-ranked model (ΔAICc) with Akaike weight (*W*AICc) value provided parenthetically. The best-fitting model for each reservoir was the global model, but it always produced a nonsensical population estimate; hence, the global models were deleted from all assessments. The highest-ranking model (i.e., model with ΔAICc = 0) for each reservoir was subsequently used to estimate abundance of unique anglers for that respective reservoir for April–July, April–August, and April–September sampling periods.

	Model		
Reservoir	p(.)(c.)(N.)	$(p^{April–Other})$(c.)(N.)	$(p^{April–May–Other})$(c.)(N.)
Branched Oak Lake	677 (0.00)	11 (0.00)	0 (1.00)
Calamus Reservoir	357 (0.00)	0 (0.65)	1 (0.35)
Harlan County Reservoir	258 (0.00)	0 (0.73)	2 (0.27)
Lake McConaughy	87 (0.00)	5 (0.09)	0 (0.91)
Merritt Reservoir	209 (0.00)	27 (0.00)	0 (1.00)
Pawnee Lake	159 (0.00)	9 (0.00)	0 (1.00)

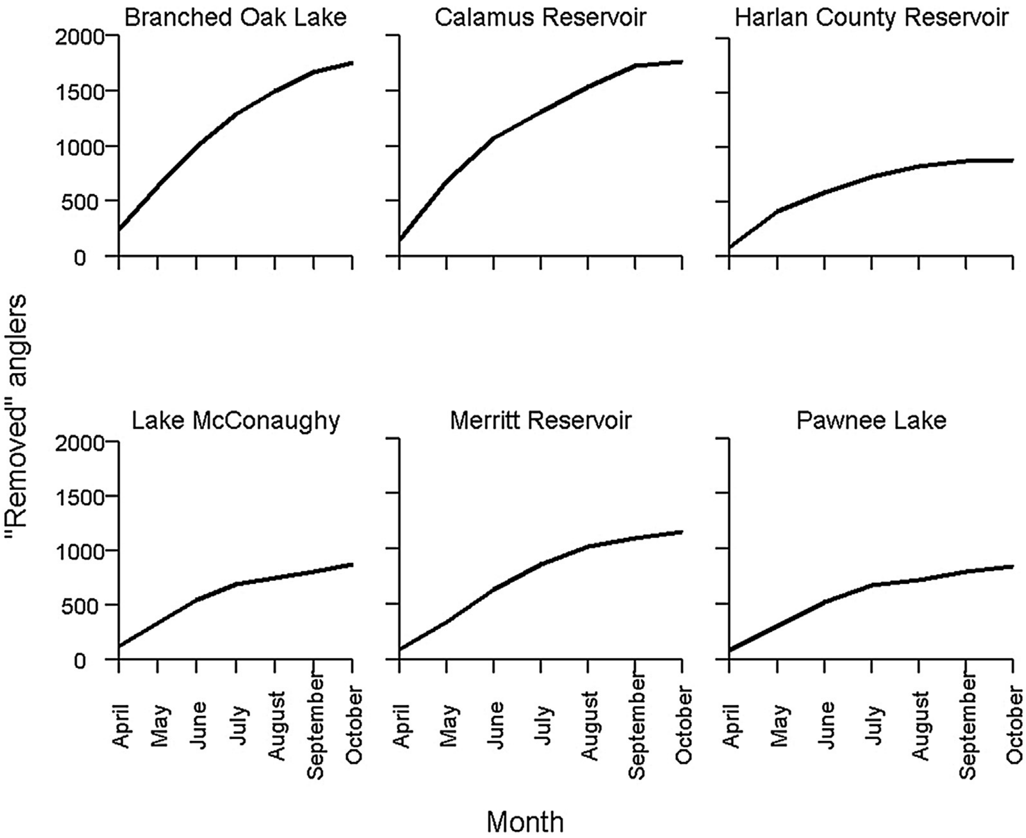

Fig. 1. Cumulative monthly responses of "no" to the question "have you been interviewed before at this waterbody, [*reservoir name*], this year?"for six Nebraska reservoirs during April–October 2015.

Table 3
Estimates of population sizes (N ± SE) for recreational anglers at six Nebraska reservoirs during 2015 with sampling periods ranging from four months (April–July) to seven months (April–October).

	Sample Duration			
Reservoir	Four Months	Five Months	Six Months	Seven Months
Branched Oak Lake	2873 ± 842	2331 ± 204	2240 ± 104	2050 ± 45
Calamus Reservoir	1823 ± 87	2069 ± 79	2250 ± 70	1992 ± 29
Harlan County Reservoir	956 ± 49	1012 ± 35	972 ± 19	929 ± 10
Lake McConaughy	969 ± 110	831 ± 22	895 ± 20	985 ± 24
Merritt Reservoir	1560 ± 305	1352 ± 85	1301 ± 41	1277 ± 24
Pawnee Lake	954 ± 112	777 ± 17	887 ± 23	916 ± 18

(ANOVA: $F_{1,3} = 0.604$, $P = 0.49$, $r^2 = 0.17$), five-month (ANOVA: $F_{1,3} = 1.838$, $P = 0.27$, $r^2 = 0.38$), six-month (ANOVA: $F_{1,3} = 1.706$, $P = 0.28$, $r^2 = 0.36$), or seven-month (ANOVA: $F_{1,3} = 1.573$, $P = 0.30$, $r^2 = 0.34$) sampling periods.

4. Discussion

The potentially large number of participants has always made problems associated with recreational fishing difficult to address politically (Cooke and Cowx, 2004; Lewin et al., 2006; McPhee et al., 2002; Post et al., 2002). Although pressure estimates are often used in lieu of population estimates, albeit with caveats attached, we found at best a weak relationship between fishing pressure and angler population size. Our results indicate natural resource agencies should avoid drawing conclusions about the number of unique users from pressure estimates. Such conclusions might not only provide misleading results but may provide results contrary to a population estimate. For example, our pressure estimates for Branched Oak Lake and Harlan County Reservoir were nearly identical, yet we estimated nearly three times as many anglers fished Branched Oak Lake. Thus, there appears to be a decoupling of angler abundance and angling pressure, though we are uncertain on the degree to which angling pressure is decoupled from the number of unique sportspersons in any system.

The first known use of the Lincoln-Petersen-type estimator (before Lincoln' and Petersen's time) was to estimate how many people were in France based on some known ratios of babies and population size in some small regions in the country (Cochran, 1978). Herein is another example of estimating how many people are in a region. Unlike most population estimates completed on wild animals, we were challenged with an unknown geographic boundary of the population to be estimated. Surveys were conducted onsite although only a portion of anglers was present at the waterbody at any given time. Thus, our approach was analogous to a system where nets sampled fish in a small and constant area of a much larger system. In this case, our reservoirs acted as our sampling locations, and the larger system was the "anglershed," or area in which anglers that visited the waterbody lived (Martin et al., 2015). A potential bias exists if movement to the waterbody (site of sampling) by individuals in the angler population is not ran-

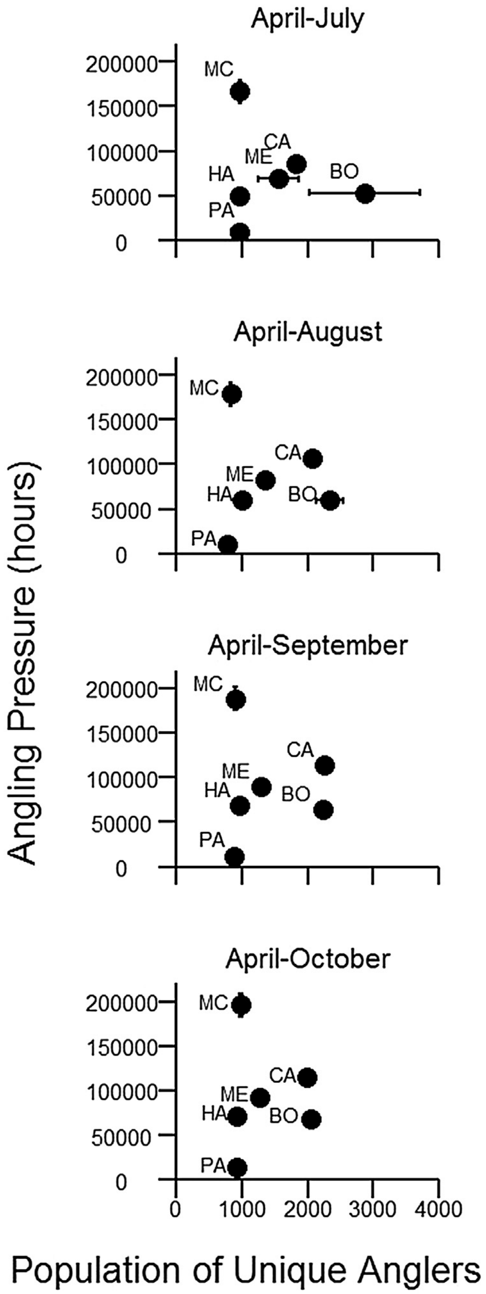

Fig. 2. Correlations of estimates for population sizes for recreational anglers with angling pressure at six Nebraska reservoirs during 2015 for four sampling periods ranging from four months (April-July; top panel) to seven months (April-October; bottom panel). Reservoirs are labeled to left of each point: BO = Branched Oak Lake, CA = Calamus Reservoir, HA = Harlan County Reservoir, MC = Lake McConaughy, ME = Merritt Reservoir, and PA = Pawnee Lake.

dom, such as a mass migration at one time through the sampling site (e.g., period around a national holiday such as the 4th of July weekend). This effect may be exacerbated in systems with cyclical fishing patterns (e.g., Pacific salmon [*Oncorhynchus* spp.] runs). A two-state model (Bailey et al., 2004)—e.g., anglers at specific reservoir and anglers elsewhere, but anglers only sampled at specific reservoir—may provide a valuable and improved means of getting around the difficulty associated with seasonality in angler use. Sampling for a two-state model needs to cover a period that allows individuals to transition between the two states. Potentially problematic, however, is the requirement for information about anglers on all previous encounters at the reservoir (i.e., specific dates of interviews) – a logistically improbable feat in most applications.

The size of the angler population will influence the accuracy and precision of the population estimate. Thus, the application of population estimation is likely limited to small and medium-sized waterbodies. If the population is extremely small (e.g., four anglers), then the probability that all anglers would be marked (or removed) during the first sampling periods would be high and there would be no unmarked individual encountered in any subsequent sampling periods, producing an extremely small data set with which to try to estimate population size. This situation is not problematic if one recognizes that a census was completed (i.e., all anglers were counted). On the other extreme, if a population is extremely large (e.g., 1 million anglers), then it is probable that anglers encountered during every sampling period would be marked (i.e., removed), yet the number of unmarked anglers encountered during subsequent periods would remain similarly high; the lack of evidence of removal in the data would not allow estimation of the population size.

We believe we generally "meet" our four modelling assumptions. Our first assumption was that anglers' memories were reliable and their answers truthful. By asking a simple yes-no question we believe this assumption is largely unviolated. Anglers had no clear reason to be untruthful. Each waterbody was primarily surveyed by one clerk, leading to higher recognition by anglers. Our second assumption was that re-organization of parties occurred only in angler parties that had already been "removed". We were unable to assess this assumption directly; even so, we suspect most anglers fish with only a few individuals, leading to relatively few changes to angler parties within a year. Our third assumption was that we had a closed population of anglers (no recruitment, immigration, emigration, or mortality) with regard to an individual reservoir. Over the course of seven months, we believe the effects of recruitment, household relocation (movement), and mortality to be minimal. Certainly, anglers often fish more than one waterbody during a season, but this does not violate the closed population assumption for our analysis of a given waterbody. Anglers who fish multiple waterbodies would simply be available for sampling in any focal reservoir, and thus would be members of the set of unique anglers at each reservoir. Our fourth assumption was that our sampling period was appropriate for angling (i.e., the number of unmarked anglers declined during our sampling). "Removed" anglers declined with time and began to asymptote towards the end of our sampling period (Fig. 1), thus we believe our fourth assumption was met.

There are several caveats to the work presented herein. We did not account for anglers that refused to participate in surveys, although refusal rates were low. We also did not account for participation bias (analogous to "trap happy" or "trap shy") either by the creel clerk or angler party. We interviewed anglers at the party-level rather than the individual-level; thus, some precision may have been lost. We attempted to sample anglers from sites throughout each reservoir. The task of contacting and sampling anglers was easier on reservoirs with limited access points than on reservoirs with numerous access points. Lake McConaughy, for example, presented a logistical challenge (124 km of shoreline and up to 14 areas with boat ramps surveyed by one creel clerk) that likely affected our estimate. To that end, our estimate for Lake McConaughy likely represents a subpopulation of anglers for the reservoir—a subpopulation that used the sites and ramps most targeted by the creel clerk.

In our study design, an angler switching reservoirs would be counted in both estimates, as the processes were separate and not linked. Thus, our population estimates of anglers at our six reservoirs cannot be summed to provide an estimate of the number of unique anglers that fished the combination of these reservoirs because anglers that fished more than one of the reservoirs in this combination would have been included in each reservoir-specific estimate. That is, summing the reservoir-specific estimates would overestimate the number of unique anglers for the combination of reservoirs. A simple change in the question asked is all that is needed if one wanted to estimate the number of unique anglers for the combination of reservoirs, rather than reservoir-specific estimates; that is, the appropriate question would become, "Have you been interviewed this year at any of the following waterbodies: [*list of waterbody names*]?" Combining multiple waterbodies, especially small waterbodies, in a local region would be a means of dealing with problems associated with sampling a small population. Likewise, our population estimates of anglers at our six reservoirs cannot be divided to provide an estimate of the number of unique anglers that fished specific portions (e.g., upper and lower halves of reservoirs) of these reservoirs. Dividing a waterbody, especially a large waterbody, into well-defined geographic areas (e.g., reservoir separated by a highway bridge) would be a means of dealing with problems associated with sampling a large population.

Accuracy and precision of population estimates, and their associated tradeoffs, are influenced by sampling design (Kowalewski et al., 2015). Thus, we expect estimates and associated variances for the number of anglers at a waterbody to be potentially different for a creel design of 6 week-days and 4 weekend-days per month for seven months compared to a creel design of 8 week-days and 8 weekend-days per month for three months. Further work is needed to understand the potential influences of creel design on accuracy and precision of angler estimates by this method.

Why estimate the population size of recreational participants, or "peopleshed," for a given water body? We believe an understanding of an entity is necessary to manage that entity effectively and efficiently. To illustrate, assume that we wish to implement a no-wake boating regulation on a 250-ha reservoir to minimize shoreline erosion and improve water quality. Before moving forward in the political process to implement this new regulation, it would be wise to know how many people will be affected (positively and negatively) by this regulation. To that end, it might be prudent to estimate the population sizes of anglers that fish this reservoir from the shore (affected positively), anglers that fish this reservoir from a boat (affected positively and perhaps negatively if they value moving their boat fast enough to plane on the water), and non-anglers that recreate on this reservoir from a boat (likely affected negatively and perhaps affected positively if they value improved water quality). If the anglers that fish from shore outnumber the other two groups 10:1, then there may be little concern about the no-wake regulation. However, if the non-anglers that recreate from a boat outnumber the anglers 10:1, then there is reason to be concerned about the proposed regulation. The appropriate course of action to implement the new regulation with the least amount of resources depends on which situation exists. This illustration highlights the need to know how many anglers are present as well as the number of other users of the reservoir. We did not estimate the abundance of participants in other recreational activities in this study, but this could be easily integrated into our surveys and doing so would improve understanding of stakeholder interests at a given waterbody.

The removal approach outlined herein could also be used to estimate the number of largemouth bass (*Micropterus salmoides*) that utilize a specified cove in a reservoir, or the number of yellow tang (*Zebrasoma flavescens*) that frequent a no-take reserve, or the percent of shovelnose sturgeon (*Scaphirhynchus platorynchus*) that frequent waters of states that allow commercial harvest. The approach could be applied to fields beyond fishery science and used to estimate the number of recreators for a park, the number of Canada goose (*Branta canadensis*) that visit a wetland, or the number of graduate students that participate in a free seminar series.

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