Fisheries Research 154 (2014) 172–178

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Angler effort and catch within a spatially complex system of small lakes

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ARTICLE INFO

Article history:
Received 27 September 2013
Received in revised form 11 February 2014
Accepted 13 February 2014
Available online 16 March 2014

Keywords:
Angler survey
Fisheries
Recreational angling
Survey design

ABSTRACT

Spatial layout of waterbodies and waterbody size can affect a creel clerk's ability to intercept anglers for interviews and to accurately count anglers, which will affect the accuracy and precision of estimates of effort and catch. This study aimed to quantify angling effort and catch across a spatially complex system of 19 small (<100 ha) lakes, the Fremont lakes. Total (±SE) angling effort (hours) on individual lakes ranged from 0 (0) to 7,137 (305). Bank anglers utilized 18 of the 19 lakes, and their mean (±SE) trip lengths (hours) ranged from 0.80 (0.31) to 7.75 (6.75), depending on the waterbody. In contrast, boat anglers utilized 14 of the 19 lakes, and their trip lengths ranged from 1.39 (0.24) to 4.25 (0.71), depending on the waterbody. The most sought fishes, as indexed by number of lakes on which effort was exerted, were anything (17 of 19 lakes), largemouth bass *Micropterus salmoides* (15 of 19 lakes), and channel catfish *Ictalurus punctatus* (13 of 19 lakes). Bluegill *Lepomis machrochirus*, crappie *Pomoxis* spp., and largemouth bass were caught most frequently across the lakes, but catch rates varied considerably by lake. Of the 1,138 parties interviewed, most parties (93%) visited a single lake but there were 77 (7%) parties that indicated that they had visited multiple lakes during a single day. The contingent of parties that visited more than one lake a day were primarily (87%) bank anglers.. The number of lake-to-lake connections made by anglers visiting more than one waterbody during a single day was related to catch rates and total angling effort. The greater resolution that was achieved with a lake specific creel survey at Fremont lakes revealed a system of lakes with a large degree of spatial variation in angler effort and catch that would be missed by a coarser, system-wide survey that did not differentiate individual lakes.

1. Introduction

There are many spatial aspects that must be considered when designing a creel survey. Spatial layout and waterbody size can affect a clerk's ability to interview and accurately count anglers, which would affect the accuracy and precision of estimates of effort and catch. Numerous researchers have investigated the complexities associated with conducting creel surveys on large (>10,000 ha) waterbodies (e.g., Soupir et al., 2006; McGlennon and Kinloch, 1997; Smucker et al., 2010). Large waterbodies, which are best sampled using a "bus route" approach (Robson and Jones, 1989; Jones and Robson, 1991) and aerial counts of anglers (Smucker et al., 2010), are often difficult to sample because numerous access points exist over a large area. Further, large waterbodies can be spatially heterogeneous such that catch rates of targeted fish species and angling effort are not uniform throughout the waterbody, requiring spatial stratification of the waterbody (Pollock et al., 1994; Soupir et al., 2006) to accurately estimate effort and catch.

Although less studied, small (<100 ha) waterbodies can also be difficult to survey, particularly when there are multiple waterbodies being assessed within a small geographic area. Trip length tends to be relatively short (i.e., hours) at small waterbodies (Pierce and Bindman, 1994) and thus the chance encounter with anglers can be small and inconsistent (i.e., dominated on weekends and holidays). Small public waterbodies can exist within a matrix of other waterbodies and given the proximity and short trips, anglers may move between several waterbodies on a single trip (Martin and Pope,

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http://dx.doi.org/10.1016/j.fishres.2014.02.013
0165-7836/

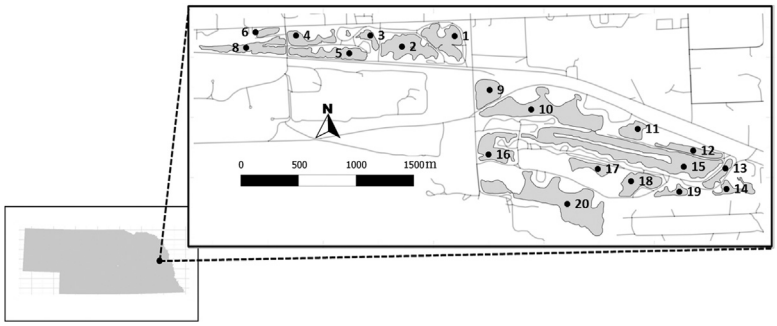

Fig. 1. Map of the Fremont lakes in Dodge County, Nebraska.

2011; Martin, 2013). Further, depending on the proximity of small, public waterbodies to urban centers, there can be large variation in effort (i.e., many counts with zeros on weekdays and many counts with large numbers on weekends) that can lead to complications when calculating effort estimates (Taylor et al., 2011).

The aim of this study was to quantify angling effort and catch across a spatially complex system of small lakes. Fremont Lakes State Park (41º 26.060′N, 96º 31.966′W; Fig. 1) (hereafter Fremont lakes) is located about two miles west of the city of Fremont, Nebraska (2011 population 26,456) and includes 19 small sandpit lakes that cover a total surface area of 265 ha. Given the proximity of the lakes to each other, travel-cost differences among lakes are negligible (i.e., <US$ 1.50 [2013 IRS mileage rate, US GSA, 2013]) and anglers can potentially move between several lakes on a single day. Of particular concern in this system is the ability to differentiate fish caught and harvested (i.e., retained by the angler) among lakes during a single day. We sought to calculate at each of the 19 Fremont lakes: (1) angling effort (hours of angling), (2) catch-per-unit effort (CPUE; N_{fish} hr^{-1}), (3) associations of CPUE and angling effort among lakes, and (4) movement patterns of anglers among lakes.

2. Methods

2.1. Study area

Fremont lakes, which ranged in area from 0.6 to 20.8 ha, were formed when groundwater filled depressions were created by sand-pit mining. These lakes shared common characteristics of being small, shallow (<5 m), groundwater fed, and irregularly shaped. Lakes were relatively close together; the greatest straight-line distance between any two lakes was 4.38 km (Fig. 1). Within the complex of lakes, anglers can fish for black bullhead *Ameiurus melas*, bluegill *Lepomis macrochirus*, common carp *Cyprinus carpio*, channel catfish *Ictalurus punctatus*, black crappie *Pomoxis nigromaculatus*, white crappie *P. annularis*, largemouth bass *Micropterus salmoides*, muskellunge *Esox masquinongy*, rainbow trout *Oncorhynchus mykiss*, and hybrid striped bass *Morone chrysops* × *M. saxatilis*. Individual lakes have been managed for different fish communities and angling opportunities. For example, catchable-size bullhead were stocked into lake 3, muskellunge were stocked into lakes 2, 8, and 20, and rainbow trout were stocked into lake 2. Further, electric-powered and non-powered boats were allowed on all lakes, whereas gas-powered boats were only allowed on lakes 15 and 20.

2.2. Angler surveys and effort counts

The angler survey for the Fremont lakes system was designed to collect standard creel information on time and date of interview, party size, angling duration (calculated by subtracting start time from interview time), most sought fish species, harvested fish, and released fish. We asked anglers to itemize the time spent and the numbers and sizes of species caught (harvested + release) among the lakes visited during that day.

A stratified multi-stage probability sampling regime (Malvestuto, 1996) was used to determine days of interviews. Twenty days were surveyed each month and stratified by day-type with 14 weekday days and 6 weekend and holiday days per month. Each creel day was further stratified into two survey periods (sunrise to 1330 [morning], and 1330 to sunset [afternoon]). During each survey shift, creel clerks conducted instantaneous counts to estimate daily effort and interviews to estimate daily catch and harvest (Malvestuto, 1996). Boat anglers were interviewed at boat ramps (primarily completed trips) and bank anglers were interviewed by roving (Pollock et al., 1994) the banks (completed and incomplete trips). During the interview process, harvested fish were enumerated and identified by creel clerks and numbers and species of released fish were recorded as specified by the angler. One angler, the representative of the party, completed the survey per interview; thus, all data were collected at the party level. Given the number of lakes, two creel clerks worked each creel shift. One creel clerk would count the number of bank and boat anglers on the northern lakes (lakes 1, 2, 3, 4, 5, 6, and 8) while the other clerk would count the number of bank and boat anglers on the southern lakes (lakes 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20). During the survey shift, there were two instantaneous counts conducted at each lake. For each count conducted, creel clerks would begin counts at a predetermined randomly selected time at a randomly selected lake (within the northern and southern groups of lakes) and move in a randomly selected direction (i.e., clockwise or counter clockwise) until all lakes had recived a count. All counts were completed in less than an hour from the start time. The mean number of anglers during the two counts of each lake was used to calculate a lake-specific daily effort (Pierce and Bindman, 1994; Malvestuto, 1996). Angler surveys were conducted from 01 April to 31 October 2011.

2.3. Numerical analysis

Monthly estimates and associated variances were calculed following methods described by Malvestuto et al. (1978), Malvestuto (1996), Pollock et al. (1994), and Pollock et al. (1997). The basic process of the extrapolations is as follows. First, angling effort for each survey day was calculated by multiplying the mean angler count by the number of hours in the survey period adjusted by the proportion of the daily period (i.e., 0.5 or half of the total hours within a day). The mean daily effort for each stratum (weekday and weekend [including US Federal holidays]) was then calculated for each month and these two mean values were weighted by the proportion of the day types per month and summed to get the effort on a typical day during the month. This estimate was then multiplied