ANGLING ACTIVITY, USE PATTERNS, AND ANGLER'S EVALUATIONS OF FISHERY QUALITY AND MANAGEMENT AT THE MARBEN PUBLIC FISHING AREA

by

HUNTER J. ROOP

(Under the direction of Cecil A. Jennings and Neelam C. Poudyal)

ABSTRACT

This study investigated angling success, use, and the human dimensions of anglers at the Marben Public Fishing Area (PFA). Results from a year-round creel survey and angler interview indicated that fishing effort rapidly increased during spring, peaked at approximately 21,856 angler-hours in May, and subsided to an annual low of 1,301 angler-hours during December. Catch and harvest estimates varied proportionally in response to fishing effort, and sunfish *Lepomis* spp. represented approximately 78% of catch and 83% of harvest compositions. Anglers ranked the quality of fishing at Marben PFA 6.45 (SD = 2.19) on a scale from one to ten, and several variables were related to fishing quality perceptions (e.g., total target fish caught, fishing location, driving distance, ethnicity). Recreational vehicle traffic entering Marben PFA was variable throughout the survey, confounding the development of a passive effort-estimation system. Anglers' perceptions of fishing quality may be improved by managing for a greater variety of fishing experiences among the impoundments (e.g., trophy ponds, high catch rate ponds).

INDEX WORDS: Centrarchidae, creel Survey, human dimensions, recreational fisheries, roving

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DEDICATION

I dedicate this thesis to my mother, Meg Roop, who left our family very suddenly on June 16, 2005. Mom—your display of strength, determination, tenacity, and unwavering dedication to life is a constant inspiration for me to strive for success while remaining true to myself.

Death is not the greatest loss in life. The greatest loss is what dies inside while still alive—never surrender. –Tupac Shakur

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My final acknowledgement is owed to my co-advisor, mentor, professor, and cherished friend, Dr. Cecil Jennings. Dr. Jennings, in my opinion, you are simply “the man.” Your sense of humor is spot on. Your breadth of knowledge is vast. Your down-to-earth demeanor is somewhat anomalous in academia, where prestige and recognition are often the daily motivation. There are few professors as approachable, humble, knowledgeable, caring, and helpful as you have been to me. Working as your graduate student has been such an honor and a privilege. I have learned a lot about working as a biologist, but I have learned even more about life in general. I am confident that the knowledge I have gained as your student will benefit me no matter where life takes me. Thank you for giving me the opportunity to earn my master’s degree at UGA and learn more about the conservation and management of our fishery resources.

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CHAPTER I

INTRODUCTION & OBJECTIVES

Recreational fishing is both a culturally and economically important outdoor activity in Georgia. Based on the *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*, 764 thousand Georgia anglers fished 8.5 million angler-days and spent $729 million on trip-related expenses to fish Georgia's waters (USDOI 2011). According to the report, though both freshwater and saltwater angling opportunities are available in Georgia, most anglers (~92%) participate in freshwater fisheries because of the abundant freshwater angling opportunities throughout the state from the coldwater trout streams of the Blue Ridge region down to the slow-flowing rivers of the coastal plain. In addition to the many large reservoirs, rivers, watershed lakes, and privately-owned farm ponds that constitute Georgia warm water fisheries, public fishing areas (PFAs) in Georgia are intensively managed freshwater impoundments that provide excellent fishing opportunities to anglers seeking a variety of recreational fishing experiences. The fisheries section of Georgia Department of Natural Resources' Wildlife Resources Division (WRD) currently manages ten PFAs throughout the state of Georgia. This study focuses specifically on anglers fishing the impoundments that make-up the Marben PFA in Mansfield, Georgia.

Management of recreational fisheries involves supervision and regulation of the three major components that define a fishery: the aquatic habitat, the fish population, and the angling population (Murphy and Willis 1996). To better understand the angling component of the fishery, managers often implement a creel survey to collect information from anglers regarding their angling activity and their opinions about the management of the fishery. Thus, creel surveys are frequently used to understand the use and human dimensions of fisheries, and information derived from creel surveys is directly useful in guiding management actions pertaining to fishing regulations, stocking efforts, habitat enhancement, and angler education programs (Pollock et al. 1994; Knuth and McMullin 1996). Conducting a creel survey involves interviewing and observing anglers—through a number of different approaches—to obtain data useful in management of a fishery (Pollock et al. 1994; Malvestuto 1996). Creel surveys provide the opportunity to not only obtain data relevant to angling activity but also to gain insight on angler preferences and attitudes towards current management strategies and regulations.

Fishery managers at the Marben PFA have limited information regarding recreational angling activity within the fishery. To evaluate the efficacy of current management efforts and fishing regulations, managers need to understand the basic aspects of recreational fishing activity, including fishing pressure, catch, and harvest. Additionally, with a goal of improving or optimizing the anglers' fishing experience, understanding what characteristics of the fishery influence anglers' satisfaction with fishery quality is also important for evaluating current management practices and garnering public support for management decisions (Fisher 1997). Information gathered from angler interviews aids managers in identifying aspects of the fishery that may need attention, including fishery characteristics that aren't directly concerned with the water bodies (e.g., accessibility to fishing sites, operating hours, angler crowding, and poor behavior of anglers). Accordingly, I conducted a roving creel survey that aimed to describe and quantify several variables related to angling activity at the Marben PFA. The survey also allowed anglers the opportunity to express opinions about several aspects of management of the fishery at Marben PFA. Because angling success is often determined by estimating and comparing variables related to catch or harvest (Colvin 2000; Hickman 2000; Bailey 2007), I examined angler's total catch, release, and fish harvest to evaluate sport fishing success. Additionally, because a number of less-tangible factors can also influence angler satisfaction with fishing quality (e.g., aesthetics, pollution, crowding; Bryan 1977), a short interview accompanied the collection of creel data to assess angler attitudes towards various aspects of the fishery.

Although the primary focus of this study was to investigate several aspects of current sport fishing activity and angler attitudes, there was also an interest in using traffic counters to indirectly monitor fishing activity at the Charlie Elliot Wildlife Center (CEWC). Therefore, in addition to conducting a roving creel survey, a vehicle intercept survey was incorporated to the study. The vehicle survey aimed to establish a reliable use-estimation system, which would primarily serve as a proxy of angler use. This system would then potentially reduce the need for future creel surveys at Marben PFA if a reliable index could be developed to estimate seasonal angling activity based on traffic volume and patterns. To the best of my knowledge, this combined roving-vehicle survey approach has never been used to develop an index for fishing pressure for a public fishing area. Developing a reliable index for estimating fishing pressure would benefit the Georgia DNR by allowing funding and other resources that would otherwise be spent on future creel surveys to be used elsewhere in management of the WMA or on other Georgia PFAs.

The goals of this study were to obtain several estimates related to angling activity and assess the satisfaction, preferences, and attitudes of anglers regarding management of the Marben PFA. My specific objectives were to:

1) quantify sport fishing effort, post-catch activity (catch, release), and fish catch by species, number, and weight in 14 Marben PFA lakes,

2) evaluate angler preferences and attitudes regarding various aspects of fisheries management at Marben PFA,

3) examine how anglers value and rank the fishing quality at Marben PFA against other fishing sites, and

4) determine the proportion of fishing traffic entering the CEWC and identify any existing relationships with available estimates of fishing pressure (effort) to develop an index for mangers to reference in the future.

These objectives were accomplished through collection of fishery-dependent, angler interview, and vehicle-intercept data from anglers at the Marben PFA and recreationists at the CEWC.

The content of this thesis is organized by four additional chapters. Chapter Two is a literature review of creel survey methods and their applications in fisheries management. Chapter Three is a stand-alone research paper that describes the creel data collection and analysis and disseminates the creel survey effort, catch, and harvest estimates; measures of angler success and fishing quality for sportfish species; and the results from the vehicle intercept survey. Similarly, Chapter Four is another stand-alone research paper that describes the collection and analysis of the human dimensions data, reports descriptive statistics from the fishery-independent, and describes a process of modeling angler's perceptions of fishing quality at Marben PFA based on a combination of situational variables, angling metrics, and subjective evaluations of anglers regarding their angling experiences at Marben PFA. Finally, Chapter Five summarizes the main findings of the two research chapters and discusses management implications based on these findings.

CHAPTER II

LITERATURE REVIEWS

Creel Survey Methods

The term “creel” refers to a woven, wicker basket used traditionally to store newly caught fish. A creel survey involves counting anglers and inspecting angler catches at a specific recreational fishing site (Pollock et al. 1994, Murphy and Willis 1996). Creel surveys were initially proposed as a means to fill an information gap that previously existed between fishery managers and their fisheries regarding status of fish stocks, rates of removal, angler success, and efficacy of regulations and other management efforts (Clark 1934). Shortly after Clark’s (1934) suggestion, civilian conservation corps (CCC) workers began to line the banks and boat ramps of fisheries around the country in an early attempt to measure the angler’s catch (Eshmeyer 1935, Lord 1935, Smith 1935). Fisheries scientists immediately recognized the usefulness of information obtained from creel surveys in understanding catch and harvest patterns within fisheries (Clark 1934, Eshmeyer 1935, Lord 1935, Smith 1935). However, because the processes of survey development, planning, and implementation were relatively new to the fisheries field, the information derived from creel surveys often resulted in unreliable estimates of fisheries characteristics along with inefficient allocation of sampling effort, time spent surveying, and financial and human resources (Knight and Malvestuto 1991). By combining information from multiple creel surveys over many years, improved survey designs have been developed that are more statistically valid than earlier surveys and emphasize efficient allocation of sampling effort and financial resources (Guthrie et al. 1991). As a result, there is a wealth of literature discussing a number of approaches and strategies for conducting soundly designed creel surveys (Guthrie et al. 1991, Pollock et al. 1994, Malvestuto 1996, Vaske 2008, Hartill et al. 2012).

A decision as to which creel survey strategy and design to use involves balancing the constraints imposed by the researcher's information objectives, desired accuracy of estimates, available manpower, financial resources, and working time frame (Weithman and Haverland 1991, Pollock et al. 1994). Additionally, the unique characteristics of the fishery of interest should be taken into account when considering survey design, as these characteristics will inevitably influence the investigators ability to contact the entire angling population (Phippen and Bergersen 1991). For these reasons, creel surveys can be conducted in many forms (e.g., mail survey, telephone interview, on-site survey, online survey), and selection of the appropriate form should align with study objectives, fishery characteristics, and feasibility of implementation. Generally, there are two approaches of surveys (i.e., on-site surveys and off-site surveys), and each approach has many specific types of surveys. These specific survey approaches have different strengths and weaknesses and are appropriate for different situations. Off-site surveys are creel surveys conducted away from fishing sites and usually require a sampling list of anglers who are contacted, oftentimes, at their residence (Pollock et al. 1994). On-site creel survey methods sample a fishery that varies in both space in time, contacting anglers either in the act of fishing or when they have completed their fishing trip (Pollock et al. 1994).

Off-site Survey Methods

Mail Surveys

Mail surveys, where anglers are issued and return voluntary questionnaires via mail, have been the preferred off-site method for many fisheries agencies because of their cost-effectiveness and simple administration (Pollock et al. 1994, Connelly and Brown 2011). In fisheries, these surveys typically investigate the human dimensions (e.g., sociological, economic) of angling populations and have limited direct application to collection of creel data (Ditton and Hunt 2001). Mail surveys are defined by their sampling frame and are represented by two major categories: license file surveys and add-on surveys (Brown 1991, Pollock et al. 1994). License file surveys are samples of potential respondents that are drawn from a list of licensed anglers for the fishery of interest (Pollock et al 1994). Add-on mail surveys can supplement an on-site survey method by obtaining additional data from a randomly selected angler once his/her fishing trip is completed. Add-on surveys are especially important when economic assessments are the primary objective of a creel survey (Pollock et al. 1994). Mail surveys are excellent for human dimensions-oriented studies because of their relatively low cost and simplicity (Brown 1991). However, mail surveys do contain some weaknesses in that they are often characterized by relatively low response rates, incomplete sampling frames, and an inability to modify or clarify questions to the respondent once the instrument is mailed (Pollock et al. 1994, Brown 1991, Vaske 2008).

Telephone Surveys

Creel surveys have also been conducted via telephone to obtain angler demographics, assess anglers' attitudes and opinions about a fishery, and even to estimate angler catch and effort (Weithman 1991, Jennings 1992, Pollock et al. 1994). Conducting a telephone survey requires a complete sampling frame of the population of interest and is usually a special registration list such as a fishing license list, boat registrations, and angling club memberships. The most well-known telephone creel survey was conducted by the Marine Recreational Fishery Statistics Survey (MRFSS) and described by Essig and Holliday (1991); however, catch rate information was not sought from this survey because of a number of biases associated with this method. Telephone surveys have not been used frequently in fisheries, but their use as a tool in fisheries management is predicted to increase (Pollock et al. 1994). Telephone surveys are characterized by relatively higher costs of implementation in comparison to other off-site methods—which may explain their limited use. However, data derived from telephone surveys can be quickly analyzed and reported in comparison to mail surveys, and some telephone surveys in fisheries have reported unexpectedly high response rates when a letter of notification is sent in advance of the actual phone call (Dillman 1978, Pollock et al. 1994, Vaske 2008).

Onsite Survey Methods

Access Point Surveys

The access point survey is an onsite-intercept method in which a creel clerk occupies access/exit points to a fishery (e.g., boat ramp, parking area) for a predetermined amount of time with the primary responsibility of counting and interviewing every angler returning from their fishing trip to obtain information related to fishing effort and catch (Hayne 1991, Pollock et al. 1994, Malvestuto 1996). Supplemental information regarding trip expenditures (economic) and social issues may also be collected during the interview process (Pollock et al. 1994). Sampling days in an access point survey are randomly selected from a spatiotemporal sampling frame consisting of all potential sampling days and sites and typically requires a multistage design (Pollock et al. 1994). Access point surveys have been used extensively by state fisheries agencies to estimate and describe catch and effort for freshwater/saltwater commercial and recreational fisheries (see Osborn and Spiller 1991, Lockwood 1997, Guillory 1998, Strehlow et al. 2012). The strengths of the access point method over offsite methods are that clerks examine angler catch onsite, clerks can detect illegally harvested catch, and information is provided immediately after the fishing trip has ended (thus, the details of the trip are fresh in the mind of the angler). Hence, creel clerks can validate angler catch by species and reduce the potential for recall bias by using this method. Weaknesses of the access point method are that avid anglers are more frequently sampled than occasional anglers (avidity bias), multiple access points can distort complete fishery coverage, and costs of implementing access point surveys are relatively higher than offsite methods (Pollock et al. 1994).

Roving Surveys

The roving creel survey employs a clerk who travels through a recreational fishery to interview anglers in the act of fishing (Malvestuto et al. 1978, Robson 1991, Pollock et al. 1994). The primary advantage of the roving approach over the access point method is that a relatively larger sample size is achieved as the clerk actively seeks out anglers (MacKenzie 1991). However, roving creel survey designs have been characterized as being relatively biased in comparison to access-point surveys because the probabilities of a party encounter are dependent on the length-of-stay of a fishing party (Robson 1991, Wade et al. 1991). Additionally, the "shadowing effect" (where the clerk falls behind schedule because of unusually long interview times) can further bias estimates of fishing effort (Wade et al. 1991). Both biases result in a significant underestimation of fishing effort; however, this underestimation can be compensated for by using a checkpoint design, which aims to keep the clerk on schedule despite unexpectedly protracted interview times. The inclusion of checkpoints involves actively monitoring interview times to ensure that the clerk reaches “checkpoints” located along the prescribed route to achieve uniform coverage of the sampling area and reduce bias associated with the shadowing effect. One method to completely avoid the shadowing effect is to replace progressive counts of anglers with instantaneous counts taken at random times during the sampling day, given that these counts do not exceed one hour (Pollock et al. 1994).

Currently, there are mixed results describing the accuracy of harvest data obtained from roving creel surveys. MacKenzie (1991), in comparing catch and harvest data from anglers who had completed their fishing trip (obtained via access-point survey) and anglers actively fishing (obtained via roving survey), determined that there were not significant differences in catch per unit effort (CPUE) between the two survey methods. However, significant differences were found with respect to harvest per unit effort (HPUE) between completed trips and uncompleted trips. A similar creel survey conducted by Kozfkay and Dillon (2010) on anglers targeting white sturgeon in the Snake River (Idaho) did not, however, find significant differences between CPUE and HPUE for anglers who had or had not completed their fishing trip. These results suggest that although CPUE estimates are relatively robust among both survey strategies, HPUE estimates are likely to be biased as they may underestimate rates of harvest when follow-up questionnaires are not used. Accordingly, the primary advantage of the access point method over the roving survey method is that catch and effort data are based on completed trips. However, for fisheries with many access points located over a large spatial area, the roving survey may be the only practical approach when collection of fishing data is a primary objective (Pollock et al. 1994, Malvestuto 1996).

Vehicle-Intercept Survey

Based on my research of established use-estimation systems, the use of vehicle surveys for the purpose of monitoring recreational activity by one user group (anglers) among a myriad of recreationists has not been attempted. Managers of national and state parks, monuments, and other recreational and historic sites have commonly conducted vehicle surveys as an essential step in data collection for the purpose of establishing a reliable *overall* use estimation system based on traffic counters (Cessford and Muhar 2003). Even so, between 40% and 63% of park and wilderness area managers use the "best guess" technique, based on informal counts, to estimate visitation especially in areas of high user dispersion and/or a low user profile (Watson et al. 2000). However, there are a number of systematic techniques used to estimate visitation to an area or event that include direct observation, on-site counters, visit registration, and inferred counts (Cessford and Muhar 2003, Raybould et al. 2000). Several frameworks exist for establishing an accurate use estimation system and generally require: 1) a statement of objectives 2) identification of specific use characteristics to be measured 3) choice of appropriate use measurement techniques 4) choice of appropriate sampling strategy and 5) choice of appropriate data analysis (Watson et al. 2000). Based on my research of studies that have sampled vehicle traffic with the intention of estimating visitation, the methods used and data types collected are site-specific and do not appear to have widespread applicability. For example, Mowen (2002) explained the components and methodologies necessary for a dedicated use-estimation system where entering vehicles were counted to estimate total visitation at metropolitan parks in Cleveland; however, the statistical methodologies for estimating site visits did not specify a subset of recreationists and were therefore unsuitable for the purposes of the CEWC study. Fix et al. (2012) surveyed vehicles exiting the Denali National Park to determine overall visitation, and this vehicle survey did improve their formula for obtaining park-wide visitation estimates. Even so, because the Denali National Park study counted exiting vehicles, the methods cannot be replicated for the CEWC vehicle study because I sampled vehicles entering CEWC. Similarly, English et al. (2001) developed a detailed use-monitoring process for Forest Service lands based on exiting vehicles and, because the depth and scale of their study was considerably large, the proposed analysis would have to be significantly altered to accommodate the design of the CEWC's vehicle survey. Therefore, the CEWC vehicle survey was designed considering its unique, site-specific characteristics in combination with the vehicle survey objective of estimating angler use—not total recreational use—at the PFA.

Sampling Design

The sampling design for any creel survey depends on the angler contact method, the observed/expected patterns of use, and the site-specific characteristics of the fishery of interest. General sampling designs used are simple random sampling without replacement, stratified random sampling, systematic random sampling, multiphase sampling, and sampling with unequal or non-uniform probabilities (Pollock et al. 1994, Murphy and Willis 1996, Cochran 1977). Onsite contact methods typically sample populations that vary in use, space, and time, and therefore require multiphase sampling, stratification, or both. Such an approach can facilitate improved overall precision of estimates, easier administration, and greater information yield (Pollock et al. 1994, Vaske 2008). The roving survey design is one of the most widely used methods in on-site creel survey (Pollock et al. 1994) and frequently employs multiphase sampling and stratification with uniform or nonuniform probabilities (e.g., Malvestuto et al.

1978, Reed and Davies 1991, Mallison and Cichra 2004, Ellender et al. 2010, Kozfday and Dillon 2010, Veiga et at. 2010).

Utility of Creel Surveys

Within the past few decades, creel surveys have been used to serve multiple purposes in fisheries management including description of angling activity, catch compositions, social and market analysis, regulatory efficacy, and biological assessments. In many studies, creel surveys are used as supplementary sampling tools to collect ancillary information necessary to accomplish primary study objectives, which often investigate the efficacy of management efforts (Colvin 2002, Allen et al. 2003, Al-Chokhachy et al. 2009, Fielder 2010). Because creel surveys have evolved to serve diverse informative purposes, descriptions of the most prominent general themes are reviewed separately.

<u>Fishery Profiles</u>

The initial purpose for developing the creel survey method of contacting anglers was solely an effort to measure the angler's catch (Clark 1934). Because national participation in recreational fishing has experienced a recent upsurge (US DOI 2011) to approximately 33.1 million anglers, the need to understand the basic fishery profile continues to be a critical element of effective fisheries management (Malvestuto 1996). In recreational fisheries, the fishery profile describes temporal and spatial variation in estimates of fishing effort, harvest rates, or total harvest within a particular fishery or region comprised of similar fisheries (Palsson 1991, Hayne 1991, Deroba et al. 2007).

Understanding the basic fishery profile is critical for effective fisheries management because recreational angling is known to affect fish stocks (Cooke and Cowx 2004, Lewin et al. 2006, Philipp et al. 2009). High exploitation rates (i.e., the fraction of fish in a population removed at a given time, within a specified time interval) can result in depensatory responses (e.g., compromised mating success, foraging, or avoidance strategies) from the exploited population when reduced below a certain threshold (McCarthy 1997, Rangeley and Kramer 1998, Day et al. 2001). A more common observation, however, is the truncation of both age and size structures in an overexploited population, attributable to both high exploitation rates and size selective harvest (Radomski 2003, Lewin et al. 2006, Rassmussen and Michaelson 1974). Reductions in both population size and age structures have been documented in Black Crappies (Willis et al. 1994), other sunfishes of the *Lepomis* genus (Drake et al. 1997, Cook et al., 2001), and Smallmouth Bass (Goedde and Coble 1981) as a result of size-selective overharvest. Conversely, very low fishing effort or overharvest of only predators or prey can disrupt stable ecological relationships in popular bass-bream fisheries and result in “bass crowded” or “Bluegill crowded” situations (Swingle and Smith 1941, Shelton et al. 1979, Aday and Graeb 2012). The resulting imbalance of the predator-prey ratio can result in poor condition of predators, stunting of prey, and poor quality fishing overall (Schramm et al. 2003, Willis and Neal 2012). Therefore, to avoid the negative effects of overharvest on populations and/or density-dependent effects of low fishing pressure, gaining an understanding of the magnitude and variability of fishing effort and harvest within a fishery is necessary so the population can be managed accordingly.

Biological Assessments

In addition to providing harvest and effort data, angler surveys can provide biological samples for a variety of analyses including estimation of growth rates, feeding habits, age structures, length-weight relationships, maturity schedules, and contaminant loadings (Pollock et al. 1994). Such investigations rely on the premise that accurate and precise estimates of catch and effort can be used for biological assessments (Crone and Malvestuto 1991, Wade et al. 1991). For example, Colvin (2002) used gill netting and tagging in combination with angler catch data to exploitation rates among year classes and to assess growth and mortality of White Bass (*Morone chrysops*). Allen et al. (2003) used an angler CPUE abundance index to estimate the effects of habitat enhancement on Lake Kissimmee, Florida. Reed and Davies (1991) used a concurrent roving creel and tagging study to evaluate the suitability of more restrictive harvest regulations for Alabama Crappie.

Data from creel surveys have also been used to model changes in harvest regulations such as minimum size limits, creel limits, and stocking rates (Quertermus 1991, Arlinghaus et al. 2010). Other investigations of supposedly exploited populations obtained results that suggest management focus shift to more restrictive angling measures (Almodovar and Nicola 1998, Font and Lloret 2011, Johnston et al. 2011). In some cases, the information from creel surveys has prevented what would have otherwise been a wasteful use of resources. For example, a utilization creel survey of a rural creek fishery in Alabama determined there were not enough anglers fishing the waters to justify a risk assessment for polychlorinated biphenyls (PCBs; Ebert et al 2012). Hence, creel survey data is useful in understanding the effects or needs of regulations in recreational fisheries, as well as providing valuable information about the angling community and fish population characteristics.

Economic Valuation

Professionals in the field of natural resource conservation and management have recognized the need to estimate the value of land and water-based natural resources as means to continue support for management or, in some cases, justify public funding for their protection (Gordon et al. 1973, Meffe and Carroll 1994, Pollock et al. 1994). By estimating the net value of recreational fisheries, the economic benefits to local communities where the fishery exists can be quantified and used to predict the loss of welfare to local communities if the fishery was removed (Pitcher and Hollingworth 2002, Arlinghaus and Cooke 2009). Hence, economic valuations of fisheries can provide reasonable and compelling evidence to support the continual management of fisheries in many cases. The travel cost method (TCM; Clawson and Knetsch 1966), contingent valuation method (CV; Davis 1963), and economic impact analyses like input-output models (IO; Miernyk 1965, Miller and Blair 1985) are the most prominent analytical methods that have been used to estimate the value of recreational fisheries from multiple perspectives (e.g., the utility gained by anglers, the economic impact of the fishery to the local community, the tax revenue gained by local and state municipalities). For example, TCM and CV have both been used to estimate the value of fishing trips for coldwater (Duffield et al. 1987, Oster et al. 1987, Wade et al. 1988) and warmwater fisheries (Sorg et al. 1985, Fiore and Ward 1987, Dorr et al. 2002) throughout North America (Swanson and McCollum 1991). Hence, these types of economic evaluation methods are necessary to properly estimate the value of a non-market good such as recreational fishing.

Human Dimensions

In fisheries research, human dimensions studies investigate the human component of fisheries management including a wide range of thoughts, opinions, and processes pertaining to fishery quality, invasive species, consumption advisories, fishing regulations, and other issues related to fisheries management. Creel surveys are more frequently being used to examine the human dimensions of fisheries because of the recognition by fisheries managers that the goal of management is to maximize the benefits of both anglers and local communities from the use of aquatic resources (Pollock et al. 1994, Knuth and McMullin 1996). Absent of input from key stakeholders, even the best science-based management approaches will fail if they invoke dissent from anglers (Pringle 1985, Van Horn 2001). In fisheries, angling satisfaction is not only determined by the quantity and quality of fish caught, but also by the environmental aesthetics, availability of facilities, environmental conditions and settings, and personal economics involved (Miranda and Frese 1991, Hutt et al. 2013). Furthermore, the recognition that anglers are not a homogenous group of people, but rather ascribe varying degrees of importance on fishery characteristics, will inevitably result in different perceptions of fishery quality and satisfaction according to their unique interests (Bryan 1977, Haun 1991, Spencer 1993, Bryan 2000).

Human dimensions-oriented creel surveys have often investigated constructs or factors believed to influence anglers' overall satisfaction with their fishing experiences (Holland and Ditton 1992, Spencer 1993, Arlinghaus 2006) . Fishing satisfaction is a difficult idea to measure and explain; however, satisfaction is an important idea because it is a close reflection of the perception of quality (Manning 1999, Manfredo et al. 1995, Joohyun et al. 2004). Satisfaction theories attempt to explain why people evaluate their experiences in a given way (Vaske 2008). Satisfaction models often relate recreationists' satisfaction levels, attitudes, or behaviors with higher-order cognitive processes (i.e., a reflection of value systems or beliefs) or expected outcomes (e.g., motivations; Vaske 2008). Because satisfaction is complex, it is often evaluated in terms of a multifaceted discrepancy model, incorporating several different factors that are believed to influence overall satisfaction (Graefe and Fedler 1986, Graefe and Drogin 1989, Vaske 2008). The general model of satisfaction is a function of two separate groups: situational variables and the subjective evaluations of the recreationist (Graefe and Fedler 1986, Whisman and Hollenhurst 1998). Situational variables can be likened to activity-general elements of fishing (Driver and Cooksey 1977, Fisher 1997) including relaxation, social interaction with family and friends, and being outdoors. Subjective evaluations are numerous and include socioeconomic and cultural characteristics, experience, attitudes and preferences, subjective norms, crowding, and risk perception (Whisman and Hollenhurst 1998, Manning 1999). This general model has been further refined and used to identify important factors affecting satisfaction across a wide variety of recreationists, including anglers (Graefe and Fedler 1986, Vaske et al. 1986, Herrick and McDonald 1992, Whisman and Hollenhurst 1998).

Investigations into the human dimensions of fisheries have resulted in a wealth of literature that highlight the diversity of fishing communities and have significant implications for fisheries managers. Hampton and Lackey (1976) used a human dimensions information to assess hypothesized disparities about the importance of output measures between anglers and fishery managers, and concluded that a disconnect did indeed exist between manager’s primary objectives and the factors determining angler’s satisfaction. Fisher (1997) grouped anglers based on their level of specialization and catch preferences and discovered that different angler groups advocated significantly different management strategies. Spencer (1993) used a motivational approach to identify angler subgroups and concluded that satisfaction levels significantly differed among groups with different motivations (e.g. angling vs. social interaction). Arlinghaus and Mehner (2005) assessed anglers' attitudes towards opposing management strategies (habitat management vs. stocking) and found that basic human characteristics (e.g., values, beliefs, and attitudes) were more meaningful predictors of management preference than traditional angler variables such as demographics, income, experience, or preferred species. Understanding the human dimensions of fisheries is a crucial component to understanding how management decisions and actions will influence angler satisfaction. Thus, information derived from creel surveys can be used to identify policies and management strategies that will improve anglers' fishing experiences and overall fishing satisfaction.

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CHAPTER III

ASSESSING ANGLING ACTIVITY (EFFORT, CATCH, AND HARVEST) AND THE EFFICACY OF A USE-ESTIMATION SYSTEM ON A MULTI-LAKE FISHERY IN MIDDLE GEORGIA.[1]

[1] Roop, H. R., N. C. Poudyal, B. J. Irwin, and C. A. Jennings. To be submitted to the *North American Journal Fisheries Management*.

Abstract

Creel surveys are valuable tools in recreational fisheries management; however, multiple-impoundment fisheries of complex spatial structure can complicate survey designs and pose logistical challenges for monitoring agencies. A non-uniform probability roving creel survey was conducted at the Marben Public Fishing Area in Mansfield, Georgia during 2013 to estimate fishery characteristics relating to fishing effort, catch, and fish harvest while simultaneously evaluating the efficacy of a passive effort-monitoring system for the fishery. Fishing effort averaged 7,523 angler-hours (h) monthly (SD = 5,956) and ranged from 21,856 h (SD = 5909) in May to 1,301 h (SD = 562) in December. The most highly sought sport fish also had higher species-specific catch rates and were 2.11 fish/hr for sunfish *Lepomis* spp., 0.42 fish/hr for Largemouth Bass *Micropterus salmoides*, 0.29 fish/hr for Channel Catfish *Ictalurus punctatus*, and 0.27 fish/hr for Black Crappie *Lepomis nigromaculatus*. A linear mixed model (LMM) assuming a negative binomial distribution was used to determine that angler catch and harvest rates were significantly higher in the spring and summer (all $p < 0.05$) than in the other seasons, but did not vary by fishing location. The relative standard errors for the proportion of fishing traffic entering Marben PFA were all above the target value of 20% (range = 37% - 104%), which indicated that the proportion of fishing traffic was highly variable, even within periods of similar fishing effort. Creel results from other comparable fisheries indicate that fishing pressure at Marben PFA is relatively high at the local scale and moderate on a regional scale. The results highlight the utility of small, intensely managed impoundments for supporting quality recreational fishing opportunities and provide key fishery characteristics that should aid management in establishing objectives for fisheries management.

Introduction

The primary goal of recreational fisheries management is to wisely and optimally use public resources to produce quality sport fish stocks for leisure or competitive fishing activities (Pollock et al. 1994, Malvestuto 1996, McCormick & Porter 2014). The wise use of fisheries resources implies efficient sampling and effective monitoring of fishing activity to ensure the sustainability of use and maximum satisfaction to anglers. When angling activity is of specific interest, recreational fisheries are typically sampled via creel surveys; however, on-site creel survey work can be both time consuming and costly for managing agencies (Pollock et al. 1994). In Georgia, numerous public and private coastal and inland fishery resources are available to anglers seeking fishing opportunities, including state-owned public fishing areas (PFAs). Public fishing areas are intensively managed warm-water fisheries that aim to provide a variety of fishing opportunities to all level of anglers in a well-maintained setting. Periodically, creel surveys are conducted on Georgia PFAs to develop fishery profiles and evaluate the efficacy of management efforts as they relate to angler success. However, a subset of these PFAs has posed logistical challenges for managers planning and designing creel surveys because of their complex spatial layout. For example, some PFAs contain multiple entrances and multiple impoundments within a small geographic area, which prevent or complicate use of traditional on-site contact methods such as standard roving or access point designs because many anglers may be missed during the survey process. Therefore, adaptation of a generic method of surveying is often required for sampling this special case of multi-lake fisheries to develop an accurate fishery profile (Chizinski et al. 2014). Because sampling such fisheries can be challenging, alternative methods of monitoring fishing activity are often considered as well. Presently, efforts to either directly or indirectly monitor fishing effort via passive or active methods (e.g., cameras, traffic counters) have varying levels of success (Douglas & Giles 2001, K. J. Hining & J. M. Rash, NC Wildlife Resources Division, personal communication) with accuracy and precision often waning as the size and spatial complexity of fisheries increases. However, considering the time and budget-intensive nature of creel surveys, alternative methods of monitoring fishing effort continue to be explored.

Efforts to survey and monitor fishing activity at the Marben PFA have been complicated by its complex spatial structure (i.e., being a mosaic of small impoundments) and multiple entrances that are prevalent along the perimeter of the facility. Fishery managers wanted to develop a profile of fishing effort, catch, and harvest on the fishery while simultaneously evaluating the potential for using traffic counters to monitor fishing effort at the facility. Developing a fishery profile that quantifies catch and harvest and describes variation in patterns of use (i.e., temporal and spatial variation) could be useful to Marben PFA fishery managers. Additionally, establishing a reliable use-estimation system in the fishery would allow managers to efficiently monitor fishing effort, potentially without the use of more expensive, alternative monitoring methods (i.e., additional creel surveys). Based on the general lack of information regarding angling activity on Marben PFA, the objectives of this study were: 1) to quantify sport fishing effort, post-catch activity (harvest, release), and fish catch by species, number, and weight in 14 Marben PFA lakes, and 2) to evaluate the potential for using traffic counters to monitor fishing effort on Marben PFA. These objectives were accomplished through analysis of voluntary angler interview data (e.g., reported hours fished, number and weight of fish caught, angling method) collected from a stratified roving creel survey with non-uniform probability sampling and vehicle survey data (vehicle type, recreational intentions) obtained from vehicles entering the facility.

Methods

Study Area

The Marben PFA is a multiple-lake fishery located within the larger Charlie Elliot Wildlife Center (CEWC) complex in Mansfield, Georgia. The Marben PFA is currently managed by the Georgia Department of Natural Resources' Wildlife Resources Division (DNR WRD). The 2,587 hectare (ha) facility includes a Wildlife Management Area (WMA) for hunting as well as approximately 121 ha of small ponds (0.4 ha) and lakes (< 40 acres) constituting the Marben PFA (Figure 1). The 22 ponds and lakes within the PFA provide anglers with the opportunity to catch a variety of species including Largemouth Bass *Micropterus salmoides* (LMB), Black Crappie *Pomoxis nigromaculatus* (BLC), Channel Catfish *Ictalurus punctatus* (CCF), and Bluegill *Lepomis machrochirus* and Redear Sunfish *Lepomis microlophus* (hereafter, *L.* spp. collectively referred to as sunfish; GAWRD 2013). During 2013, some impoundments at Marben PFA were closed for fishing or were unfishable because of low water levels; therefore, we surveyed anglers fishing the 14 impoundments that were open for fishing. Anglers at Marben PFA are required to possess a special Georgia WMA license in addition to a state of Georgia fishing license to fish the impoundments. The Marben PFA is closed for fishing on Mondays and Tuesdays and between the hours of sunset and sunrise.

Sampling Design

A theoretical expansion of the traditional roving-roving creel survey (Pollock et al. 1994) was applied to Marben PFA impoundments. Based on information provided by managers at

Marben PFA, angler attendance was expected to vary within weeks (i.e., weekend day effort was expected to be higher than weekday effort). Based on designs of previous creel surveys (Malvestuto et al. 1978, MacKenzie 1991, Ashford et al. 2013), fishing effort was also expected to vary within days (i.e., morning, afternoon, and evening). Therefore, a multi-stage sampling design based on six temporally delineated strata (Pollock et al. 1994, Murphy and Willis 1996, Vaske 2008) was used to collect effort, catch, and harvest information from Marben PFA anglers. The primary sampling units (PSUs) in this design were the day type (weekends vs. weekdays). The secondary sampling units (SSUs) were one of three 5-hr time blocks: 6:00-11:00 (AM), 11:00-16:00 (noon), and 16:00-21:00 (PM) within the PSU. Non-uniform probability sampling (Cochran 1977, Pollock et al. 1994) was used to allocate sampling probabilities to PSU and SSU strata in proportion to their expected use. Sampling probabilities were calculated based on relative proportions of fishing effort, which were determined by instantaneous counts of anglers taken during each of six time blocks on the first Friday and Saturday of each month. Ten time periods were randomly selected based on the total, unequal probability of expected fishing effort among the six temporally designated strata. According to the outcomes of each monthly random drawing, ten randomly selected sampling days were subsequently drawn that corresponded to the selected PSU-SSU combinations. For example, if five weekend day:SSU and five weekday:SSU combinations were selected, then five random calendar weekdays and five random calendar weekend days were selected and matched to the selected time periods in the order that they were drawn. Because Marben PFA is closed for fishing on Monday and Tuesday, our sampling intensity represented approximately 45% of the available fishing days/month.

The vehicle-intercept survey was always scheduled during the time block following the roving survey with the caveat that if the time block following the roving survey was of a different PSU category, the vehicle and roving surveys were conducted simultaneously (requiring two creel clerks). Based on *a priori* information provided by CEWC staff familiar with the local traffic pattern, approximately 80% of vehicle traffic was expected to occur at the northern entrance (A) and 20% was expected to occur at the southern entrance (B); therefore, eight surveys were conducted at the northern entrance and two surveys were conducted at the southern entrance each month.

Field Procedures

The roving creel survey was conducted from January 23, 2013 to December 29, 2013. On each sampling day, a starting point (one of six lakes) and direction of travel (north or south) were randomly selected by rolling a die and flipping a coin, respectively. A predetermined route was followed from lake-to-lake and anglers were approached in the order that they were first encountered. Anglers were contacted at each lake either on foot (if fishing from the bank or piers) or by boat. Information recorded by the creel clerk included total time spent fishing, fishing method, targeted species, number of anglers in the fishing party, total number and weight of each species harvested, and total number and approximate length (inches) of each species released. The angler was then thanked for his or her input and the next visible angler within the closest proximity was approached.

From January to March, fishing effort was determined by progressive counts (“count-as-you-go” method; Pollock et al. 1994) taken by the creel clerk as he proceeded through the survey area of each impoundments. From April to December, as observed fishing effort increased substantially, instantaneous counts were used to estimate total fishing effort. During instantaneous counts, creel clerks ceased angler interviews near the middle of each time block and took one instantaneous count of all anglers fishing on all lakes. Once a total count of anglers was obtained, angler interviews resumed at the point where the clerk had left off and then proceeded in the same direction of travel until the end of the sampling period.

Immediately following the conclusion of the roving creel survey, creel clerks established checkpoints at one of the two entrances to the CEWC to conduct the vehicle-intercept survey. Signage was posted for oncoming vehicles to voluntarily stop and participate in a short survey. Vehicles that stopped were asked a series of short questions:

1) “Are you entering the CEWC today?”

2) “Is the primary purpose of your visit for fishing?”

3) “How many people in your party are fishing?”

Information collected by creel clerks included vehicle type, intended recreational activity, party size, and total number of vehicles passing through. At the conclusion of the survey, the creel clerk traveled back through the fishery by vehicle to tally the number of cars/trucks parked in the designated parking lots at each lake.

Estimation Procedures – Creel data

Interview data were entered into Microsoft Excel® and double-checked against original survey sheets for validation prior to analysis. Estimates of total monthly fishing effort, catch, and harvest were calculated from the aggregation of partial day observations based on incomplete fishing trips (Pollock et al. 1994). Briefly, daily estimates of catch-per-unit effort (CPUE) and harvest-per-unit effort (HPUE) were calculated using the R_2 (mean-of-ratios) equation:

$$R_2 = \sum_{i=1}^{n} (c_i \,/\, L_i)/n$$

Where, i denotes an angler, n is the number of anglers interviewed, c_i is the catch of ith angler, and L_i is the fishing duration (h) of the ith angler (Pollock et al. 1994:179). Daily estimates of effort (Ê) were calculated by the equation:

$$\hat{E} = \sum_{i=1}^{n} {(I_i \times T)}/{\pi_i}$$

Where, I_i is the instantaneous count of anglers, T is the length of the SSU sampled, and π_i is the corresponding sampling probability of the SSU. The total probability (PSU x SSU) was not used to extrapolate daily effort because effort, catch, and harvest were calculated separately for weekends and weekdays and were then combined to provide total monthly estimates. Estimated effort (Ê) was reported in angler-hours (ang-h). Daily estimates of total catch (Ĉ) and harvest (Ĥ) were a product of estimated effort (Ê) and the daily catch or harvest rate (R_2). Variances of estimated effort (Ê), catch (Ĉ), and harvest (Ĥ) were calculated between PSUs and then combined using the following equations (Note: we only present notations for effort in these equations):

$$V\hat{a}r(\bar{e}_i) = s_i^2/n_i,$$

$$V\hat{a}r(\hat{E}_i) = N_i^2 \times V\hat{a}r(\bar{e}_i),$$

$$V\hat{a}r(\hat{E}) = V\hat{a}r(\hat{E}_1) + V\hat{a}r(\hat{E}_2),$$

and

$$S\hat{E}(\hat{E}) = \sqrt{V\hat{a}r(\hat{E})}$$

Where s_i^2 is the squared standard deviation of the monthly effort estimates from the ith PSU, n_i is the number of counts taken in the ith PSU, and N is the number of available fishing days in the ith PSU.

Angler interviews that had a fishing time of less than 0.5 h were removed from analysis (Pollock et al. 1994). Additionally, observations from the children's fishing pond (Teal pond) were removed from calculations of total catch and harvest because we believed they would positively bias the total catch estimates, specifically by inflating individual catch rates above the actual average for the other impoundments (i.e., those lakes where angler use is not age restricted). Because Teal Pond observations were removed from the analyses, a portion of the total daily estimated effort likewise needed to be removed to account for a reduction in effort directed specifically to Teal Pond. Therefore, each instantaneous count was reduced by 4% prior to expanding to daily effort. This correction factor represented the average daily proportion of fishing effort expended on Teal Pond relative to all of the other lakes based on lake-specific instantaneous count data collected from April to December.

Species-specific catch and harvest rates were calculated using the weighted average of the mean-of-ratio estimator for incomplete fishing trips and the ratio-of-means estimator for completed trip interviews for all anglers seeking LMB, BLC, CCF, sunfish, or "anything" as their primary targeted species. The Sport Fishing Index (SFI; Hickman 2000) was used to evaluate the quality of fishing for Largemouth Bass, Channel Catfish, and Black Crappie based on fishing success and pressure metrics. Species compositions of total catch and harvest were developed by multiplying the species-specific average daily catch rate by the daily estimated effort directed at that species. Non-directed catch or harvest compositions were calculated by multiplying the relative proportion of species that were reported or observed in the creel by monthly estimates of non-directed catch or harvest, respectively. Linear regression was used to determine the relationship between monthly estimates of total effort, catch, and harvest. The relative standard error (RSE; Pollock et al. 1994) was used to assess the precision of total estimates of effort, catch, and harvest.

A linear mixed model was used to examine spatiotemporal variation in catch and harvest among seasons and fishing locations (boat, bank, or fishing pier). Analyses were conducted using the “glmmadmb” package in R (version 3.0). Because fishery catch and harvest data are non-negative integer count data, typically containing a substantial number of zero count observations, a negative binomial distribution was assumed (Power and Moser 1999, Irwin et al. 2013). The negative binomial distribution is preferred to Poisson when the count data are over-dispersed (i.e., the conditional variance exceeds rather than equals the conditional mean). Therefore, catch and harvest were separately assumed to be

$$Y_{ijk} \sim NB(\mu_{ijk,} \kappa),$$

where Y_{ijk} is the angler’s catch or harvest recorded on the *k*th day at location *i* during the *j*th sampling season, μ_{ijk} is either the expected mean catch or harvest on that sample day, fishing location, and season, and κ is the over-dispersion parameter of the negative binomial distribution. The log-linear model was:

$$\eta_{ijk} = \upsilon + \beta_i + \beta_j + \lambda_k + \ln(E_{ijk})$$

where η_{ijk} is the $\log_e$–scale estimate of μ_{ijk}, υ is the fixed-effect intercept, β_i (location) and β_j (season) are additional fixed effects, λ_k is the independent random effect of day, and E_{ijk} is an effort offset term (to account for variable effort by angler, measured as number of hours fished). Thus, estimated parameters included the variance (σ^2) of the random effect of day, which were assumed to be independent and identically distributed (IID; N(0, σ2), the coefficients describing the mean effects of the various levels of location and season on catch and harvest, and the overdispersion parameter (κ) of the negative binomial distribution. Anglers that fished from multiple locations during their trip were not included in this analysis because discerning what fish were caught from each location among these anglers was not possible. A Tukey HSD post-hoc comparison was used from the R package "multcomp" to identify significant differences in catch and harvest rates among seasons and locations.

Estimation Procedures – Vehicle data

Analysis of the vehicle survey data was first guided through assessment of fishing effort data, specifically by examining the instantaneous counts of anglers. Because we wanted to develop a method of estimating fishing effort based on traffic counts, we needed to first understand temporal differences in fishing effort estimates derived from the creel survey to reduce variation in any plausible model that could predict or estimate fishing effort. Therefore, a two-way ANOVA of each daily effort estimate (based on instantaneous or progressive counts) was assessed with factors being season (four levels) and PSU (two levels). According to the outcome of this analysis, the relative standard error (RSE; Pollock et al. 1994) of the proportion of vehicle traffic that was entering CEWC to fish was calculated among seasonal and/or PSU combinations did not exhibit significantly different fishing effort. RSE values of 20% or less were considered to be reliable and precise estimates of the average proportion of traffic entering CEWC during a particular period (Pollock et al. 1994). The number of confirmed fishing vehicles during each survey period was then regressed against the number of cars parked in lots at fishing lakes. The coefficient of determination (R^2) was used to assess how much variability in fishing effort (car counts) was explained by the number of confirmed fishing vehicles at each entrance.

Results

During the survey period from January to December 2013, 115 roving surveys were scheduled. However, 12 surveys were cancelled as a result of inclement weather (hence unsafe for an onsite survey), and so 103 on-site roving surveys were completed during 2013. The response rate for the creel survey was 97% (1,159 of 1,195 fishing parties participated). Each survey lasted about 5-10 min. Additionally, 98 vehicle-intercept surveys were completed during the time period following the roving survey and the overall response rate was 53% (2,523 of 4,765 vehicles) with an average response rate per-period of 56% (SD = 20%). Seventy percent of motorists that did stop said they were entering the CEWC and 43% (n = 759) of motorists that stopped had intentions of fishing (Figure 2).

Targeted Species & Fishing Methods

Almost all of the anglers interviewed (99%) sought a preferred species; of these anglers, 34.7% targeted a second species, 5.7% targeted a third species, and 1.5% targeted a fourth species (Table 1). Sunfish ranked highest among primary, secondary, and tertiary targeted species; whereas, CCF was the highest ranked quaternary targeted species. Largemouth Bass ranked second among primary, tertiary, and quaternary target species. Sixteen percent of anglers targeted “anything that bites.” Anglers used a wide variety of bait types, often employing two methods simultaneously to target different fish species (e.g., using cut bait for catfish while using live bait for sunfish). For this reason, ascertaining the primary fishing method was difficult in many cases. Sixty percent of anglers used some form of live bait (e.g., red wigglers, nightcrawlers, mealworms, crickets, live minnows, or small sunfish), and 30% of anglers used artificial lures. Anglers who fished with lures typically targeted LMB or BLC. Seven percent of anglers used cut bait to target CCF. A few anglers trolled or used "Other" methods such as fly rods to target sunfish and Grass Carp *Ctenopharyngodon idella*.

Spatiotemporal trends in catch and harvest rates

Most anglers fished primarily from the bank (66%); whereas, the remaining anglers fished either from boats and personal watercrafts (22%) or from a fishing pier (11%). One percent (n = 12) of anglers fished from multiple locations during a single fishing trip. Catch and harvest were both heavily right-skewed with a large number of zero-count observations (Figure 3). Levels of catch and harvest were not significantly different among fishing locations (bank, boat, pier; all $p > 0.09$). However, there were significant differences in the catch and harvest among seasons; winter and fall had significantly lower catch and harvest than spring and summer seasons ($p < 0.05$; Table 2). The individual random effect of day was approximately normally distributed for both models and had a variance of 0.13 (CPUE) and $4.74e^{-09}$ (HPUE; Figure 4). The over-dispersion parameter (κ) was 0.71 for the catch model and 0.28 for the harvest model. Both models appeared to accurately predict levels of catch and harvest based on the additive effects of fishing location, season, and the random effect of sampling day (Figure 5).

Effort, Catch, and Harvest Estimates

Reported and observed catches of sportfish in Marben PFA varied considerably by species and, in some instances, spanned an order of magnitude (Table 3). Sunfish were the most abundant species by number and weight of fish caught (n=4,130) and harvested (n= 2,137; 252 kg) for the entire survey period. Ninety-five percent of the sunfish released were less than 15 cm in length. BLC had the lowest reported catch (n = 228) and release (n = 38), while LMB had the lowest observed harvest in number (n = 48) and weight (46 kg). Relatively similar numbers of LMB (n = 581) and CCF (n = 598) were caught over the survey period.

During the study period, estimated total fishing effort was 90,274 ang-h. Estimated mean monthly fishing effort was 7,523 ang-h/month (SD = 5,956) and ranged from 1,301 ang-h in December to 21,856 ang-h in May (Table 4). Directed effort varied substantially among species, and sunfish and LMB anglers comprised most (58%) of the expended fishing effort (Table 5). Total fishing pressure over the 12-month period was 808 ang-h/ha. Average monthly fishing pressure was 67 ang-h/ha (SD =53) with a low of 12 ang-h/ha in December and a high of 195 ang-h/ha in May. Greater than 70% of the total daily effort was expended on four lakes: Bennett, Margery, Fox, and Dairy (Table 6). However, these lakes are relatively large, and so standardizing effort by lake size revealed that the highest pressures (>100 ang-h/ha) occurred on smaller ponds of ~1-3 ha (e.g., Crossroads, Greenhouse, and Dairy) where relatively moderate fishing effort occurred (Figure 6). Estimated mean monthly catch among all lakes was 10,162 fish/month (SD = 9,057) and ranged from a low of 431 fish in January to a high of 28,516 fish in May; the annual total was 121,949 fish (1,089 fish/ha). The mean monthly estimate of total fish harvested was 4,624 fish/month (SD = 3,821) and ranged from an annual low of 64 fish in January to high of 11,918 fish in May; the annual total was 55,486 fish (495 fish/ha). The monthly mean weight of fish harvested was 817 kg/month (s.d. = 670) and ranged from a low of 114 kg in November to a high of 2,257 kg in May and totaled 9,799 kg of fish harvested during 2013.

Regression analysis indicated that there was a strong positive relationship between monthly estimates of harvest and monthly estimates of catch ($r^2 = 0.92$). The slope of the regression line indicated that with every one unit increase in catch, harvest increased by 0.4 fish. This estimate compares well with the portion of the overall catch rate attributable to harvest (46%; Table 5). There was also a strong, positive relationship between monthly effort estimates and monthly harvest estimates ($r^2 = 0.87$). The slope of the regression line indicated that total estimated harvest increased by 0.60 fish with each angler-hour increase in effort. This interpretation is also consistent with the observed overall harvest rate of 0.57 fish/hr (Table 7).

Monthly catch compositions revealed that sunfish dominated the total catch (78%) and harvest (83%) at Marben PFA throughout the year (Figures 4 & 5). On average, sunfish comprised approximately 66% of fish catch/month (SD = 27) and 73% of fish harvest/month (SD = 28). BLC were caught with less frequency than any other species and accounted for only 5% of overall catch and 9% of harvested fish. CCF accounted for 6% of total catch and 7% of total harvest; mean monthly catch was 6% (SD = 5) and mean monthly harvest was 8% (SD = 8). LMB accounted for 12% of total estimated catch but only 1% of total harvest. On average, LMB represented 22% of monthly catch (SD = 26) and 10% of monthly harvest (SD = 27).

Catch, Harvest, & Release Rates

Angler's catch, harvest, and release rates were different among primary target species (Table 7). The overall catch rate was 1.22 fish/h, harvest rate was 0.57 fish/hour, and release rate was 0.65 fish/hour. Sunfish anglers had the highest catch (2.11 fish/h), harvest (1.08 fish/h), and release rate (1.04 fish/h) relative to any other species. The post-catch activity of sunfish anglers was approximately equal among harvest (51%) and release (49%). BLC anglers' catch rate was the lowest among all species (0.27 fish/h), but the harvest rate was 85.7% of the total catch rate, indicating that most BLC caught were harvested. LMB anglers' reported a moderate catch rate (0.42 fish/h) and the release rate was 93.4% of the total catch rate, which indicated that most of the LMB caught were released. Finally, CCF anglers' catch rate was 0.29 fish/h and the harvest rate was 69.0% of the total catch rate (0.20 fish/h). Combining species-specific catch rates and fishing pressure estimates produced SFI values of 50 for LMB, 40 for BLC, and 40 for CCF.

Temporal Trends in Fishing Effort

Estimated daily angler effort based on instantaneous counts varied significantly among seasons ($F_{3,85}$ = 11.20, p<0.001) and among weekend and weekdays (PSUs; $F_{4,85}$ = 3.08, p = 0.02). Specifically, mean fishing effort in the winter and fall was significantly lower than fishing effort in the spring and summer. The Tukey's HSD test of season:PSU factor revealed that fishing effort did not vary significantly between PSUs within the same season, on average (all p > 0.05). Winter and fall fishing effort did not differ significantly regardless of PSU comparison (all p > 0.05). Spring and summer fishing effort did not differ significantly with the exception of spring:weekend – summer:weekday (p=0.02). Fishing effort did vary significantly among cold and warm seasons with different PSUs (all p <0.05) with the exception of fishing effort in the summer:weekday that was not found to be significantly different from winter:weekday (p = 0.80) or fall:weekday (p = 0.77).

Vehicle Intercept Survey

Because there was substantial variation in the number of anglers visiting among seasons, the data were assessed separately among seasons to reduce potential variation in response variables of interest (e.g., total vehicle counts, fishing vehicle counts). Although a significant difference in effort was not detected between PSU types, data were also assessed between PSU types as an additional exploratory measure (12 assessments total). The RSEs for the proportion of fishing traffic entering the CEWC exceeded our target value of 20% within all season:PSU combinations and within seasons (Table 8). The lowest RSEs were observed during spring (37%) and summer (43%) weekend periods and winter generally showed more variability in the proportion of fishing traffic entering CEWC (RSE range of 65%-104%). Four of 12 regression models explained a considerable amount of variation (r^2>0.60) in fishing effort as a function of fishing traffic: spring x weekend (r^2=0.81), summer x weekend (r^2= 0.60), spring (r^2 = 0.68), and summer (r^2 = 0.66). Regression models combining data between spring/summer or winter/fall indicated only a modest relationship between the number of angling vehicles entering CEWC and the number of cars in parking lots (r^2 < 0.42 for both models).

Discussion

Planning and implementing on-site creel surveys often requires adapting a generic method of surveying (e.g., roving, access, or bus-route) to the unique, site-specific characteristics of the study area (Pollock et al. 1994). Although much attention has been directed to the complexities and challenges associated with surveying spatially large fisheries (i.e., with diffuse/variable effort and many access points; Soupir et al. 2006, Vølstad et al. 2006), less attention has been given to small-scale and spatially complex fisheries with more than one water body (Chizinski et al. 2014). Developing a statistically valid and efficient survey on such fisheries can present logistical challenges and thus require adaptive approaches. This survey was designed to provide estimates of total effort, catch, and harvest on all of the 14 lakes surveyed at

Marben PFA and evaluate general trends in angler success. However, because anglers did not partition their effort, catch, and harvest by each lake visited, the ability to investigate lake-specific fishing activity was limited to estimating effort only. Because anglers fished among multiple lakes throughout the survey, accurately partitioning anglers' catch, harvest, and effort to each lake was not attempted. Although the estimates derived from this survey may be considered "coarser" than other similar surveys (e.g., Chizinki et al. 2014), this design permitted the achievement of the study objectives while minimizing the interview burden on Marben anglers.

Targeted Species

Sunfishes were clearly the most popular sportfish species among anglers. Most anglers targeted sunfishes among primary, secondary, and tertiary target species. Hence, sunfishes were popular supplementary species to target among anglers fishing for multiple species as well. Marben anglers' distribution of targeted species differed from that of the *2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* for Georgia anglers, which reported that most anglers targeted LMB, followed by sunfish, CFF, BLC, and "anything" (USDOI 2011). Largemouth Bass ranked second among primary, tertiary, and quaternary target species. Hence, the anglers at Marben PFA represent a sunfish-oriented group, where sunfish and LMB have exchanged roles as the primary target species among most anglers. Black Crappie and CCF shared a second ranking among secondary target species, which indicated that they were important secondary species despite being less-popular among the available primary target species.

Effort, Catch, & Harvest Estimates

We successfully developed a profile of angling activity at the Marben PFA during 2013; this profile estimated total fishing effort, catch, and harvest on 13 of the 14 lakes included in our study. The results showed considerable variability in the precision of catch and harvest estimates, although most fishing effort estimates were fairly precise. With the exception of January, May, November, and December, the relative standard error (RSE) of monthly effort estimates were within an acceptable level of precision (<20%; Pollock et al. 1994). The relatively low precision associated with effort estimates for January, May, November, and December was probably attributable to a combination of insufficient sampling effort and within-PSU variability in effort. As an example, daily effort estimates during May weekends were relatively precise (RSE= 13%); however, the weekday effort estimate was quite variable (RSE=58%) and was largely influenced by extrapolating effort estimates from the AM SSU with a low sampling probability of 0.03. Combining the standard errors from each PSU stratum produced an effort estimate of 23,629 ang/h (SE = 6,628) with a RSE of 57%. Three scheduled sampling events were also cancelled during May because of inclement weather during scheduled survey periods. Improving sampling accuracy (i.e., based on unbiased sampling probabilities), efficiency, and effort (Pollock et al. 1994) would likely improve the precision of effort estimates for future creel surveys at Marben PFA.

Monthly catch and harvest estimates were less precise than fishing effort, although some months produced catch estimates that were well within an acceptable level of precision (e.g., February, April, July, and October; all RSE < 20%). Catch and harvest metrics are inherently more variable than fishing effort because of among-day variability in catch estimates, variability in CPUE among species, and variability in anglers' abilities to catch and harvest species that are both influenced by their skill level, knowledge of the fishery, and harvest orientation (Malvestuto and Knight 1991, Malvestuto 1996, Ashford et al. 2013). This survey design may have also introduced another source of variability attributable to differences in catch and harvest rates among the surveyed lakes. If catch and harvest rates for various species differed among lakes, then the precision of the average daily catch or harvest rate would have been negatively affected by this new source of variability. Therefore, not surprisingly, many monthly catch and harvest estimates produced unsatisfactory levels of precision.

Based on comparisons of results from other creel surveys conducted on similar fisheries, fishing pressure at Marben PFA was certainly considerable—but not extreme. For example, Chizinski et al. (2014) conducted a creel survey on 20 small lakes in Nebraska and reported a total fishing effort of approximately 340 angler-h/ha during a 7-month study. Other studies on small state-owned fisheries have reported annual fishing pressures of 340, 453, 733, 1077, and 1538 h/ha on Oklahoma impoundments (Jarman et al. 1968); and others as high as 2,636 h/ha for some Alabama lakes (Powell 1975); and an average of 741 to 1,167 h/ha for small impoundments in Missouri (Rasmussen and Michelson 1974). Fishing pressures among Georgia PFAs have varied substantially as well, ranging from a low of 320 h/ha on Evans County PFA during 2007 to a high of 923 h/ha at Dodge County PFA during 1993. Other Georgia PFAs received intermediate pressures: for example, an estimated 473 h/ha for Hugh Gillis in 2010 , 516 h/ha for Paradise PFA in 2003 and 778 h/ha in 2009 (K. Weaver, Georgia DNR, unpublished data). Fishing pressure at Marben PFA reached a high of 195 h/ha during May, was an average of 67 h/ha (SD = 56.3) per month, and totaled 808 h/ha during 2013. Therefore, fishing pressure at Marben PFA appears to be moderate on a regional basis, but relatively high among PFAs in Georgia.

The total harvest estimates suggest that fish populations at Marben PFA are not being exploited at unsustainably high levels. With a harvest rate of 409 fish/ha or 50.8 kg/ha, sunfishes constituted most of the estimated fish harvest throughout the year. Mature and routinely fertilized ponds should yield approximately 1605 fish/ha or 174 kg/ha of sunfish on an annual basis (Lewis 1998). Natural resource agencies among southeastern states recommend annual BLG harvest rates ranging from 91 (SD = 80.8) to 116 (SD = 113.6) fish/ha or 64 (SD = 22.5) to 69 (SD = 25.4) kg/ha, on average, for small unfertilized impoundments (Daulwater and Jackson 2005). Because Marben impoundments are routinely fertilized and limed, they are assumed to produce more biomass of sunfish per hectare than unfertilized impoundments. Therefore, although sunfish harvest at Marben PFA was relatively high compared to other sportfish species, it did not warrant concern regarding overharvest. Harvest of BLC (41 fish/ha or 12.6 kg/ha) and CCF (53 fish/ha or 19 kg/ha) were relatively low. Black Crappie harvest is typically variable within a fishery because their populations naturally experience large fluctuations in density and size structure (Miranda and Allen 2000). Considering the low estimated catch and harvest of BLC over the year, Marben PFA's lakes may have contained low BLC densities that would be reflective of a "cyclical" population in its low phase. Standardized sampling could confirm or refute this hypothesis; however, if BLC populations appear stable and angling success for crappies in Marben lakes remains low, there is a potential for BLC populations to become crowded, which could potentially lead to stunting. Concurrently monitoring BLC populations and angler harvest could help managers understand whether BLC angler harvest rates reflect fluctuating population trends.

Largemouth Bass harvest was relatively low throughout the year (8 fish/ha or 8.5 kg/ha). Natural resource agencies among southeastern states recommend annual LMB harvest rates of 55

(SD = 9.2) fish/ha or 15 (SD = 5.4) to 20.6 (SD = 9.5) kg/ha, on average, for small unfertilized impoundments (Daulwater and Jackson 2005). Thus, LMB harvest appears to be well below what Marben impoundments could sustain. The low occurrence of LMB harvest at Marben PFA is consistent with the growing popularity of catch-and-release LMB fishing that has been observed nationwide over the past half-century (Allen et al. 2008, Myers et al. 2008, Isermann et al. 2013). Marben PFA anglers seem to mostly practice catch-and-release for LMB as indicated by high release rates (0.39 fish/hr) despite a modest catch rate of 0.42 fish/hr. From a biological perspective, low angler harvest of LMB may leave sufficient LMB stocks to regulate BLC populations via predation and interspecific competition for food resources. Considering the popularity of LMB on this fishery, the low occurrence of LMB harvest, and the high harvest orientation of BLC anglers, management objectives could prioritize maintaining quality-sized LMB stocks over preventing high BLC densities because angler exploitation and LMB predation should naturally manage the latter.

Spatiotemporal trends in catch & harvest

Variations in catch and harvest rates generally reflected trends in effort allocation throughout the year and did not vary significantly by location fished. That is, angler success (in terms of both catch and harvest) was significantly higher during the spring and summer than during winter and fall seasons. This temporal convergence in angling effort and success denotes the peak period of exploitation at Marben PFA. During the 5-month period from March to July, fish catch and harvest amounted to 74% and 71% of the total annual estimated catch and harvest, respectively. This time period also coincides with spawning activity for sunfish, LMB, and BLC (Heidinger 1975, Wang and Kerneham 1979, Pine and Allen 2001). Because spawning success of LMB, BLC, and sunfish is critical to the sustainable management of this fishery (i.e., maintaining a desirable predator-prey relationship and positive population growth), enforcement of existing fishing regulations (i.e., creel limits, size limits, and pole limits) during this time period should serve to aid in the sustainable management of this fishery.

Anglers exhibited similar fishing success regardless of where they were fishing, which underscores the underlying management goal of social equitability. For example, creel limits are imposed in part, to fairly distribute the potential for catch and harvest between skilled and novice anglers (Porch and Fox 1990, Noble and Jones 1993, Cook et al. 2001). Accordingly, anglers were not restricted in their potential for fishing success based on any physical limitations (e.g., handicapped pier anglers that can't traverse the banks) or monetary factors (i.e., anglers that do not have a truck, boat, and trailer). Because Marben PFA impoundments are relatively small compared to other large, local reservoirs in Georgia (e.g., lakes Lanier, Oconee, and Jackson), anglers do not need highly specialized equipment or to be in peak physical condition to fish the entirety of many impoundments. Thus, the smaller profile and intensive management of Marben PFA impoundments benefits anglers of a variety of skill levels and backgrounds equally, making it an ideal setting for recruiting new anglers while still challenging seasoned anglers.

SFI Fishing Quality metrics

The SFI values produced for LMB, BLC, and CCF indicate that quality of fishing for these species at Marben PFA meets or exceeds the average SFI value of 40. However, the holistic assessment of fishing quality was not possible in this study, because quality metric data such as relative weight, proportional stock density, and relative stock density were not obtained. Therefore, SFI values produced for these species should be considered with caution as they only represent one half of the available determinants of fishing quality. By comparing LMB SFI values to those presented in Hickman (2000) for Tennessee impoundments, quality of fishing for LMB at Marben PFA appears to exceed the quality of fishing among those impoundments that received an average SFI value of approximately 33 across all impoundments (range 20-45). To date, we are not aware of other studies that have used this index to gauge quality of fishing for species in this study; however, increasing angler success for BLC and CCF could improve the quality of fishing for these species in the future based on the range of quantity metric criteria for this particular index. Furthermore, although quality metrics were not derived from the survey data, incorporating some individual quality data would better inform assessments of quality for individual species in the future.

Vehicle-Intercept Survey

The results from the vehicle survey suggest that the use of traffic counters to monitor fishing activity would not likely provide accurate or precise estimates of fishing trips or effort. The RSEs of the average proportion of fishing traffic entering CEWC were never below the threshold value of 20% (Pollock et al. 1994), indicating that even within periods during which fishing effort was similar, the proportion of fishing traffic entering CEWC was not consistent. Because fishing effort was relatively constant within respective seasons, random or systematic variation in vehicle traffic attributable to other recreational activities or nearby residents is likely and may confound any ability to detect a consistent pattern in the data. Additionally, the relatively low response rate may have biased the data further. That is, many motorists who intended to go fishing may not have stopped. This notion is supported by the fact that the slopes of each regression equation (except during summer periods) exceeded one and the intercepts exceeded zero. These results indicated that for every confirmed vehicle entering CEWC to fish, more than one vehicle was predicted to be fishing. Because neither a consistent nor reliable estimate of fishing traffic could be obtained from these data, employing a passive-effort monitoring system based on traffic counters would probably produce inaccurate and biased estimates of fishing effort.

The literature on the application of passive effort-monitoring systems in recreational fisheries is sparse. Douglas and Giles (2001) reported that use of a single traffic counter aided in planning a creel survey on a small remote impoundment with one entrance, little access to the bank, and without known ancillary recreational activities being conducted on the impoundment. Other novel effort-monitoring approaches have proven effective in capturing the amount of fishing effort being exerted on simpler systems. For example, trail cameras were able to record entries and exits of anglers on a remote trout stream in western North Carolina (K. J. Hining & J. M. Rash, NC Wildlife Resources Division, personal communication). Outside of recreational fisheries, managers of national and state parks, monuments, and other historic sites have used traffic counters commonly to conduct vehicle surveys as an essential step in data collection for the purpose of establishing a reliable overall use estimation system (Cessford and Muhar 2003). However, between 40% and 63% of park and wilderness area managers use the “best guess” technique, based on informal counts, to estimate visitation especially in areas of high user dispersion and/or a low user profile (Watson et al. 2000). Therefore, no model or framework currently exists for estimating use by a specific group (e.g., anglers, hunters) at a multi-use facility like the CEWC. However, alternative methods and frameworks should continue to be developed and explored in the future to provide efficient and accurate means of monitoring diverse recreational use. Such methods could be valuable tools for management of natural recreational resources similar to the Charlie Elliot Wildlife Center.

Conclusions

The fishery profile developed for Marben PFA highlights the utility of small, intensely managed state-owned impoundments. This fishery supports a group of diverse anglers from highly specialized LMB anglers to the occasional angler targeting "anything that bites." The Marben PFA withstands substantial spring fishing pressure and moderate fishing pressure throughout the rest of the year. Anglers obtained consistent catches for most species throughout the survey, although sunfish generally dominated catch and harvest compositions. Largemouth Bass angling is mainly for sport at this fishery, and the low harvest-oriented anglers probably are seeking opportunities to catch trophy LMB. By assessing directed effort and species-specific catch rates collectively, we were able to determine that the quality of fishing at Marben PFA appears to be good or above average and fish harvest was sustainable.

Future studies at Marben PFA could focus on describing the relationship between BLC population abundance and angler harvest of BLC, which would potentially address the relatively low observed catch and harvest of BLC throughout most of the survey. Investigating the lake-specific size structure of sunfish populations may also explain the relatively high release rates of sunfish that were observed throughout the study. If sunfish populations were skewed heavily towards smaller and younger individuals, further management may be required to restructure those populations. Sunfish populations may be successfully restructured through supplemental feeding (Berger 1982) or by increasing predator abundance (Schneider and Lockwood 2002).

Generally, restructuring sunfish populations through culling is not a practical long-term management strategy (Schneider and Lockwood 2002). Considering the popularity of sunfishes and LMB among Marben PFA anglers, developing a diverse array of opportunities for anglers to catch sunfish and LMB (e.g., creating “trophy” ponds) would likely be well-received by Marben anglers.

Acknowledgements

The survey instrument used in this study was pretested in 2012 and approved by the University of Georgia IRB in 2013, prior to implementing the survey (project number: 2013-10485-0). We thank the Georgia Department of Natural Resources for funding this study. We thank Steve Zimpfer and Aaron Sundmark for their help with fieldwork and data collection. We also thank GA DNR biologists Keith Weaver and Jamie Dowd for their in-kind support throughout the study. We thank all anonymous reviewers who provided comments on earlier versions of this manuscript. Finally, we are grateful to all of the Marben PFA anglers who participated in creel surveys during 2013.

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Tables and Figures

Table 3-1: Percentages of anglers targeting various fish species at the Marben Public Fishing Area near Mansfield, GA during January to December 2013.

		Species				
Target Rank	*n*	LMB	BLC	Sunfish	CCF	“Anything”
Primary	1,157	25	19	31	9	16
Secondary	401	18	23	36	23	†
Tertiary	67	28	19	37	15	†
Quaternary	17	29	0	12	59	†

† Anglers did not target “anything” as secondary, tertiary, or quaternary target species.

Table 3-2: Natural log-transformed and exponentiated parameter estimates and standard errors for generalized linear mixed models in which fishing location and season were used to explain variation in angler catch and harvest of sportfishes at Marben PFA near Mansfield, GA during 2013.

	CPUE Model			HPUE Model		
Parameter	Estimate (β_{ij})	$e^{\beta}{}_{ij}$*	SE	Estimate (β_{ij})	$e^{\beta}{}_{ij}$*	SE
Intercept	-0.26	0.77	0.13	-0.81	0.44	0.15
Location						
Bank	0.00	-	-	0.00	-	-
Boat	0.09	0.84	0.11	-0.32	0.32	0.16
Pier	-0.15	0.66	0.15	-0.08	0.41	0.22
Season						
Fall	0.00	-	-	0.00	-	-
Spring	0.44	1.19	0.16	0.45	0.70	0.18
Summer	0.68	1.51	0.17	0.48	0.72	0.19
Winter	-0.37	0.53	0.21	-0.22	0.36	0.24

*Coefficients exponentiated after addition with respective intercept values and thus reflect differences in catch and harvest rates from bank location for *Season* coefficients and fall season for *Location* coefficients.

Table 3-3: Observed and reported catch, harvest, and release of Black Crappie (BLC), Channel Catfish (CCF), Largemouth Bass (LMB), and sunfish by anglers at Marben PFA (Mansfield, GA) during 2013.

				Size Class of Released Fish (cm)				
Species	Catch(n)	Harvest(n)	Harvest(kg)	<15	15-30	>30-38	>38	UK*
BLC	228	190	56	27	11	0	0	0
CCF	598	281	96	63	177	64	13	0
LMB	581	48	46	78	308	118	41	1
Sunfish	4130	2137	252	1898	95	0	0	0

*Fish of unknown length

Table 3-4: Mean monthly estimates and standard errors of total fishing effort (Ê; angler-hours), catch (Ĉ; *n* fish), harvest (Ĥ; *n* fish), and weight (Ŵ; kg) on 13 lakes at Marben PFA (Mansfield, GA) during 2013.

Month	Ê	SE (Ê)	Ĉ	SE (Ĉ)	Ĥ	SE (Ĥ)	Ŵ	SE (Ŵ)
January	2147	471	431	245	64[a]	†	177	†
February	2155	186	796	52	430	114	179	45
March	8577	790	11415	2932	7722	1975	1661	416
April	10297	1111	14140	2002	6214	261	1025	113
May	21856	5909	28516	11129	11918	7008	2257	1887
June	13924	2465	22183	6317	7858	1473	1336	242
July	8806	933	14014	2398	5868	1339	748	149
August	7223	1371	11737	3397	5467	1991	825	306
September	6690	940	12197	2727	6691	2388	859	249
October	4144	524	4487	798	2334	625	315	83
November	2902	862	1340	656	538	285	114	60
December	1301	562	694	573	384	317	303	236

† Standard error was not calculated because of insufficient replication.
[a] Harvest estimate based solely on harvest of two Largemouth Bass

Table 3-5: Monthly directed effort estimates (Ê; angler-hours) and standard errors for anglers targeting Largemouth Bass (LMB), Black Crappie (BLC), sunfish, Channel Catfish (CCF) and "anything" at Marben PFA near Mansfield, GA during 2013.

	LMB		BLC		Sunfish		CCF		"Anything"	
Month	Ê	SE	Ê	SE	Ê	SE	Ê	SE	Ê	SE
January	1099	107	1046	322	0	0	0	0	0	0
February	833	67	559	286	220	180	72	72	264	106
March	1560	263	3862	560	1796	744	318	170	1503	586
April	2591	662	2500	668	3504	576	672	174	1030	368
May	4270	1574	3808	2900	8168	1650	878	365	4731	854
June	3492	686	829	323	4485	1117	1526	450	3592	1010
July	2235	440	241	122	3725	975	1220	178	1385	236
August	2441	795	224	137	2792	734	581	265	1186	406
September	1516	386	288	181	2601	465	862	364	1424	363
October	1313	265	426	138	1879	497	229	123	298	108
November	446	158	1655	462	577	239	13	13	211	119
December	356	184	657	223	248	184	35	35	5	5

Table 3-6: Estimated mean total monthly effort (and standard deviation; TME; ang-hrs/month) and mean monthly pressure (and standard devitation; MMP; ang-hrs/ha) expended on each lake surveyed at Marben PFA near Mansfield, GA during 2013 (Teal pond excluded).

Lake	Size (ha)	%Total Effort	TME	SD	MMP	SD
Greenhouse	2.0	6.1	457	361	226	178
Crossroads	0.8	3.4	252	199	311	246
Stump	1.3	1.7	129	102	103	81
Upper Raliegh	1.5	0.7	49	39	32	25
Lower Raliegh	6.1	2.8	208	164	34	27
Little Raliegh	0.8	0.3	23	18	29	22
Dairy	2.8	8.4	631	498	223	176
Bennett	27.9	23.4	1756	1388	63	49
Margery	19.8	18.0	1351	1068	68	53
Fox	38.4	25.7	1926	1522	50	39
Otter	1.2	0.8	58	46	48	38
Shepard	7.3	7.5	564	446	77	61
Whitetail	1.6	1.3	96	75	59	46

Table 3-7: Species-specific catch (CPUE), harvest (HPUE), release (RPUE) rates, directed pressure, and sport fishing index (SFI) values for sportfish at Marben PFA (Mansfield, GA) during 2013. Percent harvest should be interpreted as the percentage of the overall catch rate that is attributable to the species-specific harvest.

Target Species	CPUE	HPUE	RPUE	% Harvest	Pressure (ang-h/ha)	SFI
"Anything"	1.08	0.49	0.59	45.0	139.5	†
LMB	0.42	0.03	0.39	6.6	197.8	50
BLC	0.27	0.23	0.04	85.7	143.7	40
Sunfish	2.11	1.08	1.04	51.0	267.8	†
CCF	0.29	0.20	0.09	69.0	57.2	40
Overall	1.22	0.57	0.65	46.6	806.0	†

†No SFI values available for this category

Table 3-8: The relative standard errors (RSEs) of the average proportion of fishing traffic entering the Charlie Elliot Wildlife Center (CEWC; Mansfield, GA) and the least-squares regression coefficient of determination (R^2) describing the proportion of variation in observed effort (i.e., number of cars in lots) explained by the number of confirmed angling motorists surveyed during 2013.

	Weekends		Weekdays		Combined	
Season	RSE (%)	R^2	RSE (%)	R^2	RSE (%)	R^2
Winter	65	0.25	104	0.12	86	0.32
Spring	37	0.81†	51	0.01	47	0.68†
Summer	43	0.60†	62	0.55	57	0.66†
Fall	62	0.44	58	0.24	68	0.24

†A significant proportion of the variation in observed fishing effort explained by the number of confirmed fishing motorists.

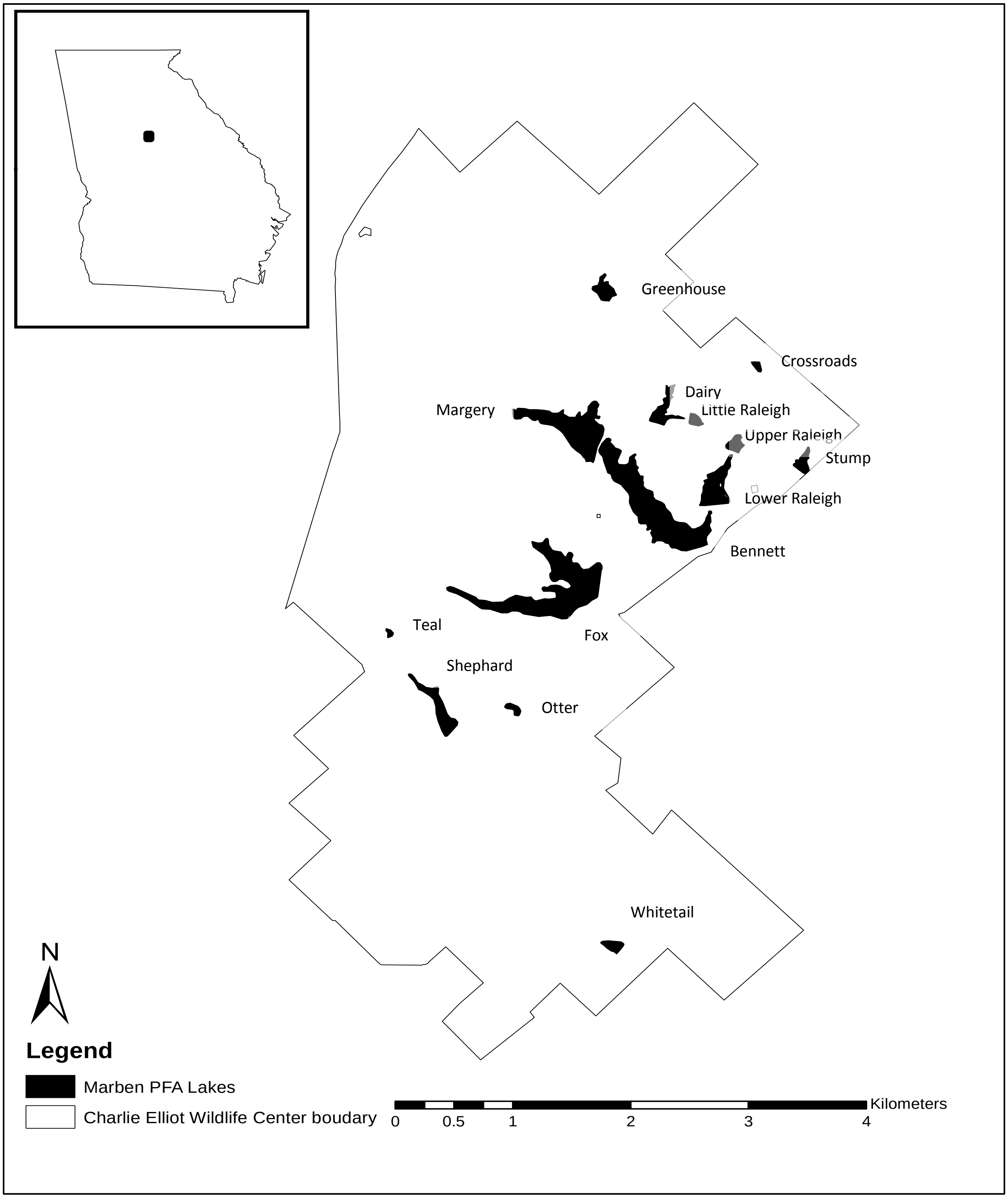

Figure 3-1: The state of Georgia (top left corner) and the Charlie Elliot Wildlife Center (Mansfield, GA) containing the Marben PFA lakes that were surveyed during 2013.

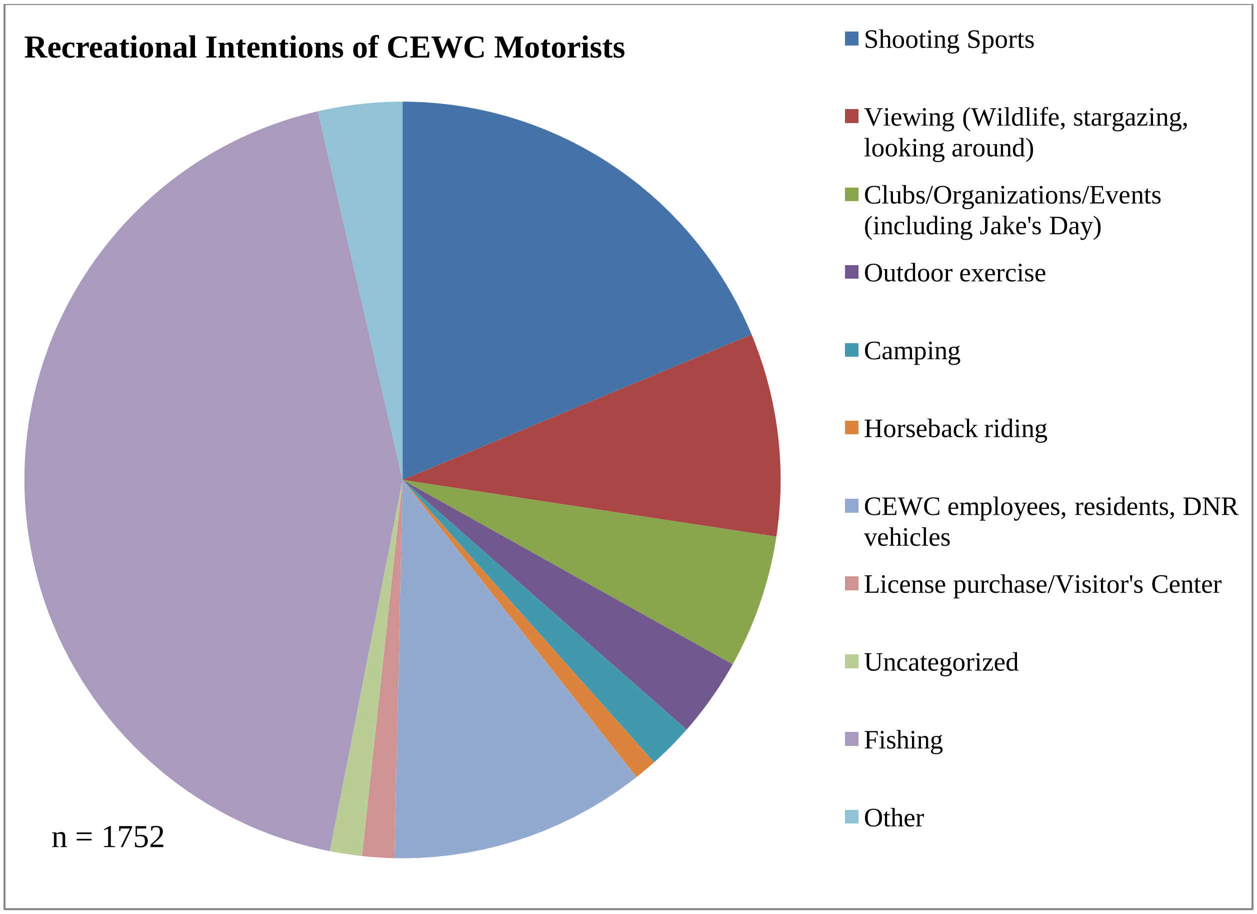

Figure 3-2: Stated recreational intentions of motorists passing through Marben Farms Road at the Charlie Elliot Wildlife Center (Mansfield, GA) during the 2013 vehicle-intercept survey.

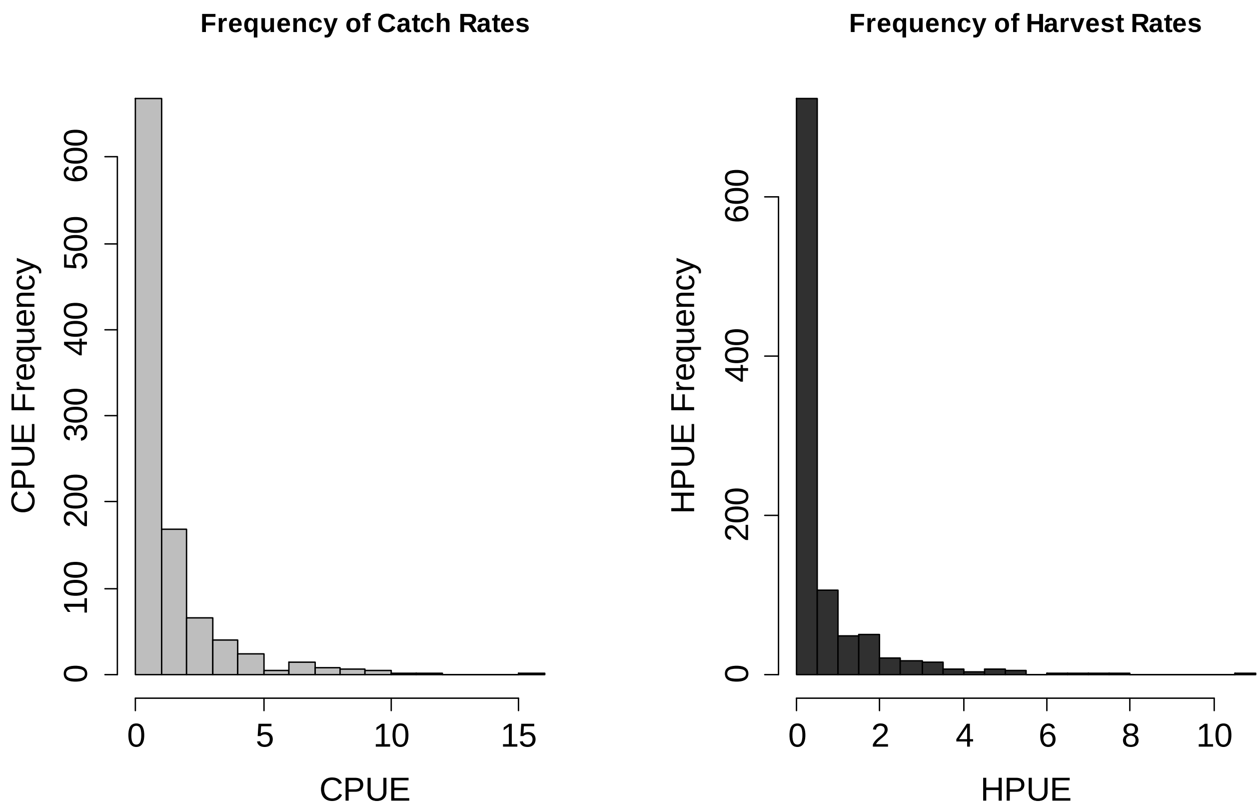

Figure 3-3: Histograms of the observed frequencies of CPUE (gray) and HPUE (black) from Marben PFA anglers during 2013.

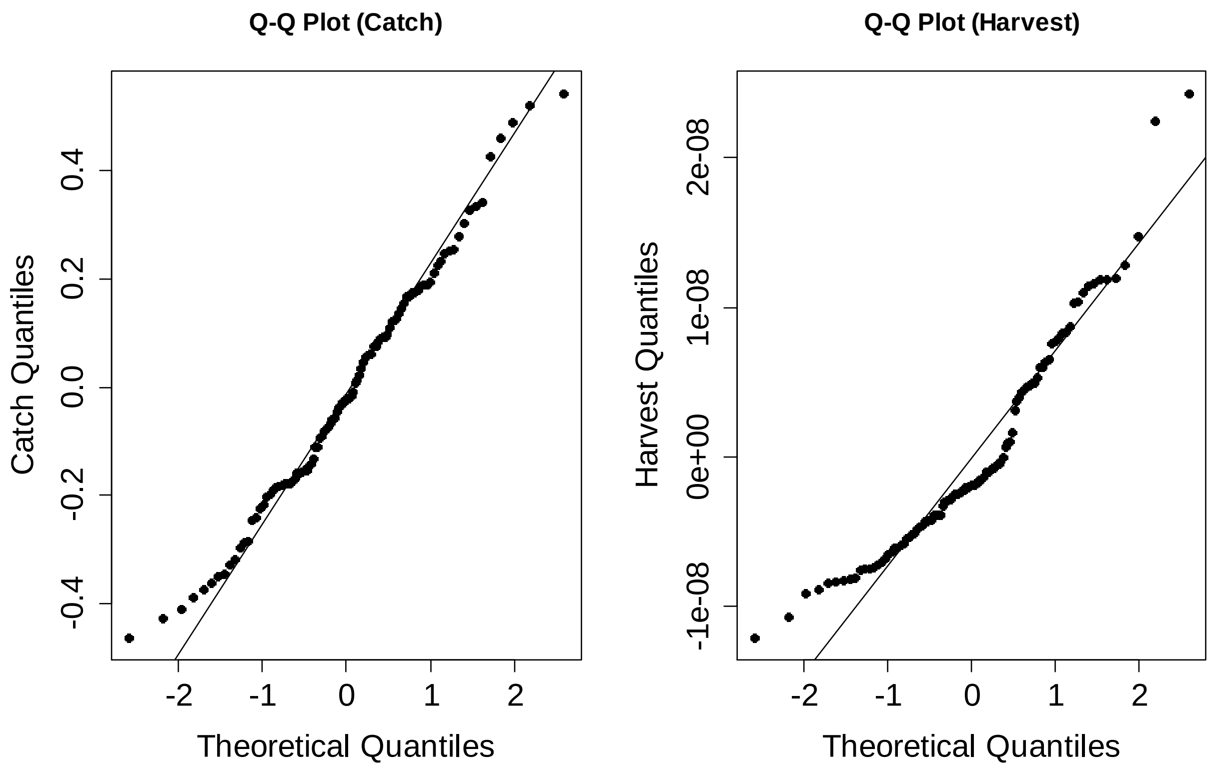

Figure 3-4: Q-Q residual plots of the individual random effect of day (n=103) based on fitting a negative binomial mixed model to catch (left) and harvest (right) of sportfishes at Marben PFA near Mansfield, GA during 2013.

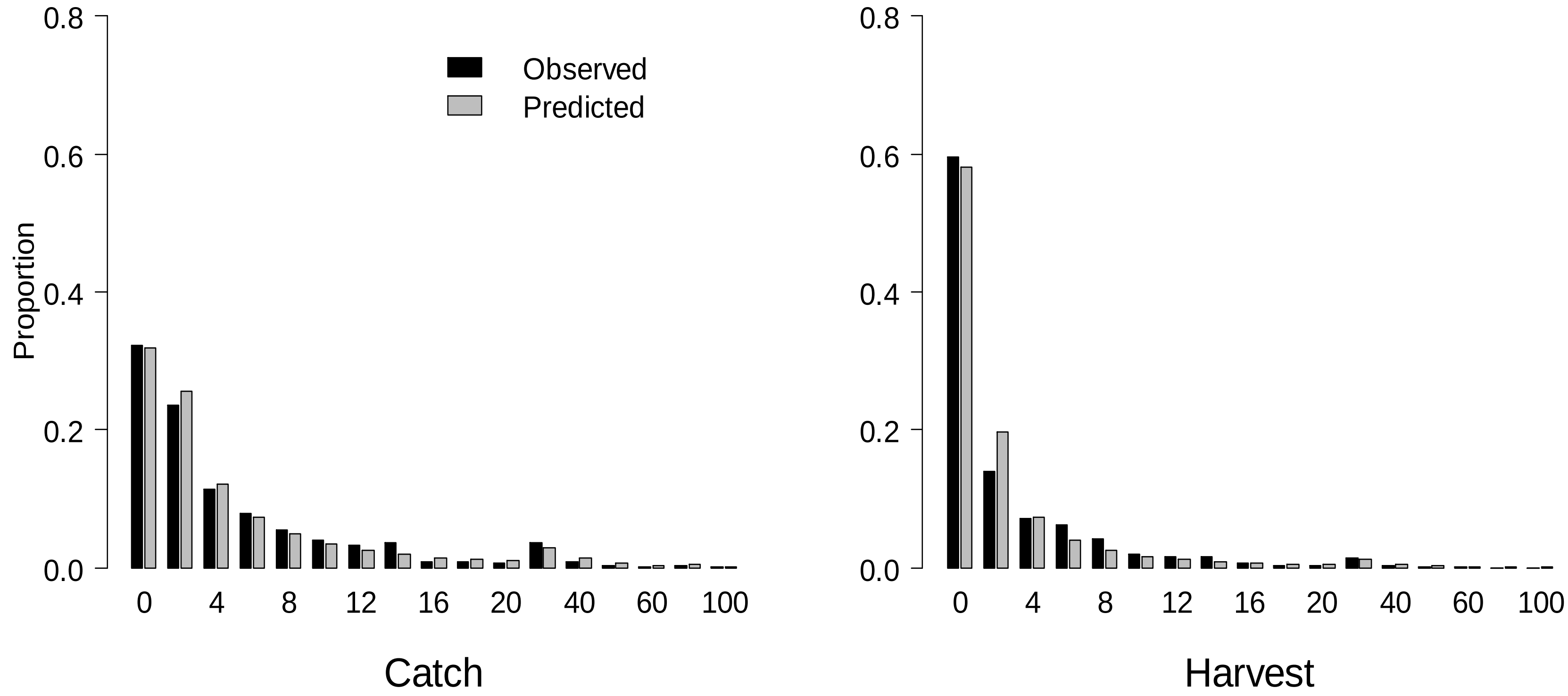

Figure 3-5: Proportion of predicted and observed values for the models of angler catch and harvest of sportfishes at Marben PFA near Mansfield, GA during 2013 in which season and fishing location (boat, bank, or pier) were considered fixed effects and the sampling day (n=103) was a random effect.

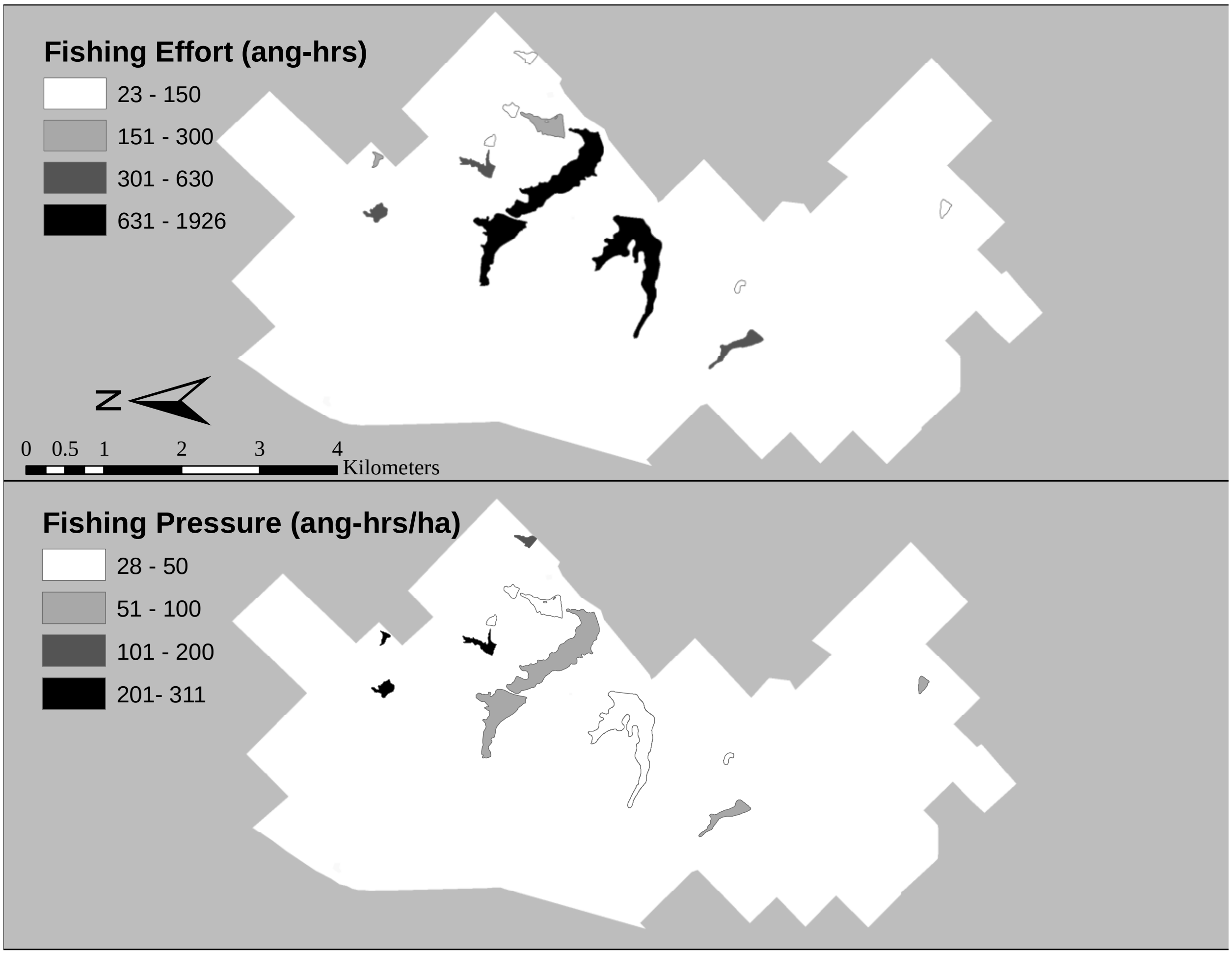

Figure 3-6: Spatial allocation of fishing effort (angler-hours) and fishing pressure (angler-hours/ha) among 13 lakes surveyed at Marben PFA in Mansfield, GA during 2013 (Teal pond excluded).

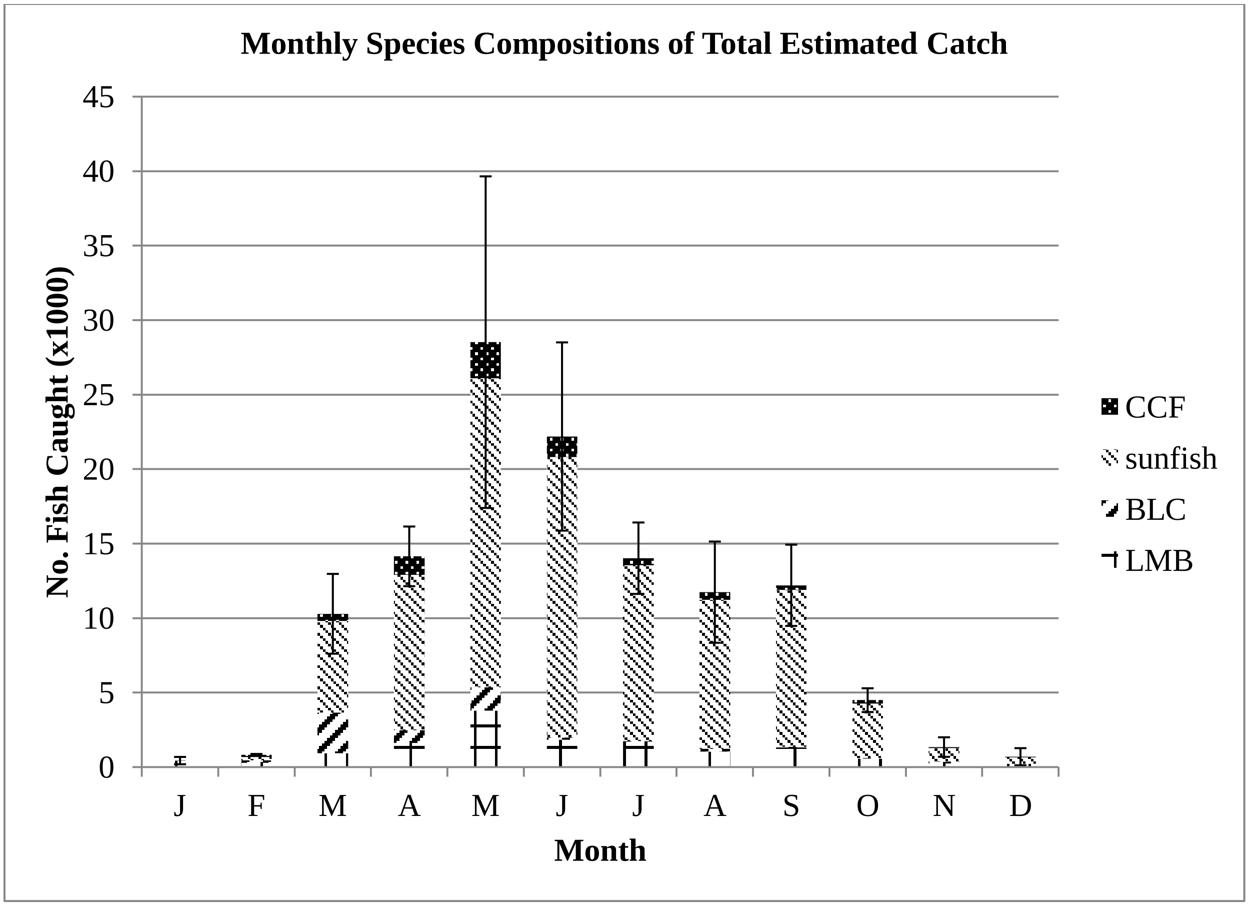

Figure 3-7: Monthly species compositions of estimated angler catch at Marben PFA near Mansfield, GA and associated standard errors for total monthly catch during 2013.

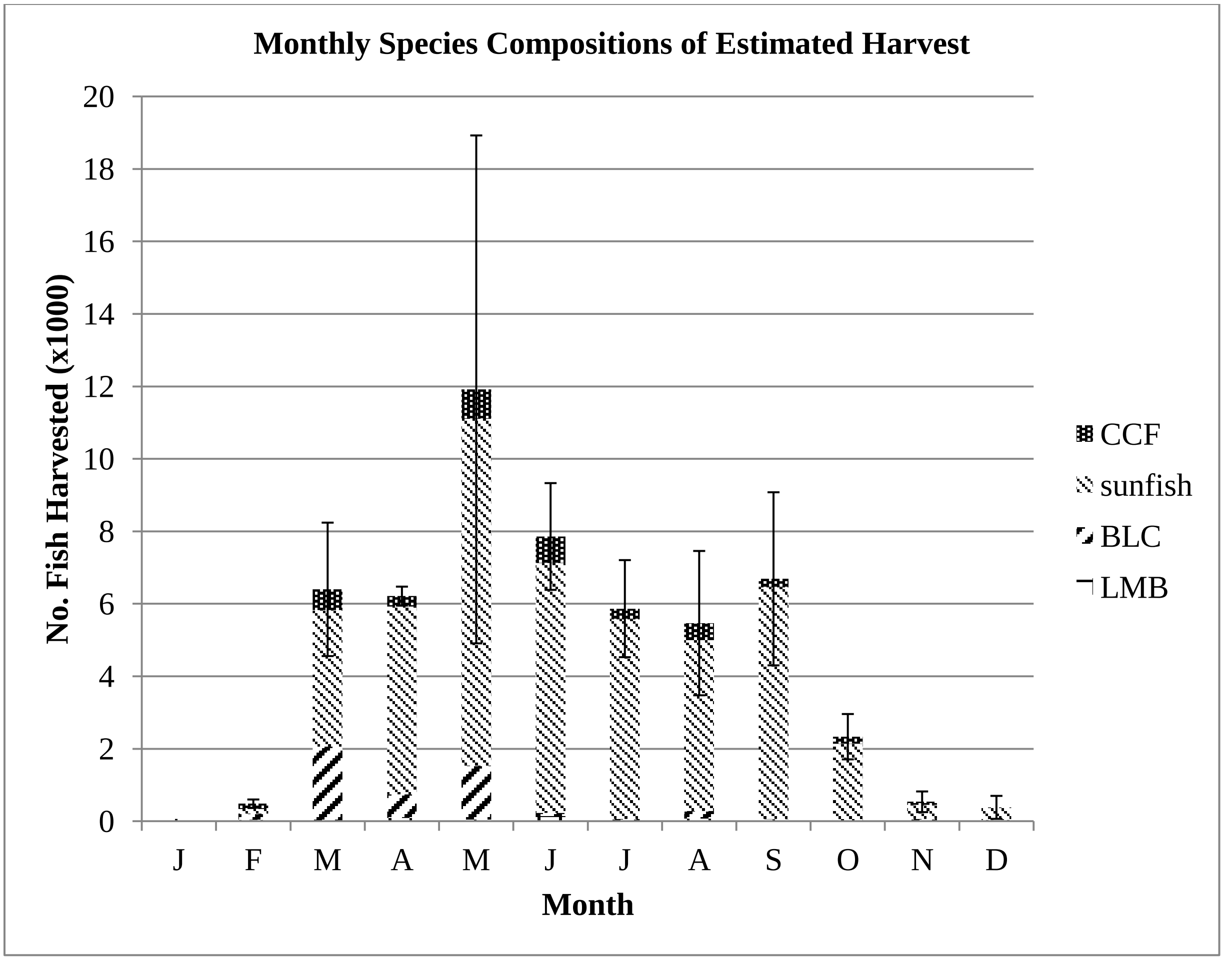

Figure 3-8: Monthly species compositions of estimated angler harvest at Marben PFA in Mansfield, GA and associated standard errors for total monthly harvest during 2013.

CHAPTER IV

IDENTIFYING FACTORS THAT INFLUENCE ANGLERS' PERCEPTIONS OF FISHERY QUALITY ON STATE-OWNED FISHING IMPOUNDMENTS[2]

[2] Roop, H. R., Jennings, C. A., & Poudyal, N. C. To be submitted to *Human Dimensions of Wildlife Management*

Abstract

Recreational fisheries are managed to produce fish stocks of a desirable quality and therefore increase the satisfaction of the angling community. However, studies in the human dimensions of fisheries have shown that angler satisfaction is influenced by many aspects of the fishing experience that are non catch-related. Thus, understanding the factors that influence anglers' perceptions of fishing quality may allow managers to specifically address elements of the fishing experience that are within their managerial control. In this paper, we used ordinal logistic regression to analyze anglers' perceptions of the quality of fishing at the Marben Public Fishing Area (Marben PFA) near Mansfield, Georgia, USA in response to situational variables, angling metrics, and anglers' subjective evaluations of the fishery. A year-long, on-site survey in 2013 yielded an effective sample size of 551 anglers after accounting for repeated anglers and first time visitors. Anglers ranked the quality of fishing at Marben PFA to be a 6.45 (SD = 2.19) on a 1-10 scale, and significantly higher ($p = 0.001$, t = 5.79, df = 803) than similar fishing sites with comparable access cost. Results from logistic regression showed that anglers who caught more fish of their target species and those fishing from boat or bank (as opposed to pier) reported significantly higher rating of fishing quality. Similarly, Caucasian anglers, anglers experiencing poor catch rates, and anglers that advocated changes to management in the form of producing more and/or larger fish reported significantly lower ratings of fishing quality. The results suggest that perceptions of fishing quality are strongly influenced by the catch-related aspects of the fishery and would serve as suitable criteria for guiding future management efforts at this fishery and among similar fisheries.

Introduction

A primary goal of recreational fisheries management is to produce and maintain quality sport fish stocks for the angling public (Pollock, Jones, & Brown 1994; McCormick & Porter 2014). Within the context of recreational fisheries, this notion of fishing quality has traditionally been defined and evaluated by some metrics that quantify either the fishing success of the angler (e.g., catch [CPUE] and harvest [HPUE] rates) or the number (e.g., stock densities [PSD, RSD]), size, and condition (e.g., relative weights; [W_r]) of the fish that are caught or are present in the fishery. These biological and population metrics are widely used by fisheries management agencies to gauge the quality of their fisheries and evaluate the effects of management actions on fish populations and angler success (Colvin 2000; Hickman 2000). By improving the quality of fishing, managers hope to increase the collective fishing satisfaction of anglers. However, many studies in the human dimensions of recreational fisheries have revealed that angling satisfaction is affected by many situational and exogenous factors that are independent of the catch-related aspects of fishing, including psychological (Fedler & Ditton 1994), social (Arlinghaus & Mehner 2004) and outdoor (Manfredo, Harris, & Brown 1984; Holland & Ditton 1992; Spencer 1993) motivations. Thus, a key disparity has been identified between the means objectives related to management of fisheries (e.g., a success rate of 1 fish/h) and the factors that have been demonstrated to influence angler satisfaction, which has been discussed in previous works (Hampton & Lackey 1976; Holland & Ditton 1992; Spencer 1993; Arlinghaus 2006). Ultimately, fishery managers now understand that high angler satisfaction cannot be achieved solely by manipulating supply-side factors such as available facilities, fish stocks, water quality, and access because angler satisfaction is also influenced by several demand-side factors (e.g., recreational motivations) that do not always fall within the scope of management (Weithman 1999; McCormick & Porter 2014).

Although fishing trip satisfaction is a common endpoint of interest in fisheries management, another construct—perception of fishing quality—may better inform biologists about the effectiveness of management efforts. Because a general goal of fisheries management is to produce fisheries of a desirable quality for anglers, a reasonable understanding of what determines quality in the mind of anglers themselves should precede management action. In the best-case scenario, fishing quality is defined primarily by the angling community (Colvin 2000) and evaluated by some objective metrics that inform biologists about the size and structure of fish populations (Hickman 2000). However, angler satisfaction often remains the focus in many studies (Holland & Ditton 1992; Spencer 1993; Arlinghaus 2006; McCormick & Porter 2014), while quality perceptions remain largely unevaluated. Because satisfaction with a fishing trip may not equally reflect a subjective perception of quality, satisfaction as an independent metric may fail to produce sufficient information regarding perceptions of fishing quality, which may be a more salient component of the fishing experience from a management perspective. Therefore, evaluating single-trip satisfaction may be less useful for guiding long-term management actions compared to more holistic indicators such as satisfaction with the fishing year (Arlinghaus 2006) or perceptions of fishing quality. Because fishing quality is one controllable component of the fishing experience (i.e., managers can manipulate populations, habitats, and regulations to produce desirable stock structures; Fisher 1997; Fedler & Ditton 1994), evaluating factors that influence anglers' perceptions of fishery quality should provide useful guidance towards improving anglers' fishing experiences.

Previous literature has established that satisfaction can be a good proxy measure of quality perceptions in several recreational contexts (Manning 1999; Manfredo et al. 1995; Joohyun et al. 2004). However, we are unaware of many other published studies that have explicitly solicited information from anglers regarding their perceptions of fishing quality. In this paper, we used a multifaceted discrepancy model that has previously been used as a theoretical basis for evaluating recreationists' satisfaction to identify variables that are important in determining anglers' perceptions of fishing quality. Using this information, management objectives can be evaluated in terms of their consistency with anglers' preferences for fishing experiences. This survey also provides a unique opportunity to understand how anglers' behaviors, attitudes, and beliefs about the management of fisheries influence their perceptions of fishing quality.

Human dimensions studies in recreational fisheries have primarily used multivariate techniques like factor or cluster analyses to identify angler subgroups that have differing fishing preferences (Hutt et al. 2013), motivations for fishing (Spencer 1993; Arlinghaus 2006), satisfaction levels (Holland and Ditton 1992), or attitudes towards management policies (Arlinghaus and Mehner 2004). Fewer studies have modeled variation in anglers' fishing satisfaction as a function of specific situational variables, subjective evaluations, or angling metrics (Graefe and Fedler 1986; McCormick and Porter 2014). Describing differences among angler subgroups can be directly useful in identifying management alternatives that can provide optimal benefits to angling communities (Holland and Ditton 1992). Furthermore, studies that have used multivariate factor analyses have identified a suite of variables that are known to affect angling satisfaction that extend beyond the catch-related aspects of angling (Spencer 1993; Arlinghaus 2006; Hutt et al. 2013). As an alternative analytical approach, predictive models can be useful because they provide information regarding effect size of explanatory variables and they can be used to model changes in fishery characteristics (e.g., average fish length, catch rates) that will result in an improved overall perception of fishery quality. For example, McCormick and Porter (2014) developed a multinomial logistic regression model to predict the probability of collective angler satisfaction as a function of angler age, catch rates, and average fish length. Thus, a predictive modeling approach may be favored over exploratory factor analyses when results are expected to directly inform future management decisions.

Theoretical Framework

Satisfaction theories in leisure and recreation explain why people evaluate their experiences in a particular way, and satisfaction models often relate recreationists' reported satisfaction, attitudes, or observed behaviors with higher-order cognitive processes (i.e., a reflection of value systems or beliefs) or underlying motivations (Vaske 2008). Because satisfaction is multidimensional, it has been evaluated in terms of a multifaceted discrepancy model that incorporates several constructs that are believed to influence overall satisfaction (Graefe and Fedler 1986; Graefe and Drogin 1989; Vaske 2008). Although there is no standard procedure for measuring satisfaction levels in outdoor recreation (Burns et al. 2003), a general model of satisfaction has been described as a function of two separate groups of variables: situational variables and the subjective evaluations of the recreationist (Graefe and Fedler 1986; Whisman and Hollenhurst 1998). Situational variables are analogous to activity-general elements in fisheries terms (Driver and Cooksey 1977; Fisher 1997) including relaxation, social interaction with family and friends, and being outdoors. Subjective evaluations are numerous and include socioeconomic and cultural characteristics, experience evaluations, attitudes and preferences, subjective norms, and crowding and risk perception (Whisman and Hollenhurst 199; Manning 1999). This general model has been further refined and used to identify important factors affecting satisfaction across a wide variety of recreationists, including anglers (Graefe and Fedler 1986; Vaske et al. 1986; Herrick and McDonald 1992; Whisman and Hollenhurst 1998). In this paper, we used this generic model of satisfaction to guide our analysis of variables that influence anglers' perceptions of fishing quality. We hypothesize that, through assessment of the subjective evaluations of anglers, angling metrics, and the situational variables that are believed to shape anglers' perceptions of fishing quality, we can develop a basic understanding of what factors are important in influencing anglers' perceptions of fishing quality at Marben PFA (Figure 1).

Methods

Study Area

The Marben Public Fishing Area (Marben PFA) is a state-owned fishery resource located within a Wildlife Management Area (WMA) in Mansfield, Georgia (Figure 2). The Marben PFA is located within the larger Charlie Elliot Wildlife Center, a facility that provides recreational opportunities to a variety of outdoors-people including hunters, hikers, bikers, campers, and anglers. Marben PFA is comprised of 22 ponds and lakes ranging in size from 0.4 to 40 ha. During 2013, several impoundments were closed for fishing or not accessible and therefore only 14 of the 22 impoundments were included in this survey. Fishery managers at the Marben PFA routinely manage the impoundments through fertilization, liming, water-level manipulations, deploying habitat structures, and supplementary stocking of some species (e.g., Channel Catfish *Ictalurus punctatus*). A subset of ponds (Teal and Clubhouse) is managed for youth fishing and is not open to the general public. Six ponds (Bennett, Dairy, Fox, Margery, Shepard, and Whitetail) have concrete ramps that allow boat-based fishing as well. Nine ponds have at least one fishing pier. With the exception of annual trip estimates, little information had been gathered from Marben PFA anglers regarding their use and preferences for management of the fishery prior to this survey.

Sampling Design and Data Collection

A roving creel survey was scheduled from January 1 to December 31, 2013. Based on information provided by managers at Marben PFA, angler attendance was expected to vary seasonally and within weeks (i.e., weekend days vs. weekdays). Based on designs of previous creel surveys (Malvestuto, Davies, & Shelton 1978; MacKenzie 1991; Ashford, Jones, & Fegley 2013), time blocks were also stratified within the sampling day, expecting that within-day variation in angling participation would occur. Therefore, we employed a multi-stage sampling design based on multiple, temporally delineated strata (Pollock et al. 1994; Malvestuto 1996; Vaske 2008). The primary sampling units (PSU) in this design were the day type (weekends vs. weekdays). The secondary sampling units (SSUs) were one of three 5-hour time blocks: 6:00-11:00 (AM), 11:00-16:00 (noon), and 16:00-21:00 (PM) within the PSU. Our design did not delineate a stratum based on holidays because all federal holidays (except Christmas, Thanksgiving, and Independence Day) occurred on a Monday or Tuesday when the fishery was closed. Non-uniform probability sampling (Cochran 1977; Pollock et al. 1994) was used to allocate sampling effort to PSU and SSU strata proportionally to their expected use. Sampling probabilities were calculated based on relative proportions of fishing effort, which were determined by instantaneous counts of anglers taken during each of six time blocks on the first

Friday and Saturday of each month. According to the outcomes of each monthly sampling schedule, 10 randomly selected sampling days that corresponded to the selected PSUs were subsequently drawn. For example, if six weekdays-SSU and four weekend-SSU strata were drawn in the initial selection, six and four randomly selected weekday and weekend days were subsequently drawn from the available calendar days, respectively. Because Marben PFA is closed for fishing on Monday and Tuesday, our sampling effort represented approximately 45% of the available fishing days/month. A 27-item angler survey was developed, approved by the University of Georgia Institutional Review Board, and pretested on 23 anglers during November and December of 2012 prior to implementing the survey in 2013. The survey included questions regarding their fishing activity that day, typical fishing habits, opinions regarding policy and management, perceived quality of fishing at Marben PFA, and demographic information (sex, age, ethnicity, zipcode).

Field Procedures

On selected sampling days, creel clerks traveled on foot or by boat throughout the fishery (i.e., from lake-to-lake) sequentially interviewing anglers within the closest walking/boating distance. On each sampling day, a starting point (one of six selected lakes) and direction of travel (north or south) were randomly selected by rolling a die and flipping a coin, respectively. Actively fishing anglers were contacted at each lake either on foot (if fishing from the bank or piers) or by boat and asked to participate in the survey. During the interview process, anglers were asked a series of 27 questions including their rating of fishing quality. In particular, anglers were asked to rank the quality of fishing at Marben PFA from 1 to 10, with 1 representing "poor quality" and 10 representing "excellent quality."

Statistical Procedures

Descriptive statistics were used to evaluate anglers' responses to individual line item questions on the survey. A T-test was used to assess significant differences in average fishing quality ratings for Marben PFA and alternative fishing sites that could be accessed at a comparable cost. The PLUM (Polytomous Universal Model) procedure for ordinal logistic regression was used to identify variables that were significantly related to anglers' perceived quality of fishing (Norušis 2005). Ordinal regression analysis is appropriate for categorical dependent variables with an ordinal structure (i.e., categories are ranked relative to each other but have no known interval measure between each category; Vaske 2008). Developing a multivariate model of perceived quality of fishing began with a Pearson's correlation matrix that identified any correlated variables. If two variables were highly correlated (i.e., with a Pearson's r value of |0.70| or greater; Gujarati 2012), one of these variables was removed from the analysis. Highly correlated variables were removed if they were logically assumed to be dependent on another explanatory variable, or if one of the two variables was less meaningful than the other from either a biological or theoretical perspective. Initially, all explanatory variables hypothesized to significantly influence anglers' perceptions of fishing quality were entered into the model as covariates (Table 2). The backwards elimination approach was used to remove independent variables that were not significantly related to perceived quality of fishing. The assumption of parallel lines was tested by evaluating the difference of the log-likelihood for the null and observed (general) model, which produced a Chi-square statistic. Goodness-of-fit was evaluated by examining the significance of Pearson and Deviance Chi-square values. The overall model test of the null hypothesis that the explanatory variables' coefficients were zero was also conducted using a Chi-square test. Rejecting the null hypothesis of this test means that the model with predictors is more useful than the model without predictors. Lastly, the Cox and Snell pseudo R-square statistic was used to evaluate the explanatory ability of the model. All hypothesis tests were conducted with an alpha of 0.05.

Results

Angler Demographics

The overall response rate during the survey period was 96% (1150 out of 1204 anglers contacted in the survey). However, 450 anglers were repeat interviewees and 149 anglers were first time visitors, and so the final sample size of completed interviews was 551. The average age of anglers sampled was 49 years (SD = 14), 89% were male, 56% were Caucasian, and 41% were African American. Anglers travelled an average of 35.8 miles (SD = 28.4) to fish at Marben PFA (Figure 3).

Descriptive Statistics

The average angler party size was 2.01 anglers (SD = 1.12). Anglers fished an average of 13.4 days per year (SD = 22.7) and had been fishing at Marben PFA an average of 8.6 years (SD = 7.6). Most anglers reported fishing during spring and summer, on weekends, in the mornings, and only participated in fishing at the CEWC (Appendix A). Anglers ranked the quality of fishing a 6.45 (SD = 2.19), which was significantly higher (p = 0.0001, t = 5.79, df = 803) than average fishing quality rankings they assigned for substitute fishing sites within the same driving distance (5.46, SD = 2.36). When asked if they believed the quality of fishing had changed at Marben PFA since their first visit, 40% of anglers believed fishing quality remained the same, 32% thought fishing quality had declined, 19% thought fishing quality improved, and 9% were unsure. When asked to identify factors that negatively influenced their fishing satisfaction, 32% of anglers selected "difficulty catching enough fish", 26% selected "operating hours", and 17% selected "water level too high/low"; all other factors were selected less than 10% of the time (Figure 4). Most anglers were satisfied with creel limits for all sportfish species at Marben PFA and believed that the current 35.5-cm minimum size limit for Largemouth Bass *Micropterus salmoides* should remain unchanged (Appendix B). Ninety-seven percent of anglers agreed with managing ponds for special use (i.e., as kid's ponds or catch-and-release only ponds). Seventy-four percent of anglers agreed that non-angling recreationists should be able to access Marben PFA lakes, while 21% disagreed and 5% were unsure. Anglers targeted multiple species simultaneously throughout the survey (Table 1). Most anglers targeted sunfish and Largemouth Bass among primary, secondary, and tertiary target species; whereas, most anglers with a quaternary target species were targeting Channel Catfish.

Ordinal Logistic Regression

The final model identified five variables that were significantly related to perceived quality of fishing rankings, and one variable (ln[distance]) was marginally significant (Table 3). The test of parallel lines failed to reject the null hypothesis that relationship between independent variables and the logits were equal for all logits (χ^2 = 44.72, p = 0.608). Significance of goodness of fit χ^2 values did not agree between Pearson (p = 0.026) and Deviance (p = 1.00) statistics. This disagreement in goodness of fit was likely because the model included multiple predictor variables including two continuous predictor variables, which resulted in many cells (87.6%) with zero frequencies (small expected values). However, the overall model test was significant (χ^2 = 119.5, p = 0.0001), which suggested that the model with predictors was better than the “intercept only” model. The Cox and Snell pseudo R^2 was 0.197. Total target catch, the only significant covariate in the model, was positively related to angler’s perception of fishing quality. The ln (distance) was also positively related to anglers perceived quality of fishing; however, this variable was not significant ($p = 0.065$) and therefore may not actually influence anglers’ perception of fishing quality. The dummy variables pier, ethnicity, poor catch, and the anglers’ perception of current size and number limit at Marben PFA were all negatively related to angler’s perception of fishing quality, indicating an inverse relationship with the probability of reporting a high quality of fishing rating.

Discussion

Our use of exploratory multivariate ordinal regression approach to identify variables that were significantly related to anglers’ perceptions of fishery quality was successful and provided new information about anglers’ opinions about fishing quality at Marben PFA. Most anglers indicated an above-average perception of fishery quality, and most of the variables initially included in the model were not significantly related to fishing quality rankings. The results of this analysis suggest that situational variables, anglers’ subjective evaluations of the fishery, and angling metrics can be useful in determining what shapes angler’s perceptions of fishing quality. At least one variable from each factor was significantly related to quality of fishing ratings, which suggests that perceived quality is similar to satisfaction with regard to its complexity and multifaceted nature (Crompton and Mackay 1989; Vaske 2008). These results from this survey have important implications relevant to both Marben PFA and the management of recreational fisheries in general.

Fishing is a goal-oriented and typically consumptive activity (with the exception of catch-and-release fisheries), and achievement of the goal such as catching or keeping a fish should produce some degree of satisfaction to the angler (Vaske 2008). Studies have consistently shown that fishing success (i.e., catching a fish) is important in determining fishing satisfaction (Miller & Graefe 2001; Arlinghaus 2006; McCormick and Porter 2014). Likewise, the results of our study suggest that anglers are more likely to have a positive perception of fishing quality when they caught increasing numbers of their target species. Anglers that reported having difficulty obtaining sufficient catches of fish were also likely to report lower quality of fishing scores. Therefore, angler success has proven to be a major determinant of quality perceptions. Marben PFA anglers mostly targeted Largemouth Bass and sunfish as primary, secondary, and tertiary target species. Therefore, maintaining or increasing catch rates for Largemouth Bass and sunfish may improve perceptions of fishing quality for most anglers. However, increasing the overall abundance of fish in general may not improve perceptions of quality, because an increase in fishing quality perception was only associated with increasing catch of target species and not the overall catch rate (i.e., including ancillary catch).

Managing impoundments to produce variable assemblages of fishes while emphasizing higher abundances of particular species among impoundments may be a solution to ensuring increased potential for fishing success. For example, the 14 impoundments surveyed in our study could be managed to promote high abundances of particular species in proportion to their popularity, with the distribution of directed effort for primary species being used to guide partitioning (Table 1). A subset of ponds could then be managed to produce high catch rates for each species; four ponds for Largemouth Bass, three for Black Crappie, four for sunfish, and one pond for Channel Catfish. Ponds managed for high predator densities would likely produce large quality prey individuals (e.g., trophy sunfish ponds), and ponds managed for high sunfish catches would also likely produce predators of quality size and condition (e.g., trophy Largemouth Bass). Using this approach, several management objectives (quality & quantity) may be accomplished simultaneously within the same impoundment. Two ponds could be set aside as unmanaged control ponds to evaluate the efficacy of management compared to the alternative of doing nothing.

Anglers who believed the impoundments should be managed for more numbers and larger sizes of particular species assigned lower fishing quality rankings, on average, than anglers who had no opinion or were satisfied with the current management strategy. Though this result may be expected, it further validates the notion that anglers' perceptions of fishing quality are, indeed, related to the characteristics of the fishery in question. Unfortunately, other survey questions did not specifically addressed anglers' catch-related attitudes; thus, evaluating the reliability or validity of this construct was not possible. However, understanding the patterns of beliefs regarding alternative management approaches would be useful specifically for Marben PFA fishery managers. For example, most anglers believed Marben PFA should be managed for both more and larger fish. These anglers selected Largemouth Bass the most, sunfish and crappie moderately, and catfish the least. Generally, these results suggest that Marben anglers desire an increased variety of opportunities for fishing to satisfy both consumptive and recreational (e.g., trophy fishing) motivations, with emphasis on the popular sportfish like Largemouth Bass and sunfish. Although managing a subset of the impoundments differently (e.g., trophy ponds, high abundance ponds) would likely require fishing regulations to be modified to meet sustainability objectives, a tangible and visible change in the management of the lakes probably would be well-received by anglers.

Anglers who fished from a pier were more likely to report lower quality of fishing ratings than anglers fishing from a boat or bank. This finding could be true for many reasons, but the two most plausible are: 1) because of the negative perception of crowding among pier anglers and 2) relatively low rates of fishing success among pier anglers relative to boat or bank anglers. The current theory on crowding suggests that anglers who encounter more people than their maximum tolerance for seeing others will feel more crowded than those who encounter less people than their norm (Vaske and Donnelly 2002). The perception of crowding then typically leads to a decrease in satisfaction with the experience or perception of quality (Needham, Vaske, Whittaker, & Donnelly 2014). However, only 6% (n = 34) of anglers identified crowding as a factor that took away from their fishing satisfaction at Marben PFA. Furthermore, only 6% (n = 2) of the anglers who identified crowding as negatively affecting their fishing satisfaction were fishing from a pier. Hence, the negative perception of fishing quality among pier anglers is more likely related to lower catch-related fishing success by pier anglers. Piers naturally restrict the angler's ability to fish the entirety of an impoundment, and because pier anglers can only fish a relatively small portion of the impoundment (compared to bank or boat anglers), they may experience lower catch rates, on average. Although, significant differences were not found in catch or harvest rates among pier, boat, and bank anglers (Chapter 3), a larger percentage of pier anglers (40%) believed that poor catch took away from their fishing satisfaction than bank anglers (31%) and boat anglers (32%). Therefore, pier anglers may have the opinion that they are obtaining insufficient catches of fish even if the catch rate actually matches that of other anglers. Deploying additional habitat structure (e.g., fish attractors) near piers may help pier anglers achieve higher fishing success (Bolding, Bonar, & Divens 2004). Additionally, ensuring adequate bank access near pier locations might also provide pier anglers alternative fishing locations adjacent to piers during unsuccessful fishing events. Improving the potential for catching fish is probably the most relevant action that could be taken to improve the fishing experience for pier anglers at Marben PFA.

Distance travelled was positively related to anglers' perceptions of fishery quality, and this relationship approached a statistically significant level (p = 0.065). Longer driving distances were associated with higher perceptions of fishing quality among Marben PFA anglers. Other studies have also found travel distance to be important in shaping decisions and opinions about the quality of fisheries. For example, Hutt et al. (2013) found that distance travelled was the most important predictor of catfish anglers' fishing preferences; however, the authors determined that reduced travel costs were a more desirable trait for a fishery. Conversely, our results suggest that the odds of an angler reporting a higher perception of fishing quality increased as distance travelled—and therefore cost—increased. Arlinghaus and Mehner (2004) found that highly specialized anglers would willingly travel farther for quality fishing opportunities than less specialized anglers. Similarly, Ward et al. (2013) discovered that non-local Rainbow Trout *Oncorhynchus mykiss* anglers in British Columbia exhibited a higher catch efficiency and more conservative harvest orientation than local anglers. Ward et al's (2013) results indicate that non-local anglers were likely more specialized than local anglers. Therefore, non-local Marben PFA anglers may be more specialized and generally have a higher perception of the fishing quality at Marben PFA than local anglers. On the same line of reasoning, the utility gained from fishing at Marben PFA may outweigh the costs of travelling to Marben PFA for non-local anglers. Considering the relatively close proximity of Marben PFA to the greater metropolitan Atlanta area, Marben PFA probably represents one of few quality rural fishing locations within a reasonable driving distance from the city.

The negative coefficient for the variable "ethnicity" suggests that, on average, Caucasian anglers assigned lower quality of fishing rankings than anglers of other ethnic backgrounds. Therefore, white anglers at Marben PFA may have had a slightly lower perception of the quality of fishing than non-white anglers, and although the coefficient was statistically significant, the effect size was relatively small. More importantly, however, this finding contributes to a growing body of literature regarding differences among races/ethnicities in outdoor recreation. General demographic variables, although useful in quantifying and describing user groups, do not usually exhibit strong predictive capabilities from a modeling perspective (Vaske 2008). Still, studies have found that significant differences do exist among ethnic groups based on behavior (Burger, Pflugh, Lurig, Von Hagen, &Von Hagen 2006), attitudes (Hunt et al. 2007), perceptions (Hunt and Ditton 2001), and participation (Toth and Brown 1997; Hunt and Ditton 2002; Floyd, Nicholas, I. Lee, J-H. Lee, & Scott 2006) in a recreational fishing context. The presence of an ethnically-based difference in quality perceptions certainly warrants further consideration. However, because we measured perceived quality holistically rather than as a function of multiple sub-dimensions, we are unable to explain the underlying cause(s) of this difference without undue speculation. Therefore, soliciting information on the beliefs of anglers regarding the quality of fishing based on multiple criteria (e.g., fish abundance, individual size, species available, and access opportunities) may allow future studies to examine differences in quality perceptions among sociodemographic groups with a higher degree of resolution and precision.

To our knowledge, this study represents the first attempt to identify variables that are related to and explain variation in anglers' perceptions of fishery quality. This study has also demonstrated that perceptions of quality behave similarly to satisfaction with respect to its multifaceted nature. Owing to this complexity, simply asking anglers a single question regarding their opinion of overall fishing quality is probably not sufficient to elucidate truth from that complexity. Alternatively, the individual components that determine overall fishing quality should also be investigated separately (e.g., number/diversity of species, success rates, number of harvestable fish, average length of fish caught) to determine what elements are strong predictors of overall quality and characterize the angling population (i.e., by harvest orientation, specialization, or motivations). Certainly, these elements would be expected to change among different angling communities and fisheries according to their unique characteristics. Similarly, measuring quality at its component levels would potentially reveal mechanisms for variation in perceptions of overall quality among specific user groups (e.g., race/ethnicity, age-group, specialization level). Considering the general decline in nature-based recreation participation in America (Kareiva 2008; Pergams & Zaradic 2008) and the need to understand preferences for recreationists, especially for growing minority groups (Rodriquez and Roberts 2002), developing tools to adequately discern particular fishing preferences among user groups will be essential for continuing the success of fisheries management programs nationwide.

The findings presented in this paper could be strengthened and validated with replication of the study. Therefore, future studies could assess anglers' perceptions of fishing quality to ascertain which criteria for assessment (quality or satisfaction) is appropriate for management in the recreational fisheries context. Including both measures of stated satisfaction and perceived quality would likely help us understand the strength of the association between satisfaction levels and quality perceptions while also understanding how different elements of the fishing experience influence both measures. Although satisfaction and quality perceptions have been demonstrated to be influenced by the same types of variables, overall fishing satisfaction could be expected to be better explained by factors related to angler motivations, preferences, and specializations. Conversely, quality perceptions could be explained by the catch-related aspects of the fishing trip and the general characteristics of the angler. By using this multidimensional approach, anglers may experience greater benefits of fishery management as our understanding of the desires of angling populations are improved.

Management Implications

This survey has provided a wealth of information about the angling community at Marben PFA. Anglers indicated strong support for the current regulatory measures and management efforts being employed on the fishery. Most anglers indicated a positive attitude towards the quality of fishing at Marben PFA, and most anglers believed that the quality of fishing at Marben PFA exceeded that of alternative fisheries that could be accessed at a comparable travel cost. Anglers' attitudes towards the quality of fishing may be improved by increasing catch rates for popular target species such as Largemouth Bass and sunfish species. However, managing to produce quality stocks of Black Crappie and Channel Catfish will also be important for sustaining the positive perception of fishing quality at Marben PFA, as a considerable portion of anglers (28%) primarily target these species as well. Consistent with the findings of recent studies in recreational fisheries (Hunt, Hutt, Schlechte, & Buckmeier 2012; Pierskalla, Ramthun, Collins, & Semmens 2013; McCormick et al. 2014), the fishing success of anglers plays a critical role in shaping opinions about fishing quality and influencing their fishing satisfaction. Providing easily accessible information regarding decisions behind administrative or managerial changes that affect anglers' abilities to fish (e.g., reducing operating hours, lowering water levels) may also reduce the incidence of angler dissatisfaction and eliminate speculation among anglers. Because Marben PFA is an important fishery resource for anglers in the communities surrounding north-central Georgia, improving the effectiveness of the management of this fishery will provide additional benefits to these communities in the future.

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Figures and Tables

Table 4-1: Percentages of anglers targeting various fish species at the Marben PFA (Mansfield, GA) during January to December 2013.

		Species				
Target Rank	*n*	LMB	BLC	Sunfish	CCF	"Anything"
Primary	1,157	25	19	31	9	16
Secondary	401	18	23	36	23	†
Tertiary	67	28	19	37	15	†
Quaternary	17	29	0	12	59	†

† anglers did not target "anything" as secondary, tertiary, or quaternary target species.

Table 4-2: Description of variables initially hypothesized to influence anglers' attitudes towards fishing quality at Marben PFA (Mansfield, GA) during 2013.

Variable	Description	Mean (SD)	% if = 1
Angling Metrics			
Fish catch†	Total number of fish caught	5.07 (9.17)	-
Weight	Total weight of fish harvested (kg)	0.41 (0.91)	-
Fish Harvest†	Total number of fish harvested	2.37 (5.62)	-
Bycatch	Number of non-target fish caught	1.00 (3.20)	
Target catch	Total number of target species caught	4.08 (8.24)	-
Subjective Evaluations			
Participation	1 if angler participated in other recreational activities, else 0.	-	31.0
Water level	1 if high/low water levels took away from satisfaction, else 0.	-	16.5
Poor catch	1 if "difficulty getting enough catch" took away from satisfaction, else 0.	-	32.1
Crowding	1 if crowding took away from satisfaction, else 0.	-	6.2
Behavior	1 if negative behavior of anglers took away from satisfaction, else 0.	-	6.5
Operating hours	1 if reduced operating hours took away from satisfaction, else 0.	-	26.0
Access	1 if poor access to fishing areas took away from satisfaction, else 0.	-	8.7
Water quality	1 if poor water quality took away from satisfaction, else 0.	-	4.2
Regulations	1 if difficult fishing regulations took away from satisfaction, else 0.	-	1.1
Management.1	1 if angler believed lakes should be managed for more and/or larger fish, else 0.	-	88.6
Management.2	1 if angler believed creel limit should increase for their target species, else 0.	-	19.2
LMB size limit	1 if angler advocated liberalized size limit for LMB, else 0.	-	20.3
Situational Variables			
Gender	1 if male, else 0.	-	89.5

Age	Angler age.	50.2 (14.1)	-
Median Income (thousands)	Median income determined by zip code.	\$51.5 (\$12.0)	-
Distance	Driving distance travelled determined by zip code.	35.8 (28.4)	-
Ethnicity	1 if angler was Caucasian, else 0.	-	56.7
Party	Number of anglers in party	2.0 (1.1)	-
Boat	1 if fishing from boat, else 0.	-	24.7
Bank†	1 if fishing from bank, else 0.	-	67.5
Pier	1 if fishing from pier, else 0.	-	9.4
Trips	Number of fishing trips taken in last year (2012)	13.4 (22.70	-
Years	Number of years angler has fished at Marben PFA	8.6 (7.7)	-

†Pearson r > 0.70

Table 4-3: Definition of variables used and ordinal regression coefficients that describe the odds of reporting a higher quality of fishing rating for anglers surveyed at Marben PFA in Mansfield, GA during 2013.

Variable	Description	β	Exp (β) odds ratio	*p*-value
Total Target Catch$_a$	Number of target species caught during fishing trip.	0.32	1.03	0.001
ln (distance)$_b$	The natural log of the approximate distance travelled to fish at Marben PFA.	0.22	1.24	0.065
Pier$_b$	Dummy variable: 1 if angler was fishing from pier, 0 otherwise.	-0.58	0.55	0.027
Ethnicity$_c$	Dummy variable: 1 if Caucasian, 0 otherwise.	-0.43	0.65	0.012
Poor Catch$_c$	Dummy variable: 1 if angler indicated “poor catch” took away from their fishing satisfaction, 0 otherwise.	-1.38	0.25	0.001
Management strategy$_c$	Dummy variable: 1 if angler thought lakes should be managed for more fish, larger fish, or both, 0 otherwise.	-0.77	0.46	0.002

$_a$Fishing metric
$_b$Situational variable
$_c$Subjective evaluation

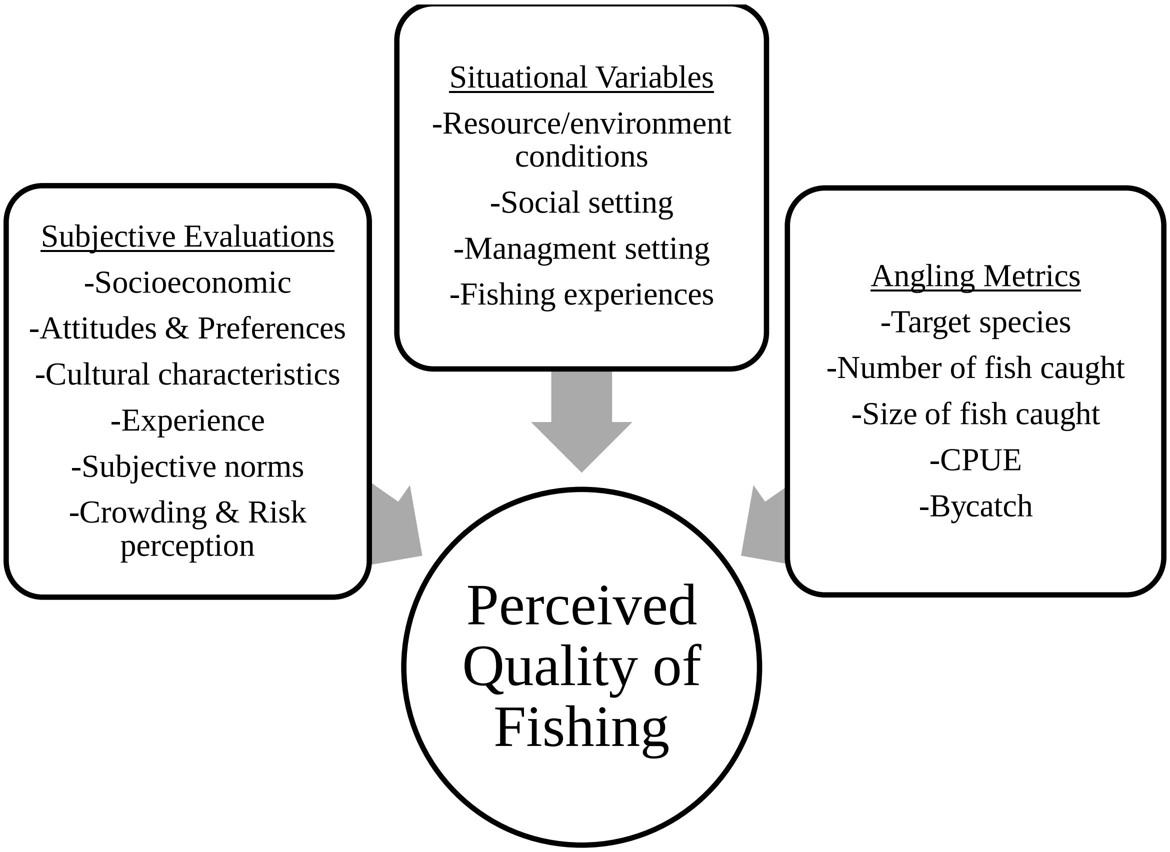

Figure 4-1: The model of perceived quality of fishing adapted from the generic model of satisfaction in outdoor recreation (Whisman & Hollenhorst 1998[3], Manning 1999[4]). The variables under the "angling metrics" category were added to this framework.

[3] Whisman, S. and S. Hollenhurst. (1998). A path model of whitewater boating satisfaction on the Cheat River of West Virginia. *Environmental Management*, 22, 109-117.

[4] Manning, R. (1999). *Studies in Outdoor Recreation: Search and Research for Satisfaction* 2nd ed. Corvallis, Oregon State University Press, 374 pp.

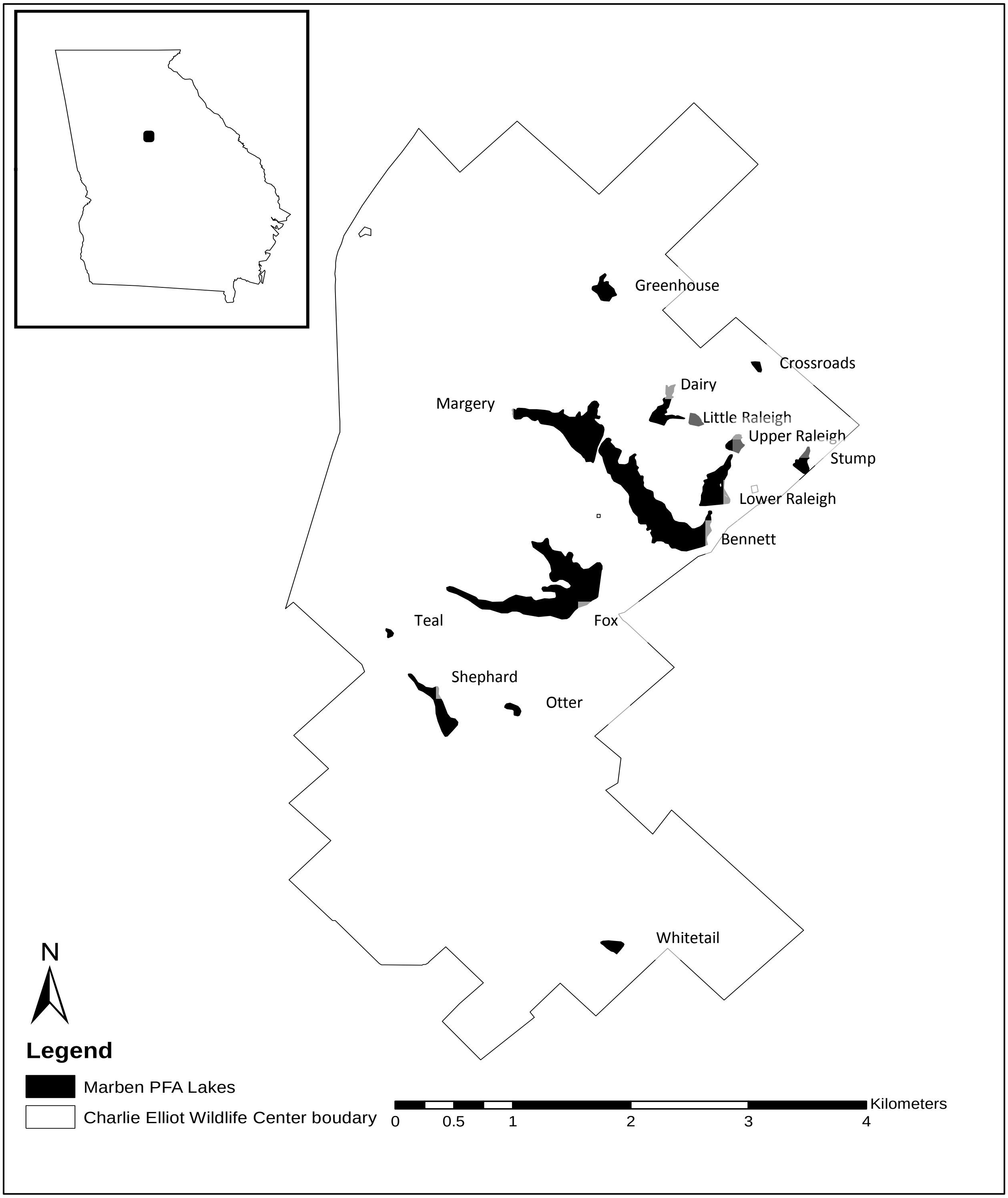

Figure 4-2: The state of Georgia (top left corner) and the Charlie Elliot Wildlife Center (Mansfield, GA) containing the Marben PFA lakes that were surveyed during 2013.

Figure 4-3: Frequency of resident zip codes reported by Marben PFA anglers (Mansfield, Georgia) during 2013.

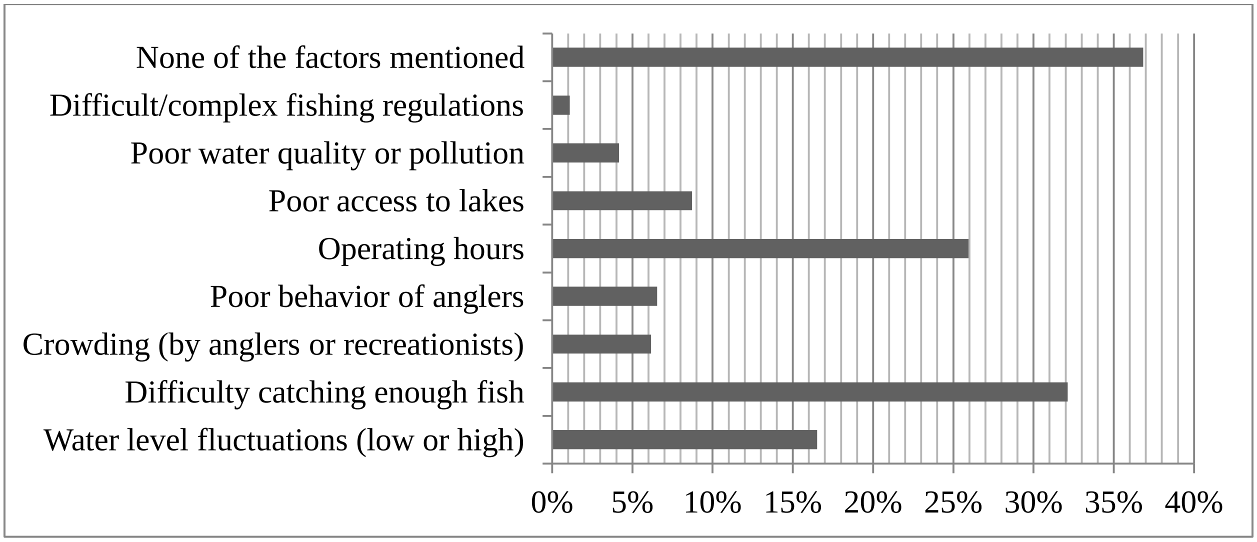

Figure 4-4: Percentages of anglers that identified factors negatively affecting their fishing satisfaction at Marben PFA near Mansfield, GA. Percentages do not sum to 100 because of multiple responses.

CHAPTER V

PROJECT SUMMARY AND MANAGEMENT IMPLICATIONS FOR THE CREEL SURVEY OF THE MARBEN PFA FISHERY

Recreational fishing in Georgia is an important nature-based activity that has strong ties to Georgia's natural and cultural resources. Owing to its unique topography and location, Georgia is one of the few states in the USA that can produce coldwater, warmwater, and saltwater fisheries all within a few hundred miles of each other. As a result, anglers spend significant effort and dollars to fish Georgia's waters. Because fishing on small ponds, lakes, and reservoirs is extremely popular among Georgia anglers, ensuring the optimal utility and management of Georgia's warmwater impoundments such as the Marben PFA benefits a considerable majority of the angling population in Georgia. Improving the quality of fishing on such fisheries may help to increase angler recruitment and retention, and thereby increase revenue from sales of state fishing licenses and WMA licenses to continue research and management of Georgia's fisheries.

The 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reported a disturbing decline in angling participation among Georgians (USDOI 2011) while other states and regions observed resurgence from 2006. This trend poses a substantial threat to the future viability of both fisheries and their respective managing agencies in Georgia. Whether the declining trend in fishing participation will continue in Georgia remains to be seen, but this survey represents a substantial effort to challenge declining angler participation by understanding anglers and their fisheries to improve upon the status quo of fisheries management. Prior to implementing the creel survey on the Marben PFA, the literature encompassing implementation of creel surveys on spatially complex fisheries like Marben PFA was sparse (Chizinski et al. 2014). Accordingly, fishery-wide surveys had not been conducted at Marben PFA and, therefore, little was known regarding the general characteristics of the fishery or the angling community. This study has provided information that will facilitate the effective management of this fishery so that anglers will be able to fish one of Georgia's popular PFAs with greater success and enjoyment.

This project had several different objectives, with the first being to develop a complete profile of the angling at Marben PFA through analysis of fishery-dependent angler data. We successfully adapted a generic roving-roving creel method to survey the multi-lake fishery, which allowed us to efficiently survey as many lakes and as many anglers as possible within a 5-hour time frame. We found that fishing effort was approximately normally distributed during 2013, rapidly increasing during the spring, peaking in May, and gradually decreasing into the cooler months of the year. The catch and harvest compositions indicated that angler success was moderate-to-excellent depending on the species being sought, with sunfish (*Lepomis* spp.) being the most popular and most frequently caught among the available sportfish. The practice of catch-and-release fishing by Largemouth Bass anglers was ubiquitous throughout the fishery; whereas, crappie anglers harvested crappie at the highest rate among all species. Sport Fishing Index (SFI; Hickman 2000), composite scores indicated that the quality of fishing for Largemouth Bass, Black Crappie, and Channel Catfish were above average and exceeded the quality of fishing for the same species among most Tennessee reservoirs for Largemouth Bass anglers. Generally, most of the fishing effort occurred on the larger centralized impoundments of the fishery, although the highest pressures were estimated for the less-centralized, intermediate-size impoundments. Future studies may consider examining the relationship between angler's catches of Black Crappie and estimated the abundance of Black Crappie to ensure that Black Crappie populations are regulated by angler harvest. Because sunfish were popular sportfish among many Marben anglers, future studies of Marben PFA impoundments could also investigate lake-specific size structure of sunfish populations to ensure that a healthy balance in size structure and abundance is being met. Overall, the results of this study underscore the value and robust capacity of the small, intensively managed impoundments that comprise the Marben PFA. By continuing the current management regime at Marben PFA, anglers will likely continue to support and enjoy fishing at Marben PFA. If fishery managers would like to increase quality perceptions, participation, and angler satisfaction, managing for greater diversity of fishing opportunities and improving catch rates appear to be the most effective means of achieving these goals.

The second component of the creel survey was to evaluate the plausibility of using traffic counters to indirectly monitor fishing effort on Marben PFA. The literature review that preceded the implementation of the vehicle survey suggested that any dedicated use-estimation system would require a measurable variable of use (either proxy or direct), sampling methodology, and method of data analysis that was unique to the system of interest (Watson et al. 2000, Cessford & Muhar 2003). Therefore, we surveyed motorists entering the Charlie Elliot Wildlife Center (CEWC) in 5-hour time blocks after the roving creel survey to determine the proportion of fishing traffic entering CEWC. The results of our analysis suggest that traffic from anglers and other recreationists was too variable, even within distinct fishing seasons, to discern any reliable pattern that could be used to monitor fishing activity. The overall response rate for the survey was 56%, and so that accuracy with which we could characterize fishing traffic patterns at CEWC with such a relatively low response rate is uncertain. Passive effort-monitoring systems have proven effective on fisheries with a simpler spatial layout than Marben PFA (Douglas and Giles 2001; K. J. Hining and J. M. Rash, NC Wildlife Resources Division, personal communication); however, recreational facilities like CEWC require additional considerations for implementing such a system including monitoring multiple entrances, partitioning vehicle traffic counts between recreationists and nearby residents, and further quantifying the abundance of recreationists that visit CEWC for purposes other than fishing. Alternative methods of monitoring fishing effort may accomplished through use of additional creel surveys, remote camera systems, rapidly improving unmanned aerial vehicle technology, or through use of voluntary information provided by anglers. A dedicated fishing-effort-monitoring system might be possible at the CEWC if the number of entrances was reduced. For example, if the main entrance were designated as “enter-only”and the southern entrance was designated as “exit-only”, then monitoring vehicle traffic in-and-out of the facility might be improved. However, the issue of nearby residential traffic is inevitably going to complicate a vehicle-based monitoring system in any scenario.

The final component of this study involved investigating the human dimensions of the Marben PFA. We interviewed anglers to understand their routine fishing activities (avidity, temporal trends in participation), perceptions of fishing quality at Marben PFA, preferences for fishing experiences at Marben PFA, and beliefs about fishing regulations and general policies that were enforced at the fishery. Generally, anglers had a positive perception of the quality of fishing at Marben PFA and most anglers provided strong support for the current management of the PFA with respect to fishing regulations (e.g., creel limits, minimum size limits). Anglers who drove longer distances to fish at Marben PFA and anglers who caught increasing numbers of their target species were more likely to report a positive perception of fishing quality than local anglers or anglers with low fishing success. Anglers that were dissatisfied with catching enough fish, fished from piers, or advocated some form of change in the current management of the fishery were likely to report a lower perceived quality of fishing, on average. Considering that fishing at Marben PFA requires additional licensing and that fishing regulations are generally more conservative than statewide regulations, the overall positive support for the management of the fishery indicates that management goals are closely aligned with most anglers' preferences for fishing experiences. However, managing Marben PFA impoundments to provide more diverse fishing experiences for anglers will likely invoke greater support by anglers, as many anglers believed that the impoundments should be managed for larger individuals and higher abundances of certain species. Providing easily accessible information regarding the rationale behind administrative/managerial decisions for the fishery would create more transparency between managing agencies and the angling community. For example, providing educational information to anglers regarding the reasons behind winter drawdowns would lead to less dissatisfaction with fluctuating water levels. Similarly, explaining why weekday fishing hours have been reduced would potentially lead to less skepticism and dissent among anglers who disagree with the decision. Although achieving 100% angler satisfaction is not practical or feasible in most circumstances, we have identified a number of ways to improve angler satisfaction and fishing quality perceptions through collection and analysis of valuable angler opinion data.

Fishery managers now have a better understanding of fishing activity and anglers' preferences for fishing experiences at Marben PFA. A feasible method of surveying this multi-lake fishery has also been demonstrated throughout this survey. The roving-roving survey method may be improved in future use if creel clerks attempt to make more than one instantaneous count per period to improve accuracy of effort estimates (Pollock et al. 1994), collect lake-specific creel information (e.g., record fishing times, catch, and harvest per lake from each angler) so that creel metrics can be derived for each impoundment (Chizinski et al. 2014), and consider using trail cameras to capture fishing effort on small, less centralized impoundments (e.g., Whitetail, Stump, Crossroads) to improve survey efficiency. While novel innovations in passive effort-monitoring methods may have some future utility in recreational fisheries, the traditional methods of monitoring fishing effort (e.g., creel surveys) currently hold the most promise for gathering unbiased data from Marben PFA.

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CHAPTER VI

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APPENDICES

Appendix A: Reported fishing frequencies and types of alternative recreational participation by anglers (n = 551) surveyed at Marben PFA in Mansfield, GA during 2013.

Item Description	Category	Percentages
Seasonal Frequency†	Spring	54.4
	Summer	50.0
	Fall	19.2
	Winter	3.4
	All	26.3
Weekly Frequency	Weekends	54.0
	Weekdays	21.0
	Both	25.0
Daily Frequency†	Morning	78.2
	Noon	60.0
	Evening	56.0
Recreation Participation†	Hunting	12.2
	Hiking	3.4
	Shooting	15.6
	Biking	0.5
	Birdwatching	0
	Camping	5.6
	Other	4.5
	None	67.9

†Percentages do not sum to 100 because of multiple responses.

Appendix B: Percentages of anglers responding to questionnaire items pertaining to fisheries management, creel limits, and the minimum size limit for Largemouth Bass at Marben PFA in Mansfield, GA during 2013.

Item Description	Categories	Percentage
Do you believe Marben lakes should be managed for more fish, larger fish, or both?	More Fish	28.1
	Larger Fish	15.8
	Both	44.6
	No Opinion	11.4
Among anglers that selected "more fish" †	LMB	46.5
	BLC	52.3
	Sunfish	53.0
	CCF	30.3
Among anglers that selected "larger fish" †	LMB	74.7
	BLC	30.0
	Sunfish	24.1
	CCF	8.0
Among anglers that selected "both" †	LMB	67.1
	BLC	43.1
	Sunfish	47.6
	CCF	26.0
Do you feel the current minimum size limit of 14" should be:	Eliminated	4.0
	Unchanged	70.0
	Reduced	16.3
	Increased	4.5
	No Opinion	4.7
	Slot Limit	0.4
Do you think the current LMB creel limit of 5 fish should be:	Unchanged	75.5
	Reduced	2.7
	Increased	8.5
	No Opinion	13.3
Do you think the current BLC creel limit of 30 fish should be:	Unchanged	80.6
	Reduced	7.6
	Increased	4.4
	No Opinion	7.4
Do you think the current bream creel limit of 15 fish should be:	Unchanged	70.4
	Reduced	1.2

	Increased	22.0
	No Opinion	6.6
	Unchanged	61.3
	Reduced	0.4
Do you think the current CCF creel limit of 5 fish should be:	Increased	23.8
	No Opinion	14.5

† Percentages do not sum to 100 because of multiple responses.

Appendix C: Example of the questionnaire administered to anglers at Marben PFA (Mansfield, GA) during 2013.

Charlie Elliott Wildlife Center Angler Survey

Resp. ID__________ LAKE:__________

TIME: 6am-11am 11am-4pm 4pm-9pm

1.HOURS SPENT FISHING: _____Hrs

2. FISHING FROM : Boat Bank Pier

3. PRIMARY METHOD: Casting Trolling Cut Bait Live Bait Other______

4. TARGET SPECIES: Bass[ ] Crappie[ ] Bream[ ] Catfish[ ] Other____[ ]

5. NUMBER OF FISH KEPT (May I look at your fish?):

Species	Numbers (#)	Weight(kg)		Species	Numbers (#)	Weight(kg)

6. NUMBER OF FISH RELEASED (Did you land any fish that you released?):

Species	<6”	6-12”	12-15”	>15”	Unknown
1.					
2.					
3.					
4.					
5.					

7. How many people are in your party today?______persons including you.

8. Over the last year, how many times did you visit CEWC for fishing? __________trips

9. Do you typically participate in any activities other than fishing (e.g., bird watching, hunting, hiking) at CEWC?

☐ Hunting ☐ Hiking ☐ Shooting ☐ Biking ☐ Bird Watching
☐ Camping ☐ Others___

10. Which season do you typically fish at CEWC?: Summer Fall Winter Spring All

11. When in the week do you typically fish?: Weekends Weekdays

12. What time of the day do you usually fish?: Morning Midday Afternoon

13. On a scale of 1 to 10 with 1 being poor and 10 being the excellent, how would you rate the current quality of fishing at CEWC lakes?

1(Poor) 2 3 4 5 6 7 8 9 10 (Excellent)

14. How long have you been fishing at CEWC lakes? _____Years

15. Would you say the quality of fishing at CEWC lakes has changed since your first visit?

☐ Improved ☐ Remained the same ☐ Declined ☐ Don't know

16. Do you have other public fishing areas similar to CEWC at the same distance from your house?

☐ Yes ☐ No ☐ Not Sure

17. On a scale of 1 to 10 with 1 being poor and 10 being the excellent, how would you rate the current quality of fishing those fishing areas?

1(Poor) 2 3 4 5 6 7 8 9 10 (Excellent)

18. Considering fishing at CEWC lakes, do any of the following take away from your fishing satisfaction?

☐ Water level too high/low
☐ Hard to get enough catch
☐ Too crowded
☐ Poor behavior of other anglers
☐ Operating hours
☐ Poor access to fishing areas
☐ Water quality/pollution
☐ Difficult/complex regulations
☐ None of the above

19. Do you believe that CEWC lakes should be managed for:

☐More Fish ☐ Larger Fish (Trophy fish) ☐ Both ☐ What types________?

20. The length limit on Largemouth bass is currently 14", do you feel this should be

☐ Eliminated ☐ Unchanged ☐Reduced to _______ ☐ Increased to ________

21. The daily creel limits are 5 Bass and 5 Catfish, 30 Crappie, and 15 Bluegill/Bream . Are changes needed?

Bass:	☐ Unchanged	☐ Reduced	☐ Increased	☐No opinion
Crappie:	☐ Unchanged	☐ Reduced	☐ Increased	☐ No opinion
Catfish:	☐ Unchanged	☐ Reduced	☐ Increased	☐No opinion
Bream:	☐ Unchanged	☐ Reduced	☐ Increased	☐No opinion

22. Do you agree with managing some lakes at CEWC for special use (e.g., kids pond, catch-&-release, boat etc.) only?

☐ Yes ☐ No ☐ Not Sure

23. Do you think that all fishing lakes at CEWC should be open to non-fishing visitors as well?

☐ Yes ☐ No ☐ Not Sure

24. What is your age?____years

25. Gender: ___Male ___Female

26. Ethnic background:

☐ Caucasian ☐ African-American ☐ Native American
☐ Hispanic/Latino ☐ Asian/Pacific Islander ☐ Other_______

27. What is your Zip Code?_______

Appendix D: An example of the signage that was used to inform motorists about the survey of vehicles entering the Charlie Elliot Wildlife Center (Mansfield, GA) during 2013.

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
WILDLIFE RESOURCES DIVISION

1785
The University of Georgia

Charlie Elliott Wildlife Center

VEHICLE SURVEY

The Center is surveying drivers on this road to collect data useful in management. Please stop by the kiosk to complete a 1-minute survey.

Appendix E: An example of the information collected from motorists during the vehicle surveys at Charlie Elliot Wildlife Center (Mansfield, GA) during 2013.

Charlie Elliott Wildlife Center Vehicle Survey Form

Date: Entrance ID: Time Code (block): 4-9pm Surveyor ID:

Vehicle type (Car, SUV, truck)	Entering CEWC (yes, no)	Fishing (yes, no)	GORP/Other (yes, no)	Party size (if fishing)

Total passing thru:________________ Total in parking lot:_____________________