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The Economic and Social Values Associated with Small South Dakota Lakes

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THE ECONOMIC AND SOCIAL VALUES ASSOCIATED WITH SMALL SOUTH DAKOTA LAKES

BY

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This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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This dissertation is dedicated to my grandparents, Shirley and Zane, Lennarth and Phyllis and Carol, parents, Lee and Kelly, and brothers, Chris and Cameron. This dissertation is also dedicated to Abby, Bailey and Maya.

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ABSTRACT

THE ECONOMIC AND SOCIAL VALUES ASSOCIATED WITH SMALL SOUTH DAKOTA LAKES

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The valuation of small fishing lakes is a vital component in understanding the importance of fishing and of recreational resources, in general. Knowing the values associated with such lakes is essential when prioritizing management activities. The overall value of a lake as a resource for human benefit is estimated as the summation of both instrumental and non-instrumental values. Instrumental values consist of economic and utilitarian values, as well as the values that a lake provides from ecosystem services. Non-instrumental values consider what the lake is worth as a good of its own, such as aesthetic, moral, and spiritual values gained by people because of the lake's existence.

In South Dakota, limited information of the economic and social values associated with small fishing and recreational lakes across the state has been collected. Many economic and social value studies have taken place on relatively larger lakes and reservoirs in the state; however, there is an abundance of small lakes that have yet to receive such research attention. With over 400 small lakes under state management, over time, many of these lakes will require costly renovation projects, such as dam repair, dredging, maintenance and replacement of docks and boat ramps, creation of fishing access, and general fisheries population management. Angler usage and economic information of the contributions of fishing and other water-related recreation at particular

lakes of interest can help prioritize these expensive renovation projects. Moreover, the non-market values that local residents place on these lakes can be just as valuable to decision-making processes as the associated economic information. When combined, the information gathered from these lakes will contribute to better economic and social value estimates of similar lakes across South Dakota, and even across the United States. The economic evaluation of small recreational lakes also provides more precise measurements of recreational value when conjoined with already existing valuation data from relatively larger and higher use lakes.

While currently published economic information has been useful in influencing management and policy decisions, the process in which data have been collected has not provided an accurate representation of the economic activity resulting from small fisheries within a region. Several other studies in South Dakota have targeted larger, more impactful fisheries resources for economic analyses; however, the economic value of the fishing industry becomes even more substantial with the addition of over 400 small lakes across the state. With few nearby opportunities for anglers to fish at larger lakes and reservoirs, the importance of quality fishing opportunities at nearby small fisheries could be sizeable, meaning that the collective economic value of these fisheries may be quite considerable. Recognizing the lack of information on this topic, I initiated this study to better understand the share that small fisheries have in the overall economic activity related to the fishing industry in South Dakota.

For my first goal, the economic activity of seven small, South Dakota fishing lakes was estimated by using the expenditures during angling trips to these individual lakes in 2016. In particular, I wanted to: (1) estimate angler use, (2) estimate the extent of

the total economic activity (TEA) associated with small fisheries, and (3) provide economic and use information that may be important to managers in determining future management priorities. The economic activity associated with angling visits to seven small fisheries in South Dakota was estimated using IMPLAN software. The average economic activity associated with fishing individual lakes in 2016 was $35,369/lake, supporting an average of 0.48 jobs and creating $5,572 in tax revenue. I observed that lakes with the highest proportion of ice fishing pressure also had the greatest associated economic activity, even though several of these had the lowest overall fishing pressure throughout the year. In addition to economic activity, zone of influence for each lake was estimated and compared with the proximity to urban centers. The inclusion of economic information from small fisheries may play an important role in influencing key strategic planning efforts by management agencies and in estimating the overall economic importance of angling on broader scales. Further, this study provides evidence of the importance of community events, such as fishing tournaments, in increasing the TEA of a small fishery and that these small fishing lakes are important assets to local communities. This study also indicated that special management strategies, such as the stocking of a catchable-size popular sportfish, can generate excitement around a fishery that may increase its use and economic activity.

While collecting the monetary value on a resource seems to be the most popular method for determining how important a resource is to a region, perhaps the value of inland fisheries transcends economic statistics. Inland fisheries can also serve a crucial non-monetary role in contributing to the overall well-being of individuals by providing opportunities to form connections between humans and nature. Freshwater fisheries

provide a wide array of ecosystem services that are important to individuals, society, and the environment, which include: food security, economic security, empowerment, cultural services, recreational services, human health and well-being, knowledge transfer and capacity building, ecosystem function and biodiversity, aquatic “canaries,” and “green” food opportunities. The ability to understand these non-market values, and the extent to which they contribute to the overall value provided by a small lake is a critical component in any decision-making process pertaining to management activities and priorities, as well as when deciding additional stakeholders that are necessary to include in these processes.

For my second goal, I determined the importance of small fishing lakes to the overall quality of life of residents living in nearby communities in South Dakota. My objectives were to (1) measure the recreational activities and other uses provided to residents by lakes near their local communities, (2) measure the attitudes and values of residents towards the lakes that are near their communities, and (3) determine the uses, respondent characteristics, and attitudes towards these lakes that are best at predicting the importance of the lakes to local residents’ overall quality of life living in their communities. I used multiple linear regression analysis to identify that the most important predictors to lakes’ importance to local residents’ quality of life were: “lake is an important community resource,” “lake is a place I enjoy visiting,” “the number of different activities participated in at lake,” and “the lake is important to local businesses.” These 4 predictors were positively related to the contribution of lakes to residents’ quality of life. My findings provide empirical evidence for the desire to incorporate community participation and economic growth objectives into management plans for local lake

resources. Realizing the diversity of recreation and leisure opportunities that lakes and adjacent lands can provide may be a simple, but critical, step in increasing economic opportunity for local regions and for providing a place for communities to hold events and ceremonies. Managers of these resources may find that agency-community collaboration, and careful co-management, can provide positive outcomes in the form of increased satisfaction among users and local communities, as well as increased overall use of the resources. Not only do these lakes contribute to economic value through angling opportunities, they also contribute in the form of non-market social values, such as increased community involvement, expanded recreational opportunities, and a greater overall quality of life.

Managers of small recreational lakes must select appropriate survey methodologies in order to collect precise, accurate, and unbiased information from their constituents regarding the lakes' economic and social valuations. Traditional survey approaches for gathering information from stakeholders have relied on on-site, mail, or telephone surveys. However, the ability to administer surveys quickly and with relatively low cost using the internet has become a popular method among managers and researchers. The rapid onset of internet surveys as a method for collecting angler information has provided limited time to assess the quality of the data being produced.

For my third goal, I compared the quality of data collected using on-site, mail, and internet survey data from the 2016 fishing year. More specifically, my objective was to determine the ability of internet surveys to estimate fishing pressure at small South Dakota lakes (evaluated with data estimated using on-site surveys of fishing pressure). A secondary objective was to compare three metrics (age, gender ratios, and satisfaction of

anglers' fishing experiences) across survey methods to demonstrate how these metrics can vary across survey methods and sampling frames. Results indicate that angling pressure estimated from internet surveys were found to be 2.2 times greater than estimates from on-site surveys across all seven lakes; however, the proportion of angler days relative to the other lakes within the study were not significantly different between on-site and internet survey methods ($p = 0.91$). Internet surveys may have been subjected to recall error and nonresponse bias, which would likely cause a large multiplier effect during extrapolation. I also found that angler satisfaction on a scale from -3 to 3 was significantly different among on-site surveys (1.46 ± 0.07) and internet surveys (-0.04 ± 0.08). This is likely due to the interpretation of two different metrics based on the recency of the fishing experience that the anglers are being asked to rate. The mean age of internet survey respondents was significantly different ($p < 0.001$) than the age of mail survey respondents (49.6 ± 0.2 and 55.6 ± 0.7, respectively). Internet respondents may have been younger than mail survey respondents as a result of internet illiteracy, and lack of internet usage by older participants. The proportion of male respondents (vs. female) for each survey method were 94.1% (on-site), 65.0% (mail), and 88.3% (internet), which were all significantly different from each other ($p < 0.001$). The gender proportions also all differed from the distribution of anglers who had purchased a South Dakota fishing license in 2016 at 78.4% males and 21.6% females. Differences in gender ratios may have been caused by the topic of the survey being administered. As internet surveys become more prevalent, researchers and managers must use caution when considering these tools. Internet surveys are a relatively cheap and efficient method of collecting angler data when used properly. However, methods such as on-site and mail surveys

should be considered in specific situations that evoke the biases and errors that are common with internet surveys, as described by this study.

CHAPTER 1: INTRODUCTION

Valuing natural resources plays a critical role in making informed management and legislative decisions. Managers are often asked to evaluate the trade-offs between hunting, fishing, and other forms of outdoor recreation (Verburg et al. 1987). Knowing the overall value associated with resources can inform managers on how to prioritize management activities across large jurisdictions, provide cost-benefit analyses for potential management plans, and inform legislative decision-makers on how to justify budget items. Several laws and governmental policies have resulted from attitudes and values held by large numbers of people, such as: the American Game Policy (1929), the Endangered Species Preservation Act (1966), the National Environmental Policy Act (1969), the National Forest Management Act (1976), and the Fish and Wildlife Conservation Act (1980; Steinhoff et al. 1987).

The term *value* has been problematic because of its ambiguity across academic genres (Brown and Manfredo 1987). In my study, I considered both the values *about* things (i.e. held values) and the values *of* things (i.e. assigned values; Brown 1984). Held values are canons and beliefs that individuals possess towards something, while assigned values are the significance or monetary worth of something. Held values are often synonymous with social values that people have towards something, such as ideas, behaviors, outcomes, experiences, and non-economic benefits. Assigned values are often known as the economic value of a particular resource, such as goods, services, and opportunities. The dichotomy of concepts between held and assigned values suggest that two constructs should be measured to appropriately value natural resources: (1) the values that form the basis for my attitudes towards resources, and (2) the natural resource

types, settings, and opportunities that provide the most value to people (Brown and Manfredo 1987).

The overall value of a lake is the summation of several different forms of values. The overall valuation of lake resources means both the appraisal of the economic values and exploration of the attitudes related to the value. Economic value is the most commonly estimated and utilized value by decision-makers when prioritizing and justifying management activities. It is regularly estimated for lakes by conducting access-point surveys of user groups to collect expenditure information or contact information, which would be followed-up by sending mail surveys asking for trip expenditure information. Often, economic information is not sufficient enough for justifying management activities at lake resources, in which case, the social value of lakes is necessary to consider the non-market values that lakes provide to local communities. The importance of social values are less visible than that of economic values, however, they are often extremely critical (Verburg et al. 1987). Social values are ordinarily estimated with mail surveys that ask a variety of Likert scale and count questions about opinions, ratings, and overall use of the lake resources. The consolidation of economic and social values can contribute immensely to an estimate of the overall value associated with a lake resource.

Statement of the Problem

In the United States, small lakes and reservoirs that require costly renovations to access points and facilities, either currently or within the near future, are abundant. Research conducting economic analyses of fisheries resources in a region rarely includes detailed data on the often numerous small lakes and impoundments that anglers are

utilizing. In South Dakota, over 400 small lakes are managed by the South Dakota Department of Game, Fish and Parks (SDGFP) for angling and other forms of outdoor recreational opportunities. The SDGFP has expressed their desire for information to estimate the overall value, including the economic activity and social values, associated with small fisheries within the state (SDGFP 2014). Recognizing the lack of information on this topic, I initiated an economic activity study to better understand the share that small fisheries play in the overall economic activity related to the fishing industry in South Dakota. With hundreds of small lakes under state management, over time, many of these lakes will require costly renovation projects, such as: dam repair, dredging, maintenance and replacement of docks and boat ramps, creation of fishing access, and general fisheries population management. Angler use and economic information of the contributions of fishing and other water-related recreation at particular lakes of interest can help prioritize these expensive renovation projects.

In addition to economic activity, I speculate that social values may be as important as the economic contribution of fishing in effort towards understanding the overall value of these water resources to residents of local communities. Adding community mail surveys to the results of my previous economic study would contribute measurements of a wider range of benefits provided by lake resources. A more expansive evaluation of social values of lakes may justify spending additional funds on improvements which could result in significant long-term increases to the use of these lake resources and return-on-investments in the form of overall resource use and community satisfaction.

Collecting information from anglers is one of the most valuable tools for the effective management of freshwater fisheries. Traditionally, methods for including public input have relied primarily upon on-site, mail, and telephone surveys. Selection of the appropriate survey methods requires researchers to identify issues such as survey length, completion time, accuracy of expected answers, complexity of questions, equipment and facilities required to conduct the survey, personnel requirements, and availability of contact information from the identified sampling frame (Vaske 2008). Therefore, a third consideration of the study is an evaluation of survey methodologies using my fisheries case study. Often, managers utilize inappropriate survey methods for the collection of human data, such as angling pressure or social values, in which they unknowingly incorporate several detrimental forms of bias or measurements. Therefore, a fisheries case study can provide managers with an example of when to use specific survey methods and how to use them to collect the data that they desire from anglers and other stakeholders.

Objectives and Research Questions

The initial goal of this study was to assess the overall values associated with seven small, South Dakota fisheries. To accomplish this goal, I administered surveys designed to collect information pertaining to economic activity generated by anglers and social values held by residents of local communities. I also wanted to provide an academic evaluation of survey methodologies using my fisheries case study. In particular, my research questions were:

1. What is the estimated total economic activity generated by anglers who travel to fish 7 small fisheries across the state of South Dakota in 2016 (Chapter 2)?

A. What is the estimated angler-use, in the form of angler-days, at these 7 lakes during specific months and seasons, and utilizing various angling methods (i.e. shore, boat, or ice fishing)?
B. What is the total economic activity at these 7 lakes during specific months and seasons, and utilizing various angling methods (i.e. shore, boat, or ice fishing)?
C. What are the zones of influence (locations anglers traveled from to fish) associated with these 7 lakes?

2. What is the importance of small fishing lakes to the overall quality of life of residents living in nearby communities in South Dakota (Chapter 3)?
   A. What recreational activities and other uses do these lakes provide to residents of local communities?
   B. What attitudes and values do residents have towards the lakes that are near their communities?
   C. What are the uses, respondent characteristics, and attitudes towards these lakes that are best at predicting the importance of the lakes to local residents' overall quality of life living in their communities?

3. How does the quality of data compare when using on-site, mail, or internet surveys to ask questions about the 2016 fishing year in South Dakota (Chapter 4)?
   A. Are there significant differences in age and gender ratios, satisfaction of anglers' fishing experiences, and estimates of fishing pressure when making comparisons across applicable survey methods?
   B. Is it feasible to use internet surveys to collect specific angler metrics in South Dakota in 2016?
   C. What guidelines should managers follow, and what biases should they avoid, when selecting a survey methods that will provide them with the type of results they are seeking?

Importance of This Research

This research can be used to make cost-benefit decisions regarding projects designed to improve the fisheries at the selected small lakes and impoundments as well as other similar waters around the state. In addition, this information can be used to document the value of fishing opportunities of small waters in South Dakota. However, the economic impact of these selected lakes does not express their full value, especially for nearby communities. For example, the value of these waters for providing inexpensive family experiences and opportunities for young anglers to get involved with

fishing contribute greatly to future economies, but are not included in the economic activity study. A more expansive evaluation of the social value of these lakes may justify spending money on improvements which can have significant long-term benefits and returns on investments. Given the prevalence of managers utilizing inappropriate survey methods for the collection of human data, a thorough assessment of data reliability from several survey methodologies will be used to help managers decide the appropriate techniques to use based upon their desired data needs.

Limitations

The results of this study pertain to the state of South Dakota and may not be relevant to other geographically and socioeconomically diverse regions. For example, small reservoirs within areas that have a higher cost-of-living may provide much greater economic activity than what I have determined for the South Dakota lakes in my study. More urbanized areas, and areas with greater/lesser amounts of available lakes in which to recreate, may immensely affect the social value associated with nearby lakes. Also, the 7 small lakes in this study do not represent a complete range of diversity of characteristics/attributes of the 400+ small lakes in South Dakota. The solution to this limitation would be to conduct additional similar studies across of geographic and sociodemographic regions, in addition to estimating correction factors that could be applied to adjust for regional variations.

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CHAPTER 2: ECONOMIC ACTIVITY GENERATED BY ANGLING AT SMALL SOUTH DAKOTA LAKES

ABSTRACT

Many agencies overlook the values affiliated with relatively small fisheries throughout their jurisdictions. The economic activity associated with angling visits to seven small fisheries in South Dakota was estimated using IMPLAN software. The average economic activity associated with fishing at individual lakes in 2016 was \$35,369/lake, which was estimated to support an average of 0.48 jobs and create \$5,572 in tax revenues. I observed that lakes with higher ice fishing pressure also had the greatest associated economic activity, even though several of these had the lowest overall fishing pressure throughout the year. In addition to economic activity, zone of influence for each lake was estimated and compared with the proximity to urban centers. The inclusion of economic information from small fisheries may play an important role in influencing key strategic planning efforts by management agencies and in estimating overall economic importance of angling on broader scales.

INTRODUCTION

Given its non-market nature, angling as a form of recreation is often neglected in economic analyses (Hutt et al. 2013). However, angling trip expenditures such as fuel, food, and equipment can have large contributions to the overall economic activity associated with the outdoor recreation sector. Fishing expenditures can stimulate economies and provide sources for sustaining jobs and creating tax revenues (Schorr et al. 1995). In the United States, an estimated $48 billion are spent annually on equipment, licenses, trips, and other recreational fishing-related items or events, which creates an economic output of $115 billion within the nation's economy and almost $15 billion in federal and state tax revenues (Southwick Associates 2012).

Recreational anglers have large impacts on the economy in the state of South Dakota, as well. South Dakota anglers fished an average of 18 days over a 12-month period that started October 2015 and ended September 2016 (Southwick Associates 2017). This added up to 3.3 million angler days (AD) and over $271 million in direct expenditures, which generated $321 million in total economic activity within the state's economy. This activity was estimated to support 3,747 jobs and to generate over $54 million in federal and state tax revenues.

The South Dakota Game, Fish and Parks (SDGFP) has expressed the need for information to estimate the economic activity associated with small fisheries within the state (SDGFP 2014). With over 400 small lakes under state management, over time, many of these lakes will require costly renovations, such as: dam repair, dredging, maintenance and replacement of docks and boat ramps, creation of fishing access, and general fisheries population management. Angler usage and economic information of the

contributions of fishing and other water-related recreation at particular lakes of interest can help prioritize these expensive renovation projects.

While currently published information has been extremely useful in influencing management and policy decisions, the process in which data have been collected has not provided an accurate representation of the economic activity resulting from small fisheries within a region. For example, an economic activity analysis of fishing in South Dakota in 2016 chose to stratify their survey into 2 regions, the “Missouri River” and “Everywhere Else” (Southwick Associates 2017). However, the study methodology was not tailored toward measuring effort and economic impacts of smaller fisheries. The data collection methodology required licensed anglers to respond to mail and internet surveys administered after a 12-month period ending in September 2016. This methodology can have a relatively high potential for recall bias in the survey’s responses. Recall bias occurs because of a respondent's inaccurate recollection of their angling trip and can be caused by telescoping and recall decay (Chu et al. 1992; Connelly and Brown 1995; Malvestuto 1996). Although an assessment, such as Southwick Associates (2017), can provide valuable information on the economic activity generated by fisheries across South Dakota, a study would need to clearly identify, and analyze separately, fisheries of different sizes to provide information on the economic activity from small fisheries within the state.

Given the potential for confusion among the public, policy makers and wildlife specialists, it is imperative to make clear distinctions between the terms: economic value, economic impact, and economic activity. Economic value is defined as the maximum amount a consumer is willing to pay for a good or experience (Melstrom and Shideler

2017). The economic value of a fishing trip is therefore the most an angler is willing to pay to take the trip, or the trip cost where they would be nearly indifferent between taking the trip or not going fishing. The economic impact varies from value in that it is based on the amount of spending brought into a region associated with an activity, such as a fishing trip. This spending affects income levels, jobs, and tax revenues within a region. The third term is the economic activity that can be generated by an activity or industry. This is the dollars that are spent on an activity within a region, and the continued flow of these dollars throughout its economy (Watson et al. 2007). Activity differs from impact in that it incorporates expenditures from residents and non-residents of a region. Economic activity does not just estimate new money brought into an economy, but all dollars spent towards an industry or event. For this study, the economic activity of seven small, South Dakota fishing lakes was estimated by using the expenditures during angling trips to these individual lakes in 2016.

Generally, research conducting economic analyses of fisheries resources in a region rarely include detailed data on the often numerous small lakes and impoundments that anglers are utilizing. Recognizing the lack of information on this topic, I initiated this study to better understand the share that small fisheries have in the overall economic activity related to the fishing industry in South Dakota. In particular, I wanted to: (1) estimate angler use, (2) estimate the extent of the total economic activity (TEA) associated with small fisheries, and (3) provide economic and use information that may be important to managers in determining future management priorities.

METHODS

Sample sites

I evaluated seven small fishing lakes and reservoirs across South Dakota that were <60 hectares in surface area (Table 2.1). The lakes I selected for my research all match criteria defined by the SDGFP that a small lake is less than <150 acres (60 ha) in surface area (SDGFP 2014). Fisheries within my study included New Underwood Dam, Curlew Dam, Fate Dam, Brake Dam, Byre Dam, Scott Slough, and Lake Alvin Dam (from west to east, respectively; Figure 2.1). These lakes were 7-52 hectares (17-127 acres) in surface area, they were 2-15 miles (3-24 kilometers) from local, small communities (populations 219 – 9,498 residents), and there were 13-57 miles (20-92 kilometers) from urban centers (population >10,000). The purpose for choosing these lakes was to select lakes with variation in distances from urban centers in order to examine if there was a substantial increase or decrease in economic activity attributed to this disparity in distance anglers travel. Popular sportfish in these lakes include, but are not limited to: Walleye *Sander vitreus*, Yellow Perch *Perca flavescens*, Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox lucius*, and Black Crappie *Pomoxis nigromaculatus*.

Angler survey

I used a stratified access-point angler survey that was conducted during the calendar year of 2016 to collect information regarding angler demographics, economic activity, angling satisfaction, and catch (Appendix A). The survey was stratified by water body, month, day type (weekend/holiday and weekday), and time of day (randomized daylight hours; Malvestuto 1996). An access-based survey was selected because of the relatively small size of these waters, and to maximize response rates and completed trip interviews while minimizing recall bias (Malvestuto 1996). The South Dakota lakes in my study were selected in three geographic clusters (western, central and eastern), which

allowed all seven lakes to be surveyed by three creel clerks on any given day. During each angler survey, the surveyor asked one angler from a party to categorize and enumerate their current trip expenditures for that day to the best of their ability. Expenditure categories included money spent at: “restaurants/bars/taverns,” “grocery/convenience stores/liquor stores,” and on “fishing gear,” “bait,” and “lodging.” An “other” category was also included in the survey for expenditures not considered to be included in the aforementioned categories (i.e. tournament entry fees, equipment repairs, and/or taxidermy). Angling license purchases were not included in this analysis, unless they were resident or non-resident 1-day licenses purchased for the day of the interview, in which case they were considered to be an expense in the “other” category. The exclusion of license purchases from the economic analysis did not have a large effect on the overall outcome, because of the rarity that an angler had purchased his/her license exclusively for that particular angling trip. Anglers were asked for expenditure information regardless of whether they had completed their fishing trip. An angling trip was considered completed when an angling group had concluded fishing at the current lake, and was assumed to be finished fishing during the current day.

Survey participants were asked not to include their vehicle fuel expenditures in any expenditure category, because the amount of fuel used during their angling trip may not be well represented by the amount of fuel they had purchased that day. For example, an angling party may have purchased a full tank of fuel for their vehicle that day, while only having to travel 10 miles. Instead, the surveyors asked how far the distance in miles that the angling party had traveled that day to arrive at the site of the angling event (D). To estimate a party’s roundtrip fuel expenditure for traveling to their fishing destination

on the day of the interview (F), I made a series of assumptions about the vehicles that were driven by the angling parties, their vehicles' average highway miles-per-gallon (MPG), and the average price of "Midwest all grades conventional retail gasoline" at the time of the study (P; EIA 2017). I considered the MPG ratings of the 10 most popular trucks and sedans for the years 1995, 2005, and 2015, according to reviews (KBB 2017). These 3 years were selected for analysis in an effort to represent the age distribution of vehicles that anglers were driving during their visits to the study lakes. Mean MPG ratings for the vehicle type-year groups (i.e. trucks-2005, sedans-2015) were estimated, followed by estimates of the vehicle type means grouped across years. Using conjecture based on observation, a weighted overall average fuel efficiency (MPG_w) was created with a truck-sedan ratio of 70-30 percent. A group's roundtrip fuel expenditure for traveling to their fishing destination on the day of the interview was then estimated as:

$$\mathrm{F} = 2\mathrm{P}\left(\frac{\mathrm{D}}{\mathrm{MPG}_w}\right). \tag{1}$$

To extrapolate observed expenditure data into estimates of total expenditures at a lake for a given time period, I first had to extrapolate observed angler counts and trip durations into estimates of angling pressure using Creel Application Software (Soupir and Brown 2008). Instantaneous angler counts were conducted by the creel clerks for each lake during the standard creel survey periods at the time of arrival, and again 2 to 3 hours later prior to leaving the survey locations. Anglers and party sizes were counted and grouped into various types of fishing, such as: "open ice" or "shack" anglers during the ice fishing season, and "boat" or "shore" anglers during the open water season. Average trip durations were calculated from creel surveys with parties who had

completed their angling trips. This resulted in angling pressure in the form of angler-hours for each fishing type within each month. The sum of these estimates resulted in an estimated annual angling pressure at each of the seven study lakes. Angler-hours were translated to angler days for entry into the economic model software program Impact Analysis for Planning (IMPLAN; IMPLAN Group LLC 2016) by dividing the average angler-hours by the average trip duration.

Economic activity analysis

This study used input-output (I-O) models described by Leontief (1986) to estimate the TEA of angling at seven small fishing lakes in South Dakota. The South Dakota state data package for 2016 within the IMPLAN model software 4.3 was used to perform these analyses. This software was originally developed by the U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station in 1976 for considering the impacts of potential management plans. (Chen et al. 2003). The IMPLAN models are derived from annual datasets that are compiled from various secondary sources and industries that are categorized in 528 economic sectors, and are based on Standard Industrial Classification codes. IMPLAN models were generated using current data on the South Dakota economy at the time of the study (i.e. 2016). The TEA was determined for each of the seven small lakes by inputting monthly averages of daily expenditures (US$/angler/activity day) within each economic sector into the IMPLAN model program. Because of small sample sizes of interviews at the three central lakes (Fate, Brakke, and Byre), the average of each expenditure category across these lakes was used for each of these individual lakes' models. The four remaining lakes had large enough sample sizes to use their own individual lake data. The TEA of these lakes were

estimated from direct, indirect, and induced effects resulting from fishing at individual small lakes across South Dakota. Direct economic effects are the direct or actual revenues that are generated by the expenditures of anglers to local businesses, industries and services within the local economy, indirect effects include the transition of dollars from a primary business to a secondary business for services such as resupplying goods and maintenance of facilities and equipment, and induced effects are the impacts generated by household purchases made by employees of the primary and secondary businesses (Hutt et al. 2013). In this study, TEA is defined as the measure of monetary contributions of all angling to South Dakota's economy that are generated by anglers. my I-O models were used to calculate the influences of these fisheries on the output of goods and services and the generation of value-added, income, federal and state-local tax revenues, and employment contributions to the economies local to the lakes in the study (Bohnsack et al. 2002). Employment in this study is reported as a combined count of both full- and part-time jobs.

Some researchers exclude resident expenditures from their calculations of economic impacts towards the local economies under the assumption that if the lake in question was not available for use, resident expenditures would likely still circulate within the local economy through purchases of other goods and services, and would not provide inputs of new money (Crompton et al. 2001; Chen et al. 2003; Stoll and Ditton 2006). However, the purpose of this study was not to estimate the economic impact to the local economies from non-local sources, but rather to measure the economic activity generated by these small fisheries relative to other fisheries or recreational industries in South Dakota. Therefore, I did not need to separate expenditures from resident and non-

resident anglers in calculating economic activity for individual lakes (Stynes 1997; Warnick et al. 2012). Furthermore, only 2.8% of anglers in my study were non-residents of South Dakota, and over 95% of the anglers at 5 out of the 7 lakes in the study resided <50 miles from the lake where they were interviewed (Table 2.2).

Zone of Influence

To evaluate the relationships between spatial distributions of anglers using individual lakes and corresponding TEA, I created "zone of influence" maps. I wanted to determine the "zone of influence" that these small fisheries had within their region. For this study, the zone of influence was considered as a measure of frequencies of trips made by angler groups from specific zip codes towards a lake when using that lake for angling. During my survey, anglers provided the zip code of their primary residence, which was recorded into a database and was later used in ArcGIS Version 10.5 (ESRI 2016) to create a zone of influence map for each lake.

RESULTS

Survey, Demographics, and Angler Days

Within the 2016 calendar year, we conducted interviews on an average of 85 weekends & holidays and 125 weekdays at each of the seven lakes in my study. In all, 1,874 total interviews were conducted, with 770 of them occurring after completed fishing trips. This was an average of 265 total interviews at each lake (min=86, max=604), with an average of 112 considered as completed trip interviews (min=25, max=258). The average party size was 2.1 anglers, and consisted of 64% adult males, 14% adult females, 16% male children and 6% female children. Anglers who responded to the interview were 94% male and 6% female.

The average distance that anglers traveled from where they woke up that morning to the lake at which they were interviewed was 27 miles (one-direction; Table 2.3). On average, anglers traveled the shortest distance to fish at Lake Alvin (16 miles) and the longest distance to fish at Brakke Dam (50 miles). The average fishing trip duration for shore, boat, and ice anglers recorded after completed trip interviews was 2.8 hours (h) with a minimum average trip duration of 2.2 h at New Underwood Dam and a maximum of 3.4 h at Curlew Dam. This translated to an average of 3,101 AD at each lake and a total of 21,710 AD across all seven lakes in 2016 (Figure 2.2). Byre Dam received the least amount of angling pressure with 1,200 AD, while Scott Slough received the most pressure with 6,527 AD. Overall, participation in shore angling received the highest proportion of AD (54%) compared to boat and ice angling (29% and 17%, respectively). Fate, Brakke, and Byre dams received the highest annual proportions of ice angling at >55% of all angling activity at these lakes, while New Underwood and Curlew dams and Lake Alvin received the highest proportion of shore angling at >65% of all angling activity. At Scott Slough, the proportions of shore anglers and ice anglers were relatively similar (47% and 42%, respectively).

Angler Expenditure and Input-Output Models

The overall average total trip expenditures for angling groups fishing at the small lakes in this study in 2016 were $29.28 (Table 2.4). The average total trip expenditures for all modes combined (shore, boat, and ice) for angling groups fishing at New Underwood Dam was the lowest at $14.14, while groups angling at Brakke Dam had the highest average expenditures at $86.60. For shore angling groups, the average total trip expenditures were highest at Brakke Dam ($31.78) and lowest at Scott Slough ($11.68),

while the average total trip expenditures for boat angling groups were also the highest at Brakke Dam ($107.58) but the lowest at New Underwood Dam ($6.41). For ice angling groups, the average total trip expenditures were highest at Byre Dam ($102.53) and lowest at Lake Alvin ($12.28). During the open water angling months (Mar-Nov), the average total trip expenditures for groups were $19.85, while they were much higher for groups during the ice fishing months (Jan, Feb, and Dec) at $48.21.

The average total economic activity generated by anglers fishing at individual small lakes in this study in 2016 was $35,369/lake, which was estimated to support an average of 0.48 jobs and to create an additional $5,572 in federal and state/local tax revenues (Table 2.5; Figure 2.2). The average social accounting matrix (SAM) multiplier, the total economic impact divided by the direct economic effects, was 1.70, which means that for every dollar spent in South Dakota by anglers fishing a lake in this study there was an economic return of $1.70. The lake with the lowest TEA generated in 2016 was New Underwood Dam providing just $16,890, with an overall SAM multiplier of 1.73, and 0.24 jobs to South Dakota’s economy. New Underwood Dam created an additional federal and state/local combined tax revenue of $2,765. Brakke Dam provided the highest TEA at $55,758 and 0.76 jobs with an overall SAM multiplier of 1.72. Brakke Dam created an additional federal and state/local combined tax revenue of $8,429.

While considering various strategies to achieve goals of angler participation and satisfaction, fisheries managers may consider converting angler participation and TEA measurements to include a spatial factor. By dividing AD by the surface area (ha) of the lake, I was able to compare consistent units across various lakes. Although Scott Slough provided the greatest amount of overall angling pressure relative to the other lakes in my

study (6,527 AD), when pressure was converted to include a spatial unit, I found that New Underwood Dam actually had the greatest economic activity in AD/ha (404 AD/ha; Table 2.6). Similarly, Brakke Dam had the greatest TEA in my study ($55,758), however, when a spatial conversion was implemented, New Underwood Dam went from having the least TEA ($16,890) to providing the greatest TEA/ha ($2,528/ha).

Zone of Influence

Of the anglers who fished the two western lakes in this study, 62% of them were residents of the nearest urban center (Rapid City; Table 2.1). The zone of influence of these two lakes was relatively small, with most anglers residing within 60 miles of the lakes where they were interviewed (Figures 2.3-2.5). A few angling parties of these western lakes were residents of eastern South Dakota and northwestern Wyoming. Contrary to the western lakes, only 11% of anglers who fished at the three central lakes were residents of the nearest urban center (Pierre). The zone of influence of these central lakes were relatively large, with several angling parties from across South Dakota having residencies >150 miles from the lakes where they were interviewed. Around 64% of the anglers who fished at the two eastern lakes in this study were residents of the nearest urban center (Sioux Falls), which provided a relatively small zone of influence. Most anglers of these eastern lakes resided within 30 miles of the lakes where they were interviewed, while a few angling parties were residents of southwestern Minnesota and northwestern Iowa.

DISCUSSION

The consideration of economic activity by season and fishing type can be used by local management agencies to direct their efforts towards distinct angler types during

specific times of the year. Generally, the months of January, February and December in South Dakota are considered to be ice fishing season, while the rest of the year is open water season (i.e. boat and shore angling). According to historical climate data (Fang and Stefan 1998), the number of simulated annual cumulative days of ice cover on small, medium-depth South Dakota lakes from 1962–1979 was between 105 and 135 days (dependent on latitude), and ice coverage had approximately taken place at the Julian days of 337 (Dec. 3) until 85 (Mar. 26) of the subsequent year. Several of these days, in which small lakes were covered by ice, provided ice thicknesses too thin for safe recreation. Using my winter creel data, I determined that the ice coverage during my study was similar to the conditions in the 1960's and 1970's (Fang and Stefan 1998).

Isermann et al. (2005) reported variation in proportions of fishing pressure between open water fishing and ice fishing seasons in South Dakota. Two of the 6 lakes in their study were found to have much greater monthly fishing pressure during ice fishing season than during open water season. Coincidentally, these two lakes were smaller in surface area relative to 3 of the other lakes they had included, which could provide additional evidence of the overall value that small sized lakes can contribute as winter fisheries. Although ice fishing season typically represents only a quarter of the year across most of South Dakota, I found that 57% of the TEA from the lakes I studied was generated by ice anglers. Upon comparison of TEA generated during the ice fishing season at individual lakes, I observed that the four lakes with the highest proportions of ice fishing pressure, as opposed to shore and boat angling, also had the highest TEA, even when considering that three of these lakes had the lowest overall fishing pressure throughout the year. I speculate that these findings are partially a result of my creel clerks

capturing interviews during several annual ice fishing tournaments, in which entry fees may range from $60-$175 per angling group. Rather than omit these data as outliers, I concluded that tournament fees should be included in my analysis, as these tournaments are annual traditions generating economic activity year after year. Also, the relatively high trip expenditures for ice fishing compared to open water fishing can be attributable to ice fishing groups averaging longer trips compared to shore anglers, who comprised most of the open water fishing category, and thus, purchasing more items (e.g., bait, food, and drink) per trip. Another possible reason for the increase in economic activity during the ice fishing months may be related to the unsafe fishing conditions at the popular, nearby fisheries of the Missouri River reservoirs. I speculate that anglers who would typically choose to fish on the Missouri River are deciding to travel to Fate, Brakke, and Byre dams during the winter months to find ice conditions strong enough for safe fishing opportunities, as the Missouri River rarely provides thick enough ice within much of this region. Finding safe ice conditions on the Missouri River reservoirs can be spatially sporadic and temporally volatile with inconsistent weather patterns within the region and variable water flow regimes. Thus, ice fishing tends to draw anglers from further distances in comparison to open water fishing for some small lakes.

Special management strategies can also influence the economic activity that a fishery may provide, which may have occurred in this investigation. A classic example of this is from Loomis (2006), whereby hypothetically increasing angler catch by 100% at the Snake River in Idaho and Wyoming, angler use was estimated to increase by 65%. This increase in angler use would result in a corresponding increase in annual economic activity and employment opportunity. From 2013-2016, Scott Slough received

supplemental stockings of 44-130 adult size Yellow Perch per hectare, annually, with the largest stocking year occurring in 2015 (SDGFP 2017). These adult Yellow Perch were not raised in a hatchery, but rather trapped from a nearby lake and transferred to Scott Slough by the SDGFP at a cost of $0.25/fish (T. St. Sauver, SDGFP, personal communication). General observation of the concurrent creel survey revealed that Yellow Perch were the dominant species caught and harvested by anglers at Scott Slough throughout 2016. Given the popularity of perch fishing at Scott Slough post-stocking, a comparison of the TEA at Scott Slough (~$44,000/year) relative to the small lakes that did not receive such supplemental stockings in my study (~$34,000/year) makes it reasonable to believe that the economic benefits of a trap-and-transfer management practice may outweigh the associated costs by 6-fold, and that the overall TEA could increase by 25% with the additional catchable-sized fish. Hypothetically, if 130 adult-size Yellow Perch at $0.25/fish are stocked per hectare in a given year, and Scott Slough is 47 hectares, this stocking would cost approximately $1,500. I found the TEA at Scott Slough to be ~$10,000 more than the average TEA of the small lakes that did not receive such supplemental stockings in my study after a similar stocking. Therefore, the cost of this supplemental stocking was about one-sixth of the additional economic activity that Scott Slough had received that could be attributed to such stocking events.

Many fisheries agencies manage for fishing opportunities across a diversity of spatial scales and distances from urban populations. Theoretically, it would be advantageous for management agencies to prioritize angling improvement projects at fisheries that will generate the greatest return-on-investment in the form of economic, environmental, and social benefits, as well as overall recreational use. Contrary to

expectation, my findings suggest that many anglers in South Dakota seemed willing to increase their trip expenditures by traveling further distances to fish at lakes that were relatively more rural in location compared to other lakes in this study. Although some variation in economic activity is likely attributed to the popularity of ice fishing at these lakes, it is intriguing to note that the lakes that generally experienced the lowest angling pressure throughout 2016 also resulted in providing the highest TEA.

CONCLUSION

While many researchers select relatively larger, more impactful fisheries resources for economic analyses, I chose to estimate the economic activity of the numerous small fisheries in South Dakota. With few nearby opportunities for anglers to fish at larger lakes and reservoirs, the importance of quality fishing opportunities at nearby small fisheries is sizeable, especially during the ice fishing season. Further, the economic importance of the fishing industry becomes even more considerable with the inclusion of over 400 small lakes in South Dakota. My study provides evidence of the importance of community events, such as fishing tournaments, in increasing the TEA of a small fishery and that these small fishing lakes are important assets to local communities. This suggests that there are opportunities for fisheries management agencies to form partnerships with local communities to raise funds for lake improvements and to sponsor fishing events. My study also indicated that special management strategies, such as the stocking of a catchable-size popular sportfish, can generate excitement around a fishery that may increase its use and economic activity. Future research may include a greater diversity of small fisheries to gain a more accurate understanding of the economic activity that they generate. Further, the social value of these lakes may be imperative in

understanding the overall value that they have to their local communities. With more information on the overall value of small fishing lakes in South Dakota, managers and lawmakers may be able to make more informed decisions on regulations, events, and fisheries improvements that will have a positive contribution to the state's fishing industry.

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Table 2.1. Surface area, distance to closest urban center (UC), and percent of anglers from UC for seven small fishing lakes in South Dakota.

Lake	Surface area		Distance to UC (mi)	Nearby UC	% anglers from UC
	Acres	Hectares			
New Underwood	17	7	23	Rapid City	61
Curlew	127	52	35	Rapid City	63
Fate	122	49	57	Pierre	7
Brakke	118	48	56	Pierre	16
Byre	117	47	57	Pierre	10
Scott	117	47	21	Sioux Falls	58
Alvin	104	42	13	Sioux Falls	69

Table 2.2. Percentage of South Dakota (SD) resident and non-resident anglers that were interviewed at seven small, South Dakota lakes in 2016. The number of total interviews in 2016 is included with completed trip interviews in parentheses.

	SD Residents (%)			
Lake	<50 miles	>50 miles	Non-Residents (%)	Interviews
New Underwood	97	1	2	236 (95)
Curlew	96	3	1	360 (137)
Fate	96	39	5	103 (47)
Brakke	67	29	4	140 (59)
Byre	76	22	2	86 (25)
Scott	96	2	2	604 (258)
Alvin	96	1	4	329 (163)
Average	89	14	3	*265 (112)*

Table 2.3. Survey and fishing trip characteristics of anglers fishing seven small, South Dakota lakes in 2016. Average distance traveled in miles (±95% confidence intervals), average trip duration is in decimal-hours, angling pressure (angler days; ±95% confidence intervals), and the proportion of angler days from boat, shore, or ice fishing.

		Average trip duration					Proportion of angler days (%)		
Lake	Distance traveled	Annual	Boat	Shore	Ice	Angler days	Boat	Shore	Ice
New Underwood	25.4 (±4.4)	2.2	2.5	2.0	2.5	2,696 (±476)	14	75	12
Curlew	32.1 (±2.2)	3.4	3.6	2.4	4.2	3,860 (±612)	19	73	8
Fate	43.4 (±8.9)	3.2	4.8	1.9	2.4	1,392 (±359)	5	28	67
Brakke	50.1 (±11.3)	3.1	4.0	1.5	3.1	1,851 (±611)	22	21	57
Byre	35.5 (±14.9)	2.6	2.7	2.5	2.7	1,200 (±751)	15	15	69
Scott	19.5 (±1.3)	2.5	2.5	2.1	3.2	6,527 (±1,168)	11	47	42
Alvin	15.9 (±2.9)	2.4	2.7	2.2	3.5	4,184 (±744)	26	66	8
Average	*26.5 (±1.6)*	*2.8*	*3.3*	*2.1*	*3.1*	*3,101* (±4.4)	*17*	*54*	*29*

Table 2.4. Average trip expenditures incurred for goods and services by anglers traveling to fish seven small, South Dakota lakes in 2016. All expenditures were estimated in 2016 US$.

	Average trip expenditures ($)			
Lake	Shore	Boat	Ice	*Lake average*
New Underwood	12.10	6.41	26.63	*14.14 (±2.49)*
Curlew	18.01	13.22	55.77	*22.83 (±6.59)*
Fate	23.75	101.57	76.94	*73.61 (±24.83)*
Brakke	31.78	107.58	102.51	*86.60 (±39.10)*
Byre	20.44	53.42	102.53	*65.22 (±20.18)*
Scott	11.68	18.59	28.57	*19.93 (±4.83)*
Alvin	15.65	19.57	12.28	*15.15 (±2.60)*
Method average	*15.41 (±1.65)*	*41.60 (±10.63)*	*48.21 (±9.63)*	*29.28 (±4.11)*

Table 2.5. Economic effects (direct, indirect, induced, and total), multipliers, federal and state/local taxes, and employment supported by anglers traveling to fish seven small, South Dakota lakes in 2016. All economic effects were estimated in 2016 US$ rounded to the nearest dollar; multiplier is a Type SAM multiplier; employment is a combined count of both full- and part-time jobs.

	Economic Effects ($)					Tax Revenues ($)			
Lake	Direct	Indirect	Induced	Total	Multiplier	Federal	State/Local	Total	Employment
New Underwood	9,789	3,037	4,063	16,890	1.73	1,496	1,269	2,765	0.24
Curlew	17,660	5,505	7,259	30,424	1.72	2,683	2,263	4,946	0.41
Fate	24,174	7,152	10,329	41,654	1.73	3,639	2,690	6,329	0.57
Brakke	32,417	9,641	13,699	55,758	1.72	4,846	3,583	8,429	0.76
Byre	21,040	6,227	9,030	36,297	1.72	3,182	2,351	5,533	0.50
Scott	28,532	11,702	3,622	43,855	1.54	3,900	3,367	7,267	0.60
Alvin	13,245	4,197	5,264	22,706	1.71	1,996	1,738	3,734	0.31
Average	*20,979*	*6,780*	*7,609*	*35,369*	*1.70*	*3,106*	*2,466*	*5,572*	*0.48*

Table 2.6. Surface area (ha), angling pressure/hectare (AD/ha) and total economic activity/hectare (TEA/ha) for seven small, South Dakota lakes in 2016. TEA is estimated in 2016 US$ rounded to the nearest dollar.

Lake	Area	AD	AD/ha	TEA	TEA/ha
New Underwood	7	2,696	404	16,890	2,528
Curlew	52	3,860	75	30,424	591
Fate	49	1,200	24	36,297	738
Brakke	48	1,851	39	55,758	1,169
Byre	47	1,392	29	41,654	881
Scott	47	6,527	138	43,855	927
Alvin	42	4,184	99	22,706	538

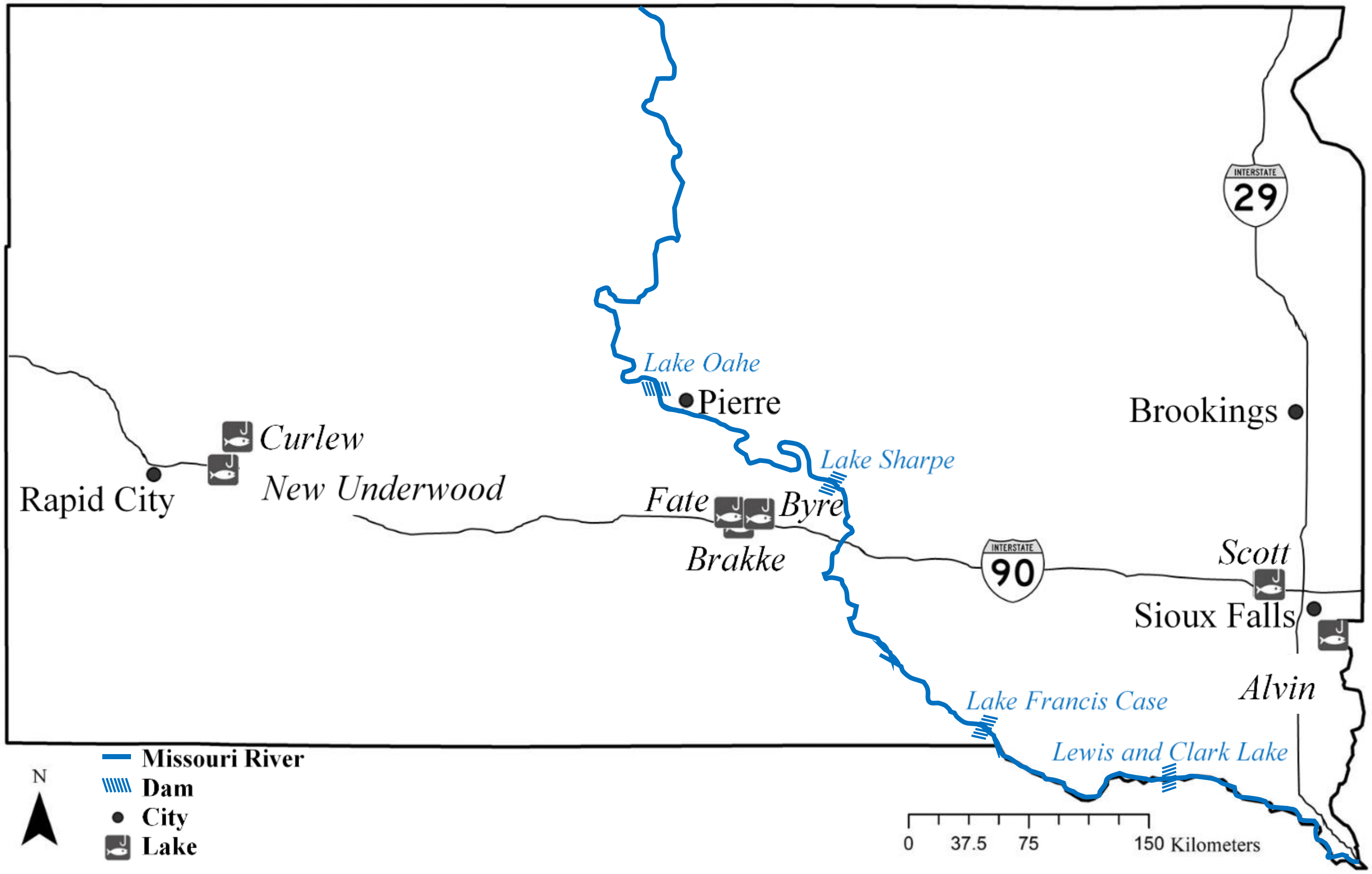

Figure 2.1. Map of the state of South Dakota, United States showing relevant urban centers, the Missouri River reservoirs and the seven small fishing lakes that were surveyed during 2016.

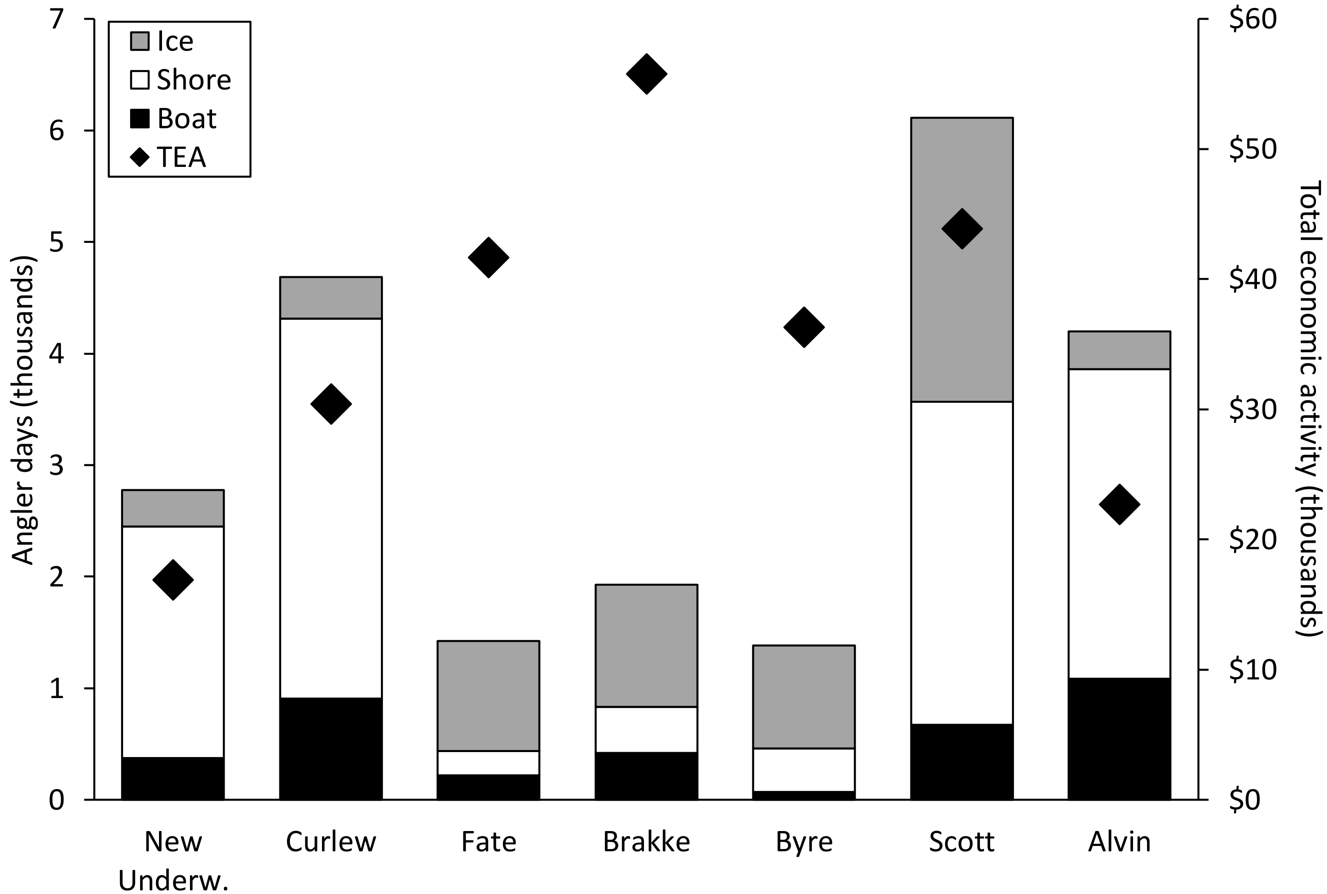

Figure 2.2. Angling pressure in angling days at seven small, South Dakota lakes in 2016 on the primary axis with proportions of angling types represented by gray, white, and black shades. The corresponding total economic activity (TEA) on the secondary axis is represented by diamonds.

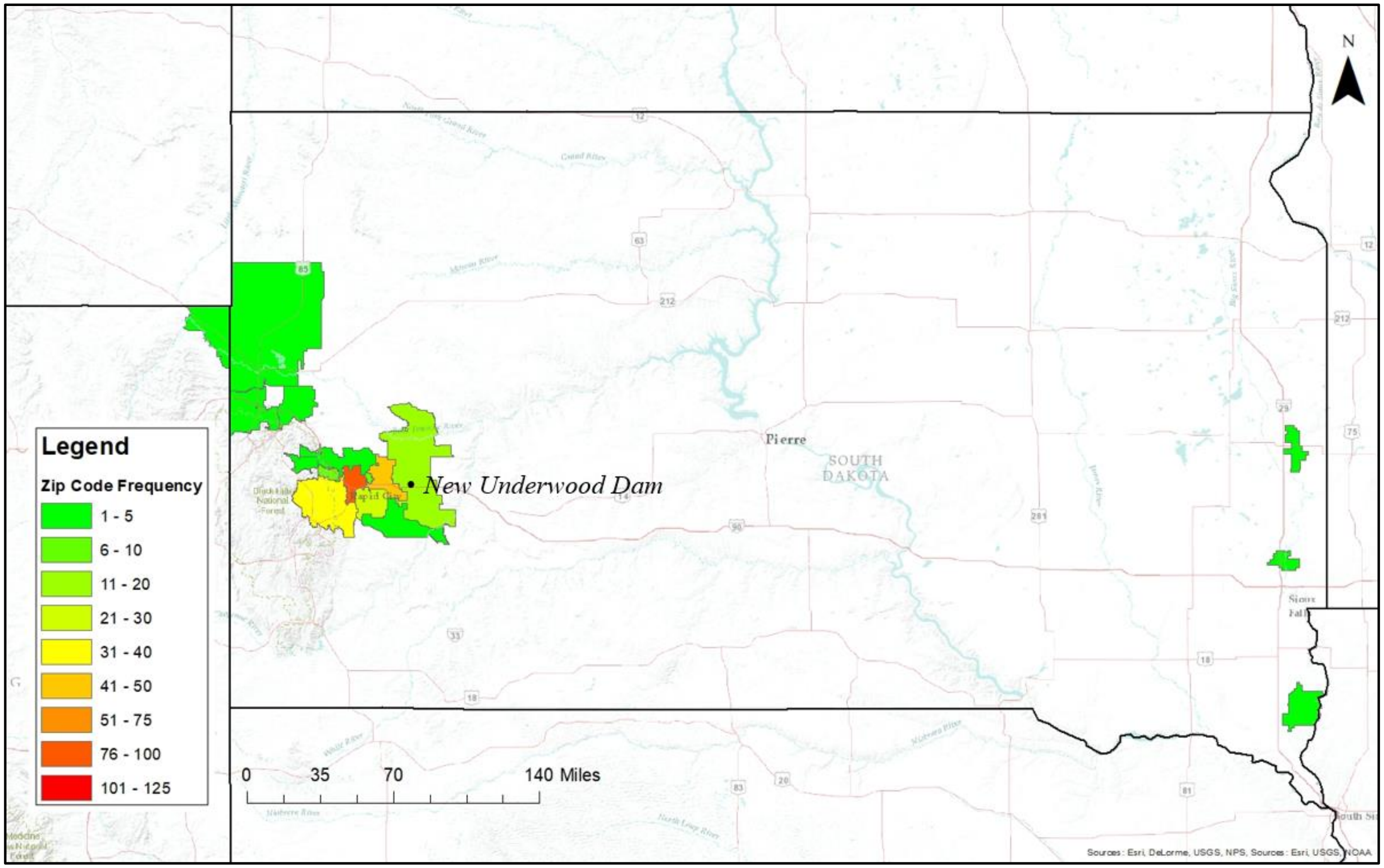

Figure 2.3. South Dakota map showing the angling zone of influence of New Underwood Dam in 2016. Polygons represent zip codes that angler groups traveled from to fish at New Underwood Dam. Green shades represent lesser numbers of angling groups from specific zip codes, while red shades represent greater numbers of angling groups.

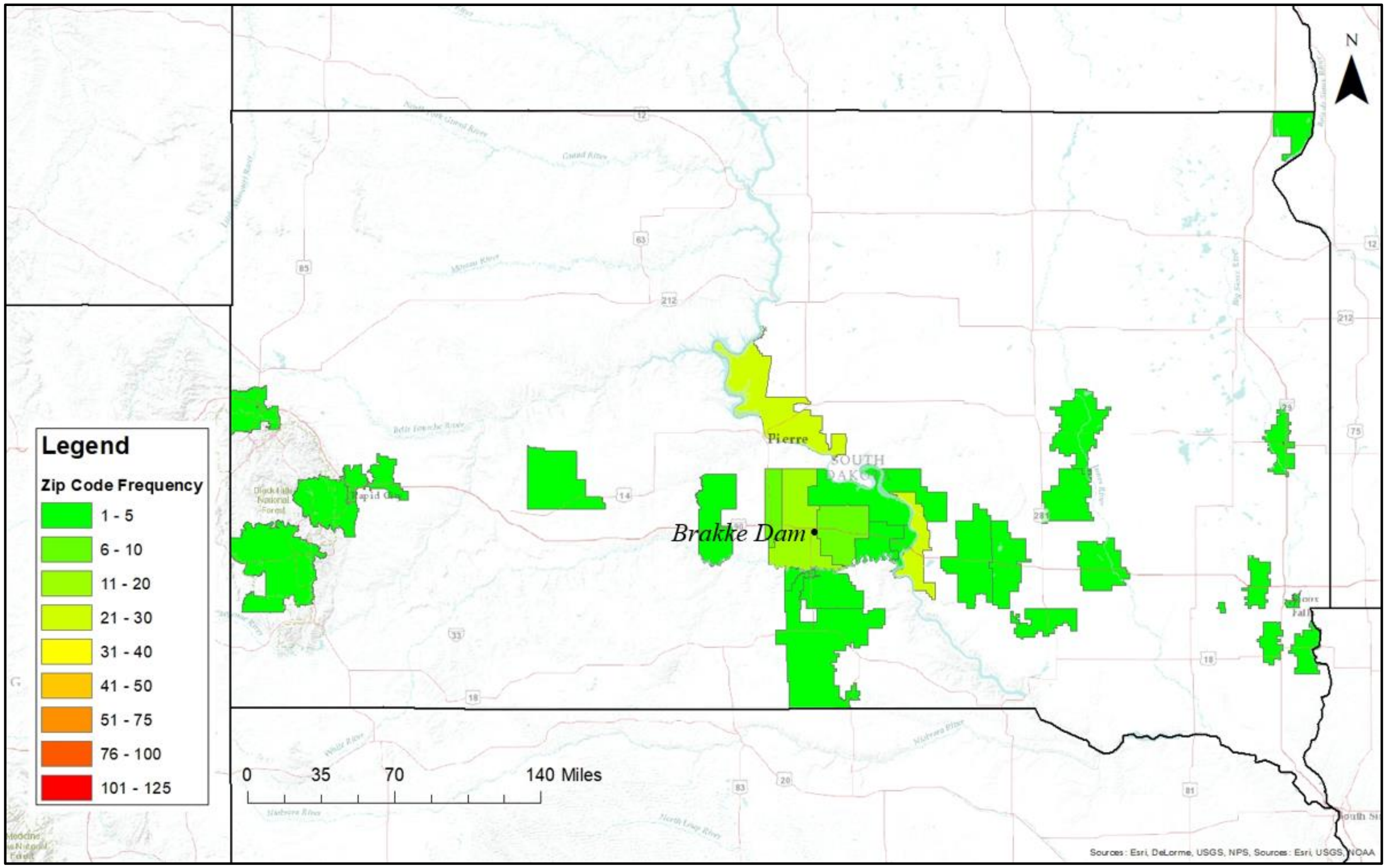

Figure 2.4. South Dakota map showing the angling zone of influence of Brakke Dam in 2016. Polygons represent zip codes that angler groups traveled from to fish at Brakke Dam. Green shades represent lesser numbers of angling groups from specific zip codes, while red shades represent greater numbers of angling groups.

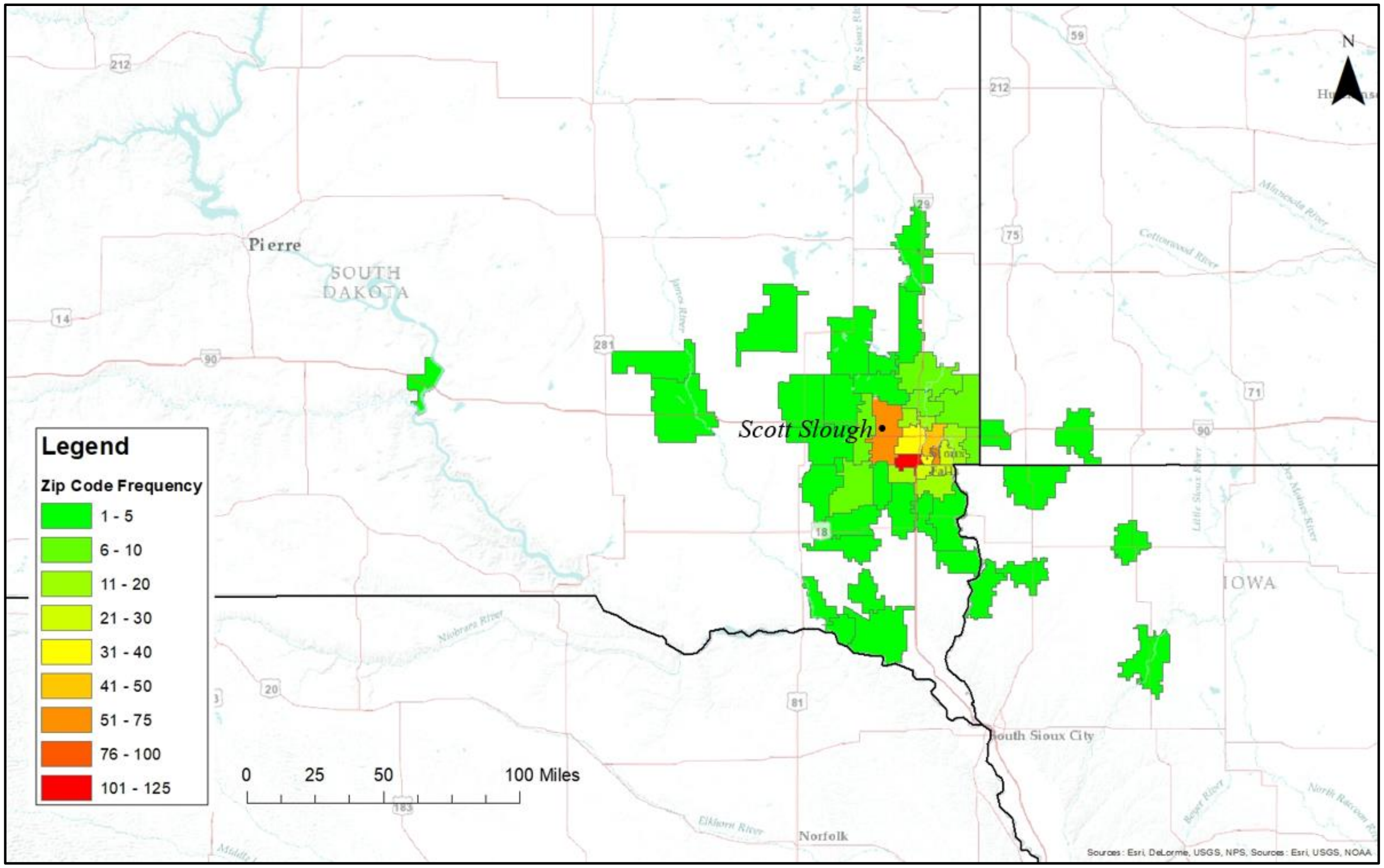

Figure 2.5. Southeastern South Dakota map showing the angling zone of influence of Scott Slough in 2016. Polygons represent zip codes that angler groups traveled from to fish at Scott Slough. Green shades represent lesser numbers of angling groups from specific zip codes, while red shades represent greater numbers of angling groups.

CHAPTER 3: FACTORS SHAPING THE SOCIAL VALUE OF SMALL LAKES TO LOCAL COMMUNITIES IN SOUTH DAKOTA

ABSTRACT

Sportfish management focuses on fish resources, as well as the people using these resources. Therefore, evaluating management performance requires assessing both environmental and human-centered outcomes of a fishery. Over 400 small lakes in South Dakota are managed by the state agency to provide convenient opportunities for anglers and other recreational user groups. In January of 2017, a total of 3,753 questionnaires were mailed to residents near 7 small lakes that were diverse spatially and in their proximities to larger urban centers across South Dakota. I received completed surveys from 1,318 respondents (40% response rate). I measured the values associated with a local lake that affect residents' quality of life (dependent variable), familiarity with the lake, activities participated in at the lake, evaluations of conditions and amenities at the lakes, and demographic variables. Analyses identified the social value of lakes relative to proximity to populations and the relationship between lake uses, lake evaluations, and demographics with the social value of the lakes. Multiple linear regression analysis identified that the most important predictors to lakes' importance to local residents' quality of life were: "lake is an important community resource," "lake is a place I enjoy visiting," "the number of different activities participated in at lake," and "the lake is important to local businesses." These 4 predictors were positively related to the contribution of lakes to residents' quality of life. My findings suggest that local fisheries generate many social benefits to local communities beyond the economic contribution from fishing.

INTRODUCTION

Managing for more expansive sets of values and opportunities that recreational resources can provide has become essential in today's society with a growing number of diverse stakeholder groups. Managers of public trust resources (i.e. government officials, private charities, community organizers) are increasingly expected to show the wider benefits of their sites in terms of society and community development in the form of environmental services (ES; Stolton et al. 2015). Small lake resources can provide society with a variety of ES which may have measurable economic and non-market values that have yet to be included in policy and management plans. Attempting to place a monetary value on these ES would likely underestimate the overall value of individual small lake resources because (a) many ES cannot be bought and sold in existing markets (e.g., bequest and existence values), and (b) many are not easily quantified in dollars (e.g., moral and spiritual opportunities; Steinman et al. 2017). Therefore, the overall value of these individual small lakes is the sum of their economic value in addition to the sum of all ES that have not been converted to currency. Today's resource managers are tasked with determining how to quantify, combine, and compare these diverse values associated with their recreational resources, and then consider how these values could change subsequent to alterations in management objectives.

Lake resources provide a multitude of outdoor recreational opportunities for residents and visitors of a local region, which can include: angling, hunting, swimming, boating, kayaking, picnicking, wildlife viewing, etc. They can provide a backdrop for ceremonies or an open space for flying kites. The most common methods for estimating the values associated with lakes as recreational resources are the travel cost method

(Fleming and Cook 2008; Cordell and Bergstrom 1993), the contingent valuation method (Cummings et al. 1986; Mitchell and Carson 1989), and the hedonic pricing method (Lansford and Jones 1995; Taylor 2003). However, the process of placing an economic value on nonmarket goods and services remains problematic (Wilson and Carpenter 1999). These methods attempt to place monetary values on non-market benefits provided by decisions to use natural resources, such as lakes, for recreational purposes. However, they generally fail to consider the complete set of values of all ES that lakes can provide (Lynch et al. 2016), which can include passive use values such as existence values for current residents, or bequest values for future residents (Flores 2003). When measuring the value of an outdoor recreation site such as a lake, the value of the site must be separated from the value of the whole recreational experience.

Examples of non-market outdoor recreation values are copious throughout the literature (Pope et al. 1984; Johnson and Linder 1986; Oster et al. 1987; Cooper and Loomis 1991; van Vuuren and Roy 1993; Boyer and Polasky 2004; McKean et al. 2005; Stoll et al. 2006; Bowker et al. 2007; Knoche and Lupi 2007; Lee et al. 2009). Johnson and Linder (1986) estimated the direct economic benefits of South Dakota wetlands as a recreation resource for resident hunters and realized that wetland related hunting expenditures contributed substantially to the recreation economy of South Dakota. Using a willingness-to-sell technique, they estimated the value for public wetlands was $53,872,263 (dollars in 1983) which converts to a price of $4,047 per hectare for the privilege to hunt on public wetlands during the 1983 season. While the purpose of their study was to estimate the direct economic benefits wetlands provided to hunters, they alluded to the fact that hunting by resident sportsmen represents only one of the

recreational uses of South Dakota wetland resources. Alternative uses which yield direct and measurable economic benefits include hunting by non-residents, trapping, fishing, canoeing, photography, hiking, nature study, cross country skiing, camping, and picnicking. To the extent that these uses are non-competitive, the consumers' surplus each generated is additive, thus increasing the value of wetlands. Oster et al. (1987) estimated the total annual net benefit provided by all recreational activities at Flaming Gorge at $3,443,024 with a present value of the annual net benefit from recreation estimated at $84,388,518 based on a 4% discount rate and a 100 year time horizon. Given that they only surveyed people who were recreating at Flaming Gorge Reservoir, their estimated value does not consider measures of passive use values such as existence values for non-recreating residents.

Freshwater fisheries provide a wide array of ES that are important to individuals, society, and the environment, which include: food security, economic security, empowerment, cultural services, recreational services, human health and well-being, knowledge transfer and capacity building, ecosystem function and biodiversity, aquatic “canaries,” and “green” food opportunities (Lynch et al. 2016). Examples of the economic benefits stemming from freshwater fisheries can be observed in the commercial and recreational fishing segments (Anderson et al. 1986; Wedekind et al. 2001; Chen et al. 2003; Welcomme et al. 2010; Hutt et al. 2013; Cooke and Murchie 2015; NMFS 2018; Sundmark and Gigliotti 2019). Sundmark and Gigliotti (2019) provide evidence of the economic benefits that can be generated by recreational angling at seven small (<60 ha) South Dakota fisheries, and concluded that the total economic activity they contribute can range from $17,000 to $56,000 ($\bar{x}$ = $35,000) to the local region, annually. Not only

do freshwater lakes provide economic benefits through direct fishing activities, they also generate substantial income and job opportunities through secondary service activities, such as gear provision and maintenance, food service industry, tourism, and other essential services for commercial or recreational fishing trips (Welcomme et al. 2010).

While economic value seems to be the most popular method for determining how important a resource is to a region, perhaps the value of inland fisheries transcends economic statistics. Inland fisheries can also serve a crucial non-monetary role by contributing to the overall well-being of individuals by providing opportunities for forming connections between humans and nature. It has been demonstrated that recreational angling can provide psycho-social benefits that include relaxation, stress relief, and reduction in negative emotions (Floyd et al. 2006). Fishing opportunities can also reduce substance abuse amongst youth and help them to form a greater connection with the natural environment, especially in rural settings (Louv 2008).

For lake managers to provide opportunities that fulfill all the needs of local community members, they must be informed of the variety of values lakes provide and incorporate them into management plans. Providing recreational fishing opportunities and maintaining acceptable water quality are objectives that are certainly beneficial. However, lake managers must deal with a variety of values besides recreational opportunity and environmental security (Klessig 2001). Many small-scale fisheries provide opportunities that positively benefit communities and are linked to their community identities (Weeratunge et al. 2014). In rural regions, local fisheries can contribute to a sense of community and local culture, as well as providing nearby recreational opportunities for residents (Smith et al. 2003; Weeratunge et al. 2014). In

urban areas, development decisions often fail to consider the values of environmental amenities, such as lakes, parks, trails, streams, and prairies resulting in negative environmental, economic, and social consequences to communities (Sander and Polasky 2009; Artell 2011). Often, water resources provide settings for community festivals and other religious, educational, and cultural events that residents participate in. They can also provide economic opportunities to local communities in the form of the harvest of natural resources, ecotourism, or agricultural irrigation (Klessig 2001). Given the wide range of ES that lakes can provide, their overall value to communities should not be surprising.

Cases in which agency-community collaboration have provided unique and positive outcomes for water resources are abundant within the literature (Pinkerton and Weinstein 1995; Kenney 1997; Amarasinghe and De Silva 1999; Imperial and Kauneckis 2003; Schusler et al. 2003; Kearney et al. 2007; Vedwan et al. 2008; LWRC 2015). Imperial and Kauneckis (2003) examined the evolution of watershed governance in the Lake Tahoe Basin, in which the early years of watershed management were characterized by a high degree of conflict. However, during the 1990's there was a shift from conflict oriented interactions among agencies and civil society groups in the basin toward increasingly cooperative approaches to addressing basin problems. This deviation in management approach clearly indicated the important role that collaboration plays in improving watershed governance by allowing organizations to implement projects that otherwise would have been challenging (i.e. habitat restoration projects), improving the efficiency of permit processes and enforcement efforts, and implementing environmental improvement actions. Vedwan et al. (2008) describes how the management of Lake

Okeechobee in Florida began as a “Command and Control” style of management but has given way to a systems approach. This approach incorporates system-wide planning which highlights the usefulness of a transparent, inclusive, and participatory decision-making process by the agencies and communities involved.

Stein and Anderson (2002) describe an example of agency-community planning in the Leech Lake watershed of Minnesota. In an attempt to develop a better understanding of rural residents’ landscape values within an ecosystem and benefits-management context, managers conducted three focus group meetings to identify valued ecological features in the Leech Lake watershed, benefits they attain from the watershed, and changes they would like to see to the planning and management of the region. Managers followed this up by sampling stakeholders to measure their attitudes and values for the role of nature in their community, valued ecological features, potential landscape benefits, and potential planning and management changes and found that stakeholders value the natural ecosystem and experiential benefits associated with nature, but they also indicate values directly tied to their community. Overall, Stein and Anderson (2002) found that increased collaboration with locals appears to be the most supported strategy to achieve difficult landscape management goals.

In the United States, small lakes and reservoirs that require costly renovations to access points and facilities are abundant either currently, or within the near future. In South Dakota, over 400 small lakes are managed by the South Dakota Department of Game, Fish and Parks (SDGFP) for angling and other forms of outdoor recreational opportunities. Based on the results of a concurrent economic study using the same lakes (Sundmark and Gigliotti 2019), I speculate that social values may be as important as the

economic contribution of fishing in effort towards understanding the overall value of these water resources to residents of local communities. Adding community mail surveys to the results of my previous economic study (chapter 1) would contribute measurements of a wider range of benefits provided by lake resources. A more expansive evaluation of social values of lakes may justify spending additional funds on improvements which could result in significant long-term increases to the use of these lake resources and return-on-investments in the form of overall resource use and community satisfaction. My goal of this study was to determine the importance of small fishing lakes to the overall quality of life of residents living in nearby communities in South Dakota. My objectives were to (1) measure the recreational activities and other uses provided to residents by lakes near their local communities, (2) measure the attitudes and values of residents towards the lakes that are near their communities, and (3) determine the uses, respondent characteristics, and attitudes towards these lakes that are best at predicting the importance of the lakes to local residents' overall quality of life living in their communities.

METHODS

I evaluated the opinions of local residents towards seven small, recreational lakes across South Dakota that included New Underwood Dam, Curlew Dam, Fate Dam, Brake Dam, Byre Dam, Scott Slough, and Lake Alvin Dam (from west to east, respectively; Figure 3.1). These lakes are 7-52 hectares (17-127 acres; Table 3.1) in size, and match the criterion defined by the SDGFP that a small lake is less than <150 acres (60 ha) in surface area (SDGFP 2014). Popular recreational activities at these lakes include: fishing, boating, picnicking, swimming, taking a dog for a swim, hunting, gathering with family

or friends, etc. Lakes were 2-15 miles (3-24 kilometers) from local, small communities and 13-57 miles (20-92 kilometers) from urban centers (population >10,000). Communities that were within the zip codes included in the survey were generally small and rural with zip code population sizes ranging from 419 to 6,217 residents.

In January of 2017, questionnaires were mailed to 3,753 random residents of zip codes of the communities nearest to the seven small, South Dakota lakes within my study. I used four separate, but nearly identical, questionnaires based on the communities nearest to the seven lakes (hereafter identified as the Western, Lyman County, Scott Slough, and Lake Alvin surveys; Table 3.1). The Western survey was sent to 1,091 residents of the New Underwood and Box Elder communities and respondents evaluated both the New Underwood Dam and Curlew Dam. The Lyman County survey was sent to 619 residents of four communities (Presho, Kennebec, Reliance, and Oacoma) and respondents evaluated three lakes (Fate Dam, Brakke Dam, and Byre Dam). The Scott Slough survey was sent to 1,043 residents of Humbolt and Hartford communities and respondents evaluated Scott Slough and the Lake Alvin survey was sent to 1,000 residents of Harrisburg and respondents evaluated Lake Alvin. Mailing addresses used in my study were purchased from Survey Sampling International (www.surveysampling.com). The initial mail survey was sent January 2, 2017 and a reminder postcard was sent to residents who had not responded approximately 1 month later at the beginning of February, followed by a second mailing of the original survey near the beginning of March and the survey concluded on March 28th of 2017.

For each lake evaluated in the surveys, respondents rated their familiarity with the lake, the types of outdoor recreation they participate in at specific individual lakes, the

number of days spent shore, boat, or ice fishing at these lakes, five items rating fishing, ten items measuring their general opinion of the lake, and their rating of the importance of the lake towards their overall quality of life while living in their communities (Appendix A). Following the lake specific questions, each survey ended with a question asking respondents to rate the importance of fishing compared to other types of outdoor recreation, their household composition (i.e. number of men, women and children), the number of years they had lived at their current residence, age and gender, plus any optional comments they may have about the management of their local lakes.

I used IBM SPSS version 25 software for my statistical analyses. I used Pearson correlation coefficient (Pearson *r*) analysis and multiple linear regression to identify the relationship of 14 independent variables measuring various uses, attitudes and values in predicting my dependent variable, the contribution that lakes provide to residents' overall quality of life living within their communities ("Overall, how would you rate the importance of your local lake to your overall quality of life living within your community?"). This dependent variable was recorded on a Likert scale with 0 being "not at all important" and 4 being "extremely important." Specific survey responses that were incorporated in the global model as independent variables included whether the particular lake: is scenic, peaceful, has good water quality, crowded, a place they enjoy visiting, a good place to take a family, important to some local businesses, and an important community resource. These variables were recorded on a Likert scale with 1 being "strongly disagree" and 5 being "strongly agree". Also included as independent variables were the number of activities that a respondent participated in at a specific lake in 2016 (selected from a list of 11 activities), fishing participation at the specific lake in 2016

(fished or not fished), respondent age, respondent gender, number of years the respondent had lived at current address, and whether the household composition included children. Data from Likert-scale questions were analyzed as interval scale data, since the responses are conceptualized to be continuous at the latent (i.e. unobserved) level, even though they are typically measured (i.e. observed) as discrete variables (Borgatta and Bohrnstedt 1980).

Though some variables from my dataset were in violation of the assumptions of normality, Havlicek and Peterson (1977) explain that the Pearson *r* is insensitive to extreme violations and to the measurement level of the data being analyzed. Beginning with a global model consisting of 14 predictor variables, I used a forward-stepwise linear regression analysis to reduce the amount of variables within the model and maintain a relatively high adjusted *R*-squared. The model considered as being the most predictive was selected by comparing the adjusted *R*-squared values of several models. When comparing a model's change in *R*-squared values relative to the former model in a forward-stepwise linear regression analysis, if the change in *r*-squared value from the previous model to the current model was found to be substantial (>0.01) the new parameter was included within the reduced model. The importance of variables within the reduced model were calculated by sum of the decrease in error when split by a variable. To provide a relative importance value bound between 0 and 1, each variable importance value was divided by the highest variable importance value.

RESULTS

Out of 3,753 total surveys sent to residents of communities near my study lakes, 447 were undeliverable and I received 1,318 responses for a 40% response rate (Table

3.1). For my variable measuring the importance of each lake contributing to the respondents quality of life living in the community I had an average response of 8% selecting that the lake is "not at all important" to their overall quality of life living in their community, 17% selecting that the lake is "slightly important", 34% selecting "moderately important", 31% selecting "very important", and 9% selecting "extremely important (Table 3.2). The three centrally located lakes (Byre, Brakke, and Fate) received higher importance ratings for contributing to residents' "quality of life" in their communities compared to the other four lakes in the study (Figure 3.2).

Twelve of my 14 independent variables had a significant correlation with my dependent variable, "quality of life" (Table 3.3). The three highest correlations with the dependent variable were: "importance of the lake as a community resource" (r = 0.52), the "lake is a place the resident enjoys visiting" (r = 0.49), and the "importance of the lake to local businesses" (r = 0.43).

The linear model most predictive of a lake's importance to a resident's overall quality of life living within their community contained 4 variables: "lake is an important community resource", "lake is a place I enjoy visiting", "the number of different activities participated in at lake", and "the lake is important to local businesses" (Tables 3.4 and 3.5). The model explained 40% of the variability of the dependent variable around its mean adjusted for the number of predictors in the model (Adj. R^2 = 0.40; Figure 3.3).

DISCUSSION

In this study, I considered many services that lakes can provide to residents that may influence their reported quality of life while living within their communities.

Surprisingly, I found that angling opportunities provided by individual lakes were not important in predicting the contribution of the lakes towards residents' quality of life. Rather, the indicated quality of life provided by these small lakes was most related to a sense of community, a wider variety of leisure opportunities, and the economic benefits they provide to the community. Hagerty et al. (2001) discussed that a person's quality of life is often determined by a variety of direct and indirect factors that can be provided by water resources, including their health, employment, relationships, and their leisure. My study included several services provided by lakes, similar to Hagerty et al. (2001) that provide to the overall quality of life of local residents.

Empirical evidence from our study suggests that the ability of lakes to exist as settings for community involvement opportunities may be the most important contribution to the overall quality of life that these small lakes provide to local residents. Lakes can provide settings for community festivals and other religious, educational, and cultural events for residents. In some cases, lakes can provide a sense of identity or pride to local communities in which outsiders may refer to them as a specific "fishing community" or as a "boating community" (Weeratunge et al. 2014). Property and housing values can also increase generously by the presence of lakes, which were the most influential attribute in housing prices given a suite of environmental characteristics in the Netherlands (Luttik 2000). Lloyd and Auld (2002) describe lakes as being a key ingredient in the trend of developing highly planned, amenity rich, community environments that have been associated with claims that quality of life can be enhanced if people choose to live in such surroundings. My study echoed these sentiments by

discovering that a sense of contribution to the community may be the most important contribution to the overall quality of life that lakes provide to local residents.

The availability of natural resources with a variety of activities close to people's homes is important and attractive to many (Cordell et al. 1999). However, little empirical evidence exists to explain the positive relationship between the number of recreation and leisure activities provided by a lake and the lake's overall recreational value. My study adds to the growing body of literature about the Recreational Opportunity Spectrum, which provides a framework for managing recreation opportunities based on six physical, biological, social, and managerial factors that can be utilized by recreationists to obtain diverse experiences (Clark and Stankey 1979). Specifically, my study provides evidence to strengthen the Water and Land Recreation Opportunity Spectrum created by Aukerman and Haas (2011) to better manage for diversity and satisfaction in recreation at water resources. Similar to this spectrum, I found that a positive relationship exists between the number of recreation and leisure activities provided by a lake and the importance of a lake to overall quality of life. Within my model, the "number of different activities that a person participated in at a lake" variable provided for 20% of the model's predictive power. My study, as well as several examples in the literature, describes a growing demand among recreationists for greater variety in recreational and leisure opportunities provided by shared spaces and natural resources (Gigliotti 1983; Betz et al. 1999; Cordell et al. 1999; Gundersen et al. 2015). Water not only provides a medium for angling opportunities, it can also provide space for physically active leisure which may enhance participants' quality of life by providing positive experiences through event

participation and contributing to psychological involvement in physical activity (Sato et al. 2014).

Water resources and amenities can play an important role in the economic development of rural communities, which in turn provides a greater quality of life (Deller et al. 2001). I found that the ability for lakes to provide economic opportunities for local communities was an important factor in the model explaining the importance of lakes to residents' overall quality of life within their communities. This variable provided for 13% of the predictive power within my model. In parts of the world, lakes can provide fish for exportation as a commodity or for local consumption (Klessig 2001). They can also be utilized as water supplies for crop irrigation, transportation, and power generation. However, in the United States, a large component of the overall use for lake settings is made up by various recreational and tourism opportunities, such as: angling, swimming, boating, nature viewing, and hiking. These recreational uses were most common among the 7 lakes within my study. In order for these recreational opportunities to exist, local communities typically provide services, such as: hospitality, food and drink providers, gear outfitters, medical providers, etc. In rural parts of America that are developing most rapidly, particularly in South Dakota, natural amenities and other non-market attributes may be the driving factors in economic growth that contribute to overall quality of life (Nord and Cromartie 1997; Beale and Johnson 1998). Marcouiller et al. (2004) found that counties with more river- or lake-related natural amenities tended to equalize income distribution more rapidly than those with less. Therefore, lakes not only provide engines for economic activity, but they can also balance economic opportunity for local residents. A study by Johnson and Rasker (1995) indicated that scenic beauty, a quality

environment, a sense of ruralness, and recreation opportunity dominate the decision where to locate a business in the Montana counties of the Greater Yellowstone region. With the recent trend of urbanization among younger people, rural communities must find methods to retain and recruit new residents by providing amenities that are desirable to younger generations that may not be available within urban areas. As found in my study, lakes are amenities that can increase the economic prosperity of a region, which in turn can increase the overall quality of life within the nearby communities.

With desires for lakes to provide economic and social opportunities for local communities, it is becoming increasingly important for agencies to collaborate with communities and local stakeholders to fulfil management desires. One site in my study provides an example of agency-community collaboration in which the state of South Dakota possesses shoreline property on Lake Byre dam near the small community of Kennebec, South Dakota. While officially managed under South Dakota Game, Fish and Parks' authority, many management decisions for this property are developed and acted upon by the city of Kennebec in order to better provide for the needs of the community. One example of a beneficial use that the Lake Byre property provides to the community of Kennebec is a summer festival called "Byre Days". This is an annual festival in which community members participate in several forms of recreational activities and religious services, such as: swimming, boating, athletic competitions, picnicking, and church services. This case may serve as an example of the positive outcomes that can be provided by agency-community collaboration in co-management of lake resources.

A number of examples have identified beneficial outcomes from agency-community collaboration for managing water resources; however, the ability to perform

public involvement techniques while maintaining authority over a decision-making process and preserving high levels of public satisfaction continues to be challenging. Several obstacles still confront stakeholder groups in their efforts to build consensus, including contextual, compositional, operational, organizational, ideological, and power and capacity obstacles (Margerum 2002). However, when collaboration strategies highlight common values and interests, participants often find productive ways to work together and generate greater public value. Collaboration between agencies, communities and other stakeholders remains an important strategy for improving functions of water resource governance (Imperial and Kauneckis 2003). As Wondolleck and Yaffee (2000) state, “An agency’s long-term capacity for collaboration requires ongoing experimentation and an explicit process of learning from the experiments.”

CONCLUSION

My findings provide empirical evidence for the desire to incorporate community participation and economic growth objectives into management plans for local lake resources. Realizing the diversity of recreation and leisure opportunities that lakes and adjacent lands can provide may be a simple, but critical step in increasing economic opportunity for local regions and for providing a place for communities to hold events and ceremonies. Managers of these resources may find that agency-community collaboration and careful co-management can provide positive outcomes in the form of increased satisfaction among users and local communities, as well as increased overall use of the resources. Not only do these lakes contribute in economic value through angling opportunities, they also contribute in the form of non-market social values, such

as increased community involvement, expanded recreational opportunities, and a greater overall quality of life.

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Table 3.1. Description of 4 surveys sent to 9 communities near 7 small lakes in South Dakota, 2017.

Survey	Community	Zip code population	Lake (ha)	Initial Sample	Number Undeliverable	Number Responses	Response Rate
Western	New Underwood	1,210	New Underwood Dam (8)	1,091	215	260	30%
	Box Elder	6,217	Curlew Dam (55)				
Lyman County	Presho	689	Fate Dam (66)	619	38	272	47%
	Kennebec	419	Brakke Dam (53)				
	Reliance	445	Byre Dam (31)				
	Oacoma	522					
Scott Slough	Humbolt	1,200	Scott Slough (43)	1,043	99	405	43%
	Hartford	4,713					
Lake Alvin	Harrisburg	5,906	Lake Alvin (43)	1,000	95	381	42%
Total				3,753	447	1,318	40%

Table 3.2. Importance of each lake to respondents' "quality of life" living within their community.

Lake	Importance of Lake to "Quality of Life"					
	Number	Not	Slightly	Moderately	Very	Extremely
New Underwood	198	12%	17%	38%	24%	8%
Curlew	197	13%	17%	35%	26%	10%
Fate	205	5%	12%	35%	38%	10%
Brakke	236	3%	17%	27%	45%	9%
Byre	224	4%	10%	31%	40%	15%
Scott	354	10%	22%	38%	23%	6%
Alvin	380	11%	19%	34%	26%	10%
Total	1,794	8%	17%	34%	31%	9%

Table 3.3. Descriptive statistics of 14 predictors included in a global model predicting the importance of a lake to residents' overall quality of life living within their communities in 2017. The table includes sample size (N) of responses that were included in the regression analysis, the minimum, maximum, mean, and standard deviation (SD) values for responses to survey questions, and the Pearson's correlation coefficient (*r*) with associated *p*-values (*p*) comparing the response variable to each predictor variable.

Variable	N	min	max	mean	SD	*r*	*p*
Dependent							
Quality of life	1794	0	4	2.2	1.1	1.00	-
Independent							
Lake is important community resource	1543	1	5	4.1	0.8	0.52	0.00
Lake is a place resident enjoys visiting	1522	1	5	4.0	0.8	0.49	0.00
Lake is important to local businesses	1336	1	5	3.6	0.9	0.43	0.00
Lake is a good place to take a family	1519	1	5	3.9	0.8	0.42	0.00
Number of activities at lake	2137	0	11	2.3	2.4	0.42	0.00
Lake is scenic	1651	1	5	4.0	0.8	0.31	0.00
Lake is peaceful	1659	1	5	4.1	0.7	0.28	0.00
Fished at lake in 2016	2137	0	1	0.4	0.5	0.21	0.00
Lake has good water quality	1433	1	5	3.3	1.0	0.19	0.00
Lake is often crowded	1452	1	5	2.8	0.9	0.08	0.00
Years respondent lived at address	2084	1	91	21.8	18.6	0.08	0.00
Respondent age	2032	15	100	55.6	16.3	0.04	0.09
Household includes children	2081	0	1	0.3	0.5	-0.04	0.13
Gender (proportion of males)	2069	1	2	1.4	0.5	0.03	0.20

Table 3.4. Final model predicting the importance of a lake to residents' overall quality of life living within their communities in 2017 using forward-stepwise linear regression with the 14 dependent variables.

Variables	Relative Variable Importance	β	95% CI's Lower	95% CI's Upper	Adjusted *R Square*	*R Square* Change	*F Change*	*p* -value
Constant	-	1.33	1.24	1.41	-	-	-	-
Lake is important community resource	0.42	0.37	0.30	0.45	0.29	0.29	503.18	< 0.001
Lake is a place resident enjoys visiting	0.25	0.27	0.20	0.34	0.36	0.07	142.52	< 0.001
Number of activities participated in at lake	0.20	0.08	0.05	0.10	0.38	0.02	45.11	< 0.001
Lake is important to local businesses	0.13	0.18	0.12	0.24	0.40	0.02	33.61	< 0.001

Table 3.5. Mean values for each of the four dependent variables in the model predicting local residents' rating of the importance of their lake to their quality of life living in their community.

Importance of Lake to Quality of Life	Important community resource[1]	Place residents enjoy visiting[1]	Important to local businesses[1]	Number of activities[2]
Not important	0.1	0.2	-0.3	1.1
Slightly important	0.6	0.5	0.1	1.7
Moderately important	1.0	0.8	0.5	2.4
Very important	1.4	1.3	0.9	3.4
Extremely important	1.7	1.7	1.2	4.8

[1] Mean: Strongly Disagree = -2, Disagree = -1, Neutral = 0, Agree = +1, Strongly Agree = +2
[2] Mean of the number of activities that respondents reported doing at their local lake: range = 0 to 11 activities.

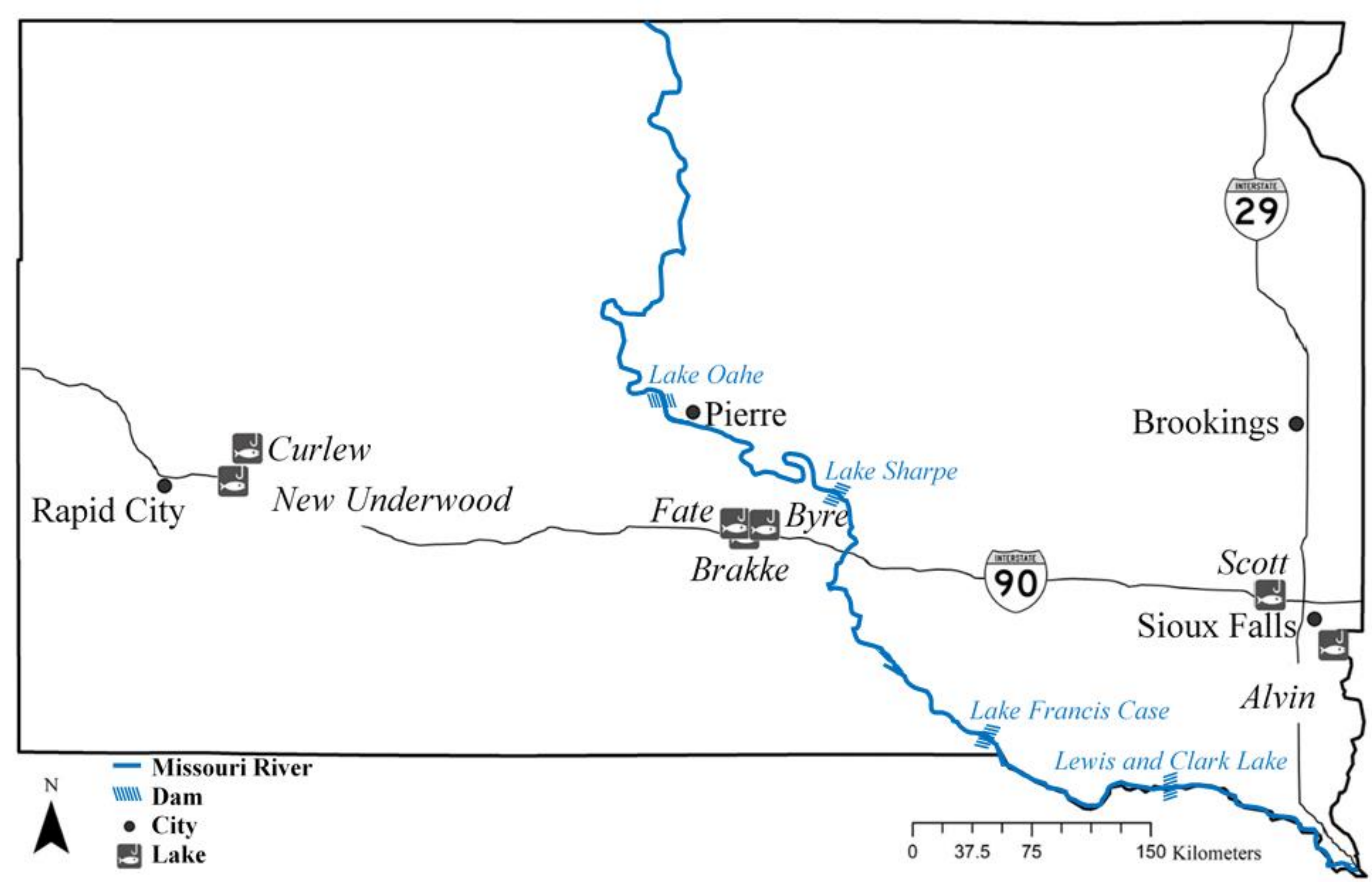

Figure 3.1. Map of the state of South Dakota, United States showing relevant urban centers and seven small fishing lakes that were surveyed during 2016.

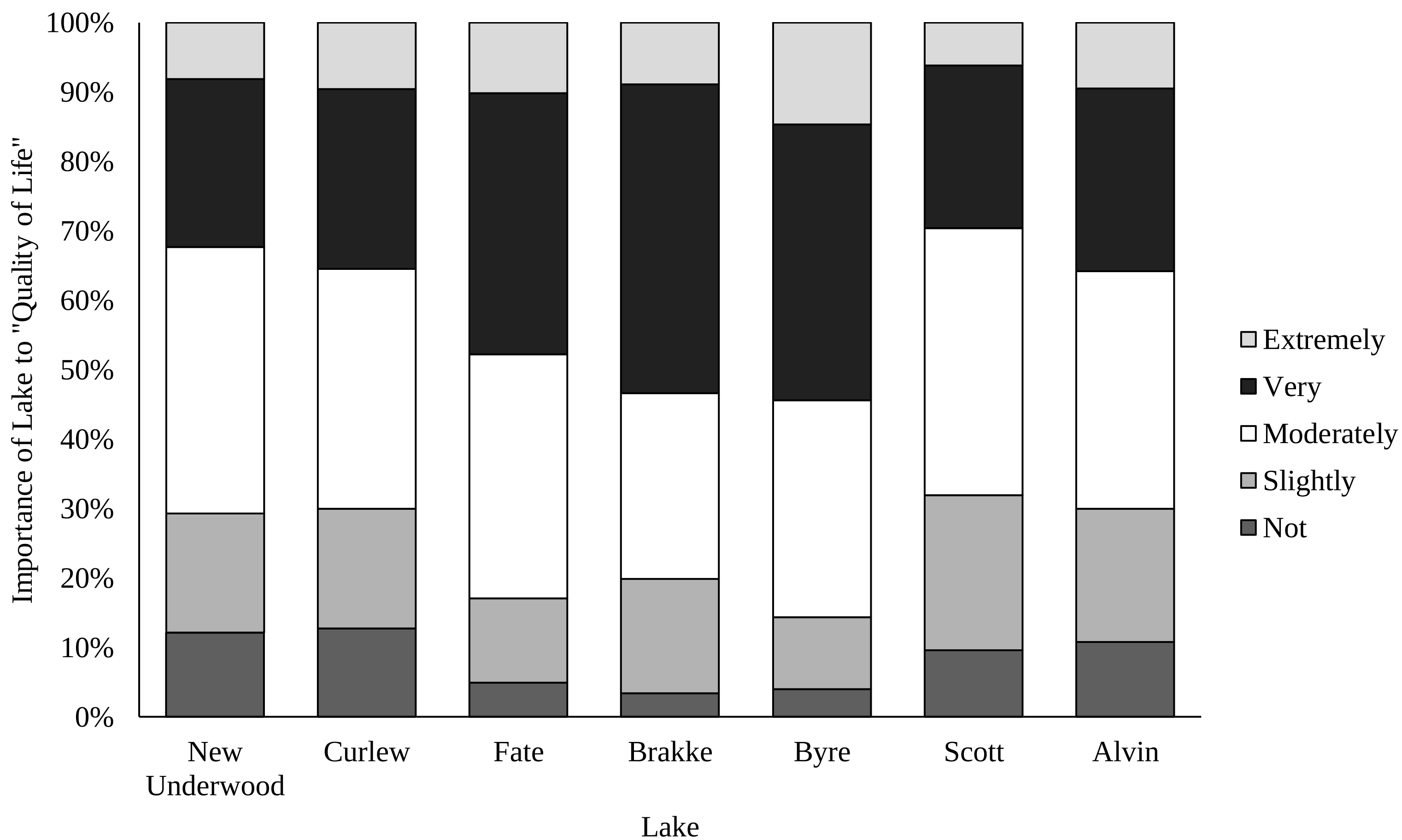

Figure 3.2. Percent responses for "importance of a lake to a person's quality of life living within their community" for each of the seven lakes in my study, 2017.

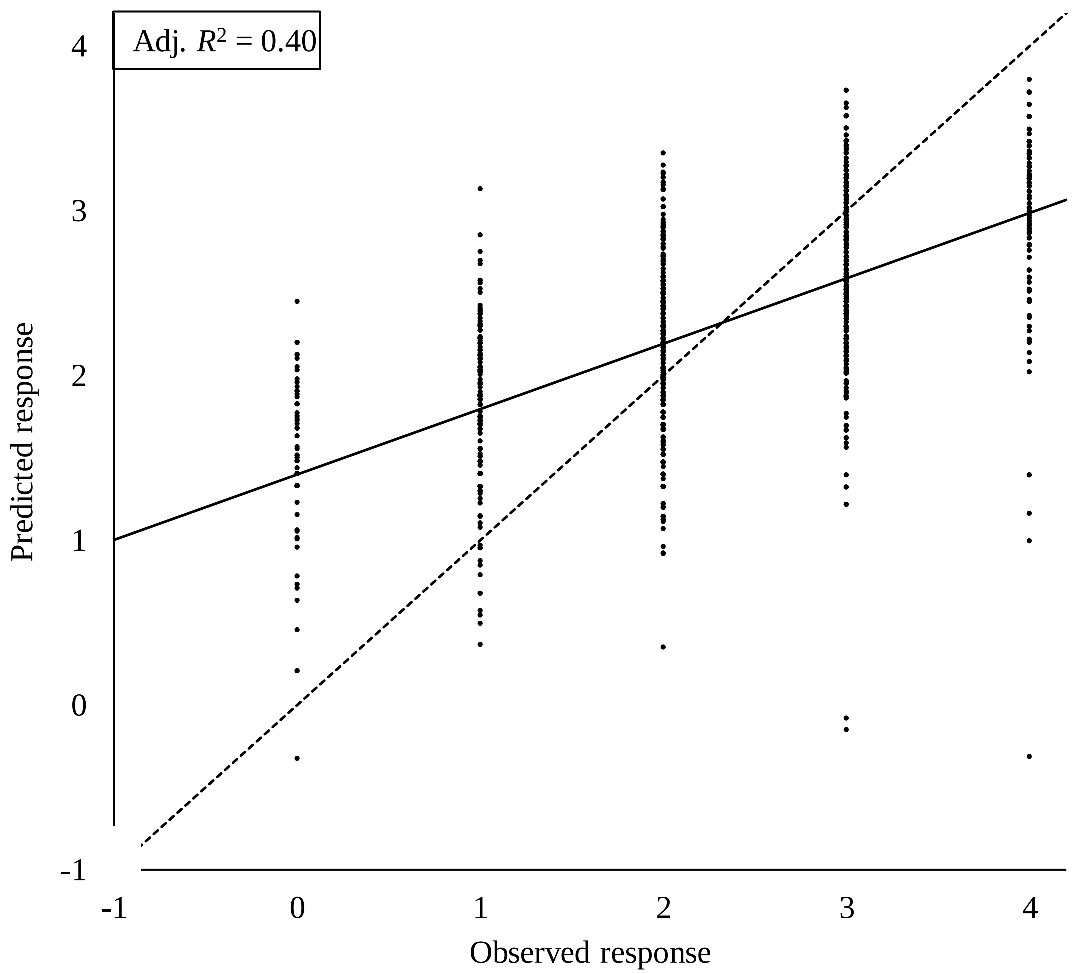

Figure 3.3. Observed response to a survey item asking for the "importance of a lake to a person's quality of life living within their community" compared to predicted responses generated from a final model consisting of 4 predictor variables. The survey item is from a series of surveys sent to residents near specified lakes in South Dakota in 2017. The solid line represents the linear regression model generated (Adj. R^2 = 0.40), while the dotted line represents a 1-to-1 line for reference (Adj. R^2 = 1.0).

CHAPTER 4: COMPARISON OF ON-SITE, MAIL, AND INTERNET SURVEY DATA: A FISHERIES CASE STUDY

ABSTRACT

Collecting information from anglers is one of the most valuable tools for the effective management of freshwater fisheries. Several different survey methods are currently employed by management agencies to collect angler data, such as: demographics, satisfaction, resource use and harvest, economic activity, etc. My study aimed to dissect the appropriate uses and associated biases corresponding to on-site, mail, and internet surveys using a case study of 7 small, South Dakota fisheries. I also determined the efficacy of using internet survey data to estimate angling pressure as compared to on-site survey estimates. Results indicate that angling pressure estimated from internet survey data was found to be 2.2 times greater than estimates from the on-site survey across all seven lakes, however, the proportion of angler days relative to the other lakes within the study were not significant differently between on-site and internet survey methods. Internet surveys may have been subjected to recall error and nonresponse bias, which may cause a large multiplier effect during extrapolation. I also found that angler satisfaction on a scale from -3 to 3 was significantly different among on-site surveys (1.46 ± 0.07) and internet surveys (-0.04 ± 0.08). This is likely due to the interpretation of 2 different metrics based on the recency of the fishing experience that the anglers are being asked to rate. The mean age of internet survey respondents was significantly different than the age of mail survey respondents (49.6 ± 0.2 and 55.6 ± 0.7, respectively). Internet respondents may have been younger than mail survey respondents as a result of internet illiteracy, and lack of internet usage by older participants, in general. The proportion of male respondents (vs. female) for each survey method were 94.1% (on-site), 65.0% (mail), and 88.3% (internet), which were all significantly

different from each other. They also all differ from the distribution of anglers who had purchased a South Dakota fishing license in 2016 at 78.4% males and 21.6% females. Differences in gender ratios may have been caused by the topic of the survey being administered. As internet surveys become more prevalent, researchers and managers must use caution when considering these tools. Internet surveys are a relatively cheap and efficient method of collecting angler data when used properly. However, methods such as on-site and mail surveys should be considered in specific situations that elicit the biases and errors that are common with internet surveys, as described by this study. If feasible, managers should consider mixed-mode surveys in an attempt to identify and eliminate any biases and errors in their survey data.

INTRODUCTION

Natural resource agencies have long recognized the need to incorporate public input into decision-making processes that involve public trust resources. In fact, public participation is now a legal requirement or prerequisite for most governmental decision-making processes in the Western world (Creighton 2005). Traditionally, methods for including public input have relied primarily on on-site, mail, and telephone surveys. Selection of the appropriate survey methods requires researchers to identify issues such as survey length, completion time, accuracy of expected answers, complexity of questions, equipment and facilities required to conduct the survey, personnel requirements, and availability of contact information from the identified sampling frame (Vaske 2008). Depending on the survey method used, surveys can be costly, time consuming, and have inherent associated biases (i.e. non-response bias, interviewer bias, social-desirability bias, etc.).

On-site surveys can be useful when the contact information of a survey's sampling frame is unavailable, and when people being surveyed are less likely to respond to self-administered surveys, such as mail or internet surveys (Vaske 2008). They are useful in collecting accurate information in studies with small spatial sampling frames, and with good access-points. They typically return a high response rate relative to self-administered surveys, because researchers can have a high degree of control of the interviews. Researchers can explain the rationale and importance of the survey, as well as provide additional information that may help respondents understand individual survey items (Groves and McGonagle 2001; Pollock, Jones, and Brown 1994). However, since most on-site surveys require participants to stop what they are doing to provide a certain

degree of undivided attention to the researcher, it is critical that these surveys must not exceed the amount of time that respondents are willing to provide to the survey. On-site surveys are generally more expensive to conduct than other survey methods because of the time and cost associated with staffing and training for survey administration, travel to the site and possible lodging expenditures. Interviewers must be trained in interpersonal communications, the purpose of the survey, the questionnaire format, and how to respond to unsolicited comments or questions from the respondents (Salant and Dillman 1994).

Creel surveys are a common form of on-site surveys that fisheries managers use for collecting angler information, such as: angler demographics, participation, harvest, satisfaction, opinions, and associated socioeconomic aspects of fishing (Pollock et al. 1997; Lockwood et al. 1999; Hutt et al 2013; Greiner et al. 2016). Often, these are access-point creel surveys in which a trained creel clerk will interact with an angler after their fishing trip has concluded. As such, these on-site surveys will not likely be affected by recall errors and biases, and nonresponse bias is typically a non-issue. However, other biases and weakness must be noted when collecting and interpreting on-site survey data. Social desirability is a form of bias that may affect comparisons of in-person and self-administered survey methods in which there is a tendency of survey respondents to answer questions in a manner that will be viewed favorably by survey administrators (MacDonald and Dillman 1968). Sullivan (2003) provides an example in which he studied anglers' exaggeration of catches of Walleyes *Stizostedion vitreum* at Alberta sport fisheries to determine whether reported caught-and-released fish were indicative of actual catch. Using angler reported data compared with test angled data he learned that anglers exaggerated more as fishing success declined, which may have been caused by a form of

social desirability known as prestige bias. Another limitation of creel surveys is sampling error caused by avidity bias. Anglers who fish more often have a greater chance of being interviewed at a particular location, which are consequently sampled in proportion to their avidity (Ditton and Hunt 2001). While avidity does not bias pressure and harvest estimates, the opinions of more avid anglers may receive greater weight in decision making processes (Connelly and Brown 1995).

Mail surveys are a very common method used in survey research. One of the greatest strengths of mail surveys is the lack of time obligation expected from survey administrators (Dillman 2007). Since these surveys are self-administered, researchers do not need to spend time and financial resources to train interviewers, and they do not need to travel to the research site(s) during the extent of the survey period. For mailed or internet surveys, respondents can choose time periods that are convenient to complete the questionnaire and take more time to participate in longer and more complex surveys. Rather, dependent upon the specific plan of implementation, researchers can expect mail surveys to take around 2 months from the construction of the survey instrument to when data is entered into a digital database. Given that mail surveys are more likely to ensure confidentiality of the respondents, they are much less susceptible to social desirability bias than in-person interview methods (i.e. on-site or telephone; Vaske 2008). However, mail survey participants have less incentive to participate and more of a chance to examine the questionnaires before deciding whether to participate, which often leads to lower response rates than in-person methods. Survey participants who struggle to comprehend components of the questionnaire will not have a trained interviewer to provide clarity, and researchers do not have the ability to control who actually completes

the questionnaire, if the respondent had consulted others, the order in which questions were answered, and whether the respondents skip questions from boredom or lack of comprehension (Salant and Dillman 1994).

Fisheries managers often use mail surveys to collect valuable angler information, as well (Ditton et al. 1980, 1990; Ditton and Fedler 1983; Ferguson and Green 1987; Tarrant et al. 1993; Arterburn et al. 2003; Chen et al. 2003; Hutt et al. 2013; Beardmore et al. 2014). Often, such surveys rely upon angler provided information from the previous year's activity. Asking anglers to provide information from their fishing experiences over a 12–month recall period often leads to the potential for several different constructs to be considered as the same. For example, Vrtsika et al. (2010) assessed crowding and related satisfaction at the Santee waterfowl hunting area using two different time frames with both on-site and mail surveys. Their mail survey indicated a crowding problem had existed, which may represent a more lasting impression of the experience. However, hunter's evaluations of crowding from a boat ramp survey were relatively low (mean=2.8, all groups) on the 9-point scale, and satisfaction was found to be more related to harvest than to crowding. Surveys that incorporate long recall periods may receive responses that are representative of experiences which had been more memorable throughout the period, and may include subconscious comparisons to other fishing experiences within, or outside of, the recall period. However, surveys that immediately follow their fishing trip often lead to a more recent evaluation, which is more likely to be affected by more holistic experience variables like weather, companionship, and properly functioning equipment.

Several biases and errors can also be associated with longer recall periods. Research has shown that subjects tend to round upward when recalling recreation participation over longer time periods (Tarrant and Manfredo 1993). Rounding upward, or digit preference, can lead to overestimates in harvest and angling pressure estimates, especially when large extrapolations are included in the analyses (Connelly and Brown 1995; Miller and Anderson 2002). Often, studies which use long recall periods, or fail to control for nonresponse bias, tend to overestimate angling participating and use of other recreation resources (Chase and Harada 1984). Nonresponse bias occurs as a result of nonrespondents having lower angling participation rates than respondents (Brown and Wilkins 1978; Tarrant and Manfredo 1993). Nonresponse bias can be assessed through repeated attempts to contact respondents, sometimes trying other survey methods, which can be used to create correction factors (Brown 1991; Connelly and Brown 1995).

Over the years as internet technology has expanded, many wildlife and fisheries agencies have begun to utilize online and cellphone app surveys as a means to deliver, accept, and summarize results from their customers in a relatively cheap and timely manner. However, online surveys can often lack the scientific rigor that is imperative for credible public participatory research (Dillman 2000; Lukacs 2007; Duda and Nobile 2010). While on-site surveys generally collect information based on a day’s activity, mail and internet surveys often have longer recall periods that can introduce significant recall and digit preference biases.

Internet surveys are also subject to a variety of sampling biases such as age and gender bias. Internet surveys are often represented by relatively younger respondents than what the sampling frame would suggest (Kwak and Raddler 2002; Kaplowitz et al. 2004;

Evans and Mathur 2005; Graefe et al. 2011; Lesser et al. 2011; Shin et al. 2012; Carrozzino-Lyon et al. 2013; Guo et al. 2016; Henderson and Gigliotti 2018). Graefe et al. (2011) compared demographics, outdoor recreation activity patterns, and attitudes toward conservation issues of randomly sampled Pennsylvania residents collected via mail and online survey methods within a mixed-mode survey design and found that internet respondents were significantly younger, averaging 47 years old compared to 57 for mail survey respondents. However, other literature has provided contradictory results in that there is no significant difference in age, that internet respondents were older than mail survey respondents, or that relatively older age groups tend to respond to internet surveys at a higher rate, in general (Gigliotti 2011; Gigliotti and Dietsch 2014; Gigliotti and Henderson 2015; Rübsamen et al. 2017). Rübsamen et al. (2017) used data from the Hygiene and Behaviour Infectious Diseases Study to compare response patterns between an online-only and a mixed-mode survey design. They found that participants in the mixed-mode group were significantly younger than those in the online-only group (median age of 47 vs. 50 years; respectively). They explained that higher willingness to participate in scientific surveys may have compensated for lower internet literacy in older age groups, and that internet literacy of older age groups will likely increase in years to come.

Variation in respondent genders are often skewed towards males in angler surveys (Duda and Nobile 2010). However, it is important to consider the gender ratio offered by the sampling frame when considering if gender bias exists in your survey. Even when considering the sampling frame, some internet surveys can have gender bias because the topic of the survey. Duda and Nobile (2010) surveyed a sampling frame consisting of

people who held South Carolina Saltwater Recreational Fisheries Licenses who had also provided an e-mail address when they purchased their licenses in 2009. Out of the total population of 102,610 license holders only 2,548 responded to the online survey. After comparing respondent demographics to a database of all license holders, they found that 94% of the online survey participants were male while the actual percent possessing a South Carolina Saltwater Recreational Fisheries License was 81% male.

My study considers the convergent validity across survey sampling methods for collecting data from anglers. Convergent validity focuses on the extent to which the various survey methods are able to provide similar estimates of important metrics that are used to manage recreational resources (Tarrant and Manfredo 1993). As such, I compared the quality of data collected using on-site, mail, and internet survey data from the 2016 fishing year. I asked respondents to provide input about 7 small fishing lakes across South Dakota using similar questions across all 3 survey types. More specifically, my primary objective was to determine the ability of internet surveys to estimate fishing pressure at small South Dakota lakes (evaluated with data estimated using on-site surveys of fishing pressure). A previous study by Henderson and Gigliotti (2018) evaluated the use of internet surveys for conducting statewide angler surveys in South Dakota. My findings provide to the growing body of literature on this topic. The South Dakota Game, Fish and Parks (SDGFP) has ~400 small lakes to manage, and given the cost of administering on-site surveys on large spatial scales, internet surveys could be a relatively inexpensive and efficient method for collecting fishing pressure.

A secondary objective was to compare three metrics (age, gender ratios, and satisfaction of anglers' fishing experiences) across applicable survey methods to

demonstrate how these metrics can vary across survey methods and sampling frame. The demographic variables age and gender were chosen because these two metrics can be compared with the true value in the sampling frame (license database), which is collected at time of license purchase. Satisfaction was chosen because it is a key metric used by SDGFP to evaluate performance (Henderson and Gigliotti 2015).

METHODS

Study locations

I evaluated seven small, lacustrine fisheries across South Dakota that were <60 hectares in surface area (Table 4.1). The lakes I selected for my research all match the criterion defined by the SDGFP that a "small lake" is less than 150 acres (60 ha) in surface area (SDGFP 2014). Lakes within my study included New Underwood Dam, Curlew Dam, Fate Dam, Brake Dam, Byre Dam, Scott Slough, and Lake Alvin Dam (from west to east, respectively; Figure 4.1). The lakes were 17-127 acres (7-52 hectares) in surface area, and were 2-15 miles (3-24 kilometers) from local, small communities (population 219 – 9,498 residents) and 13-57 miles (20-92 kilometers) from urban centers (population >10,000 residents). Zip codes included in the mail survey were generally small and rural with population sizes ranging from 419 to 6,217 residents. Popular recreational activities at the lakes included in these surveys involve: fishing, boating, picnicking, swimming, taking a dog for a swim, hunting, gathering with family or friends, etc. Popular sportfishes in these lakes include, but are not limited to: Walleye *Sander vitreus*, Yellow Perch *Perca flavescens*, Largemouth Bass *Micropterus salmoides*, Northern Pike *Esox lucius*, Bluegill *Lepomis macrochirus*, and Black Crappie *Pomoxis nigromaculatus*.

On-site survey

I used a stratified access-point angler survey that was conducted during the calendar year of 2016 to collect information regarding angler use, catch, expenditures, satisfaction, and demographics (Appendix A). The survey was stratified by water body, month, day type (weekend/holiday and weekday), and time of day (randomized daylight hours; Malvestuto 1996). An access-based survey was selected because of the relatively small size of these waters, and to maximize response rates and completed trip interviews while minimizing recall bias (Malvestuto 1996). The lakes in my study were selected in three geographic clusters (western, central, and eastern), which allowed all seven lakes to be surveyed by 3 creel clerks on any given day.

Instantaneous angler counts were conducted simultaneously with the angler surveys as a method for estimating angling pressure. Angler counts were conducted by the creel clerks for each lake during the standard creel survey periods at the time of arrival, and again 2 to 3 hours later prior to leaving the survey locations. Anglers and party sizes were counted and grouped into various types of fishing, such as: “open ice” or “shack” anglers during the ice fishing season, and “boat” or “shore” anglers during the open water season.

Mail survey

During January of 2017, questionnaires were mailed to 3,753 random residents of zip codes of the communities nearest to the seven small, South Dakota lakes within my study. I used four separate, but nearly identical, questionnaires based on the communities nearest to the seven lakes (hereafter identified as the Western, Lyman County, Scott Slough and Lake Alvin surveys; Table 4.2). Mailing addresses used in my study were

purchased from Survey Sampling International (www.surveysampling.com). I used a modified version of Dillman's (2000) Tailored Design Method (i.e., multiple contacts to increase response rate) for mail survey development and implementation, which can be adapted readily for use with mail and/or web-based surveys. The initial mail survey was sent January 2, 2017 and a reminder postcard was sent to residents who had not responded approximately 1 month later at the beginning of February, followed by a second mailing of the original survey near the beginning of March and the survey concluded on March 28th of 2017.

Each survey consisted of five general survey items, as well as five survey items specific to individual lakes (Appendix B). General survey items asked residents about the importance of fishing compared to other types of outdoor recreation, their household composition (i.e. number of men, women, and children), the number of years they had lived at their current residence, age and gender of respondents, plus any optional comments they may have about the management of their local lakes. Individual lake survey items asked about the local residents' familiarity with specific lakes within the survey, the types of outdoor recreation they participate in at specific individual lakes, the number of days spent shore, boat or ice fishing at these lakes, their ratings of SDGFP management of the specific lake resources, and the importance of individual lakes towards their overall quality of life while living in their communities.

Internet survey

Data were collected by a SDGFP survey sent via email using the SurveyMonkey ® platform. Survey results were categorized by the license type purchased by South Dakota anglers. Emails were initially sent to 101,889 licensed anglers on January 1st,

2016 with follow-up reminders sent on January 9th and January 18th, 2016 (Table 4.3). The internet survey closed on January 24th, 2016. The survey first asked all participants about fishing frequency and regional locations fished, harvest, evaluation of fishing, and satisfaction (Appendix C). This was followed by questions about fishing at the seven specific lakes in the previous on-site and mail surveys. Survey items that were specific to each of the seven lakes in the previous on-site and mail surveys consisted of: angling participation and avidity at a specified lake, distance and motivations for angling at a specified lake, and ratings and satisfaction of fishing experiences at a specified lake. The survey ended with questions about their motivations for fishing, importance of fishing and demographic variables (gender, age, and county residence). An opportunity to provide optional comments about fishing in South Dakota was provided at the conclusion of the survey.

Statistical analyses

Data from on-site and mail surveys were initially entered and stored in Microsoft® Excel® 2013. Data from the internet survey was entered into IBM SPSS version 25 software (SPSS). All data was transferred into SPSS, which was used for statistical analyses and comparisons across survey methodologies (i.e. angling pressure, satisfaction, and demographic comparisons).

Angling pressure was estimated and compared between on-site and internet survey methodologies. On-site angling pressure was estimated using the instantaneous angler counts along with estimated trip durations from completed trip interviews. Average trip durations were calculated from creel surveys with parties who had completed their angling trips. Observed angler count data was extrapolated and average

trip durations were estimated to create estimates of angling pressure using the Creel Application Software (Soupir and Brown 2008) resulting in angling pressure in the form of angler-hours. The sum of these estimates resulted in an estimated annual angling pressure at each of the seven study lakes. Angler-hours were translated to angler-days (AD) by dividing the average angler-hours by the average trip duration. Angling pressure estimates could then be provided in the form of angler-days per: lake, acre, month, year, and fishing type/season.

Angling pressure in AD from internet surveys was estimated by initially calculating the number of anglers who fished at each lake. First, I calculated the number of anglers who fished in South Dakota in 2016 by license type (multiply the number of licenses sold by the proportion of anglers who fished in 2016; Table 4.4.) Next, I multiplied the number of anglers who fished in South Dakota by the proportion of anglers who fished at each lake by license type (Table 4.5) to give us the estimated number of South Dakota anglers that fished at a specified lake (Table 4.6). To calculate AD, I multiplied the number of anglers fishing by the average days of fishing at each lake (Table 4.7). I used a Chi-squares analysis to compare differences in proportional angler days on a lake (relative to the other lakes in this study) between estimates from on-site and internet surveys, and Cramer’s V was used to assess the effect size. Note: In my survey I measured days fished at each lake using an ordinal scale, therefore I had to estimate an average number of days fished for each ordinal value (Figure 4.2). However, I recommend measuring the number of days fished at each lake using an interval scale in future internet surveys (e.g., asking for the total days fished) to avoid having to estimate average days fished using a mathematical correction.

Comparisons in responses for fishing satisfaction between on-site and internet survey methods were composed of responses from 2 separate, but nearly identical, questions. Both on-site and mail surveys were measured on identical 7-point Likert scales. However, the on-site survey measured anglers' satisfaction with their fishing experience that day, while the internet survey measured anglers satisfaction with their fishing experience over the entire year of 2016 measured. Since satisfaction questions asked about the specific lakes that anglers had fished at, comparisons in satisfaction measurements between survey methods were made for each of the 7 study lakes using independent sample *t*-tests, and Hedges' *g* was used to provide a measure of effect size.

Respondent mean age was compared between mail and internet survey methods using independent sample *t*-tests, and Hedges' *g* was used to provide a measure of effect size. Respondent gender ratios were compared across all 3 survey methods using a one-way analysis-of-variance, and eta (η) was used to provide a measure of effect size. The proportional gender distribution of anglers who had purchased a South Dakota fishing license in 2016 was determined from the SDGFP license database. An initial Levene's test was used to check that variances were equal for all samples. The Levene's test was found to be significant, indicating that variances are assumed to be unequal. Therefore, a *post hoc* Tamhane's T2 analysis was used to determine if the gender ratios for the three survey types differed significantly, which is a conservative pairwise comparison test that is based on a *t*-test and is appropriate when the variances are unequal (Vaske 2008).

For all independent sample *t*-tests, an initial Levene's test was used to check that variances are equal for all samples. I used Hedges' *g* as a measure of effect size for these comparisons, which tells you how much one group deviates from another. For example, a

"*g*" of 1 indicates the two groups differ by 1 standard deviation, while a "*g*" of 2 indicates they differ by 2 standard deviations. Hedges' *g* was used, rather than Cohen's *d* or Glass' delta, since it provides a measure of effect size weighted according to the relative size of each sample (Ellis 2010). I used an eta (η) value for analysis of variance comparison for respondent gender ratios across survey methods, which are analogous to R^2 values in regression analysis. Eta values can be interpreted as the proportion of variance in the dependent variable explained by difference among the categories of the independent variable (Vaske and Shelby 2008).

RESULTS

Results of surveys

During the 2016 calendar year, I conducted on-site interviews on an average of 85 weekends and holidays and 125 weekdays at each of the seven lakes in my study. In all, 1,874 total on-site interviews were conducted, with 770 of them occurring after completed fishing trips. This was an average of 265 total interviews at each lake (min=86, max=604), with an average of 112 considered as completed trip interviews (min=25, max=258; Table 4.1). The average party size was 2.1 anglers, and consisted of 64% adult males, 14% adult females, 16% male children, and 6% female children. Out of 3,753 total mail surveys sent to random residents of communities near my study lakes, 447 were undeliverable and I received 1,318 responses for a 40% total response rate (Table 4.2). The lowest response rate was with my Western survey (30%), and my highest response rate was with my Lyman County survey (47%). Email surveys were sent to people holding a 2016 South Dakota fishing license (adjusted number sent = 101,889), which produced 24,992 completed questionnaires (24.5% return rate; Table 4.3).

Angling pressure estimation comparisons

Angling pressure was estimated and compared from on-site creel survey data and off-site internet survey data. Average fishing trip duration recorded from my on-site creel survey was 2.8 hours (h) with a minimum average trip duration of 2.2 h at New Underwood Dam and a maximum average trip duration of 3.4 h at Curlew Dam. This translated to an average of 3,101 AD at each lake and a total of 21,710 AD across all seven lakes in 2016 (Table 4.8). Byre Dam received the least amount of angling pressure with 1,200 AD, while Scott Slough received the most pressure with 6,527 AD. Angling pressure estimated from my 2016 internet survey ranged from 1,346 AD at Byre Dam to 13,821 AD at Scott Slough. The average angling pressure estimated from my internet survey was 7,431 AD and the total was 52,020 across all seven study lakes. Angling pressure estimates from the internet survey averaged 2.2 times greater than estimates from the on-site survey across all seven lakes; however, the proportion of angler days relative to the other lakes within the study were not significantly different between on-site and internet survey methods ($p = 0.82$).

Satisfaction comparisons

The average daily satisfaction with angling experiences across my seven study lakes in South Dakota that was collected using on-site surveys was 1.46 ± 0.07 on a scale of -3 to 3, and lake averages went from 1.22 ± 0.13 at Scott Slough to 1.71 ± 0.20 at New Underwood Dam (Table 4.9). The average annual satisfaction with angling experiences across my seven study lakes collected with an internet survey was -0.04 ± 0.08 using the same scale, and lake averages went from -0.40 ± 0.16 at Lake Alvin to 0.66 ± 0.21 at Brakke Dam. Comparisons between on-site and internet surveys provided significantly

different satisfaction ratings for all seven lakes in my study ($p < 0.001$ for all lakes). The effect sizes of these comparisons using Hedges' g values were found to range from 0.62 for Byre Dam to 1.23 for Fate Dam. Much greater proportions of anglers reported being satisfied with their fishing experiences during on-site surveys compared to internet surveys (Figure 4.3).

Demographics comparisons

The mean age of mail survey respondents was 55.6 ± 0.7 years (mean±95% CI), while the mean age of internet survey respondents was 49.6 ± 0.2 years. Respondent ages between mail and internet survey methods were significantly different ($t = 16.21$; df = 2,341; $p < 0.001$). The value of Hedges' g for this comparison was 0.40, which indicates the two groups differ by 40% of one standard deviation. Only 35% of mail survey respondents were 50 years of age or younger, while 48% of internet survey respondents were 50 years of age or younger (Figure 4.4).

Our on-site survey had 1,737 male participants and 108 female participants (n = 1,875), my mail survey had 1,345 male participants and 724 female participants (n = 2,069), and my internet survey had 21,077 male participants and 2,795 female participants (n = 23,875). The proportion of male respondents (vs. female) for each survey method were: 94.1% (on-site), 65.0% (mail), and 88.3% (internet; Figure 4.5). Respondent genders were found to differ significantly between on-site, mail, and internet survey methods ($F = 518.5$; $p < 0.001$; $\eta = 0.19$). The *post hoc* Tamhane' T2 analysis found that none of the gender ratios across the three survey types were statistically similar ($\alpha = 0.05$; $p < 0.001$). The proportional gender distribution of anglers who had purchased a South Dakota fishing license in 2016 was 78.4% males and 21.6% females.

DISCUSSION

Angling pressure estimation comparisons

My internet surveys overestimated fishing pressure (measured in angler-days) at all seven lakes compared to the estimate of fishing pressure estimated from my on-site surveys. I make the assumption that my on-site survey provides a more accurate estimate than the internet survey and propose that the internet survey overestimates fishing pressure due to a combination of recall and nonresponse biases. Discrepancies in angling pressure between on-site and off-site survey methods have been documented previously in the literature (Hiett and Worrall 1977; Fisher et al. 1991; Tarrant et al. 1993; Connelly and Brown 1995; Osborn and Matlock 2010). Osborn and Matlock (2010) examined recall bias by sending mail surveys to registered Texas boat owners in an attempt to determine if fishing effort estimates differed based on recall periods of 1-month and 1-year. They found that estimates of angling pressure were affected by the recall period of the administered survey. Connelly and Brown (1995) compared diary and mail methodologies for a cohort of anglers who fished Lake Ontario to examine biases associated with 12-month recall from mail questionnaires, and found that 44-45% of angler days are overestimated on a 12-month recall mail questionnaire. They estimated the mean annual days fished at Lake Ontario from the diary data was 5.1 days, while the mail survey data estimated 10.7 days. Their off-site (i.e. mail or internet survey) estimates of fishing pressure were 2.1 times greater than their on-site estimates (i.e. diary or creel survey), which closely resemble the findings from my study (2.2 times greater).

The precision of anglers' estimated number of fishing days and details about specific trips seems to decrease as recall period increases, which is not surprising. It is

easy to assume that a shorter recall period would allow anglers to remember specific fishing trips, and even details about individual trips, especially if the recall period is within hours or days of a fishing event, rather than months. However, given the consistency in estimates of angling pressure across the literature between on-site and off-site methodologies, it seems possible that a correction factor could adjust off-site estimates to account for recall inflation, and to achieve similar estimates as those from on-site surveys (Fischer et al. 1991; Connelly and Brown 1995; Henderson and Gigliotti 2018). Biased survey data may still be valuable if the magnitude is predictable (Brown 1991).

Angling pressure estimates from my creel survey data and internet survey data may have differed because of response errors by survey takers in conjunction with multiplier effects from extrapolating small sample sizes to large populations. For example, if 1 internet survey respondent mistakenly recalled fishing 1 day at Byre Dam in 2016, when they didn't actually fish at Byre Dam that year, the estimated AD would increase by over 6 days. Similarly, the 2016 AD estimate for Scott Slough would increase by over 11 days. This may be a form of response error. Response errors can result from inadequate concepts or questions in the survey instrument, inadequate training of interviewers, breakdowns in the interview process, or respondents misunderstanding, forgetting, or deliberately falsifying information in their response (McNabb 2013). In my study, the latter-mentioned of the possible 3 reasons for response error was the likely culprit in creating the discrepancy in angling pressure estimates between the two survey methods.

Nonresponse bias may have also caused my data to misrepresent the actual amount of days that anglers fished at a lake. Nonresponse bias occurs when respondents' answers are different from the possible answers of those within the sampling frame who did not respond (Vaske 2008; Duda and Nobile 2010). Often, non-response bias can contribute to overestimates of angling effort in fisheries management surveys (Brown 1991; Fisher 1996). This could be influenced by more invested anglers choosing to complete surveys, rather than more casual or generalist anglers (Fisher 1996). My internet survey had an overall response rate of 24.5%, which provides ample opportunity for nonresponse bias to alter the outcome of my AD estimates. My sampling design did not incorporate an assessment of nonresponse bias so it is likely that nonresponse bias contributed to the overestimated internet survey results.

While internet surveys can provide angling pressure estimates more rapidly and at lower cost, I found that these estimates were more than double what my on-site creel survey estimates provided. Internet survey data may have been plagued by recall errors, extrapolation errors, and nonresponse bias. However, on-site survey data may have been affected by relatively small sample sizes, interviewer bias, social desirability bias, and the lack of ability to administer the survey during all 365 days of the 2016. So, which survey methodology provides appropriate data to come up with an angling pressure estimate that is closest to reality? I hypothesize that the real angling pressure that my study lakes experienced was somewhere between the on-site and internet estimates. More specifically, I speculate that the true angling pressure will be closer to that estimated from the on-site survey, as opposed to the internet survey. This is because of the large magnitude of error that can be introduced by the inability of anglers to recall fishing

events over a 12 month period, which can lead to large extrapolation error in the final angling pressure results. On-site surveys tend to provide much more conservative estimates, particularly when used to estimate angling pressure at relatively small, lower use lakes. The use of correction factors that bridge the gap between on-site and internet questionnaires, in conjunction with follow-up nonresponse bias surveys, could yield the best estimates of fishing participation (Connelly and Brown 1995). I suggest that estimates of angling pressure be carefully evaluated depending upon the length of the period of participation subjects were asked to recall, and I echo the sentiments that 2-month recall periods between internet surveys could provide a more cost effective estimate that is closer to the real angling pressure (Hiett and Worrall 1977; Osborn and Matlock 2010).

Alternative procedure for estimating fishing pressure from internet surveys of small lakes. Although the internet data generally overestimates fishing pressure at these low use fisheries, the proportion of the estimates were relatively similar for the two survey methods relative to other lakes within a study. Therefore, proportional data may be used to estimate fishing pressure at low use fisheries using internet survey data. Since internet data tends to overestimate pressure, an alternative method for using internet survey data to estimate fishing pressure at small, relatively low use lakes would entail conducting an on-site survey of one or more small lakes and at the end of the season also conducting an internet survey of the same lakes plus other similar lakes. Then calculate a correction factor by determining the difference between the on-site survey estimates with the internet survey estimates and using that correction factor to adjust the internet estimates for the other lakes that were not surveyed on-site. For example, suppose the

researcher has a good estimate of fishing pressure that is based on an annual on-site survey, in addition to an estimate of pressure that is based upon internet data. A correction factor would be calculated by dividing the "actual" on-site survey estimate by the internet survey estimate. Assuming the researcher is considering other lakes that are relatively similar in size and use this correction factor can be applied to the internet estimated angling pressure to provide a more realistic value of actual angling pressure. For example, if Lake A has an estimated angling pressure of 1,000 AD based on an annual on-site survey, but had an estimated pressure of 2,500 AD based on internet survey data, the correction factor would equal 0.4. If Lake B has no on-site data, but experiences 5,000 AD base on internet survey estimates, the correction factor of 0.4 from Lake A multiplied by the internet estimate of 5,000 from Lake B would equal a corrected estimate of 2,000 AD for Lake B.

Using Relative Internet Survey Data at Small Lakes. Another potential use for angling pressure estimated by internet surveys would be to make comparisons and draw conclusions of one lake relative to lakes with similar attributes, or to the same lake at different time periods. This use of internet survey data may not provide accurate angling pressure estimates. However, by comparing one lake to another after using the same internet survey procedure for both lakes, researchers can be justified in saying that, hypothetically, Lake A has 2.5 times the angling pressure than Lake B. Researchers can also compare a lake relative to itself to claim that fishing pressure has increased or decreased at a lake across temporal scales. For example, using internet data, Lake A may have an estimated pressure of 1,000 AD in 2016, but one year later using the same methodology the estimate is 1,500 AD. This increase in pressure of 150% may be

significant enough to alert managers that the management activities that have taken place at Lake A have been successful over the past year. This form of relative fishing pressure information may be valuable when considering temporal trends in angling participation at various lakes in management jurisdictions and when prioritizing lakes based upon their fishing pressures relative to other similar lakes. If accurate estimates of fishing pressure is not necessary, and relative comparisons are acceptable, internet surveys can provide a less time consuming and much more cost effective alternative to on-site surveys for management decisions that are based upon fishing pressure.

Satisfaction comparisons

I found relatively large and consistent variation in satisfaction ratings measured by on-site and internet surveys, which may be a function of different concepts that are being measured. Manfredo (1984) concluded that surveys administered using different time frames are actually measuring different concepts. The internet survey asks for a rating of annual fishing satisfaction at individual lakes, which is a different attitudinal construct than satisfaction measured by the on-site survey that asks anglers for a rating of their daily fishing experiences at individual lakes. Evaluating overall average satisfaction at a single lake for the past year may stimulate thought comparisons with many previous fishing experiences and locations compared to evaluating daily satisfaction immediately at the end of a fishing experience, which is more likely affected by different, and a more recent, set of variables like weather, companionship, catch rate, and properly functioning equipment. Because variation in time frames measured by different survey methods can affect the outcomes of satisfaction responses, care must be used while comparing and

interpreting satisfaction measurements between on-site and offsite measures of recreational experiences.

Our study provided evidence that anglers tend to remember their fishing experiences differently over distinctive temporal recall periods, or that they use different subconscious constructs during their satisfaction rating process. While some might inappropriately mistake this disparity for a form of recall bias, in which respondents inaccurately recall an event (Hogg et al. 2010), I must consider that the disparity in temporal scales of the surveys may allow for 2 distinct constructs to be measured. Stewart and Hull (1992) examined the concepts of “real-time satisfaction” (RTS) and “post hoc satisfaction” (PHS) experienced by hikers, in which satisfaction was assessed at 12 times during a day hike (RTS), on-site immediately after the hike (PHS-0), at home 3 months after the hike (PHS-3), and at home 9 months after the hike (PHS-9). The authors found that RTS and PHS-0 measures (on-site) were significantly greater than PHS-3 and PHS-9 measures (off-site). They explained that RTS is an evaluation of a recreationist’s current state during the recreation/tourism experience, while PHS appraises the recreation experience evaluated after the on-site activity has occurred. They suggest the need for two distinct constructs of satisfaction because of the differential ability to control the effects of context and a contrasting emphasis on recall of past experiences.

Angler satisfaction measured by my internet survey (summated annual satisfaction) at each individual lake was more negative compared to the average satisfaction from my on-site surveys measured on the day of fishing. Thomas and Diener (1990) found that people tend to underestimate the frequency of positive emotions, but

not negative emotions, which is consistent with the view that the relative weakness of positive emotional experiences makes them more forgettable. Anglers may have a subconscious tendency to recall negative experiences at a higher rates than their recollection of positive fishing experiences over the course of a calendar year, while anglers responding to surveys the day of their fishing event may be more likely to recall the positive experiences from their trip.

Social desirability is a form of bias that may influence comparisons of on-site and off-site survey methods. The disparity in satisfaction ratings that I found between on-site surveys and internet surveys from my study could, in part, be reflective of the subconscious decisions of anglers to respond favorably while communicating to a real person, as opposed to responding less favorably to self-administered surveys. Connelly and Brown (2000) provide an example in which they surveyed Lake Ontario anglers in 1994, 1995 and found that for some components of trip satisfaction and for overall trip satisfaction, telephone survey respondents reported being more satisfied with their fishing experiences than mail survey respondents. This may partially have been reflective of a method bias, such as social desirability bias.

Demographics comparisons

Our results revealed that internet survey respondents are significantly younger than mail survey respondents, which is similar to several other studies in survey literature (Kwak and Raddler 2002; Kaplowitz et al. 2004; Evans and Mathur 2005; Graefe et al. 2011; Lesser et al. 2011; Shin et al. 2012; Carrozzino-Lyon et al. 2013; Guo et al. 2016; Henderson and Gigliotti 2018). Lesser et al. (2011) compared a mixed-mode survey to a traditional mail survey to examine differences in hunter characteristics and opinions of

Oregon hunters. Half of their sample received a traditional mail survey while the other half received a mixed-mode survey in which they were first asked to complete the questionnaire on the internet and then sent a printed version if they did not respond to the internet questionnaire. They demonstrated that mixed-mode surveys can provide an advantage over internet surveys by offering an opportunity for people who are less likely to have internet access, such as older and less affluent individuals, a means to participate in the survey.

These results reveal that one can expect variations in gender proportions from on-site, mail, and internet surveys. However, caution needs to be exercised while making these comparisons given that they may have different sampling frames. Within my on-site survey, the gender variable was determined as the sex of an angler that had been interviewed at a specific lake site. Gender in my internet survey was calculated as the sex of the respondent based upon a sampling frame of all South Dakota fishing license purchasers that had provided an email address in 2016. These sampling frames imply that a strong correlation should exist between the gender proportions of the survey respondents from my on-site and internet surveys and the gender proportion of South Dakota anglers (78% male). I found that both on-site and internet surveys had higher male respondent representation than what I expected based upon the gender proportion of South Dakota anglers, which is consistent with findings by Duda and Nobile (2010) in which they found that the gender proportion of their sampling frame was 81% male, while the gender proportion of those responding to the online survey was actually 94% male.

My mail survey used a sampling frame that included random residents of zip codes representing communities nearby the seven study lakes, which changes my expected gender proportion to be 50% male (i.e. South Dakota gender ratio; U.S. Census Bureau 2011). I found that the mail survey (65% male) also had a higher male respondent representation than what I had predicted based upon the assumption that the communities within my mail survey shared the same gender ratios with the whole state of South Dakota (close to 50/50 males/females). This disparity may be explained by the tendency for men to respond to a mail survey related to angling, which may cause a higher proportion of males than expected from the sampling frame.

Does it really matter if a sample's respondents do not match the gender profile of their corresponding population in a fisheries or outdoor recreation survey? Do differences exist between genders across important measurements, such as satisfaction or motivation? Age and gender are generally the two variables that one can compare survey results with actual population parameters. This provides an opportunity to estimate how accurately survey results may represent true population values. One of the most important implications for managers and planners has to do with recruiting, retaining, and reactivating (R3) outdoor recreationists. Understanding differences that may exist in motivations between genders and what makes each gender more satisfied is critical to R3 efforts, and significant gender bias within the coverage of a survey sample may underrepresent these measurements relative to the actual population. Difference in angling satisfaction between genders may exist because of a lack of targeted management actions towards motivations that could make women more satisfied with their angling experiences. Gigliotti and Metcalf (2016) examined the motivations of female deer

hunters in the Black Hills of South Dakota and found that female hunters selected the social aspect of hunting (i.e. enjoying the time spent with friends/family) as the greatest motivation compared to a variety of other harvest and non-harvest motivations. Moore et al. (2008) examined gender-based differences in birdwatchers' participation and commitment and found that, generally speaking, men's leisure experiences focus on competition and achievement whereas women are more oriented toward sociability and relationships. Perhaps, management activities that may increase success of R3 efforts should incorporate more opportunities for outdoor social events and companionship opportunities. These are applied examples of reasons why making sure that a sample's respondents match the gender profile of its corresponding population in a fisheries or outdoor recreation survey.

CONCLUSIONS

This research compared the precision of an on-site survey, mail survey, and internet survey in addressing satisfaction and angling pressure. I also compared respondent demographics, such as age and gender between the 3 survey methods. My study was consistent with much of the literature in that internet survey respondents tend to be significantly younger than mail survey respondents, and that the gender distribution between survey methods can depend on the survey's sampling frame. However, the topic of the surveys may also influence the gender distribution towards more closely representing that of fishing license purchasers. Angling satisfaction was found to be significantly lower using the internet surveys, as opposed to the on-site survey data, because the surveys were measuring two different constructs of satisfaction. The evaluation of a recreationist's current state during the recreation/tourism experience

versus the appraisal of the recreation experience evaluated after the on-site activity has occurred. Psychological differences associated with the recollection of satisfaction at various recall periods may have also contributed to the difference in satisfaction measurements. I found angling pressure estimates generated from internet survey data to be ~2.2 times greater than the estimates generated from on-site surveys. This was likely a product of the inability of anglers to remember fishing trips over longer recall periods, followed by the large extrapolation error associated with these misreported events.

I suggest that managers consider using survey methods that involve shorter recall periods, as well as incorporating mixed-mode survey methods into their sampling design. There is no doubt that internet surveys will continue to be rapid and cost-effective as a form of data collection from anglers. However, given the limitations and biases discussed, the ability to incorporate an on-site survey design to pair with an off-site internet survey would allow researchers to reduce measurement errors and reduce the effects of many of the sampling biases described. As technology advances and the number of people who have access to the internet increases, the internet will continue to develop into a major instrument of data collection for resource managers and social scientists. However, managers must be careful when interpreting and comparing the results of internet surveys with on-site and mail survey results. This will lead to more accurate data, which serves everyone's best interest.

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Table 4.1. Surface area and distance to closest urban center (UC) for seven small fishing lakes in South Dakota. The number of total on-site interviews in 2016 is included with completed trip interviews in parentheses.

	Surface area				
Lake	Acres	Hectares	Distance to UC (mi)	Nearby UC	Interviews
New Underwood	17	7	23	Rapid City	236 (95)
Curlew	127	52	35	Rapid City	360 (137)
Fate	122	49	57	Pierre	103 (47)
Brakke	118	48	56	Pierre	140 (59)
Byre	117	47	57	Pierre	86 (25)
Scott	117	47	21	Sioux Falls	604 (258)
Alvin	104	42	13	Sioux Falls	329 (163)

Table 4.2. Description of the 4 mail surveys sent to 9 communities near 7 small lakes in South Dakota, 2017.

Survey	Community	Zip code population	Lake (ha)	Initial Sample	Number Undeliverable	Number Responses	Response Rate
Western	New Underwood	1,210	New Underwood Dam (8)	1,091	215	260	30%
	Box Elder	6,217	Curlew Dam (55)				
Lyman County	Presho	689	Fate Dam (66)	619	38	272	47%
	Kennebec	419	Brakke Dam (53)				
	Reliance	445	Byre Dam (31)				
	Oacoma	522					
Scott Slough	Humbolt	1,200	Scott Slough (43)	1,043	99	405	43%
	Hartford	4,713					
Lake Alvin	Harrisburg	5,906	Lake Alvin (43)	1,000	95	381	42%
Total				3,753	447	1,318	40%

Table 4.3. Results of a statewide internet survey sent to anglers who had purchased a South Dakota fishing license in 2016, and had provided an email address.

2016 Fishing License	Initial Number Sent	Adjusted Number Sent[1]	Number Returned	Percent Returned[2]
Resident Adult Combination	37,524	34,865	9,424	27.0%
Resident Adult Annual	29,729	27,087	4,279	15.8%
Resident Senior Annual	4,234	3,560	1,084	30.4%
Resident Senior Combination	5,640	5,009	1,793	35.8%
Resident Junior Combination	4,500	4,194	612	14.6%
Nonresident Annual	11,813	10,966	3,284	30.0%
Nonresident Family	5,203	4,849	1,663	34.3%
Nonresident 3-Day	7,397	6,830	1,837	26.9%
Nonresident 1-Day	4,922	4,529	1,016	22.4%
Total	110,962	101,889	24,992	24.5%

[1] Adjusted Number Sent = Initial Number Sent – (Bounced + Opted Out)
[2] Percent Returned is based on the Adjusted Number Sent

Table 4.4. Estimated number of licenses sold, estimated proportion of license holders that fished, and estimated number of anglers fishing in South Dakota in 2016.

2016 Fishing License	Number of Licenses Sold	Proportion Fishing	Number Fishing
Resident Adult Combination	47,783	0.847	40,472
Resident Adult Annual	61,922	0.934	57,835
Resident Senior Annual	12,815	0.783	10,034
Resident Senior Combination	8,423	0.764	6,435
Resident Junior Combination	8,063	0.885	7,136
Nonresident Annual	27,388	0.973	26,649
Nonresident Family	9,588	0.974	17,744[1]
Nonresident 3-Day	19,735[2]	0.991	19,557
Nonresident 1-Day	17,168[2]	0.979	16,807
Total	212,885	--	202,669

[1] 17,744 = number people fishing on the Family License (9,339 families X 1.9 anglers per family)
[2] Estimated number of unique license holders

Table 4.5. Proportion of South Dakota anglers from each license type that fished at one or more of the 7 small, South Dakota lakes in my study in 2016. Estimates are calculated from internet surveys that were sent to anglers who purchased a fishing license for South Dakota in 2016.

		Proportion of South Dakota anglers that fished at lake						
License type	Estimated anglers	New Underwood	Curlew	Fate	Brakke	Byre	Scott	Alvin
Res Adult Comb	40,472	0.019	0.020	0.008	0.015	0.005	0.032	0.024
Res Adult Annual	57,835	0.028	0.032	0.003	0.010	0.003	0.041	0.037
Res Senior Annual	10,034	0.019	0.013	0.001	0.004	0.001	0.014	0.016
Res Senior Comb	6,435	0.014	0.016	0.005	0.009	0.001	0.021	0.014
Res Junior Comb	7,136	0.041	0.037	0.010	0.016	0.004	0.035	0.025
Nonres Annual	26,649	0.001	0.001	0.003	0.004	0.002	0.008	0.002
Nonres Family	17,744	0.001	0.001	0.001	0.001	0.001	0.011	0.006
Nonres Three-Day	19,557	0.000	0.000	0.001	0.001	0.001	0.006	0.002
Nonres One-Day	16,807	0.001	0.003	0.000	0.000	0.000	0.007	0.001
Total	202,669	-	-	-	-	-	-	-

Table 4.6. Estimated number of South Dakota anglers that fished at one or more of the 7 small, South Dakota lakes in my study in 2016. Estimates are calculated from internet surveys that were sent to anglers who purchased a fishing license for South Dakota in 2016.

		Estimated number of South Dakota anglers that fished at lake						
License type	Estimated anglers	New Underwood	Curlew	Fate	Brakke	Byre	Scott	Alvin
Res Adult Comb	40,472	769	809	324	607	202	1,295	971
Res Adult Annual	57,835	1,619	1,851	174	578	174	2,371	2,140
Res Senior Annual	10,034	191	130	10	40	10	140	161
Res Senior Comb	6,435	90	103	32	58	6	135	90
Res Junior Comb	7,136	293	264	71	114	29	250	178
Nonres Annual	26,649	27	27	80	107	53	213	53
Nonres Family	17,744	18	18	18	18	18	195	106
Nonres Three-Day	19,557	0	0	20	20	20	117	39
Nonres One-Day	16,807	17	50	0	0	0	118	17
Total	202,669	3,023	3,252	728	1,542	511	4,835	3,756

Table 4.7. Internet survey estimates for unique anglers and the average number of days fished for unique anglers at 7 small, South Dakota lakes in 2016. Internet surveys were sent to anglers who purchased a fishing license for South Dakota in 2016.

Lake	Estimated Unique Anglers	Average Days Fished
New Underwood	3,023	2.96
Curlew	3,252	3.09
Fate	728	2.64
Brakke	1,542	2.64
Byre	511	2.63
Scott	4,835	2.86
Alvin	3,756	3.16
Total	17,647	--

Table 4.8. Total fishing pressure in angler-days and percent fishing pressure at 7 small, South Dakota lakes in 2016. On-site surveys were conducted during the calendar year of 2016 from January-December. Internet surveys were sent to anglers who purchased a fishing license for South Dakota in 2016.

	Estimated Angler Days		Percent Angler Days*	
Lake	On-site	Internet	On-Site	Internet
New Underwood	2,696	8,945	12%	17%
Curlew	3,860	10,056	18%	19%
Fate	1,392	1,920	6%	4%
Brakke	1,851	4,063	9%	8%
Byre	1,200	1,346	6%	3%
Scott	6,527	13,821	30%	27%
Alvin	4,184	11,870	19%	23%
Total	*21,710*	*52,020*	*100%*	*100%*

*χ^2 = 2.88; *df* = 6; *p*-value = 0.824; Cramer's V = 0.120

Table 4.9. Mean Satisfaction (95% confidence intervals) of respondents with their fishing experiences at 7 small, South Dakota lakes in 2016. On-site surveys asked about anglers' daily fishing satisfaction on individual lakes, while internet surveys asked about anglers' annual fishing satisfaction on individual lakes. Satisfaction was measured on a scale from -3 to 3 (Very Dissatisfied to Very Satisfied), with 0 being "Neutral". Independent samples *t*-test comparisons were made between on-site and internet survey respondents for individual lakes, and Hedges' g (*g*) was used to provide a measure of effect size.

	Mean satisfaction ±95% CI's					*t*-test for equality of means			
Lake	On-site (daily)		Internet (annual)			*t*	df	Sig. (2-tailed)	*g*
New Underwood	1.71	±0.20	0.02	±0.17		12.56	546	<0.001	1.15
Curlew	1.71	±0.14	-0.24	±0.20	*	16.14	621	<0.001	1.09
Fate	1.75	±0.27	0.47	±0.33	*	5.90	188	<0.001	1.23
Brakke	1.32	±0.28	0.66	±0.21		3.71	307	<0.001	0.83
Byre	1.51	±0.33	0.65	±0.31		3.82	152	<0.001	0.62
Scott	1.22	±0.13	-0.15	±0.15		13.75	949	<0.001	0.90
Alvin	1.34	±0.16	-0.40	±0.16	*	15.17	688	<0.001	1.13

*Equal variance not assumed based on Levene's test.

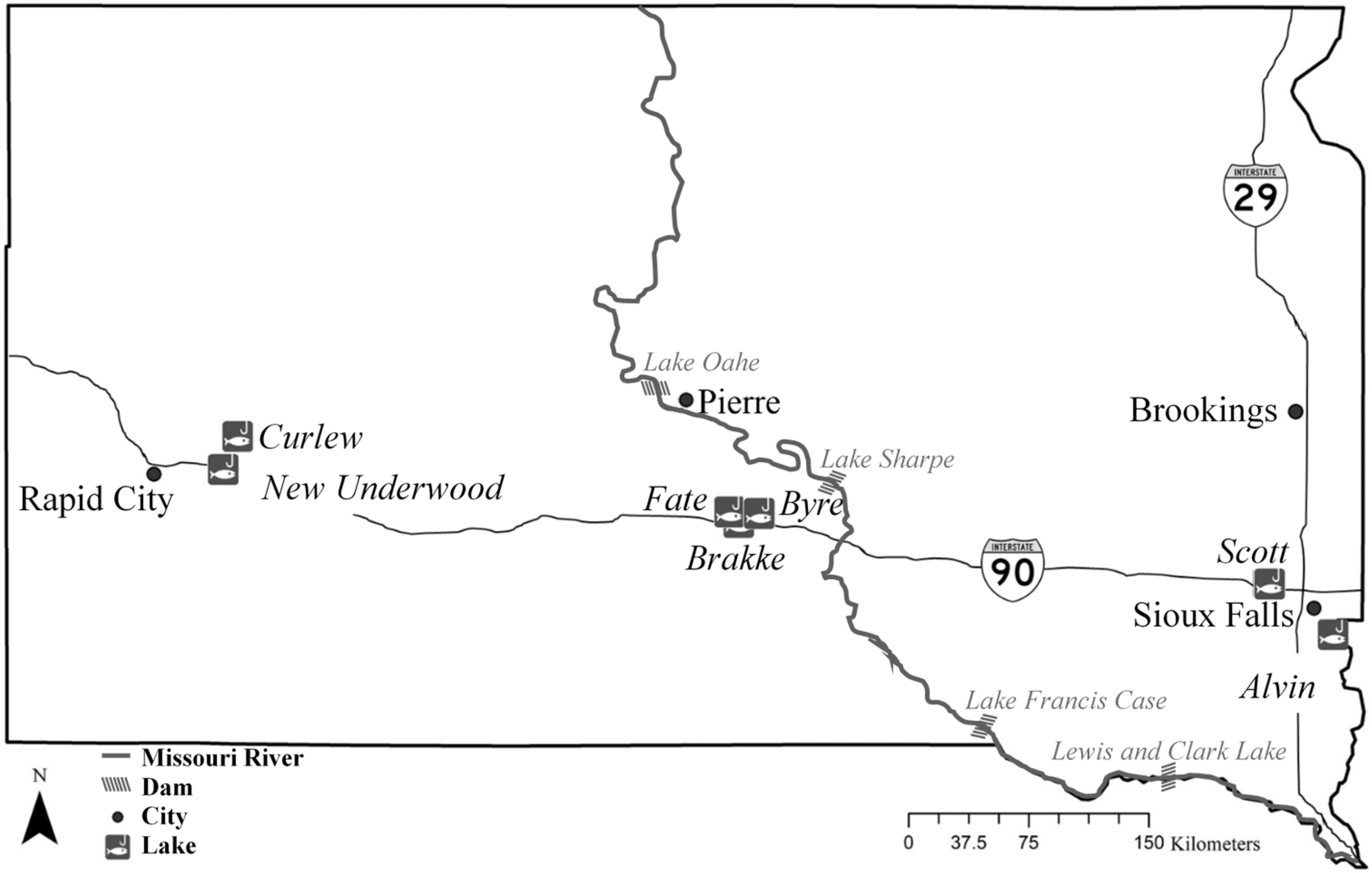

Figure 4.1. Map of the state of South Dakota, United States showing relevant urban centers, the Missouri River reservoirs and the seven small fishing lakes that were surveyed during 2016.

Ordinal Measure of Days Fished at Each Lake	Days Fished Value for each Ordinal Value
1 Day	1.00 Day
2 – 3 Days	2.34 Days
4 – 5 Days	4.34 Days
6 – 10 Days	7.34 Days
11 – 20 Days	14.00 Days
21 – 30 Days	24.00 Days
31 – 40 Days	34.00 Days
41 - 50 Days	44.00 Days
> 50 Days	64.00 Days

Figure 4.2. Conversion of ordinal response measurements of days fished to an interval scale of days fished from an internet survey sent to anglers who purchased a fishing license for South Dakota in 2016. The survey asked anglers to report days fished at 7 small, South Dakota lakes in 2016 using ordinal responses.

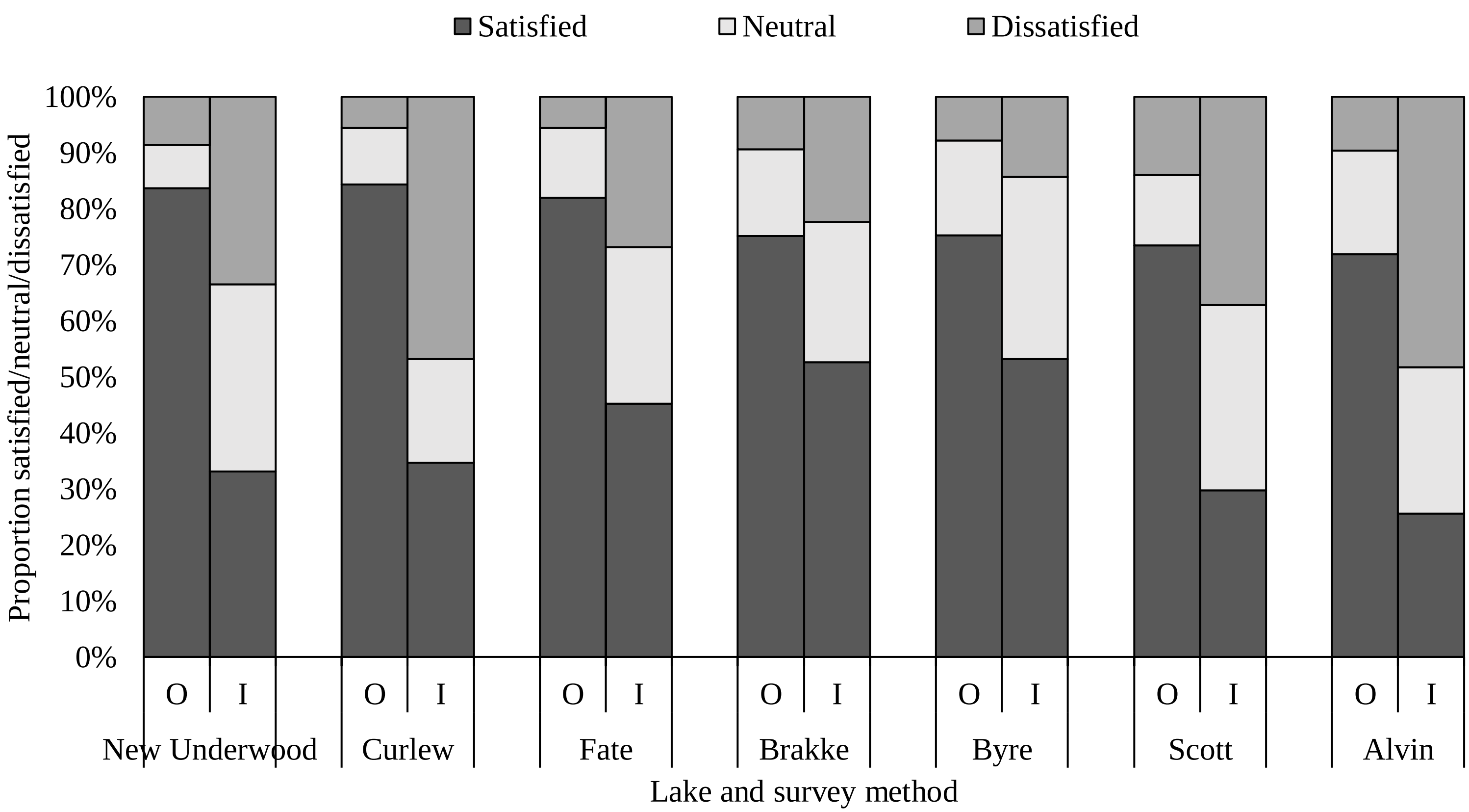

Figure 4.3. Proportion of respondents that were satisfied, neutral, or dissatisfied with their fishing experiences at 7 small, South Dakota lakes in 2016. Comparisons were made between on-site (O) and internet (I) survey respondents for each lake. On-site surveys asked about anglers' daily fishing satisfaction on individual lakes, while internet surveys asked about anglers' annual fishing satisfaction on individual lakes.

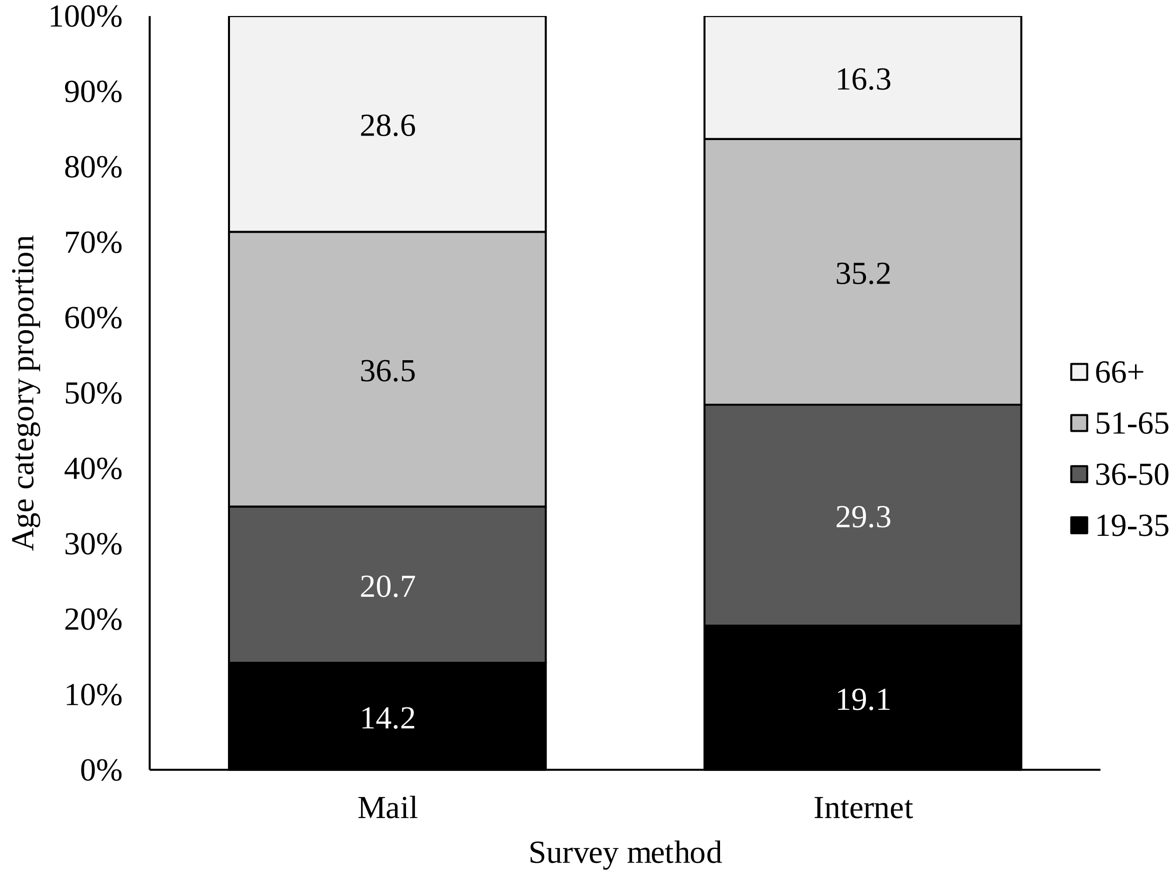

Figure 4.4. Proportions of respondent age categories for mail and internet surveys sent during 2017 in South Dakota. Mail surveys were sent to random residents of zip codes of the communities nearest to 7 small, South Dakota lakes within my study. Internet surveys were sent to anglers who purchased a fishing license for South Dakota in 2016.

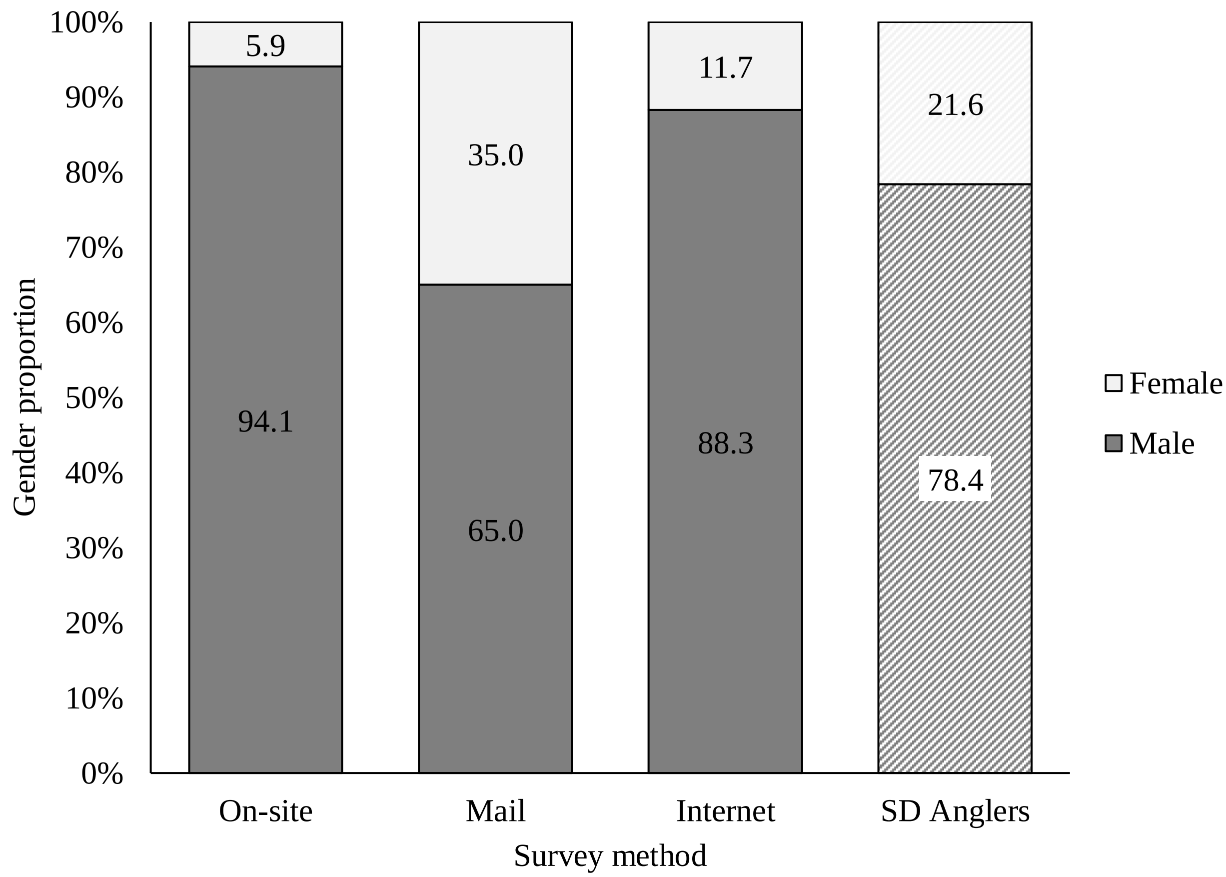

Figure 4.5. Proportional distribution of respondents' gender for on-site, mail, and internet surveys compared with South Dakota fishing license purchasers during 2016. On-site surveys were conducted during the calendar year of 2016 from January-December to collect information regarding angler demographics, economic activity, angling satisfaction, and catch at the 7 small, South Dakota lakes within my study. Mail surveys were sent to random residents of zip codes of the communities nearest to 7 lakes within my study. Internet surveys were sent to anglers who purchased a fishing license for South Dakota in 2016.

CHAPTER 5: MANAGEMENT RECOMMENDATIONS

Economic Activity Associated with Fishing at Small South Dakota Lakes

Economic activity information can be used by local management agencies to direct their efforts towards high use seasons and locations. Although ice fishing season typically represents only a quarter of the year across most of South Dakota, I found that 57% of the TEA from the lakes I studied was generated by ice anglers. Upon comparison of TEA generated during the ice fishing season at individual lakes, I observed that the four lakes with the highest proportions of ice fishing pressure (as opposed to shore and boat angling) also had the highest TEA, even when considering that three of these lakes had the lowest overall fishing pressure throughout the year. I speculate that these findings are partially a result of several annual ice fishing tournaments, relatively higher trip expenditures for ice fishing (compared to open water fishing), and unsafe ice fishing conditions at nearby fisheries of the Missouri River reservoirs, thereby drawing anglers from further distances during safe ice conditions.

I also hypothesize that special management strategies can influence the economic activity of a small fishery. From 2013-2016, the SDGFP had stocked Scott Slough with supplemental stockings of 44-130 adult size Yellow Perch per hectare, annually, with the largest stocking year occurring in 2015 (SDGFP 2017). Given the popularity of Yellow Perch *Perca flavescens* fishing at Scott Slough post-stocking, a comparison of the TEA at Scott Slough (~$44,000/year) relative to the small lakes that did not receive such supplemental stockings in my study (~$34,000/year) makes it reasonable to believe that the economic benefits of a trap-and-transfer management practice may outweigh the

associated costs by 6-fold, and that the overall TEA could have increased by 25% with the additional catchable-sized fish.

My study provides evidence of the importance of community events (i.e. fishing tournaments) in increasing the TEA of a small fishery and that these small fishing lakes are important assets to local communities. This suggests that there are opportunities for fisheries management agencies to form partnerships with local communities to raise funds for lake improvements and to sponsor fishing events. My study also indicated that special management strategies, such as the stocking of a catchable-size popular sportfish, can generate excitement around a fishery that may increase its use and economic activity. Future research may include a greater diversity of small fisheries to gain a more accurate understanding of the economic activity that they generate. With more information on the value of small fishing lakes in South Dakota, managers and lawmakers may be able to make more informed decisions on regulations, events, and fisheries improvements that will have a positive economic contribution to the state's fishing industry.

Social Value of Small South Dakota Lakes to Local Communities

Managers of public trust resources (i.e. government officials, private charities, community organizers) are increasingly expected to show the wider benefits of their sites in terms of society and community development in the form of environmental services (ES; Stolton et al. 2015). Freshwater lakes are resources that provide a wide array of ES that are important to individuals, society, and the environment, which include: food security, economic security, empowerment, cultural services, recreational services, human health and well-being, knowledge transfer and capacity building, ecosystem function and biodiversity, aquatic "canaries," and "green" food opportunities (Lynch et

al. 2016). Based on the results of my economic study, I speculate that social values may be as important as the economic contribution of fishing in understanding the overall value of these water resources to residents of local communities. Adding community mail surveys to the results of my previous economic study would contribute measurements of a wider range of benefits provided by lake resources. A more expansive evaluation of social values of lakes may justify spending additional funds on improvements which could result in significant long-term increases to the use of these lake resources and return-on-investments in the form of overall resource use and community satisfaction. Surprisingly, I found that angling opportunities provided by individual lakes were not important in predicting the contribution of the lakes towards residents' quality of life. Rather, the indicated quality of life provided by these small lakes was most related to a sense of community, a wider variety of leisure opportunities, and the economic benefits they provide to the community. With desires for lakes to provide economic and social opportunities for local communities, it is becoming increasingly important for agencies to collaborate with communities and local stakeholders to fulfil management desires.

My findings provide empirical evidence for the desire to incorporate community participation and economic growth objectives into management plans for local lake resources. Not only do these lakes contribute in economic value through angling opportunities, they also contribute in the form of non-market social values, such as increased community involvement, expanded recreational opportunities, and a greater overall quality of life. Realizing the diversity of recreation and leisure opportunities that lakes and adjacent lands can provide may be a simple, but critical, step in increasing economic opportunity for local regions and for providing a place for communities to hold

events and ceremonies. Managers of these resources may find that agency-community collaboration, and careful co-management, can provide positive outcomes in the form of increased satisfaction amongst users and local communities, as well as increased overall use of the resources.

Comparisons of Survey Methods for Collecting Angler Information

Traditionally, methods for including public input have relied primarily upon on-site, mail, and telephone surveys. Over the years as internet technology has expanded, many wildlife and fisheries agencies have begun to utilize online and cellphone app surveys as a means to deliver, accept, and summarize results from their customers in a relatively cheap and timely manner. Selection of the appropriate survey methods requires researchers to identify issues such as survey length, completion time, accuracy of expected answers, complexity of questions, equipment and facilities required to conduct the survey, personnel requirements, and availability of contact information from the identified sampling frame (Vaske 2008). My study focused on the extent to which the various survey methods are able to provide similar estimates of important metrics that are used to manage recreational resources. As such, I compared the quality of data collected using on-site, mail, and internet survey data from the 2016 fishing year. My primary objective was to determine the ability of internet surveys to estimate fishing pressure at small South Dakota lakes (evaluated with data estimated using on-site surveys of fishing pressure), and my secondary objective was to compare three metrics (age, gender ratios and satisfaction of anglers' fishing experiences) across applicable survey methods to demonstrate how these metrics can vary across survey methods and sampling frame. I found that my internet surveys consistently overestimated fishing pressure (measured in

angler-days) at all seven lakes compared to the fishing pressure estimated from my on-site surveys. I suggest a few alternative uses for internet survey pressure estimates, such as making relative comparisons across time scales and across other similar lakes, or creating correction factors to extrapolate on to internet survey pressure estimates from other similar lakes.

I found relatively large and consistent variations in satisfaction ratings measured by on-site and internet surveys. Anglers responding to on-site surveys reported greater satisfaction with their fishing experience compared to anglers responding to internet surveys. This may be a function of the surveys being administered using different time frames, which means they are actually measuring different concepts. Because variation in time frames measured by different survey methods can affect the outcomes of satisfaction responses, care must be used while comparing and interpreting satisfaction measurements between on-site and offsite measures of recreational experiences.

I found that internet survey respondents were significantly younger than mail survey respondents, and that gender proportions also differed significantly between all three survey methods. One of the most important implications for managers and planners has to do with recruiting, retaining, and reactivating (R3) outdoor recreationists. Understanding differences that may exist in motivations between genders and what makes each gender more satisfied is critical to R3 efforts, and significant gender bias within the coverage of a survey sample may underrepresent these measurements relative to the actual population.

I suggest that managers consider using survey methods that involve shorter recall periods if greater accuracy is an important survey objective, as well as incorporating

mixed-mode survey methods into their sampling design. There is no doubt that internet surveys will continue to be rapid and cost-effective as a form of data collection from anglers. However, given the limitations and biases that I have discussed, the ability to incorporate an on-site survey design to pair with an off-site internet survey would allow for researchers to reduce measurement errors and reduce the effects of many of the sampling biases I have described. As technology advances and the number of people who have access to the internet increases, the internet will continue to develop into a major instrument of data collection for resource managers and social scientists. However, managers must be careful when interpreting and comparing the results of internet surveys with on-site and mail survey results.

Conclusion

Decision-makers must consider all of the values associated with small fishing lakes when prioritizing and administering activities that will affect both users and non-users of the resources. Economic data for the seven small lakes in this study will provide the South Dakota Game, Fish and Parks with more precise estimates of economic activity that can be expected at the ~400 similar small fishing lakes across the state. In addition to the economic information, my social evaluation of these lakes contribute considerably to the appraisal of overall values associated with small recreational lakes in South Dakota. A more expansive evaluation of values associated with small lakes may justify spending additional funds on improvements which could result in significant long-term increases to the use of these lake resources and return-on-investments in the form of overall resource use and community satisfaction. To be able to collect relevant and unbiased information about lakes from users and non-users, it is imperative to select the appropriate survey

methodology. This will lead to more accurate data and more informed decisions, which serves everyone's best interest.

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Appendix A. Survey instrument used by creel clerks in South Dakota small lakes economics study in 2016.

Date: ____/____/ 2016
Month Day

Lake: ❑Scott ❑Alvin
❑ Brakke ❑Fate ❑Byre
❑ New Underwood ❑Curlew

Time: ________ / ________ / ________ Completed Trip: ❑
start fishing / interview / finish fishing

Activity: Fishing: ❑Shore ❑Boat/etc. ❑Ice ❑Other: ________________
Boating: ❑Boat ❑Canoe ❑Kayak ❑Other: ________________

Party Composition: Adults (18 and older): [_____] Males [_____] Females

Children (number/ages): Males: [___/__________] Females [___/__________]

Interviewee: ❑Male ❑Female

License Code(s):

Distance traveled from home ❑ or other ❑: _______miles

Residence/Zip Code: ______________

Expenditure Type (total for party):	Money Spent by party
Restaurants/Bars/Taverns	
Grocery/Convenience stores / liquor stores	
Fishing gear	
Boat Fuel	
Bait	
Lodging (if they traveled from "other")	
Other: list	

Other list, e.g.: car rental, repairs to fishing equipment or boat, taxidermy, or anything bought specifically for this trip (e.g., special clothing), even if it will be used for future fishing/boating trips.

Importance: [______] / Rating of Fishing: [______] / Satisfaction: [______]

Fish Caught & Kept by fishing party:

Fish	Caught	Kept	Fish	Caught	Kept
Yellow perch			Catfish		
Walleye			Bullhead		
N. Pike			Trout		
Largemouth Bass			Carp		
Crappie			Drum		
Sunfish					

Other: list #Caught/Kept ____

Appendix B. Example of lake specific questions (questions 1 – 5) asked on the community surveys and general questions (6 – 9) asked at the end of each survey.

(name of lake)

1. How familiar are you with (*name of lake*)? *Please check the response that best describes how familiar you are with (name of lake).*

   - ❑ a) **Completely unfamiliar**, i.e., I don't even know where it is or don't remember ever hearing about (*name of lake*) → *Please skip ahead to question # 6 (page 4)*
   - ❑ b) **Slightly familiar** – I know where it is but I have never actually visited (*name of lake*), other than maybe driving past it → *Please skip ahead to question # 4 (page 3)*
   - ❑ c) **Moderately familiar** – I have visited (*name of lake*) (meaning you stopped there either for fishing or for other reasons) a few times (less than 10 visits ever)
   - ❑ d) **Very familiar** – I have visited (*name of lake*) (either for fishing or other reasons) many times (10 or more total visits ever)

2. What types of activities have you done on any of your visits to *(name of lake)*? *Please check all that apply.*

❑ a) Shore fishing	❑ b) Boat fishing	❑ c) Ice fishing
❑ d) Picnicking	❑ e) Taking your dog for a swim	❑ f) Swimming
❑ g) Getting together with some friends (not fishing)	❑ h) Getting some alone time to enjoy nature	❑ i) Taking a family there to enjoy the area
❑ j) Hunting	❑ k) Other, *please specify*: ______________________________	

➢ If you did any fishing at *(name of lake)* in 2016 (January 1 – December 31) about how many days did you do each type of fishing in *(name of lake)* in 2016?

______ Days of Shore Fishing

______ Days of Boat Fishing

______ Days of Ice Fishing

3. If you fished in *(name of lake)* in 2016, please answer this set of questions, if not than skip ahead to the next section.

How would you rate *(name of lake)* on each of the following……	**Very Poor**	**Poor**	**Fair**	**Good**	**Very Good**	**No Opinion**
a) Management of the fishery by Game, Fish & Parks	❑	❑	❑	❑	❑	❑
b) Overall fishing quality	❑	❑	❑	❑	❑	❑
c) Shore fishing opportunities	❑	❑	❑	❑	❑	❑
d) Boat fishing opportunities	❑	❑	❑	❑	❑	❑
e) Ice fishing opportunities	❑	❑	❑	❑	❑	❑

4. Your Opinions about ***(name of lake)***

(*name of lake*)…	**Strong Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**No Opinion**
a) Is scenic	❑	❑	❑	❑	❑	❑
b) Is peaceful	❑	❑	❑	❑	❑	❑
c) Has good water quality	❑	❑	❑	❑	❑	❑
d) Is often crowded	❑	❑	❑	❑	❑	❑
e) Is important to me	❑	❑	❑	❑	❑	❑
f) Has good fishing	❑	❑	❑	❑	❑	❑
g) Is a place I enjoy visiting	❑	❑	❑	❑	❑	❑
h) Is a good place to take a family	❑	❑	❑	❑	❑	❑
i) Is important to some local businesses	❑	❑	❑	❑	❑	❑
j) Is an important community resource	❑	❑	❑	❑	❑	❑

5. Overall, how would you rate the importance of *(name of lake)* to your overall quality of life living in Lyman County?

Not at all Important	Slightly Important	Moderately Important	Very Important	Extremely Important
❑	❑	❑	❑	❑

6. **Skip this question if you do NOT fish.** How important is **fishing** to you in relation to all your other types of recreation? *Please check (☑) only one response.*

❑ 1. MY MOST IMPORTANT RECREATIONAL ACTIVITY

❑ 2. VERY IMPORTANT, BUT NOT THE MOST IMPORTANT

❑ 3. MODERATELY IMPORTANT

❑ 4. SLIGHTLY IMPORTANT

❑ 5. NOT IMPORTANT

❑ 6. NO OPINION

Information about Yourself

7. How many people live at the address where this survey was sent?

______ Adult males (including adult children age 18 or older)

______ Adult females (including adult children age 18 or older)

Children:	Ages	Males	Females
	0 – 5	______	______
	6 – 11	______	______
	12 - 17	______	______

8. About how many years have you lived at this address? ______ years

9. Your age: _______ Gender: ❑ Male ❑ Female

(spaces was provided for optional comments)

Appendix C. Example of the internet survey sent to fishing license purchasers in South Dakota in 2017. In addition to questions about the anglers and their fishing experiences in South Dakota as a whole, I included surveys were questions specific to 7 small lakes that were also part of the corresponding economics and social values studies. This example shows these specific questions from Scott Lake. However, the questions specific to the other 6 lakes were identical.

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

1. Fishing Activity

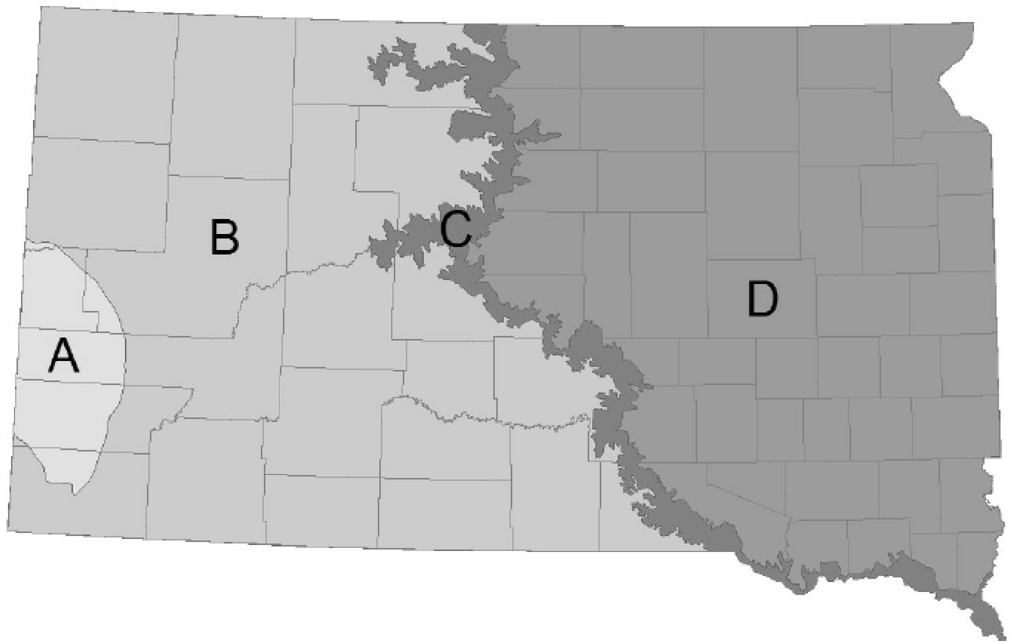
* 1. About how many days did you fish in South Dakota during the entire year of 2016 (January 1 - December 31, 2016)? If you did not fish, please select 0, which will skip you to the end of the survey.

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

2. Where You Fished?

1

South Dakota Regions



2. Where did you fish last year? Please estimate the number of days that you fished in each region of the state indicated on the above map.

Your total should equal the total NUMBER of DAYS that you listed in question # 1. Fill in all boxes (write a zero (0) for any place that you did not do any fishing).

A. Black Hills (Days)

B. West River (outside of the Black Hills) (Days)

C. Missouri River (Days)

D. East River (Days)

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Conducted by South Dakota State University for S.D. Game, Fish, & Parks

3. Fishing: Harvest and Evaluation

3. To the best of your ability please estimate how many of the following types of fish you **kept** for all of your fishing in South Dakota in 2016. Please write zero (0) or leave blank if you did not keep any of the fish species listed here.

Walleye and/or sauger - Total Kept	
Bass (largemouth and/or smallmouth) - Total Kept	
Northern pike - Total Kept	
Trout (all types) - Total Kept	
Yellow perch - Total Kept	
Catfish and/or Bullhead - Total Kept	
Sunfish (bluegill, green, rock bass) - Total Kept	
Crappie - Total Kept	
Carp (common carp and/or silver carp) - Total Kept	
White bass - Total Kept	

4. How would you rate the fishing in South Dakota last year (2016) in terms of numbers and size of fish caught?

- Very Poor
- Poor
- Fair
- Good
- Very Good
- No Opinion

5. Overall, how dissatisfied or satisfied were you with your total South Dakota fishing experience last year (2016)?

- Very Dissatisfied
- Moderately Dissatisfied
- Slightly Dissatisfied
- Neutral or No Opinion
- Slightly Satisfied
- Moderately Satisfied
- Very Satisfied

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

4. Fishing Companions

6. Please check who you fished with in South Dakota in 2016 (please check all that apply).

- [ ] fished alone
- [ ] fished with South Dakota family members, relatives and/or friends
- [ ] Fished with nonresident family members, relatives and/or friends
- [ ] fished in tournaments
- [ ] fished as a club activity

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

5. Special Focus Area - **Scott Lake**

Seven small lakes or impoundments have been selected for a special focus on use this year. Please check no or yes to each question asking if you fished that lake or impoundment in 2016. Checking yes will direct you to a small set of questions specific to the lake or impoundment. Checking no or not sure will skip you to the next lake or impoundment.

Because these questions have a skip-function you must answer the question to proceed through the survey.

7. Did you fish at Scott Lake in 2016?
(Scott Lake is located in Minnehaha County, near Hartford, west of Sioux Falls)

- ◯ No
- ◯ Yes
- ◯ Not Sure

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

6. Fishing at Scott Lake

Located in Minnehaha County, near Hartford, west of Sioux Falls.

8. About how many days did you fish at Scott Lake in 2016?

9. About how far from your home is Scott Lake?

10. For your fishing at Scott Lake ...

- did you travel there from home specifically to fish
- were you in the area visiting family/friends
- were you vacationing or camping in the area
- just traveling through and stopped to fish
- other

11. How would you rate Scott Lake in terms of ...

	Very Poor	Poor	Fair	Good	Very Good	No Opinion
Numbers of fish caught						
Sizes of fish caught						
Water quality						
Shore fishing access						
Boat fishing access						
Facilities at the lake						
Appearance of the area						
Solitude/Peacefulness						
Being a place for family fishing						

12. In terms of all the fishing you normally do in a year, how important is Scott Lake to your overall enjoyment and ability to fish in South Dakota?

- Not Important
- Slightly Important
- Moderately Important
- Very Important
- No Opinion

13. Overall, how dissatisfied or satisfied were you with your fishing at Scott Lake last year (2016)?

- Very Dissatisfied
- Moderately Dissatisfied
- Slightly Dissatisfied
- Neutral (neither dissatisfied or satisfied)
- Slightly Satisfied
- Moderately Satisfied
- Very Satisfied
- No Opinion

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

7. Special Focus Area - **Lake Alvin**

14. Did you fish at Lake Alvin in 2016?
(Lake Alvin is located in Lincoln County, south of Sioux Falls)

- No
- Yes
- Not Sure

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

55. Overall, how dissatisfied or satisfied were you with your fishing at Curlew Lake last year (2016)?

- Very Dissatisfied
- Moderately Dissatisfied
- Slightly Dissatisfied
- Neutral (neither dissatisfied or satisfied)
- Slightly Satisfied
- Moderately Satisfied
- Very Satisfied
- No Opinion

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

19. Reasons for Fishing, Importance of Fishing & Information About Yourself

56. Which statement best describes the MOST important reason for why YOU like fishing.

- To bring fish home to eat
- To enjoy nature, the outdoors and the beauty of the area
- For the excitement that fishing provides, e.g., the feeling one gets when you have a fish on the line, etc.
- For companionship, enjoying the time spent with friends and/or family
- To catch a trophy fish to hang on the wall or otherwise to demonstrate fishing skills and accomplishment
- To get away and relax
- To learn and perfect fishing skills to become a proficient angler
- To compete in a fishing tournament

57. How important is fishing to you in relation to all you other types of recreation? Fishing is...

- 1. My MOST Important recreational activity
- 2. Very Important, but not the most important
- 3. Moderately Important
- 4. Slightly Important
- 5. Not Important
- 6. No Opinion

58. What is your gender?

- Male
- Female

59. What is your age?

Years

60. In what county do you live?

Angler Survey 2016 - Adult Combination License (2016)
Conducted by South Dakota State University for S.D. Game, Fish, & Parks

20. Optional Comments

Thank you for participating in this year's "Fishing in South Dakota" survey!

61. You can use this space for optional comments about fishing in South Dakota. These comments will be added to the report that will be given to the GFP Commission, staff and made available to the public.

Please do NOT include your name or contact information because these comments may become public information.

Also, please do not use this space to request information or expect a response from specific questions because GFP does not receive these comments until the final report is produced and an effort is made to remove contact information before the information is compiled into a report.