SEGMENTING ANGLERS BY
LIFESTYLES, LAKE TYPES, AND MANAGEMENT PREFERENCES

By

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ABSTRACT

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Information on angler behaviors and preferences is vital for management efforts that enhance fishery resources and provide public benefits. This dissertation adds to the angler human dimensions literature on angler segments and preferences by using two surveys of Michigan's recreational anglers in support of three dissertation chapters to: (1) test the effectiveness of a widely-used marketing segmentation methodology for profiling angler behavior, (2) enhance existing lake classifications with data on user (i.e. angler) characteristics and fishing behaviors and, (3) model anglers' preferences over management outcomes in the Great Lakes.

In the first chapter, although the commercially-available classification approach examined is easily implemented, the evaluation suggests that while adept at producing market segments that are accessible and stable over time, statistical relationships between our segment variable and the fishing behaviors and purchase behaviors were generally weak. The results highlight limitations of using this generic approach to develop market segments that exhibit similar within-group fishing and license purchase behaviors.

Chapter two examines the relationship between a recent inland lake landscape-based classification effort and angler-reported trip characteristics from an ongoing, statewide angler survey. The research goal was to develop managerially-relevant inland lake angler descriptions. Results from a multinomial probit model largely supported the descriptive analysis. Marginal effects for several of the angler trip characteristics and species targets were large and statistically

significant. While not originally intended as an angler behavior classification strategy, the result demonstrate that the lake characteristics and species assemblages used to classify Michigan's inland lake resources may also serve as an integrated (social and biological) classification system for inland lake fisheries resources.

In support of Great Lakes management plans, chapter three reports on a stated preference survey of Michigan anglers' preferred outcomes from management activities in four Great Lakes and Lake St. Clair. Discrete choice trade-off questions were analyzed using conditional logit models. Results showed anglers generally expressed stronger preferences for management outcomes related to ecosystem health attributes and recreational opportunity attributes. To further demonstrate the managerial applications of the trade-offs quantified by the research, predicted preferences were calculated to illustrate the importance of species abundance relative to increasing average fish size. The model was also used to calculate choice probabilities for three hypothetical Great Lakes management strategies which differed in their emphasis on Pacific salmon, prey base, risks of ecosystem collapse and average fish size. Specifically, predicted probabilities were calculated for management outcomes that emphasized; (A) an fishery with more Pacific salmon and less native sportfish, (B) less Pacific salmon and more native sportfish, and (C) the status quo or same as today management option. In general, choice probabilities for the average angler, which can be interpreted as the average amount of support for management outcomes, were greater for management outcomes favoring a native species emphasis.

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INTRODUCTION

Fisheries management represents a complex socio-ecological system (Martin & Pope 2010) and licensed anglers represent one of the most important constituent groups for state fishery managers (Connelly, Keeler, & Knuth. 2013). Therefore, information on angler behaviors and preferences is vital for management efforts that enhance fishery resources and provide public benefits.

Michigan's vast freshwater resources include four Great Lakes, Lake St. Clair and thousands of inland lakes. Faced with the challenge of managing heterogeneous systems across large landscapes, many state agencies utilize resource classification systems to describe and inventory resources and plan for and prioritize their management activities. In addition nearly all state fisheries management agencies have implemented angler data collection strategies to inform fisheries management plans and to better understand and communicate with anglers (e.g. creel surveys, license sales analyses, angler surveys, marketing and outreach activities) (Simoes 2009).

The objectives of this dissertation are to (1) evaluate a segmentation method for developing actionable angler market segments for marketing and outreach efforts, (2) develop a managerially-relevant inland lake angler classification system and, (3) measure and forecast angler's preferences for Great Lakes management. These objectives are addressed in turn in each of the three chapters of this dissertation.

Two surveys of Michigan's recreational anglers support these efforts. The Michigan Recreational Angler Survey (MRAS) was designed as part of a long-term, statewide survey strategy to describe the status and distribution of angling effort across all of Michigan's fisheries (Simoes 2009). The MRAS database provides a rich source of self-reported demographic information as well as fishing behaviors. As an outgrowth of that effort, the multi-mode Great Lakes Angler Survey was developed to inform Great Lakes management plans. In addition to demographics and general fishing behaviors, the Great Lakes Angler Survey included questions related to program awareness, management preferences, management opinions and a stated preference choice experiment section.

Researchers have used a broad range of individual-level variables and broader socialization or social-structural variables to describe recreational subgroups and their behaviors. Commercially-available segmentation systems linked to zip codes (e.g. Esri Tapestry™ Segmentation) are widely available and offer a convenient method for developing information-rich and accessible consumer profile descriptions. The approach has also been advocated for informing angler recruitment and retention strategies because some segments exhibit different propensities to purchase licenses Southwick Associates (2006). Chapter one builds upon this earlier research by using self-reported fishing behavior data from the MRAS and license purchase behavior from the Michigan Retail Sales System license database to further evaluate the effectiveness of this segmentation strategy for developing behaviorally-distinct angler market segments. Weak associations between the behavior variables and the market segments we tested suggest that the exclusive use of LifeMode classifications to reach anglers with specific behaviors is unlikely to be effective. However future examination may be warranted in light of the availability of less aggregated Esri Tapestry™ segments and the anticipated improvements in these segments with continued growth and diversity of consumer information resources.

In lake-rich states such as Michigan, the multitude of inland lakes, their diverse morphological, chemical and biological characteristics and differing fisheries management strategies result in wide array of angling experiences available to anglers. To characterize Michigan's inland lake fishery resources and inform management decisions, Wehrly et al. (2012) identified six distinct inland lake classes and fish assemblages utilizing biological data and spatially extensive variables. In order to develop managerially-relevant inland angler profiles, Chapter two employed a multinomial probit model to examine the relationship between the outcome variable (lake class) with information from the MRAS database including demographics and detailed information on fishing trips (the nature of the trip, methods used and species targeted) as our predictor variables. The results demonstrate that some trip characteristics and trips targeting particular species significantly increased the likelihood of fishing in particular inland lake classes. While the influence of lake characteristics on angler behavior may seem intuitive (i.e. the effect of lake size, lake remoteness, and species profiles) our results show that the relationship is not completely reliable. For example, some inland lake classes attracted anglers targeting species that were not relatively abundant, and therefore not prominent in the original classification strategy. While not originally intended as an angler behavior classification strategy, the result demonstrate that the lake characteristics and species assemblages used to classify Michigan's inland lake resources may also serve in an integrated (social and biological) classification system for inland lake fisheries resources.

Great Lakes management strategies are characterized by conflicting and often polarizing management approaches related to Pacific salmonines and native species rehabilitation. Additional system-wide management challenges stem from invasive species impacts and broader environmental changes occurring in the Great Lakes. Policy decisions and management strategies are further complicated by a lack of Great Lakes angler preference information. The Great Lakes Angler Survey for Chapter three included a stated-preference choice experiment to examine Michigan anglers' preferred outcomes from management activities in four Great Lakes and Lake St. Clair. Broadly, respondents were more supportive of management outcomes favoring walleye, yellow perch and salmon species, and were indifferent in terms of lake trout abundance. However, preferred lake management outcomes differed by lake. To further illustrate managerial implications of the results, we used the model to predict support for Great Lakes management strategies differentiated by their emphasis on Pacific salmon, prey base, risks of ecosystem collapse and average fish size. In general, choice probabilities, interpreted as predicted support, were greater for outcomes with a native species emphasis. In contrast to single-item opinion measurement questions, the stated-preference choice model provides Great Lakes managers with an understanding of the relationship and relative importance of multiple management attributes as they contribute to angler preferences for management outcomes, and the tradeoffs anglers might make when considering both ecosystem health attributes and recreational opportunity attributes jointly.

CHAPTER 1

Evaluating the effectiveness of a commercial geodemographic market segmentation methodology for classifying recreational angler behavior

Motivation

Despite continued population growth, U.S. fishing license sales peaked in 1988 and have continued on a gradual downward trend, with national sales in 2013 down 11% (USFWS 2014). For most states, license fees combined with federal excise taxes represent the vast majority of state expenditures for fisheries management. Therefore, general declines in license sales and angling participation have a direct impact on the ability of fisheries agencies to manage fisheries, protect and enhance aquatic resources and meet angler needs. Beyond the possible financial implications, a declining recreational angler constituency may erode public and political support for fisheries management and aquatic resource conservation (e.g. Organ et al. 2012; Sutton, Dew & Higgs 2009). Angling participation is also of interest to the fishing industries and businesses that support angling activities (Murdock, Backman, Ditton, Hoque & Ellis 1992; Sutton, Dew & Higgs 2009; Aas & Arlinghaus 2009; Kuehn, Luzadi & Brincka 2013). Declines in U.S. license sales and fishing participation have been a catalyst for state, federal, academic and private sector participation research and recruitment and retention initiatives. Beginning the mid 90's, surveys of agency personnel revealed that many state fisheries agencies had implemented public awareness and education strategies (Ross & Loomis 1999), angler human dimensions surveys (Wilde, Ditton, Grimes, & Riechers 1994; Fisher & Burroughs 2003), and recruitment and retention efforts (Mather, Parrish, Stein, & Muth 1995). To specifically address declines in angling and hunting participation, natural resource agencies have instated advisory boards

(Illinois Department of Natural Resources 2009) developed recruitment and retention action plans (Oregon Department of Fish and Wildlife 2012), developed agency-stakeholder recruitment and retention councils (Minnesota Department of Natural Resources 2013) and incorporated management metrics for ongoing evaluation of participation rates (Michigan Department of Natural Resources 2013). Researchers have examined the relationship between angling participation and demographic characteristics, motivations and cognitions (e.g. Fedler & Ditton 2001; Bissel, Duda, & Young 1998; Floyd & Lee 2002; Heberlin, Serup, & Ericsson 2008; Schroeder, Nemeth, Sigurdson, & Walsh 2008; Arlinghuas 2006; Hunt & Ditton 2002; Arlinghaus, Tilner & Bork 2014; Schroeder, Fulton, Nemeth, Sigurdson, & Walsh, 2008)). Consulting firms have developed marketing plans (e.g. Responsive Management 2009) and conduct ongoing participation and market trend analyses (e.g. Southwick Associates 2012) to aid agency decision making. Finally, revenues generated as part of the Sport Fish Restoration Act provide grant support for outreach, education and participation research and fund the Recreational Boating & Fishing Foundation "Take Me Fishing ™" national campaign aimed at increasing boating and fishing participation through advertising, direct mail marketing, educational programs and commissioned research. A series of recent projects, funded by Sport Fish Restoration multi-state grants, have classified anglers using a commercially available geodemographic classification system (i.e. Esri Tapestry™ Segmentation) with the goal of identifying market segments to inform recruitment and retention campaigns (see American Sportfishing Association 2007; Southwick Associates 2007; Southwick Associates 2006). Geodemographic segmentation is a neighbored classification approach which combines information from public and private resources to characterize and group households. The method is widely applied by businesses, and the above projects have shown that commercially available geodemographic segments can be used to identify addresses in neighborhoods that are more likely to purchase licenses. This paper further explores theses segmentation approaches with a specific focus on their relationship to angler behaviors.

Commercially available market segmentation systems are widely applied in the private sector for informing business decisions. Data compilers, marketing firms, and the businesses utilizing this information benefit from increased accessibility to a range of information on consumers and consumer behavior from both public and private sources as well as improvements in technology and computational power. Our primary objective was evaluate the utility of the Esri Tapestry™ Segmentation approach as an angler market segmentation methodology, specifically in developing distinct angler subgroups in terms of their fishing and license purchase behaviors. While there is a rich body of work conducted by human dimensions researchers to support the concept of angler segments exhibiting significant differences in motivations, preferences, behaviors and participation, the human dimensions literature lacks an evaluation of these commercially available, generic segmentation approaches. Knowledge of current limitations and future research needs is critical as managers, researchers, stakeholders and businesses consider these programs for profiling angler subgroups, predicting participation and developing targeted marketing and communication efforts for education, promotion and related recruitment and retention purposes.

Background

A Marketing Approach to Natural Resource Management

Operating within diverse and often competitive consumer markets, market segmentation techniques have been widely applied in the private sector to drive all aspects of marketing tactics (e.g. distribution, product development, site location, pricing, media choice) and to define overall organizational strategic planning and mission development (Tonks 2009). The opposite or “mass marketing” approach for products and services finds fewer applications in businesses and in market research (e.g. Vogt 2011, Bruwer & Li 2007).

In the public sector, movement toward a marketing-oriented approach has mirrored development within the private sector, as agencies revise standardized service approaches in favor of targeted strategies aimed at satisfying the identified needs of particular client groups (Crompton & Lamb1986). Angler human dimensions research, so often motivated by agency management issues related to user group conflicts, equity, regulation formation, and participation declines is grounded in the premise that the “average angler” does not exist, originally inspired by Shafer’s (1969) research. More than three decades of human dimensions research has produced a rich body of literature to support the concept of angler populations as a collection of heterogeneous subgroups. These subgroups often exhibit significant differences in preferences, motivations and behaviors (e.g., Bryan 1977; Chipman & Helfrich 1988; Ditton 1996; Fisher 1997; Romberg 1999; Connelly, Knuth, & Brown 2001; Finn & Loomis 2001; Hunt & Ditton 2002; Sutton 2003; Kyle, Norman, Jodice, Graefe, & Marsinko 2007; Anderson, Ditton, & Hunt 2007; Hutt & Bettoli 2007).

The user profile research conducted to support natural resource agency decision making connotes a “marketing perspective” (Ditton 1996). Many human dimensions researchers have noted the marketing-related applications of this research, including: promoting more active and targeted engagement within a broader competitive leisure market (Aas & Arlinghaus 2009); designing promotional strategies (Floyd & Lee 2002; Schroeder et al. 2008); informing outreach and communication programs (e.g. Romberg 1999; Brown 1987; Connelly, Brown, & Knuth

2000; Ditton 2004); developing marketing strategies and identifying market products (Scott, Ditton, Stoll, & Eubanks. 2005; Connelly et al. 2000); targeting angler groups for public involvement and education efforts (Romberg 1999); providing information to transform attitudes and beliefs of citizens (Chase, Lauber, & Decker, 2001) and , increasing customer awareness and satisfaction and addressing user group conflicts (Ditton 1996).

The cognitive and motivational theoretical approaches commonly used by market researcher (as well as human dimensions researchers) to predict and explain human behavior have been adapted from the psychology and social psychology fields. Cognitive hierarchies model the impact of vales, attitudes and norms on behavioral intentions and behavior (Fishbein & Ajzen 1975). Subsequent reconceptualization (e.g. Warhsaw 1980a 1980b) emphasized the importance of condition-specific cognitive measures, consumer needs (i.e. motivations) and constraints (e.g. capability, affordability, accessibility). Contemporary consumer behavior models illustrate a wide array of internal (e.g. attitudes, motivations, perception) and external (e.g. family, demographics, reference groups, culture) domains that may influence individual behaviors (Hawkins & Mothersbaugh 2010). These factors interact with each other and together drive the development of self-concept and it's manifestation: "lifestyle"- or the way consumers live, including the products purchased and how consumers use them, think about them and feel about them (Hawkins & Mothersbaugh 2010, O'Shaughnessy 2013)

Recreation Participation Research

Leisure and human dimensions research related to recreation participation (including fishing and hunting) has explored a broad range of variables at the individual-level (i.e. cognitions, demographic characteristics, motivations) as well as broader socialization or social-structural influences (i.e. family, society, environment). Measures of cognitions can contribute to the understanding recreation behavior including participation patterns (Hunt & Grado 2010;

Vaske & Manfredo 2012). A number of demographic and socio-demographic variables have also been found to relate to fishing participation including gender, race and age (e.g. Fedler & Ditton 2001; Floyd & Lee 2002; Floyd, Nicholas, Lee, Lee, & Scott 2006; Hunt & Ditton 2002.) The relatively limited research examining the relationship between motivations and fishing participation has found associations between affiliation (Fedler 2000) as well as appreciation and health motivation factors (Schroeder et al. 2008).

Recent research related to hunter recruitment and retention and global fishing participation rates has advocated for expanding upon the use of individual-level variables to include higher-order influences (see Larson, Stedman, Decker, Siemer, & Baumer 2014 and Arlinghaus, Tillner, & Bork 2014). These researchers argue that individual decision making and behaviors are nested within and influenced by social-structural variables. For hunting, Larson et al. (2014) posit the concept of "social habitat"- to identify complex social and environmental factors that impact individual actions. These variables include family, friends or mentors (i.e. micro); communities and organizations (i.e. meso); and urbanization, media, culture, and state and federal policies (i.e. macro) variables.

Big Data and a Commercial Geodemographic Market Segmentation Approach

Projects funded by a Sport Fish Restoration multi-state conservation grant awarded jointly to the Association of Fish and Wildlife Agencies and the American Sportfishing Association, included appending Esri Tapestry™ Segmentation geodemographic descriptions to available state fishing license sales data for several states, including Michigan (see American Sportfishing Association 2007; Southwick Associates 2007; Southwick Associates 2006). Esri's multivariate geodemographic segmentation strategy utilizes data reduction and clustering techniques to profile the aggregate preferences and lifestyles of consumers residing in a geographic area. A combination of geographic, demographic, general behavior and psychographic measures totaling more than 60 attributes originate from a combination of sources including Census data and databases containing information on consumer behavior characteristics (e.g. Survey of the American Consumer ™ from GfK MRI). Based on a variety of socioeconomic and demographic factors, the methodology classifies US neighborhoods into 65 market segments as well as aggregated summary groups based on lifestyle and lifestage (i.e. LifeMode Groups) and geographic and physical features (i.e. Urbanization Groups). Esri recommends appending geodemographic market segments with available client data (e.g. customer data) to develop more robust costumer or "lifestyle" profiles (Esri Tapestry™ Segmentation Reference Guide 2014). The combination of consumer data and "neighborhood geography" permits profiling geographic areas to inform development and distribution of new products and to target marketing efforts (Esri Tapestry™ Segmentation Reference Guide 2014).

Geodemographics is characterized as a neighborhood classification approach, and is used broadly in market research, market analysis and advertising (Harris, Sleight and Webber 2005). In both the United States and Great Britain the initial availability of electronic/machine readable small area data from the Census (1970 and 1971) spurred the fields of geodemographics and growing interest in applications in the public and private sectors for service delivery and direct marketing purposes (Birkin, Clarke, Clarke, & Wilson 1996). Geodemographic analysis is based largely on the premise that lifestyle, and thus consumption is largely driven by demographic factors (Mitchell 1995). Market research companies and data providers such as Nielsen and Esri have also incorporated consumer data (e.g. product consumption, media usage, consumer surveys) into their geodemographic approach.

The term "lifestyle" is used frequently within Esri Tapestry™ reference manuals and throughout the fishing license analyses (i.e. Southwick Associates 2006). Understanding the complex nature of purchase behaviors prompted the development of the lifestyle concept as a multi-measure construct incorporating important behavioral predictors including measures of activities (i.e. behavior), interests and opinions (i.e. attitudes) - together termed, lifestyle (see Gonzalez and Bello 2002 for a review). The lifestyle construct has been applied widely in market research to classify consumer segments and subsequently inform marketing strategies (e.g. Thach & Olsen 2004; Bruwer & Li 2007; Gonzalez & Bello 2002; Zhu, Wang, Yan, & Wu. 2009; Todd & Lawson 2001). These studies typically involve segmenting consumers based on respondent's answers to multi-measure lifestyle questions, and describing consumer preferences and usage rates. A review of marketing service and consumer research company webpages listed as Esri's sources for private and public household-level information (e.g. GfK MRI and Acxiom), suggests that widely recognized attitude, interest and opinion or "lifestyle" variables are indeed collected through consumer surveys.

The approach used by Southwick Associates (2006) provided a mechanism for further describing the diversity of license purchasers, in terms of culture, lifestage, household structure, employment, media preferences, purchase behaviors, hobbies, interests and related demographic and behavioral characteristics. Broadly, the reports identified potential sales growth areas with the objective of increasing fishing license sales to and revenues from particular segments. The Michigan report (Southwick Associates 2006) examined segment size, rates of decline, churn rate, and sales to population to identify segments deserving "extra consideration" for recruitment and retention strategies. Several Michigan segments demonstrated a higher propensity to purchase fishing licenses. The researchers provided inferences based on dominant segment characteristics such as income and lifestage. The preliminary nature of the analysis was underscored, with recommendations for additional research to understand angler perceptions and constraints and controlled/experimental promotional mailings to segments.

Recent research examining internet search behaviors in order to support angler recruitment programs underscores the increased usage of internet and electronic media and the potential of using new platforms for collecting and monitoring information spatially and temporally (Martin, Pracheil, DeBoer, Wilde, & Pope 2012). As a result of increased connectivity and technological advancements the amount of data generated, stored and consumed is expected to continue to grow exponentially (McKinsey Global Institute 2011). Large-volume data sets (i.e. "big data") are increasingly being applied in customer analysis and behavioral prediction across a multitude of sectors (George, Haas, & Pentland 2014). Businesses and market research companies utilizing and developing large-volume data accumulate fine-grained, individual-level data from multiple public and private sources originating from governmental organizations, private business transactions, consumer purchases, information searches, social media usage, and consumer reviews to name a few (George et al. 2014) . In addition to growing the volume of information available for analysis, greater connectivity has altered consumer expectations- necessitating more personalized, tailored and data-driven messaging to attract customers and grow a customer base (Arthur 2013).

Commercial market segmentation systems built upon "big data" sources offer a convenient method for identifying large, stable and accessible groups of customers exhibiting similar within-group behaviors (i.e. market segments) driving the activities of an organization's marketing mix- or the product, place, price and promotion and communication activities (content, timing and medium). Information on the size, growth, location and behaviors of angler subgroups is critical for building customer relationship management information systems (Vogt

2010; Dann, Alvarado, Palmer, Schroeder, & Stephens 2008; George et al. 2014); informing resource management decisions, and developing strategic marketing efforts that maximize marketing efficiency (i.e. return on investment). With increasing access to a wide array of variables, commercially available market segmentation systems also represent a method for developing location-based market segments that incorporate many of the individual-level, social psychological and social-structural variables shown to affect recreation participation rates. The richness of statewide angler survey efforts coupled with dynamic lifestyle characterizations from commercially available consumer segmentation systems may also provide opportunities for further monitoring and evaluation of expanding and new angling markets. Motivated by the growing availability of commercial segmentation software and the potential for developing angler subgroups suitable for these efforts, our research objective is to evaluate the commercially available, generic segmentation approach (i.e. Esri Tapestry™ Segmentation) as an angler market segmentation methodology, specifically in developing distinct angler subgroups in terms of their fishing and license purchase behaviors.

Methods

Data Collection

To evaluate the utility of the commercially available geodemographic classification system (Esri Tapestry™), we utilized angler data generated from the Michigan Recreational Angler Survey (MRAS). The MRAS is a long-term statewide angler survey that tracks angling effort across all of Michigan's fisheries (Simoes 2009). Following a modified Tailored Design Method (Dillman 2007), four contacts were made, which included (1) an initial survey, cover letter and business reply envelope, (2) a reminder/ thank you postcard, (3) a replacement survey, cover letter with a more urgent appeal and business reply envelope, and (4) a final postcard (Appendix A). The MRAS uses simple random samples of fishing licenses drawn monthly from the Michigan Department of Natural Resources Retail Sales System (RSS) database. The MRAS average monthly response rate over this period was 48%.

The MRAS database provides self-reported demographic information including, household income, education, household structure and race and ethnicity as well as general fishing characteristics and fishing behaviors specific to Michigan. Additional angler characteristics, specifically age, gender, address and license purchasing behavior were obtained from the RSS. For this research, we utilized data on anglers from the monthly samples from the RSS during the 2009 – 2012 fishing seasons, N = 45,504, along with the MRAS survey responses for these samples. All analyses of the survey data use post-stratification weights to ensure the respondent sample matches the sample joint distribution of age and license type.

As mentioned above, in addition to describing 65 distinct Tapestry Profile Segments, Esri Tapestry™ produces 12 aggregated summary LifeMode groups characterized by "lifestyle and lifestage composition". LifeMode groups encompass as few as two Tapestry Segments (*High Hopes* LifeMode group) to as many as nine (*Senior Styles* LifeMode group). We evaluated Esri's 12 category LifeMode classification based on Esri's recommendation for analyzing a smaller number of markets and where lifestyle- or lifestage-related behavior are important. Additionally our choice of the 12 category LifeMode classification is based on previous angler segmentation efforts which developed a similar number of distinct angler segments (e.g. Fisher 1997, Connelly et al. 2001, Romberg 1999, Hutt & Bettoli 2007). Both respondent and nonrespondent angler records (addresses) were geocoded using Esri Business Analyst 10.1. The resulting Esri Tapestry™ classifications were used to conduct our evaluations.

Analysis

As previously stated, our objective was to assess whether angler classifications based on their geodemographic segment accurately discriminate among known fishing behaviors and purchase behaviors of actual anglers. Many authors have offered criteria and statistical methods to aid in the evaluation of market segments (e.g. Wilkie 1994; Kotler 1984; Smith 1989; Tonks 2009; Everitt, Landau, Leese and Stahl 2011; Milligan 1996). Depending on the context, some combination of researcher judgment and statistical tests support segment evaluation, which usually include: (a) accessibility (an organization must be able to easily reach or access the identified segments), (b) durability or stability (segments need to remain relevant over an extended period of time), (c) segment size or substantiality (segments should be large enough to warrant separate attention), (d) identifiability or homogeneity (i.e. maximized between-segment variation and minimized within-segment variation (e) responsiveness or defensibility (segments differ on characteristics relevant to the organizations services or products; i.e., segments require different marketing approaches or marketing mixes).

Analysis of bivariate correlation was used to compare our recent classification results to previous results (Southwick Associates 2006). Chi-square tests of independence were used to examine relationships between fishing behavior variables and LifeMode group. Given our large sample size and in order to provide comparative descriptive measures of the degree of association (Gilner, Vaske and Morgan, 2001) we report Cramer's *V* as a measure of the strength of the relationship between variables based on the chi-square statistic. We also report Goodman and Kruskal Tau denoted by τ, to quantify the reduction in misclassification error (i.e. proportional peduction in error). Whereas Cramer's *V* is based on the value of the X^2 statistic, differences in τ values may be interpreted across studies (Agresti 1979) with larger τ, signifying stronger association between variables. τ is defined as:

$$\tau = \frac{E_1 - E_2}{E_1}$$

where E_1 is the number of errors expected based on the marginal distribution of the dependent variable and E_2 is the summation of errors over the categories of the independent variable based on the conditional distribution of the dependent variable (Agresti 1979). We used One-Way ANOVA to test between-group differences of LifeMode groups. For variables with unequal variance, we report alternative versions of the F statistic (i.e. Welch's adjusted F ratio). Again, given our large sample size, small differences in group means may be statistically significant. Therefore, eta squared (η^2) and omega squared (ω^2) are reported as two measures of strength of association. Eta squared is an effect size measurement (strength of association) for the ANOVA and is interpreted as the proportion of the variance in the continuous, dependent variable explained by the independent variable (Tabachnick & Fidell 2001), calculated as the ratio of the sum of squares between groups to the total sum of squares:

$$\eta^2 = \frac{SS_{between}}{SS_{total}}.$$

Although Eta squared is commonly reported, it describes only the proportion of systematic (between groups) variance in the sample. Omega squared estimates the strength of association between the independent variable and dependent variable in the population, accounting for the number of groups and for error variance, or the error that cannot be explained by systematic differences between groups. Therefore, Omega squared is considered a less biased measure of magnitude of effect than is Eta squared (Tabachnick & Fidell 2001):

$$\omega^2 = \frac{SS_{between} - (df_{effect})(MS_{within})}{SS_{total} + MS_{within}}.$$

The interpretation of relative effect sizes are discussed by Cohen (1992) and Cohen (1988) with values of 0.01, 0.06 and 0.14 indicating a small, medium and large amount of association between variables, respectively. In addition, Scheffe and Games-Howell post hoc procedures were conducted to determine the total number of pairs of the twelve LifeMode groups in which means differed significantly.

Results

We report first on geocoding results of angler records (i.e. Michigan angler segment classification assignments) using Esri Business Analyst 10.1. This initial geocoding process included our entire sample, both survey respondents and nonrespondents. Subsequent analysis of behavioral variable associations included only survey respondents.

Michigan Angler Segment Classifications

Over 90% of anglers from our sample are categorized by 7 LifeMode classifications, *High Society, Upscale Avenues, Senior Styles, Family Portrait, Traditional Living, Factories and Farms*, and *American Quilt* (see Table 1). The median household incomes for members of the *Factories and Farms* and the *American Quilt* are among the lowest of the twelve LifeMode groups. These groups are also characterized by rural living and rural activities (including fishing and hunting), employment in the manufacturing and agricultural industries, and an aging population with a greater proportion of retirees. In contrast, members of the well-educated *Upscale Avenues* LifeMode group are characterized by “prosperity” with median household incomes second only to the *High Society* LifeMode group. Broadly, *Upscale Avenues* and *High Society* LifeMode groups are characterized by their greater purchasing power and discretionary income reflected by their leisure activities, mobility and investments. The remaining dominant groups are aptly named. Members of the older *Senior Styles* form one of the largest LifeMode groups, living in households without children, with varying residential choices and lifestyles and wide income ranges attributed to retirement income or Social Security payments. Members of the *Traditional Living* LifeMode group “convey the perception of middle America” with modest incomes falling in between the extremes reported by other LifeMode groups, a higher median age, with many anticipating retirement and completion of child-rearing responsibilities. Finally, the median incomes of the *Family Portrait* LifeMode group display the greatest range, and are characterized by youth, family life and the presence of children (Table 1).

As was reported by Southwick Associates (2006) the license buying population generally reflects Michigan’s population with some relatively minor differences. *American Quilt* and *Factories & Farms* are better represented in the license buying population, while above average income *High Society* customers are underrepresented. There was also a significant positive correlation between classification proportions from our recent sample of Michigan anglers from the 2009 - 2012 fishing seasons and classification proportions reported by Southwick Associates (2006), (r = .912, p <.001, N=12). Despite differences in methodology (prior classifications by Southwick Associates (2006), examined the total license purchase population for 2005) the proportions of anglers assigned to LifeMode groups are comparable, suggesting consistency with the classification approach. Slight differences between relative proportions may be accounted for by changes in the State population or changes in Esri's data resources given the dynamic nature of their classification methodology (Table 1).

Table 1 Esri Tapestry LifeMode Classifications

ESRI Tapestry™ LifeMode classifications applied to randomly sampled licensed anglers from 2009, 2010, 2011 and 2012 fishing season (N = 42,433), Southwick Associates (2006) license purchasers from the 2005 Michigan license database (N=1,163,767) and ESRI Tapestry™ profile descriptions. Significant positive correlation between the two classification proportions, r =.912, $p < 0.001$, N=12)

LifeMode Membership	Description	MI Sample (2009 - 2012)	Michigan 2005 License Purchasers	Percent of Michigan Population	ESRI Tapestry™ profile description
1	*High Society*	10.9%	9.5%	13.2%	affluent, well educated, professional employment, highest income, married, least ethnically diverse, fast growing, travel, active
2	*Upscale Avenues*	16.6%	17.5%	18.2%	prosperous, well educated, above-average income,
3	*Metropolis*	2.7%	2.6%	7.5%	city families, urban lifestyles, row houses, public transportation, service related jobs, diverse housing, age and incomes
4	*Solo Acts*	2.0%	5.4%	4.3%	city life, single, young, well educated, professionals, urban lifestyles
5	*Senior Styles*	14.2%	11.6%	11.9%	large group, retires, income f/ Soc. Sec. & pensions,
6	*Scholars and Patriots*	0.8%	1.5%	1.6%	young, lower incomes, college and military, low home ownership,
7	*High Hopes*	2.4%	4.6%	3.7%	young, mobile, college educated, couples, single parents, and singles
8	*Global Roots*	1.2%	2.3%	2.9%	ethnically diverse, young, modest income, renters, recent immigrants, mostly with children
9	*Family Portrait*	4.6%	4.1%	3.7%	fastest growing, young families, ethnically diverse, 30% Hispanic descent, single family homes
10	*Traditional Living*	11.2%	15.2%	14.5%	middle America, settled families, older, slow growing neighborhoods, traditional media use
11	*Factories and Farms*	18.8%	12.5%	8.9%	lower income, rural living, manufacturing and agriculture employment, small communities, families
12	*American Quilt*	14.7%	13.3%	9.5%	small towns, rural areas, mobile homes, rural lifestyle

Esri Tapestry™ LifeMode and Behavioral Variable Associations

Of the 45,504 individuals who were contacted from our simple random sample 19,635 returned surveys. After accounting for eliminated cases and undeliverable addresses the final adjusted response rate was 48% (Appendix B). A comparison of respondents and non-respondent characteristics revealed statistically significant differences in age, residency, gender, and license type. The mean age of respondents was significantly higher than nonrespondents (p<0.001), Michigan residents (X^2 =58.762, df=1, p <0.001) and females (X^2 =4.542, df=1, p =0.033) were somewhat more likely to respond and a smaller proportion of Resident Restricted and Temporary (24-hour and 72-hour licenses) license holders responded to our survey, with the remaining commonly issued license types (Resident All Species, Non-Resident All Species, Senior Restricted, and Senior All Species comprising a slightly larger proportion of our respondents (X^2 =1441.437, df=7, p <0.001). In order to correct for possible response/nonresponse bias, weights for respondents were computed according to the joint distribution of age and license type (Appendix C). All analyses of the survey data use these weights.

Chi-square test of independence and ANOVA performed to examine the relationship between fishing behavior variables and LifeMode were significant (see Table 2 and Table 3). However, chi-square directional measures of strength of association Proportional Reduction in Error (i.e. Goodman and Kruskal tau) were generally under 1%, suggesting a very weak association. Values of Cramer's *V* also suggest a small effect, with all values under .30, with a range between 0.05 and 0.17. One-way ANOVA analyses of fishing behaviors and license purchase behaviors revealed statistically significant main effects. However eta squared (η^2) and estimated omega squared (ω^2) for many variables were below .02, indicating a small amount of the total variation in the average behavioral variables is attributable to differences in LifeMode classification (Cohen 1992; Cohen 1988). Further, the number of significant differences identified through post hoc comparisons using Scheffe and Games-Howell ranged between 13 and 56.

With few exceptions, our license segmentation approach using four aggregated license types (resident, resident senior, nonresident and temporary) produced relatively larger τ values, (as well as eta squared (η^2) and estimated omega squared (ω^2)) suggesting this procedure may provide greater discrimination and may account for more of the total variation in angler behaviors compared to the Esri Tapestry™ segmentation strategy (Table 2 and Table 3).

Table 2 Comparison of Segmentation Approaches

Comparison of segmentation approaches. Comparisons using twelve Esri Tapestry™ LifeMode segments, four aggregated license types segments (senior, non-senior, nonresident, temporary and other). Measures of strength of association and Post hoc tests: Eta squared (η^2); omega squared (ω^2); Goodman Kruskal Tau (τ); Cramer's V (V); Games-Howell (GH); Scheffe (S). All values p <0.001 unless noted. Variables with values of p > 0.05 have been omitted from this table.

Behavior variable	12 Esri Tapestry™ LifeMode			4 License Types		
General Fishing Behaviors						
Fishing Experience (Mean, years)	η^2= 0.012	ω^2= 0.011	GH=39/66	η^2= 0.299	ω^2=0.298	GH=5/6
Boat Ownership (0,1)	τ= 0.02		V= 0.141	τ= 0.018		V= 0.134
Catch Disposition (e.g. mostly keep, catch and release)	τ= 0.015		V= 0.124	τ= 0.01		V= 0.102
Fishing with a companion (0,1)	τ= 0.022		V= 0.05	τ= 0.007		V= 0.086
Fishing Outside State (0,1)	τ= 0.013		V= 0.115	τ= 0.156		V= 0.396
Fishing behavior in last 12 months						
Fishing Frequency (1 to 3 times in past 12 months)	τ= 0.004*		V= 0.055	τ= 0.037		V= 0.28
Fish Frequency (10 or more times in past 12 months)	τ= 0.004*		V= 0.055	τ= 0.037		V= 0.28
Species Diversity (# of species fished)	η^2= 0.008	ω^2= 0.007	GH= 14/66	η^2= 0.058	ω^2=0.058	GH= 5/6
Method Diversity (# of methods used to fish)	η^2= 0.009	ω^2= 0.008	S= 13/66	η^2= 0.065	ω^2=0.065	GH= 5/6
Total Species and Method Diversity	η^2= 0.007	ω^2= 0.006	GH= 13/66	η^2= 0.270	ω^2=0.058	GH= 6/6
Michigan Fishing Experience (Mean, years)	η^2= 0.020	ω^2= 0.020	GH= 13/66	η^2= 0.059	ω^2=0.270	GH= 6/6
Water body type						
Waterbody Diversity (sum of waterbody indicators)	η^2= 0.003	ω^2= 0.003	S= 47/66	η^2= 0.060	ω^2=0.060	GH= 6/6
Great Lakes Fishing (0,1)	τ= 0.004		V= 0.06	τ= 0.006		V= 0.078
Inland Lakes Fishing (0,1)	τ= 0.006		V= 0.078	τ= 0.041		V= 0.203
Rivers (0,1)	τ= 0.009		V= 0.094	τ= 0.03		V= 0.174

* p < 0.05

Table 3 Comparison of Segmentation Approaches

Comparison of segmentation approaches. Comparisons using twelve Esri Tapestry™ LifeMode segments, four aggregated license types segments (senior, non-senior, nonresident, temporary and other). Measures of strength of association and Post hoc tests: Eta squared (η^2); omega squared (ω^2); Goodman Kruskal Tau (τ); Cramer's *V* (*V*); Games-Howell (GH); Scheffe (S). All values p <0.001 unless noted. Variables with values of p > 0.05 have been omitted from this table.

Species targeted in last 12 months	**12 Esri Tapestry™ LifeMode**			**4 License Types**		
Bass (0,1)	τ= 0.003		*V*= 0.056	τ= 0.032		*V*= 0.179
Catfish (0,1)	τ= 0.018		*V*= 0.133	τ= 0.016		*V*= 0.125
Northern Pike (0,1)	τ= 0.006		*V*= 0.075	τ= 0.028		*V*= 0.166
Panfish (0,1)	τ= 0.009		*V*= 0.094	τ= 0.05		*V*= 0.224
Salmon (0,1)	τ= 0.003		*V*= 0.052	τ= 0.006		*V*= 0.078
Suckers (0,1)	τ= 0.013		*V*= 0.112	τ= 0.014		*V*= 0.118
Trout (0,1)	τ= 0.006		*V*= 0.077	τ= 0.007		*V*= 0.081
Walleye (0,1)	τ= 0.008		*V*= 0.091	τ= 0.021		*V*= 0.145
Fishing methods used in last 12 months						
Natural Bait (0,1)	τ= 0.012		*V*= 0.111	τ= 0.058		*V*= 0.241
Artificial Bait (0,1)	τ= 0.003		*V*= 0.053	τ= 0.014		*V*= 0.12
Trolling (0,1)	τ= 0.007		*V*= 0.085	τ= 0.008		*V*= 0.091
Casting from Boat (0,1)	τ= 0.004		*V*= 0.065	τ= 0.022		*V*= 0.15
Casting from Shore (0,1)	τ= 0.003		*V*= 0.056	τ= 0.033		*V*= 0.182
Fly Fishing (0,1)	τ= 0.003		*V*= 0.058			
Ice Fishing (0,1)	τ= 0.02		*V*= 0.142	τ= 0.045		*V*= 0.212
License purchase behaviors						
Vendor (e.g. MDNR E-License; major grocery / department store; major sporting goods; other)	τ= 0.014		*V*= 0.113	τ= 0.013		*V*= 0.13
License obtained (days since season start)	η^2= 0.010	ω^2= 0.010	GH= 40/66	η^2= 0.120	ω^2=0.120	GH= 6/6
License purchasing (2001-2012)	η^2= 0.022	ω^2= 0.022	GH= 56/66	η^2= 0.188	ω^2=0.188	GH= 6/6
License purchasing (2008-2012)	η^2= 0.018	ω^2= 0.018	GH= 49/66	η^2= 0.172	ω^2=0.172	GH= 6/6
Personal computer usage (0,1)	τ= 0.028		*V*= 0.167	τ= 0.072		*V*= 0.268

Tables 4 and Table 5 contain a subset of the variables we tested. Relatively to other variables we tested, a larger amount of the total variation was attributable to differences in LifeMode classification. Interestingly, these fishing behavior and license purchase variables further highlight a dichotomy between the lower-income *Factories and Farms* and *American Quilt LifeMode* Groups and the above-average income *High Society* and *Upscale Avenues* LifeMode groups. In contrast to *Factories and Farms* and *American Quilt LifeMode* groups, *High Society LifeMode* members were the most likely to fish outside Michigan, fished the least, were the most likely to fly fish, and were the most likely to practice catch and release. The fishing behaviors of the *High Society* LifeMode group were mirrored by the similarly affluent *Upscale Avenues* LifeMode group, which once again in contrast to *Factories and Farms* and *American Quilt* LifeMode groups, were more likely to fish outside the state of Michigan, were less likely to keep their catch and more likely to practice catch and release. In terms of license purchase behaviors, *High Society* and *Upscale Avenues* were more likely to use purchase a license online directly through the MDNR e-license system, and to make those license purchases later in the season. For more detailed statistical output which includes group means, group percents, chi-square, ANOVA and measures of strength of association, see Appendix D.

Table 4 Comparison of LifeMode fishing behavior characteristics

Comparison of LifeMode fishing behavior characteristics. One-way ANOVA, Chi-square tests of independence, directional and strength of association measures.

LifeMode	Description	Fishing Frequency[a]		Catch Disposition[b]		Fly fishing[c]	Fishing Outside State[d]
		1 to 3 times	10 or more times	Mostly Keep	Mostly Catch & Release		
1	High Society	27.1%	44.5%	22.3%	45.9%	21.5%	36.6%
2	Upscale Avenues	21.4%	51.8%	28.1%	35.3%	16.8%	30.0%
3	Metropolis	21.7%	51.8%	38.1%	32.5%	14.1%	27.4%
4	Solo Acts	30.3%	43.2%	20.7%	48.0%	24.8%	35.7%
5	Senior Styles	19.3%	53.8%	32.3%	31.6%	15.6%	23.7%
6	Scholars & Patriots	23.0%	54.9%	25.6%	41.0%	22.5%	23.1%
7	High Hopes	20.2%	50.8%	26.0%	38.9%	18.0%	27.1%
8	Global Roots	22.6%	52.8%	25.3%	30.2%	13.5%	18.6%
9	Family Portrait	27.0%	47.3%	22.6%	42.7%	16.0%	32.9%
10	Traditional Living	20.0%	53.4%	27.7%	35.2%	15.7%	25.3%
11	Factories and Farms	18.0%	55.5%	37.8%	23.3%	15.8%	22.0%
12	American Quilt	15.9%	60.6%	36.0%	23.9%	16.5%	22.2%
	Average	20.6%	53.0%	30.6%	32.8%	16.9%	26.8%

[a] X^2=271.461, df=55, p <.001; Tau = .004, p <.05; Cramer's V = .055, p <.001, N=18,012

[b] X^2=573.750, df=22, p < .001; Tau = .015, p <.001; Cramer's V = .124, p <.001, N=18,528

[c] X^2=59.659, df=11, p <0.001; Tau = .003, p <0.001; Cramer's V = .058, p <0.001, N=17,495

[d] X^2=248.509, df =11, p <.001; Tau = .013, p <.001; Cramer's V = .115, p <.001, N=18,689

Table 5 Comparison of LifeMode license purchasing characteristics

Comparison of LifeMode Michigan license purchasing characteristics. One-way ANOVA, Chi-square tests of independence, directional and strength of association measures.

LifeMode	Description	Vendor*				Days (since season start)[b]	Computer Usage[c]
		DNR[a]	Grocery / Department[a]	Sporting Goods[a]	Other[a]		
1	High Society	12.5%	31.4%	15.0%	41.2%	90.4	90.1%
2	Upscale Avenues	7.1%	35.2%	12.1%	45.6%	84.1	82.8%
3	Metropolis	4.6%	36.4%	11.2%	47.8%	76.9	69.5%
4	Solo Acts	9.6%	37.5%	13.4%	39.5%	90.7	88.1%
5	Senior Styles	4.5%	32.8%	9.5%	53.2%	78.9	76.4%
6	Scholars and Patriots	7.7%	46.9%	12.8%	32.5%	90.2	90.8%
7	High Hopes	5.5%	44.4%	9.4%	40.8%	87.2	83.0%
8	Global Roots	5.1%	43.3%	9.1%	42.5%	85.7	71.4%
9	Family Portrait	8.2%	38.3%	11.6%	41.9%	87.9	85.0%
10	Traditional Living	4.3%	38.9%	11.8%	45.0%	81.9	76.7%
11	Factories and Farms	3.6%	33.3%	5.3%	57.7%	76.3	70.6%
12	American Quilt	3.8%	29.6%	6.2%	60.4%	75.9	70.5%
	TOTAL	5.8%	34.4%	9.8%	50.0%	81.5	78.0%

[a] X^2=1804.836, df=33,p <.001; Tau = .014, p <.001; Cramer's V = .113, p <.001, N=47,266

[b] Lavene = (df1=11,df2=44,832),7.738, p<.001; Welch's F=(df1=11,df2=6340.987)= 40.905, p <.001; ω^2= 0.0098; η^2=0.0100; Games-Howell 40/66, α =(.05)

[c] X^2=516.492, df=33,p <.001; Tau = .028, p <.001; Cramer's V = .167, p <.001, N=18,542

* Vendor categories indicate the method used for purchasing fishing licenses: DNR= Michigan's online e-license system; Grocery/Department= large chain grocery and department store businesses; Sporting Goods: large chain sporting goods businesses; Other= small and locally owned businesses

Discussion

Southwick Associates (2006) classified licensed anglers using Esri Tapestry™ Segmentation and concluded that the segment lifestyles descriptions can help discern likely license purchasers and inform cost-effective marketing and recruitment programs. Here, we build upon those efforts by using self-reported fishing behavior data and license purchase data to evaluate this commercially available, generic segmentation approach as an angler market segmentation methodology, specifically in developing distinct angler subgroups in terms of their fishing and license purchase behaviors. Our discussion begins by summarizing our findings regarding the market segment evaluation criteria mentioned above: segment accessibility, stability, size and finally aspects of segment behavioral variables- identifiability and responsiveness.

With respect to segment accessibility, geodemographic classifications provide location-based market segment descriptions. Esri Tapestry™ Segmentation categories are developed by combining Census data with consumer behavior characteristics to profile the aggregate preferences and lifestyles of people who live in a geographic area (i.e. block groups, Census tracts, ZIP codes). Therefore, these descriptions meet the accessibility criteria suggesting they might be suitable for developing accessible market segments for use in direct mailing campaigns to specific locations as part of outreach, education or promotional communication strategies, or informing regional resource management decisions (e.g. county, watershed, management unit).

Comparisons of our classification results to previous research (Southwick Associates 2006) provided a measure of classification stability or durability. Our findings mirrored the dichotomy or “split profile” reported by Southwick Associates (2006), with, broadly, a larger segment comprised of anglers with average or lower than average incomes living in working-class or rural communities (e.g. *Factories and Farms* and *American Quilt*), and another suburban, above-average income segment (e.g. *High Society* and *Upscale Avenues*). Bivariate correlations were positive and significant suggesting this classification methodology may be stable overtime.

With respect to segment size, several LifeMode groups representing large portions of the angling public were identified. Specifically, seven LifeMode classifications, *High Society, Upscale Avenues, Senior Styles, Family Portrait, Traditional Living, Factories and Farms*, and *American Quilt* encompassed over 90% of the angling population. These market segments each represent substantial portions of the angler market, which may warrant tailored marketing approaches. Of these seven LifeMode classifications, the Family Portrait LifeMode group is the smallest segment, however given the focus of previous license campaigns on families and children, this angler segment may be of particular importance to state agencies.

For several of the fishing behaviors and license purchase behavior variables examined, we note modest differences between segments classified by Esri Tapestry™ LifeMode. Statistically significant and meaningful differences in fishing and license purchase behaviors would suggest that these groups might respond differently to marketing mixes, necessitating the development of tailored marketing approaches. However, as previously stated, additional statistical tests examining of the association between variables (i.e. Goodman Kruskal Tau, Cramer's *V* and ANOVA) suggest weak relationships. Therefore, the LifeMode classification approach did not meet identifiability or homogeneity segmentation criteria (i.e. maximized between-segment variation and minimized within-segment variation) or responsiveness or defensibility segmentation criteria (i.e. meaningful differences in behavioral characteristics requiring different marketing approaches). Thus, the exclusive use of LifeMode classifications to reach anglers with specific behaviors is unlikely to be effective. In their present form, the aggregated and likely demographically-driven Esri Tapestry™ LifeMode classification system should perhaps be limited to inquiries projecting angling participation or targeting demographic groups or geographic regions for general information and education purposes rather than as a basis for reaching customers with more specific angling behaviors.

Weak associations identified in our research may be partially explained by (a) the nonspecific nature of lifestyle measures and other segmentation variables used in this generic commercial segmentation approach, (b) the diverse demographic and socioeconomic characteristics of 65 Esri Tapestry™ segments encompassed by the LifeMode groups we tested, (c) and the weak relationship between demographic variables and angling behavior. While the Lifestyle construct is widely applied in market research, many researchers, using the Lifestyle or similar constructs, have made a distinction between general and more service-specific and/or salient attitude measures (e.g. Pierce, Manfredo, and Vaske 2001, Lawson and Todd 2002; Gonzalez and Bello 2002, Crompton & Lamb 1986, Vaske and Manfredo 2012). The use of generic lifestyle segmentation descriptions may present an additional challenge in determining content as well as construct validity- or what is ultimately being measured (Tonks 2009).

Although we report weak associations between the behavior variables and market segments we tested, further examination of these classification systems may be warranted. In light of the availability of less-aggregated Esri Tapestry™ segments, it is possible that some of the 65 less aggregated segments may meet the identifiability or homogeneity segmentation criteria (i.e., they may produce some more homogeneous market segments that have distinguishable behaviors). Moreover, with the growing volume of consumer data and advances in large-volume data analysis (George et al. 2014; McKinsey Global Institute 2011), we expect businesses, data compilers, and marketing firms will continue to be innovative in their collection and application of consumer information resources. In the meantime, researchers and natural resource managers interested in further developing angler segments for recruitment and retention activities might consider developing statistical models that include spatially-explicit social structures (Larson et al. 2014) and new and salient consumer behavior variables from the burgeoning geodemographic field.

CHAPTER 2

Describing anglers using an inland lake classifications system

Motivation

Classification systems are fundamental to most branches of science in which researchers use “data mining techniques” to uncover data structure and organize large data sets so that the information may be more easily understood and analyzed (Everitt et al. 2011). Classification systems for natural resources exist for both terrestrial and aquatic ecosystems and at multiple scales (e.g. USFWS National Wetlands Inventory, Gawler (2008), USDA Watershed Condition Framework, Krost et al. 2007). To predict and model species distributions, researchers have utilized existing habitat categories or developed new classifications systems for a variety of ecosystems, including: boreal wetlands (Morissette 2013), ocean reefs (Malcolm et al 2010) streams systems (Frissell et al. 1986), estuaries (Schoch 2012), inland lakes (Wehrly et al. 2012), woodland patches (Collier et al. 2012) and invertebrate habitat (Duffey 2010). Resource managers faced with the challenge of managing heterogeneous systems across large landscapes often with limited resources, utilize classification approaches to describe and inventory natural resources, plan for and prioritize management and conservation activities, identify important habitat-species associations or predict habitat conditions and species occurrences.

For large states with an abundance of inland lakes, lake distribution and lake diversity presents managers and policy makers with additional challenges in terms of adequately sampling, describing, and predicting responses from environmental changes and management activities (Wehrly et al. 2012). Utilizing readily available spatially extensive variables (including lake network position, morphometry, connectivity and lake thermal regime), Wehrly et al. (2012) identified six distinct inland lake classes and fish assemblages for Michigan's inland lakes. The classifications will enable managers to characterize Michigan's inland lake fishery resources, allocate monitoring efforts, inform management decisions including stocking, predict inland lake responses to management actions and communicate and validate management decisions. The authors focused on lakes 4-ha and larger because of their ability to support exploitable sportfish populations. Although these classifications are ecologically meaningful, they do not directly account for angler behaviors.

Classification of inland lake anglers

Fisheries represent complex socio-ecological systems (Martin and Pope 2010) and licensed anglers represent one of the most important constituent groups for state fishery managers (Connelly et al. 2013). In lake-rich states such as Michigan, the multitude of inland lakes, their diverse morphological, chemical and biological characteristics and differing fisheries management strategies result in wide array of angling experiences available to anglers. Inland lake fishing is the predominant angling activity reported by Michigan's recreational anglers (Jamsen 1985, Simoes 2009) and represents the majority of angler's reported fishing trips (Simoes 2014). Further, the species most often targeted by Michigan's anglers include species and species classes found largely in inland lakes (e.g. panfish, bass and walleye) (Simoes 2009).

The development of biological and social classification systems to describe complex fishery problems has been identified as a major challenge in fisheries science and management (Connelly et al. 2001). Human dimensions researchers have underscored the importance of applying social data to fisheries management decision making, including the allocation of management funds (Fisher 1997), clarification of management objectives (Dobson et al. 2005), implementation of regulations with knowledge of which angler groups will be most affected

(Fisher 1997; Manfredo et al. 1998), legitimizing fishery policies with stakeholders (Sutton and Tobin 2009, Kruegger and Decker 1999; Brown 1987, Hunt and Grado 2010) and, understanding the impact of anglers on fishery resources (Lupi et al. 2005).

Fisheries management typically occurs on a species-by-species and lake-by-lake basis (Tonn et al. 1983). Therefore, a useful segmentation approach involves identifying and describing anglers who participate in specific fishery locations or fisheries (Romberg 1999). When combined with information on other aspects of a fishery (resource integrity, catch rates, physical setting, assess, etc.) managers can develop a reliable description of the fishery which includes a description of its participating anglers, and the factors that make a given fishery appealing to specific angler markets **(**Romberg 1999).

The goal of this research was to develop managerially-relevant inland lake angler segments. Because many states have developed biological classification systems of fisheries resources, our goal is to describe the characteristics of angler groups using a biological classification system to describe inland lake anglers in terms that are useful to managers. The research is motivated by the availability and scope of both the Michigan Recreational Angler Survey data and landscape-based classification of inland lake fish assemblages (i.e. Wehrly et al. 2012). Further development of classification systems for Michigan's fisheries using angler survey data is warranted and may prove particularly informative for guiding management and monitoring programs and communicating both the ecological and sociological reasons for inland lake management decisions.

Our research included the following objectives: (1) Examine the characteristics of inland lake anglers for each lake class; (2) and, Develop a model to predict the types of anglers that take trips to particular lake classes.

Methods

Data Collection

The population of interest included anglers who reported trips to inland lakes in Michigan. We used data from the Michigan Recreational Angler Survey (MRAS) a monthly mail survey of anglers in Michigan. Our sample frame for the MRAS was the Michigan Department of Natural Resources Retail Sales System database. For this research, we utilized monthly simple random samples drawn from the Retail Sales System database during the 2008 – 2012 fishing seasons. Following a modified Tailored Design Method (Dillman 2007), four contacts were made by mail, which included (1) an initial survey, cover letter and business reply envelope, (2) a reminder/ thank you postcard, (3) a replacement survey, cover letter with a more urgent appeal and business reply envelope, (4) a final postcard (Appendix A). The MRAS survey response rate for the months of data used here was 46% after adjusting for undeliverable mail and deceased persons.

The MRAS database provides a rich source of self-reported demographic information as well as general fishing characteristics and fishing behaviors specific to Michigan. Additional angler characteristics, specifically age, gender, and license type were obtained from the Retail Sales System. Information for angler trips includes the location of the trip, whether fishing was the primary purpose of the trip, whether the trip was an overnight trip, and whether the trip involved multiple rivers and lakes. More specific trip details included the fishing mode and which fish species were targeted.

Angler's reported the inland lake name, the county the lake was located and the nearest city. Nonresponse, incomplete answers and misspellings can confound the determination of the exact inland lake a trip was taken. However we used an iterative process to match and decipher angler's trip location data to unique inland lake codes using Esri Python. Following this process, unique lake identification codes were matched to the lake classification system developed by Wehrly et al. (2012). See Appendix E for lake classification procedures and results of inland lake coding and lake classification assignment. We cross-referenced the trips to identified inland lakes against the classification system developed by Wehrly et al. (2012), assigning lake classes (i.e. Lake Class 1...Lake Class 6) to 1,886 unique inland lakes. In summary, a total of 14,889 inland trips from our original sample 16,241 were assigned one of the six available lake classification number and used in our analysis (Appendix E).

Model

Fishing trips to one of the six available lake classes constitutes an unordered, multinomial discrete outcome. A multinomial probit model was used given our observed outcome variable (lake class) and the distribution of our continuous and dichotomous predictor variables.

The stochastic error terms for multinomial probit are assumed to have independent, standard normal distributions. As per Greene (2002):

$$U_{ij} = x'_{ij}\beta_j + \varepsilon_{ij},\ \ j = 1, \dots, J \textit{ and } \left[\varepsilon_{i1}, \varepsilon_{i2}, \dots \varepsilon_{iJ}\right] \sim N[O, \Sigma]$$

Where U_{ij} is an index function that describes angler *i's* preference for alternative *j*, x_i are characteristics of the anglers (e.g., behaviors and demographics), and β_j are the parameters to be estimated that relate the angler characteristics to the *J* alternatives. The term in the log-likelihood that corresponds to *i*'s choice of alternative q is

$$Prob[choice\ q] = Prob\left[U_q > U_j, j = 1, \dots, J, j \neq q\right].$$

By normalizing the estimated parameters against an arbitrarily chosen baseline (β_q), we can write the probability as follows:

$$Prob[choice\ q] = Prob\left[\varepsilon_1 - \varepsilon_q > (x_i)'\left(\beta_1 - \beta_q\right), \ldots, \varepsilon_J - \varepsilon_q > (x_i)'(\beta_J - \beta_q)\right]$$

Without loss of generality, one can then further normalize so that $\beta_q = 0$, which allows estimation of the *J*-1 of the preference parameters relative to $\beta_q = 0$. Because the observed outcome variable (lake class) represents six discrete lake classes (i.e. 1 - 6), the multinomial probit model will identify five sets of estimated parameters that explain the relationship between angler characteristics, x_i and factors related to an angler's lake class choice. The most frequent inland lake class outcome was Class 1 (41% of cases). Class 1 was thus chosen as the baseline so that the predicted parameters measure the attractiveness of other inland lake classes relative to Class 1 inland lakes. The predictor variables are defined in Table 6. In this paper we refer to groups of species by their general association with water type. In our results and discussion, largemouth bass and panfish are considered warmwater species, smallmouth bass, northern pike, yellow perch and walleye are considered coolwater species, and trout and salmon are considered coldwater species.

Table 6 Predictor variables for the multinomial probit model

Variable	Definition	Variable Type
Demographics		
Age	Angler age (years)	continuous
Age_Squared	Angler age (years), squared	continuous
Gender	1= male	binary
Michigan Resident (1/0)	1= Michigan resident	binary
Restricted License (1/0)	1= restricted (no trout and salmon)	binary
Trip Characteristics		binary
Main Purpose (1/0)	1= fishing was main purpose of trip	binary
Overnight Trip (1/0)	1= overnight fishing trip	binary
Multiple Lakes/Rivers (1/0)	1= visited multiple waterbodies	binary
Fishing Mode		binary
Boat (1/0)	1=angler used a boat for fishing	binary
Wade/Shore (1/0)	1= angler waded or shore fished	binary
Ice fishing (1/0)	1= angler ice fished	binary
Species Targeted		binary
Warmwater		
Largemouth Bass (1/0)	1= species was targeted	binary
Panfish Species (1/0)	1= species was targeted	binary
Coolwater		
Smallmouth Bass (1/0)	1= species was targeted	binary
Northern Pike (1/0)	1= species was targeted	binary
Yellow Perch (1/0)	1= species was targeted	binary
Walleye (1/0)	1= species was targeted	binary
Coldwater		
Trout Species (1/0)	1= species was targeted	binary
Salmon Species (1/0)	1= species was targeted	binary

Marginal effects

The multinomial probit parameters provide information on the direction and statistical significance of the parameter, but give no understanding of the practical size of the effect of the variable. Marginal effects show how the likelihood shifts among lake class options due to an incremental change in the predictor/independent variables, demonstrating the sensitivity of lake class choice to the characteristics of anglers (Greene,2002). Because probabilities must sum to one, the marginal effects across the *J* classes will also some to one (up to any rounding errors).

Results and Discussion

Descriptive Statistics

Before discussing the results of the multinomial probit model, we briefly discuss features that characterize our data. Table 7 combines inland lake characteristics adapted from Wehrly et al. (2012) with angler demographic and trip characteristics (means and percents) from MRAS and license data. Inland lake classes were well represented by Lake Classes 1 and 2. Fishing trips to these lake classes accounted for 41% and 26% of angler trips, respectively (Table 7). Results of statistical tests from this analysis suggests there is a relationship between the outcome variable (Lake Class) and several demographic and trip characteristics.

Inland lakes in Lake Classes 1 and 2 are characterized by high degree days, high mean temperatures and distributions primarily within the lower peninsula of Michigan. In both lake classes, fishing was more likely to be the main purpose of the trip, anglers were less likely to make overnight trips and also somewhat less likely to fish at multiple sites. For the abundant, deep, warmwater, southern lower peninsula inland lakes categorized as Lake Class 1, warmwater species and especially panfish species were targeted at a relatively higher rate compared to other lake classes. In Lake Class 2 a mix of warmwater, coolwater and coldwater species were targeted. Compared to other lake classes, somewhat higher targeting of largemouth bass, smallmouth bass and salmon species occurred in Lake Class 2. Inland lakes in Lake Class 3 are concentrated in the western upper peninsula and are described as having low-degree days, low mean temperatures, high depth and large surface area. In these lakes, coolwater species are the prominent indicator species, but the lake class is also characterized by the presence of coldwater species. Smallmouth bass, trout and especially walleye were targeted at a relatively higher rate by anglers fishing in these lakes. Compared to other lake classes, anglers fishing in inland lakes classified as Lake Class 3 were also less likely to hold a restricted license and were somewhat more likely to make overnight trips. Inland lakes in Lake Classes 4 and 5 both occupy northern climes (upper peninsula and northern lower peninsula). However compared to Lake Class 5, inland lakes in Lake Class 4 are relatively smaller, more common and the prominent indicator species include more coolwater species, coldwater species and fewer species tolerant of low oxygen. Panfish species and most coolwater species comprised similar proportions of species targeted by anglers in Lake Class 4 and 5, however anglers fishing in Lake Class 4 targeted walleye at a relatively lower rate and trout were targeted at a much higher rate. Anglers also reported similar trip characteristics to Lake Classes 4 and 5- for both inland lake classes about half of the anglers fishing reported overnight trips and a relatively small percentage reported that fishing was the main purpose of the trip. However compared to most other lake classes, anglers fishing in the larger coolwater lakes (Lake Class 5) were more likely to be residents, use a boat, hold restricted licenses, and more likely to fish exclusively at this site. Finally, inland lakes in Lake Class 6 are found primarily in the upper peninsula, are described as shallow, having low-degree days, intermediate mean temperatures and intermediate surface areas. The prominent indicator species include white sucker, walleye, yellow perch, northern pike. Anglers reported targeting the latter three species at somewhat higher rates compared to other lake classes. Anglers fishing in these lakes were also much less likely to be residents, reported more overnight trips, and trips to multiple sites.

These descriptive results suggest the lake classification developed by Weherly et al. (2012) may also serve to classify anglers in terms of their fishing behaviors and trip characteristics. The next section presents the results of the multinomial probit classification model.

Table 7 Lake characteristics, classification, and angler characteristics

Lake class characteristics and sportfish species in order of prominence (adapted from Wehrly et al. 2012) and angler demographic and trip characteristics from the Michigan Recreational Angler Survey.

	Lake Class					
Lake Class Number	**1**	**2**	**3**	**4**	**5**	**6**
Lake Characteristics						
Species abundance	warmwater sp	coolwater sp	coolwater sp	warmwater sp	coolwater sp	coolwater sp
relative size	small	large	large	small	intermediate	intermediate
depth (mean)	relatively high depth	deeper	deeper			lowest depth
temperature (mean)	highest	similar	lowest	similar	similar	similar
percent of lakes	59%	less abund	less abund	33%	rare	rare
surface area %	25%	22%	22%	< 10%	14%	8%
location	SLP, Coastal NP	LP	Western UP, N	UP, NLP	NL, UP	NL, UP
Lake Classifications						
Number (Total = 14,889)	6,172	3,816	1,513	822	2,037	529
Percent	41.5%	25.6%	10.2%	5.5%	13.7%	3.6%
Angler Characteristics						
Age (mean)	48.99	48.98	49.4	48.92	49.76	50.98
Gender (% female)	21%	22%	21%	23%	26%	28%
Resident (% Yes)	90%	84%	74%	80%	90%	63%
License (% restricted)	63%	56%	43%	50%	61%	48%
Main Purpose (% Yes)	75%	75%	67%	63%	62%	67%
Overnight Trip (% Yes)	25%	31%	54%	51%	52%	59%
Number Days (mean)	1.79	2.16	2.87	2.73	2.79	3.22
Multiple Rivers / Lakes	16%	16%	23%	27%	17%	29%
Boat fishing	68%	69%	74%	67%	74%	76%
Shore/Wade fishing	18%	17%	9%	19%	11%	9%
Ice fishing	9%	9%	13%	8%	11%	11%

Table 7 (Cont'd)

Lake class characteristics and sportfish species in order of prominence (adapted from Wehrly et al. 2012) and angler demographic and trip characteristics from the Michigan Recreational Angler Survey.

	Lake Class					
Lake Class Number	**1**	**2**	**3**	**4**	**5**	**6**
Species Targeted						
Warmwater						
Largemouth Bass	25%	22%	9%	21%	16%	13%
Panfish Species	36%	26%	13%	26%	23%	20%
Coolwater						
Smallmouth Bass	11%	15%	16%	13%	14%	12%
Northern Pike	10%	11%	14%	14%	15%	17%
Yellow Perch	12%	13%	18%	13%	15%	18%
Walleye	5%	10%	25%	8%	15%	18%
Coldwater						
Trout Species	1%	2%	4%	5%	1%	1%
Salmon Species	1%	2%	1%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%

Multinomial Probit Model

The multinomial probit model was estimated using the 14,889 total usable observations. The observed distribution of trips for Lake Classes 1 through 6 were 42%, 26%, 10%,6% 14% and 4% respectively (shown in Table 7); the fitted class probabilities (shown in the column headings of Table 8) closely match the data, although the model slightly over-predicts Class 2 and under-predicts Class 3. We present the marginal effects from the multinomial probit model in Table 8. The majority of the variables in our model were discrete (1/0) regressors, with the exception of our continuous age variables, Age and Age Squared. Holding other variables in the model constant, we interpret the direction and magnitude of the marginal effect of each variable on the probability of fishing in a particular lake class. The empirical analysis largely supported the descriptive analysis of the survey. In general, angler demographic predictors in our model were relatively less influential in predicting the lake class visited, compared to characteristics of the trip and especially species targets.

Table 8 Marginal effects, standard errors and significance levels from probit estimates

	Lake Class 1		**Lake Class 2**		**Lake Class 3**	
	Pr(Class =1) =0.4235		Pr(Class =2) =0.2890		Pr(Class =3) =0.0641	
Demographics	Marginal effect	S.E.	Marginal effect	S.E.	Marginal effect	S.E.
Age	0.0036**	0.0016	0.0010	0.0014	-0.0017**	0.0007
Age_Squared / 1000	-0.0436**	0.0000	-0.0120	0.0170	0.0000**	0.0000
Gender	0.0665***	0.0105	0.0053	0.0096	-0.0131**	0.0054
Michigan Resident (1/0)	0.0948***	0.0127	-0.0745***	0.0123	-0.0514***	0.0074
Restricted License (1/0)	0.0833***	0.0091	-0.0172**	0.0082	-0.0376***	0.0045
Trip Characteristics						
Main Purpose (1/0)	0.0095	0.0109	0.0480***	0.0095	-0.0049	0.0049
Overnight Trip (1/0)	-0.1504***	0.0101	-0.0536***	0.0091	0.0474***	0.0053
Multiple Lakes/Rivers (1/0)	-0.0095	0.0117	-0.0413***	0.0101	0.0151**	0.0057
Fishing Mode						
Boat (1/0)	-0.0392*	0.0200	-0.0050	0.0182	0.0172*	0.0090
Wade/Shore (1/0)	-0.0203	0.0219	0.0289	0.0207	-0.0023	0.0110
Ice fishing (1/0)	-0.0694**	0.0238	-0.0115	0.0222	0.0319**	0.0148
Species Targeted						
Warmwater						
Largemouth Bass (1/0)	0.1057***	0.0097	0.0298***	0.0088	-0.0770***	0.0045
Panfish Species (1/0)	0.1694***	0.0088	-0.0421***	0.0082	-0.0915***	0.0051
Coolwater						
Smallmouth Bass (1/0)	-0.1434***	0.0102	0.0579***	0.0099	0.0562***	0.0062
Northern Pike (1/0)	-0.0606***	0.0109	-0.0287**	0.0096	-0.0039	0.0047
Yellow Perch (1/0)	-0.0988***	0.0100	0.0042	0.0093	0.0449***	0.0056
Walleye (1/0)	-0.2496***	0.0100	-0.0006	0.0100	0.1361***	0.0077
Coldwater						
Trout Species (1/0)	-0.0330	0.0243	-0.0367*	0.0204	0.0490***	0.0133
Salmon Species (1/0)	-0.1020**	0.0332	0.2867***	0.0337	-0.0314***	0.0086

* $p < 0.10$; ** $p < 0.05$; *** $p \leq 0.001$

Table 8 (Cont'd)

	Lake Class 4 Pr(Class =4) =0.0587		Lake Class 5 Pr(Class =5) =0.1367		Lake Class 6 Pr(Class =6) =0.0279	
Demographics	Marginal effect	S.E.	Marginal effect	S.E.	Marginal effect	S.E.
Age	-0.0004	0.0007	-0.0018*	0.0011	-0.0006	0.0005
Age_Squared / 1000	0.0047	0.0000	0.0248**	0.0000	0.0091*	0.0000
Gender	-0.0047	0.0052	-0.0340***	0.0078	-0.0200***	0.0042
Michigan Resident (1/0)	-0.0078	0.0060	0.0842***	0.0063	-0.0452***	0.0060
Restricted License (1/0)	-0.0178***	0.0044	0.0039	0.0063	-0.0146***	0.0030
Trip Characteristics						
Main Purpose (1/0)	-0.0114**	0.0051	-0.0437***	0.0077	0.0026	0.0031
Overnight Trip (1/0)	0.0331***	0.0052	0.1005***	0.0076	0.0231***	0.0036
Multiple Lakes/Rivers (1/0)	0.0286***	0.0061	-0.0081	0.0077	0.0153***	0.0041
Fishing Mode						
Boat (1/0)	-0.0109	0.0094	0.0308**	0.0134	0.0070	0.0061
Wade/Shore (1/0)	0.0016	0.0101	-0.0072	0.0158	-0.0007	0.0075
Ice fishing (1/0)	-0.0114	0.0100	0.0547**	0.0206	0.0056	0.0089
Species Targeted						
Warmwater						
Largemouth Bass (1/0)	-0.0011	0.0045	-0.0401***	0.0065	-0.0173***	0.0029
Panfish Species (1/0)	-0.0085**	0.0043	-0.0126**	0.0062	-0.0147***	0.0030
Coolwater						
Smallmouth Bass (1/0)	-0.0089*	0.0047	0.0398***	0.0077	-0.0016	0.0032
Northern Pike (1/0)	0.0156**	0.0055	0.0586***	0.0080	0.0191***	0.0040
Yellow Perch (1/0)	-0.0023	0.0048	0.0303***	0.0072	0.0218***	0.0038
Walleye (1/0)	-0.0196***	0.0046	0.1046***	0.0087	0.0292***	0.0044
Coldwater						
Trout Species (1/0)	0.0942***	0.0169	-0.0654***	0.0126	-0.0081	0.0058
Salmon Species (1/0)	-0.0489***	0.0053	-0.0833***	0.0157	-0.0211***	0.0043

* $p < 0.10$; **$p < 0.05$; ***$p \leq 0.001$

Demographics

The marginal effect of our age variables (Age and Age Squared) was small (< 0.01), i.e. less than 1 percentage point, and statistically significant for only 3 lake classes (see Table 8, rows 3 and 4). Controlling for other variables, a one unit change in Age and Age Squared had a small influence on the probability of fishing in a particular lake class. While our analysis of group means demonstrated statistically significant age differences across lake classes, those differences may not be of practical importance because mean ages were quite similar across lake classes.

Compared to our age variables, our model suggests that Gender had a larger impact on the propensity to fish at particular lake classes (Table 8, row 5). Holding all other variables constant, being male significantly increased the probability of fishing in Lake Class 1 by 7 percentage points. For the remaining lakes, where the marginal effect was statistically significant, being male reduced the likelihood of fishing. Specifically, in Lake classes 3, 5 and 6, being male decreased the probability of fishing by 1 to 3 percentage points (-0.0131, -0.0340, -0.0200 respectively).

Our residency variable (Michigan Resident) was positive for Lake Classes 1 and 5 and correspondingly negative for Lake Classes 2, 3 and 6 (Table 8, row 6). Being a resident increased the probability of fishing in Lake Classes 1 and 5 by 8 to 9 percentage points (0.0948;0.0842, respectively) and reduced the probability of fishing in Lake Classes 2, 3 and 6 by 5 to 7 percentage points (-0.0745; -0.0514; -0.0452, respectively). These results are also consistent with our descriptive analysis (see Table 7).

We collapsed our license categories into one discrete license variable (Restricted License) (Table 8, row 7)[1]. In broad terms, anglers in our sample possess some form of a restricted fishing license or alternatively, an "all species" fishing license. The latter license category permits trout and salmon fishing. Restricted license holders had a significantly higher propensity for fishing in Lake Class 1 (0.0833), while for the remaining lakes the marginal effects were negative or not significant. Holding a restricted license reduced the probability of fishing in Lake Classes 3, 4 and 6 by 2 to 4 percentage points, (-0.0172; -0.0376; -0.0178; -0.0146). These results are somewhat consistent with the indicator species supported by these lake classes and the estimated marginal effects of these targeted species variables (discussed below).

Trip Characteristics

Our variable representing whether fishing was the main purpose of the trip (Main Purpose) was positive for the southern inland lakes (Lake Class 2), and negative or not significant for the remaining lakes (Table 8, row 9). The southern lakes in Lake Class 2 are located relatively closer to large population centers. Controlling for other variables in the model, trips focused on a single water body were more likely to occur in these lakes. In contrast, fishing trips that might be part of some other travel to the region were more likely to occur in the generally smaller and less common northern inland lakes (Lake Classes 4 and 5).

Our overnight variable (Overnight Trip), representing whether a fishing trip was part of an overnight trip, was an important determinant in our model (Table 8, row 10). The marginal

[1] In our sample, the fishing licenses issued to anglers included designations for residency (Michigan resident and nonresident) and seniors (anglers 65 or older). These licenses are further specified as either ""Restricted" or "All Species". The latter permits fishing for trout and salmon. Combined, these licenses comprised 93% of our sample. The remaining less commonly issued license types (e.g. Military, 24hour and 72 hour) permit fishing for trout and salmon (i.e All Species). We aggregated all license types in our sample into one discrete license variable based on the Restricted and All Species designation. Across all license types, 57% are Restricted, with the remaining 43% All Species.

effect of our overnight variable was negative and significant for the less remote inland lakes classified as Lake Classes 1 and 2 (15 and 5 percentage points, respectively) and correspondingly positive for the remaining relatively remote and/or less abundant inland Lake Classes (effects ranged from 2 to 10 percentage points).

The primary mode of fishing was disaggregated from one categorical variable, into three separate discrete variables, specifically: those involving a boat (Boat); those involving fishing from the shore or wading (Wade/Shore); and, ice fishing (Ice) (Table 8, rows 13, 14 and 15). The marginal effects were significant only for Lake Classes 1, 3 and 5 and only for the Boat and Ice fishing variables. Given the general climate and ice free periods, the results are not surprising-- anglers who reported ice fishing had a higher propensity for fishing in lakes predominantly found in the north (Lake Classes 3 and 5), and a lower propensity for fishing in the south (Lake Class 1). Similarly, fishing from a boat increased the probability of fishing in Lake Classes 3 and 5 and decreased the probability of fishing in Lake Class 1.

Species Targeted

Eight variables representing fish species and species groups targeted on a trip were examined in our model. The marginal effects for each of the species-targeted variables were statistically significant in at least 4 of the 6 inland lake classes. Marginal effects were on average larger compared to our other variables, and ranged from 1 percentage point to 29 percentage points. Generally the results support the results of our descriptive analysis and show that specific angler-targeted species or classes of species (i.e. warmwater, coolwater or coldwater) were significant predictors of lake class choice in our model.

Controlling for other variables in our model, anglers targeting largemouth bass and anglers targeting panfish were more likely to fish in Lake Class 1, which are generally southern lower peninsula and coastal northern peninsula lakes. The marginal effects for these variables were also relatively large (11 and 17 percentage points, respectively) while for the remaining coolwater and cold water species, marginal effects were large and negative for Lake Class 1. In contrast to inland lakes classified by Lake Class 1 the marginal effects of the targeted species variables for Lake Class 2 lacked a clear warmwater, coolwater or cold water species focus. However, targeting salmon significantly increased the probability of fishing in Lake Class 2 by 29 percentage points. Although our descriptive analysis demonstrated that salmon comprise just 2% of the total species targeted by anglers, that proportion was relatively large compared other lake classes. For Lake Class 3, the marginal effects for warmwater species (largemouth bass and panfish) were negative. However, fishing for most of the coolwater or coldwater species in our model (with the exception of Northern Pike and Salmon) increased the likelihood of fishing in Lake Class 3. In particular, fishing for walleye significantly increased the probability of fishing in Lake Class 3 (by 14 percentage points). Results from our model suggest Lake Class 4 supports an inland lake coldwater fishery for trout. The marginal effect for targeting trout was large (10 percentage points) and positive for this lake class. The marginal effects for most of the remaining species were negative or only marginally positive. As was the case with targeting salmon for inland lakes classified as Lake Class 2, trout do not comprise a large proportion of the total species targeted by anglers in Lake Class 4; however the 4% that targeted trout at Lake Class 4 was relatively large compared to the proportions that targeted trout at most other lake classes. This was further supported by the propensity of “all species” license holders to fish in Lake Class 4 (see above).

The species profiles from our descriptive analysis for Lake Classes 5 and 6 were relatively uniform and do not reveal a unique fishery for Lake Classes 5 and 6 as was the case in other lakes classes (e.g. the dominance of warmwater species in Lake Class 1, salmon in Lake Class 2, walleye in Lake Class 3, or trout in Lake Class 4). However, whereas targeting particular species or warmwater species or a mix of coolwater and coldwater species increased the likelihood of fishing in other lake classes, controlling for other variables in the model, anglers targeting several coolwater species were more likely to fish in Lake Class 5 and 6. Fishing for walleye, northern pike and to some degree smallmouth bass and yellow perch increased the propensity to fish in inland lakes classified by Lake Class 5. Marginal effects for the remaining coldwater (trout and salmon) and warmwater species (panfish and largemouth bass) where negative. Similarly, although the marginal effects for Lake Class 6 were all relatively small, fishing for coolwater species (northern pike, yellow perch and walleye) increased the likelihood of fishing in these lakes. The marginal effects for the remaining coldwater and warmwater species were either negative or not significant.

Summary and Conclusions

Although previous classifications of inland lakes are ecologically meaningful, they do not directly account for angler behavior. Recreational angling is an important activity on inland lakes, and anglers have significant impacts on the resource. The goal of this research was to develop managerially-relevant segments of anglers associated with the biological lake classifications developed in Wehrly et al (2012). We identified several important angler characteristics related to fishing in particular lake classes. The next section includes a summary description of the six inland lake classes including the characteristics of anglers fishing at each class.

Lake Class 1

This lake class consists of small, deep, warm inland lakes, and resident anglers, anglers possessing a restricted license, anglers making day trips and anglers targeting warmwater species (largmouth bass and panfish) comprised a larger proportion of the clientele making trips to this lake class. Controlling for other variables in the model, anglers with these characteristics also had a higher propensity to fish in these lakes. The species that were the strongest predictors of fishing in this lake class (Largemouth bass and panfish species) were also prominent indicator species in the earlier lake classification by Wehrly et al (2012).

Lake Class 2

This lake class consists of large, deep, warm inland lakes and anglers making day trips, trips focused one a single waterbody, trips where fishing was more likely to be the main purpose of the trip, and anglers targeting a cross section of warmwater, coolwater and coldwater species comprised a larger proportion of the clientele making trips to this lake class. Controlling for other variables in the model, anglers with these characteristics as well as nonresident anglers and anglers possessing all species licenses had a higher propensity to fish in these lakes. The top-ranking indicator species from the previous lake classifications by Wehrly et al. (2012) are bowfin, longnose gar, common carp and channel catfish. On the whole, these species are generally not considered highly desirable sportfish species. However, despite their lower abundance and frequency of occurrence in this lake class, largemouth bass, smallmouth bass and especially salmon were important predictors of fishing in this lake class. Results from our model suggest Lake Class 2 supports an inland lake coldwater fishery for salmon—anglers targeting inland lake salmon where much more likely to fish in this lake class. Finally, despite the occurrence of panfish species as an ecological indicator, our model suggests fishing for panfish did not increase the likelihood of fishing in these lakes.

Lake Class 3

Inland lakes in this category are large, are deep, are among the coldest, and are predominantly located in the western upper peninsula and northern Michigan. Nonresidents are somewhat more likely to fish in these lakes, as are anglers holding all species licenses, anglers using a boat, anglers that are ice fishing, anglers making overnight trips, anglers fishing in more than one waterbody and anglers targeting smallmouth bass, yellow perch as well as trout. Walleye were a prominent indicator species in earlier ecological classifications (Wehrly et al. 2012), and they comprised a larger proportion of the species targeted by anglers, and, controlling for other variables in the model, they are an important predictor of fishing trips to this lake class.

Lake Class 4

Although similar in some ecological aspects to Lake Class 1, the anglers differed since anglers possessing "all species" licenses, anglers making overnight trips, anglers visiting multiple fishing sites, and anglers combing their fishing trips with other non-fishing activities have a higher propensity of fishing in these small somewhat abundant northern inland lakes. Our model suggests fishing for northern pike modestly increases the likelihood of fishing at these lakes, however the marginal effects for trout were considerably larger. Largemouth bass, yellow perch and panfish species were important ecological indicators in these lakes. However results of our descriptive analysis and model showed that these species comprised a relatively small to modest proportion of species targets and were also not strong predictors of fishing in this lake class. Further our descriptive analysis and results from our model suggests this lake class supports a non-negligible inland lake cold water fishery for trout.

Lake Class 5

This lake class consists of rare, intermediately-sized, northern, coolwater lakes and resident anglers, female anglers, anglers using a boat, anglers that are ice fishing, anglers making overnight trips, anglers making trips in which fishing was not the main purpose, and anglers targeting coolwater species are more likely to fish these lakes. Although a relatively large proportion of anglers fishing in these lakes possessed restricted licenses, this was not a significant variable in our model which controls for the effects of other variables. The species targeted in these lakes are somewhat inconsistent with the dominant indicator sportfish found in these lakes. Northern pike and yellow perch are both dominant indicator species (Wehrly 2012) and strong predictors of fishing in this lake class. However the remaining coolwater species (i.e. walleye and smallmouth bass) which were also strong predictors when targeted by anglers, are not prominent ecological indicators in these lakes. Finally, despite their importance as ecological indicator species, the marginal effects of targeting warmwater species were negative for Lake Class 5.

Lake Class 6

While inland lakes in this class are somewhat similar to Lake Class 5, in terms of their rarity, size, and northern distribution, nonresident anglers, female anglers, anglers holding an all species license, anglers making overnight trips, and anglers making trips to multiple waterbodies are more likely to fish in these lakes. Walleye, yellow perch and northern pike were both prominent indicator species (Wehrly et al. 2012) and when targeted by anglers were important predictor of fishing in these lake classes.

A key challenge to human dimensions researchers has been to identify and quantify the different angler segments to help managers estimate the relative demand for different types of opportunities (Fisher 1997). While effective at describing the diversity and size of particular angler subgroups, human dimensions researchers have noted problems with applying angler profiles based on specialization, desired recreational experiences and preferred site conditions (Connelly et al. 2013). Fully integrated management perspectives include collecting and understanding the interdependence of biological and social data in order to make informed and justifiable management decisions (Hunt and Grado 2010, Johnston 2010).

Our integration of angler use provides a richer description of existing lake classifications and can also be used for prioritizing management efforts including stocking, facility development, and communication. For example, where multiple management options are available to achieve the same biological outcome, managers may design rules and regulations inclusive of the motives and preferences of angler subgroups that dominate the angler constituency at particular waterbodies (e.g. Hutt and Bettoli 2007; Hunt and Grado 2010 pp430).

Although the influence of lake characteristics on angler behavior may seem intuitive (i.e. the effect of lake size, lake remoteness, and species profiles), our results show that the relationship is not completely congruent. In particular, our model suggests that angler species targets do not always mirror the ecological profiles of species found in some lakes. Additionally, our research is novel in meeting the call for development of managerially relevant angler classifications based on inland lake fishery resources (Connelly et al. 2013), and it does so in a manner that builds upon a tradition of ecological classification research in fisheries and natural resources more generally.

CHAPTER 3

Management preferences of Michigan's Great Lakes Anglers

Motivation

Covering 94,000 square miles and holding 5,500 cubic miles of water, the Great Lakes contain roughly 21% of the world's freshwater supply and are the largest freshwater system on Earth (EPA 2014). The Great Lakes support shipping networks, provide recreational opportunities and support tourism, agricultural and industrial sectors of the economy that are dependent on these water resources. Due in part to their diverse geology, the Great Lakes provide a rich diversity of habitats supporting commercial and recreational fisheries (Moll et al. 2013). Four Great Lakes and nearly 3,200 miles of coastline define Michigan's border.

Fisheries managers, researchers and stakeholders tasked with developing and implementing management plans are often faced with conflicts among management objectives to support this large and diverse system. For example, following the reduction and extirpation of native salmonids in the Great Lakes and due in part to extensive stocking programs and naturalization, Pacific salmonine have effectively replaced native top-predator salmonids in much of the Great Lakes. The proliferation of these species in the Great Lakes accompanied important economic, biological and ecological consequences. In the wake of what was an unprecedented ecosystem-level biomanipulation of a freshwater system, Great Lakes managers are now faced with management conundrum Claramunt et al. (2013). The authors highlight conflicting and often polarizing management strategies related to Pacific salmonines and native species rehabilitation, a discussion intensified in the wake of Lake Michigan's Chinook salmon crash in the late 1980's. Central to the differences in management perspectives is determining which species (or species mix) will achieve a more balanced, stable, resilient ecosystem, limiting the risk of future fish stock collapse.

Policy decisions and management strategies are further complicated by a lack of Great Lakes angler preference information (Thayer and Loftus 2013). Although "public expectations and desires factor prominently" in the goals and objectives of Michigan Department of Natural Resources Fish Community Objectives (circa 1995 and 2003), researchers acknowledge the need for reassessment and adjustment (Claramunt 2013). Our objective was to inform the development of fishery management plans in four Great Lakes (Erie, Huron, Michigan and Superior) and Lake St. Clair, using a stated-preference choice model to examine anglers' preferred management outcomes. In our model, an angler's preferred management outcome is explained by the various attributes embodied in the management outcome alternative. We use the model to estimate relative preferences, willingness to make tradeoffs between attributes, and to illustrate likely angler support for Great Lakes management strategies differentiated by emphasis on Pacific salmon, prey base, and risk of ecosystem collapse.

Choice Experiment

Following initial development of statistical models employing a behavioral theory component (random utility theory) (McFadden 1974), choice experiments have been widely used by marketing researchers to measure consumer preferences for different levels of attributes in a given product (Louviere et al. 2000) and later within resource and environmental economics where no markets exist (Hanley et al. 1998). Hunt (2005) includes a review of published literature applying choice models to recreational fishing (and more specifically fishing site choice), that began in the 1980's.

In a choice experiment, participants are asked to choose their preferred alternative from a set of two or more alternatives comprised of different levels of attributes. The stated preference choice experiment format measures consumer preference for different levels of attributes in a given alternative (Louviere and Woodworth 1983, Louviere et al. 2000), can be designed to minimize unwanted correlation between attribute levels (Hunt 2005, Hanley et al. 1998) and offers the ability to examine hypothetical goods that may not currently exist Adamowicz et al. 1994).

Participant choices reveal tradeoffs between the levels of attributes presented in each of the alternatives. Attributes and attribute levels in choice experiments vary according to researcher's design and therefore fall somewhere within in the spectrum of "laboratory experiments" and non-experimental observational studies (Harrison and List 2004). Hypothetical management outcomes for stated preference choice models may be constructed using a suite of relevant attributes and attribute levels to facilitate the estimation of all model parameters, permitting researchers to estimate the effects of attributes independently from each other (Hanely et al. 1998, Adamowicz et al. 1998).

Hunt et al. (2010) implemented a discrete choice stated-preference choice model that solicited Canadian respondent's most preferred outcome among the status quo and two competing hypothetical outcomes for Lake Huron. Hunt et al. (2010) employed a choice model with species abundance levels for 5 species, fish size, risk of fish stock collapse and prey fish community. Each attribute contained three levels informed by consultations with fisheries managers and survey testing. Results indicated that anglers generally preferred outcomes that decreased risk of fish stock collapse and increased native prey fish communities, average fish size and species abundances. To further illustrate management implications, Hunt et al. (2010)

also estimated Ontarian's support for two contrasting management outcomes- specifically one outcome emphasizing Chinook salmon abundance and another emphasizing lake trout and walleye abundance.

We implement a stated-preference choice models to examine Michigan angler's preferred outcomes from management activities in four Great Lakes (Erie, Huron, Michigan and Superior) and Lake St. Clair, and use attributed and a choice format that adapted and replicated for Michigan anglers the stated preference choice model Hunt et al. (2010) implemented with Ontarian anglers for Lake Huron. Figure 1 shows an example of a choice used in our study.

Figure 1: Image of example Great Lakes Angler Survey Choice Experiment.

If these were the only three possible outcomes from managing Lake Superior, which would you prefer?

*Please indicate **below** by checking your most preferred outcome* (**A, B, or C**) *for a future of <u>Lake Superior</u>.*

	Outcome A	**Outcome B**	**Outcome C**
Ecosystem			
Risk of fish stock collapse	same as today	slightly increased risk	same as today
Prey fish community (smaller fish that are food for species below)	mostly native prey	same as today	
Number of Fish			
Chinook Salmon	50% less	same as today	
Coho Salmon	same as today	50% more	
Lake Herring	50% more	same as today	
Lake Trout	50% less	50% more	
Lake Whitefish	50% more	50% less	
Rainbow Trout	50% less	50% more	
Splake	50% more	50% less	
Yellow Perch	50% less	50% more	
Average Size of Fish	50% smaller	50% larger	same as today
Preferred Outcome (choose one)	☐	☐	☐

Random Utility Theory

The choice model /statistical analysis in our choice experiment is motivated by a respondent's underlying utility. Random utility models have been widely used in situations where a single product is chosen from a finite set of alternatives and the alternatives can be characterized by a set of attributes. Random utility theory applies utility maximization theory to choices among discrete alternatives to estimate preferences based on choices made by respondents (McFadden 1974). Here the choices are gathered through a choice experiment. The underlying assumption of a choice experiment is that when confronted with sets of alternatives composed of several attributes, respondents will choose the alternative that leaves them best off, maximizing their wellbeing or utility (utility maximization). All of the relevant product attributes (i.e. attributes of the alternatives in the choice experiment) are known to the consumer when the choice is made. Randomness enters the model because not all of the relevant attributes are measured by the researcher.

Within the random utility model approach, angler i's utility for alternative j is given by U_{ij}. Faced with *J* alternatives, if the angler ranks a particular alternative, *k*, as most preferred, then U_{ik} is assumed to be the maximum among the *J* utilities. Let Y_i be a variable indicating the best alternative for individual *i*. The probability that alternative *k* is best is given by:

$$\mathrm{Prob}(Y_i = k) = \mathrm{prob}\big(U_{ik} > U_{ij}\, for\ all\ \forall j \neq k\big) \qquad \textbf{(1)}$$

Because utility is latent researchers specify utility in two components, one that is deterministic (observable) and another that is stochastic (unobserved). The deterministic component is the Preference for the vector of attributes which describes the product (i.e.

management outcome alternative) measured by the researcher, denoted, βx_{ij}. The stochastic component represents a random error term, denoted ε_{ij}. Since individual errors cannot be observed from the perspective of researchers, each alternative has a probability of being chosen. In our case, the *i*th angler is faced with *J* management outcome alternatives. Following McFadden (1974) and Adamowicz (1998) the utility of alternative *j*, U_{ij}, can be represented as:

$$U_{ij} = \beta x_{ij} + \varepsilon_{ij} \tag{2}$$

The joint density of the random vector $\varepsilon'_i = \left(\varepsilon_{i1,\ldots,}\varepsilon_{iJ}\right)$ is denoted as $f(\varepsilon_i)$. With this density, the researcher can make probabilistic statements about the decision maker's choice. Different discrete choice models are obtained from different specifications of this density, in other words different distribution for the unmeasured portion of utility. If the error terms, ε, are independent and identically distributed and follow a standard type I extreme-value distribution, a conditional logit model can be used to estimate the probability of a respondent's choice (McFadden 1974; Louviere et al. 2000, Alberini 2007). The probability that *k* is best is:

$$prob\ (Y_i = k) = \frac{exp(\beta x_{ik})}{\sum \exp(\beta x_{ij})} \tag{3}$$

By presenting anglers with alternative management scenarios consisting of different characteristics, *x*, we can use the choice probabilities to estimate the preference parameters β by maximum likelihood. In our case, respondents were presented a choice scenario and were asked to choose between the status quo or "same as today" and two alternative management outcomes with attributes of risk of fish stock collapse, prey fish community, species abundance levels for fish species and average fish size. Three levels were used to describe each attribute (see Table 9).

Table 9 Attributes and attribute levels for states preference choice model

Attribute Name	Levels	Model Attribute Levels	Corresponding Survey Attribute
Risk of fish stock collapse (RISK)	3	0,1	slightly increased risk ; slightly decreased risk ; same as today
Prey fish community (PREY)	3	0,1	mostly introduced prey; mostly native prey; same as today
Number of Fish			
Channel Catfish	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Largemouth Bass	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Panfish	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Smallmouth Bass	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Walleye	3	-0.5, 0.5, 0	50% less; 50% more; same as today
White Bass	3	-0.5, 0.5, 0	50% less; 50% more; same as today
White Perch	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Yellow Perch	3	-0.5, 0.5, 0	50% less; 50% more; same as today
Average Size of Fish (SIZE)	3	-0.5, 0.5, 0	50% smaller; 50% larger; same as today

Carrying forward with the Lake Erie example and following the attribute levels used in the choice experiment (and described above) equation (4) shows the model we are estimating:

(4)

$$
\begin{aligned}
U_{ij} = \alpha + \beta_{RISK:slightly\ increased\ risk} * X_{RISK:slightly\ increased\ risk} + \beta_{RISK:slightly\ decreased\ risk} \\
* X_{RISK:\ slightly\ decreased\ risk} + \beta_{PREY:mostly\ introduced\ prey} \\
* X_{PREY:mostly\ introduced\ prey} + \beta_{PREY:mostly\ native\ prey} * X_{PREY:mostly\ native\ prey} \\
+ \beta_{Channel\ Catfish:50\%less} * X_{Channel\ Catfish:50\%less} + \beta_{Channel\ Catfish:50\%more} \\
* X_{Channel\ Catfish:50\%more} + \beta_{Largemouth\ Bass:50\%less} * X_{Largemouth\ Bass:50\%less} \\
+ \beta_{Largemouth\ Basse:50\%more} * X_{Largemouth\ Bass:50\%\ more} + \beta_{Panfish:50\%less} \\
* X_{Panfish:50\%less} + \beta_{Panfish:50\%more} * X_{Panfish:50\%more} + \beta_{Smallmouth\ Bass:50\%less} \\
* X_{Smallmouth\ Bass:50\%less} + \beta_{Smallmouth\ Bass:50\%more} * X_{Smallmouth\ Bass:50\%more} \\
+ \beta_{Walleye:50\%less} * X_{Walleye:50\%less} + \beta_{Walleye:50\%more} * X_{Walleye:50\%more} \\
+ \beta_{White\ Bass:50\%less} * X_{White\ Bass:50\%less} + \beta_{White\ Bass:50\%more} * X_{White\ Bass:50\%more} \\
+ \beta_{White\ Perch:50\%less} * X_{White\ Perch:50\%less} + \beta_{White\ Perch:50\%more} \\
* X_{White\ Perch:50\%more} + \beta_{Yellow\ Perch:50\%less} * X_{Yellow\ Perch:50\%less} \\
+ \beta_{Yellow\ Perch:50\%more} * X_{Yellow\ Perch:50\%more} + \beta_{SIZE:50\%smaller} * X_{SIZE:50\%smaller} \\
+ \beta_{SIZE:50\%\ larger} * X_{SIZE:50\%\ larger} + \varepsilon
\end{aligned}
$$

where α is an alternative specific constant for the status quo, X is a vector of attributes that take on various levels for each alternative within a choice set, β is a vector of unknown preference parameters associated with those attributes, and ε is an error term. All coefficients in the model are estimated relative to the base case “same as today”.

Marginal Rate Substitution (MRS)

Once the model is estimated, the rate of tradeoff between two attributes is the ratio of their respective β coefficients, in economics these tradeoffs are referred to as the Marginal Rate Substitution. Holding all other attributes constant, the MRS is equal to the change in one attribute X_1 required to compensate the individual for a one unit change in another attribute X_2, (the amount of X_1required to keep the individual at the same level of utility before the one unit change in X_2). Equation (5) and (6) illustrate how to calculate MRS as the total derivative of utility with respect to X_2 and X_1 and set this derivative to zero so that utility doesn't change, as per Train (2009):

$$dU = \beta_1 dX_1 + \beta_2 dX_2 = 0. \qquad \textbf{(5)}$$

Solving for a change in X_1 that keeps utility constant when X_2 changes gives

$$\partial X_1 / \partial X_2 = -\beta_2 / \beta_1. \qquad \textbf{(6)}$$

The negative sign indicates that the two changes are in the opposite direction: assuming both attributes are desirable, to keep utility constant, X_2 must rise when X_1decreases. Examining these ratios provides further insight into the relative importance anglers place on attributes at each of the five lakes and the trade-offs anglers make between different levels of attributes, holding all of the other attributes constant (all else equal).

In our results that follow, respondents generally preferred management outcomes that both increased average fish size and the abundance of several sport fish species. We calculate MRS for abundance of a species (e.g. an X_1) relative to an increase or decrease in overall average fish size (X_2). Assuming a change in the abundance level of a particular species, the MRS estimates change in overall average fish size necessary to keep anglers at the same level of utility. For example, an MRS of 2.5 for a change in walleye abundance from "same as today" to 50% more, means that all else equal, management outcomes with 50% more walleye, would be equally preferred to management outcomes with walleye levels the "same as today" and overall average fish size 2.5 levels larger. For each lake, MRS are calculated relative to ther average size of fish and are presented in Appendix J.

Data

Survey Development: Pretests

The mixed mode survey was conducted using both mail and internet questionnaires. The questions were developed using an iterative process guided by the results of focus group and one-on-one cognitive interviews with 54 individuals (Kaplowitz et al. 2004). Initial testing was conducted in a focus group setting with nine licensed Michigan Great Lakes anglers. A subsequent version of the survey, which included modified versions of the stated-preference choice question implemented by Hunt et al. (2010), was tested in one-on-one in-person cognitive interviews with 20 Great Lakes anglers. Finally, following methods reported by Weicksel (2012), 25 cognitive interviews were conducted remotely with resident Great Lakes and non-Great Lakes anglers recruited from a web survey panel. The latter pretesting approach more closely resembled the actual experience actual survey respondents would face, thus providing important insights and opportunities for viewing the choice selection process. Pretests were concluded once it was clear that respondents comprehended survey tasks and that survey information was clearly communicated to respondents.

Survey Sample, Survey Strategy, Response Rate

Our sample frame was the MDNR Retail Sales System database. We randomly drew 3,095 licensed Michigan anglers from a list of resident anglers, 18 years and older. Following a modified Tailored Design Method (Dillman 2007), four contacts were made. For each of the first three contacts, anglers were provided with the web-based survey address and a unique code to access the web survey. A final paper survey package was mailed to remaining non-respondents. After accounting for undeliverable addresses the final response rate was 36% (Appendix F).

In addition to the choice experiment, both the web and paper questionnaires included sections with included behavioral and demographic questions and additional questions related to opinions, preferences and awareness. Details of the survey strategy and examples of survey materials are provided in Appendix F.

The choice experiment section of the questionnaires began with a separate introductory page containing an explanation of the format and purpose of the proceeding choice experiment section. The page also contained an explanation of each of the attributes (i.e. "Glossary"). Following the opening explanation and glossary, respondents were shown five different choice sets (one for each lake: Lake Huron, Lake Erie, Lake Superior, Lake Michigan, Lake St. Clair.). Respondents were asked to choose their preferred management outcome from two possible outcomes and a baseline, or "same as today" condition. Each outcome was described using eleven attributes that provided information about risk of fish stock collapse, prey fish community, abundance of eight fish species and the overall average size of fish species. The format closely follows Hunt et al. (2010). The suite of eight fish species presented in each outcome scenario were not uniform across all lakes for each lake and included species with the highest reported creel effort as well as species of management interest (personal communication, MDNR).

Experimental Design

The choice experiment approach is essentially a structured method of data generation, relying on careful design of choice tasks and definition of attribute space (Hanley et al 1998). The set of attributes and levels displayed in Table 11 (above) can be viewed as setting the space to be spanned in the choice experiment (Adamowicz 1994, pg 276). Our experimental design was generated using Ngene software (Choice Metrics 2011). Our chosen orthogonal design, as generated by Ngene, allows for isolating the separate effects of individual attributes on choice. The experimental design consisted of 40 distinct choice sets for each of the five lakes. We used a random number generator to assign choice sets. Each angler viewed one of the 40 distinct choice sets, describing management outcomes for each of the five lakes..

Results and Discussion

A comparison of respondents and non-respondent characteristics revealed statistically significant differences in age and license (there were no significant differences in gender). Specifically, the mean age of respondents was significantly higher than nonrespondents ($p<0.001$) and a smaller proportion of resident restricted, military and temporary (24-hour and 72-hour licenses) responded to our survey, with the remaining commonly issued license types (Senior Restricted, Resident All Species, Senior All Species comprising a slightly larger proportion of our respondents (X^2 =126.057, df=4, p <0.001). To correct for possible response/nonresponse bias, post-stratification weights for respondents were computed according to the joint distribution of age and license type following Holt and Smith (1979) (Appendix G). All results we report on use the generated weights.

Management preferences of Michigan's Anglers

Respondents were asked to choose their preferred management outcome from two hypothetical outcomes and a baseline, or "same as today" condition for four Great Lakes (Erie, Huron, Michigan and Superior) and Lake St. Clair. Each outcome was described using eleven attributes that provided information about risk of fish stock collapse, prey fish community, abundance of eight fish species and the overall average size of fish species. All coefficients in the model are estimated relative to the baseline or "same as today" attribute (Table 10).

The number of individuals completing the choice experiment question for each lake ranged from 925 to 951. Across all lakes statistically significant parameter estimates followed the expected direction, with positive parameter estimates for ecological health attributes (decreasing risks of fish stock collapse, a more native prey fish community), and recreational opportunities (increased average fish size and greater abundance of most fish species). Relative to other species, increased abundance of walleye (and to a lesser extent yellow perch and salmon species) most affected choice for management options. However the number of significant parameter estimates and their relative magnitude varied across models for each of the five lakes. We interpret these parameter estimates and estimate tradeoffs below.

Relative to other species, increased walleye abundance was particularly important to angler management choices for Lake St. Clair, Lake Michigan and Lake Erie. In Lake Huron, where there was relatively less distinction among species preferences, angler preferences for increased abundance of Chinook salmon were somewhat greater than walleye, followed closely by northern pike. For Lake Superior, where walleye were not part of the choice set, parameter estimates for all eight species were statistically significant, with increased abundance of Chinook and Coho salmon most preferred. Across lakes, parameter estimates for lake trout were not significant, with the exception of Lake Superior, where anglers placed much less emphasis on increased abundances of lake trout relative to other species.

In addition to interpreting relative preferences for management outcomes, we examined tradeoffs between attributes implied by the parameter estimates. Although increased average fish size was an important component of management outcomes for anglers across all lakes, increasing the abundance of many native species (most notably walleye) was relatively more important. For those systems, tradeoff calculations demonstrate that all else equal, anglers would require some magnitude of an increase in overall fish size in order to be indifferent toward a decreased abundance of those native species. For three of the lakes (Lake Huron, Lake Michigan and Lake Superior), nonnative salmonid species were included in the choice set. Only in Lake Huron were nonnative salmonid species (i.e. Chinook salmon and rainbow trout) relatively more important than average fish size.

Table 10 Parameter estimates for conditional logit model

	Lake Erie	Lake Huron	Lake Michigan	Lake St Clair	Lake Superior
observations	2802	2787	2853	2775	2790
Log likelihood	-983.62511	-974.47639	-1012.4024	-961.80954	-987.67065
Pseudo R2	0.0566	0.0631	0.0397	0.0695	0.0501
Attribute					
Status quo	0.1287	0.3841**	0.0310	0.8492**	0.3848**
Risk of fish stock collapse (RISK)					
slightly decreased risk	0.2404*	0.44013**	0.0662	0.3489**	0.0429
slightly increased risk	-0.0709	0.0175	-0.1035	0.0226	-0.2947**
Prey fish community (PREY)					
mostly native prey	0.0615	0.4925**	0.0223	0.2957**	0.2092
mostly introduced prey	-0.2579**	0.1362	-0.0953	0.2746**	-0.0307
Number of Fish					
Brown Trout			0.3853**		
Channel Catfish	-0.1843			0.0451	
Chinook Salmon		0.6359**	0.3012**		0.4473**
Coho Salmon			0.2932**		0.4226**
Lake Herring		0.1444			0.3022**
Lake Trout		0.1083	0.1487		0.2368**
Lake Whitefish					0.2774*
Largemouth Bass	0.3384**			0.3240**	
Muskellunge/Muskie				0.2169*	
Northern Pike		0.5975***			
Panfish	0.3866**			0.2645**	
Rainbow Trout		0.5034***	0.1864		0.2934**
Smallmouth Bass	0.7077***	0.3013**	0.1746	0.2030	
Splake					0.2624**
Sturgeon				-0.0261	
Walleye	0.7895***	0.6064***	0.6307***	0.8524***	
White Bass	0.1180				
White Perch	0.2662**				
Yellow Perch	0.3034**	0.4759***	0.4491***	0.4304**	0.3983**
Average Size of Fish (SIZE)	0.3113**	0.4425**	0.4767**	0.3614**	0.4848**

* $p < .10$; **$p < .05$; ***$p < .001$

Predicted choice probabilities are calculated using the parameter estimates from our model, and the relevant attribute levels (characteristics of the alternative). The predicted choice probabilities for each scenario can be taken as a measure of the average respondent's preference for the alternatives and in that sense predicted support for each of the three alternatives. To further illustrate managerial implications of the results, we developed scenarios to explore the average angler support for the status quo or "same as today" option as compared with two polarizing management scenarios differentiated by their emphasis on Pacific salmon versus native sportfish species. In addition to species abundances, the characteristics of the alternatives describe possible ecological conditions likely to accompany these management scenarios, with prey base, risk of ecosystem collapse and average fish size taking on the relevant attribute levels (e.g. +1,0,-1). Specifically, for the salmon focus, prey base is set to "mostly introduced," risk of fish stock collapse is set to "slightly increased," fish size is set to 50% smaller, salmon abundances are raised by 50% and other species are reduced by 50%. For the native species focus, prey base is set to "mostly native," risk of fish stock collapse is set to "slightly decreased," fish size is set to 50% larger, salmon abundances are reduced by 50% and other species are raised by 50%. For the status quo, variables are set to their mid-point, or same as today levels. See (Appendix H) for exact lake-specific management alternatives including attribute levels and choice probability calculations. Because they each include a Pacific salmon component, we focus our scenario analyses on to Lake Huron, Lake Michigan and Lake Superior. In general, choice probabilities, interpreted as predicted support, were greater for outcomes with a native species emphasis, as compared to a Pacific salmon emphasis and the status quo (i.e. "same as today option"). Although the general scenarios for each lake are similar, the level of predicted support for each of the three lakes varied because the estimated preference parameters and exact species vary across lakes. It is important to note that these results apply to the average angler represented by our study and are for the hypothetical management scenarios that were examined, Subsets of anglers are likely to have substantially different preferences, and alternative assumptions about the attribute values that underlie the scenarios (e.g., changes in average fish size) would lead to different levels of predicted support for each scenario.

Table 11 Predicted probabilities

Predicted percentage of anglers choosing management alternatives focused on: Pacific Salmon, native species or the "same as today".*

	Pacific Salmon Focus	Native Species Focus	Same as Today
Lake Huron	7%	73%	20%
Lake Michigan	18%	49%	33%
Lake Superior	11%	57%	32%

* For the Pacific Salmon Focus, prey base is set to mostly introduced, risk of fish stock collapse is set to slightly increased, fish size is set to 50% smaller, salmon abundances are raised by 50% and other species are reduced by 50%. For the Native Species Focus, prey base is set to mostly native, risk of fish stock collapse is set to slightly decreased, fish size is set to 50% larger, salmon abundances are reduced by 50% and other species are raised by 50%. For the Same as Today or status quo, variables are set to their mid-point, or same as today levels.

Lake Erie

In the following sections, we review the results for each lake. For Lake Erie, anglers preferred management outcomes that favored ecological health attributes, and that also increased average fish size. In terms of species abundances, walleye had the largest effect on outcome choice, followed by smallmouth bass, panfish, largemouth bass, yellow perch, and white perch. In Lake Erie, relative preferences for walleye and smallmouth bass far exceeded preferences for all other species. The magnitude of the relative importance of walleye and smallmouth bass was unique to the Lake Erie system; in the remaining lakes, species preferences were either not as distinct, or were clearly dominated by walleye alone. Trade-off calculations further underscored the importance of walleye and smallmouth bass in particular to management outcomes in Lake Erie. Holding other variables constant (all else equal), anglers were willing to make relatively greater trade-offs in the average size of fish in Lake Erie to maintain or increase walleye and smallmouth bass abundance.

Given the potential for more restrictive walleye and yellow perch regulations (Lake Erie Committee 2013), new management strategies, regulatory changes or outreach activities that both enhance and promote the Lake Erie smallmouth bass fishery could serve to offset the lower abundance of walleye and regulation restrictions. Additionally, enhancement of the white perch fishery, or promotion of more preferred species (e.g. largemouth bass and panfish) may also serve to offset the more restrictive yellow perch regulations.

Lake Huron

For Lake Huron, our findings in part mirrored the angler preferences reported for Canadian waters of Lake Huron by Hunt et al (2010), despite the differences in some of the species attributes and the sample frame between the two studies. In our model results for Lake Huron, Chinook salmon and walleye abundance also had a large effect on choice probabilities and respondents also expressed preferences for decreasing risks of fish stock collapse and more native prey fish communities. However, species preferences were somewhat uniform. Parameter estimates for Chinook salmon were closely followed by walleye and northern pike. Trade-off calculations suggest anglers were willing to tradeoff average fish size to maintain or increase the abundance of five species: Chinook salmon, walleye, northern pike, rainbow trout and to a lesser degree, yellow perch.

The comparable parameter estimates for Chinook salmon, walleye and northern pike in our model suggest that these species are viewed as closer substitutes for one another in Lake Huron. In contrast to other lake systems, fisheries managers may consider a broader suite of management strategies that increased the abundance of a combination of these three species. For both yellow perch and smallmouth bass recent evidence of strong recruitment and significant increase in abundance (Riley 2013) may explain relatively small effect on management outcome choice probabilities.

To illustrate managerial implications of the results, we estimated choice probabilities for competing hypothetical management strategies, one focused on increasing the abundance of Chinook salmon and rainbow trout and another focused on increasing abundance of the remaining native species. Given large and significant parameter estimates for native species, Table 11 shows that nearly three quarters of anglers were predicted to support a native species emphasis outcome (see Appendix H for the exact computations).

Lake Michigan

For Lake Michigan, parameter estimates for the status quo and ecological considerations were not significant. Estimates were significant for four species, and were strongest walleye, followed by yellow perch, brown trout, Chinook salmon and Coho salmon. The relative importance of increasing overall fish size for Lake Michigan is notable. With the exception of walleye, anglers placed more emphasis on average fish size than increases in fish species abundance. Preferences for yellow perch were second only to walleye; therefore tradeoff calculations for yellow perch mirrored the tradeoff calculations for increased fish size. Management outcomes that increased yellow perch and decreased abundances of Coho salmon, Chinook salmon, brown trout would be equally preferred to management outcomes that maintained these species abundances. To illustrate managerial implications of the results, we estimated choice probabilities for competing hypothetical management strategies, one focused on increasing the abundance of Chinook salmon, Coho salmon and rainbow trout and another focused on increasing abundance of the remaining native species (see Table 11). Compared to Lake Huron and Lake Superior, the predicted support was less clear for Lake Michigan, with just under 50% of anglers predicted to support the native species emphasis outcome, and nearly one-third preferring the status quo.

Lake St. Clair

Anglers indicated preferences for the status quo, decreased risk of fish stock collapse, and increased average fish size for Lake St Clair. Preferences for prey fish community were mixed. Preferences were greatest for walleye, followed by yellow perch, largemouth bass, panfish and muskellunge. Increases in fish abundance for two species (walleye and yellow perch) were more preferable than fish size. For the remaining species (channel catfish, smallmouth bass and sturgeon) angler's preferences were not significantly different than zero.

Lake Superior

Anglers indicated preferences for the status quo, decreased risk of fish stock collapse and larger fish size for Lake Superior. Angler's preferences for prey fish community outcomes were not significantly different from zero. Preferences were greatest for Chinook salmon, followed by Coho Salmon, yellow perch, lake herring, rainbow trout, lake whitefish, splake and lake trout. Anglers placed greater emphasis on increased average fish size than on increases in abundance of any of the fish species. For Lake Superior 56% of anglers were predicted to support the native species emphasis outcome for the management scenarios examined in Table 11, with just under one-third choosing the status quo.

Comparing Preferences of Great Lakes and Non Great Lakes Anglers

All of the results and interpretations presented so far are for models that use all of the survey respondents and capture the average preferences for those respondents. However, not all anglers actually fish in Great Lakes. Slightly less than half of respondents (47%) reported fishing in the Great Lakes and connecting waterways in the last 12 months. We tested whether interaction with our Great Lakes fishing variable (*Great Lakes and connecting waterways fishing in last 12 months*) provided any significant improvement to account for preference heterogeneity between anglers that fished the Great Lakes in the past year and those that did not. Results of log likelihood ratio tests failed to reject the null hypothesis of equal preferences, suggesting preferences for management outcomes were not significantly different between groups (Appendix I).

However, from a managerial perspective, we felt it was important to examine the outcome preferences for Lake Huron and Lake Michigan, controlling for anglers who indicated they focused their Great Lakes fishing on these lakes in the last 12 months. These had the two largest shares of our sampled anglers that fished them, and thus provided adequate model sample sizes to separately estimate preferences for anglers that fished these lakes. These lakes also are of special management interest. Separate models controlling for Lake Huron and Lake Michigan anglers who indicated the mostly fished at these lakes are presented in (Appendix I). In sum, these models showed that anglers that recently fished at Lake Huron placed more weight on Chinook and walleye than the average respondent, and that anglers that recently fished at Lake Michigan placed more weight on yellow perch, and Coho salmon, and brown trout, and less weight on walleye than the average respondent.

Conclusions and Management Implications

The goal of this paper was to investigate the preferences that Michigan anglers have for fisheries management outcomes in four Great Lakes (Lake Erie, Lake Huron, Lake Michigan, Lake Superior) and Lake St. Clair. In general, anglers were supportive of management outcomes that reduced fish stock collapse, provided a prey fish community with more native species, and increased the abundance and size of most sport fish species. Management outcomes that increased the abundance of walleye, yellow perch and salmon species were also more preferred.

An important outcome of this study is the ability to estimate the tradeoffs anglers make among different attributes. Across all lakes, tradeoff calculations demonstrate angler preferences for increased abundance of native sport fish species. For these systems, anglers have stronger preferences for increasing the abundance of these native species, than for management outcomes that produce larger average fish size. In Lake Huron, preferences for Chinook salmon and rainbow trout were accompanied by strong preferences for walleye and northern pike.

Estimated choice probabilities for hypothetical management scenarios with a native species focus v. pacific salmon focus were estimated to illustrate the managerial implications of the results. Given large and significant parameter estimates for native species in Lake Huron, nearly three quarters of anglers were predicted to support a native species emphasis outcome. For Lake Michigan, the predicted support was less clear, with just under 50% of anglers predicted to support the native species emphasis outcome, and nearly one-third choosing the status quo. For Lake Superior 56% of anglers were predicted to support the native species emphasis outcome, with just under one-third choosing the status quo.

The choice experiment we employed provides a mechanism for future inquiries regarding management preferences. The choice experiment format could be implemented in future angler inquiries to elicit angler preferences toward the complex nature of biological management, including uncertain outcomes, competing management outcomes or as part of a standardized protocol to measure Great Lakes angler preferences (evaluate trends, gauge support for management changes, etc.).

Limitations of this study include the hypothetical nature of the management scenarios examined and the pooled or average preferences presented above. The choice scenarios presented to anglers were effective for revealing tradeoffs between levels of attributes presented in each of the alternatives. However, when we illustrated the predicted support for the hypothetical management scenarios we made assumptions about the attributes to enter into the scenario, but these attribute levels may not be biological feasible for some or all of the Great Lake systems in this study. Further, we highlight that we did find evidence of relevant preference heterogeneity within Lake Huron and Lake Michigan and suspect similar differences in preferences exist between subgroups of anglers differentiated by fishing frequency and perhaps by other characteristics (e.g. proximity to the lake, avidity, commitment). Thus, the preferences of management-relevant subgroups of anglers are likely to reveal different preferences than those reported here for the average angler in our study.

APPENDICES

APPENDIX A

Michigan Recreational Angler Survey (MRAS)

Mailing Procedures

Monthly samples for the MRAS originate from the Michigan Department of Natural Resources, Retail Sales System database. The sample population is Licensed Anglers (all license types, age 18+). The simple random sample is conducted monthly.

Once the sample has been received from the MDNR, the "Customer ID" is used to cross-check the current sample against all previously sampled anglers. Removing repeats should ensure that the survey is not sent to the same individual more than once. After repeats are removed, the remaining list is examined and entries missing key information (e.g., name of licensee, address of licensee) are removed. Cases containing extraneous information are edited for correctness, where possible, or removed. Licensees with addresses outside the U.S. or Canada are also removed from the sample. Once the final sample is established, each licensee in the sample is assigned a unique project code (Angler ID) which is used for the duration of the project.

An outside vendor (currently ASAP Printing, Okemos, MI) is contracted to conduct all outgoing mailing procedures. The outside vendor conducts a National Change of Address (NCOA) check of licensees, mail merge, prints and packages all components of the mailings and applies the appropriate postage to all mailings. The completed packages are then pre-sorted and mailed First-Class through the United States Postal Service. Each business reply envelope contains the unique project code (Angler ID) assigned to each individual in our sample. After conducting the NCOA, but prior to printing, packaging and mailing materials, the vendor contacts the researcher for a proof approval.

Mailing Content and General Timeline

The procedures for the mail survey were adapted from on the methods in Mail and Internet Surveys (Dillman 2007). The first mailing includes: 1) a cover letter printed on MSU letterhead explaining the importance and objectives of the survey; 2) the four page survey instrument; and, 3) a self-addressed, postage paid, business reply envelope. The first mailing is followed approximately 5 days later by a reminder / thank you postcard. Approximately 30 days after the first mailing, non-respondents receive a third mailing containing: 1) a **second** cover letter printed on MSU letterhead which again explains the importance and objectives of the survey with a slightly more urgent appeal; 2) a replacement survey instrument; and, 3) a self-addressed, postage paid, business reply envelope. Approximately 14 days after the third mailing, non-respondents received a fourth and final reminder / thank you postcard with a slightly more urgent appeal. The survey instrument itself varies monthly only in Part B, fishing activities during the most recent month. The researcher updates the calendar to reflect the most recently completed month for the survey round.

Data Collection and Management Procedures

Returned business reply envelopes and undeliverable mailings are grouped by the week of their receipt. All returned mailings are coded to inform follow-up mailings to non-respondents. Additional communications from respondents directed to the principal investigator including short notes, letters, pictures and refusals are coded and filed appropriately. Initially, returned business reply envelopes were opened and the project code appearing on the business reply envelope is written on the top of the corresponding survey. Current procedures include a preprinted Angler ID on the survey. Some small percentage of surveys may be unidentifiable because they are returned in non-project envelopes, or the survey code is illegible (i.e. crossed out). All of the returned surveys and additional communications are stored in locked offices on the Michigan State University campus.

Sampling History

Simple random sample of 5,000 individuals who purchased fishing licenses between April 1, 2008 and July 31, 2008 was drawn on August 27, 2008. A second random sample of 6,000 individuals who purchased fishing licenses between April 1, 2008 and August 31, 2008 was drawn on September 8, 2008. Each sample included all possible license types. The sampling continued as above, with modifications only to the monthly sample amount. Simple random samples for the following periods were as follows:

- September 2008 through November 2009: 2,500 individuals
- December 2009 through June 2010: 1,250 individuals
- July 2010 through February 2013: 500 individuals

Survey Instrument

They survey instrument was designed to capture angling seasonality, cover all fishing activity within Michigan, incur low costs per respondent and collect both short term and longer term trip information balancing the benefits of long recall periods with the needs for accuracy. Longer recall (activities over the last 12 months) are limited to general angler behavior questions: fishing in Michigan (yes/no); participation in fishing events (yes/no); fishing in other countries or states besides Michigan (yes/no); types of waterbodies fished; number of trips taken (range); and fish species sought and methods used.

To meet our objectives, the survey instrument contains 21 multi-part questions over four major sections: Part A) general fishing activities during the last 12 months; Part B) fishing activities during the most recent month (e.g., June); Part C) details of the recent fishing trip(s); Part D) usual fishing activities, background and demographic information (see Figure A1).

Figure A.1: Image of Michigan Recreational Angler Survey.

MICHIGAN STATE UNIVERSITY

MICHIGAN FISHING SURVEY

PART A: YOUR MICHIGAN FISHING DURING THE PAST 12 MONTHS

Please complete and return this questionnaire **even if you did not** go fishing in the past 12 months.

1. In the past 12 months, did you go fishing in Michigan?

☐ No (skip to **PART D, question 9**)
☐ Yes

2. In the past 12 months, how many times have you gone fishing in Michigan?

☐ 1 time
☐ 2 or 3 times
☐ 4 or 5 times
☐ 6 to 9 times
☐ 10 to 19 times
☐ 20 or more times

3. In the past 12 months, what types of water bodies did you fish at in Michigan?
(check all that apply)

☐ Michigan rivers
☐ Michigan inland lakes
☐ Great Lakes and connecting waterways

4. In the past 12 months, have you competed in any fishing events in Michigan?

☐ No
☐ Yes ➔ (If Yes) How many events?
_______ fishing events

5. For each of the types of fish listed below, indicate which methods, if any, you used to try catching that type of fish in Michigan in the past 12 months.
(check all that apply)

Method of fishing

Type of fish	Natural Bait	Artificial Bait	Trolling	Casting from boat	Casting from shore/pier	Fly fishing	Ice fishing	Other method
Bass	☐	☐	☐	☐	☐	☐	☐	☐
Catfish	☐	☐	☐	☐	☐	☐	☐	☐
Panfish	☐	☐	☐	☐	☐	☐	☐	☐
Pike	☐	☐	☐	☐	☐	☐	☐	☐
Salmon	☐	☐	☐	☐	☐	☐	☐	☐
Suckers	☐	☐	☐	☐	☐	☐	☐	☐
Trout	☐	☐	☐	☐	☐	☐	☐	☐
Walleye	☐	☐	☐	☐	☐	☐	☐	☐
Other ______	☐	☐	☐	☐	☐	☐	☐	☐

PART B: YOUR MICHIGAN FISHING IN MAY 2012

6. Did you go fishing in Michigan during the month of MAY 2012?

☐ No (skip to **PART C, question 7**)
☐ Yes ➔

(If Yes) Circle the days that you fished in MAY

MAY 2012						
S	M	T	W	T	F	**S**
		1	2	3	4	**5**
6	7	8	9	10	11	**12**
13	14	15	16	17	18	**19**
20	21	22	23	24	25	**26**
27	28	29	30	31		

Figure A.1 (Cont'd)

Use this map to help answer questions in **PART C** regarding your **TWO MOST RECENT MICHIGAN FISHING TRIPS**. A fishing trip is **any time you went fishing**, **no matter where or how long** you fished.
Place X's near the locations of your **two most recent** fishing trips.

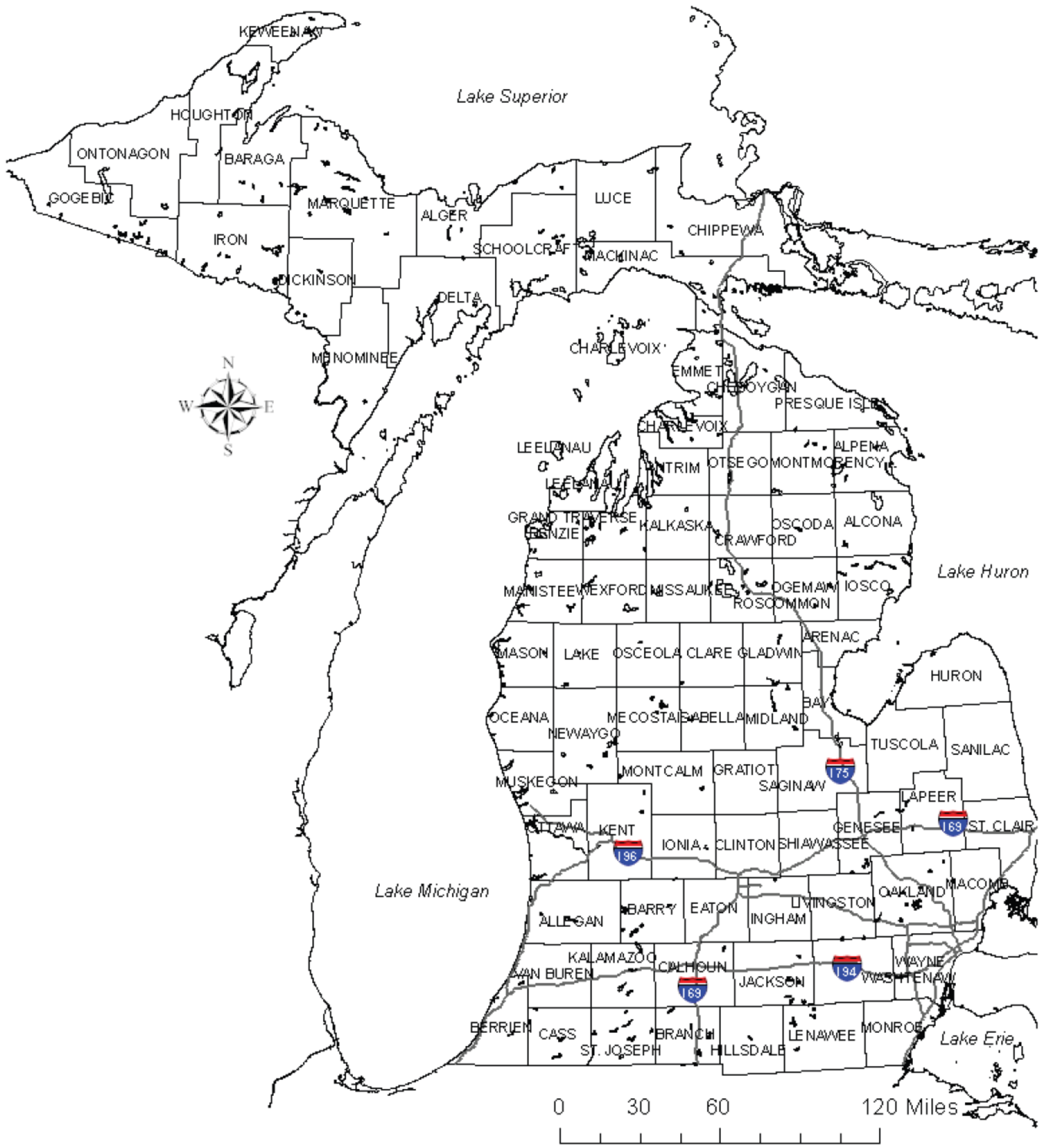

Figure A.1 (Cont'd)

PART C: YOUR TWO MOST RECENT MICHIGAN FISHING TRIPS

For the purposes of this survey, a fishing trip is **any time you went fishing**, **no matter where or how long** you fished.

		7. Your Most Recent Michigan Fishing Trip			8. Your Second Most Recent Michigan Fishing Trip		
Trip Characteristics		↓			↓		
Date		month:________ year:_ _ _ _			month:________ year:_ _ _ _		
Was fishing the main purpose of the trip?		☐Yes ☐No			☐Yes ☐No		
Was it an overnight trip?		☐Yes ☐No			☐Yes ☐No		
How many days did you fish on this trip?		_____ day(s)			_____ day(s)		
Did you fish at multiple rivers or lakes?		☐Yes ☐No			☐Yes ☐No		
Main Trip Location (where most time was spent)		↓			↓		
River or Lake (check one)		☐River ☐Lake			☐River ☐Lake		
Name of River or Lake		Name:________________________			Name:________________________		
Nearest city/town/village		City:________________________			City:________________________		
County		County:______________________			County:______________________		
Please mark the general location on the map		Put an "X" on the map			Put an "X" on the map		
Primary Fishing Mode (check one)		↓			↓		
Primarily from the shoreline		☐			☐		
Primarily wading		☐			☐		
Primarily from a boat (trailered to site)		☐			☐		
Primarily from a boat (already at site)		☐			☐		
Charter boat		☐			☐		
Ice fishing		☐			☐		
Fish Species You Targeted, Caught or Released (check all that apply)		Targeted	Number Caught	Number Released	Targeted	Number Caught	Number Released
Bass	Largemouth	☐	___ fish	___ fish	☐	___ fish	___ fish
	Smallmouth	☐	___ fish	___ fish	☐	___ fish	___ fish
Carp	Common Carp	☐	___ fish	___ fish	☐	___ fish	___ fish
Catfish	Bullhead, Channel and Flathead	☐	___ fish	___ fish	☐	___ fish	___ fish
Pikes	Muskie/Muskellunge	☐	___ fish	___ fish	☐	___ fish	___ fish
	Pike	☐	___ fish	___ fish	☐	___ fish	___ fish
Panfish	Yellow Perch	☐	___ fish	___ fish	☐	___ fish	___ fish
	White Perch or White Bass	☐	___ fish	___ fish	☐	___ fish	___ fish
	Bluegill/ Pumpkinseed/Sunfish	☐	___ fish	___ fish	☐	___ fish	___ fish
	Black/White Crappie	☐	___ fish	___ fish	☐	___ fish	___ fish
	Rock Bass	☐	___ fish	___ fish	☐	___ fish	___ fish
Salmon & Trout	Chinook/King Salmon	☐	___ fish	___ fish	☐	___ fish	___ fish
	Coho/Silver Salmon	☐	___ fish	___ fish	☐	___ fish	___ fish
	Rainbow Trout (Steelhead)	☐	___ fish	___ fish	☐	___ fish	___ fish
	Brook/Speckled Trout	☐	___ fish	___ fish	☐	___ fish	___ fish
	Brown Trout	☐	___ fish	___ fish	☐	___ fish	___ fish
	Lake Trout	☐	___ fish	___ fish	☐	___ fish	___ fish
	Lake Whitefish/Whitefish	☐	___ fish	___ fish	☐	___ fish	___ fish
Suckers	Longnose, Redhorse and White	☐	___ fish	___ fish	☐	___ fish	___ fish
Walleye	Walleye	☐	___ fish	___ fish	☐	___ fish	___ fish
Other Species	Name:__________	☐	___ fish	___ fish	☐	___ fish	___ fish
	Name:__________	☐	___ fish	___ fish	☐	___ fish	___ fish
	Name:__________	☐	___ fish	___ fish	☐	___ fish	___ fish

Figure A.1 (Cont'd)

PART D: YOUR USUAL FISHING ACTIVITIES AND BACKGROUND

Summaries of the following questions help us represent the fishing activities of all types of anglers. Individual answers are CONFIDENTIAL.

9. About how old were you the first time you went fishing? (even if you did not catch a fish)
_______ years old

10. How many years have you fished in Michigan?
________ years

11. Do any of the following live in your household? (check all that apply)
- ☐ Spouse or significant other
- ☐ Children age 5 and under
- ☐ Children age 6 to 17 years old
- ☐ Other immediate family
- ☐ Extended family members or other adults
- ☐ None of these

12. How many people in your household have a current fishing license, including yourself?
_______ people

13. Which of the following best describes who you usually fish with? (check one)
- ☐ No one else
- ☐ Friends
- ☐ Family / relatives
- ☐ Other _______

14. Do you own a boat that you use for fishing?
- ☐ No
- ☐ Yes ➔ (if Yes) Check all that apply
  - ☐ Motor boat
  - ☐ Canoe/kayak
  - ☐ Other _______

15. When you go fishing, what do you usually do with the legal size fish you catch? (check one)
- ☐ Mostly keep my catch
- ☐ Keep some, release some
- ☐ Mostly catch and release

16. Do you use a computer to access the internet for personal use?
- ☐ No
- ☐ Yes

17. In the past 12 months, have you fished in other countries or in other states, besides Michigan?
- ☐ No
- ☐ Yes

18. Which of the following best describes your employment status? (check one)
- ☐ Employed fulltime
- ☐ Part-time
- ☐ Retired
- ☐ Un-employed
- ☐ Other _______

19. What is your highest level of education? (check one)
- ☐ Less than High School degree
- ☐ High School degree or GED
- ☐ Some post High School or some college
- ☐ Bachelor's Degree
- ☐ Graduate Degree

20. What is your race or ethnic background? (check all that apply)
- ☐ Asian
- ☐ American Indian or Alaska Native
- ☐ Black or African American
- ☐ Native Hawaiian or Pacific Islander
- ☐ Hispanic, Latino or Spanish Origin
- ☐ White, non-Hispanic
- ☐ Other

21. Which of the following best describes your annual household income? (check one)
- ☐ $0- 24,999
- ☐ $25,000-49,999
- ☐ $50,000-74,999
- ☐ $75,000-99,999
- ☐ $100,000-149,999
- ☐ $150,000 or more

Comments:

If you have misplaced your postage-paid envelope, please return this survey to: Frank Lupi, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI 48824-1222. THANK YOU!

Figure A.2: Michigan Recreational Angler Survey Contact letter

DATE

<Name>
<Street>
<City>, <State> <ZIP>

Your help is needed with a study of fishing in Michigan. The study is being conducted by Michigan State University's Department of Fisheries and Wildlife for the Michigan Department of Natural Resources, Fisheries Division. The results from this survey will help natural resource agencies make fisheries management decisions that better reflect the needs of people that fish in Michigan.

You are part of a small sample of people being asked about their fishing activities. *Your* answers are needed to help ensure the results accurately represent the people who fish in Michigan.

Whether you go fishing often or only occasionally, *your input is important*. Please let us know what you think by completing the enclosed questionnaire and returning it in the prepaid envelope.

Your individual views will be completely confidential and your privacy will be protected to the maximum extent permitted by law. Also, your participation in the survey is voluntary, and you may refuse to answer certain questions. If you have any concerns or questions about this research study, such as scientific issues, how to do any part of it, or if you believe you have been harmed because of the research, please contact Frank Lupi, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI 48824-1222; lupi@msu.edu, 517-432-3883.

If you have any questions or concerns about your role and rights as a research participant, or would like to register a complaint about this research study, you may contact, anonymously if you wish, Michigan State University Human Research Protection Program at 517-355-2180, FAX 517-432-4503, or e-mail irb@msu.edu, or regular mail at: 202 Olds Hall, Michigan State University, East Lansing, MI 48824.

Thank you very much for helping with this important study.

Sincerely,

Frank Lupi

Frank Lupi
Associate Professor
Enclosure

Figure A.2: (Cont'd)

DATE

<Name>
<Street>
<City>, <State> <ZIP>

I recently sent you a survey about your fishing activities in Michigan. To the best of my knowledge, I have not heard from you.

I am writing to you again because **your input is vital!** You are part of a small sample of people who are being asked about their fishing activities.

Your answers are needed to help ensure the results accurately represent the people who fish in Michigan. *Your answers* will help natural resource agencies make management decisions that better reflect the needs of people that fish in Michigan.

Please take a few minutes to share your viewpoint by filling out this short survey.

Your individual views will be completely confidential and your privacy will be protected to the maximum extent permitted by law. Also, your participation in the survey is voluntary, and you may refuse to answer certain questions. If you have any concerns or questions about this research study, such as scientific issues, how to do any part of it, or if you believe you have been harmed because of the research, please contact Frank Lupi, Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, MI 48824-1222; lupi@msu.edu, 517-432-3883.

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Thank you very much for helping with this important study.

Sincerely,

Frank Lupi
Associate Professor
Enclosure

APPENDIX B

Chapter 1 Response Rate

Table B 1 Michigan Recreational Angler Survey Response Rate

Adjusted response rate [19,635 / 45,504-(1851+2524+3)]= 47.7%

	Number	Percent
Cases Eliminated	1851	4.1%
Undeliverable	2524	5.5%
Refusals	14	0.0%
Deceased	3	0.0%
Surveys Returned	19635	43.2%
Surveys Not Returned	21477	47.2%
Total	45504	100%

APPENDIX C

Chapter 1 Respondent and Non-Respondent characteristics and Data Weights

Of the 45,504 individuals who were contacted from our simple random sample from March 2009 through February 2012, 19,635 returned surveys. After accounting for eliminated cases and undeliverable addresses, the final adjusted response rate was 47.7%. A comparison of respondent and non-respondent characteristics revealed statistically significant differences in age, residency, gender, and license type. The mean age of respondents was significantly higher than nonrespondents (p<0.001), Michigan residents (X^2 =58.762, df=1, p <0.001) and females (X^2 =4.542, df=1, p =0.033) were somewhat more likely to respond and a smaller proportion of resident restricted, temporary (24-hour and 72-hour licenses) license holders responded to our survey, with the remaining commonly issued license types (Resident All Species, Non-Resident All Species, Senior Restricted, and Senior All Species comprising a slightly larger proportion of our respondents (X^2 =1441.437, df=7, p <0.001) (**Table C.1**).

These results are suggestive of age and license type differences in respondents to the survey. To correct for possible response/nonresponse bias, weights for the survey respondents are computed according to the distribution of age, gender, residency and license type. For the continuous variable age and the multiple-category variable license type, the distribution of the variables was examined and categories were imposed to create relatively even distributions. Post stratification case weights are arrived at by normalizing the percent in sample and percent of respondents for jointly distributed categories (Holt and Smith 1979). For example, the percentage of resident, males, age 18-24, with restricted licenses in our sample (2.4%) was divided by the percent of respondents for that joint distribution (1.69%) to arrive at a case weight of 1.4484. Case weights were applied to respective jointly distributed categories. There are 6 age ranges (18-24, 25-34, 35-44, 45-54, 55-64, 65-94), two license categories (Restricted and All Species), two gender categories, and two resident categories (MI resident, NonMichigan Resident) (See Table C.2 through C.5).

Table C 1 MDNR sample, respondents and nonrespondent characteristics.

	MDNR Sample	Respondents	NonRespondents	*statistic*	df	*p*
Michigan Residents	84.0%	85.5%	82.9%	58.762^{c}	1	<0.001
Non-Residents	16.0%	14.5%	17.1%			
Females	18.1%	18.5%	17.8%	4.542^{c}	1	0.033
Males	81.9%	81.5%	82.2%			
Mean Age	47.14	51.69	43.658	1.442^{f}		<0.001
Standard Deviation (Age)	16.221	15.699	15.743			
License Type*						
Resident Restricted	40.0%	34.1%	44.6%			
Resident All Species	29.5%	32.9%	26.9%			
Non-Resident Restricted	4.9%	4.9%	4.9%			
Non-Resident All Species	2.6%	3.0%	2.3%			
Senior Restricted	5.2%	6.8%	4.0%	1441.437	7	< 0.001
Senior All Species	6.9%	10.2%	4.3%			
Temporary (24hr & 72hr)	10.4%	7.8%	12.3%			
Other Licenses	0.5%	0.3%	0.7%			

A total of 45,504 anglers were contacted from the 2009 through 2012 fishing season. Subscript c denotes chi-square. Subscript f denotes ANOVA F statistic.

Table C 2 Post-stratification weights: Age and License Distributions (males residents).

Age and License Type Distribution for Male Residents from the MDNR Retails Sales System sample

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	5.7%	8.4%	9.4%	11.0%	8.9%	6.5%	49.9%
All Species	3.9%	7.4%	8.8%	10.9%	9.5%	9.7%	50.2%

Age and License Type Distribution for Male Resident Survey Respondents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	2.9%	5.0%	6.7%	9.7%	10.5%	8.2%	42.8%
All Species	2.6%	6.1%	8.2%	12.7%	13.2%	14.3%	57.2%

Table C.4. Age and License Type Sample Weights for Male Residents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94
Restricted	1.9838	1.6846	1.3997	1.1330	0.8526	0.7931
All Species	1.4736	1.2077	1.0740	0.8591	0.7200	0.6802

Table C 3 Post-stratification weights: Age and License Distributions (female residents)

Age and License Type Distribution for female residents from the MDNR Retails Sales System sample

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	8.8%	12.8%	12.2%	16.7%	12.8%	8.4%	71.7%
All Species	3.2%	4.7%	4.9%	6.9%	4.8%	3.8%	28.3%

Age and License Type Distribution for female resident Survey Respondents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	5.5%	8.1%	10.0%	17.7%	16.5%	11.4%	69.2%
All Species	1.9%	3.9%	4.4%	8.5%	6.9%	5.3%	30.8%

Age and License Type Sample Weights for female residents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94
Restricted	1.591337	1.580754	1.22828	0.94229	0.777402	0.742324
All Species	1.637317	1.220612	1.119879	0.807801	0.694536	0.713903

Table C 4 Post-stratification weights: Age and License Distributions (male nonresidents)

Age and License Type Distribution for male nonresidents from the MDNR Retails Sales System sample

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	2.2%	4.1%	5.5%	6.1%	6.5%	5.2%	29.6%
All Species	5.8%	12.9%	13.6%	15.9%	13.1%	9.0%	70.3%

Age and License Type Distribution for male nonresident Survey Respondents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	1.3%	2.5%	4.3%	6.8%	9.4%	8.4%	32.7%
All Species	3.0%	6.3%	11.2%	16.6%	17.5%	12.8%	67.4%

Age and License Type Sample Weights for male nonresidents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94
Restricted	1.6693	1.6289	1.2741	0.9095	0.6958	0.6218
All Species	1.9677	2.0336	1.2189	0.9579	0.7501	0.7060

Table C 5 Post-stratification weights: Age and License Distributions (female nonresidents)

Age and License Type Distribution for female Nonresidents from the MDNR Retails Sales System sample

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	2.4%	**5.7%**	5.8%	9.8%	7.9%	5.8%	37.4%
All Species	7.9%	14.2%	12.2%	14.4%	9.6%	4.4%	62.7%

Age and License Type Distribution for female NonResident Survey Respondents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	**Total**
Restricted	1.7%	**3.6%**	4.7%	12.5%	10.2%	9.3%	41.9%
All Species	3.2%	11.0%	10.8%	14.8%	12.9%	5.5%	58.1%

Age and License Type Sample Weights for female NonResidents

License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94
Restricted	1.4484	1.5823	1.2415	0.7856	0.7759	0.6207
All Species	2.4829	1.2892	1.1279	0.9754	0.7462	0.7958

APPENDIX D

Chapter 1 Esri Tapestry segmentation strategy evaluation.

Examination of LifeMode segments and general fishing behaviors (D.1), Michigan-specific fishing behaviors (D.2 through D.4) and license purchase behavior (D.5). Chi-square tests of independence, Cramer's *V*, Goodman and Kruskal Tau, One-Way ANOVA *F* statistic, Welch's adjusted *F* ratio, and eta-squared (η^2) and an adjusted omega square (ω^2).

Table D 1 Comparison of LifeMode general fishing behavior characteristics

LifeMode	Description	Fishing Experience[a] (Mean)	Boat Ownership[b]	Catch Disposition Mostly Keep[c]	Catch Disposition Mostly Catch&Release[c]	Companion[d]	Fishing Outside State[e]
1	*High Society*	40.60	58.4%	22.3%	45.9%	93.3%	36.6%
2	*Upscale Avenues*	39.94	63.6%	28.1%	35.3%	93.4%	30.0%
3	*Metropolis*	40.33	38.2%	38.1%	32.5%	92.8%	27.4%
4	*Solo Acts*	36.66	43.3%	20.7%	48.0%	89.3%	35.7%
5	*Senior Styles*	42.00	59.1%	32.3%	31.6%	90.5%	23.7%
6	*Scholars and Patriots*	31.20	42.0%	25.6%	41.0%	91.0%	23.1%
7	*High Hopes*	35.20	50.4%	26.0%	38.9%	89.0%	27.1%
8	*Global Roots*	35.30	47.2%	25.3%	30.2%	91.5%	18.6%
9	*Family Portrait*	37.20	52.8%	22.6%	42.7%	92.7%	32.9%
10	*Traditional Living*	39.26	51.7%	27.7%	35.2%	92.4%	25.3%
11	*Factories and Farms*	40.28	66.0%	37.8%	23.3%	92.8%	22.0%
12	*American Quilt*	42.04	67.8%	36.0%	23.9%	90.3%	22.2%
	Average	40.23	60.2%	30.6%	32.8%	92.1%	26.8%

[a]Lavene = (df_1=11,df_2=18,127),7.492, p<.001; Welch's F=($df1$=11,$df2$=1825.797)= 19.878, p <.001; ω^2= 0.0111; η^2= 0.0117; Games-Howell 39/66, α =(.05)

[b] X^2=2008.108, df = 11, p < .001; Tau = .020, p <.001; Cramer's V = .141, p <.001, N=18,688

[c] X^2=573.750, df=22, p < .001; Tau = .015, p <.001; Cramer's V = .124, p <.001, N=18,528

[d] X^2=40.488, df=11, p <.001; Tau = .002, p <.001; Cramer's V = .050, p <.001, N=16510

[e] X^2=248.509, df =11, p <.001; Tau = .013, p <.001; Cramer's V = .115, p <.001, N=18,689

Table D 2 Comparison of LifeMode Michigan-specific fishing behavior characteristics

Life Mode	Description	Fishing Frequecy [a] 1 to 3 times	Fishing Frequecy[a] 10 or more times	Species Diversity[b]	Method Diversity[c]	Total Species and Method Diversity[d]	Michigan Fishing Experience[e]	Waterbody Diversity[f]	Great Lakes[g]	Inland Lakes[h]	Rivers[i]
1	*High Society*	27.1%	44.5%	3.11	3.61	8.51	30.69	1.70	49.0%	76.8%	43.8%
2	*Upscale Avenues*	21.4%	51.8%	3.31	3.79	9.20	32.40	1.72	49.4%	79.1%	43.7%
3	*Metropolis*	21.7%	51.8%	3.39	3.18	8.40	29.57	1.70	43.5%	63.4%	63.1%
4	*Solo Acts*	30.3%	43.2%	3.28	3.37	8.37	27.06	1.71	49.8%	70.6%	50.5%
5	*Senior Styles*	19.3%	53.8%	3.42	3.71	9.38	34.38	1.76	52.3%	74.4%	49.3%
6	*Scholars&Patriots*	23.0%	54.9%	3.59	3.85	10.12	21.03	1.88	46.1%	80.9%	60.9%
7	*High Hopes*	20.2%	50.8%	3.53	3.64	9.29	27.53	1.81	44.4%	78.2%	58.2%
8	*Global Roots*	22.6%	52.8%	3.69	3.54	9.75	25.81	1.73	34.4%	78.1%	60.0%
9	*Family Portrait*	27.0%	47.3%	3.20	3.62	8.84	28.15	1.67	46.6%	78.2%	42.4%
10	*Traditional Living*	20.0%	53.4%	3.49	3.78	9.81	31.48	1.77	48.8%	78.6%	49.6%
11	*Factories&Farms*	18.0%	55.5%	3.41	3.86	9.55	34.20	1.76	44.1%	79.3%	53.0%
12	*American Quilt*	15.9%	60.6%	3.63	4.02	10.40	36.08	1.83	49.7%	82.3%	51.3%
	TOTAL	20.6%	53.0%	3.39	3.77	9.41	32.66	1.75	48.3%	78.1%	49.0%

[a] X^2=271.461, df=55, p <.001; Tau = .004, p <.05; Cramer's V = .055, p <.001, N=18,012

[b]Lavene = (df_1=11,df_2=17,483),6.983, p<.001; Welch's F=(df_1=11,df_2=1777.895)= 12.701, p <.001; ω^2= 0.0070; η^2= 0.0076; Games-Howell 14/66, α =(.05)

[c]F=(df_1=11,df_2=17493)= 14.391, p <.001; ω^2=0.0083; η^2= 0.0090; Scheffe 13/66, α =(.05)

[d]Lavene = (df_1=11,df_2=17,482),6.792, p<.001; Welch's F=(df_1=11,df_2=1782.877)= 10.505, p <.001; ω^2= 0.0060; η^2= 0.0066; Games-Howell 13/66, α =(.05)

[e]Lavene = (df_1=11,df_2=17,983),3.881, p<.001; Welch's F=(df_1=11,df_2=1817.258)= 34.572, p <.001; ω^2= 0.0195; η^2=0.0201; Games-Howell 47/66, α =(.05)

[f]F=(df_1=11,df_2=18080)= 5.614, p <.001; ω^2=0.0028; η^2= 0.0034; Scheffe 3/66, α =(.05)

[g] X^2=64.079, df=11 p <.001; Tau = .004, p <.05; Cramer's V = .060, p <.001, N=18,081

[h] X^2=109.202, df=11, p <.001; Tau = .006, p <.05; Cramer's V = .078, p <.001, N=18,084

[i] X^2=158.101, df=11, p <.001; Tau = .009, p <.05; Cramer's V = .094, p <.001, N=18,084

Table D 3 Comparison of LifeMode and species fished for in last 12 months

Life Mode	Description	Bass[a]	Catfish[b]	Nortern Pike[c]	Panfish[d]	Salmon[e]	Suckers[f]	Trout[g]	Walleye[h]
1	*High Society*	74.1%	12.7%	41.4%	64.7%	31.0%	4.5%	34.1%	47.8%
2	*Upscale Avenues*	72.1%	17.3%	44.9%	73.7%	32.4%	8.5%	31.6%	49.9%
3	*Metropolis*	80.6%	40.5%	35.5%	62.8%	23.8%	14.1%	29.0%	50.7%
4	*Solo Acts*	71.2%	21.2%	40.4%	60.3%	39.7%	9.3%	46.0%	39.4%
5	*Senior Styles*	69.9%	18.4%	47.0%	70.8%	30.5%	9.9%	36.0%	58.9%
6	*Scholars and Patriots*	73.9%	11.7%	50.5%	73.0%	35.1%	16.2%	51.4%	43.2%
7	*High Hopes*	76.7%	29.4%	46.7%	72.4%	33.2%	10.3%	36.1%	47.5%
8	*Global Roots*	80.1%	37.2%	44.9%	71.2%	29.5%	20.5%	32.1%	53.2%
9	*Family Portrait*	74.3%	18.5%	43.4%	68.4%	27.0%	7.6%	31.5%	47.9%
10	*Traditional Living*	76.0%	26.6%	46.0%	73.7%	28.0%	11.4%	30.6%	56.1%
11	*Factories and Farms*	70.3%	23.4%	44.7%	75.9%	29.9%	14.5%	30.2%	51.3%
12	*American Quilt*	70.8%	18.7%	53.3%	76.3%	33.5%	14.3%	38.1%	57.9%
	TOTAL	72.3%	20.2%	45.8%	72.2%	30.9%	10.8%	33.5%	52.7%

[a] X^2=55.382, df=11, p <0.001; Tau = .003, p <0.001; Cramer's V = .056, p <0.001, N=17,493

[b] X^2=307.492, df=11, p <0.001; Tau = .018, p <0.001; Cramer's V = .133, p <0.001, N=17,493

[c] X^2=97.464, df=11 p <0.001; Tau = .006, p <0.001; Cramer's V = .075, p <0.001, N=17,495

[d] X^2=153.450, df=11, p <0.001; Tau = .009, p <0.001; Cramer's V = .094, p <0.001, N=17,495

[e] X^2=46.787, df=11, p <0.001; Tau = .003, p <0.001; Cramer's V = .052, p <0.001, N=17,496

[f] X^2=221.102, df=11, p <0.001; Tau = .013, p <0.001; Cramer's V = .112, p <0.001, N=17,492

[g] X^2=102.700, df=11, p <0.001; Tau = .006, p <0.001; Cramer's V = .077, p <0.001, N=17,494

[h] X^2=144.096, df=11, p <0.001; Tau = .008, p <0.001; Cramer's V = .091, p <0.001, N=17,497

Table D 4 Comparison of LifeMode and bait types used in the last 12 months

Life Mode	Description	Natural Bait[a]	Artificial Bait[b]	Trolling[c]	Casting From Boat[d]	Casting From Shore[e]	Fly Fishing[f]	Ice Fishing[g]
1	*High Society*	75.2%	76.2%	50.5%	65.8%	49.4%	21.5%	20.8%
2	*Upscale Avenues*	82.4%	77.4%	51.3%	67.7%	52.6%	16.8%	29.2%
3	*Metropolis*	82.4%	63.9%	32.0%	49.6%	59.2%	14.1%	17.0%
4	*Solo Acts*	66.9%	67.5%	47.4%	60.3%	50.0%	24.8%	18.5%
5	*Senior Styles*	83.7%	73.8%	49.0%	62.2%	53.4%	15.6%	30.8%
6	*Scholars and Patriots*	82.9%	75.7%	42.3%	64.0%	67.6%	22.5%	28.8%
7	*High Hopes*	81.7%	75.4%	43.4%	63.0%	59.0%	18.0%	21.2%
8	*Global Roots*	85.3%	73.1%	35.9%	64.1%	58.3%	13.5%	19.9%
9	*Family Portrait*	80.8%	76.0%	42.9%	67.2%	53.4%	16.0%	23.4%
10	*Traditional Living*	86.1%	75.4%	45.9%	64.7%	58.3%	15.7%	29.1%
11	*Factories and Farms*	86.0%	75.4%	49.4%	67.0%	53.7%	15.8%	35.7%
12	*American Quilt*	87.0%	76.7%	55.5%	67.9%	54.9%	16.5%	40.5%
	TOTAL	83.1%	75.5%	49.3%	65.6%	53.9%	16.9%	30.3%

[a] X^2=215.506, *df*=11, *p* <0.001; Tau = .012, p <0.001; Cramer's V = .111, p <0.001, N=17,495

[b] X^2=48.328, *df*=11,*p* <0.001; Tau = .003, p <0.001; Cramer's V = .053, p <0.001, N=17,495

[c] X^2=126.157,*df*=11, *p* <0.001; Tau = .007, p <0.001; Cramer's V = .085, p <0.001, N=17,496

[d] X^2=73.887, *df*=11, *p* <0.001; Tau = .004, p <0.001; Cramer's V = .065, p <0.001, N=17,495

[e] X^2=54.102, *df*=11, *p* <0.001; Tau = .003, p <0.001; Cramer's V = .056, p <0.001, N=17,490

[f] X^2=59.659, df=11, *p* <0.001; Tau = .003, p <0.001; Cramer's V = .058, p <0.001, N=17,495

[g] X^2=351.569, df=11, *p* <0.001; Tau = .020, p <0.001; Cramer's V = .142, p <0.001, N=17,494

Table D 5 Comparison of LifeMode and license purchasing behavior

LifeMode	Description	Vendor DNR[a]	Vendor Marjor Grocery / Department[a]	Vendor Marjor Sporting Goods[a]	Vendor Other[a]	Days (since season start)[b]	Fidelity 2001-2012 [c]	Fidelity 2008-2012[d]	Computer Usage
1	High Society	12.5%	31.4%	15.0%	41.2%	90.44	5.89	3.05	90.1%
2	Upscale Avenues	7.1%	35.2%	12.1%	45.6%	84.13	6.43	3.29	82.8%
3	Metropolis	4.6%	36.4%	11.2%	47.8%	76.91	5.55	2.93	69.5%
4	Solo Acts	9.6%	37.5%	13.4%	39.5%	90.75	4.54	2.59	88.1%
5	Senior Styles	4.5%	32.8%	9.5%	53.2%	78.87	6.59	3.33	76.4%
6	Scholars and Patriots	7.7%	46.9%	12.8%	32.5%	90.22	4.38	2.66	90.8%
7	High Hopes	5.5%	44.4%	9.4%	40.8%	87.24	5.24	2.91	83.0%
8	Global Roots	5.1%	43.3%	9.1%	42.5%	85.70	4.74	2.69	71.4%
9	Family Portrait	8.2%	38.3%	11.6%	41.9%	87.94	5.81	3.06	85.0%
10	Traditional Living	4.3%	38.9%	11.8%	45.0%	81.86	6.10	3.13	76.7%
11	Factories and Farms	3.6%	33.3%	5.3%	57.7%	76.33	6.84	3.42	70.6%
12	American Quilt	3.8%	29.6%	6.2%	60.4%	75.89	7.03	3.49	70.5%
	TOTAL	5.8%	34.4%	9.8%	50.0%	81.45	6.35	3.24	78.0%

[a]X^2=1804.836, df=33,p <.001; Tau = .014, p <.001; Cramer's V = .113, p <.001, N=47,266

[b]Lavene = (df_1=11,df_2=44,832),7.738, p<.001; Welch's F=(df_1=11,df_2=6340.987)= 40.905, p <.001; η^2= 0.0100; ω^2= 0.0098; Games-Howell 40/66, α =(.05)

[c]Lavene = (df_1=11,df_2=47,254),16.403, p<.001; Welch's F=(df_1=11,df_2=6687.155)= 106.097, p <.001; η^2=0.0224; ω^2= 0.0222; Games-Howell 56/66, α =(.05)

[d]Lavene = (df_1=11,df_2=47,254),13.737, p<.001; Welch's F=(df_1=11,df_2=6659.125)= 79.317, p <.001; η^2=0.0182; ω^2= 0.0179; Games-Howell 49/66, α =(.05)

[a]X^2=516.492, df=33,p <.001; Tau = .028, p <.001; Cramer's V = .167, p <.001, N=18,542

APPENDIX E

Inland Lake Classification Process and Response Rate

Inland lake trip locations where identified using some combination of the water body name and nearest city and county. Identified inland lakes were coded with a unique identification number developed by the Michigan Department of Natural Resources, Institute for Fisheries research. Identified lakes were then matched to the lake classification system developed by Wehrly et al. (2012). A total of 2,125 unique inland lake identification numbers were generated. Of those, 1,886 were assigned a lake classification number (1-6) resulting in 14,889 individual trips with an inland lake classification code reported by 13,053 anglers. General Survey Response is total number of responses to the survey. Many respondents did not report trips because they (1) did not fish in last 12 months or (2) did not complete the section (i.e. item nonresponse).

Table E 1 Inland Lake Classifications

Michigan Recreational Angler Survey. Survey dates begining July 2008 through February 2012. Raw data, adjusted response rate, identification results and number and percent of identified trips. General Survey Response is response to the survey. Adjusted response rate (Response / ((Total Sample - (Undeliverables + Deceased)).

	number	percent
Sample	70,273	
General Survey Response	31,046	
Adjusted Survey Response		46%
Number of anglers reporting at least one inland lake trip	13,053	
Unique Inland Lakes	2,125	
Unique Inland Lakes classification number	1,886	89%
Analyzed inland lake trips	14,889	

APPENDIX F

Chapter 3 Great Lakes Angler web-survey, paper survey, contact letters and postcards.

Following a modified Tailored Design Method (Dillman 2007), we mailed three contacts over the course of one month (from November 7 to November 21, 2012): an invitation letter, a ¼ sheet reminder postcard (in color) and, a 1/2 sheet reminder postcard (in color). A fourth contact, consisting of a final survey package with most of the original web survey questions, was mailed 3.5 months later (March 28, 2013) to non-respondents. During all four contacts, anglers were provided with the web-based survey address and a unique code to access the web survey. In total, 459 individuals responded the survey through the internet, and 577 individuals responded to the final mail survey. After accounting for undeliverable addresses the final adjusted response rate was 36% (Table H.1).

Both the web survey and paper survey instruments included 4 main sections (A) a section gathering general fishing behavior and fishing activities over the last 12 months, (B) a choice experiment section, (C) a section soliciting levels of awareness, levels of agreement, importance rankings, and preferences related to a variety of management programs, issues and challenges, and (D) a section of background and demographic questions. The survey instrument mailed to non-respondents to the web survey largely duplicated the original web survey instrument, with a reduction primarily in part (C).

Table F 1 Great Lakes Angler survey response

Great Lakes Angler survey. Adjusted response rate [3095 /1036-256] = 36%

	Number	Percent
Undeliverables	256	8.3%
Web-based survey response	459	14.8%
Mail survey response	577	18.6%
Total Surveys Returned	1036	33.5%
Surveys Not Returned	767	24.8%
Total	3095	100.0%

APPENDIX G

Chapter 3 Data Weights

The mean age of respondents was significantly higher than nonrespondents ($p<0.001$) and a smaller proportion of resident restricted and temporary or 24-hour and 72-hour licenses responded to our survey, with the remaining commonly issued license types (Senior Restricted, Resident All Species, Senior All Species comprising a slightly larger proportion of our respondents (X^2 =142.18, df=7, p <0.001) (see Table I.1).

These results are suggestive of age and license type differences in respondents to the survey. To correct for possible response/nonresponse bias, post-stratification weights for the survey respondents are computed according to the distribution of age and license type. For the continuous variable age and the multiple-category variable license type, the distribution of the variables was examined and categories were imposed to create relatively even distributions. Post stratification case weights are arrived at by normalizing the percent in sample and percent of respondents for jointly distributed categories (Holt and Smith 1979). The base is our sample frame the MDNR Retail Sales System database (RSS). There are 6 age ranges (18-24, 25-34, 35-44, 45-54, 55-64, 65-94) and two license categories (Restricted and All Species).

Table G 1 MDNR sample, respondents and nonrespondent characteristics

	MDNR Sample	Respondents	Nonrespondents	statistic	df	p
Female	20.7%	20.6%	20.8%			
Mean Age	46.58	52.88	43.39	250.506[f]	1	<0.001
Standard Deviation (Age)	16.439	15.277	16.085			
License Type[c]						
Resident Restricted	50.5%	40.2%	55.6%			
Senior Restricted	5.8%	7.9%	4.8%			
Resident All Species	32.0%	36.1%	30.0%	127.445	4	<0.001
Senior All Species	7.8%	13.6%	4.9%			
Military & Temporary (24Hour&72Hour)	3.8%	2.2%	4.6%			

N=3,095. Subscript c denotes chi-square. Superscript f denotes ANOVA F statistic

Table G 2 Post-stratification weights: Age and License type distributions.

Joint Age and License Type Distributions from the MDNR Retail Sales System sample

	Age Category						
License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	Total
Restricted	8.14%	9.14%	10.18%	11.57%	11.02%	6.37%	56.41%
All Species	4.43%	6.91%	7.30%	8.69%	8.11%	8.17%	43.62%

Joint Age and License Type Distributions of Survey Respondents

	Age Category						
License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94	Total
Restricted	3.67%	4.54%	7.14%	11.39%	12.93%	8.78%	48.46%
All Species	2.70%	4.15%	5.98%	10.81%	14.09%	13.80%	51.54%

Age and License Type Sample weights

	Age Category					
License Category	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-94
Restricted	2.21981	2.01552	1.42488	1.015547	0.851822	0.724643
All Species	1.637803	1.665883	1.220157	0.803958	0.575466	0.592221

APPENDIX H

Chapter 3 Predicted Choice Probabilities
Lake Huron, Lake Michigan and Lake Superior

Predicted Choice Probabilities

Lake Huron, Lake Michigan and Lake Superior

To further illustrate managerial implications of the results, we used the model to predict support for Great Lakes management strategies differentiated by their emphasis on Pacific salmon, prey base, risks of ecosystem collapse and average fish. Recall that the probability of preferring option *k* is:

$$prob\ (Y_i = k) = \frac{exp(Bx_{ik})}{\sum \exp(Bx_{ij})}$$

where *x* are the observed variables relating to the alternative management strategies, β are the parameters that were estimated. Tables J1 through J3 represent three management alternatives for which choice probabilities are calculated: a Pacific Salmon focus with increased risk of fish stock collapse, more nonnative prey, and smaller average size fish (column A), a native species focus (column B) with decreased risk of fish stock collapse, more native prey, and larger average size fish and the status quo or "same as today" (column C). For each lake, the tables show the specific values assumed for each of the attributes under each of the three alternatives. In general, choice probabilities, interpreted as predicted support, were greater for outcomes with a native species emphasis, as compared to a Pacific salmon emphasis and the status quo or "same as today option".

Table H 1 Predicted Probabilities: calculations for Lake Huron

	Pacific Salmon Focus		Native Focus		Status Quo	
	A		B		C	
	X	β*X	X	β*X	X	β*X
Status Quo	0	0	0	0	1	0.3841
Risk of fish stock collapse (RISK)						
slightly decreased risk	0	0	1	0.440075	0	0
slightly increased risk	1	0.0175052	0	0	0	0
Prey fish community (PREY)						
mostly native prey	0	0	1	0.492458	0	0
mostly introduced prey	1	0.1361696	0	0	0	0
Number of Fish						
Chinook	0.5	0.31793765	-0.5	-0.31794	0	0
Lake Herring	-0.5	-0.07221215	0.5	0.072212	0	0
Lake Trout	-0.5	-0.05414565	0.5	0.054146	0	0
Northern Pike	-0.5	-0.29875695	0.5	0.298757	0	0
Rainbow Trout	0.5	0.2517238	-0.5	-0.25172	0	0
Smallmouth Bass	-0.5	-0.15064415	0.5	0.150644	0	0
Walleye	-0.5	-0.30319165	0.5	0.303192	0	0
Yellow Perch	-0.5	-0.23793475	0.5	0.237935	0	0
Average Size of Fish (SIZE)	-0.5	-0.221272	0.5	0.221272	0	0
TOTALS (Σ B* X)		-0.61482105		1.701029		0.3841
Exp of Σ β*X		0.540737652		5.479582		1.468293
ExpA + ExpB+ ExpC		7.48861237		7.488612		7.488612
Choice probabilities		0.072207991		0.731722		0.19607

Table H 2 Predicted Probabilities: calculations for Lake Michigan

	Pacific Salmon Focus		Native Focus		Status Quo	
	A		B		C	
	X	β*X	X	β*X	X	β*X
Status Quo	0	0	0	0	1	0.030972
Risk of fish stock collapse (RISK)						
slightly decreased risk	0	0	1	0.066193	0	0
slightly increased risk	1	-0.1034979	0	0	0	0
Prey fish community (PREY)						
mostly native prey	0	0	1	0.02227	0	0
mostly introduced prey	1	-0.0953338	0	0	0	0
Number of Fish						
Brown Trout	0.5	0.1926342	-0.5	-0.19263	0	0
Chinook Salmon	0.5	0.1505957	-0.5	-0.1506	0	0
Coho Salmon	0.5	0.146603	-0.5	-0.1466	0	0
Lake Trout	-0.5	-0.07434915	0.5	0.074349	0	0
Rainbow Trout	0.5	0.09317505	-0.5	-0.09318	0	0
Smallmouth Bass	-0.5	-0.08727995	0.5	0.08728	0	0
Walleye	-0.5	-0.31534315	0.5	0.315343	0	0
Yellow Perch	-0.5	-0.22453205	0.5	0.224532	0	0
Average Size (SIZE)	-0.5	-0.23836335	0.5	0.238363	0	0
TOTALS (Σ B* X)		-0.5556914		0.445323		0.030972
Exp of Σ β*X		**0.573675485**		**1.560994**		**1.031456**
ExpA + ExpB+ ExpC		**3.166125645**		**3.166126**		**3.166126**
Choice probabilities		**0.181191636**		**0.49303**		**0.325779**

Table H 3 Predicted Probabilities: calculations for Superior

	Pacific Salmon Focus		Native Focus		Status Quo	
	A		B		C	
	X	β*X	X	β*X	X	β*X
Status Quo	0	0	0	0	1	0.384753
Risk of fish stock collapse (RISK)						
slightly decreased risk	0	0	1	0.042865	0	0
slightly increased risk	1	-0.2946737	0	0	0	0
Prey fish community (PREY)						
mostly native prey	0	0	1	0.209188	0	0
mostly introduced prey	1	-0.03065	0	0	0	0
Number of Fish						
Chinook Salmon	0.5	0.2236385	-0.5	-0.22364	0	0
Coho Salmon	0.5	0.2112997	-0.5	-0.2113	0	0
Lake Herring	-0.5	-0.15105595	0.5	0.151056	0	0
Lake Trout	-0.5	-0.11837985	0.5	0.11838	0	0
Lake Whitefish	-0.5	-0.138666	0.5	0.138666	0	0
Rainbow Trout	0.5	0.1466966	0.5	0.146697	0	0
Splake	-0.5	-0.13118715	0.5	0.131187	0	0
Yellow Perch	-0.5	-0.19910945	0.5	0.199109	0	0
Average Size (SIZE)	-0.5	-0.2423972	0.5	0.242397	0	0
TOTALS (Σ Β* X)		-0.7244845		0.944607		0.384753
Exp of Σ β*X		**0.484574303**		**2.571802**		**1.469252**
ExpA + ExpB+ ExpC		**4.525628723**		**4.525629**		**4.525629**
Choice probabilities		**0.107073366**		**0.568275**		**0.324651**

APPENDIX I

Great Lakes and Non-Great Lakes Anglers
Lake Huron and Lake Michigan Model Comparison

Great Lakes and Non-Great Lakes Anglers

Lake Huron and Lake Michigan Model Comparison

Slightly less than half of respondents (47%) reported fishing in the Great Lakes and connecting waterways in the last 12 months. Compared to anglers who did not report fishing in the Great Lakes, these Great Lakes Anglers were slightly less likely to be female, were more likely to hold All Species licenses, fished more frequently, less likely to fish inland lakes and more likely to fish in rivers. More Great Lakes Anglers reported owning a boat used for fishing, and held membership in fishing organizations or clubs and attended fisheries-related public meetings, citizen advisory committee meetings or other fisheries meetings. Great Lakes Anglers targeted many species, but were nearly twice as likely to target trout and walleye and were three times more likely to target salmon species. Great Lakes anglers also employed a greater diversity of bait types and fishing techniques, in particular Great Lakes anglers were more likely to report offshore boating, near shore boating and trolling techniques (Table K 1 and K2).

We tested whether interaction with our Great Lakes fishing variable (*Great Lakes and connecting waterways fishing in last 12 months*) provided any significant improvement to account for preference heterogeneity in the model. Results of log likelihood ratio tests failed to reject the null hypothesis of equal preferences, suggesting preferences for management outcomes were not significantly different between groups (Table K3). However, from a managerially perspective, we felt it was important to examine the outcome preferences for Lake Huron and Lake Michigan, controlling for anglers who focus their fishing on these lakes.

Separate models controlling for Lake Huron and Lake Michigan anglers who indicated they mostly fished at these lakes are presented in Table K4 and K5. The results in Table K4 and K5 highlight the different emphasis placed on increasing the average size and abundance of Pacific salmon and native species. Anglers who predominately focused their fishing in Lake Huron (see table K4) placed relatively greater importance on management outcomes that increased average fish size as well as the numbers of Chinook salmon, northern pike and especially walleye. Lake Huron anglers placed relatively less emphasis on smallmouth bass, and for rainbow trout the parameter estimates were not statistically significant. In terms of ecosystem variables, non-Lake Huron anglers placed more importance on decreasing risk of fish stock collapse and more native prey fish, while Lake Huron anglers were indifferent. Although broadly the relative species preferences of Lake Huron angler mirror our full model, the magnitude of the parameter estimates for the most preferred species (i.e. walleye, Chinook salmon and northern pike) stand in contrast to the relatively more uniform species preferences of our full model. Lake Huron angler utility will be disproportionality negatively affected by management outcomes that decrease Chinook salmon. However, given Lake Huron angler's strong preferences for management outcomes favoring northern pike and walleye and lower preferences for rainbow trout the predicted probabilities over the illustrative management scenarios are quite similar in spirit to those in Table J1 (our calculations demonstrate slightly higher preferences for the "Native Focus" [73%] and slightly lower for "status quo" [20%]).

Anglers who predominately focused their fishing in Lake Michigan (see Table K5) placed more emphasis on the status quo, increased average fish size, and greater abundance of yellow perch, brown trout and Coho salmon. Lake Michigan anglers placed relatively less emphasis on walleye. Although not statistically significant, preferences for Chinook salmon and smallmouth bass were smaller. For all lakes, including Lake Michigan, we reported that outcomes increasing numbers of walleye most affected the choice of management outcomes. For Lake Michigan anglers, yellow perch, brown trout and Coho salmon dominate outcome preferences. Lake Michigan anglers are somewhat more likely to support management outcomes that favored these nonnative species (our calculations demonstrate somewhat higher preferences for “Native Focus” [58%] and slightly lower for “status quo [30%]).

Table I 1 Comparison of Great Lakes and non-Great Lakes anglers

	Non-Great Lakes Anglers	Great Lakes Anglers	Total	Statistic	df	Probability
Female	25.1%	18.9%	22.2%	5.911	1	0.015
Mean Age	46.84	46.45	46.66			
Standard Deviation (Age)	16.502	16.154	16.333			
Education (% Bachelor's or Graduate Degree)	33.1%	33.5%	31.2%			
License Type						
Resident Restricted	60.7%	39.1%	50.6%			
Senior Restricted	6.7%	4.7%	5.8%			
Resident All Species	21.8%	46.3%	33.3%	74.415[c]	4	<0.001
Senior All Species	7.6%	8.2%	7.9%			
Temporary (24Hour&72Hour)	3.1%	1.6%	2.4%			
Fishing Frequency (past 12 months)						
1 time	7.4%	2.1%	4.8%			
2 or 3 times	20.1%	6.2%	13.3%			
4 to 5 times	17.2%	14.8%	16.0%	88.495[c]	5	<0.001
6 to 9 times	12.7%	11.3%	12.0%			
10 to 19 times	18.4%	19.1%	18.7%			
20 or more time	24.2%	46.6%	35.1%			
Waterbodies Fished (past 12 months)						
Michigan Inland Lakes	82.2%	70.4%	76.7%	19.935[c]	1	<0.001
Michigan Rivers	38.1%	53.7%	45.5%	25.425[c]	1	<0.001
Great Lakes Most Fished (past 12 months)						
Lake Erie	3.6%	12.1%	7.6%			
Lake Huron	4.4%	22.7%	13.0%			
Lake Michigan	19.9%	42.6%	30.6%	441.729[c]	5	<0.001
Lake St. Clair	4.2%	11.5%	7.6%			
Lake Superior	1.1%	6.6%	3.7%			
No Response *or* Did NOT fish in the Great Lakes	66.8%	4.5%	37.5%			
Michigan Fishing Experience	36.26	37.61	36.91			
Standard deviation (Experience)	25.563	15.948	21.468			
Boat Ownership	54.4%	73.3%	63.6%	37.799[c]	1	<0.001
Fishing Organization Member	8.1%	16.4%	12.1%	16.311[c]	1	<0.001
Public Meeting Attendance	2.9%	10.9%	6.8%	24.693[c]	1	<0.001

[c] Chi square statistic; [df] degrees of freedom;

Table I 2 Comparison of Great Lakes and non-Great Lakes anglers

	Non-Great Lakes Anglers	Great Lakes Anglers	Total	Statistic	df	Prob.
Species Targeted (last 12 months)						
Bass	76.9%	73.1%	75.1%			
Catfish	19.1%	23.8%	21.3%	3.388[c]	1	0.066
Panfish	72.0%	74.8%	73.3%			
Pike	48.1%	52.4%	50.1%			
Salmon	17.3%	54.0%	34.6%	153.702[c]	1	<0.001
Suckers	9.3%	15.6%	12.2%	9.493[c]	1	0.002
Trout	26.0%	47.0%	35.9%	49.336[c]	1	<0.001
Walleye	38.9%	75.6%	56.1%	140.934[c]	1	<0.001
Methods Used (last 12 months)						
Natural Bait	78.1%	89.7%	83.6%	25.278[c]	1	< 0.001
Artificial Bait	68.7%	85.8%	76.8%	42.360[c]	1	< 0.001
Trolling	32.2%	67.1%	48.6%	126.402[c]	1	< 0.001
Boat Near Shore	60.3%	78.4%	68.8%	39.612[c]	1	< 0.001
Boat Off Shore	40.4%	73.7%	56.1%	116.045[c]	1	< 0.001
Shore Pier	46.9%	46.7%	51.3%	9.046[c]	1	0.003
Fly Fishing	12.4%	18.1%	15.1%	6.518[c]	1	0.011
Ice Fishing	23.3%	39.6%	31.0%	32.125[c]	1	< 0.001

[c] Chi square statistic; [df] degrees of freedom;

Table I 3 Log likelihood ratio tests: Great Lakes and non-Great Lakes anglers

Log likelihood ratio test comparing the fit of our unconstrained model (controlling for Great Lakes fishing in the last 12 months) to our constrained model. Observed differences in model fit for each of the five lakes were not statistically significant. *df*=13. Log likelihood ratio= -2(L(constrained)-L(unconstrainted)). Data used calculated post-stratification weights.

Lake	**Constrained Model**	**Unconstrained model**	**Statistic**	**df**
Lake Erie	983.62511	972.22234	22.80554	13
Lake Huron	974.47639	965.33448	18.28382	13
Lake Michigan	1012.4024	1004.63313	15.53854	13
Lake St Clair	961.80954	953.01705	17.58498	13
Lake Superior	987.67065	983.15323	9.03484	13

Table I 4 Lake Huron model comparison.

Parameter estimates for conditional logit model for Lake Huron. Full model repeats the information in Table 10. Non Lake Huron anglers (column 3) did not indicate they fished most in Lake Huron in the past 12 months. Lake Huron anglers (column 4) indicated they fished most in Lake Huron in the past 12 months.

	Lake Huron Full Model	**Lake Huron Non Lake Huron Anglers**	**Lake Huron Lake Huron Anglers**
observations	2787	2409	378
Log likelihood	-974.47639	-845.56626	-116.87023
Pseudo R2	0.0631	0.0609	0.1635
Attribute			
Status quo	0.3841**	0.4999***	0.2638
Risk of fish stock collapse (RISK)			
slightly decreased risk	0.44013**	0.4764***	0.3100
slightly increased risk	0.0175	-0.0033	0.2963
Prey fish community (PREY)			
mostly native prey	0.4925**	0.5889***	-0.1325
mostly introduced prey	0.1362	0.1649	-0.1148
Number of Fish			
Brown Trout			
Channel Catfish			
Chinook Salmon	0.6359**	0.5870***	0.8854**
Coho Salmon			
Lake Herring	0.1444	0.1906	-0.1465
Lake Trout	0.1083	0.1485	-0.1325
Northern Pike	0.5975***	0.5617***	0.8517**
Rainbow Trout	0.5034***	0.5461***	0.2637
Smallmouth Bass	0.3013**	0.3051**	0.2522**
Walleye	0.6064***	0.5131***	1.2596***
Yellow Perch	0.4759***	0.4501***	0.5469
Average Size (SIZE)	0.4425**	.3940**	0.6607**

* $p < .10$; **$p < .05$; ***$p \leq .001$

Table I 5 Lake Michigan model comparison.

Parameter estimates for conditional logit model for Lake Michigan Full model repeats the information in Table 10. Non Lake Michigan anglers (column 3) did not indicate they fished most in Lake Michigan in the past 12 months. Lake Michigan anglers (column 4) indicated they fished most in Lake Michigan in the past 12 months.

	Lake Michigan Full Model	**Lake Michigan Non Lake Michigan Anglers**	**Lake Michigan Lake Michigan Anglers**
observations	2853	1920	933
Log likelihood	-1012.4024	-685.95221	-316.67244
Pseudo R2	0.0397	0.0416	0.0639
Attribute			
Status quo	0.0310	0.2178	-0.3788*
Risk of fish stock collapse (RISK)			
slightly decreased risk	0.0662	0.0734	-0.0098
slightly increased risk	-0.1035	-0.0920	-0.0989
Prey fish community (PREY)			
mostly native prey	0.0223	0.0752	-0.0732
mostly introduced prey	-0.0953	-0.0205	-0.2750
Number of Fish			
Brown Trout	0.3853***	0.3174**	0.5706**
Channel Catfish			
Chinook Salmon	0.3012**	0.3330**	0.2161
Coho Salmon	0.2932**	0.1959	0.5187**
Lake Herring			
Lake Trout	0.1487	0.0891	0.2662
Northern Pike			
Rainbow Trout	0.1864	0.1435	0.2992
Smallmouth Bass	0.1746	0.2576*	0.0033
Walleye	0.6307***	0.7158***	0.4481**
Yellow Perch	0.4491***	0.3346**	0.7841***
Average Size (SIZE)	0.4767***	0.4761***	0.5347**

* $p < .10$; ** $p < .05$; *** $p \leq .001$

APPENDIX J

Chapter 3: MRS Calculations

Table J 1 Marginal Rate Substitution calculations relative to Average Size

Marginal Rates Substitution calculation (calculations relative to Average Size; $\partial X_1/\partial X_2 = -\beta_2/\beta_1$)

	Lake Erie	Lake Huron	Lake Michigan	Lake St Clair	Lake Superior
Attribute					
Status quo	-0.4134	-0.8679	-0.0650	-2.3495	-0.7936
Risk of fish stock collapse (RISK)					
slightly decreased risk	-0.7724	-0.9944	-0.1388	-0.9654	-0.0884
slightly increased risk	0.2278	-0.0396	0.2171	-0.0626	0.6078
Prey fish community (PREY)					
mostly native prey	-0.1976	-1.1128	-0.0467	-0.8182	-0.4315
mostly introduced prey	0.8285	-0.3077	0.2000	-0.7598	-0.0307
Number of Fish					
Brown Trout			-0.8082		
Channel Catfish	0.5920			-0.1248	
Chinook Salmon		-1.4369	-0.6318		-0.9226
Coho Salmon			-0.6150		-0.8717
Lake Herring		-0.3264			-0.6232
Lake Trout		-0.2447	-0.3119		-0.4884
Lake Whitefish					-0.5721
Largemouth Bass	-1.0870			-0.8963	
Muskellunge/Muskie				-0.6001	
Northern Pike		-1.3502			
Panfish	-1.2419			-0.7318	
Rainbow Trout		-1.1376	-0.3909		-0.6052
Smallmouth Bass	-2.2734	-0.6808	-0.3662	-0.5616	
Splake					-0.5412
Sturgeon				0.0722	
Walleye	-2.5363	-1.3702	-1.3230	-2.3583	
White Bass	-0.3791				
White Perch	-0.8550				
Yellow Perch	-0.9748	-1.0753	-0.9420	-1.1908	-0.8214
Average Size (SIZE)	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000

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