

UNDERSTANDING AVIDITIES OF RECREATIONAL ACTIVITIES FOR PEOPLE
POSSESSING FISHING LICENSES AND RESIDING IN URBAN ENVIRONMENTS

by

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UNDERSTANDING AVIDITIES OF RECREATIONAL ACTIVITIES FOR PEOPLE POSSESSING FISHING LICENSES AND RESIDING IN URBAN ENVIRONMENTS

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Recreational fishing is one of the world's most popular pastimes, wherein participation is associated with sociodemographic factors. Even so, fishing license sales are declining in the USA in conjunction with a reduction in rural populations as people move to urban areas. Thus, urban areas are constantly growing in population size, population diversity, and geographic size suggesting a need to understand fishing participation in these growing areas. Natural resource managers often use participation to understand recreationists, yet avidity could provide a new way to understand recreationists. The goal of our study is to understand what sociodemographic factors influence the fishing avidity of urban anglers and what relationships exist between fishing avidity and other recreational-activity avidities of anglers who reside in urban environments. Specifically, we asked: 1) do Esri Demographics' urbanization groups better predict fishing avidity of anglers within an urban setting than sociodemographic factors typically gathered in surveys, and 2) what relationships (positive and negative) exist among avidities of recreational activities for fishing-license holders within an urban environment? We created generalized linear models and used an information theoretic approach to evaluate influences of sociodemographic factors on fishing avidity, and we used Principal Component Analysis to evaluate relationships among avidities of

recreational activities. We sent the 2020 Omaha Recreation Survey to a random subset population of 2019 fishing-license holders that resided within the four urbanization groups of Omaha, Nebraska, as designated by Esri Demographics. We determined that Esri Demographics' urbanization groups did not predict fishing avidity better than *a priori* models of common sociodemographic factors. We report a weighted average model of sociodemographic factors (i.e., employment, sex, household size, household gross income, education, R3 retained, R3 reactivated, day license holder, multi-year license holder, additional fishing members in the household, and age) to predict fishing avidity for individuals residing in urban environments. No recreational-activity avidity has a strong negative relationship with fishing avidity. Recreational fishing avidity has strong positive relationships with avidities of ice fishing, hunting, and golf. Our study provides new understanding of how urban anglers recreate in urban environments throughout the USA, which could aid management agencies with development of avidity thresholds to categorize anglers, explore opportunities for co-development of recreational activities for anglers, and identify targets of fishing effort.

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CHAPTER 1. SOCIODEMOGRAPHIC FACTORS INFLUENCE RECREATIONAL-FISHING AVIDITY

Introduction

Humanity is experiencing rapid metropolitan area growth, which in turn increases the diversity of urban populations (Champion 2001; Pickett et al. 2001; Grimm et al. 2008). Currently, more than 50% of the global population resides within urban areas and by 2050, urban areas are projected to contain almost 80% of the global population as rural populations steadily decline (Grubler et al. 2012; Scheuer et al. 2017). Management agencies often use sociodemographic factors to analyze various conditions among diverse human populations (age, sex, gross income, and education level) to assist in characterizing the growing populations (Feldman and Hornik 1981; Lee et al. 2016). Differences among population densities and distributions in growing urbanized areas can result in varying use demands for recreational areas (Li et al. 2020). Along with increased urban area growth and population diversification, recreational opportunities arise within urban areas offering many opportunities for residents.

Across the globe, fishing is a popular activity, both for recreation and as a means for sustenance (Hoffmann 1985; Rothlisberger et al. 2010; Arlinghaus et al. 2021). On average, individuals who pursue recreational fishing opportunities in the USA fish 16 days per year (a measure of avidity), whereas anglers in Europe fish on average 5-10 days (Floyd et al. 2006; Hyder et al. 2018). Both recreational fishing and sustenance fishing are known to natural resource managers as a part of a social-ecological system connected to nature (Pope et al. 2016; Arlinghaus et al. 2021). Thus, participation rates (i.e., proportion of people that engage in activities) in recreational fishing generally increase,

level off then decline with economic development (Arlinghaus et al. 2021). There are societal economic benefits associated with recreational fishing; however, anglers also perceive fishing as enjoyable, such as continuing to fish when economic models would predict anglers to quit, resulting in non-monetary gains (Gatewood and McCay 1990). For example, USA residents spent approximately \$42 billion on recreational fishing activities (Lee et al. 2016). Including sociodemographic factors in models aimed at quantifying fishing could produce better predictions of fishing participation, as models based solely on economic variables underestimate angler participation (Gatewood and McCay 1990).

Common sociodemographic factors (i.e., age, sex, income, and education) are associated with fishing participation (Lee et al. 2016). During 2001, 21% of USA individuals aged 35–44 fished and 19% of individuals aged 25–34 fished, whereas only 8% of anglers 65 years and older fished (Floyd et al. 2006). Younger individuals tend to have greater fishing participation than older individuals (Lee et al. 2016); although the average age of anglers in the USA has increased since 1990 (Valdez et al. 2019). It is estimated that more than 70% of anglers in the USA identify as male (Zhang et al. 2021). Individuals towards the lower end of the economic scale tend to participate less in fishing than individuals toward the higher end of the economic scale (Floyd et al. 2006). Individuals that possess a college degree tend to participate less in fishing than non-college degree holders (Lee et al. 2016). In addition to understanding the influences of individual sociodemographic factors on participation, it is also important to understand the influence of individual sociodemographic factors on recreational fishing avidity, but

these factors often interrelate, suggesting that a grouping of such factors may provide better explanatory power.

Esri Demographics' urbanization groups and tapestry segmentation is a unique way to group various sociodemographics to the zone improvement plan (ZIP) code level for researchers to conduct analyses. Esri Demographics group by spatial location and consider demographic information such as age, education, population size, employment level, and population density (Armstrong and Stedman 2019; Esri Demographics 2022). Esri Demographics tapestry segmentation was used by Texas natural resource managers to better understand catfish management strategies (Schlechte et al. 2021). The identification of angler clusters helped aid Texas Parks and Wildlife to focus their management strategies by marketing fisheries that match catch-related angler motivations (Schlechte et al. 2021). Researchers have identified angler behavior trends (i.e., where anglers choose to fish, type of fish sought, and method of access) of urban anglers by using Esri Demographics' urbanization groups (Barlow 2022). The clustering of demographics, such as Esri Demographics, allows managers to clearly identify areas where management actions could be implemented (Schlechte et al. 2021; Barlow 2022). Thus, the use of Esri Demographics' clustering has been useful for understanding the recreational pursuits of anglers generally (Schlechte et al. 2021), although scale (local, state, and regional) may be a factor.

As urban sprawl continues to develop, urban environments are going to be key areas for understanding anglers in the USA. During the first decade of the 21st century, a vast majority of anglers, 89%, resided in urban areas and the population of minority anglers doubled from 7% to 14% (Valdez et al. 2019). Anglers in the USA actively

support fisheries management practices through the purchases of fishing licenses and paying taxes on fishing related items via the Dingle-Johnson Act (Cooke and Murchie 2015). As urban anglers have a large influence on natural resource management, it is vital that management practices and policies relating to these audiences and the resources they use are continually evaluated and adapted.

One way to begin evolving our management practices is to use updated sociodemographic tools to better understand the role sociodemographic factors have on fishing avidity for anglers that reside within urban environments. When analyzing anglers, managers often focus on participation (i.e., buying, or not, a fishing license); however, fishing avidity (i.e., number of days an angler fishes) can provide a better understanding of fishing habits and efforts.

Omaha, Nebraska, is an urban environment with a densely populated area with diverse sociodemographic factors among the anglers that reside there. Understanding the sociodemographic composition of urban environments and the sociodemographic relation to recreational fishing is essential for comprehending the factors that influence fishing avidity within urban environments. To improve the management of natural resources for anglers residing within urban environments, we will 1) determine if Esri Demographics' urbanization groups better predict fishing avidity than other typically gathered sociodemographic data. If Esri Demographics' urbanization groups do not predict fishing avidity better than other sociodemographic data, then we will 2) build a parsimonious model that best predicts fishing avidity within an urban environment.

Methods

Esri Urbanization Groups

Esri Demographics developed a system that provides a detailed description of America's neighborhoods by dividing residential areas into distinct segments based on socioeconomic and demographic compositions; that is, neighborhoods with similar sociodemographic characteristics are grouped into tapestries (Esri Demographics 2022). Tapestries use market segmentation, which encompasses various demographic and socioeconomic variables, to form an array of demographic and socioeconomic variables that identify unique consumer markets in the USA (Esri Demographics 2022). Tapestry segments are not static, but rather reflect population growth, demographic, and socioeconomic change, and shifts in individual behaviors over the last decade. Tapestry segments are changing as urbanization continues; current tapestry segments form 67 distinct markets, which Esri summarizes into 14 life mode groups and six urbanization groups (Esri Demographics 2022).

We chose to use Esri Demographic's urbanization groups due to the organization of its market segments and geographical and physical features (e.g., age, education, population size, employment level, and population density) to create a basis for sub-setting an angler population residing in a metropolitan area (Esri Demographics 2022). The six distinct urbanization groups as defined by Esri Demographics from urban to rural include: Principal Urban Centers, Urban Periphery, Metro Cities, Suburban Periphery, Semi Rural, and Rural. Two urbanization groups, Semirural and Rural, are not exhibited in the Omaha metropolitan survey area. Our survey frame population, anglers that reside in the Omaha metropolitan area, is comprised of four distinct urbanization groups:

Principal Urban Centers, Urban Periphery, Metro Cities, and Suburban Periphery.

Principal Urban Centers is defined as containing young, mobile individuals that live in densely populated areas in the downtown area of urban environments (Esri Demographics 2022). Households within Principal Urban Centers are normally renters occupied by single occupants or roommates, and half of the consumers use public transportation and exhibit frequent use of the internet (Esri Demographics 2022). Urban Periphery is defined as containing city life for young beginning families that focus most of their leisure activities on children. Households within Urban Periphery tend to live in single-family houses or apartments (Esri Demographics 2022). Metro Cities is defined as containing affordable city life including metropolitan cities or satellite cities for single households living in duplexes or apartments. Households within Metro Cities tend to include college students and Generation X couples who share interests in a range of city life amenities such as dancing and clubbing to museums and concerts (Esri Demographics 2022). Suburban Periphery is defined as containing the suburban areas on the edges of urban areas that are the fastest growing among the urbanization groups. Households within Suburban Periphery tend to be families with children living in family-friendly neighborhoods, most of whom are well-educated and have two incomes (Esri Demographics 2022).

Survey

In corporation with the Nebraska Game and Parks Commission (NGPC) and the University of Nebraska-Lincoln (UNL) we developed the 2020 Omaha Recreation Survey and contracted the Bureau of Sociological Research (BOSR) to administer the survey. The 2020 Omaha Recreation Survey included 34 questions to understand anglers'

recreation habits, behaviors, demographic information, places fished, and targeted fish species. The survey frame consisted of individuals who resided within the Omaha, Nebraska, metropolitan area (Figure 1.1) and who purchased a Nebraska 2019 recreational fishing-permit. The types of fishing permits considered in this study include: 1-day fishing license, 3-day fishing license, annual fishing license, 3-year fishing license, 5-year fishing license, lifetime fishing license, 1-day non-resident fishing license, and annual non-resident fishing license. We assigned anglers to Esri urbanization groups, based on residential ZIP codes (Figure 1.2). We desired a sample size of 200 anglers per urbanization group (i.e., an equal sample size for each urbanization group). Thus, we attempted to survey 850 anglers per urbanization group given an anticipated 24% response rate. Among the 850 surveys sent to each urbanization group, 340 surveys were delivered by email and 510 surveys were delivered by mail. We sent 850 surveys to all urbanization groups, except we sent 718 surveys (292 sent via email and 416 sent via mail) to all 2019 licensed anglers that resided in Principal Urban Centers (i.e., no subsample for this urbanization group) to try and obtain an equal sample size from the Omaha metropolitan area.

Survey Administration

The survey was administered by BOSR, which involved a series of mailings. The first contact (February 6, 2020) sent to each 2019 fishing-permit holder without an email address within our survey frame ($n = 1,735$) included a cover letter explaining the purpose of the survey, a copy of the survey, and prepaid postage and envelope to mail back to BOSR. The first contact also included an initial web survey to a random sample of fishing-permit holders with a working email address ($n = 1,564$). One week after the

initial mailing (February 14, 2020), BOSR sent a postcard reminder to all paper non-respondents reminding them to complete the angler survey. The same day all web non-respondents were sent an email reminder to complete the angler survey. The BOSR sent a second and final email reminder to web non-respondents on February 20, 2020, and a second mail package reminder to paper non-respondents on February 27, 2020. Finally, BOSR sent a third and final mail package to all non-respondents on April 8, 2020. Data collection ended on June 4, 2020.

Data Quality

Data from collected mail surveys were entered, with supervision and training by BOSR staff, using Epi Info 6 software with data saved on BOSR's secure network. Data quality was ensured by dual entry authentication. They processed paper mail-survey data in a two-step authentication process. First, a data-entry worker would enter the responses from a single survey. Second, another data-entry worker would re-enter the survey and be notified of any discrepancies from the first data-entry worker. Supervisory staff were available to answer questions about discrepancies.

The web respondents entered their responses directly into a computer instrument. There were no additional data entry or processing steps for the web entries. Data were recorded and stored on a secure server controlled by BOSR within the Sociology Department at UNL.

The BOSR used the Statistical Package for the Social Sciences (SPSS) software package to process and document the dataset. The dataset was exported from Epi Info 6 into an SPSS system, which was transferred electronically to the Nebraska Cooperative Fish and Wildlife Research Unit. We removed any duplicate or blank surveys. Next, we

merged both (web and mail) datasets. Unrealistic responses were removed. For instance, one angler recorded 900 days spent watching television or using the internet and we converted that value to a “NA” value for that angler.

Data Analyses

The analyses to determine whether sociodemographic factors influence fishing avidity were performed in RStudio (RStudio Team 2020). We used the “haven” package in RStudio to load the SPSS data into RStudio (RStudio Team 2020). To better fit the assumption of normally distributed data for modeling, we natural log-transformed the days spent fishing (Question 24a). The sociodemographic models were Esri Demographics’ urbanization groups, Sex, Life Stage (age, employment level, and household size), Socioeconomic (household gross income and education level), Participation (R3 stage, type of fishing license purchased, and additional fishing members in the household), Urban Area (as defined by Nebraska Game and Parks Commission biologists), and Null (Table 1.1). We created six sociodemographic generalized linear models to predict fishing avidity to test against the Esri urbanization group model (seven models total; Table 1.2). A global model was not included because we were testing the utility of Esri Demographics’ urbanization groups to predict fishing avidity. Sociodemographic information was provided by questions 27 (household size), 28 (additional fishing members within the household), 29 (employment level), 30 (education level), 31 (ZIP code for Esri Demographics’ urbanization group), 32 (age), and 33 (household gross income).

We used the Nebraska Game and Parks Commission license database to obtain type of fishing-permit purchased, license purchase history—2019 and back, which we

categorized as recruited, retained, and reactivated statuses (R3) If an angler had no purchase history with Nebraska Game and Parks Commission and bought a 2019 fishing-permit, then he or she was categorized as Recruited. If an angler purchased a license during 2018 and again during 2019, then he or she was categorized as a Retained angler. If an angler's purchase history did not match the other two conditions, then he or she was categorized as a Reactivated angler. Fisheries biologists located within the Nebraska Game and Parks Commission's Lincoln office categorized the Omaha metropolitan area into six distinct groups for the Urban Area model (Figure 1.3). We categorized employment levels on a scale of 0-7; we assigned 0 being "retired or unemployed", 1 being a "student", 2 being "part-time employment", 3 being "student and part-time employment", 4 being "full-time employment", 5 being "combination of categories 1 and 4 or 2 and 3", 6 being "combination of categories 1 and 5 or 2 and 4", and 7 being "combination of categories 3 and 4 or 2 and 5", and then summed the values for each respondent because an angler could select multiple categories of employment level question 29. The age of the angler was calculated as their age of January 1, 2019 to match the survey frame (i.e., 2019 – year born). Education level question 30 was categorized on a scale of 1-7; 1 possessing "some schooling", 2 possessing a "high school or GED", 3 possessing "some college", 4 possessing an "Associate or trade school degree", 5 possessing a "bachelor's degree", 6 possessing a "master's degree", and 7 possessing a "Doctorate, law, or medical degree". Household gross income was categorized on a scale of 1-11; 1 earning less than \$10 thousand, 2 earning \$10 thousand to less than \$20 thousand, 3 earning \$20 thousand to less than \$30 thousand, 4 earning \$30 thousand to less than \$40 thousand, 5 earning \$40 thousand to less than \$50 thousand, 6 earning \$50

thousand to less than \$75 thousand, 7 earning \$75 thousand to less than \$100 thousand, 8 earning \$100 thousand to less than \$150 thousand, 9 earning \$150 thousand to less than \$200 thousand, 10 earning \$200 thousand to less than \$250 thousand, and 11 earning \$250 thousand or more. Permit types were grouped into three categories: “Day” for anglers that purchased 2019 1- or 2019 3-day fishing-permits, “Annual” for anglers that purchased a 2019 annual fishing-permits, and “Multi-Year” for anglers that purchased a 3- or 5-year fishing-permit that was valid during 2019. Omaha anglers that listed a “Non-Resident” license were removed from the analysis ($n = 3$). The Urban Area model, as defined by Nebraska Game and Parks Commission biologists, was categorized into: West, North, Central, Southwest, South, and Southeast (Figure 1.3). We determined which of the sociodemographic general linear models (glm) best predicted fishing avidity using the Akaike Information Criterion (AIC), analyzed using the “AICmodavg” package in RStudio (RStudio Team 2020). All models that has a $\Delta AICc$ score ≤ 2 were considered as models that best predict fishing avidity (Burnham and Anderson 2004). Non-respondents within the education and gross income questions were removed from the analysis.

Response Bias

We used a Kolmogorov-Smirnov test to evaluate whether cumulative probability distributions of angler age differed between respondent and non-respondents. Thus, we chose to evaluate whether age influences the likelihood of responding to our survey. We evaluated significance for Kolmogorov-Smirnov test at $\alpha < 0.05$, and used the “ks.test” function in R.

Model Selection

We chose to use an information theoretic approach to test against the Esri Demographics' urbanization group model (Urbanization Group model) against pre-specified models that have been shown previously to be important predictors of fishing avidity. Sex of anglers (Sex model) was assessed alone due to the sex of the angler having a large influence on participation (Zhang et al. 2021). We grouped education and income (Socioeconomic model) together because these sociodemographic factors tend to be related (Lubetkin et al. 2005). We grouped age, employment level, and household size (Life Stage model) because these sociodemographic factors also tend to be related (Kuznets 1978).

We had non-sociodemographic factors within our analysis. The non-sociodemographic factors included three models (i.e., Participation, Urban Area, and Null). The Participation model was included due to high levels of interest from Nebraska Game and Parks Commission biologists, and comprised fishing-permit purchased, additional fishing members within the household, and R3 typology. We also wanted to understand how Nebraska Game and Parks Commission biologists viewed the Omaha area, which gave us another spatial model (Urban Area model). Lastly, a Null model was included to understand whether we were testing relevant sociodemographic factors with respect to fishing avidity.

Fishing Avidity Weighted Average Model

We chose to further develop a parsimonious model to understand sociodemographic factors influencing fishing avidity. Sociodemographic factors included: sex, age, employment level, fishing-permit purchased, household size,

additional fishing members in household, education level, household gross income, R3 type, and urban area, and build a model from the candidate list with a $\Delta AICc$ of ≤ 2 . We used the AICmodavg package in RStudio to calculate weighted estimates for each of the sociodemographic factors (RStudio Team 2020). Using RStudio's "modavg" function within AICmodavg, we calculated estimates for each parameter in the models it was included in and averaged the estimates. We validated the model by using 80% of the respondents to recreate the weighted average model and the other 20% of the respondents to validate the model with the weighted average model equation.

Results

Of the 3,299 licensed anglers sent mail or email surveys, 2% were determined ineligible due to a wrong address in the license database, and 12% had undeliverable addresses. There were 876 surveys completed (partially or wholly), 692 by paper and 184 by web. A response rate of 27% was determined using the American Association for Public Opinion Research's definition of Response Rate 2 (The American Association for Public Opinion Research 2023). The BOSR obtained refusals and refused mail from <1% of the sample.

After classifying our Omaha anglers by permit type our sample size decreased from 879 anglers to 876 anglers. There were 182 anglers who did not respond to education (question 30) and household income (question 33), so we removed those non-respondents from further analysis. This left 694 anglers for analyses.

Age distributions differed ($P = 0.02$) between respondents and non-respondents (Figure 1.4). Younger anglers were less responsive to our survey, whereas older anglers were more responsive.

Participation was the best fitting model of our subset to predict fishing avidity for 2019 fishing-permit holders in Omaha (Table 1.3). The Participation model outperformed the next closest model, Socioeconomic, by a ΔAICc score of 53, and contained all the AICc weight for the seven models (Table 1.3). Urbanization Group model was ranked towards the bottom of the list with a ΔAICc score of 73 (Table 1.3). The Null model ranked higher than the Life Stage, Urban Area, and Urbanization Group models with a ΔAICc score of 72, whereas the Urban Area model had a ΔAICc score of 77 and was the last ranked model (Table 1.3). We proceeded to select a parsimonious glm model to predict fishing avidity, because the Urbanization Group model was not a best-fitting model. The top model contained an AICc weight of 0.19, compared to the next model that had an AICc weight of 0.18 and a ΔAICc of 0.12 (Table 1.4).

We created generalized linear models without Esri Demographics' urbanization group and had six models with a ΔAICc score < 2 and nine models with a ΔAICc score < 4 (Table 1.4). The top six models of fishing avidity contained negative relationships with the age of an angler, household size, education, and income, and positive relationships was associated with additional fishing members in the household and employment level (Table 1.5). Type of fishing license purchased, R3 type, and sex of the angler were factors included within the top seven models (Table 1.5). The weighted average glm model to predict fishing avidity is:

$$\log_e(A) = 2.93 - 0.002 \cdot \text{Age} + 0.03 \cdot \text{Emp} - 0.79 \cdot \text{Day} + 0.48 \cdot \text{MY} - 0.12 \cdot \text{HS} + 0.26 \cdot \text{FM} - 0.14 \cdot \text{Edu} - 0.03 \cdot \text{GI} + 0.30 \cdot \text{Ret} - 0.28 \cdot \text{Rec} + 0.27 \cdot \text{M}.$$

Discussion

Our primary goal was to determine whether Esri Demographics' urbanization groups could predict fishing avidity better than other sociodemographic factors typically collected and we concluded they did not. In fact, Esri Demographics' urbanization groups ranked worse than the null model. Although Esri Demographics' urbanization groups have been useful when understanding some angler behaviors (e.g. places fished and fish species targeted) (Barlow 2022). The Participation model, which included the type of permit bought, R3 type, and additional fishing members in the household, outperformed all other sociodemographic model groups. The Participation model likely ranked the highest because this model contained fishing participation factors (i.e., permit type and R3 type); that is participation predicted avidity suggesting that avidity of anglers residing in the Omaha metropolitan area is fairly homogenous.

The best fitting parsimonious models describing fishing avidity contained sociodemographic factors (age, education level, sex, household size), similar to prior research notable for fishing participation (Floyd and Lee 2002; Kuehn et al. 2013; Arlinghaus et al. 2021). In contrast, household gross income was not included in the top AICc models; this is contrary to prior research that suggests gross income is a key characteristic to understand recreational habits (DaRugna 2020; McFarlin 2021). Our analyses did support that in Omaha, non-advanced degree holders and males tend to have a higher fishing avidity than advanced degree holders and females (Floyd et al. 2006; Lee et al. 2016; Arlinghaus et al. 2021). We noted that the increase in household size decreased fishing avidity among urban anglers whereas having additional anglers in one's household increased fishing avidity among urban anglers. However, understanding

relationships with fishing avidity can become complicated with many parameters included.

The weighted model that we developed consisted of age, possessing a day fishing license, increased household size, increase in education level, increase in gross income, and being a recruited angler have a negative relationship with avidity. Whereas, employment level, possessing a multi-year fishing-permit, increased fishing members in the household, being a retained angler, and being a male angler have a positive relationship with fishing avidity. We were surprised with anglers that possessed higher educational degrees and higher gross income had a negative relationship with fishing. Prior literature suggested that an increase in gross income would have a positive relationship with fishing (Floyd et al. 2006). However, our results could suggest that anglers residing within Omaha, that have a greater household gross income, recreate in other recreational activities.

Our research was designed to better understand what sociodemographic factors influence fishing avidity within urban environments. We conclude that within the Omaha metropolitan area young males without graduate education (i.e., bachelor's degree or less) that purchased a fishing-permit have a greater fishing avidity. We had a low R^2 value for our top model within the *a priori* selected model AICc analyses, suggesting that there are other sociodemographic factors that we did not consider that could assist with predicting fishing avidity. Other demographics such as race and ethnicity could be useful because urban areas are diverse and dynamic (Murdock et al. 1992; Floyd and Lee 2002). To increase fishing avidity across urban environments, the focus could be drawn to encouraging members within a household to fish, targeting female individuals to increase

diversity within the sport, and improving location access for anglers (Fedler and Ditton 2001).

Agencies may desire to manage anglers based on target thresholds of recreational fishing avidity. Research on angling avidity thresholds includes three categories: low avidity being < 4 days a year, medium avidity being 4-23 days a year, and high avidity being > 23 days a year (Mason et al. 2020). Anglers that resided within Omaha fished 23 days on average during 2019, which is greater than the nationwide average of 16 days (Lee et al. 2016). Having anglers with high avidity can influence anglers' decisions to interact with state agencies on conservation efforts (Midway et al. 2020). Anglers that are active members in angling clubs generally had a positive mindset when interacting with state agencies and assisting with conservation efforts (Williams and Moss 2001).

Within our sampling frame, the Kolmogorov-Smirnov test resulted in significant differences in angler between respondents and non-respondents. Older anglers were more likely to respond to our survey. Future research efforts need to emphasize connections with younger anglers. Obtaining other demographic variables when selling fishing permits could strengthen future research assessments of response bias. Further, our study was unable to gather information about the fishing avidity of anglers that reside within rural environments.

Urban areas are constantly evolving and diversity among all sociodemographic factors are changing. Our fishing avidity model could be used to predict fishing avidity of anglers within Omaha, Nebraska, for future years. Management agencies could use our model to input anglers' sociodemographic information and output a predicted average fishing avidity for that specific angler type. Our research conducted within Omaha,

Nebraska, likely applies to other urban areas (i.e., Lincoln, Nebraska; Des Moines, Iowa; Kansas City, Missouri) although further evaluation is needed. As recreational participation has doubled in minority groups, this could be an important area of study in Omaha, Nebraska, and other similar areas (Valdez et al. 2019). Our research can also be applied to other recreational activities (e.g., hunting, boating, and wildlife viewing) to assess participants' avidity within various activities.

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Table 1.1. List of variables, abbreviations, descriptions, and options used in the generalized linear models to describe fishing avidity of 2019 fishing permit holders that resided in Omaha, Nebraska. Data are all in integer format.

Variable	Abbreviation	Description	Unit	Category
Avidity	A	Days spent fishing within a year	Days	-
Urban Periphery	Urb	Esri Demographics' urbanization group	-	0,1
Metro Cities	Met	Esri Demographics' urbanization group	-	0,1
Suburban Periphery	Sub	Esri Demographics' urbanization group	-	0,1
Male	M	Male sex of angler	-	0,1
Age	Age	Age of the angler	Years (whole number)	-
Employment level	Emp	Employment level of the angler	-	0:7
Household size	HS	Additional household members in the angler's residence	Persons	0:11
Household gross income	GI	Household gross income of the angler's residence	-	1:11
Education level	Edu	Education level of the angler	-	1:7

Table 1.1 cont.

Variable	Abbreviation	Description	Units	Category
Day fishing license	Day	A 1- or 3-day Nebraska resident fishing-permit	-	0,1
Multi-year fishing license	MY	A 3- or 5-year Nebraska resident fishing-permit	-	0,1
Fishing family members	FM	Additional fishing members within the angler's residence	-	0:6
Retained angler	Ret	Angler that bought a Nebraska fishing permit the prior year (i.e., 2019)	-	0,1
Recruited angler	Rec	Angler that had no purchase history of a Nebraska fishing license but purchased one in 2019	-	0,1
North	N	North area designated by Nebraska Game and Parks Commission biologists of the Omaha metropolitan area	-	0,1
South	S	South area designated by Nebraska Game and Parks Commission biologists of the Omaha metropolitan area	-	0,1
Southeast	SE	Southeast area designated by Nebraska Game and Parks Commission biologists of the Omaha metropolitan area	-	0,1
Southwest	SW	Southwest area designated by Nebraska Game and Parks Commission biologists of the Omaha metropolitan area	-	0,1
West	W	West area designated by Nebraska Game and Parks Commission biologists of the Omaha metropolitan area	-	0,1

Table 1.2. List of all candidate models used to evaluate fishing avidity of Omaha, Nebraska, anglers that possessed a 2019 fishing permit. (See Table 1.1 for abbreviations).

Model	Equation
Urbanization Group	$\log_e(A) \sim (\text{Intercept}) + \text{Urb} + \text{Met} + \text{Sub} + \text{error}$
Sex	$\log_e(A) \sim (\text{Intercept}) + \text{M} + \text{error}$
Life Stage	$\log_e(A) \sim (\text{Intercept}) + \text{Age} + \text{Emp} + \text{HS} + \text{error}$
Socioeconomic	$\log_e(A) \sim (\text{Intercept}) + \text{GI} + \text{Edu} + \text{error}$
Participation	$\log_e(A) \sim (\text{Intercept}) + \text{Day} + \text{MY} + \text{FM} + \text{Ret} + \text{Rea} + \text{error}$
Urban Area	$\log_e(A) \sim (\text{Intercept}) + \text{N} + \text{S} + \text{SE} + \text{SW} + \text{W} + \text{error}$
Null	$\log_e(A) \sim (\text{Intercept}) + \text{error}$

Table 1.3. Model selection results for Akaike's Information Criteria (AICc) contains sociodemographic models to best predict fishing avidity. Anglers were 2019 Nebraska fishing license holders that resided in the Omaha metropolitan area.

Model	K	AICc	Δ AICc	AICcWt
Participation	7	2209.41	0	1
Socioeconomic	4	2263.05	53.64	0
Sex	3	2278.37	68.95	0
Null	2	2281.74	72.33	0
Urbanization Group	5	2282.79	73.38	0
Life Stage	5	2286.63	77.22	0
Urban Area	7	2286.76	77.34	0

Table 1.4. Model selection results for Akaike's Information Criteria (AICc) table contains sociodemographic information to best predict fishing avidity. Anglers were 2019 Nebraska fishing license holders that reside in the Omaha metropolitan area. This includes all models with a delta AIC score of < 4. (See Table 1.2 for abbreviations and Table 1.5 for model equations).

Model	(Intercept)	Age	Emp	Permit Type	HS	FM	Edu	GI	R3 Type	Sex	df	AICc	ΔAICc	weight
A	2.85			+	-0.12	0.26	-0.15		+	+	10	2178.99	0	0.19
B	2.97			+	-0.12	0.26	-0.13	-0.03	+	+	11	2179.12	0.12	0.18
C	2.93		0.03	+	-0.12	0.26	-0.13	-0.04	+	+	12	2180.01	1.02	0.11
D	2.99	-0.003		+	-0.12	0.25	-0.15		+	+	11	2180.44	1.44	0.09
E	2.81		0.02	+	-0.12	0.25	-0.15		+	+	11	2180.44	1.45	0.09
F	3.08	-0.002		+	-0.12	0.26	-0.13	-0.03	+	+	12	2180.74	1.75	0.08
G	2.99	-0.001	0.03	+	-0.12	0.26	-0.13	-0.03	+	+	13	2182.01	3.01	0.04
H	2.92	-0.002	0.02	+	-0.12	0.25	-0.15		+	+	12	2182.21	3.22	0.04
I	3.05			+	-0.11	0.24	-0.15		+		9	2182.37	3.38	0.03

Table 1.5. List of candidate models used to develop the weighted average fishing avidity model from the global generalized linear model ranking of Omaha, Nebraska, anglers that possessed a 2019 fishing permit. (See Table 1.2 for abbreviations and Table 1.4 for model rankings).

Model	Equation
A	$\log_e(A) \sim (\text{Intercept}) + M + HS + Edu + Ret + Rec + Day + MY + FM$
B	$\log_e(A) \sim (\text{Intercept}) + M + HS + Edu + GI + Ret + Rec + Day + MY + FM$
C	$\log_e(A) \sim (\text{Intercept}) + M + Emp + HS + GI + Edu + Ret + Rec + Day + MY + FM$
D	$\log_e(A) \sim (\text{Intercept}) + M + Age + HS + Edu + Ret + Rec + Day + MY + FM$
E	$\log_e(A) \sim (\text{Intercept}) + M + Emp + HS + Edu + Ret + Rec + Day + MY + FM$
F	$\log_e(A) \sim (\text{Intercept}) + M + Age + HS + GI + Edu + Ret + Rec + Day + MY + FM$



Figure 1.1. Omaha, Nebraska, metropolitan area with the designated ZIP codes that were used for the 2020 Omaha Recreation Survey conducted by University of Nebraska-Lincoln and Nebraska Game and Parks Commission used to survey anglers.

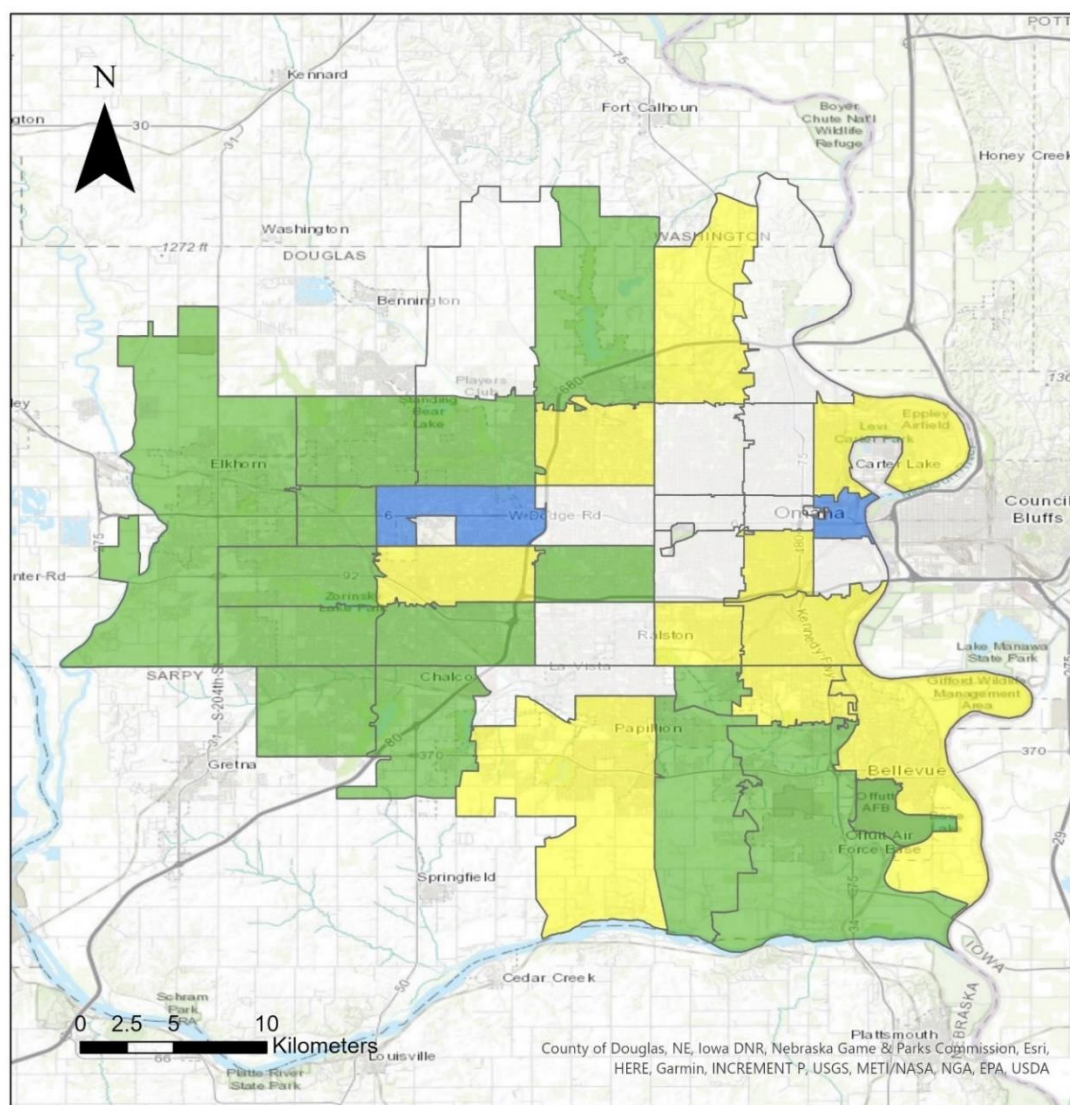


Figure 1.2. Esri Demographics' urbanization groups that exist within the Omaha, Nebraska, metropolitan area. Listed from most urban to suburban are Principal Urban Centers (blue), Urban Periphery (white), Metro Cities (yellow), and Suburban Periphery (green).

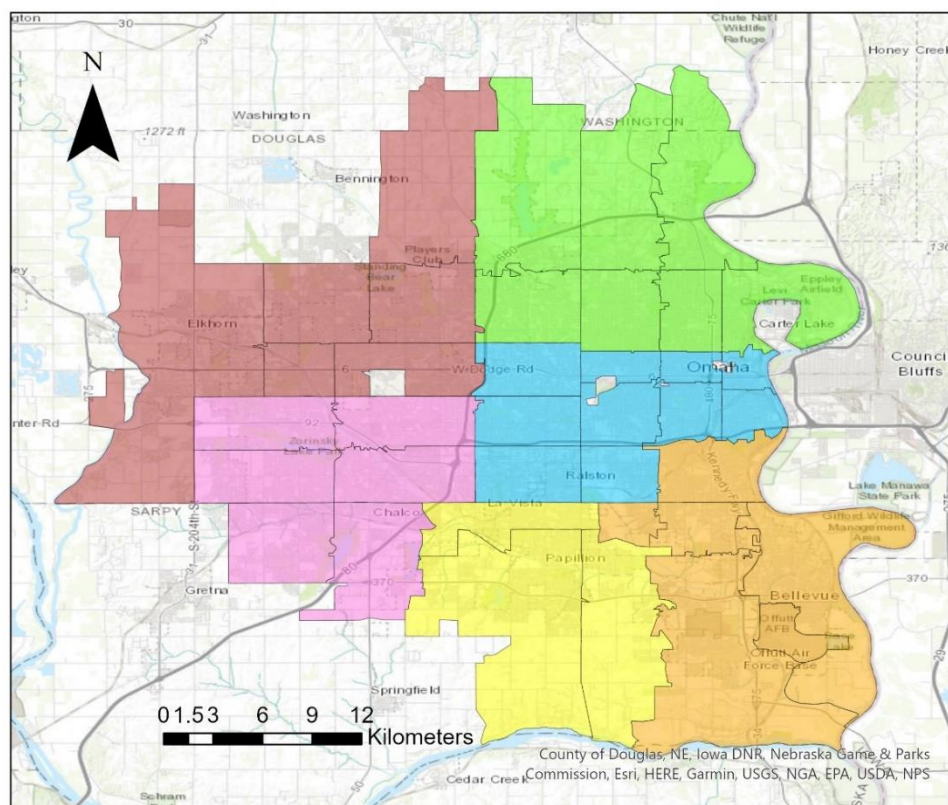


Figure 1.3. Omaha, Nebraska, urban area model as defined by Nebraska Game and Parks Commission biologists. Listed are the six areas defined as West (maroon), North (green), Central (blue), Southwest (pink), South (yellow), and Southeast (orange).

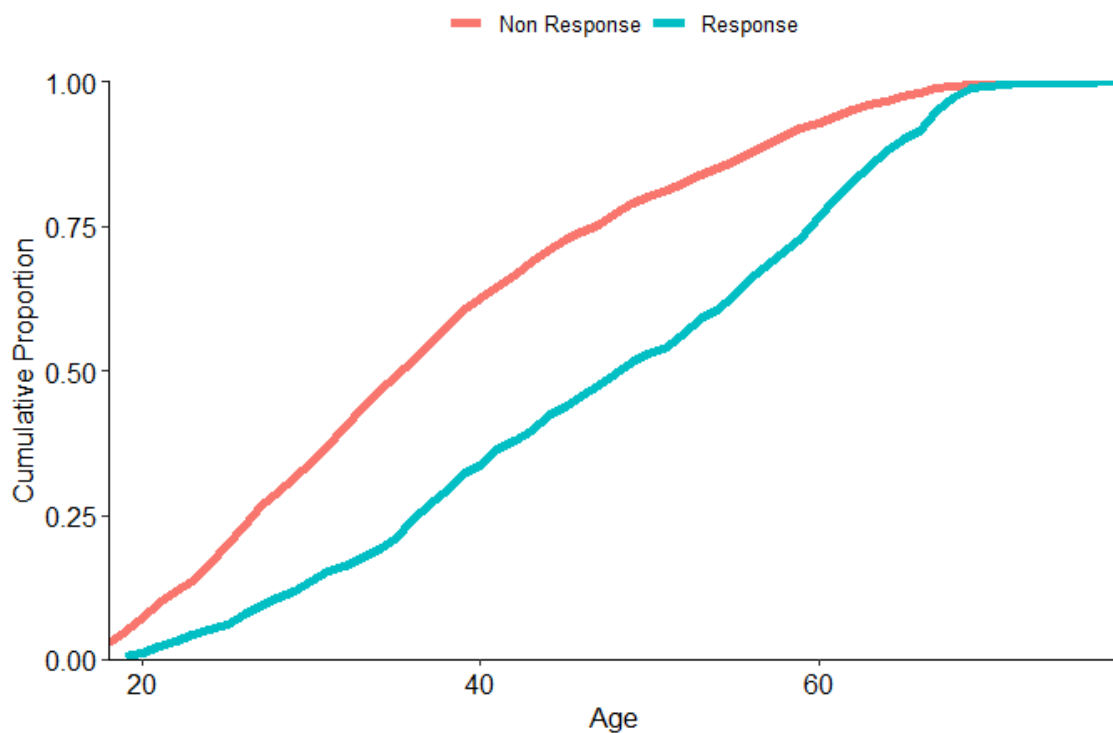


Figure 1.4. Cumulative proportion as an assessment for potential response bias, by age of respondents and non-respondents to the 2020 Omaha Recreation Survey. Responses differed (Kolmogorov-Smirnov test: $P = 0.02$). Residents that are younger (18 – 40 years old) that possessed a 2019 fishing-permit were less likely to respond to the survey than older anglers.

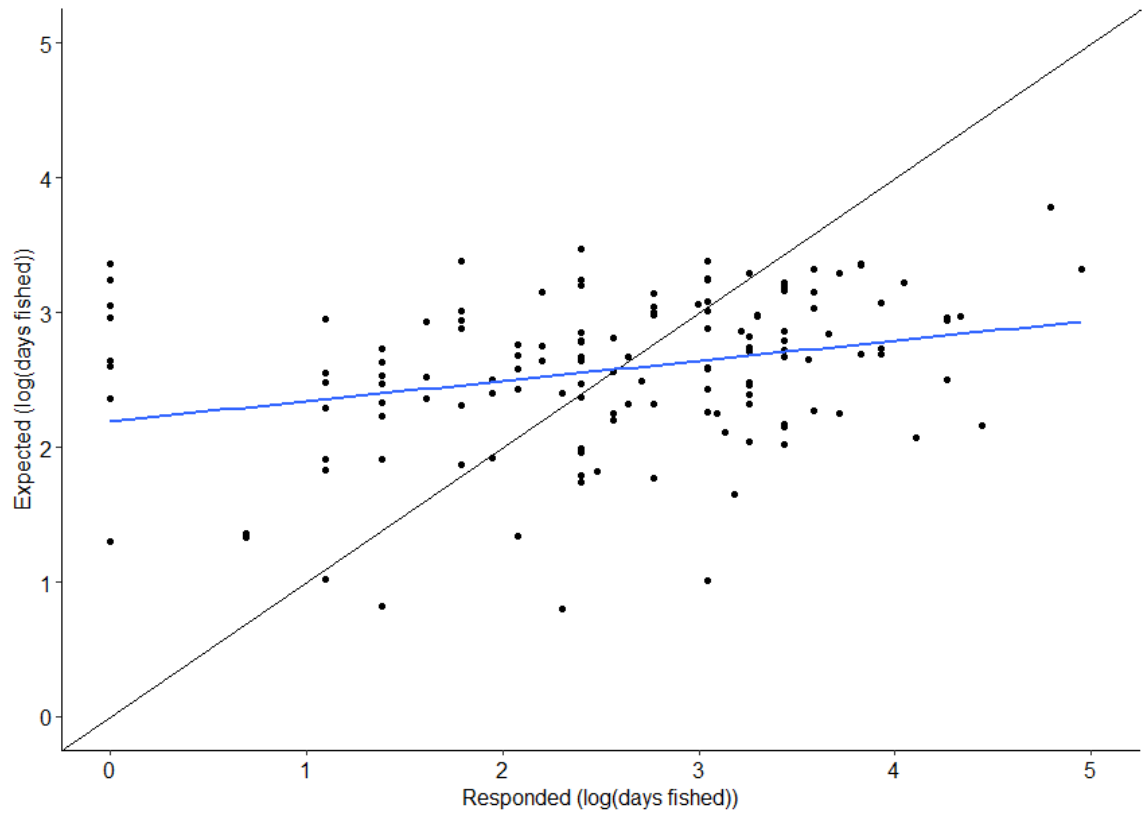


Figure 1.5. Validation of the fishing avidity weighted average model. The black line indicates a slope of 1 and the blue line indicates the trend of the data. The validation used 20% of the respondents and the model used 80% of the respondents from the 2020 Omaha Recreation Survey.

CHAPTER 2. ASSOCIATIONS OF RECREATIONAL-ACTIVITY AVIDITIES FOR ANGLERS

Introduction

Recreational activities are a significant aspect of everyday life (Türkmenadağ and Erdem 2020). Recreation boosts morale, increases social relationships, builds skills and knowledge, and improves well-being (Veal 1992; Godbey 2009; Fancourt et al. 2021). Throughout history, people have sought recreation and its associated benefits as an escape from the stresses of work (Bryant and Forsyth 2005). Recreation is accessible to everyone because of the wide range of activities that are encompassed (Bryant and Forsyth 2005). However, due to longer work hours, most individuals tend to neglect their personal and family recreational needs (Bonebright et al. 2000); this is unfortunate because a “balance” between work and recreation contributes toward positive health (Wu et al. 2016).

Participation in recreational activities offers many personal (i.e., mental wellness, physical health), social (i.e., economic gains, forming relationships) and societal benefits (Brajša-Žganec et al. 2011; Sirgy et al. 2017; Fancourt et al. 2021). Engagement in outdoor and indoor activities can influence physical performance and overall happiness by activating mechanisms within the endocrine and central nervous systems (Olusola and Femi 2006; Fancourt et al. 2021), especially when related to personal well-being (Sirgy et al. 2017). Individuals participating in group activities can build social resources and develop specific learning traits (Fancourt et al. 2021). Economic gains associated with recreational participation help local and national economies, and these gains have increased over time, such as household expenditures devoted to recreation increased from

2% in the late 1800s to 6% in 1991 (Phaneuf and Smith 2005). During 2016, outdoor recreational activities accounted for 2% of the gross domestic product of the USA (Highfill and Franks 2019). Even so, some recreational activities are preferred over others. The most popular recreational activities among Americans are walking, sightseeing, family gatherings, and being on a beach or by water; in contrast, adventure sports, team sports, hunting, and fishing were the least popular (Cordell et al. 1999). Yet, adventure sports, team sports, hunting, and fishing are still popular among many individuals, with some individuals demonstrating high avidities for those activities.

Across the globe, fishing is a popular activity that can be recreational, as well as provide sustenance to anglers (Hoffmann 1985; Rothlisberger et al. 2010; Arlinghaus et al. 2021). Both recreational and work-related fishing are known to natural resource managers to be a part of a social-ecological system that is connected to nature (Pope et al. 2016; Arlinghaus et al. 2021). Participation in recreational fishing increases with societal economic development, as people pursue fishing as a recreational activity rather than engaging in fishing as a source of sustenance or for survival (Arlinghaus et al. 2021). Recreational fishing is known to have economic gains; however, anglers also perceive fishing as enjoyable, such as anglers enjoying their time fishing when economic models would predict them to quit fishing, providing nonmonetary benefits (Gatewood and McCay 1990). Quantifying recreational fishing in solely economic models based on angler motivation underestimates predictions of angler participation (Gatewood and McCay 1990).

Through time, fishing has evolved from being a source of sustenance to being a recreational sport with cultural appeal (Arlinghaus et al. 2021). Culturally, countries with

a long history of fishing have greater participation rates among anglers, indicating that the importance of fishing is passed down through generations (Arlinghaus et al. 2021). The recreational-fishing culture has expanded to different angling groups, and many how-to books, memoirs, and magazines make this sport accessible to nearly anyone (Arlinghaus et al. 2021). Despite expanded recreational fishing opportunities, natural resource managers have observed a decline in fishing participation since 1990 (Hutt and Neal 2010; Arlinghaus et al. 2015; Greiner et al. 2016; Roop et al. 2021). Overfished water bodies, degraded systems, and climate change could potentially cause a reduction or loss of interest in recreational fishing due to systems appearing less desirable (Daw et al. 2012; Pope et al. 2016). Water bodies that experience aquatic life die-off, leftover trash, and nutrient overload from ground baiting can discourage anglers from fishing in certain areas (Cooke and Cowx 2004). Though economic development increases participation in recreational fishing, there is a threshold where economic development can hinder participation rates by inland fisheries, such as society altering fisheries by policies, aesthetics, or commercial needs (Smith 1986; Arlinghaus et al. 2021). In areas with high economic development, such as urban areas (where 80% of the U.S. population resides), there are abundant recreational activities other than fishing available to residents (Pickett et al. 2001; Greiner et al. 2016). Due to the abundance of recreational activities, there could be increasing competition between fishing and other recreational opportunities in urban areas (Cordell and Super 2000; Pickett et al. 2001).

There are several concerns with the decrease in recreational fishing participation, such as economic loss, lost culture, lost fishing knowledge, competition with other activities, and environmental issues. Fishing is important to management agencies as a

source of revenue by means of the North America Model of Wildlife Conservation.

Without fishing (and hunting, to a larger extent), natural resource management agencies would be more limited. The number of fishing licenses sold by Nebraska Game and Parks Commission (NGPC) decreased from 158,000 during 2021 to 146,000 during 2022 (NGPC 2023), and have decreased the last 8 years, with the exception of a slight increase in 2020 due to the Covid-19 pandemic (NGPC 2015, 2023). Anglers' time spent at work is a primary determinate of available recreation time (Bonebright et al. 2000). Thus, recreational activities that fit within the limited time that anglers have will be more appealing (Southwick et al. 2012). Changing attitudes and ideologies have affected recreational fishing cultural norms; especially evident in the shift from sustenance to recreation and catch-and-release fishing (Arlinghaus et al. 2021). Though catch-and-release fishing is promoted as a way for managers to meet anglers' needs management agencies may be unable to structure fish communities to meet angler needs (Sass and Shaw 2020). Thus, to better meet anglers' needs, management agencies could look towards avidity instead of participation in managing anglers.

The current decline in participation rates in recreational fishing raises concerns about the activity's future among management agencies. Declining participation produces decreasing revenue for management agencies and their management actions (Price et al. 2020). Further, a decrease in fishing effort influences community structures of fish due to the decline in harvest (Sass and Shaw 2020). To retain current anglers and recruit new participants, it is important to understand the factors influencing avidities of anglers' recreational activities avidities' (Hinrichs et al. 2020). To improve the understanding of anglers' recreational activity avidities within urban settings, we 1) focus on identifying

relationships among recreational activities that are present within urban areas, and 2) provide management recommendations based off our results.

Methods

Survey

In corporation with the Nebraska Game and Parks Commission (NGPC) and the University of Nebraska-Lincoln (UNL) we developed the 2020 Omaha Recreation Survey and contracted the Bureau of Sociological Research (BOSR) to administer the survey. The 2020 Omaha Recreation Survey included 34 questions to understand anglers' recreation habits, behaviors, demographic information, places fished, and targeted fish species. The survey frame consisted of individuals who resided within the Omaha, Nebraska, metropolitan area (Figure 1.1) and who purchased a Nebraska 2019 recreational fishing-permit. The types of fishing permits considered in this study include: 1-day fishing license, 3-day fishing license, annual fishing license, 3-year fishing license, 5-year fishing license, lifetime fishing license, 1-day non-resident fishing license, and annual non-resident fishing license. We assigned anglers to Esri urbanization groups, based on residential ZIP codes (Figure 1.2). We desired a sample size of 200 anglers per urbanization group (i.e., an equal sample size for each urbanization group). Thus, we attempted to survey 850 anglers per urbanization group given an anticipated 24% response rate. Among the 850 surveys sent to each urbanization group, 340 surveys were delivered by email and 510 surveys were delivered by mail. We sent 850 surveys to all urbanization groups, except we sent 718 surveys (292 sent via email and 416 sent via mail) to all 2019 licensed anglers that resided in Principal Urban Centers (i.e., no

subsample for this urbanization group) to try and obtain an equal sample size from the Omaha metropolitan area.

Esri Urbanization Groups

Esri Demographics developed a system that provides a detailed description of America's neighborhoods by dividing residential areas into distinct segments based on socioeconomic and demographic compositions; that is, neighborhoods with similar sociodemographic characteristics are grouped into tapestries (Esri Demographics 2022). Tapestries use market segmentation, which encompasses various demographic and socioeconomic variables, to form an array of demographic and socioeconomic variables that identify unique consumer markets in the USA (Esri Demographics 2022). Tapestry segments are not static, but rather reflect population growth, demographic, and socioeconomic change, and shifts in individual behaviors over the last decade. Tapestry segments are changing as urbanization continues; current tapestry segments form 67 distinct markets, which Esri summarizes into 14 life mode groups and six urbanization groups (Esri Demographics 2022).

We chose to use Esri Demographic's urbanization groups due to the organization of its market segments and geographical and physical features (e.g., age, education, population size, employment level, and population density) to create a basis for subsetting an angler population residing in a metropolitan area (Esri Demographics 2022). The six distinct urbanization groups as defined by Esri Demographics from urban to rural include: Principal Urban Centers, Urban Periphery, Metro Cities, Suburban Periphery, Semi Rural, and Rural. Two urbanization groups, Semirural and Rural, are not exhibited in the Omaha metropolitan survey area. Our survey frame population, anglers that reside

in the Omaha metropolitan area, is comprised of four distinct urbanization groups: Principal Urban Centers, Urban Periphery, Metro Cities, and Suburban Periphery. Principal Urban Centers is defined as containing young, mobile individuals that live in densely populated areas in the downtown area of urban environments (Esri Demographics 2022). Households within Principal Urban Centers are normally renters occupied by single occupants or roommates, and half of the consumers use public transportation and exhibit frequent use of the internet (Esri Demographics 2022). Urban Periphery is defined as containing city life for young beginning families that focus most of their leisure activities on children. Households within Urban Periphery tend to live in single-family houses or apartments (Esri Demographics 2022). Metro Cities is defined as containing affordable city life including metropolitan cities or satellite cities for single households living in duplexes or apartments. Households within Metro Cities tend to include college students and Generation X couples who share interests in a range of city life amenities such as dancing and clubbing to museums and concerts (Esri Demographics 2022). Suburban Periphery is defined as containing the suburban areas on the edges of urban areas that are the fastest growing among the urbanization groups. Households within Suburban Periphery tend to be families with children living in family-friendly neighborhoods, most of whom are well-educated and have two incomes (Esri Demographics 2022).

Survey Administration

The survey was administered by BOSR, which involved a series of mailings. The first contact (February 6, 2020) sent to each 2019 fishing-permit holder without an email address within our survey frame ($n = 1,735$) included a cover letter explaining the

purpose of the survey, a copy of the survey, and prepaid postage and envelope to mail back to BOSR. The first contact also included an initial web survey to a random sample of fishing-permit holders with a working email address ($n = 1,564$). One week after the initial mailing (February 14, 2020), BOSR sent a postcard reminder to all paper non-respondents reminding them to complete the angler survey. The same day all web non-respondents were sent an email reminder to complete the angler survey. The BOSR sent a second and final email reminder to web non-respondents on February 20, 2020, and a second mail package reminder to paper non-respondents on February 27, 2020. Finally, BOSR sent a third and final mail package to all non-respondents on April 8, 2020. Data collection ended on June 4, 2020.

Data Quality

Data from collected mail surveys were entered, with supervision and training by BOSR staff, using Epi Info 6 software with data saved on BOSR's secure network. Data quality was ensured by dual entry authentication. They processed paper mail-survey data in a two-step authentication process. First, a data-entry worker would enter the responses from a single survey. Second, another data-entry worker would re-enter the survey and be notified of any discrepancies from the first data-entry worker. Supervisory staff were available to answer questions about discrepancies.

The web respondents entered their responses directly into a computer instrument. There were no additional data entry or processing steps for the web entries. Data were recorded and stored on a secure server controlled by BOSR within the Sociology Department at UNL.

The BOSR used the Statistical Package for the Social Sciences (SPSS) software package to process and document the dataset. The dataset was exported from Epi Info 6 into an SPSS system, which was transferred electronically to the Nebraska Cooperative Fish and Wildlife Research Unit. We removed any duplicate or blank surveys. Next, we merged both (web and mail) datasets. Unrealistic responses were removed. For instance, one angler recorded 900 days spent watching television or using the internet and we converted that value to a “NA” value for that angler. Watching television and using the internet was dropped from the analysis due to it being an outlier from the rest of the recreational activities (McFarlin 2021).

Data Analysis

We determined positive and negative relationships between recreational fishing and other recreational activities using Principal Component Analysis (PCA). Analyses were performed in RStudio (RStudio Team 2020). We used the “haven” package in RStudio to load the SPSS data into RStudio (RStudio Team 2020). The PCA reduced the 26 recreational activities into 10 Principal Components (PCs) while retaining the variation of the dataset. Principal Components describes the variation and combines the variables so that most of the information within the data set is explained in the first PC. For this analysis, we used questions Q24, Q25, and Q26 from the Omaha 2020 Angler Survey (Barlow 2022). If an angler did not at least partially answer all three recreational activity questions, then the angler was removed from the analysis. Each question had many subparts, thus for subparts of a given question if an angler provided an answer for the days spent recreating for at least one recreational activity within a question, then all

NA values were converted to 0 days, assuming that the respondent did answer the question in full rather than refusing to answer a portion of the question.

We analyzed the PCA loading plots that represent the relationships and strength of relationships among the 26 recreational activities to understand synergistic and antagonistic relationships. We analyzed two separate loading plots. A loading plot illustrates how strongly a variable influences a PC. The angle between variables in the loading plot represents how closely correlated variables are with each other. An angle of 0° would have a synergistic relationship, an angle of 90° would have a neutral correlation, and an angle of 180° would have an antagonistic relationship (Figure 2.1). Due to having zero-inflated data, we developed two loading plots: a loading plot representing the 26 recreational activities from the 2020 Omaha Recreation Survey (Figure 2.2), and a loading plot representing the recreational avidities with median days spent recreated greater than or equal to one (Figure 2.3). We also generated scree plots to visualize the variance being explained within the PCA loading plots (Figure 2.4).

Results

Of the 3,299 licensed anglers sent mail or email surveys, 2% were determined ineligible due to a wrong address in the license database, and 12% had undeliverable addresses. There were 879 surveys completed (partially or wholly), 695 by paper and 184 by web. A response rate of 27% was determined using the American Association for Public Opinion Research's definition of Response Rate 2 (The American Association for Public Opinion Research 2023). The BOSR obtained refusals and refused mail from <1% of the sample. After classifying our Omaha anglers by permit type, we reduced the number of surveys from 879 anglers to 794 anglers giving us the most robust sample size.

We analyzed the variance explained by the PCA loading plots' dimensions by using scree plots. The scree plot connected with the PCA loading plot (Figure 2.3) suggests by the first and second dimension of the PCA loading plot that we can account for 48% of the variance within the data (Figure 2.4B). The scree plot for the PCA loading plot (Figure 2.2) containing the 26 recreational activities from the 2020 Omaha Survey, resulted in accounting for 24% of the variance in the second dimension (Figure 2.4A).

We determined a synergistic avidity relationship between avidities for fishing, golf, hunting, ice fishing (i.e., PCA loading plots) as recreational activity-avidity vectors were close together on the loading plot (Figure 2.2). There were no activities that had an antagonistic relationship with fishing's avidity or any recreational activity's avidities, however, there were some activities that had a semi-antagonistic avidity relationship with recreational fishing. We also inferred that the other recreational activity's avidities have a neutral relationship to the vectors having angles from the origin around 90° (Figure 2.2).

Discussion

We conclude that urban anglers in Omaha devote a substantial amount of time to pursuing recreational activities due to the diverse average avidities among the recreational activities (Figure 2.5). To increase participation in recreational fishing, natural resource managers should recognize that urban anglers within Omaha participate in a wide variety of indoor and outdoor recreational activities. Management agencies could continue to use television and the internet to promote outdoor recreational activities to increase recreational avidities amongst anglers or other recreationists. Anglers that participate in fishing are also participating in other recreational activities for the same reason (i.e., relaxation, mental well-being, health benefits, etc.; Southwick et al. 2012). In

the 2020 Omaha Recreation Survey, we identified watching television as the most recreated activity on average by our anglers. Watching television could pose the greatest competition to recreational fishing by its ease of access and how accustomed people have gotten to watching television (Southwick et al. 2012). However, watching television could be an effective marketing tool for angling and give natural resource managers an innovative way to interact with urban anglers.

We documented that anglers residing in Omaha participate in a wide variety of recreational activities ranging from relaxing activities (i.e., camping, photography, and woodworking) to more active activities (i.e., fitness, adventure sports, and fishing), perhaps due to living in an environment providing easy access to many recreational opportunities. Omaha has more than 250 city parks and more than 20 public lakes, which provide the opportunities for urban anglers to participate in the many activities that we asked about in the survey (Omaha Parks Recreation Public Property 2023). Activities such as watching television and fitness are more readily available to urban residents, require no special gear to participate, and are easy recreational activities to develop the necessary skill set to have greater avidities than other recreational activities. The ability to have access to and the ability to easily participate in activities can drive how our anglers participate recreationally (Cordell et al. 1999). Thus, ease of recreating can cause urban anglers to have higher avidities in watching television and fitness compared to other recreational activities within the survey (i.e., adventure sports, ice fishing, and winter sports).

We noted that no recreational activity had an antagonistic avidity relationship with recreational fishing (Figure 2.2). There were a few recreational activities that had a

semi-antagonistic avidity relationship with fishing (i.e., wildlife viewing, gardening, and sewing; Figure 2.2). Even so, activities such as ice fishing, hunting, and boating had a synergistic avidity relationship with fishing. The activities of camping and boating can generally be combined with recreational fishing. Similarly, urban angler's avidities that had a synergistic relationship with photography also had a synergistic relationship with wildlife viewing. One cause of there being many neutral relationships with recreational fishing could be that affected urban anglers are lured into other recreational activities that take up smaller blocks of their time (Balsman and Shoup 2008).

Anglers that reside within an urban setting participate in a wide range of recreational activities and their avidities vary among recreational activities (Figure 2.5). The wide range of participation of urban anglers can translate to competition among recreational activities. Similarly, like organisms in an ecosystem, the abundance of resources can influence what an organism consumes (Peterson et al. 1998). The abundance of activities and time constraints can influence how many, or what, activities urban anglers participate. The urban anglers that responded to the 2020 Omaha Recreation Survey reported that they participated in many recreational activities, including fishing.

As natural resource managers within state agencies, we need to recognize the physical and mental benefits of recreational activities. We also need to recognize economic benefits and declining participation in natural resource-related recreational activities. Managers can use competing activities to their advantage by using them as promotional tools to find more innovative ways to interact with urban anglers. As metropolitan areas grow, technology will advance along with them (Weeks 2010). The

use of technology can be widely used to help further promote synergistic recreational activities' avidities with fishing, but also be used to further enhance participation in recreational fishing.

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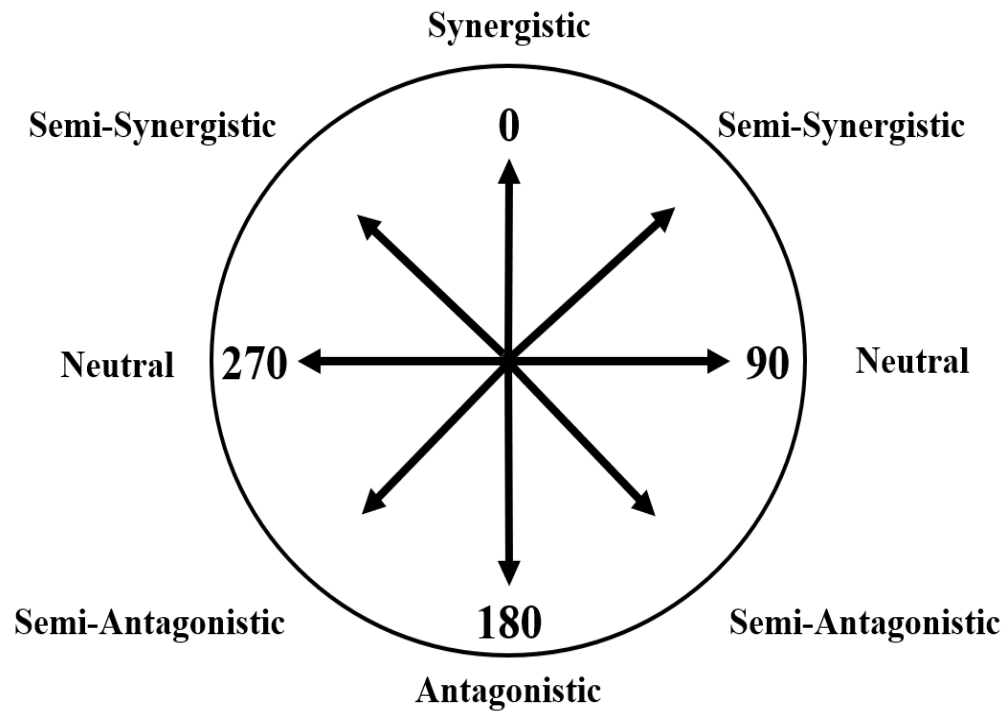


Figure 2.1. Conceptual model for interpreting positive and negative relationships among Principal Component Analysis vectors. The conceptual model rotates like a compass with a recreational activity of interest as the 0-degree vector.

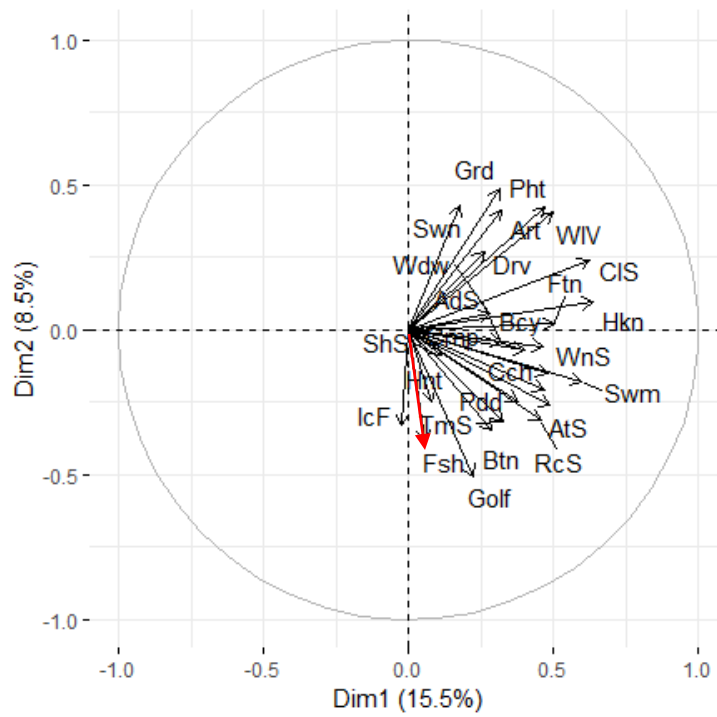


Figure 2.2. PCA loading plot representing 26 recreational activities within the 2020 Omaha Recreation Survey. Abbreviations for the recreational activities are in (Table 1). Within the two dimensions represented on the plot we can explain 24% of the variance within the loading plot. Fishing vector represented by red arrow.

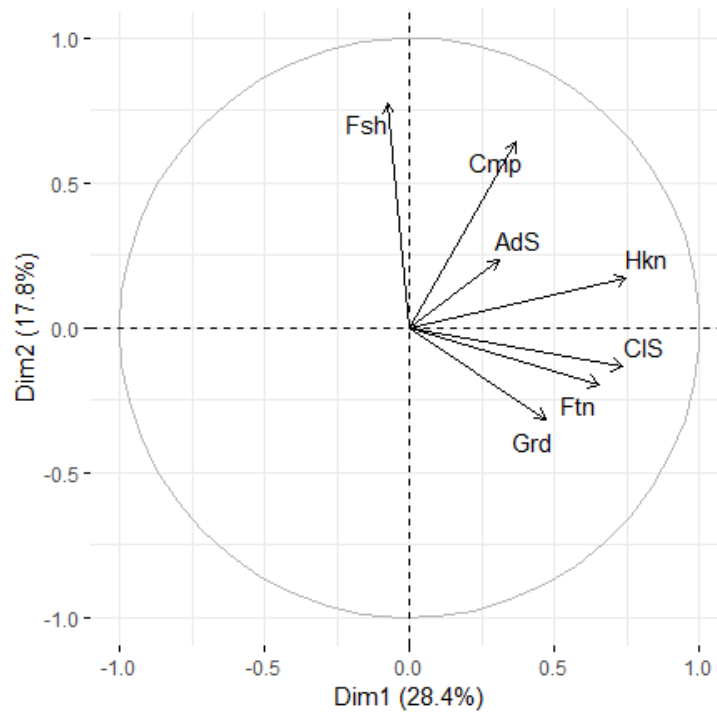


Figure 2.3. PCA loading plot representing the recreational activities with a median day participated ≥ 1 within the 2020 Omaha Recreation Survey. Abbreviations for the recreational activities are in Table 1. Within the two dimensions represented on the plot we can explain 48% of the variance within the loading plot.

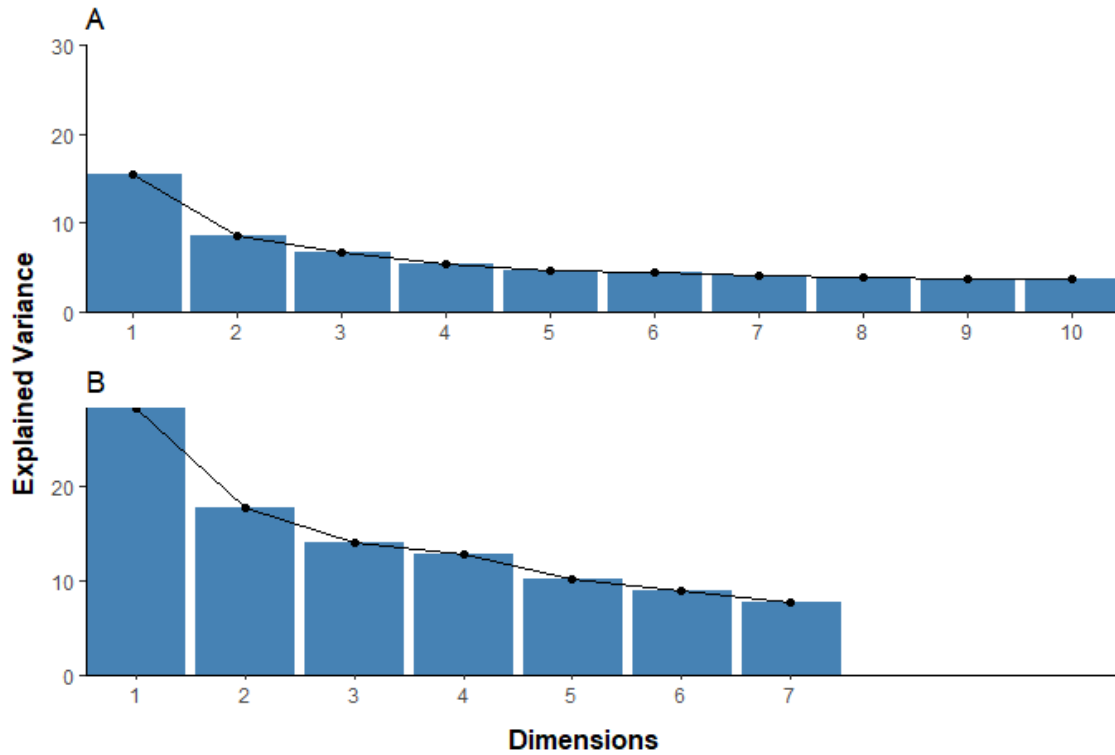


Figure 2.4. Scree plots representing the two Principal Component Analysis loading plots. The number of dimensions explains the total variance explained. The All-recreational activity plot (A) includes the 26 recreational activities. The median participated scree plot (B) includes the recreational activities within the survey that had a median avidity of 1 or greater.

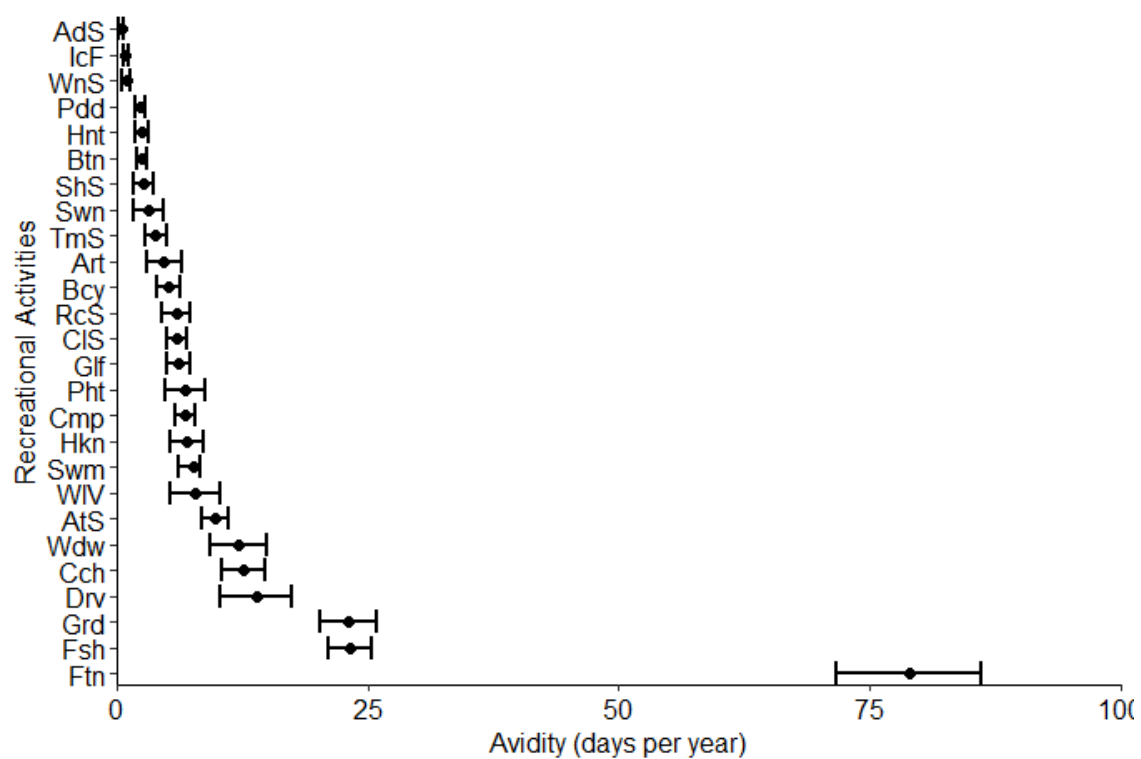


Figure 2.5. Mean recreational-activity avidity \pm SE of 2019 fishing-permit holders that resided within the Omaha metropolitan area.

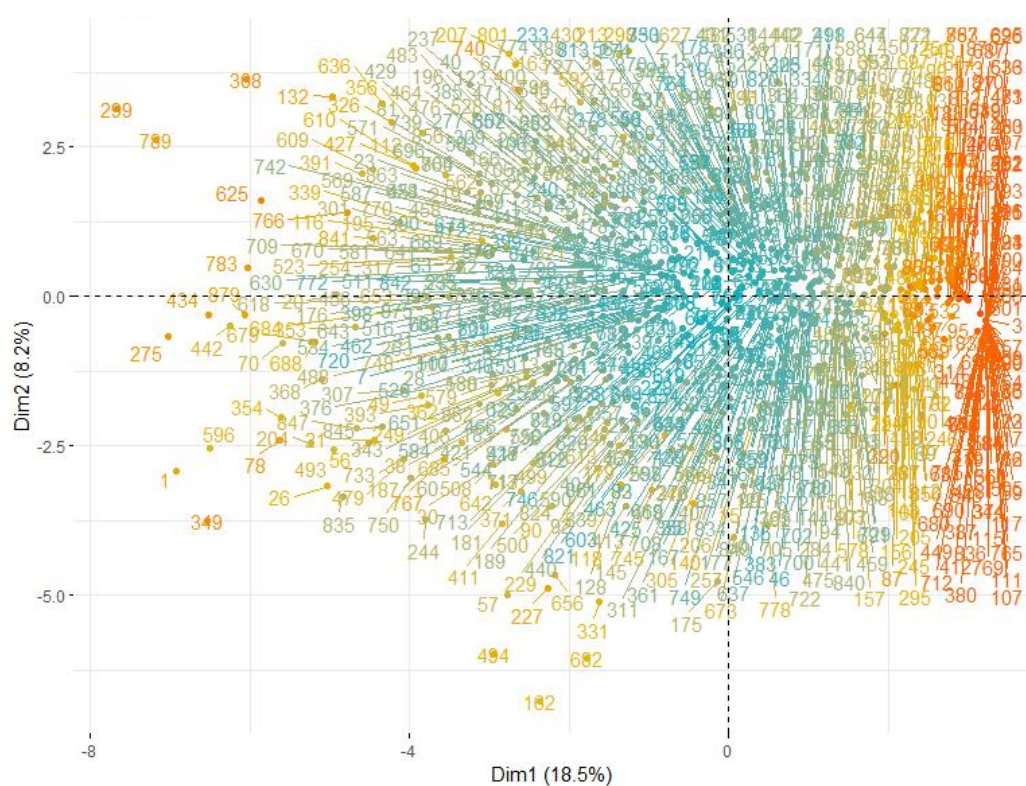


Figure 2.6. Principal Component Analysis representing the 797 angles that responded to the 2020 Omaha Recreation Survey.

Table 2.1. The 26 recreational activities within the 2020 Omaha Recreation Survey that we used for the analyses. We generated abbreviations for the recreational activities using the abbreviation function in RStudio.

Activity	Abbreviation	Activity	Abbreviation
Adventure Sports	AdS	Hiking	Hkn
Art	Art	Hunting	Hnt
Attending Sports	AtS	Ice Fishing	IcF
Bicycling	Bcy	Paddlesports	Pdd
Boating	Btn	Photography	Pht
Camping	Cmp	Recreational Sports	RcS
Coaching	Cch	Sewing	Swn
Cultural Sites	ClS	Shooting Sports	ShS
Driving	Drv	Swimming	Swm
Fishing	Fsh	Team Sports	TmS
Fitness	Ftn	Wildlife Viewing	WlV
Gardening	Grd	Winter Sports	WnS
Golf	GlF	Woodworking	Wdw

CHAPTER 3. MANAGEMENT RECOMMENDATIONS AND FUTURE RESEARCH QUESTIONS

Management Recommendations

We conclude that avidity is a key factor when evaluating recreational activities. Management agencies could 1) develop avidity thresholds to categorize anglers with low-, medium-, and high-avidity groups, 2) predict fishing avidity of Nebraska anglers, 3) explore co-dependence of recreational activity avidities, and 4) discover new opportunities for targeting angler effort.

Our urban environments are constantly evolving; thus, we need to adapt our management strategies with the changing environment. Key factors that influenced our avidity model were being a male, being a retained angler, and possessing a day- or multi-year-fishing permit. R3 efforts continue to influence fisheries management strategies in Nebraska. If management agencies are interested in how many days specific anglers' fish, they can input sociodemographic data into the Nebraska fishing avidity model and have an average avidity for a specific angler typology. Anglers that have a greater avidity for fishing, or in a high-avidity category, tend to be more conservation minded and tend to work well with management agencies (Williams and Moss 2001, Midway et al. 2020). The Nebraska avidity model could be a useful tool for managing our anglers and be able to use the Omaha anglers as a reference for fisheries management by improving aquatic ecosystems and improving engagement with the public.

We conclude that the downtown part of Omaha is the most densely populated area (Figure 3.1), yet also has the least amount per capita of fishing-permit holders (Figure 3.2). The downtown area of Omaha could be a target area for management agencies to

recruit new anglers. Most public waterbodies within the Omaha metropolitan area are located within the suburban areas. Similarly, the suburban areas have more fishing permit holders (Figure 3.3). Management agencies could work with private corporations that have private waterbodies and open those waterbodies to the public for more fishing opportunities within the downtown area of Omaha. Alternatively, more opportunities for river access along the Missouri River could offer more opportunities for fishing access for urban anglers. More fishing access could entice residents to increase their fishing avidity allowing for fishing avidity to be more spread across Omaha. Angling avidity could be tied to angler behavior, such as anglers in Omaha tend to have moderately sized angler sheds and travel to fish in preferred waterbodies (Ruskamp 2018; Barlow 2022).

Omaha anglers partake in many recreational activities. Thus, recreational activity-avidity is something management agencies could incorporate into management plans. The co-dependence of recreational activities avidities in chapter two can connect fishing to new groups of recreationists. Fishing avidity has a strong synergistic relationship with avidities of ice fishing, hunting, and golf, but also neutral relationships with avidities of hiking, recreational fitness, woodworking, and adventure sports. Thus, the synergistic and neutral relationships with fishing could be used as a gateway to other recreational groups and entice individuals to fish more as a means of physical and mental health. Fishing has the third largest avidity when compared to the other recreational activities that we offered in our survey, suggesting that fishing is a popular recreational activity in Omaha, but not the most popular among anglers. Omaha anglers within our survey have an average avidity of 23 days. Similarly, Omaha angler avidity would categorize them into the high avidity category according to NOAA, suggesting that Omaha anglers could work well

with management agencies in promoting the sport. Watching television and using the internet was not included in our analysis due to television and the internet having triple the avidity than all other activities. However, television and the internet could be used as a tool to advertise and connect with urban anglers and other recreationists about recreational opportunities.

Future Research Questions

- What are the low-, medium-, and high-fishing avidity thresholds in Omaha, Nebraska, and does the National Oceanic and Atmospheric Administration avidity thresholds apply to freshwater fisheries located in the Midwest?
- Does our Nebraska fishing avidity model predict fishing avidity effectively in other urban areas (e.g., Lincoln, Nebraska; Des Moines, Iowa; Kansas City, Missouri)?
- Does our Nebraska fishing avidity model predict fishing avidity effectively in rural areas (e.g., Henry County, Lincoln County)?
- If we target a new group of recreationists (i.e., campers, hunters, or bicyclists) within Omaha, would we observe similar avidities for that specific activity?
- Does fish-species preference affect fishing avidity?
- Did fishing avidity change for urban anglers after the 2020 Covid-19 pandemic?

- Does avidity differ between anglers that solely participate in ice fishing versus anglers that solely participate in open-water fishing?
- If we sampled a random subset of the Omaha metropolitan area population, would avidities of the 27 recreational activities differ from our analysis?
- How would social catchment data collected in the 2020 Omaha Recreation Survey differ compared to social catchment data collected from creel surveys?
- Does fishing avidity differ among where anglers fish (i.e., Omaha, Nebraska, or outside of Nebraska)?
- Does being a more actively involved recreationist influence response bias with recreational surveys?

References

- Barlow, B. 2022. Demographic groups differ in urban recreational behavior. University of Nebraska-Lincoln, Lincoln, Nebraska.
- Midway, S. R., J. Adriance, P. Banks, S. Haukebo, and R. Caffey. 2020. Electronic self-reporting: angler attitudes and behaviors in the recreational red snapper fishery. *North American Journal of Fisheries Management* 40(5):1119–1132.
- Ruskamp, C. N. 2018. Landscape structure and dynamics of recreational fisheries. University of Nebraska-Lincoln, Lincoln, Nebraska.
- Williams, A. E., and B. Moss. 2001. Angling and conservation at sites of special scientific interest in England: economics, attitudes and impacts. *Aquatic Conservation: Marine and Freshwater Ecosystems* 11(5):357–372.

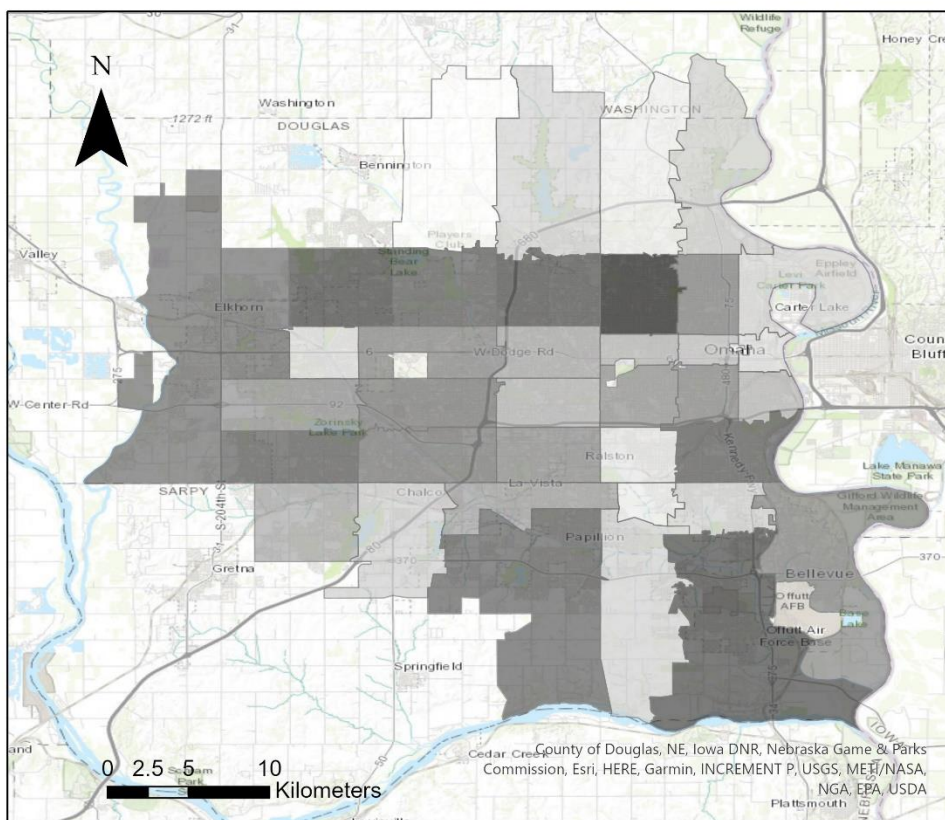


Figure 3.1. Total population that resided within the Omaha, Nebraska, metropolitan area during 2020. The darker zip codes have a higher number of residents than lighter zip codes.

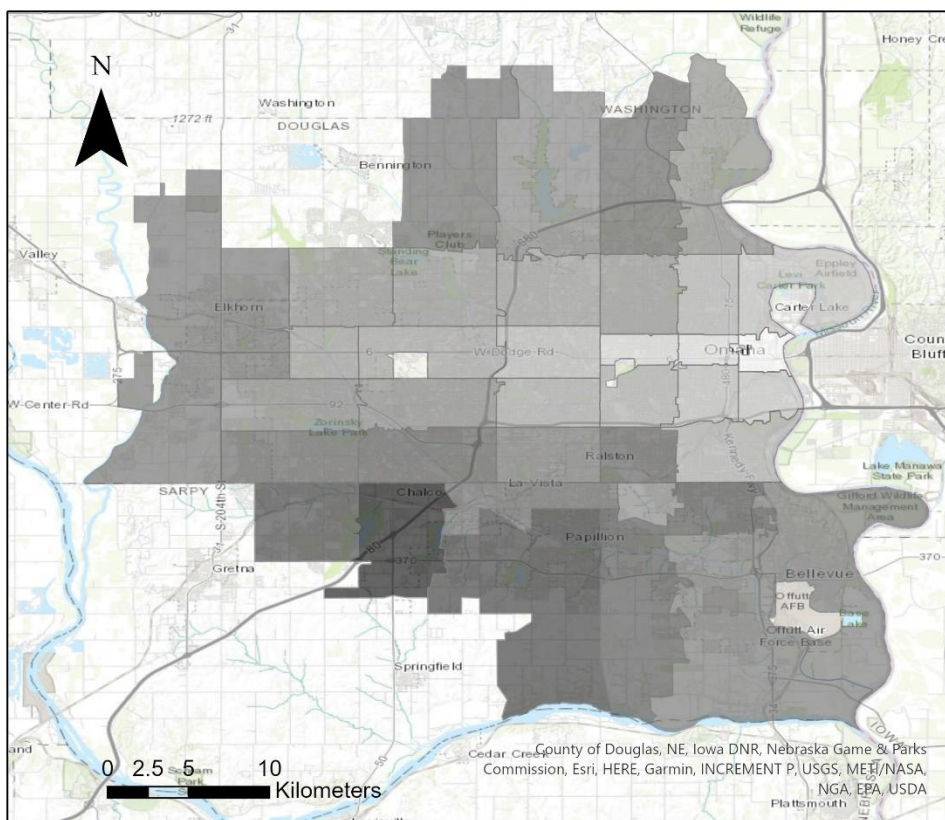


Figure 3.2. The proportion of fishing permit holders to total population that resided within the Omaha, Nebraska, metropolitan area during 2020. The darker zip codes have a higher proportion of fishing permit holders than lighter zip codes.

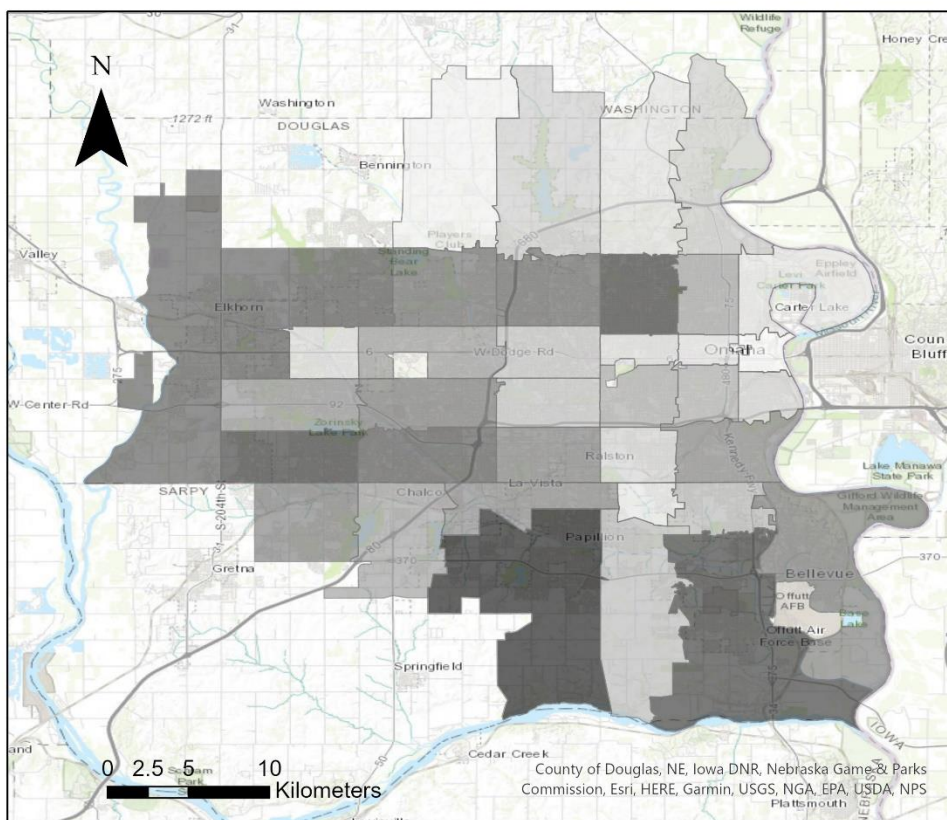


Figure 3.3. Total fishing permit holders that resided within the Omaha, Nebraska, metropolitan area during 2020. The darker zip codes have a higher number of fishing permit holders than lighter zip codes.

Glossary

Angler: One who participates in fishing for recreational purposes.

Antagonistic: Interaction of activities such that the total effect is less than the sum of the individual activity.

Avidity: The interest or enthusiasm to pursue an activity. Quantifies as the number of days per year in which activity was pursued.

Fishing: The ability to catch fish by means of hook-and-line for recreational purposes.

Licensed Angler: Individual that purchased legal documentation to participate in fishing activities during the fishing season.

Leisure: Activity in which an individual expresses the free exercise of their creative capacity and does at will for relaxation, diversion, broadening knowledge, or spontaneous social participation (comprised of indoor and outdoor recreation).

Outdoor recreation: Physical activity or experience conducted away from the confines of a building.

Participation: The action of taking part in something, (yes or no).

Principal Component Analysis: Technique for analyzing large datasets containing a high number of dimensions or features per observation, increasing the interpretability of data while preserving the maximum amount of information, and enabling the visualization of multidimensional data.

Recreation: Physical activity or experience during leisure time, usually chosen voluntarily by the participant, either because of the immediate satisfaction to be derived from it, or because the participant perceives some personal or social values to be achieved by the activity or experience.

Synergistic: Interaction of activities such that the total effect is greater than the sum of the individual activity.

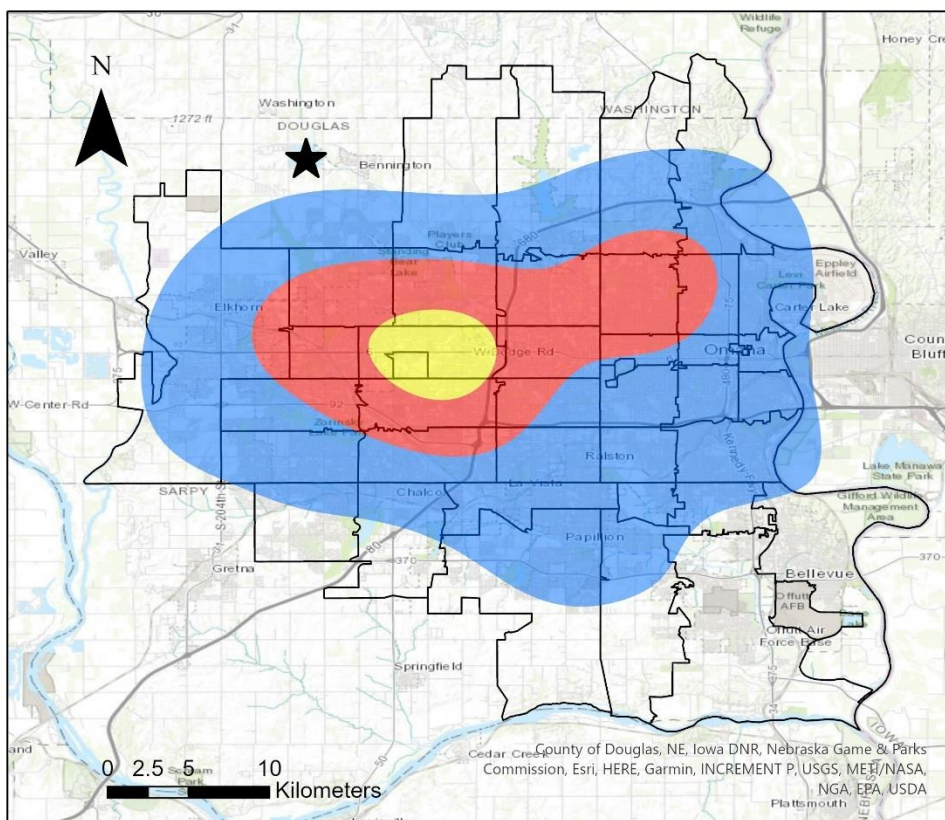
Tapestry segmentation: A segmentation system designed by Esri Demographics to identify consumer markets in the United States of America using demographic characteristics.

Urban setting: The place and conditions in which something happens or exists within the city limits.

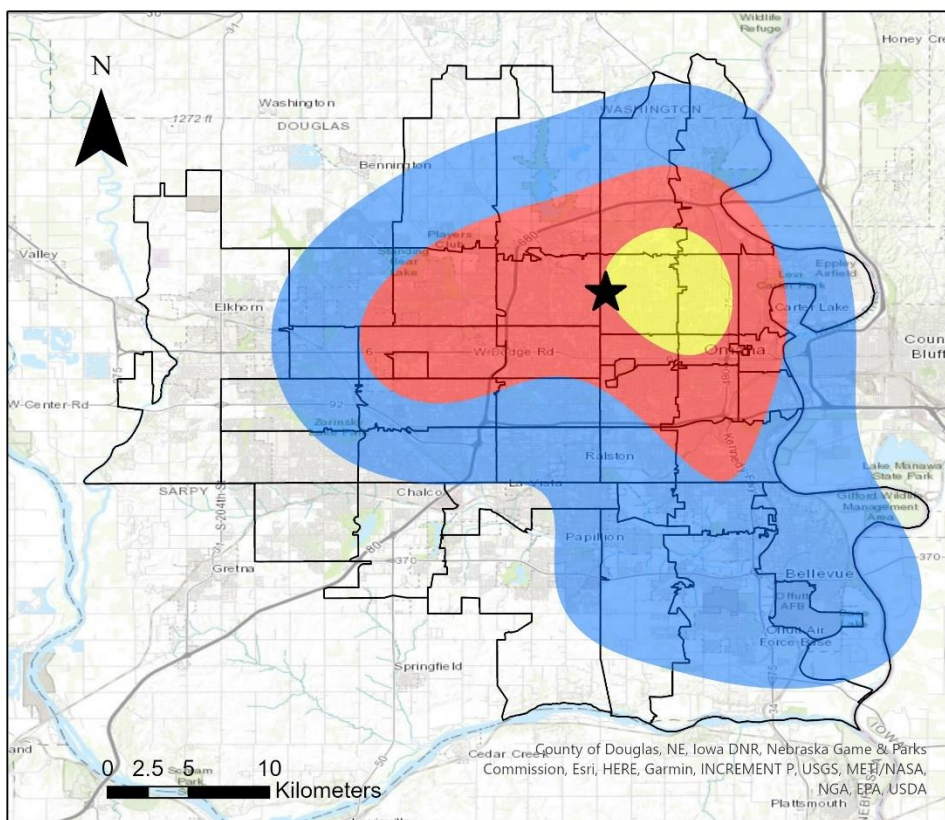
Urbanization group: A collection of ZIP codes whose residents represent similar demographic characteristics.

ZIP code: Zone Improvement Plan codes; 5-digit number that specifies an individual destination post office or mail delivery area.

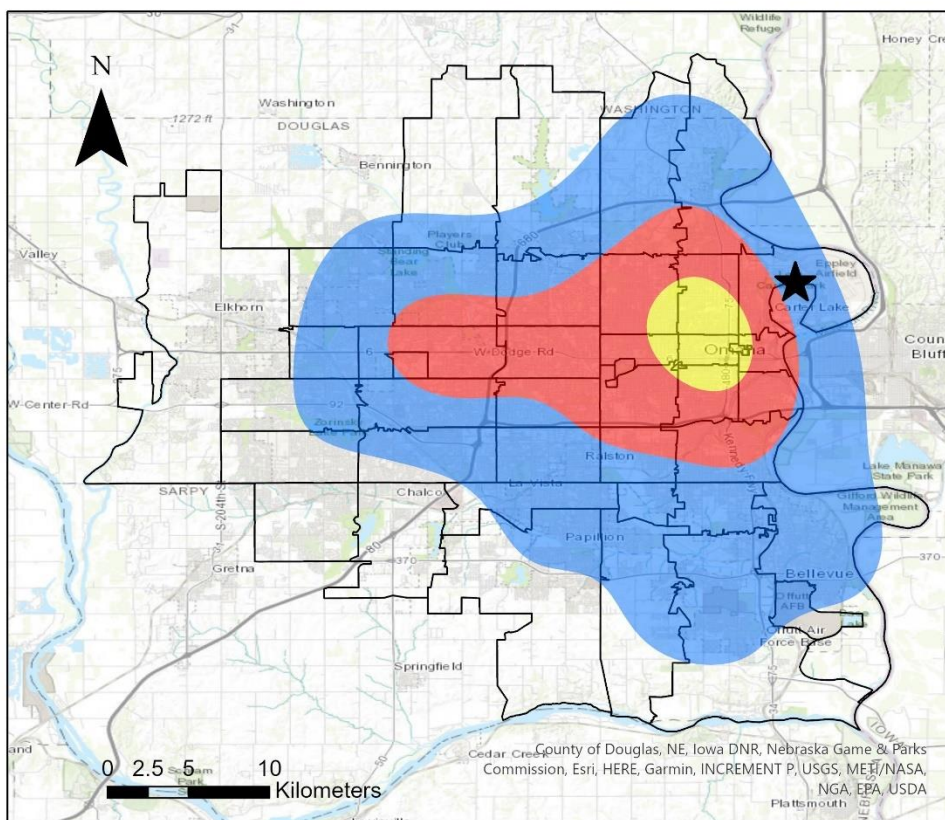
Appendix 1. Omaha angler residents' social catchments at waterbodies located within Omaha, Nebraska. Lake location is designated by the black star on the kernel density maps. Social catchment percentage is colored by 95% (blue), 50% (red), and 10% (yellow) (Ruskamp 2018).



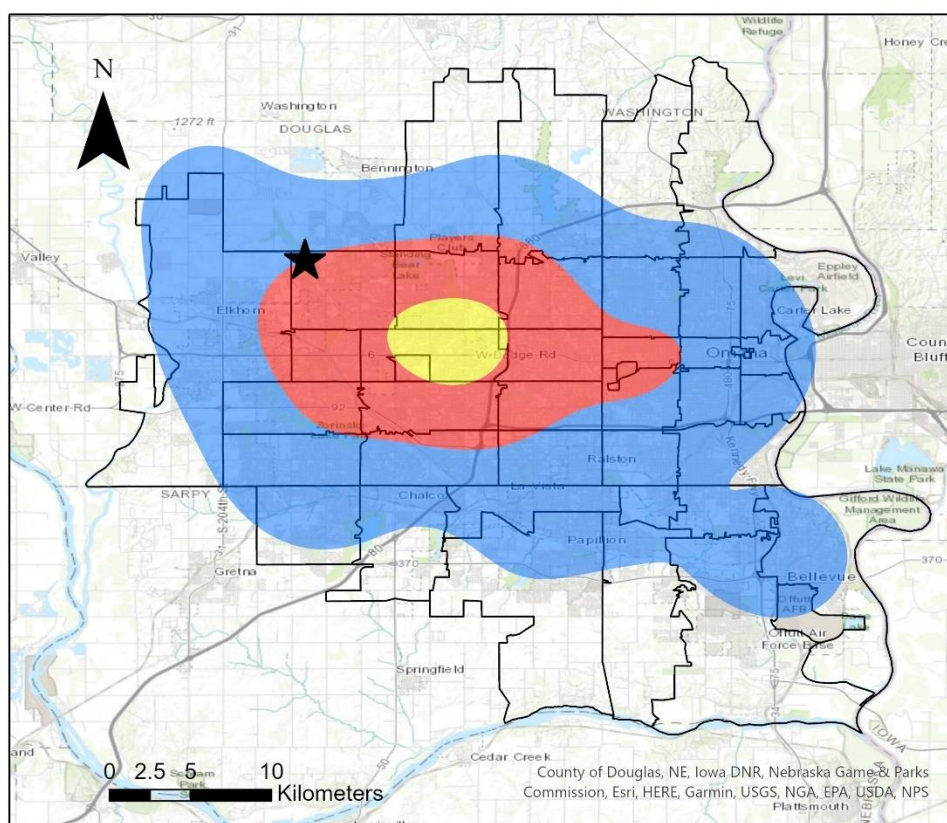
Appendix 1.1. Angler social catchment of Bennington Lake.



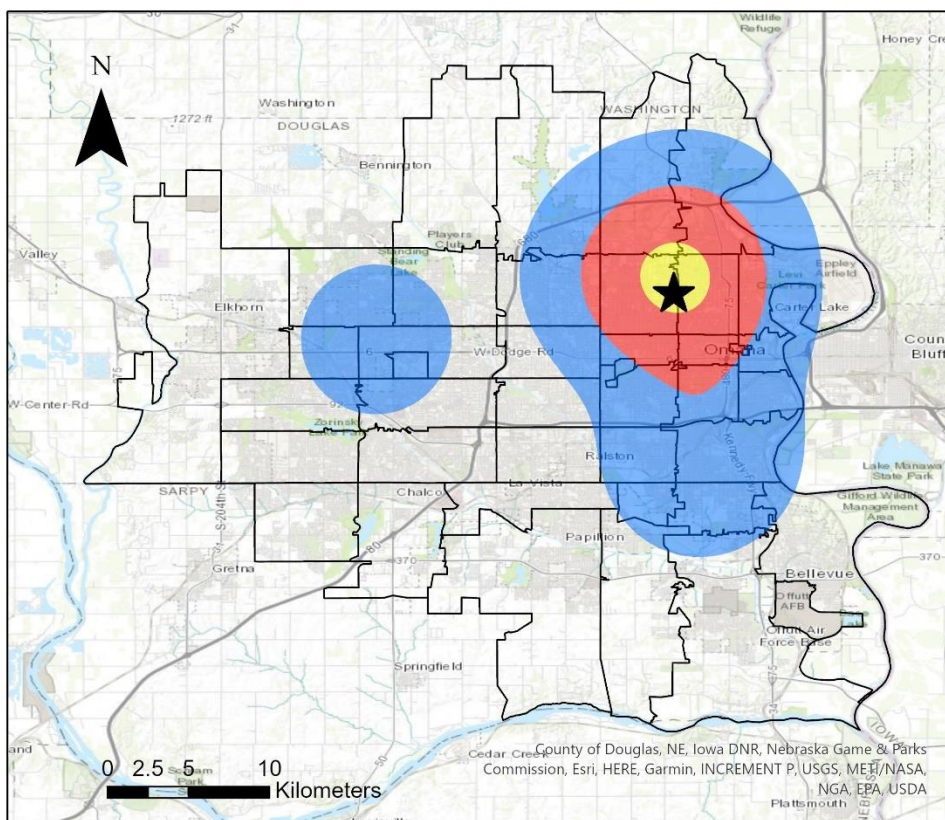
Appendix 1.2. Angler social catchment of Benson Lake.



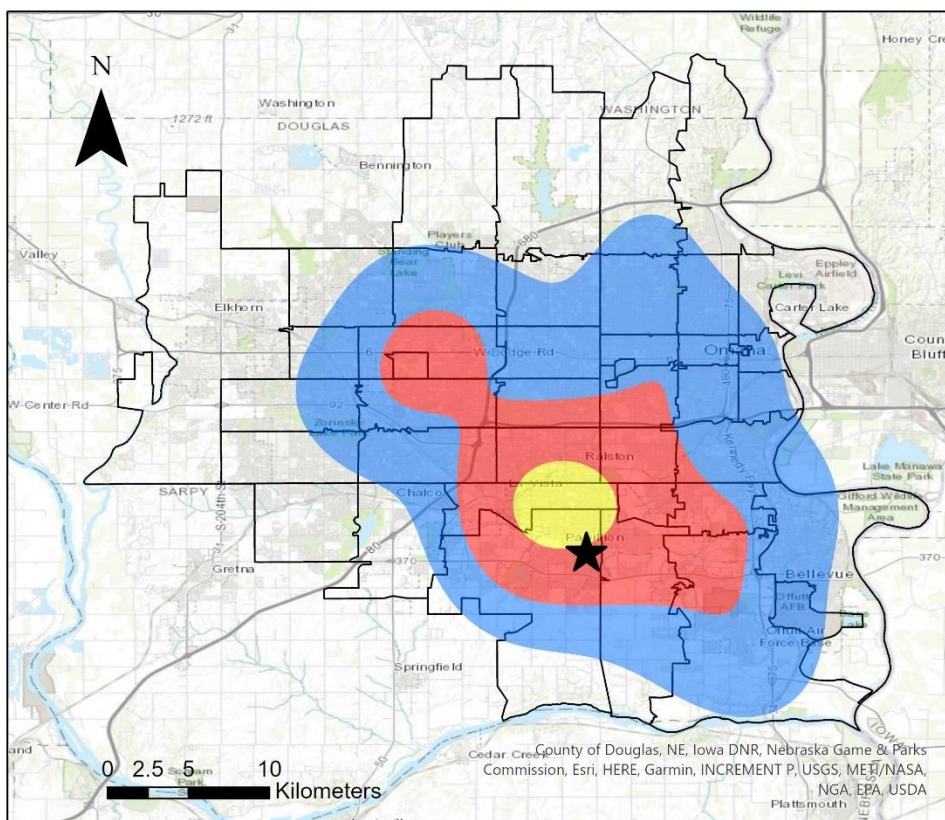
Appendix 1.3. Angler social catchment of Carter Lake.



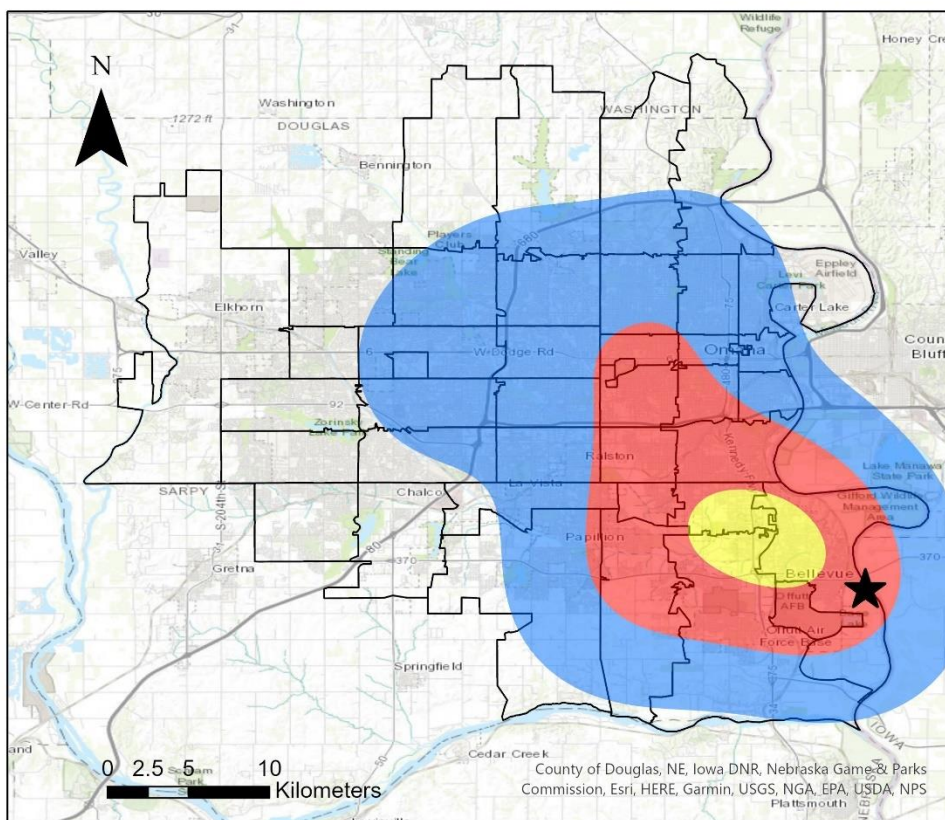
Appendix 1.4. Angler social catchment of Flanagan Lake.



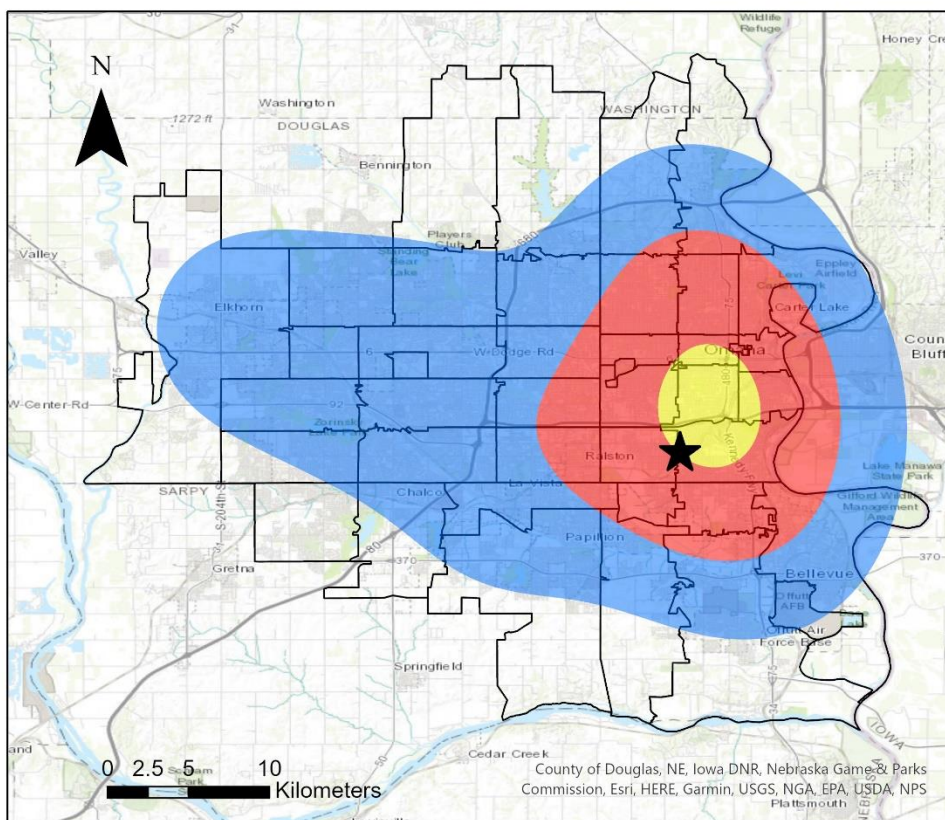
Appendix 1.5. Angler social catchment of Fontenelle Lake.



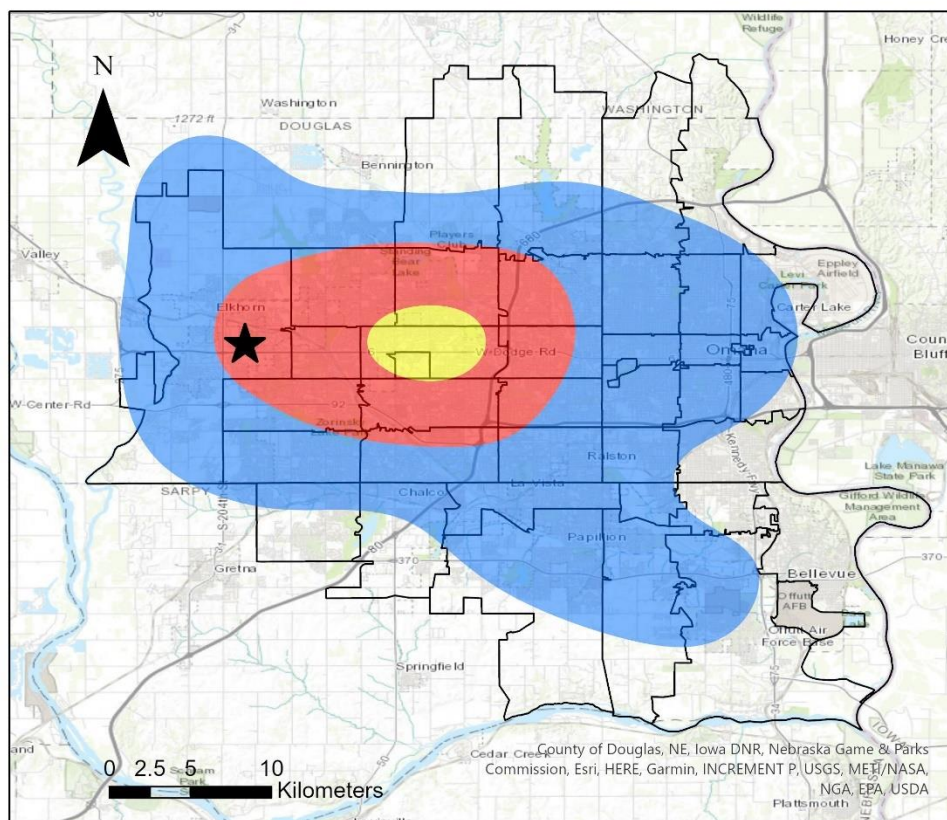
Appendix 1.6. Angler social catchment of Hallek Lake.



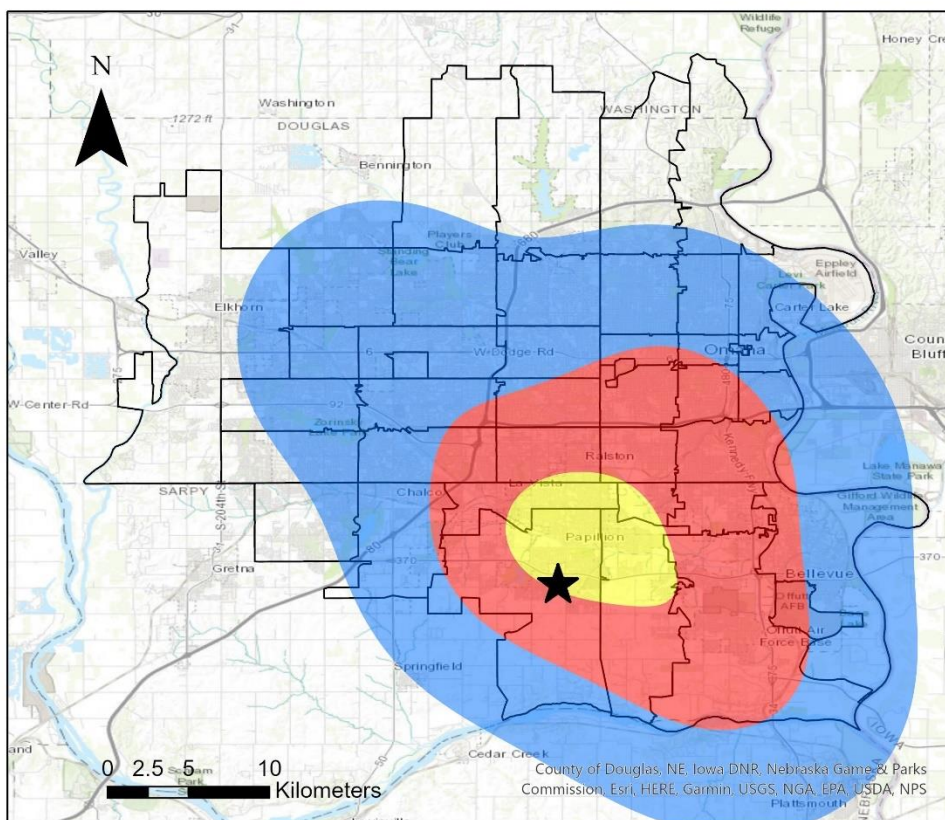
Appendix 1.7. Angler social catchment of Haworth Lake.



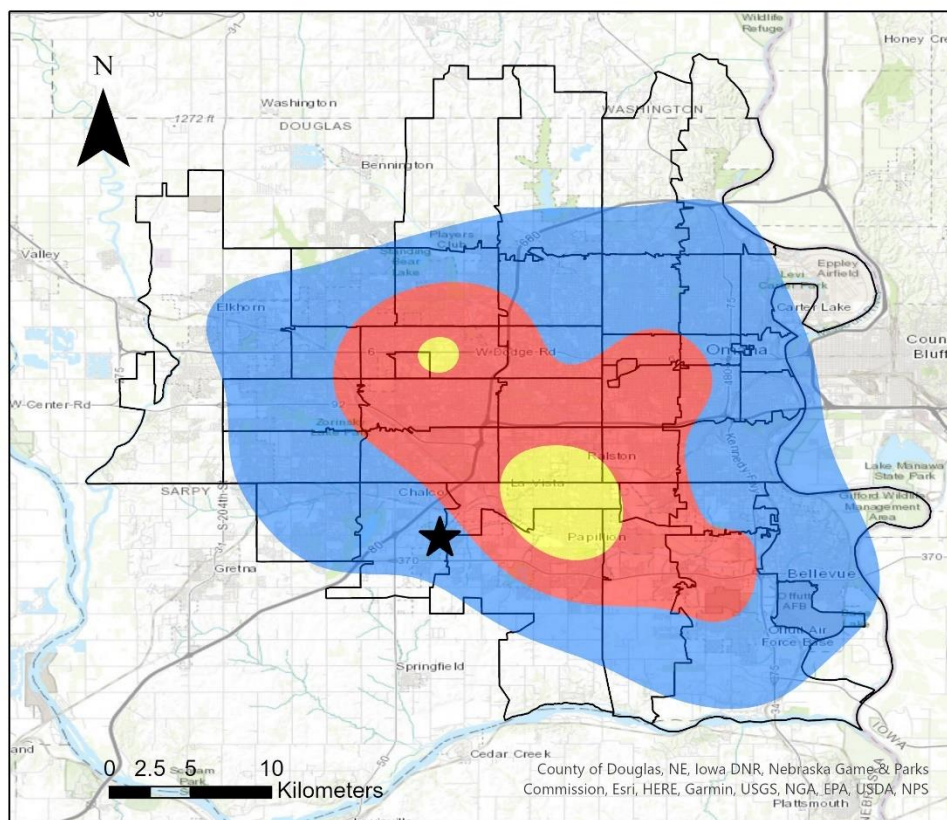
Appendix 1.8. Angler social catchment of Hitchcock Lake.



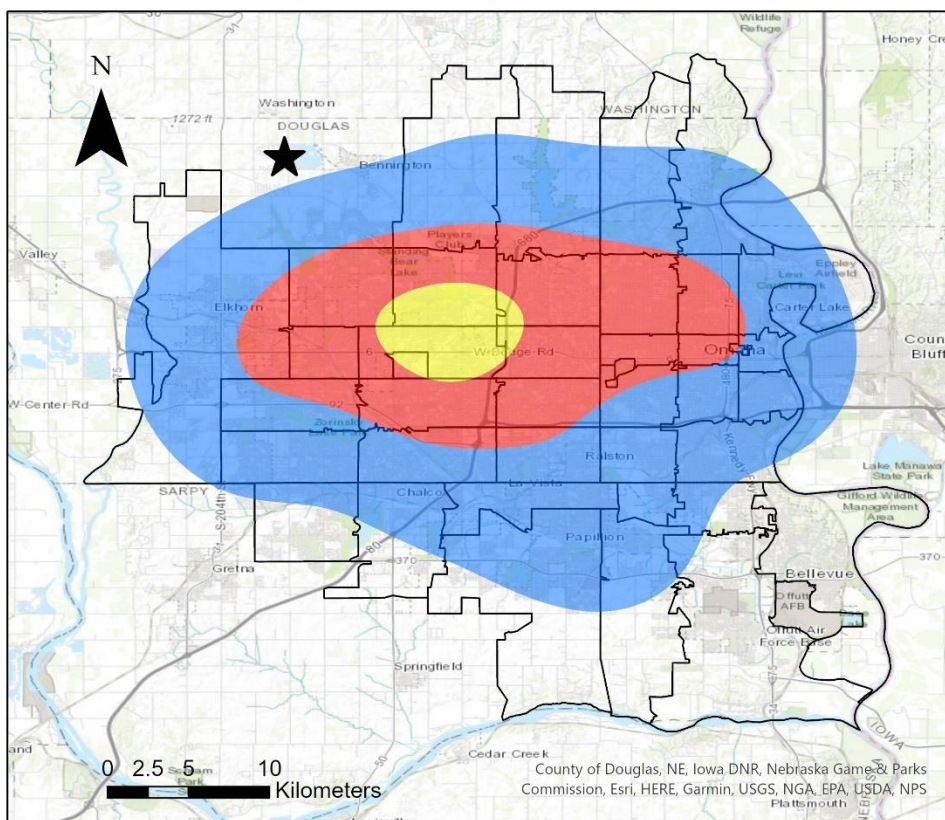
Appendix 1.9. Angler social catchment of Lawrence Youngman Lake.



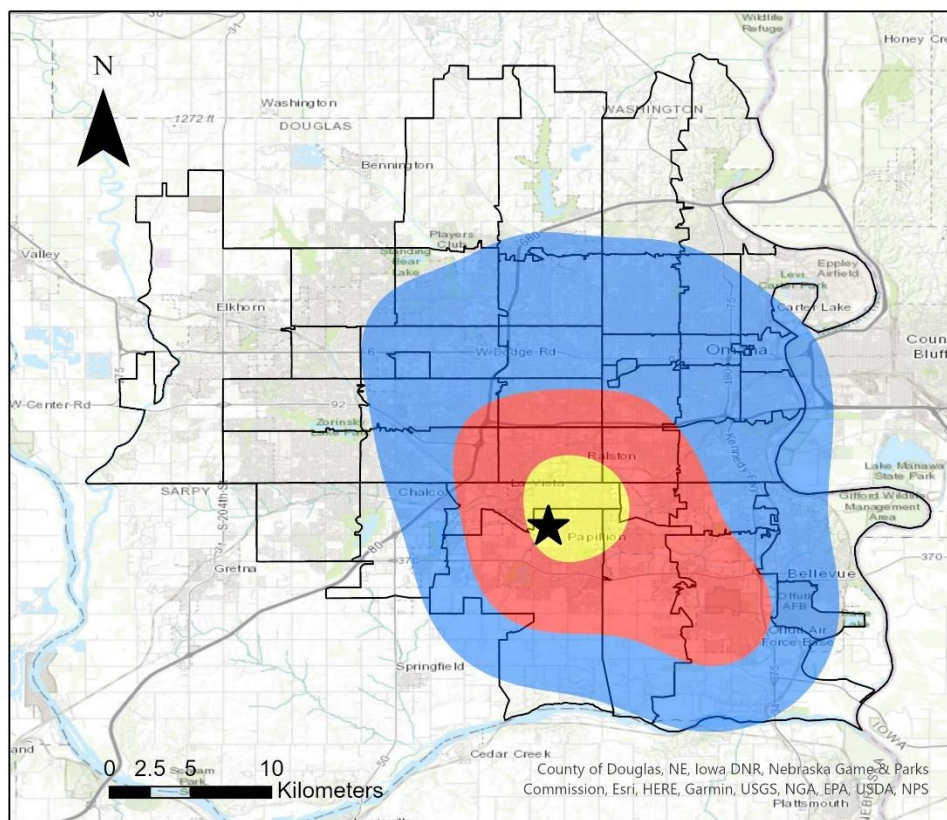
Appendix 1.10. Angler social catchment of Midlands Lake.



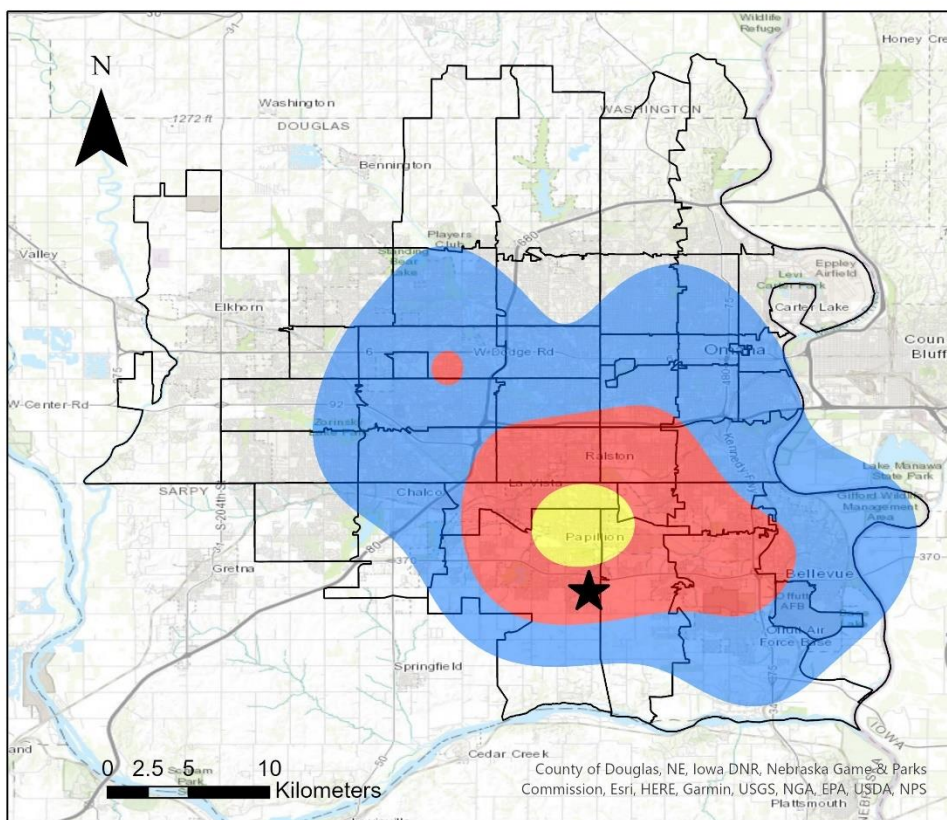
Appendix 1.11. Angler social catchment of Prairie Queen Lake.



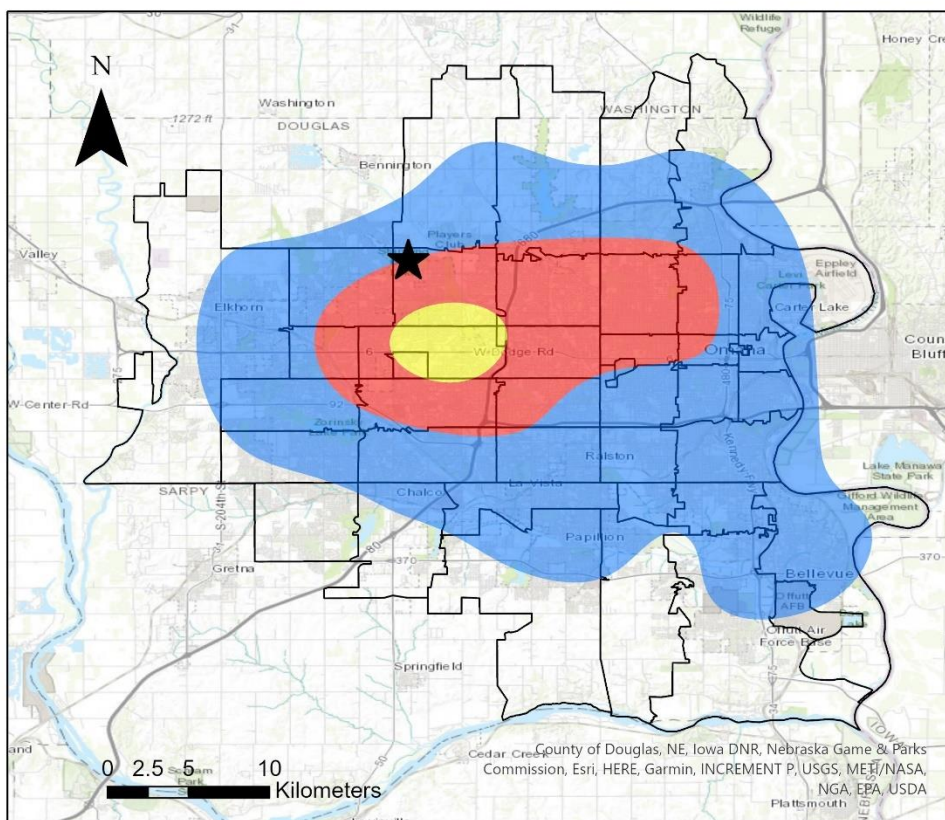
Appendix 1.12. Angler social catchment of Prairie View Lake.



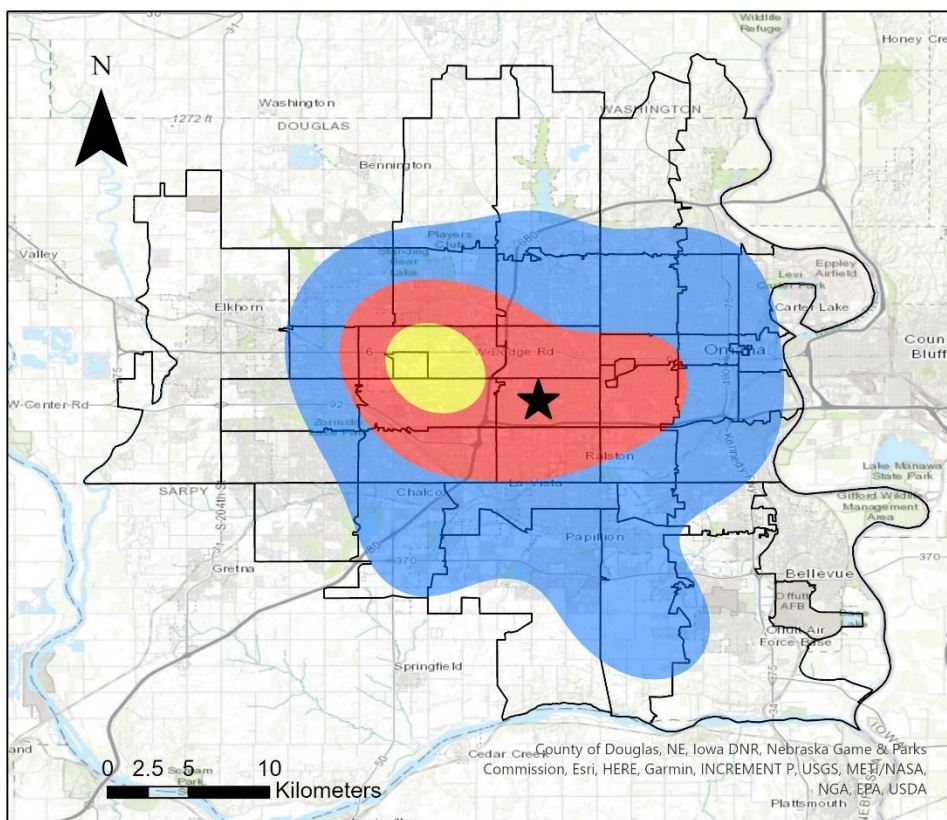
Appendix 1.13. Angler social catchment of Schwer Lake.



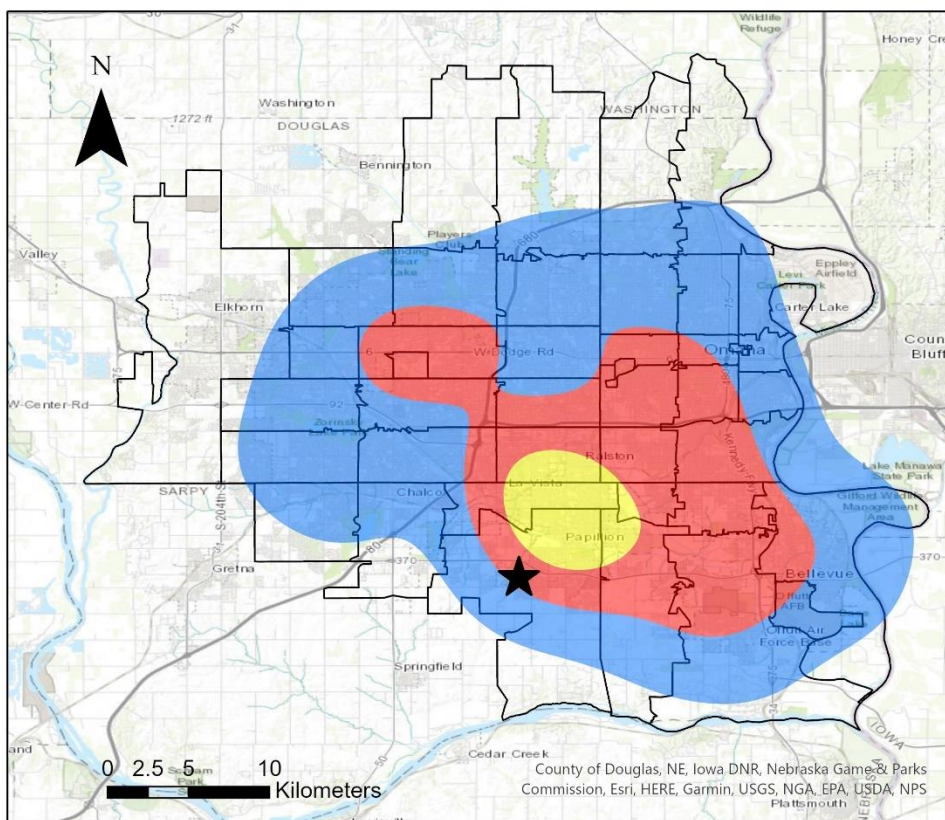
Appendix 1.14. Angler social catchment of Shadow Lake.



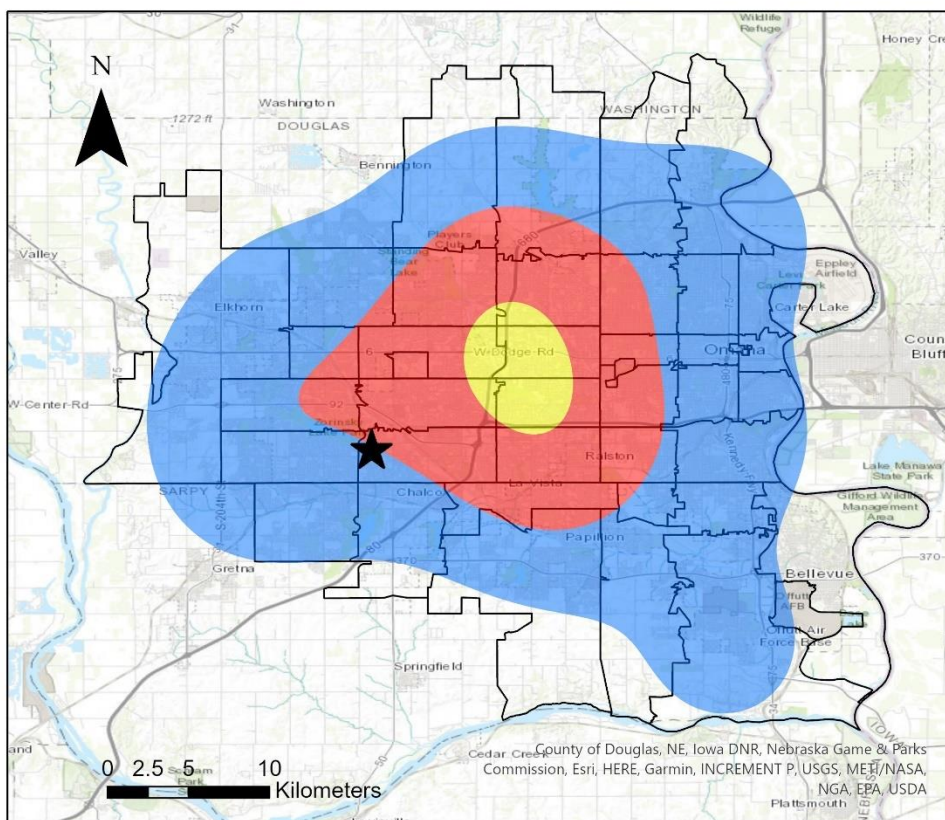
Appendix 1.15. Angler social catchment of Standing Bear Lake.



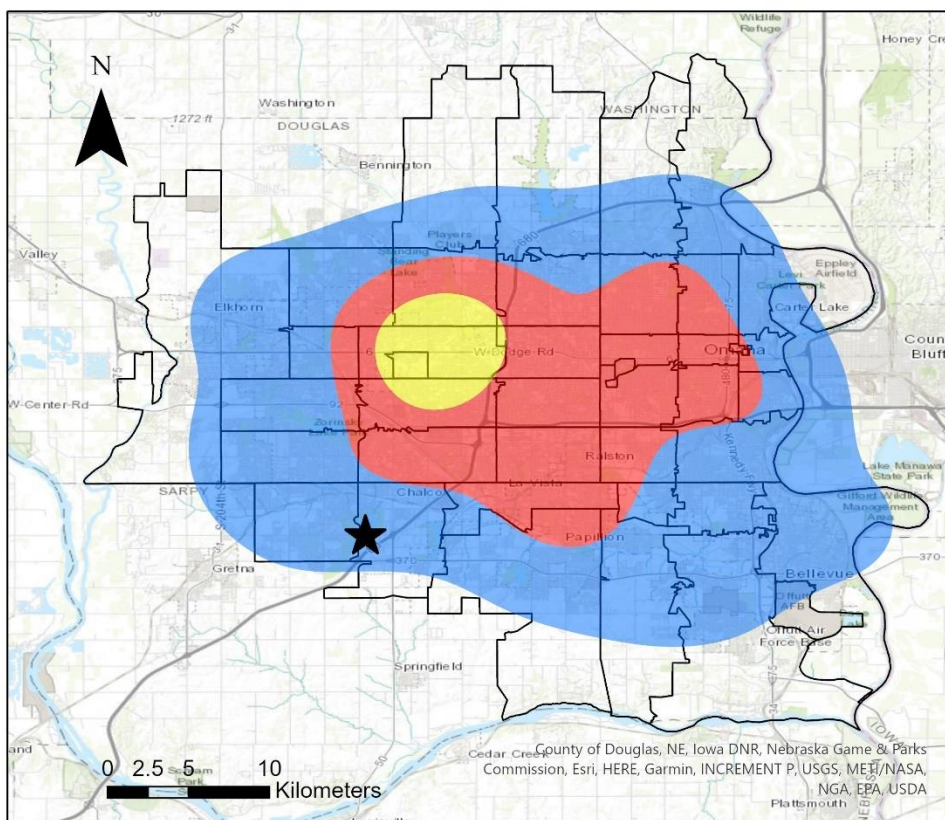
Appendix 1.16. Angler social catchment of Towl Lake.



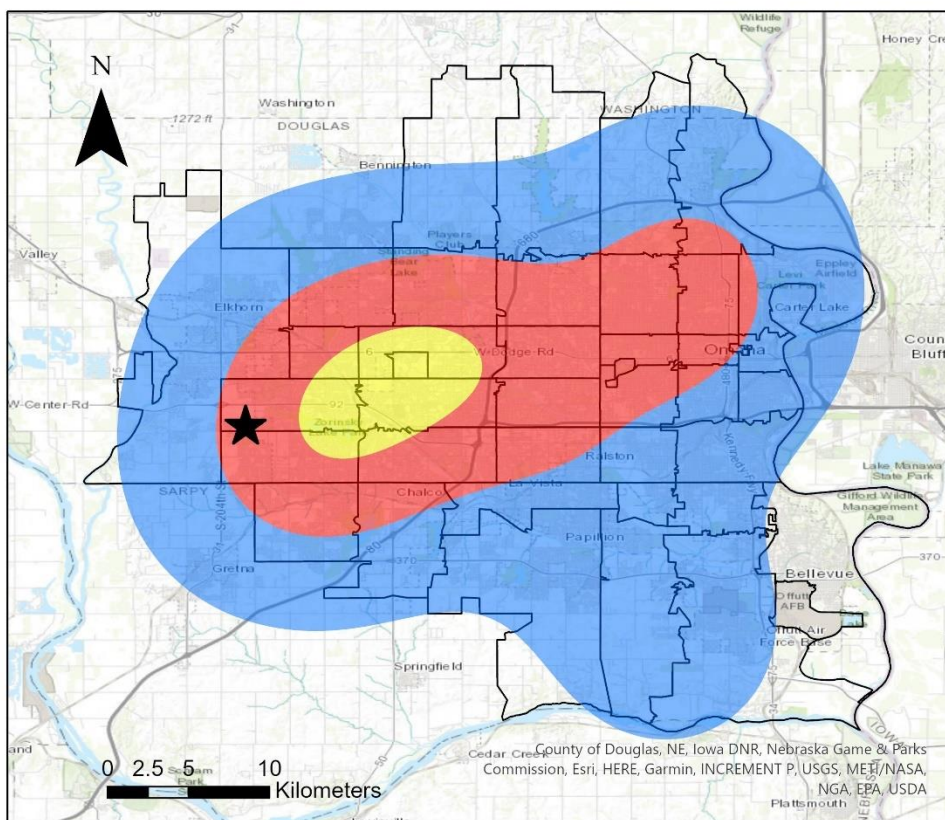
Appendix 1.17. Angler social catchment of Walnut Creek Lake.



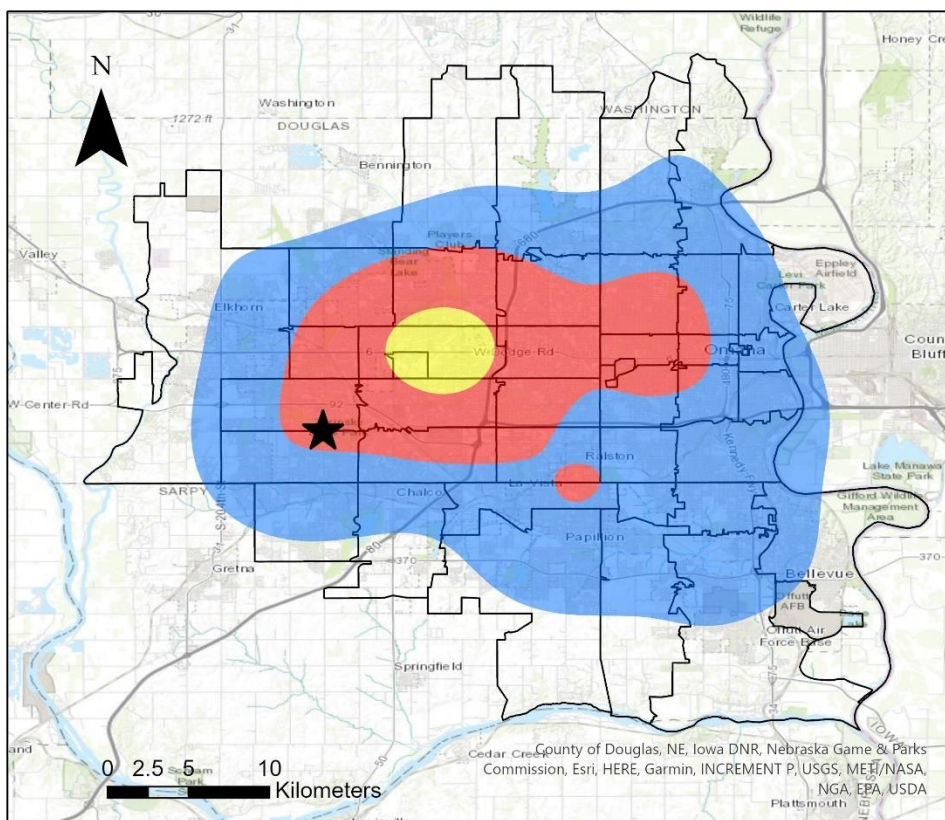
Appendix 1.18. Angler social catchment of Walnut Grove Lake.



Appendix 1.19. Angler social catchment of Wehrspann Lake.

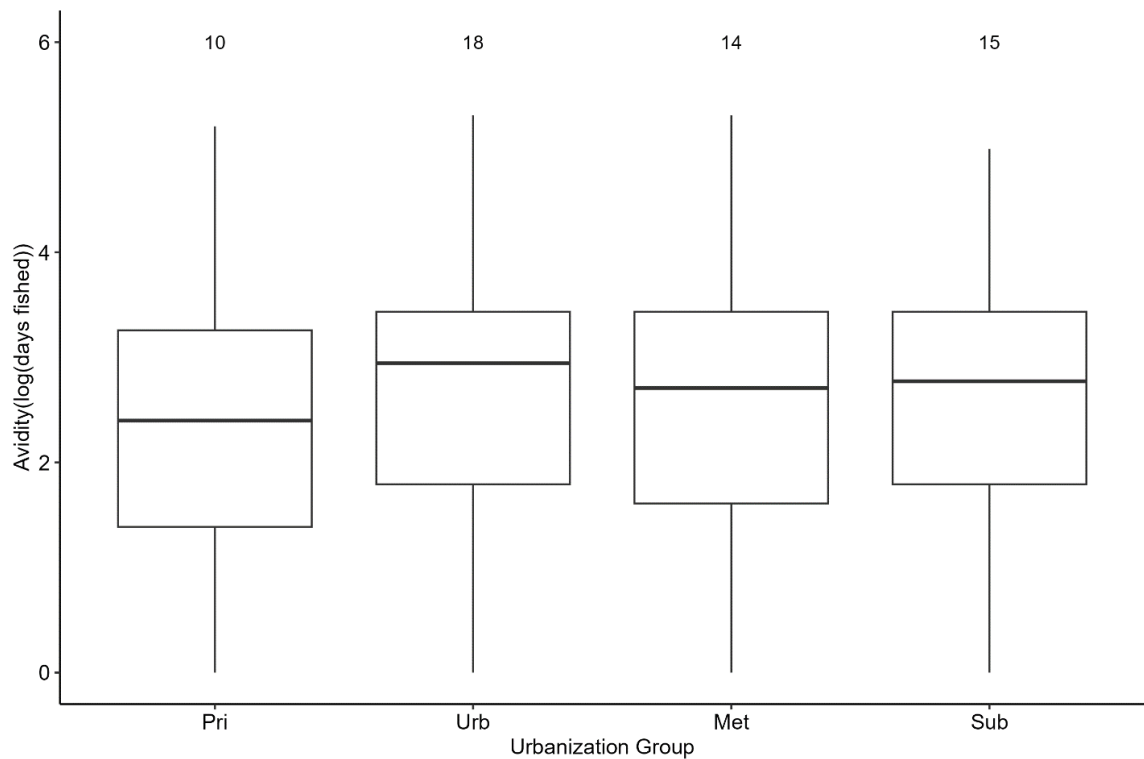


Appendix 1.20. Angler social catchment of Whitehawk Lake.

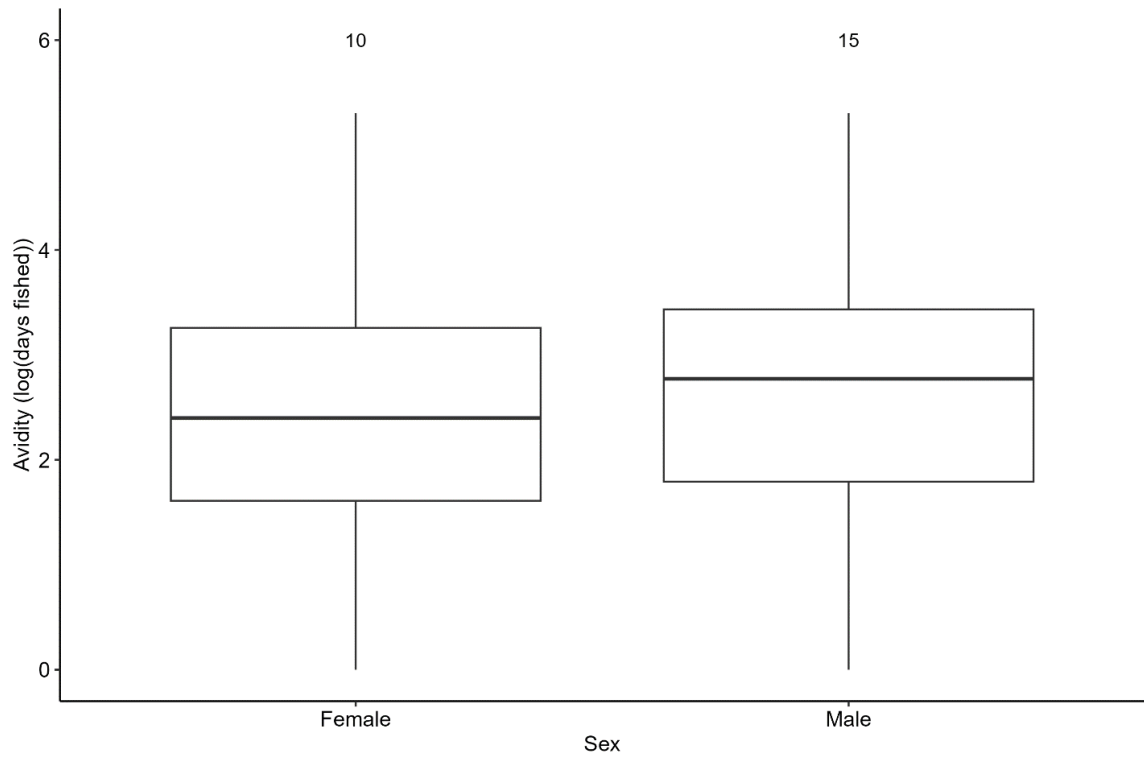


Appendix 1.21. Angler social catchment of Zorinsky Lake.

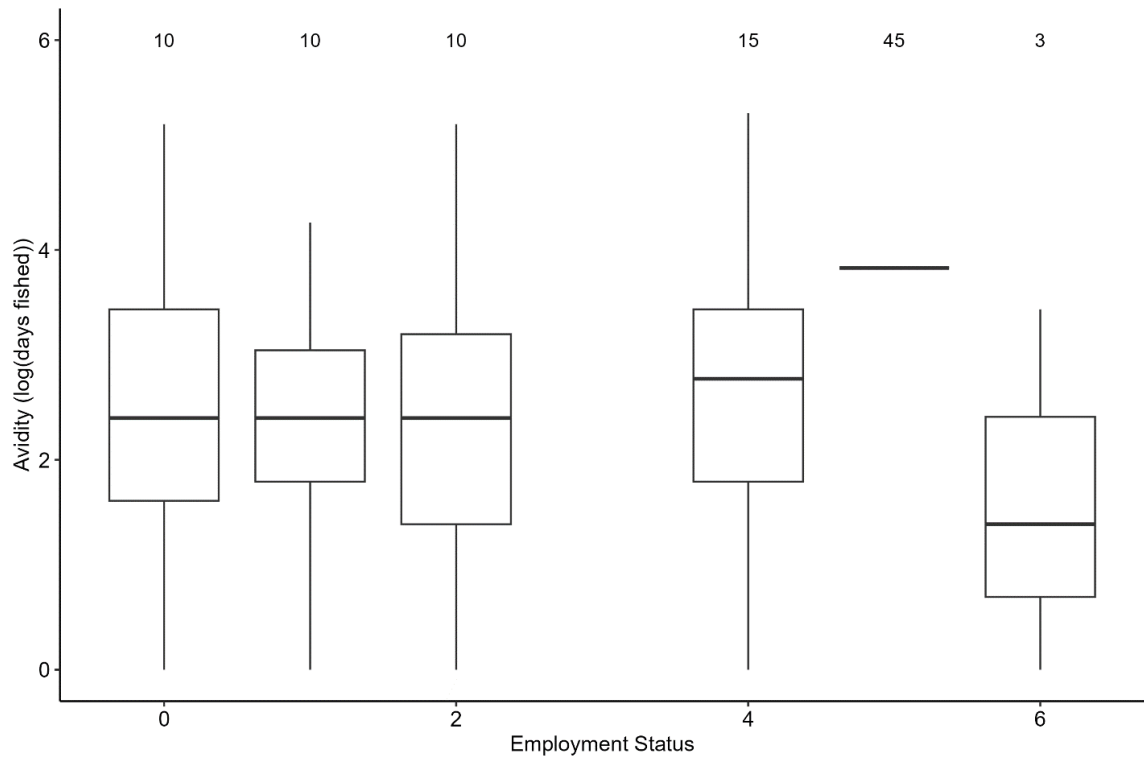
Appendix 2. Box plots for sociodemographic factors in Chapter 1. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25^{th} percentile $- 1.5 * \text{interquartile range}$) and maximum (75^{th} percentile $+ 1.5 * \text{interquartile range}$).



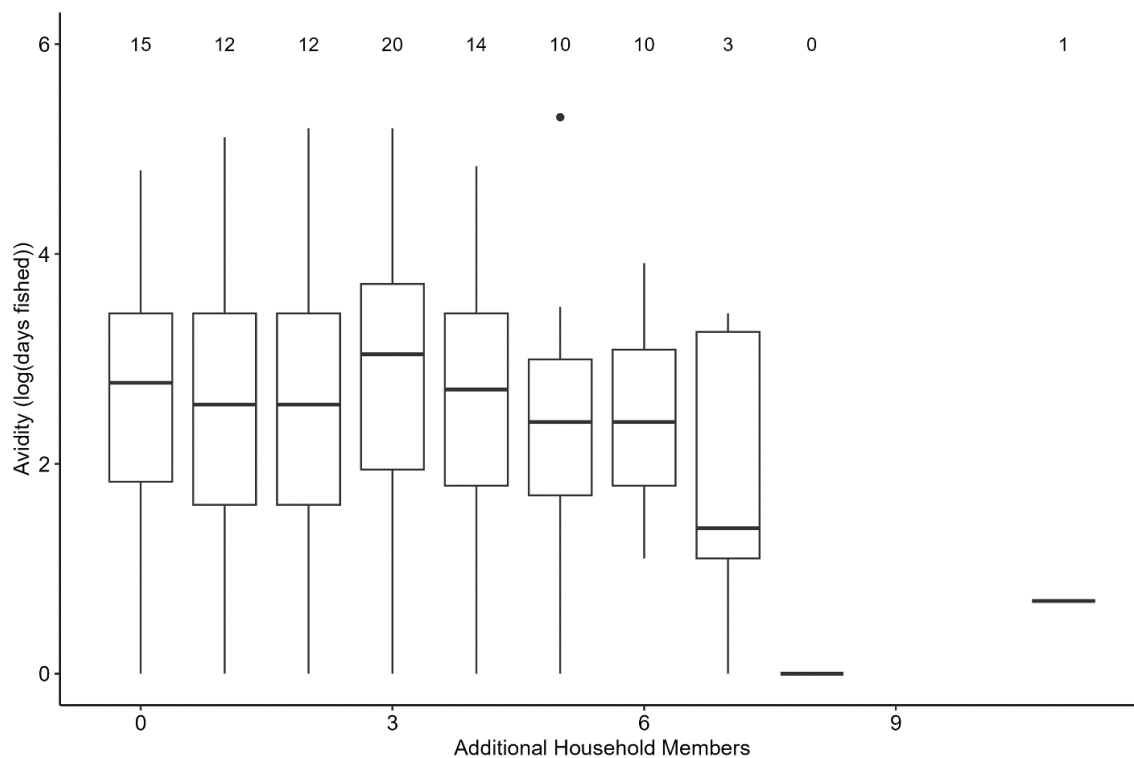
Appendix 2.1. Boxplots of fishing avidity and Esri Demographics' urbanization groups from urban to suburban (left to right) for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range).



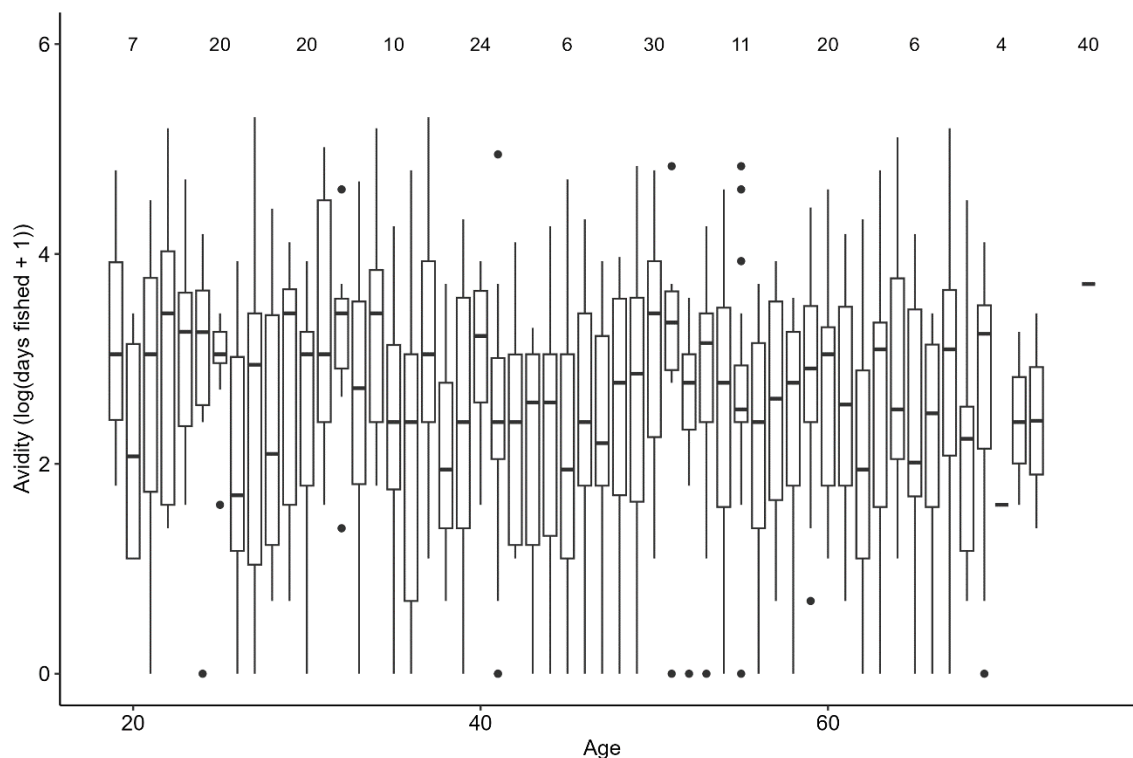
Appendix 2.2. Boxplots of fishing avidity and sex of an angler for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska.. Median days spent fishing are above each group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range).



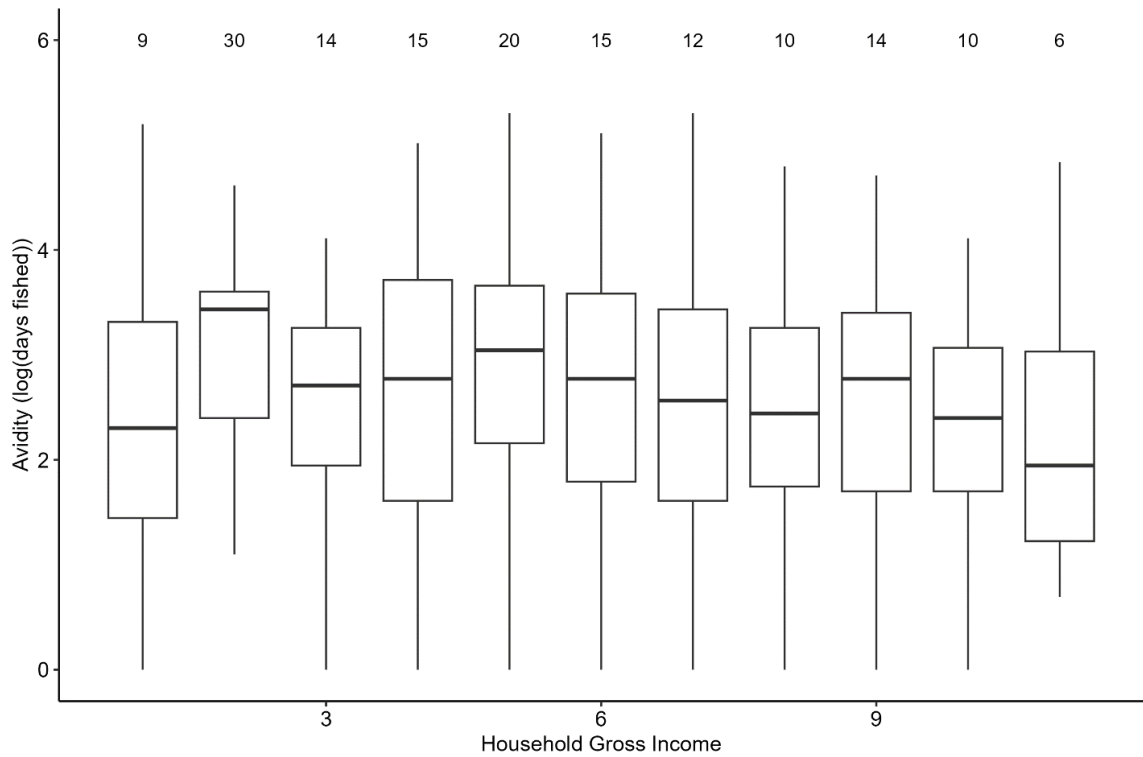
Appendix 2.3. Boxplots of fishing avidity and employment level for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Anglers within group zero were retired or non-employed, anglers within group one are students, anglers within group two are part-time employees, anglers within group four are full time employees, anglers within group five are full-time employees and students, and anglers within group six are full-time employees as well as part time employees. No anglers within our survey answered as full-time employee, part-time employee, and a student. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range).



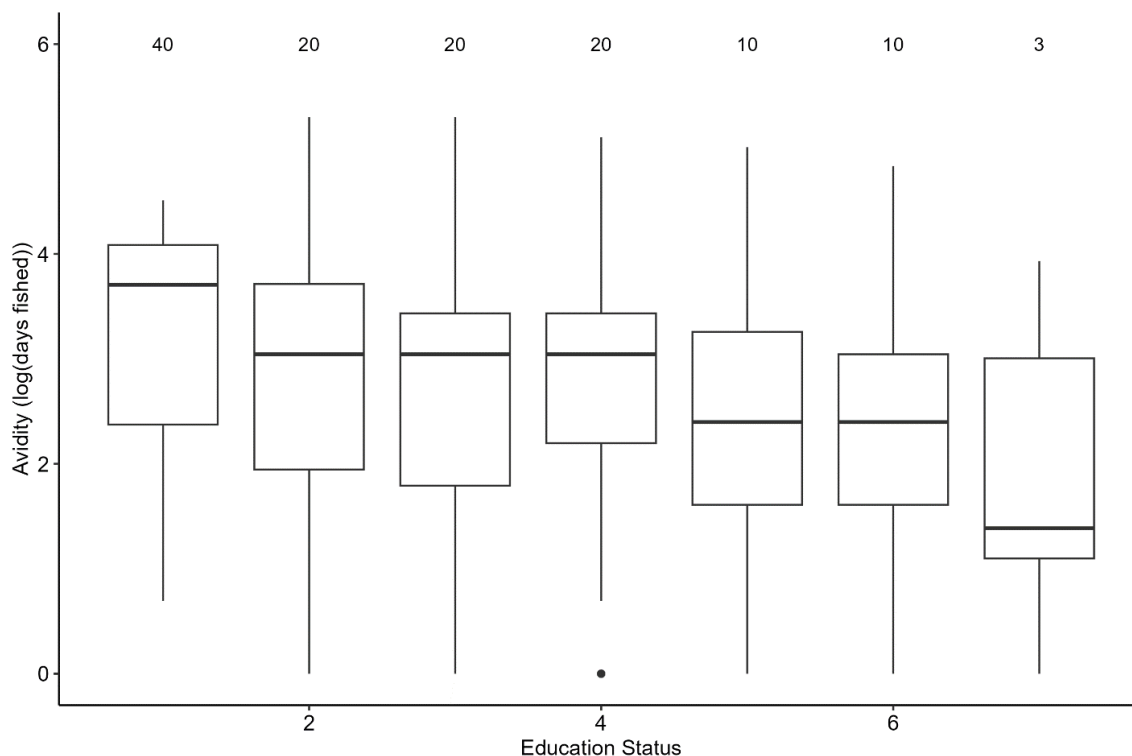
Appendix 2.4. Boxplots of fishing avidity and additional household members within the respondent's residence for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range).



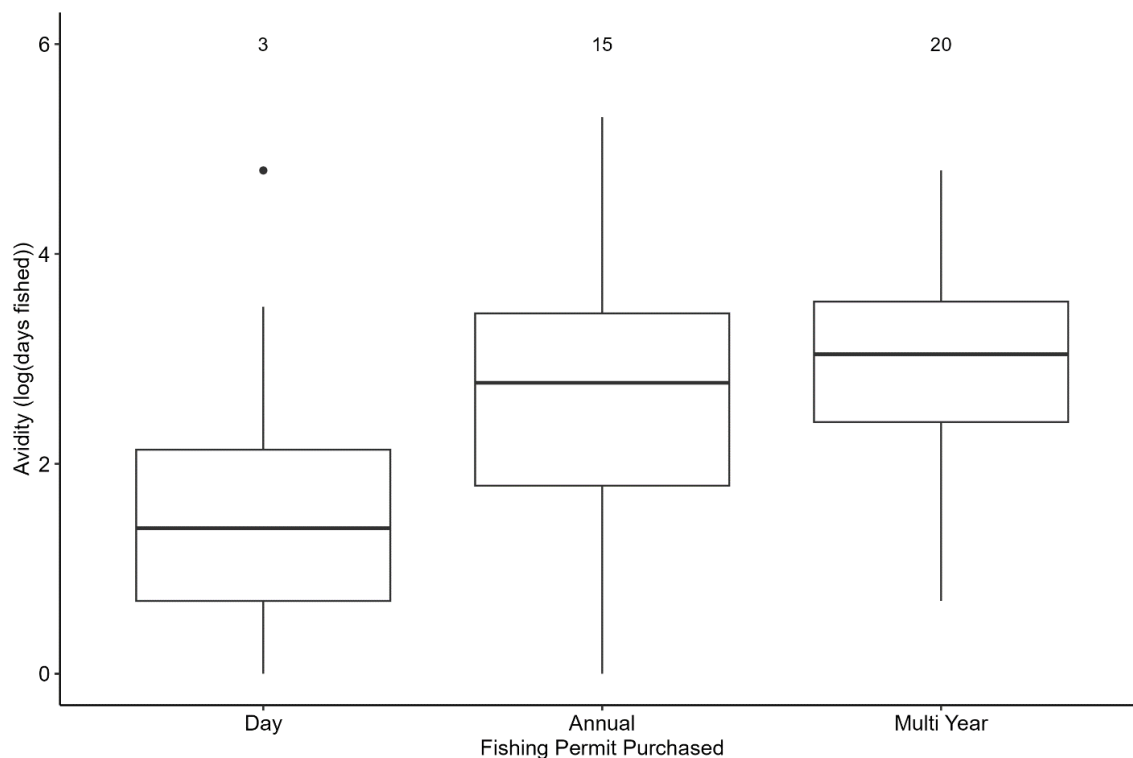
Appendix 2.5. Boxplots of fishing avidity and the age of anglers during 2019 for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25^{th} percentile $- 1.5 * \text{interquartile range}$) and maximum (75^{th} percentile $+ 1.5 * \text{interquartile range}$). Outliers within each group are designated by points.



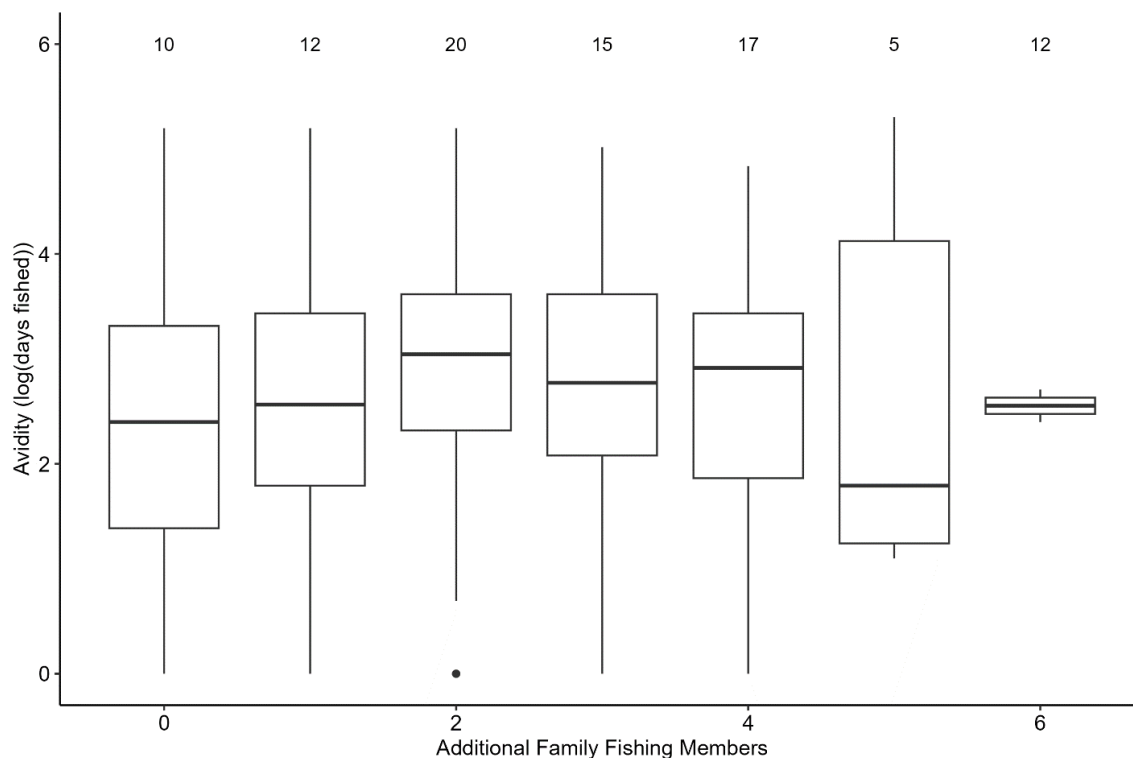
Appendix 2.6. Boxplots of fishing avidity and household gross income for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Anglers in group 1 reported a household gross income less than \$10,000. Anglers in group 2 reported a household gross income between \$10,000 and less than \$20,000. Anglers in group 3 reported a household gross income between \$20,000 and less than \$30,000. Anglers in group 4 reported a household gross income between \$30,000 and less than \$40,000. Anglers in group 5 reported a household gross income between \$40,000 and less than \$50,000. Anglers in group 6 reported a household gross income between \$50,000 and less than \$75,000. Anglers in group 7 reported a household gross income between \$75,000 and less than \$100,000. Anglers in group 8 reported a household gross income between \$100,000 and less than \$150,000. Anglers in group 9 reported a household gross income between \$150,000 and less than \$200,000. Anglers in group 10 reported a household gross income between \$200,000 and less than \$250,000. Anglers in group 11 reported a household gross income greater than \$250,000. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range).



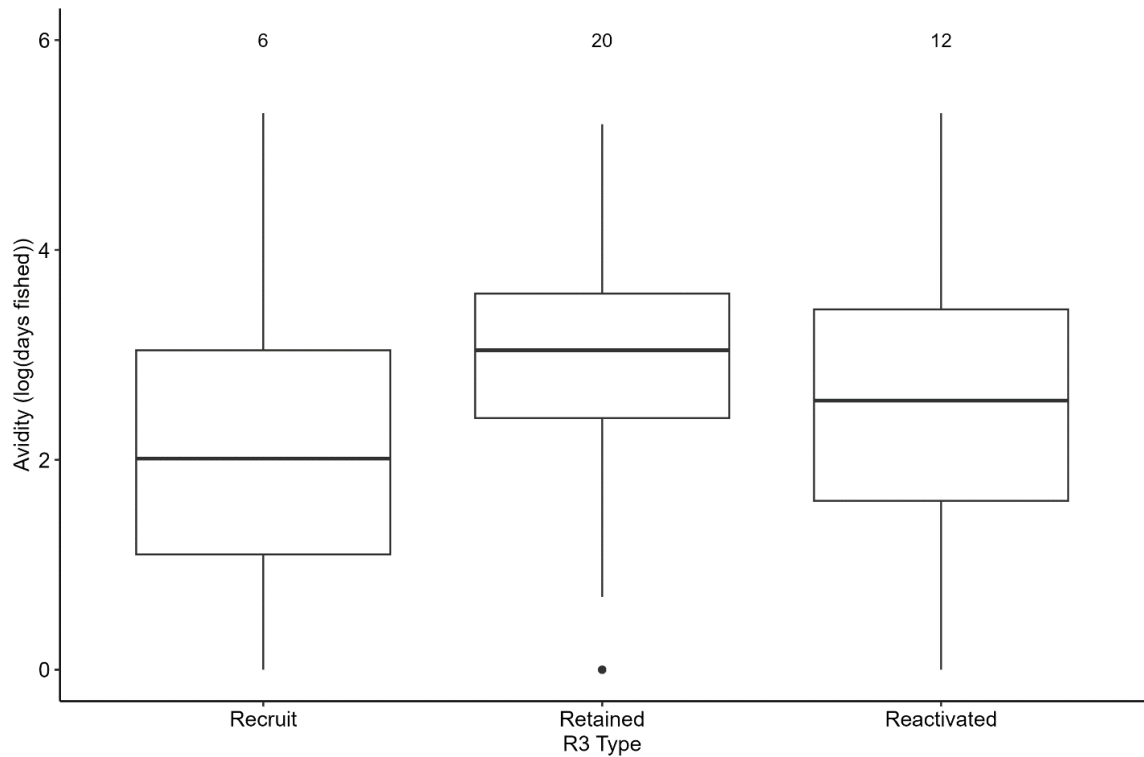
Appendix 2.7. Boxplots of fishing avidity and the education level for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Group 1 contains anglers with some schooling. Group 2 contains anglers with a high school diploma or GED. Group 3 contains anglers with some college education. Group 4 contains anglers with an Associate or trade degree. Group 5 contains anglers with a Bachelor's degree. Group 6 contains anglers with a master's degree. Group 7 contains anglers with a Doctorate, law, or medical degree. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25^{th} percentile – $1.5 * \text{interquartile range}$) and maximum (75^{th} percentile + $1.5 * \text{interquartile range}$). Outliers are designated by points.



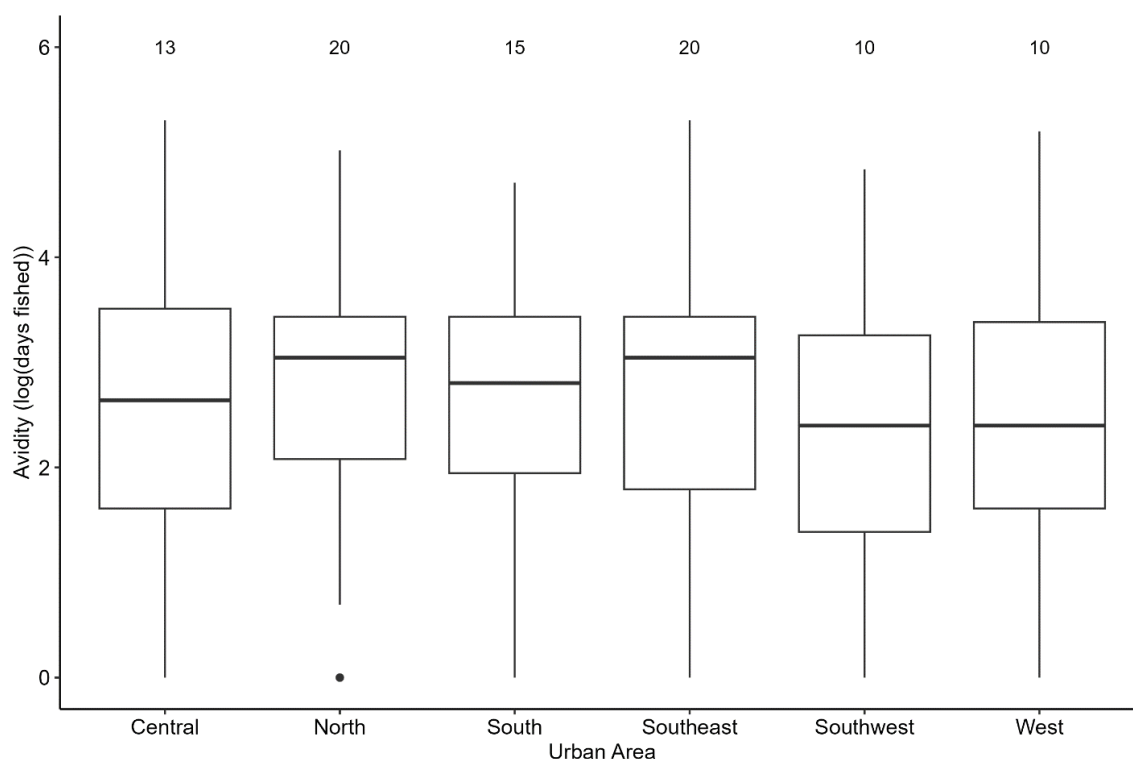
Appendix 2.8. Boxplots of fishing avidity and the fishing permit purchased during 2019 for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. The day category includes 1-day and 3-day licenses, the annuals category includes annual fishing permits, and the multi-year category includes 3-year and 5-year fishing licenses. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25^{th} percentile $- 1.5 * \text{interquartile range}$) and maximum (75^{th} percentile $+ 1.5 * \text{interquartile range}$). Outliers are designated by points.



Appendix 2.9. Boxplots of fishing avidity and additional family members within the respondents' residence that also possessed a 2019 fishing-permit for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range). Outliers are designated by a point.

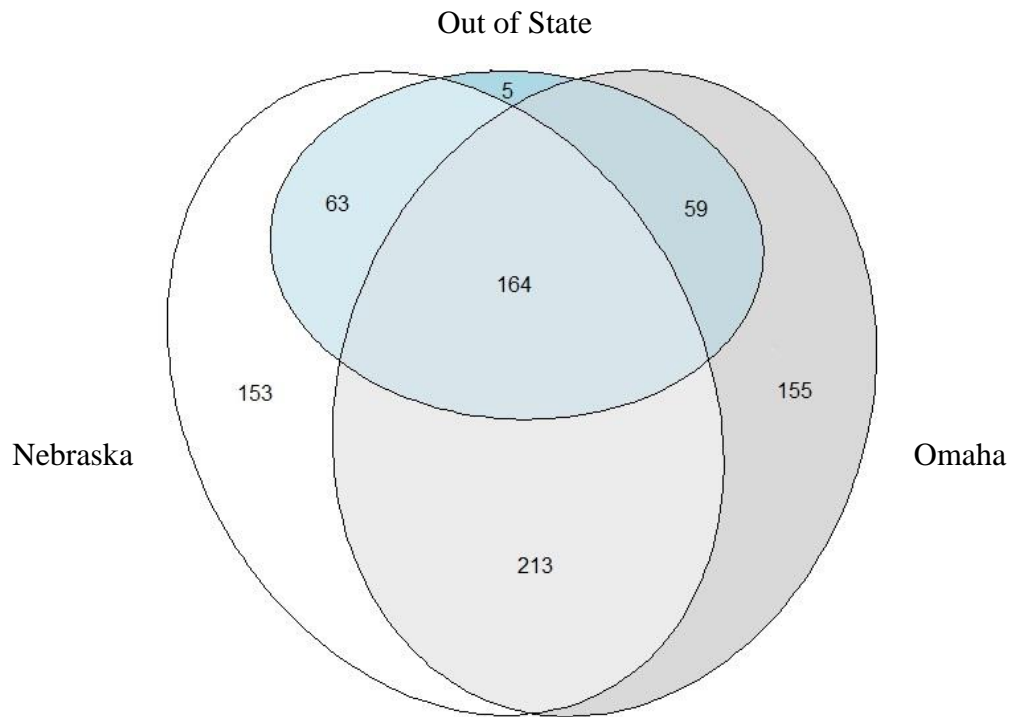


Appendix 2.10. Boxplots of fishing avidity and the r3 groups of 2019 fishing permit holders for residents that purchased a 2019 fishing-permit and resided within omaha, nebraska. Recruited anglers were those that did not possess a nebraska fishing license before 2019. Retained anglers were those that possessed a nebraska fishing license multiple years, including 2019, without a break in license possession. Reactivated anglers were those that possessed a 2017 and 2019 nebraska fishing license, but not a 2018 nebraska fishing license. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25th percentile – 1.5 * interquartile range) and maximum (75th percentile + 1.5 * interquartile range). Outliers are designated by points.



Appendix 2.11. Boxplots of fishing avidity and the Omaha, Nebraska, urban area as categorized by Nebraska Game and Parks biologist in alphabetical order for residents that purchased a 2019 fishing-permit and resided within Omaha, Nebraska. Median days spent fishing are above each urbanization group. Whiskers on the boxplots represent the minimum (25^{th} percentile $- 1.5 * \text{interquartile range}$) and maximum (75^{th} percentile $+ 1.5 * \text{interquartile range}$). Outliers are designated by points.

Appendix 3. Venn diagram of 2019 fishing-permit holders that resided within the Omaha metropolitan area and where they fish.



Appendix 3.1. Venn diagram of 2019 fishing-permit holders that responded to the 2020 Omaha Recreation Survey and locations fished during 2019.

Appendix 4. R code used for thesis analyses

```
# Kyle Hansen
```

```
# Thesis Analysis
```

```
# 2023-03-30
```

```
setwd("C:/Users/k4han/OneDrive/Desktop/Master Project Data")
```

```
# Libraries -----
```

```
#install.packages("factoextra")
```

```
#install.packages("rgl")
```

```
#install.packages("adehabitatHR")
```

```
#install.packages("eepTools")
```

```
#install.packages("performance")
```

```
#install.packages("MuMIn")
```

```
#install.packages("tidycensus")
```

```
library(haven)
```

```
library(ggthemes)
```

```
library(ggpubr)
```

```
library(foreach)
```

```
library(naniar)
```

```
library(factoextra)
```

```
library(rgl)
```

```
library(ggcorrplot)
```

```
library(pander)
```

```
library(car)
```

```
library(ngpcAnglersheds)
```

```
library(adehabitatHR)
```

```
library(AICcmodavg)
```

```

library(broom)
library(SciViews)
library(grid)
library(gridExtra)
library(eeptools)
library(lubridate)
library(tidycensus)
library(tigris)
library(Hmisc)
library(performance)
library(MuMIn)
library(sf)
library(glmtoolbox)
library(tidyverse)

# GG Themes -----

theme_mine <- function(base_size = 18, base_family = "Franklin Gothic Demi") {
  # Starts with theme_grey and then modify some parts
  theme_classic(base_size = base_size, base_family = base_family) %+replace%
  theme(
    strip.background = element_blank(),
    strip.text.x = element_text(size = 14),
    strip.text.y = element_text(size = 14),
    axis.text.x = element_text(size=14),
    axis.text.y = element_text(size=14, hjust=1),
    axis.ticks = element_line(colour = "black"),
    axis.title.x= element_text(size=14),
    axis.title.y= element_text(size=14,angle=90),
  )
}

```

```

panel.background = element_blank(),
panel.border =element_blank(),
panel.grid.major = element_blank(),
panel.grid.minor = element_blank(),
panel.margin = unit(1.0, "lines"),
plot.background = element_blank(),
plot.margin = unit(c(0.5, 0.5, 0.5, 0.5), "lines"),
axis.line.x = element_line(color="black", size = 2),
axis.line.y = element_line(color="black", size = 2)
)
}

```

```

theme_mine_presentation <- function(base_size = 18, base_family = "Franklin Gothic Demi") {
  # Starts with theme_grey and then modify some parts
  theme_classic(base_size = base_size, base_family = base_family) %+replace%
  theme(
    axis.text.x = element_text(size=14, color = "white"),
    axis.text.y = element_text(size=14, hjust=1, color = "white"),
    axis.ticks = element_line(colour = "white"),
    axis.title.x = element_text(size=14, color = "white"),
    axis.title.y = element_text(size=14,angle=90, color = "white"),
    panel.background = element_rect(fill = "transparent", color = NA),
    panel.border = element_blank(),
    panel.grid.major = element_blank(),
    panel.grid.minor = element_blank(),
    plot.background = element_rect(fill = "transparent", color = NA),
    axis.line.x = element_line(color="white", size = 2),
    axis.line.y = element_line(color="white", size = 2)
  )
}

```

```
}
```

```
# Data -----
```

```
df <- read_sav("Anglers_Data_Final.sav") # Data frame for the 2020 Omaha Angler Survey
```

```
#dfOmahaInvit <- read.csv("omaha_invites_final.csv")
```

```
dfOmahaInvit_rev <- read.csv("omaha_invites_final_v2.csv") # Contains additional variables  
(i.e., age) for surveys sent to Omaha anglers
```

```
dfOmahaInvit2 <- dfOmahaInvit_rev %>% # Contains the completed surveys with license type,  
purchase history from 2010 through 2019, and sex of the angler
```

```
  filter(complete_survey >= 1)
```

```
Survey_nonrespond <- dfOmahaInvit_rev %>%
```

```
  filter(complete_survey == 0)
```

```
merge(df, dfOmahaInvit2, by.x = "NewID", by.y = "new_id") -> dfmerge # Merged the angler  
final data frame with the Omaha invite data that contains the license type, purchase history, and  
sex of each angler
```

```
dfmerge %>%
```

```
  separate(NewID, c("Tapestry", "extra"), 3) %>% #To add the original column back, add remove  
= FALSE
```

```
  select(-extra) -> df_2
```

```
#df_2$p
```

```
df2NASIS <- read_sav("NASIS20W_Data_REC.sav") # Data frame for the 2020 Winter NASIS  
Survey
```

df_2 %>%

```
rename(Fishing = Q24A,
       Ice_Fishing = Q24B,
       Hunting = Q24C,
       Shooting_Sports = Q24D,
       Camping = Q24E,
       Wildlife_Viewing = Q24F,
       Bicycling = Q24G,
       Adventure_Sports = Q24H,
       Paddlesports = Q24I,
       Boating = Q24J,
       Winter_Sports = Q24K,
       Swimming = Q24L,
       Hiking = Q24M) %>%
```

```
rename(Photography = Q25A,
       Gardening = Q25B,
       Sewing = Q25C,
       Woodworking = Q25D,
       Art = Q25E,
       Cultural_Sites = Q25F,
       Driving = Q25G,
       Watching_TV = Q25H,
       Golf = Q26A,
       Attending_Sports = Q26B,
       Coaching = Q26C,
       Team_Sports = Q26D,
       Recreational_Sports = Q26E,
       Fitness = Q26F,
       Other = Q26G) %>%
```

```

replace(is.na(.), 0) %>%

select(-Mode, -Q2A: -Q3, -Q5, -Q9A: -Q19h, -Q21: -Q23P, -Q34, contains("p20")) -> df_filtered #
Contains the information for future thesis analyses

cols_to_count <- c("Fishing", "Ice_Fishing", "Hunting", "Shooting_Sports", "Camping",
                  "Wildlife_Viewing", "Bicycling", "Adventure_Sports", "Paddlesports",
                  "Boating", "Winter_Sports", "Swimming", "Hiking", "Photography", "Gardening",
                  "Sewing", "Woodworking", "Art", "Cultural_Sites", "Driving", "Watching_TV",
                  "Golf", "Attending_Sports", "Coaching", "Team_Sports", "Recreational_Sports",
                  "Fitness")

zeros_in_rows <- df_filtered %>%

  rowwise() %>%

  mutate(zeros = sum(c_across(cols_to_count) == 0)) # Counted the number of zeros in the rows
for the recreational activities columns. Rows with 27 zeros get removed due to angler not filling
out that section of the survey.

dat <- zeros_in_rows %>%

  filter(zeros < 27) # Removed the rows with 27 zeros

dat %>%

  replace_with_na(list(Watching_TV = 900)) -> dat

dat[is.na(dat)] = 0

summary(dat)

dat %>%

  select(-zeros) -> dat

dat %>%

  mutate(Age = 2019 - Q32) -> dat # Converted the year born column in the survey to a new
column for the anglers age.

```

Employment status will be on a scale of 0 to 7, due to anglers being in multiple categories

dat %>%

mutate(Q29A = ifelse(Q29A == 1, 4, Q29A)) -> dat # Converted the full time employee to a rank of 4

dat %>%

mutate(Q29B = ifelse(Q29B == 1, 2, Q29B)) -> dat # Converted the part time employee to a rank of 2

dat %>%

mutate(Q29C = ifelse(Q29C == 1, 0, Q29C)) -> dat # Converted the retired employee to a rank of 0

dat %>%

mutate(Q29E = ifelse(Q29E == 1, 1, Q29E)) -> dat # Converted the student employee to a rank of 1

dat %>%

mutate(Q29F = ifelse(Q29D == 1, 0, Q29D)) -> dat # Converted the unemployed to a rank of 0

dat %>%

rowwise() %>%

mutate(Employment = sum(across(Q29A: Q29F))) -> dat # Combined the employment status questions from the survey data into a new column called Employment and summed the total
summary(dat\$Employment)

dat %>%

mutate(Generation = case_when(
Q32 >= 1995 ~ "Gen Z",

```

Q32 >= 1980 ~ "Millennial",
Q32 >= 1965 ~ "Gen X",
Q32 >= 1946 ~ "Baby Boomer",
Q32 >= 1925 ~ "Silent Gen")) -> dat # Generation column created for the anglers

#dat %>%

# rowwise() %>%

#mutate(License_history = sum(str_count(fish_history, "1"))) -> dat # Summed the license
purchase history and have a range of 1-10 for years a fishing license was purchased

# Kernel Heat Maps -----

dat %>%

select(-Tapestry, -Q1A: -Q4D, -Q7A: -Q30, -Q32, -Q33TOTAL) %>%
rename(Bennington = Q6A,
       Benson_Park = Q6B,
       Carter = Q6C,
       Flanagan = Q6D,
       Fontenelle = Q6E,
       Haworth = Q6F,
       Hitchcock_Park = Q6G,
       Kramer = Q6H,
       Hallek = Q6I,
       Lawrence_Youngman = Q6J,
       Midlands = Q6K,
       Prairie_Queen = Q6L,
       Prairie_View = Q6M,
       Schwer_Park = Q6N,
       Shadow = Q6O,

```

```

Standing_Bear = Q6P,
Towl_Park = Q6Q,
Walnut_Creek = Q6R,
Walnut_Grove = Q6S,
Wehrspann = Q6T,
Whitehawk = Q6U,
Zorinsky = Q6V) %>%

select(-urbanization_groups: -Age) %>%

mutate(Q31 = as.character(Q31)) -> OmahaReservoirs # Created data frame consisting of days
fished at each Omaha Reservoir

# save(OmahaReservoirs, file = "Kyledata.r") # File to save to Keith Hurley's flash drive

# Omaha counties are Douglas and Sarpy

# Tigress package https://cran.r-project.org/web/packages/tigris/index.html

# Colors for legened

# Viridis package https://cran.r-project.org/web/packages/viridis/vignettes/intro-to-viridis.html

Bennington <- OmahaReservoirs %>% filter(Bennington>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for
Bennington Lake. 58 anglers fished

Bennington_map <- createAnglershedCounties(Bennington,

      counties=c("nebraska,sarpy",
                  "nebraska,douglas"),
      percLevels=c(90,50,10),
      percColors = c("red", "yellow", "blue"),

```

```

outputType = "sf") # Anglershed for Bennington Lake with Omaha
counties

```

```

Bennington_map |>
  st_as_sf(coords = c("long", "lat"), crs=4326) |>
  st_transform(st_crs(RoadsDS)) |>
  group_by(percLevel) |>
  summarise(geometry = st_combine(geometry)) |>
  st_cast("POLYGON") |>
  st_make_valid() |>
  st_intersection() |>
  st_cast('MULTIPOLYGON') -> Bennington_map_sf

```

```

Bennington_map_sf <- Bennington_map_sf[,-3]

st_write(Bennington_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'Bennington_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = Bennington_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Bennington Lake") +
  theme_void() -> Bennington_map_roads

```

```

Bennington_map_roads+geom_point(aes(x = -96.1892,y = 41.3720), shape = 23, size = 5, fill =
"black") -> Bennington_map_roads

```

```
Benson_Park <- OmahaReservoirs %>% filter(Benson_Park>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Benson
Park Lake. 25 anglers fished
```

```
Benson_map <- createAnglershedCounties(Benson_Park,
                                       counties=c("nebraska,sarpy",
                                                  "nebraska,douglas"),
                                       percLevels=c(90,50,10),
                                       percColors = c("red", "yellow", "blue"),
                                       outputType = "sf") # Anglershed for Benson Park Lake with Omaha
counties
```

```
Benson_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Benson_map_sf
```

```
Benson_map_sf <- Benson_map_sf[,-3]

st_write(Benson_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Benson_kernels_102723.shp'))
```

```
ggplot() +
  geom_sf(data = Benson_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
```

```
labs(title = "Benson Lake") +
theme_void() -> Benson_map_roads
```

```
Benson_map_roads+geom_point(aes(x = -96.0196,y = 41.2975), shape = 23, size = 5, fill =
"black")
```

```
Carter <- OmahaReservoirs %>% filter(Carter>=1) %>% mutate(Q31=as.character(Q31)) %>%
pull(Q31) # Values made to create anglershed for Carter Lake. 73 anglers fished
```

```
Carter_map <- createAnglershedCounties(Carter,
                                     counties=c("nebraska,sarpy",
                                                "nebraska,douglas"),
                                     percLevels=c(90,50,10),
                                     percColors = c("red", "yellow", "blue"),
                                     outputType = "sf") # Anglershed for Carter Lake with Omaha counties
```

```
Carter_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Carter_map_sf
```

```
Carter_map_sf <- Carter_map_sf[,-3]
st_write(Carter_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Carter_kernels_102723.shp'))
```

```
percColors = c("10" = "red", "50" = "yellow", "90" = "blue")
```

```

ggplot() +
  geom_sf(data = Carter_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Carter Lake") +
  theme_void() -> Carter_map_roads

```

```

Carter_map_roads+geom_point(aes(x = -95.9291,y = 41.2976), shape = 23, size = 5, fill = "black")
-> Carter_map_roads

```

```

Flanagan <- OmahaReservoirs %>% filter(Flanagan>=1) %>% mutate(Q31=as.character(Q31))
%>% pull(Q31) # Values made to create anglershed for Flanagan Lake. 80 anglers fished

```

```

Flanagan_map <- createAnglershedCounties(Flanagan,
                                          counties=c("nebraska,sarpy",
                                                      "nebraska,douglas"),
                                          percLevels=c(90,50,10),
                                          percColors = c("red", "yellow", "blue"),
                                          outputType = "sf") # Anglershed for Flanagan Lake with Omaha counties

```

```

Flanagan_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Flanagan_map_sf

```

```

Flanagan_map_sf <- Flanagan_map_sf[,-3]

st_write(Flanagan_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Flanagan_kernels_102723.shp'))

ggplot() +

  geom_sf(data = Flanagan_map_sf, aes(fill = as.factor(percLevel))) +

  geom_sf(data = RoadsDS) +

  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +

  scale_fill_manual("AnglerShed", values = percColors) +

  labs(title = "Flanagan Lake") +

  theme_void() -> Flanagan_map_roads

Flanagan_map_roads+geom_point(aes(x = -96.1865,y = 41.3123), shape = 23, size = 5, fill =
"black") -> Flanagan_map_roads

Fontenelle <- OmahaReservoirs %>% filter(Fontenelle>=1) %>% mutate(Q31=as.character(Q31))
%>% pull(Q31) # Values made to create anglershed for Fontenelle Lake. 11 anglers fished

Fontenelle_map <- createAnglershedCounties(Fontenelle,

      counties=c("nebraska,sarpy",

                  "nebraska,douglas"),

      percLevels=c(90,50,10),

      percColors = c("red", "yellow", "blue"),

      outputType = "sf") # Anglershed for Fontenelle Lake with Omaha
counties

Fontenelle_map %>%

  st_as_sf(coords = c("long", "lat"), crs=4326) %>%

  st_transform(st_crs(RoadsDS)) %>%

```

```

group_by(percLevel) %>%
summarise(geometry = st_combine(geometry)) %>%
st_cast("POLYGON") %>%
st_make_valid() %>%
st_intersection() -> Fontenelle_map_sf

```

```

Fontenelle_map_sf <- Fontenelle_map_sf[,-3]

st_write(Fontenelle_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Fontenelle_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = Fontenelle_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Fontenelle Lake") +
  theme_void() -> Fontenelle_map_roads

```

```

Fontenelle_map_roads+geom_point(aes(x = -95.9827,y = 41.2974), shape = 23, size = 5, fill =
"black")

```

```

Haworth <- OmahaReservoirs %>% filter(Haworth>=1) %>% mutate(Q31=as.character(Q31))
%>% pull(Q31) # Values made to create anglershed for Haworth Lake. 13 anglers fished

```

```

Haworth_map <- createAnglershedCounties(Haworth,
                                         counties=c("nebraska,sarpy",
                                                      "nebraska,douglas"),
                                         percLevels=c(90,50,10),
                                         percColors = c("red", "yellow", "blue"),
                                         outputType = "sf") # Anglershed for Haworth Lake with Omaha counties

```

```

Haworth_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Haworth_map_sf

Haworth_map_sf <- Haworth_map_sf[,-3]

st_write(Haworth_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'Haworth_kernels_102723.shp'))

ggplot() +
  geom_sf(data = Haworth_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Haworth Lake") +
  theme_void() -> Haworth_map_roads

Haworth_map_roads+geom_point(aes(x = -95.8855,y = 41.1351), shape = 23, size = 5, fill =
"black") -> Haworth_map_roads

Hitchcock_Park <- OmahaReservoirs %>% filter(Hitchcock_Park>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for
Hitchcock Park Lake. 14 anglers fished

Hitchcock_map <- createAnglershedCounties(Hitchcock_Park,

```

```

counties=c("nebraska,sarpy",
           "nebraska,douglas"),
percLevels=c(90,50,10),
percColors = c("red", "yellow", "blue"),
outputType = "sf") # Anglershed for Hitchcock Park Lake with Omaha
counties

```

```

Hitchcock_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Hitchcock_map_sf

```

```

Hitchcock_map_sf <- Hitchcock_map_sf[,-3]

st_write(Hitchcock_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Hitchcock_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = Hitchcock_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Hitchcock Lake") +
  theme_void() -> Hitchcock_map_roads

```

```

Hitchcock_map_roads+geom_point(aes(x = -95.9796,y = 41.2061), shape = 23, size = 5, fill =
"black")

```

```
Kramer <- OmahaReservoirs %>% filter(Kramer>=1) %>% mutate(Q31=as.character(Q31)) %>%
pull(Q31) # Values made to create anglershed for Kramer Lake. 3 anglers fished. Need at least 5
to generate map.
```

```
Hallek <- OmahaReservoirs %>% filter(Hallek>=1) %>% mutate(Q31=as.character(Q31)) %>%
pull(Q31) # Values made to create anglershed for Hallek Lake. 65 anglers fished
```

```
Hallek_map <- createAnglershedCounties(Hallek,
                                     counties=c("nebraska,sarpy",
                                                "nebraska,douglas"),
                                     percLevels=c(90,50,10),
                                     percColors = c("red", "yellow", "blue"),
                                     outputType = "sf") # Anglershed for Hallek Lake with Omaha counties
```

```
Hallek_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Hallek_map_sf
```

```
Hallek_map_sf <- Hallek_map_sf[,-3]

st_write(Hallek_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Hallek_kernels_102723.shp'))
```

```
ggplot() +
  geom_sf(data = Hallek_map_sf, aes(fill = as.factor(percLevel))) +
```

```

geom_sf(data = RoadsDS) +
geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
scale_fill_manual("AnglerShed", values = percColors) +
labs(title = "Hallek Lake") +
theme_void() -> Hallek_map_roads

```

```

Hallek_map_roads+geom_point(aes(x = -96.0317,y = 41.1532), shape = 23, size = 5, fill = "black")
-> Hallek_map_roads

```

```

Lawrence_Youngman <- OmahaReservoirs %>% filter(Lawrence_Youngman>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for
Lawrence Youngman Lake. 94 anglers fished

```

```

Lawrence_map <- createAnglershedCounties(Lawrence_Youngman,
                                         counties=c("nebraska,sarpy",
                                                    "nebraska,douglas"),
                                         percLevels=c(90,50,10),
                                         percColors = c("red", "yellow", "blue"),
                                         outputType = "sf") # Anglershed for Lawrence Youngman Lake with
Omaha counties

```

```

Lawrence_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Lawrence_map_sf

```

```

Lawrence_map_sf <- Lawrence_map_sf[,-3]

st_write(Lawrence_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Lawrence_kernels_102723.shp'))

ggplot() +

  geom_sf(data = Lawrence_map_sf, aes(fill = as.factor(percLevel))) +

  geom_sf(data = RoadsDS) +

  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +

  scale_fill_manual("AnglerShed", values = percColors) +

  labs(title = "Lawrence Youngman Lake") +

  theme_void() -> Lawrence_map_roads

Lawrence_map_roads+geom_point(aes(x = -96.2197,y = 41.2704), shape = 23, size = 5, fill =
"black") -> Lawrence_map_roads

Midlands <- OmahaReservoirs %>% filter(Midlands>=1) %>% mutate(Q31=as.character(Q31))
%>% pull(Q31) # Values made to create anglershed for Midlands Lake. 7 anglers fished

Midlands_map <- createAnglershedCounties(Midlands,

      counties=c("nebraska,sarpy",

                  "nebraska,douglas"),

      percLevels=c(90,50,10),

      percColors = c("red", "yellow", "blue"),

      outputType = "sf") # Anglershed for Midlands Lake with Omaha counties

Midlands_map %>%

  st_as_sf(coords = c("long", "lat"), crs=4326) %>%

  st_transform(st_crs(RoadsDS)) %>%

  group_by(percLevel) %>%

  summarise(geometry = st_combine(geometry)) %>%

```

```

st_cast("POLYGON") %>%
st_make_valid() %>%
st_intersection() -> Midlands_map_sf

```

```

Midlands_map_sf <- Midlands_map_sf[,-3]

st_write(Midlands_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Midlands_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = Midlands_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Midlands Lake") +
  theme_void() -> Midlands_map_roads

```

```

Midlands_map_roads+geom_point(aes(x = -96.0378,y = 41.1260), shape = 23, size = 5, fill =
"black") -> Midlands_map_roads

```

```

Prairie_Queen <- OmahaReservoirs %>% filter(Prairie_Queen>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Prairie
Queen Lake. 232 anglers fished

```

```

PrairieQ_map <- createAnglershedCounties(Prairie_Queen,
  counties=c("nebraska,sarpy",
             "nebraska,douglas"),
  percLevels=c(90,50,10),
  percColors = c("red", "yellow", "blue"),
  outputType = "sf") # Anglershed for Prairie Queen Lake with Omaha
counties

```

```

PrairieQ_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> PrairieQ_map_sf

PrairieQ_map_sf <- PrairieQ_map_sf[,-3]

st_write(PrairieQ_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'PrairieQ_kernels_102723.shp'))

ggplot() +
  geom_sf(data = PrairieQ_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Prairie Queen Lake") +
  theme_void() -> PrairieQ_map_roads

PrairieQ_map_roads+geom_point(aes(x = -96.0647,y = 41.0953), shape = 23, size = 5, fill =
"black") -> PrairieQ_map_roads

Prairie_View <- OmahaReservoirs %>% filter(Prairie_View>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Prairie
View Lake. 45 anglers fished

PrairieV_map <- createAnglershedCounties(Prairie_View,

```

```

counties=c("nebraska,sarpy",
           "nebraska,douglas"),
percLevels=c(90,50,10),
percColors = c("red", "yellow", "blue"),
outputType = "sf") # Anglershed for Prairie View Lake with Omaha
counties

```

```

PrairieV_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> PrairieV_map_sf

```

```

PrairieV_map_sf <- PrairieV_map_sf[,-3]

st_write(PrairieV_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'PrairieV_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = PrairieV_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Prairie View Lake") +
  theme_void() -> PrairieV_map_roads

```

```

PrairieV_map_roads+geom_point(aes(x = -96.1983,y = 41.3733), shape = 23, size = 5, fill =
"black") -> PrairieV_map_roads

```

```
Schwer_Park <- OmahaReservoirs %>% filter(Schwer_Park>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Schwer
Park Lake. 22 anglers fished
```

```
Schwer_map <- createAnglershedCounties(Schwer_Park,
                                     counties=c("nebraska,sarpy",
                                                "nebraska,douglas"),
                                     percLevels=c(90,50,10),
                                     percColors = c("red", "yellow", "blue"),
                                     outputType = "sf") # Anglershed for Schwer Park Lake with Omaha
counties
```

```
Schwer_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Schwer_map_sf
```

```
Schwer_map_sf <- Schwer_map_sf[,-3]

st_write(Schwer_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Schwer_kernels_102723.shp'))
```

```
ggplot() +
  geom_sf(data = Schwer_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
```

```
scale_fill_manual("AnglerShed", values = percColors) +
labs(title = "Schwer Lake") +
theme_void() -> Schwer_map_roads
```

```
Schwer_map_roads+geom_point(aes(x = -96.0537,y = 41.1674), shape = 23, size = 5, fill =
"black") -> Schwer_map_roads
```

```
Shadow <- OmahaReservoirs %>% filter(Shadow>=1) %>% mutate(Q31=as.character(Q31)) %>%
pull(Q31) # Values made to create anglershed for Shadow Lake. 64 anglers fished
```

```
Shadow_map <- createAnglershedCounties(Shadow,
                                     counties=c("nebraska,sarpy",
                                                "nebraska,douglas"),
                                     percLevels=c(90,50,10),
                                     percColors = c("red", "yellow", "blue"),
                                     outputType = "sf") # Anglershed for Shadow Lake with Omaha counties
```

```
Shadow_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Shadow_map_sf
```

```
Shadow_map_sf <- Shadow_map_sf[,-3]

st_write(Shadow_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Shadow_kernels_102723.shp'))
```

```

ggplot() +
  geom_sf(data = Shadow_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Shadow Lake") +
  theme_void() -> Shadow_map_roads

```

```

Shadow_map_roads+geom_point(aes(x = -96.0283,y = 41.1354), shape = 23, size = 5, fill =
"black") -> Shadow_map_roads

```

```

Standing_Bear <- OmahaReservoirs %>% filter(Standing_Bear>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Standing
Bear Lake. 214 anglers fished

```

```

StandBear_map <- createAnglershedCounties(Standing_Bear,
      counties=c("nebraska,sarpy",
      "nebraska,douglas"),
      percLevels=c(90,50,10),
      percColors = c("red", "yellow", "blue"),
      outputType = "sf") # Anglershed for Standing Bear Lake with Omaha
counties

```

```

StandBear_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%

```

```
st_intersection() -> StandBear_map_sf
```

```
StandBear_map_sf <- StandBear_map_sf[,-3]
```

```
st_write(StandBear_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'StandBear_kernels_102723.shp'))
```

```
ggplot() +
```

```
  geom_sf(data = StandBear_map_sf, aes(fill = as.factor(percLevel))) +
```

```
  geom_sf(data = RoadsDS) +
```

```
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
```

```
  scale_fill_manual("AnglerShed", values = percColors) +
```

```
  labs(title = "Standing Bear Lake") +
```

```
  theme_void() -> StandBear_map_roads
```

```
StandBear_map_roads+geom_point(aes(x = -96.1209,y = 41.3187), shape = 23, size = 5, fill =
"black") -> StandBear_map_roads
```

```
Towl_Park <- OmahaReservoirs %>% filter(Towl_Park>=1) %>% mutate(Q31=as.character(Q31))
%>% pull(Q31) # Values made to create anglershed for Towl Park Lake. 27 anglers fished
```

```
Towl_map <- createAnglershedCounties(Towl_Park,
                                     counties=c("nebraska,sarpy",
                                                  "nebraska,douglas"),
                                     percLevels=c(90,50,10),
                                     percColors = c("red", "yellow", "blue"),
                                     outputType = "sf") # Anglershed for Towl Park Lake with Omaha counties
```

```
Towl_map %>%
```

```
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
```

```
  st_transform(st_crs(RoadsDS)) %>%
```

```

group_by(percLevel) %>%
summarise(geometry = st_combine(geometry)) %>%
st_cast("POLYGON") %>%
st_make_valid() %>%
st_intersection() -> Towl_map_sf

```

```

Towl_map_sf <- Towl_map_sf[,-3]

st_write(Towl_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'Towl_kernels_102723.shp'))

```

```

ggplot() +
  geom_sf(data = Towl_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Towl Lake") +
  theme_void() -> Towl_map_roads

```

```

Towl_map_roads+geom_point(aes(x = -96.0589,y = 41.2345), shape = 23, size = 5, fill = "black") -
> Towl_map_roads

```

```

Walnut_Creek <- OmahaReservoirs %>% filter(Walnut_Creek>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Walnut
Creek Lake. 214 anglers fished

```

```

WalCreek_map <- createAnglershedCounties(Walnut_Creek,
      counties=c("nebraska,sarpy",
      "nebraska,douglas"),
      percLevels=c(90,50,10),
      percColors = c("red", "yellow", "blue"),

```

```
outputType = "sf") # Anglershed for Walnut Creek Lake with Omaha
counties
```

```
WalCreek_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> WalCreek_map_sf
```

```
WalCreek_map_sf <- WalCreek_map_sf[,-3]
st_write(WalCreek_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'WalCreek_kernels_102723.shp'))
```

```
ggplot() +
  geom_sf(data = WalCreek_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Walnut Creek Lake") +
  theme_void() -> WalCreek_map_roads
```

```
WalCreek_map_roads+geom_point(aes(x = -96.0686,y = 41.1395), shape = 23, size = 5, fill =
"black") -> WalCreek_map_roads
```

```
Walnut_Grove <- OmahaReservoirs %>% filter(Walnut_Grove>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for Walnut
Grove Lake. 19 anglers fished
```

```
WalGrove_map <- createAnglershedCounties(Walnut_Grove,
                                         counties=c("nebraska,sarpy",
                                                     "nebraska,douglas"),
                                         percLevels=c(90,50,10),
                                         percColors = c("red", "yellow", "blue"),
                                         outputType = "sf") # Anglershed for Walnut Grove Lake with Omaha
counties
```

```
WalGrove_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> WalGrove_map_sf
```

```
WalGrove_map_sf <- WalGrove_map_sf[,-3]
st_write(WalGrove_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps', '/',
'WalGrove_kernels_102723.shp'))
```

```
ggplot() +
  geom_sf(data = WalGrove_map_sf, aes(fill = as.factor(percLevel))) +
  geom_sf(data = RoadsDS) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
  scale_fill_manual("AnglerShed", values = percColors) +
  labs(title = "Walnut Grove Lake") +
  theme_void() -> WalGrove_map_roads
```

```
WalGrove_map_roads+geom_point(aes(x = -96.1503,y = 41.2091), shape = 23, size = 5, fill =
"black") -> WalGrove_map_roads
```

```
Wehrspann <- OmahaReservoirs %>% filter(Wehrspann>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for
Wehrspann Lake. 203 anglers fished
```

```
Wehrspann_map <- createAnglershedCounties(Wehrspann,
                                           counties=c("nebraska,sarpy",
                                                       "nebraska,douglas"),
                                           percLevels=c(90,50,10),
                                           percColors = c("red", "yellow", "blue"),
                                           outputType = "sf") # Anglershed for Wehrspann Lake with Omaha
counties
```

```
Wehrspann_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Wehrspann_map_sf
```

```
Wehrspann_map_sf <- Wehrspann_map_sf[,-3]
st_write(Wehrspann_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Wehrspann_kernels_102723.shp'))
```

```
ggplot() +
```

```

geom_sf(data = Wehrspann_map_sf, aes(fill = as.factor(percLevel))) +
geom_sf(data = RoadsDS) +
geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +
scale_fill_manual("AnglerShed", values = percColors) +
labs(title = "Wehrspann Lake") +
theme_void() -> Wehrspann_map_roads

```

```

Wehrspann_map_roads+geom_point(aes(x = -96.1559,y = 41.1592), shape = 23, size = 5, fill =
"black") -> Wehrspann_map_roads

```

```

Whitehawk <- OmahaReservoirs %>% filter(Whitehawk>=1) %>%
mutate(Q31=as.character(Q31)) %>% pull(Q31) # Values made to create anglershed for
Whitehawk Lake. 12 anglers fished

```

```

Whitehawk_map <- createAnglershedCounties(Whitehawk,
      counties=c("nebraska,sarpy",
      "nebraska,douglas"),
      percLevels=c(90,50,10),
      percColors = c("red", "yellow", "blue"),
      outputType = "sf") # Anglershed for Whitehawk Lake with Omaha
counties

```

```

Whitehawk_map %>%
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
  st_transform(st_crs(RoadsDS)) %>%
  group_by(percLevel) %>%
  summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Whitehawk_map_sf

```

```

Whitehawk_map_sf <- Whitehawk_map_sf[,-3]

st_write(Whitehawk_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat _Maps', '/',
'Whitehawk_kernels_102723.shp'))

ggplot() +

  geom_sf(data = Whitehawk_map_sf, aes(fill = as.factor(percLevel))) +

  geom_sf(data = RoadsDS) +

  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +

  scale_fill_manual("AnglerShed", values = percColors) +

  labs(title = "Whitehawk Lake") +

  theme_void() -> Whitehawk_map_roads

Whitehawk_map_roads+geom_point(aes(x = -96.2199,y = 41.2200), shape = 23, size = 5, fill =
"black") -> Whitehawk_map_roads

Zorinsky <- OmahaReservoirs %>% filter(Zorinsky>=1) %>% mutate(Q31=as.character(Q31)) %>%
pull(Q31) # Values made to create anglershed for Zorinsky Lake. 195 anglers fished

Zorinsky_map <- createAnglershedCounties(Zorinsky,
  counties=c("nebraska,sarpy",
    "nebraska,douglas"),
  percLevels=c(90,50,10),
  percColors = c("red", "yellow", "blue"),
  outputType = "sf") # Anglershed map for Zorinsky Lake with Omaha counties

Zorinsky_map %>%

  st_as_sf(coords = c("long", "lat"), crs=4326) %>%

  st_transform(st_crs(RoadsDS)) %>%

  group_by(percLevel) %>%

```

```
summarise(geometry = st_combine(geometry)) %>%
  st_cast("POLYGON") %>%
  st_make_valid() %>%
  st_intersection() -> Zorinsky_map_sf
```

```
Zorinsky_map_sf <- Zorinsky_map_sf[,-3]
```

```
st_write(Zorinsky_map_sf, paste0('C:/Users/k4han/OneDrive/Desktop/Heat_Maps/', '/',
'Zorinsky_kernels_102723.shp'))
```

```
ggplot() +  
  geom_sf(data = Zorinsky_map_sf, aes(fill = as.factor(percLevel))) +  
  geom_sf(data = RoadsDS) +  
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1) +  
  scale_fill_manual("AnglerShed", values = percColors) +  
  labs(title = "Zorinsky Lake") +  
  theme_void() -> Zorinsky_map_roads
```

```
Zorinsky_map_roads+geom_point(aes(x = -96.1726,y = 41.2197), shape = 23, size = 5, fill =
"black") -> Zorinsky_map_roads
```

```
Overall <- OmahaReservoirs %>% mutate(Q31=as.character(Q31)) %>% pull(Q31)
```

[illegible]

```
Overall_map2 <- createAnglershedCounties(Overall,
                                         counties=c("nebraska,sarpy",
                                                    "nebraska,douglas"),
                                         percLevels=c(90,50,10),
                                         percColors = c("red", "yellow", "blue")) # Anglershed map for Omaha
respondents with Omaha counties

Overall_map2+labs(title = "Overall Angler Participation")+theme(legend.background =
                                                                element_rect(fill = "grey90"))
```

Make maps with and without the 99% for the overall map for NGPC meeting

AICc Analysis -----

```
dat %>%
```

```
  select(-Q1A: -Q1B, -Q6A: -Q20, -Ice_Fishing: -Q26OTH, -urbanization_groups, -permit_year,
         -complete_survey) -> AICdat
```

```
#ggplot(data = AICdat) +
```

```
# geom_density(aes(Fishing), fill = "lightblue")
```

```
#ggplot(data = AICdat) +
```

```
# geom_density(aes(log(Fishing + 1)), fill = "lightblue")
```

```
AICdat %>%
```

```
  mutate(Fishing = log(Fishing + 1)) -> AICdat # Transformed the days spent fishing into a base
log format. Natural log. To complete inverse equation is exp(log fishing) - 1.
```

```
AICdat <- AICdat %>%
```

```

mutate(permit_type_comb = case_match(permit_type,
  "2019 Resident 1-Day Fish" ~ "Day",
  "2019 Resident 3-Day Fish" ~ "Day",
  "2019 Resident Annual Fish" ~ "Annual",
  "2019 Resident Lifetime (age 46+) Fish" ~ "Multi_Year",
  "3YR 2019-21 Resident Fish" ~ "Multi_Year",
  "5YR 2019-23 Resident Fish" ~ "Multi_Year",
  "2019 Non-Resident 1-Day Fish" ~ "Non-Resident",
  "2019 Non-Resident Annual Fish" ~ "Non-Resident",
  .default = permit_type)) %>%

  filter(permit_type_comb != "Non-Resident") # Combined the permit types into different
categories. Non resident license holders removed.

unique(AICdat$permit_type_comb)

# AICdat <- AICdat %>%

# mutate(fish_history = ifelse(fish_history == 0, NA, fish_history)) %>%

# mutate(License_history = ifelse(License_history == 0, NA, License_history)) # There were 0
values in the license history and those values got turned to NA

AICdat <- AICdat %>%

mutate(Urban_Area = case_when(
  Q31 == 68022 ~ "West",
  Q31 == 68116 ~ "West",
  Q31 == 68164 ~ "West",
  Q31 == 68134 ~ "North",
  Q31 == 68142 ~ "West",
  Q31 == 68122 ~ "North",
  Q31 == 68152 ~ "North",

```

Q31 == 68112 ~ "North",
Q31 == 68104 ~ "North",
Q31 == 68111 ~ "North",
Q31 == 68110 ~ "North",
Q31 == 68132 ~ "Central",
Q31 == 68131 ~ "Central",
Q31 == 68102 ~ "Central",
Q31 == 68106 ~ "Central",
Q31 == 68105 ~ "Central",
Q31 == 68108 ~ "Central",
Q31 == 68118 ~ "West",
Q31 == 68154 ~ "West",
Q31 == 68114 ~ "Central",
Q31 == 68130 ~ "Southwest",
Q31 == 68144 ~ "Southwest",
Q31 == 68124 ~ "Central",
Q31 == 68135 ~ "Southwest",
Q31 == 68137 ~ "Southwest",
Q31 == 68127 ~ "Central",
Q31 == 68136 ~ "Southwest",
Q31 == 68138 ~ "Southwest",
Q31 == 68128 ~ "South",
Q31 == 68046 ~ "South",
Q31 == 68117 ~ "Central",
Q31 == 68107 ~ "Southeast",
Q31 == 68157 ~ "Southeast",
Q31 == 68133 ~ "South",
Q31 == 68147 ~ "Southeast",
Q31 == 68123 ~ "Southeast",

```

Q31 == 68005 ~ "Southeast",
Q31 == 68113 ~ "Southeast",
)) # Groups zip codes into groups for the urban area as described by Game and Parks

```

```

AICdat %>%
  select(ID, p2015: p2019) %>%
  pivot_longer(p2015: p2019, names_to = "year", values_to = "value") %>%
  mutate(year = gsub("p", "", year),
         year = as.numeric(year)) %>%
  filter(value != 0) %>%
  group_by(ID) %>%
  summarise(minyear = min(year),
            nyears = length(year)) %>%
  ungroup() %>%
  mutate(R3_Type = case_when(minyear == 2019 & nyears == 1 ~ "Recruit",
                             minyear != 2019 & nyears == 5 ~ "Retained",
                             minyear != 2019 & nyears < 5 ~ "Reactivated")) %>%
  select(ID, R3_Type) %>%
  inner_join(AICdat, join_by("ID")) -> AICdat2 # R3 coding for license history

```

```

AICdat2 %>%
  mutate(Q27 = replace(Q27, ID == 32250, 7),
         Q27 = replace(Q27, ID == 33015, 6),
         Q27 = replace(Q27, ID == 33265, 6),
         Q27 = replace(Q27, ID == 34240, 6),
         Q27 = replace(Q27, ID == 36158, 6),
         Q27 = replace(Q27, ID == 38097, 6),
         Q27 = replace(Q27, ID == 31209, 5),
         Q27 = replace(Q27, ID == 31227, 5),

```

```
Q27 = replace(Q27, ID == 33124, 5),
Q27 = replace(Q27, ID == 35198, 5),
Q27 = replace(Q27, ID == 35378, 5),
Q27 = replace(Q27, ID == 36338, 5),
Q27 = replace(Q27, ID == 37328, 5),
Q27 = replace(Q27, ID == 38013, 5),
Q27 = replace(Q27, ID == 38382, 5),
Q27 = replace(Q27, ID == 31239, 4),
Q27 = replace(Q27, ID == 31279, 4),
Q27 = replace(Q27, ID == 32038, 4),
Q27 = replace(Q27, ID == 32091, 4),
Q27 = replace(Q27, ID == 32257, 4),
Q27 = replace(Q27, ID == 33182, 4),
Q27 = replace(Q27, ID == 33216, 4),
Q27 = replace(Q27, ID == 33242, 4),
Q27 = replace(Q27, ID == 33380, 4),
Q27 = replace(Q27, ID == 34040, 4),
Q27 = replace(Q27, ID == 34362, 4),
Q27 = replace(Q27, ID == 37311, 4),
Q27 = replace(Q27, ID == 37340, 4),
Q27 = replace(Q27, ID == 31159, 3),
Q27 = replace(Q27, ID == 31324, 3),
Q27 = replace(Q27, ID == 32021, 3),
Q27 = replace(Q27, ID == 32033, 3),
Q27 = replace(Q27, ID == 32239, 3),
Q27 = replace(Q27, ID == 32260, 3),
Q27 = replace(Q27, ID == 33049, 3),
Q27 = replace(Q27, ID == 33386, 3),
Q27 = replace(Q27, ID == 34082, 3),
```

```
Q27 = replace(Q27, ID == 34230, 3),
Q27 = replace(Q27, ID == 35021, 3),
Q27 = replace(Q27, ID == 35042, 3),
Q27 = replace(Q27, ID == 35232, 3),
Q27 = replace(Q27, ID == 35238, 3),
Q27 = replace(Q27, ID == 35300, 3),
Q27 = replace(Q27, ID == 35366, 3),
Q27 = replace(Q27, ID == 36041, 3),
Q27 = replace(Q27, ID == 37072, 3),
Q27 = replace(Q27, ID == 37156, 3),
Q27 = replace(Q27, ID == 37193, 3),
Q27 = replace(Q27, ID == 37302, 3),
Q27 = replace(Q27, ID == 37314, 3),
Q27 = replace(Q27, ID == 38046, 3),
Q27 = replace(Q27, ID == 38182, 3),
Q27 = replace(Q27, ID == 31026, 2),
Q27 = replace(Q27, ID == 31359, 2),
Q27 = replace(Q27, ID == 32299, 2),
Q27 = replace(Q27, ID == 33091, 2),
Q27 = replace(Q27, ID == 33179, 2),
Q27 = replace(Q27, ID == 33197, 2),
Q27 = replace(Q27, ID == 33266, 2),
Q27 = replace(Q27, ID == 34067, 2),
Q27 = replace(Q27, ID == 34161, 2),
Q27 = replace(Q27, ID == 34163, 2),
Q27 = replace(Q27, ID == 34188, 2),
Q27 = replace(Q27, ID == 34214, 2),
Q27 = replace(Q27, ID == 34313, 2),
Q27 = replace(Q27, ID == 34323, 2),
```

```

Q27 = replace(Q27, ID == 34377, 2),
Q27 = replace(Q27, ID == 35092, 2),
Q27 = replace(Q27, ID == 35109, 2),
Q27 = replace(Q27, ID == 35281, 2),
Q27 = replace(Q27, ID == 35358, 2),
Q27 = replace(Q27, ID == 35369, 2),
Q27 = replace(Q27, ID == 37227, 2),
Q27 = replace(Q27, ID == 37334, 2),
Q27 = replace(Q27, ID == 38132, 2),
Q27 = replace(Q27, ID == 38140, 2),
Q27 = replace(Q27, ID == 38157, 2),

Q27 = replace(Q27, ID == 38258, 2)) -> AICdat2 # Adjusting values within household size
due to swaps with Q27OTH

```

```
AICdat2 %>%
```

```

mutate(Q27OTH = replace(Q27OTH, ID == 32250, 0),
      Q27OTH = replace(Q27OTH, ID == 33015, 0),
      Q27OTH = replace(Q27OTH, ID == 33265, 0),
      Q27OTH = replace(Q27OTH, ID == 34240, 0),
      Q27OTH = replace(Q27OTH, ID == 36158, 0),
      Q27OTH = replace(Q27OTH, ID == 38097, 0),
      Q27OTH = replace(Q27OTH, ID == 31209, 0),
      Q27OTH = replace(Q27OTH, ID == 31227, 0),
      Q27OTH = replace(Q27OTH, ID == 33124, 0),
      Q27OTH = replace(Q27OTH, ID == 35198, 0),
      Q27OTH = replace(Q27OTH, ID == 35378, 0),
      Q27OTH = replace(Q27OTH, ID == 36338, 0),
      Q27OTH = replace(Q27OTH, ID == 37328, 0),
      Q27OTH = replace(Q27OTH, ID == 38013, 0),

```

Q27OTH = replace(Q27OTH, ID == 38382, 0),
Q27OTH = replace(Q27OTH, ID == 31239, 0),
Q27OTH = replace(Q27OTH, ID == 31279, 0),
Q27OTH = replace(Q27OTH, ID == 32038, 0),
Q27OTH = replace(Q27OTH, ID == 32091, 0),
Q27OTH = replace(Q27OTH, ID == 32257, 0),
Q27OTH = replace(Q27OTH, ID == 33182, 0),
Q27OTH = replace(Q27OTH, ID == 33216, 0),
Q27OTH = replace(Q27OTH, ID == 33242, 0),
Q27OTH = replace(Q27OTH, ID == 33380, 0),
Q27OTH = replace(Q27OTH, ID == 34040, 0),
Q27OTH = replace(Q27OTH, ID == 34362, 0),
Q27OTH = replace(Q27OTH, ID == 37311, 0),
Q27OTH = replace(Q27OTH, ID == 37340, 0),
Q27OTH = replace(Q27OTH, ID == 31159, 0),
Q27OTH = replace(Q27OTH, ID == 31324, 0),
Q27OTH = replace(Q27OTH, ID == 32021, 0),
Q27OTH = replace(Q27OTH, ID == 32033, 0),
Q27OTH = replace(Q27OTH, ID == 32239, 0),
Q27OTH = replace(Q27OTH, ID == 32260, 0),
Q27OTH = replace(Q27OTH, ID == 33049, 0),
Q27OTH = replace(Q27OTH, ID == 33386, 0),
Q27OTH = replace(Q27OTH, ID == 34082, 0),
Q27OTH = replace(Q27OTH, ID == 34230, 0),
Q27OTH = replace(Q27OTH, ID == 35021, 0),
Q27OTH = replace(Q27OTH, ID == 35042, 0),
Q27OTH = replace(Q27OTH, ID == 35232, 0),
Q27OTH = replace(Q27OTH, ID == 35238, 0),
Q27OTH = replace(Q27OTH, ID == 35300, 0),

Q27OTH = replace(Q27OTH, ID == 35366, 0),
Q27OTH = replace(Q27OTH, ID == 36041, 0),
Q27OTH = replace(Q27OTH, ID == 37072, 0),
Q27OTH = replace(Q27OTH, ID == 37156, 0),
Q27OTH = replace(Q27OTH, ID == 37193, 0),
Q27OTH = replace(Q27OTH, ID == 37302, 0),
Q27OTH = replace(Q27OTH, ID == 37314, 0),
Q27OTH = replace(Q27OTH, ID == 38046, 0),
Q27OTH = replace(Q27OTH, ID == 38182, 0),
Q27OTH = replace(Q27OTH, ID == 31026, 0),
Q27OTH = replace(Q27OTH, ID == 31359, 0),
Q27OTH = replace(Q27OTH, ID == 32299, 0),
Q27OTH = replace(Q27OTH, ID == 33091, 0),
Q27OTH = replace(Q27OTH, ID == 33179, 0),
Q27OTH = replace(Q27OTH, ID == 33197, 0),
Q27OTH = replace(Q27OTH, ID == 33266, 0),
Q27OTH = replace(Q27OTH, ID == 34067, 0),
Q27OTH = replace(Q27OTH, ID == 34161, 0),
Q27OTH = replace(Q27OTH, ID == 34163, 0),
Q27OTH = replace(Q27OTH, ID == 34188, 0),
Q27OTH = replace(Q27OTH, ID == 34214, 0),
Q27OTH = replace(Q27OTH, ID == 34313, 0),
Q27OTH = replace(Q27OTH, ID == 34323, 0),
Q27OTH = replace(Q27OTH, ID == 34377, 0),
Q27OTH = replace(Q27OTH, ID == 35092, 0),
Q27OTH = replace(Q27OTH, ID == 35109, 0),
Q27OTH = replace(Q27OTH, ID == 35281, 0),
Q27OTH = replace(Q27OTH, ID == 35358, 0),
Q27OTH = replace(Q27OTH, ID == 35369, 0),

```

Q27OTH = replace(Q27OTH, ID == 37227, 0),
Q27OTH = replace(Q27OTH, ID == 37334, 0),
Q27OTH = replace(Q27OTH, ID == 38132, 0),
Q27OTH = replace(Q27OTH, ID == 38140, 0),
Q27OTH = replace(Q27OTH, ID == 38157, 0),
Q27OTH = replace(Q27OTH, ID == 38258, 0)) -> AICdat2 # Adjusting values within Q27OTH
to equal 0

```

```

AICdat2 %>%
  filter(zip != 51503) %>%
  filter(zip != 51510) %>%
  filter(zip != 57367) %>%
  filter(zip != 66207) %>%
  filter(zip != 68003) -> AICdat2 # Removed respondents with a zip code outside of our survey
frame.

```

```

AICdat2 %>%
  mutate(Q33TOTAL = ifelse(Q33TOTAL == 0, NA, Q33TOTAL)) %>%
  mutate(Q30 = ifelse(Q30 == 0, NA, Q30)) -> AICdat2 # Made non response values from 0 to NA

```

```

AICdat2 %>%
  filter(!is.na(Q30)) %>%
  filter(!is.na(Q33TOTAL)) -> AICdat3 # Removed NA angler responses from the Education and
Income variables.

```

```

AICdat3 %>%
  dplyr::mutate(permit_type_comb = str_replace(permit_type_comb, "Multi Year",
"Multi_Year")) -> AICdat3

```

```

Esri_custom_order <- c("Pri", "Urb", "Met", "Sub")

```

```
AICdat2$Tapestry <- factor(AICdat2$Tapestry, levels = Esri_custom_order)
```

```
mod1 <- glm(Fishing ~ Tapestry, data = AICdat2) # Esri Urbanization Group model for days fished
summary(mod1)
```

```
tapply(AICdat2$Fishing, AICdat2$Tapestry, median) # Median values for urbanization groups of
anglers for the boxplots. Met median = 2.772589, Pri median = 2.397895, Sub median =
2.564949, and Urb = 3.044522
```

```
ggplot(data = mod1) + # Days spent fishing box plot for each urbanization group
  geom_boxplot(aes(x = Tapestry, y = Fishing)) +
  labs(x = "Urbanization Group", y = "Avidity(log(days fished))") +
  annotate("text", x = "Met", y = 6, label = 15) +
  annotate("text", x = "Pri", y = 6, label = 10) +
  annotate("text", x = "Sub", y = 6, label = 12) +
  annotate("text", x = "Urb", y = 6, label = 20) +
  theme_pubr()
```

```
mod2 <- glm(Fishing ~ sex, data = AICdat2) # Sex model for days fished
summary(mod2)
```

```
tapply(AICdat2$Fishing, AICdat2$sex, median) # Median values for sex of anglers for the
boxplots. Female median = 24.99741, male median = 59.23645
```

```
ggplot(data = mod2) + # Days spent fishing box plot for sex.
  geom_boxplot(aes(x = sex, y = Fishing), color = "black", fill = "springgreen4") +
  labs(x = "Sex", y = "Avidity (log(days fished))") +
  annotate("text", x = "Female", y = 6, label = 10) +
  annotate("text", x = "Male", y = 6, label = 15) +
  theme_mine() -> Avidity_sex_box
```

```
ggsave(Avidity_sex_box, filename = "Avidity_sex_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod2) + # Days spent fishing box plot for sex.
```

```
  geom_boxplot(aes(x = sex, y = Fishing)) +
  labs(x = "Sex", y = "Avidity (log(days fished))") +
  annotate("text", x = "Female", y = 6, label = 10) +
  annotate("text", x = "Male", y = 6, label = 15) +
  theme_pubr() -> Avidity_sex_box_thesis
```

```
# ggplot(data = mod2) +
#   geom_point(aes(x = sex, y = Fishing)) +
#   geom_smooth(mapping = aes(x = sex, y = Fishing), method = "glm", se = FALSE) +
#   labs(x = "Sex", y = "Fishing Days") +
#   theme_classic() # Point plot for days fished with angler sex.
```

```
mod3 <- glm(Fishing ~ Age + Employment + Q27, data = AICdat2) # Life stage model for days
fished containing age, employment, and household size

summary(mod3)
```

```
as.data.frame(tapply(AICdat2$Fishing, AICdat2$Age, median)) -> Median_Age_Numbers #
Median values for age of anglers for the boxplots.
```

```
Median_Age_Numbers %>%
  rename("Median" = "tapply(AICdat2$Fishing, AICdat2$Age, median)") %>%
  mutate(Median = exp(Median)-1) -> Median_Age_Numbers
```

```
tapply(AICdat2$Fishing, AICdat2$Employment, median) # Median values for employment of
anglers for the boxplots.
```

tapply(AICdat2\$Fishing, AICdat2\$Q27, median) # Median values for household size of anglers for the boxplots.

```
ggplot(data = mod3) +
  geom_boxplot(aes(group = Employment, x = Employment, y = Fishing)) +
  labs(x = "Employment Status", y = "Avidity (log(days fished))") +
  annotate("text", x = 0, y = 6, label = 12) +
  annotate("text", x = 1, y = 6, label = 10) +
  annotate("text", x = 2, y = 6, label = 7) +
  annotate("text", x = 4, y = 6, label = 15) +
  annotate("text", x = 5, y = 6, label = 45) +
  annotate("text", x = 6, y = 6, label = 30) +
  theme_mine() # Box plot representing days fished with employment status.
```

```
ggplot(data = mod3) +
  geom_boxplot(aes(group = Employment, x = Employment, y = Fishing)) +
  labs(x = "Employment Status", y = "Avidity (log(days fished))") +
  annotate("text", x = 0, y = 6, label = 12) +
  annotate("text", x = 1, y = 6, label = 10) +
  annotate("text", x = 2, y = 6, label = 7) +
  annotate("text", x = 4, y = 6, label = 15) +
  annotate("text", x = 5, y = 6, label = 45) +
  annotate("text", x = 6, y = 6, label = 30) +
  theme_pubr() # Box plot representing days fished with employment status.
```

```
ggplot(data = mod3) +
  geom_boxplot(aes(group = Q27, x = Q27, y = Fishing), color = "black", fill = "springgreen4") +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6, 7, 8, 11), y = 6,
    label = c(15, 11, 12, 20, 14, 10, 10, 3, 0, 1)) +
```

```
labs(x = "Household Size", y = "Avidity (log(days fished))") +  
theme_minimal() -> Avidity_householdsize_box # Box plot representing days fished with  
household size.
```

```
ggsave(Avidity_householdsize_box, filename = "Avidity_householdsize_box.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod3) +  
geom_boxplot(aes(group = Q27, x = Q27, y = Fishing)) +  
annotate("text", x = c(0, 1, 2, 3, 4, 5, 6, 7, 8, 11), y = 6,  
label = c(15, 11, 12, 20, 14, 10, 10, 3, 0, 1)) +  
labs(x = "Household Size", y = "Avidity (log(days fished))") +  
theme_pubr()
```

```
ggplot(data = mod3) +  
geom_boxplot(aes(group = Age, x = Age, y = Fishing), color = "black", fill = "springgreen4") +  
labs(x = "Age", y = "Avidity (log(days fished + 1))") +  
theme_minimal() -> Avidity_age_box # Point plot representing days fished with angler age.
```

```
ggsave(Avidity_age_box, filename = "Avidity_age_box.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod3) +  
geom_boxplot(aes(group = Age, x = Age, y = Fishing)) +  
annotate("text", x = c(20, 25, 30,  
35, 40, 45, 50, 55, 60, 65,  
70, 75), y = 6,  
label = c(12, 20, 20, 10, 22, 7, 25, 10, 15, 7, 8, 40)) +  
labs(x = "Age", y = "Avidity (log(days fished + 1))") +  
theme_pubr()
```

```
mod4 <- glm(Fishing ~ Q33TOTAL + Q30, data = AICdat2) # Socioeconomic model for days fished
containing household gross income and education. Household gross income had 85 NAs.
Education had 32 NAs.
```

```
summary(mod4)
```

```
#mod4_2 <- lm(Fishing ~ Q33TOTAL + Q30, data = AICdat2)
```

```
#summary(mod4_2)
```

```
tapply(AICdat2$Fishing, AICdat2$Q33TOTAL, median)
```

```
tapply(AICdat2$Fishing, AICdat2$Q30, median)
```

```
ggplot(data = mod4) +
```

```
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL), color = "black", fill =
"springgreen4") +
```

```
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
```

```
    label = c(7, 30, 14, 15, 20, 16, 12, 10, 14, 10, 6)) +
```

```
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
```

```
  theme_mine() -> Avidity_income_box # Box plot representing days fished with household gross
income.
```

```
ggsave(Avidity_income_box, filename = "Avidity_income_box.png", path =
```

```
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4) +
```

```
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL)) +
```

```
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
```

```
    label = c(7, 30, 14, 15, 20, 16, 12, 10, 14, 10, 6)) +
```

```
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
```

```
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
```

```
theme_pubr()
```

```
ggplot(data = mod4) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30), color = "black", fill = "springgreen4") +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(35, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_mine() -> Avidity_education_box # Box plot representing the days fished with education
status.
```

```
ggsave(Avidity_education_box, filename = "Avidity_education_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30)) +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(35, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_pubr()
```

```
ggplot(data = mod4) +
  geom_point(aes(x = Q30, y = Q33TOTAL))
```

```
Permit_custom_order <- c("Day", "Annual", "Multi Year")
```

```
AICdat2$permit_type_comb <- factor(AICdat2$permit_type_comb, levels =
Permit_custom_order)
```

```
R3_custom_order <- c("Recruit", "Retained", "Reactivated")
```

```
AICdat2$R3_Type <- factor(AICdat2$R3_Type, levels = R3_custom_order)
```

```
mod5 <- glm(Fishing ~ permit_type_comb + Q28 + R3_Type, data = AICdat2)# Participation
model containing license purchase history, license bought, and fishing members in household

summary(mod5)
```

```
tapply(AICdat2$Fishing, AICdat2$permit_type_comb, median)

tapply(AICdat2$Fishing, AICdat2$Q28, median)

tapply(AICdat2$Fishing, AICdat2$R3_Type, median)
```

```
ggplot(data = mod5) +

  geom_boxplot(aes(x = permit_type_comb, y = Fishing, group = permit_type_comb)) +

  annotate("text", x = c("Day", "Annual", "Multi Year"), y = 6,

    label = c(3, 15, 20)) +

  labs(x = "Fishing Permit Purchased", y = "Avidity (log(days fished))") +

  theme_pubr()
```

```
ggplot(data = mod5) +

  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28), color = "black", fill = "springgreen4") +

  labs(x = "Family Fishing Members", y = "Avidity (log(days fished))") +

  theme_mine_presentation() -> Avidity_fishingmember_box
```

```
ggsave(Avidity_fishingmember_box, filename = "Avidity_fishingmember_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5) +

  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28)) +

  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6), y = 6,

    label = c(10, 12, 20, 15, 15, 4, 12)) +

  labs(x = "Additional Family Fishing Members", y = "Avidity (log(days fished))") +

  theme_pubr()
```

```
ggplot(data = mod5) +
  geom_boxplot(aes(x = R3_Type, y = Fishing, group = R3_Type)) +
  annotate("text", x = c("Recruit", "Retained", "Reactivated"), y = 6,
    label = c(6, 20, 12)) +
  labs(x = "R3 Type", y = "Avidity (log(days fished))") +
  theme_pubr()
```

```
mod6 <- glm(Fishing ~ Urban_Area, data = AICdat2) # Urban area as defined by NGPC fisheries
biologists.
```

```
summary(mod6)
```

```
tapply(AICdat2$Fishing, AICdat2$Urban_Area, median)
```

```
ggplot(data = mod6) +
  geom_boxplot(aes(x = Urban_Area, y = Fishing, group = Urban_Area)) +
  annotate("text", x = c("Central", "North", "South", "Southeast", "Southwest", "West"), y = 6,
    label = c(13, 20, 17, 20, 10, 10)) +
  labs(x = "Urban Area", y = "Avidity (log(days fished))") +
  theme_pubr()
```

```
mod7 <- glm(Fishing ~ sex + Age + Employment + Q27 +
  Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28 + Urban_Area, data = AICdat2)
# Global model without urbanization group and urban area model
summary(mod7)
```

```
mod8 <- glm(Fishing ~ 1, data = AICdat2) # Null model
summary(mod8)
```

```

mod9 <- glm(Fishing ~ sex + Age + Employment + Q27 +
            Q33TOTAL + Q30 + Urban_Area, data = AICdat2, na.action = na.omit)

summary(mod9)

# AICc analysis code

models <- list(mod1, mod2, mod3, mod4, mod5, mod6, mod8)

mod.names <- c('Urbanization Groups', 'Sex', 'Life Stage', 'Socioeconomic', 'Participation', 'Urban
Area', "Null")

aictab(cand.set = models, modnames = mod.names) -> AIC_Table1

write.csv(AIC_Table1, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table1.csv", row.names = FALSE, )

dredge(mod7) -> Globalmod

model.sel(Globalmod) -> AIC_Table2 # Parsimonious AIC with all groups except Urbanization
Groups

write.csv(AIC_Table2, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table2.csv", row.names = FALSE, )

#dredge(mod9) -> Globalmod2

#model.sel(Globalmod2)

subset(Globalmod, delta < 8) # Models with delta AIC less than 8 will be presented

summary(AICdat)

# Model Performance tests

model_performance(mod7)

model_performance(mod6)

```

```

model_performance(mod10)
compare_performance(mod6, mod7, verbose = FALSE)
test_performance(mod7)
test_performance(mod6)
test_vuong(mod7)
test_wald(mod7)

summary(mod6)$adj.r.squared

mod10 <- glm(Fishing ~ sex + Age + Q27 +
             + Q30 + R3_Type + permit_type_comb + Q28, data = AICdat2, na.action = na.pass) #
Top parsimonious model from the parsimonious AIC model

# https://easystats.github.io/performance/ # Checks model fitness and guidelines

# PCA -----

dat %>%
  select(-Tapestry, -ID: -Q20, -Other: -Q33TOTAL, -urbanization_groups: -fishing_history, -p2010:
  -Generation) -> RecAct # Data frame of recreational activities from the survey

summary(RecAct)

RecAct %>%
  select(-Watching_TV) -> RecAct5 # Watching TV removed due to being an outlier.

Reccorr <- cor(RecAct)

#ReccorrSig <- rcorr(as.matrix(RecAct))

```

```

#ReccorrSig <- rcorr(RecAct, type = c("pearson"))
#Reccorr5 <- cor(RecAct5)

ggcorrplot::ggcorrplot(Reccorr, type = "lower") -> Ch2_reccorrplot
ggcorrplot::ggcorrplot(Reccorr5, type = "lower")

ggsave(Ch2_reccorrplot, filename = "Ch2_reccorrplot.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

#bg = "transparent" # Include this at the end of ggsave function to have a transparent
background

res.pca <- prcomp(RecAct, scale = TRUE) # Compute PCA
fviz_eig(res.pca) -> All_rec_sceerplot
fviz_pca_ind(res.pca,
  col.ind = "cos2", # Color by the quality of representation
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
) -> All_rec_indivPCA

fviz_pca_var(res.pca,
  col.var = "contrib", # Color by contributions to the PC
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
) -> All_rec_varPCA

eig.val <- get_eigenvalue(res.pca) # Eigen values for the PCA
eig.val

```

```
# Results for Variables
```

```
res.var <- get_pca_var(res.pca)
```

```
res.var$coord      # Coordinates
```

```
res.var$contrib     # Contributions to the Principal Components
```

```
res.var$cos2        # Quality of representation
```

```
# Results for individuals
```

```
res.ind <- get_pca_ind(res.pca)
```

```
res.ind$coord       # Coordinates
```

```
res.ind$contrib     # Contributions to the Principal Components
```

```
res.ind$cos2        # Quality of representation
```

```
ggsave(All_rec_screepplot, filename = "All_rec_screepplot.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggsave(All_rec_indivPCA, filename = "All_rec_indivPCA.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggsave(All_rec_varPCA, filename = "All_rec_varPCA.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
RecAct %>%
```

```
  select(-Team_Sports, -Art, -Sewing, -Photography, -Winter_Sports,  
         -Adventure_Sports, -Shooting_Sports, -Hunting,  
         -Ice_Fishing) -> RecAct2 # Recreation Activities with 3rd quartile greater than 0
```

```
summary(RecAct2)
```

```
res.pca2 <- prcomp(RecAct2, scale = TRUE) # Compute PCA
```

```
fviz_eig(res.pca2) -> Quart3_rec_screepplot
```

```
fviz_pca_ind(res.pca2,
```

```

col.ind = "cos2", # Color by the quality of representation
gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
repel = TRUE # Avoid text overlapping
) -> Quart3_rec_indivPCA

fviz_pca_var(res.pca2,
  col.var = "contrib", # Color by contributions to the PC
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
) -> Quart3_rec_varPCA

eig.val2 <- get_eigenvalue(res.pca2) # Eigen values for the PCA
eig.val2

# Results for Variables
res.var2 <- get_pca_var(res.pca2)
res.var2$coord # Coordinates
res.var2$contrib # Contributions to the Principal Components
res.var2$cos2 # Quality of representation

# Results for individuals
res.ind2 <- get_pca_ind(res.pca2)
res.ind2$coord # Coordinates
res.ind2$contrib # Contributions to the Principal Components
res.ind2$cos2 # Quality of representation

ggsave(Quart3_rec_screplot, filename = "Quart3_rec_screplot.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

```

```
ggsave(Quart3_rec_indivPCA, filename = "Quart3_rec_indivPCA.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggsave(Quart3_rec_varPCA, filename = "Quart3_rec_varPCA.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
RecAct %>%
```

```
select(-Team_Sports, -Art, -Sewing, -Photography, -Winter_Sports,
-Adventure_Sports, -Shooting_Sports, -Hunting,
-Ice_Fishing, -Wildlife_Viewing, -Coaching, -Bicycling, -Paddlesports,
-Boating, -Swimming, -Recreational_Sports, -Driving, -Golf,
-Woodworking) -> RecAct3 # Recreation Activities with median greater than 0
summary(RecAct3)
```

```
res.pca3 <- prcomp(RecAct3, scale = TRUE, center = TRUE) # Compute PCA
```

```
fviz_eig(res.pca3) -> Median_rec_screplot
```

```
fviz_pca_ind(res.pca3,
col.ind = "cos2", # Color by the quality of representation
gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
repel = TRUE # Avoid text overlapping
) -> Median_rec_indivPCA
```

```
fviz_pca_var(res.pca3,
col.var = "contrib", # Color by contributions to the PC
gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
repel = TRUE # Avoid text overlapping
) -> Median_rec_varPCA
```

```
summary(res.pca3)
```

```
eig.val3 <- get_eigenvalue(res.pca3) # Eigen values for the PCA
```

```
eig.val3
```

```
# Results for Variables
```

```
res.var3 <- get_pca_var(res.pca3)
```

```
res.var3$coord      # Coordinates
```

```
res.var3$contrib     # Contributions to the Principal Components
```

```
res.var3$cos2        # Quality of representation
```

```
# Results for individuals
```

```
res.ind3 <- get_pca_ind(res.pca3)
```

```
res.ind3$coord      # Coordinates
```

```
res.ind3$contrib     # Contributions to the Principal Components
```

```
res.ind3$cos2        # Quality of representation
```

```
ggsave(Median_rec_screepplot, filename = "Median_rec_screepplot.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggsave(Median_rec_indivPCA, filename = "Median_rec_indivPCA.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggsave(Median_rec_varPCA, filename = "Median_rec_varPCA.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
RecAct %>%
```

```
  unite(Sports, Golf, Team_Sports, Recreational_Sports, sep = "") %>%
```

```
  group_by(Sports) %>%
```

```
  summarise(total = sum(Sports)) -> RecActAdjusted # Combining like recreational activities  
together and summing the days recreated for the combined activities
```

```
RecAct$SportsCombo <- RecAct$Golf + RecAct$Team_Sports + RecAct$Recreational_Sports +
RecAct$Winter_Sports
```

```
RecAct$WatchSportsCombo <- RecAct$Attending_Sports + RecAct$Coaching
```

```
RecAct$WaterActCombo <- RecAct$Boating + RecAct$Paddlesports + RecAct$Swimming
```

```
RecAct$WildlifeCombo <- RecAct$Camping + RecAct$Wildlife_Viewing
```

```
RecAct$OutdoorActCombo <- RecAct$Bicycling + RecAct$Adventure_Sports
```

```
RecAct$VacationCombo <- RecAct$Driving + RecAct$Cultural_Sites
```

```
RecAct$HomeActCombo <- RecAct$Woodworking + RecAct$Sewing + RecAct$Art +
RecAct$Gardening
```

```
RecAct$ShootingCombo <- RecAct$Hunting + RecAct$Shooting_Sports
```

```
RecAct$FishingCombo <- RecAct$Fishing + RecAct$Ice_Fishing
```

```
RecAct$OutdoorFitnessCombo <- RecAct$Hiking + RecAct$Fitness
```

```
RecAct %>%
```

```
  select(SportsCombo, WatchSportsCombo, WaterActCombo, WildlifeCombo,
OutdoorActCombo, VacationCombo, HomeActCombo, ShootingCombo, FishingCombo,
OutdoorFitnessCombo, Photography, Watching_TV) -> RecAct4
```

```
RecAct %>%
```

```
  select(-SportsCombo: -OutdoorFitnessCombo) -> RecAct
```

```
res.pca4 <- prcomp(RecAct4, scale = TRUE) # Compute PCA
```

```
fviz_eig(res.pca4)
```

```
fviz_pca_ind(res.pca4,
```

```
  col.ind = "cos2", # Color by the quality of representation
```

```
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
```

```
  repel = TRUE # Avoid text overlapping
```

```
)
```

```

fviz_pca_var(res.pca4,
  col.var = "contrib", # Color by contributions to the PC
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
)

eig.val4 <- get_eigenvalue(res.pca4) # Eigen values for the PCA
eig.val4

# Results for Variables
res.var4 <- get_pca_var(res.pca4)
res.var4$coord      # Coordinates
res.var4$contrib     # Contributions to the Principal Components
res.var4$cos2        # Quality of representation

# Results for individuals
res.ind4 <- get_pca_ind(res.pca4)
res.ind4$coord      # Coordinates
res.ind4$contrib     # Contributions to the Principal Components
res.ind4$cos2        # Quality of representation

pca_3d <- res.pca3$x[,1:3]
plot3d(pca_3d, col = "blue", size = 2) -> PCA3Dplot

pca_3v <- res.var$x[,1:3]
plot3d(pca_3v, col = "blue", size = 2)

res.pca5 <- prcomp(RecAct5, scale = TRUE) # Compute PCA, without watching television
fviz_eig(res.pca5)

```

```
fviz_pca_ind(res.pca5,
  col.ind = "cos2", # Color by the quality of representation
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
)
```

```
fviz_pca_var(res.pca5,
  col.var = "contrib", # Color by contributions to the PC
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE # Avoid text overlapping
)
```

```
eig.val5 <- get_eigenvalue(res.pca5) # Eigen values for the PCA
eig.val5
```

Results for Variables

```
res.var <- get_pca_var(res.pca5)
res.var$coord # Coordinates
res.var$contrib # Contributions to the Principal Components
res.var$cos2 # Quality of representation
```

Results for individuals

```
res.ind <- get_pca_ind(res.pca5)
res.ind$coord # Coordinates
res.ind$contrib # Contributions to the Principal Components
res.ind$cos2 # Quality of representation
```

Pairwise Correlation -----

```
summary(RecAct)
```

```
#RecAct %>%
```

```
# select(-Tapestry) -> RecActPearson
```

```
RecActcor <- cor(RecAct, method = "pearson") # Pearson correlation analysis for recreational activities
```

```
print(RecActcor)
```

```
write.csv
```

```
# Other Analyses -----
```

```
ggplot(data = AICdat, aes(x = License_history)) +
```

```
  geom_histogram(binwidth = 1, color = "black", fill = "blue") +
```

```
  labs(x = "Years Fishing License Bought") +
```

```
  scale_x_continuous(breaks = seq(0, 10, by = 1)) +
```

```
  coord_cartesian(expand = FALSE) +
```

```
  theme_classic())# Histogram that displays the license purchase history from 2010 - 2019 for each angler
```

```
ks_result <- ks.test(AICdat$Age, "punif") # Kolmogorov-Smirnov test for year born and response to survey
```

```
print(ks_result)
```

```
ks_x_seq <- seq(min(AICdat$Age), max(AICdat$Age), length.out = 100) # Created sequence of values for the x axis
```

```
ecdf_values <- ecdf(AICdat$Age)(ks_x_seq) # Calculated the empirical cumulative distribution
```

```
ks_age_plot <- data.frame(x = ks_x_seq, ecdf = ecdf_values) # KS data frame for plotting
```

```
ggplot(ks_age_plot, aes(x)) +
  geom_line(aes(y = ecdf, color = "Respondents Age"), size = 1) +
  stat_function(fun = pnorm, args = list(mean = mean(AICdat$Age), sd = sd(AICdat$Age)),
    aes(color = "Theoretical Distribution"), size = 1, linetype = "dashed") +
  labs(x = "Angler Age", y = "Cumulative Probability") +
  theme_classic()# KS plot showing age distribution from survey respondents
```

```
# Survey Non-respondent Analyses -----
```

```
Survey_nonrespond %>%
  mutate(dob = mdy(dob),
    age = floor(year(Sys.Date()) - year(dob))) -> Survey_nonrespond
```

```
Survey_nonrespond %>%
  na.omit() -> Survey_nonrespond
summary(Survey_nonrespond)
```

```
Survey_nonrespond %>%
  filter(age > 21) -> Survey_nonrespond # Sample Size of 3,270 with the removal of underage
  anglers that were sent a survey
summary(Survey_nonrespond)
```

```
Survey_nonrespond %>%
  mutate(age = age - 4) -> Survey_nonrespond # Converted age of angler tot he age they were at
  the end of 2019
```

```
ks_result2 <- ks.test(Survey_nonrespond$age, "punif") # Kolmogorov-Smirnov test for year born
  and response to survey
print(ks_result2)
```

```

ks_x_seq2 <- seq(min(Survey_nonrespond$age), max(Survey_nonrespond$age), length.out =
100) # Created sequence of values for the x axis

ecdf_values2 <- ecdf(Survey_nonrespond$age)(ks_x_seq2) # Calculated the empirical
cumulative distribution

ks_age_plot2 <- data.frame(x = ks_x_seq2, ecdf = ecdf_values2) # KS data frame for plotting


ggplot(ks_age_plot2, aes(x)) +

  geom_line(aes(y = ecdf, color = "Non-Respondents Age"), size = 1) +

  stat_function(fun = pnorm, args = list(mean = mean(Survey_nonrespond$age), sd =
sd(Survey_nonrespond$age)),

    aes(color = "Theoretical Distribution"), size = 1, linetype = "dashed") +

  labs(x = "Angler Age", y = "Cumulative Probability") +

  theme_classic()# KS plot showing age distribution from survey respondents

#

Overall_Non <- Survey_nonrespond %>% mutate(zip=as.character(zip)) %>% pull(zip)

Overall_Non_map <- createAnglershed(Overall_Non,

  states=c("nebraska",

    "iowa",

    "kansas",

    "missouri",

    "wyoming",

    "colorado"),

  percLevels=c(90,50,10),

  percColors = c("red", "yellow", "blue")) # Anglershed map for Omaha
respondents with Omaha counties

Overall_map+labs(title = "Overall Angler Participation")+theme(legend.background =

  element_rect(fill = "grey90"))

```

```

Overall_Non_map <- createAnglershedCounties(Overall_Non,
      counties=c("nebraska,sarpy",
                  "nebraska,douglas",
                  "nebraska,washington",
                  "nebraska,saunders",
                  "nebraska,dodge",
                  "nebraska,cass"),
      percLevels=c(99, 90,50,10),
      percColors = c("green","red", "yellow", "blue")) # Anglershed map for
Omaha respondents with Omaha counties
Overall_Nonmap+labs(title = "Overall Angler Participation")+theme(legend.background =
      element_rect(fill = "grey90"))

```

```

Survey_nonrespond %>%
  group_by(age) %>%
  count() %>%
  ungroup() %>%
  mutate(prob = cumsum(n)/sum(n),
         type = "Non Response") -> cumulative_prob_nonrespond

```

```

AICdat %>%
  rename(age = Age) %>%
  group_by(age) %>%
  count() %>%
  ungroup() %>%
  mutate(prob = cumsum(n)/sum(n),
         type = "Response") -> cumulative_prob_respond

```

```

bind_rows(cumulative_prob_nonrespond , cumulative_prob_respond) -> Age_KS

```

```

ggplot(data = Age_KS) +
  geom_line(aes(x = age, y = prob, color = type), size = 2) +
  labs(x = "Age", y = "Probability", color = NULL) +
  coord_cartesian(expand = FALSE) +
  ylim(0,1) +
  theme_pubr() -> KS_Test

ks.test(cumulative_prob_nonrespond$prob, cumulative_prob_respond$prob)

ggsave(KS_Test, filename = "KS_Test.png", path = "C:/Users/k4han/OneDrive/Desktop/Master
Project Data", width = 9, height = 6, units = "in")

# Test Analysis -----

NE_counties <- counties(state = 'NE', cb = TRUE, resolution = '20m')

plot(NE_counties)

Omaha_counties <- c('Douglas', 'Sarpy')
NE_counties %>%
  filter(NAME %in% Omaha_counties) -> DougSarpy
plot()

plot(Omaha_counties)

Omaha_zips2 <- rbind_tigris(lapply(Omaha_counties, function(x) roads(state = 'NE', county = x)))

Omaha_roads <- primary_secondary_roads("NE")

```

```
st_intersection(Omaha_roads, DougSarpy) -> RoadsDS
```

```
plot(Omaha_zips2)
```

```
Carter_map %>%
```

```
  st_as_sf(coords = c("long", "lat"), crs=4326) %>%
```

```
  st_transform(st_crs(RoadsDS)) %>%
```

```
  group_by(percLevel) %>%
```

```
  summarise(geometry = st_combine(geometry)) %>%
```

```
  st_cast("POLYGON") %>%
```

```
  st_make_valid() %>%
```

```
  st_intersection()-> Carter_map_sf
```

```
percColors = c("10" = "red", "50" = "yellow", "90" = "blue")
```

```
ggplot() +
```

```
  geom_sf(data = Carter_map_sf, aes(fill = as.factor(percLevel))) +
```

```
  geom_sf(data = RoadsDS) +
```

```
  geom_sf(data = DougSarpy, color = "red", fill = NA) +
```

```
  scale_fill_manual("AnglerShed", values = percColors) +
```

```
  labs(title = "Carter Lake") +
```

```
  theme_void() -> Carter_map_roads
```

```
Omaha_roads <- primary_secondary_roads("NE")
```

```
st_intersection(Omaha_roads, DougSarpy) -> RoadsDS
```

```
plot(Omaha_roads$geometry)
```

```
Omaha_zips <- zctas(starts_with = c("68"), year = 2010, state = "NE")
```

```
plot(Omaha_zips)
```

```
om_zips <- zctas(omaha_ua)
```

```
AICdat3 %>%
```

```
  select(Fishing, zip) %>%
```

```
  mutate(Fishing = exp(Fishing) - 1) %>%
```

```
  group_by(zip) %>%
```

```
  summarize(Fishing = mean(Fishing)) -> AICdat4
```

```
AICdat4$zip <- as.character(AICdat4$zip)
```

```
summary(AICdat4)
```

```
write.csv(AICdat4, "C:/Users/k4han/OneDrive/Desktop/Master Project  
Data/AICdat4.csv", row.names = FALSE, )
```

```
# Other Figs -----
```

```
# Average days recreated for 2020 Omaha Rec activities
```

```
summary(RecAct)
```

```
Fishing <- 23.26
```

```
Ice_Fishing <- 0.8695
```

```
Hunting <- 2.514
```

Shooting_Sports <- 2.73

Camping <- 6.817

Wildlife_Viewing <- 7.764

Bicycling <- 5.152

Adventure_Sports <- 0.522

Paddlesports <- 2.4

Boating <- 2.546

Winter_Sports <- 0.9624

Swimming <- 7.7226

Hiking <- 7

Photography <- 6.783

Gardening <- 23.1

Sewing <- 3.201

Woodworking <- 12.19

Art <- 4.72

Cultural_Sites <- 6.014

Driving <- 13.9

Watching_TV <- 177.2

Golf <- 6.147

Attending_Sports <- 9.77

Coaching <- 12.69

Team_Sports <- 3.893

Recreational_Sports <- 5.966

Fitness <- 78.93

Activities <- c("Fishing", "Ice Fishing", "Hunting", "Shooting Sports", "Camping",
 "Wildlife Viewing", "Bicycling", "Adventure Sports", "Paddlesports",
 "Boating", "Winter Sports", "Swimming", "Hiking", "Photography",
 "Gardening", "Sewing", "Woodworking", "Art", "Cultural Sites", "Driving",

```
"Golf", "Attending Sports", "Coaching", "Team Sports",
"Recreational Sports", "Fitness") # Activity name list
```

```
Mean_Days <- c(23.26, 0.8695, 2.514, 2.73, 6.817, 7.764, 5.152, 0.522, 2.4, 2.546, 0.9624,
7.7226, 7, 6.783, 23.1, 3.201, 12.19, 4.72, 6.014, 13.9, 6.147, 9.77,
12.69, 3.893, 5.966, 78.93)
```

```
# Upper standard error level for rec activities
```

```
Mean_Upper <- c(25.34704, 1.107283, 3.131866, 3.717227, 7.806363, 10.25646, 6.346837,
0.7729177,
2.917043, 3.095014, 1.365496, 8.315912, 8.66775, 8.754717, 25.94678, 4.677955,
14.99779, 6.460553, 6.996732, 17.5147, 7.361507, 11.10134, 14.86042,
4.958023, 7.346326, 86.10246)
```

```
# Lower standard error level for rec activities
```

```
Mean_Lower <- c(21.17241, 0.6317386, 1.896992, 1.74325, 5.827263, 5.271771, 3.956802,
0.270997,
1.883459, 1.996579, 0.559222, 6.135782, 5.33225, 4.811155, 20.25146, 1.723551,
9.381136, 2.979848, 5.030872, 10.28454, 4.932094, 8.439442, 10.51474,
2.828677, 4.58592, 71.76203)
```

```
Rec_MeanDays <- data.frame(Activities, Mean_Days)
```

```
Rec_MeanDays$Upper <- Mean_Upper
```

```
Rec_MeanDays$Lower <- Mean_Lower
```

```
sd(RecAct$Fishing)/(sqrt(length(RecAct$Fishing))) -> FishingSE # standard error
```

```
mean(RecAct$Fishing) + 1.96*FishingSE # Upper confidence interval 25.34704
```

```
mean(RecAct$Fishing) - 1.96*FishingSE # Lower confidence interval 21.17241
```

```
sd(RecAct$Ice_Fishing)/(sqrt(length(RecAct$Ice_Fishing))) -> Ice_FishingSE # standard error
mean(RecAct$Ice_Fishing) + 1.96*Ice_FishingSE # Upper confidence interval 1.107283
mean(RecAct$Ice_Fishing) - 1.96*Ice_FishingSE # Lower confidence interval 0.6317386
```

```
sd(RecAct$Hunting)/(sqrt(length(RecAct$Hunting))) -> HuntingSE # standard error
mean(RecAct$Hunting) + 1.96*HuntingSE # Upper confidence interval 3.131866
mean(RecAct$Hunting) - 1.96*HuntingSE # Lower confidence interval 1.896992
```

```
sd(RecAct$Shooting_Sports)/(sqrt(length(RecAct$Shooting_Sports))) -> Shooting_SportsSE #
standard error
mean(RecAct$Shooting_Sports) + 1.96*Shooting_SportsSE # Upper confidence interval
3.717227
mean(RecAct$Shooting_Sports) - 1.96*Shooting_SportsSE # Lower confidence interval 1.74325
```

```
sd(RecAct$Camping)/(sqrt(length(RecAct$Camping))) -> CampingSE # standard error
mean(RecAct$Camping) + 1.96*CampingSE # Upper confidence interval 7.806363
mean(RecAct$Camping) - 1.96*CampingSE # Lower confidence interval 5.827263
```

```
sd(RecAct$Wildlife_Viewing)/(sqrt(length(RecAct$Wildlife_Viewing))) -> Wildlife_ViewingSE #
standard error
mean(RecAct$Wildlife_Viewing) + 1.96*Wildlife_ViewingSE # Upper confidence interval
10.25646
mean(RecAct$Wildlife_Viewing) - 1.96*Wildlife_ViewingSE # Lower confidence interval
5.271771
```

```
sd(RecAct$Bicycling)/(sqrt(length(RecAct$Bicycling))) -> BicyclingSE # standard error
mean(RecAct$Bicycling) + 1.96*BicyclingSE # Upper confidence interval 6.346837
mean(RecAct$Bicycling) - 1.96*BicyclingSE # Lower confidence interval 3.956802
```

```
sd(RecAct$Adventure_Sports)/(sqrt(length(RecAct$Adventure_Sports))) -> Adventure_SportsSE
# standard error
```

mean(RecAct\$Adventure_Sports) + 1.96*Adventure_SportsSE # Upper confidence interval
0.7729177

mean(RecAct\$Adventure_Sports) - 1.96*Adventure_SportsSE # Lower confidence interval
0.270997

sd(RecAct\$Paddlesports)/(sqrt(length(RecAct\$Paddlesports))) -> PaddlesportsSE # standard
error

mean(RecAct\$Paddlesports) + 1.96*PaddlesportsSE # Upper confidence interval 2.917043

mean(RecAct\$Paddlesports) - 1.96*PaddlesportsSE # Lower confidence interval 1.883459

sd(RecAct\$Boating)/(sqrt(length(RecAct\$Boating))) -> BoatingSE # standard error

mean(RecAct\$Boating) + 1.96*BoatingSE # Upper confidence interval 3.095014

mean(RecAct\$Boating) - 1.96*BoatingSE # Lower confidence interval 1.996579

sd(RecAct\$Winter_Sports)/(sqrt(length(RecAct\$Winter_Sports))) -> Winter_SportsSE # standard
error

mean(RecAct\$Winter_Sports) + 1.96*Winter_SportsSE # Upper confidence interval 1.365496

mean(RecAct\$Winter_Sports) - 1.96*Winter_SportsSE # Lower confidence interval 0.559222

sd(RecAct\$Swimming)/(sqrt(length(RecAct\$Swimming))) -> SwimmingSE # standard error

mean(RecAct\$Swimming) + 1.96*SwimmingSE # Upper confidence interval 8.315912

mean(RecAct\$Swimming) - 1.96*SwimmingSE # Lower confidence interval 6.135782

sd(RecAct\$Hiking)/(sqrt(length(RecAct\$Hiking))) -> HikingSE # standard error

mean(RecAct\$Hiking) + 1.96*HikingSE # Upper confidence interval 8.66775

mean(RecAct\$Hiking) - 1.96*HikingSE # Lower confidence interval 5.33225

sd(RecAct\$Photography)/(sqrt(length(RecAct\$Photography))) -> PhotographySE # standard
error

mean(RecAct\$Photography) + 1.96*PhotographySE # Upper confidence interval 8.754717

$\text{mean}(\text{RecAct}\$\text{Photography}) - 1.96 * \text{PhotographySE}$ # Lower confidence interval 4.811155

$\text{sd}(\text{RecAct}\$\text{Gardening}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Gardening}))) \rightarrow \text{GardeningSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Gardening}) + 1.96 * \text{GardeningSE}$ # Upper confidence interval 25.94678

$\text{mean}(\text{RecAct}\$\text{Gardening}) - 1.96 * \text{GardeningSE}$ # Lower confidence interval 20.25146

$\text{sd}(\text{RecAct}\$\text{Sewing}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Sewing}))) \rightarrow \text{SewingSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Sewing}) + 1.96 * \text{SewingSE}$ # Upper confidence interval 4.677955

$\text{mean}(\text{RecAct}\$\text{Sewing}) - 1.96 * \text{SewingSE}$ # Lower confidence interval 1.723551

$\text{sd}(\text{RecAct}\$\text{Woodworking}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Woodworking}))) \rightarrow \text{WoodworkingSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Woodworking}) + 1.96 * \text{WoodworkingSE}$ # Upper confidence interval 14.99779

$\text{mean}(\text{RecAct}\$\text{Woodworking}) - 1.96 * \text{WoodworkingSE}$ # Lower confidence interval 9.381136

$\text{sd}(\text{RecAct}\$\text{Art}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Art}))) \rightarrow \text{ArtSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Art}) + 1.96 * \text{ArtSE}$ # Upper confidence interval 6.460553

$\text{mean}(\text{RecAct}\$\text{Art}) - 1.96 * \text{ArtSE}$ # Lower confidence interval 2.979848

$\text{sd}(\text{RecAct}\$\text{Cultural_Sites}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Cultural_Sites}))) \rightarrow \text{Cultural_SitesSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Cultural_Sites}) + 1.96 * \text{Cultural_SitesSE}$ # Upper confidence interval 6.996732

$\text{mean}(\text{RecAct}\$\text{Cultural_Sites}) - 1.96 * \text{Cultural_SitesSE}$ # Lower confidence interval 5.030872

$\text{sd}(\text{RecAct}\$\text{Driving}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Driving}))) \rightarrow \text{DrivingSE}$ # standard error

$\text{mean}(\text{RecAct}\$\text{Driving}) + 1.96 * \text{DrivingSE}$ # Upper confidence interval 17.5147

$\text{mean}(\text{RecAct}\$\text{Driving}) - 1.96 * \text{DrivingSE}$ # Lower confidence interval 10.28454

$\text{sd}(\text{RecAct}\$\text{Watching_TV}) / (\text{sqrt}(\text{length}(\text{RecAct}\$\text{Watching_TV}))) \rightarrow \text{Watching_TVSE}$ # standard error

```
mean(RecAct$Watching_TV) + 1.96*Watching_TVSE # Upper confidence interval 187.571
mean(RecAct$Watching_TV) - 1.96*Watching_TVSE # Lower confidence interval 166.7728
```

```
sd(RecAct$Golf)/(sqrt(length(RecAct$Golf))) -> GolfSE # standard error
mean(RecAct$Golf) + 1.96*GolfSE # Upper confidence interval 7.361507
mean(RecAct$Golf) - 1.96*GolfSE # Lower confidence interval 4.932094
```

```
sd(RecAct$Attending_Sports)/(sqrt(length(RecAct$Attending_Sports))) -> Attending_SportsSE #
standard error
mean(RecAct$Attending_Sports) + 1.96*Attending_SportsSE # Upper confidence interval
11.10134
mean(RecAct$Attending_Sports) - 1.96*Attending_SportsSE # Lower confidence interval
8.439442
```

```
sd(RecAct$Coaching)/(sqrt(length(RecAct$Coaching))) -> CoachingSE # standard error
mean(RecAct$Coaching) + 1.96*CoachingSE # Upper confidence interval 14.86042
mean(RecAct$Coaching) - 1.96*CoachingSE # Lower confidence interval 10.51474
```

```
sd(RecAct$Team_Sports)/(sqrt(length(RecAct$Team_Sports))) -> Team_SportsSE # standard
error
mean(RecAct$Team_Sports) + 1.96*Team_SportsSE # Upper confidence interval 4.958023
mean(RecAct$Team_Sports) - 1.96*Team_SportsSE # Lower confidence interval 2.828677
```

```
sd(RecAct$Recreational_Sports)/(sqrt(length(RecAct$Recreational_Sports))) ->
Recreational_SportsSE # standard error
mean(RecAct$Recreational_Sports) + 1.96*Recreational_SportsSE # Upper confidence interval
7.346326
mean(RecAct$Recreational_Sports) - 1.96*Recreational_SportsSE # Lower confidence interval
4.58592
```

```
sd(RecAct$Fitness)/(sqrt(length(RecAct$Fitness))) -> FitnessSE # standard error
```

```
mean(RecAct$Fitness) + 1.96*FitnessSE # Upper confidence interval 86.10246
```

```
mean(RecAct$Fitness) - 1.96*FitnessSE # Lower confidence interval 71.76203
```

```
Rec_MeanDaysOrder <- c("Ftn", "Fsh", "Grd", "Drv", "Cch",
                        "Wdw", "AtS", "WIV", "Swm",
                        "Hkn", "Cmp", "Pht", "GlF", "ClS",
                        "RcS", "Bcy", "Art", "TmS", "Swn",
                        "ShS", "Btn", "Hnt", "Pdd", "WnS",
                        "IcF", "AdS") # Ordered the rec activities from most days spent recreating to least
amount of days recreated
```

```
ggplot(data = Rec_MeanDays) +
  geom_errorbarh(aes(xmax = Upper, xmin = Lower, y = Activities_Abr), size = 0.75, color =
"black") +
  geom_point(aes(x = Mean_Days, y = Activities_Abr), size = 2, color = "black") +
  scale_y_discrete(limits = Rec_MeanDaysOrder) +
  xlim(0,100) +
  labs(y = "Recreational Activities", x = "Avidity") +
  theme_pubr() -> RecAct_meanDays # Figure illustrating the mean days recreated for each
recreational activity with standard error bars
```

```
RecAct_meanDays + theme(axis.text.y = element_text(size = 24))
```

```
ggsave(RecAct_meanDays, filename = "RecAct_meanDays.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = Rec_MeanDays) +
  geom_errorbarh(aes(xmax = Upper, xmin = Lower, y = Activities_Abr), size = 1, color = "white")
+
  geom_point(aes(x = Mean_Days, y = Activities_Abr), size = 2, color = "white") +
```

```

scale_y_discrete(limits = Rec_MeanDaysOrder) +
xlim(0,100) +
coord_cartesian(expand = FALSE) +
labs(y = "Recreational Activity", x = "Avidity") +
theme_mine_presentation() -> RecAct_meanDayspres

```

```

ggsave(RecAct_meanDayspres, filename = "RecAct_meanDayspres.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

```

```

Activities_Abr <- abbreviate(Activities, minlength = 3, dot = FALSE, strict = TRUE) # Abbreviated
Rec Activities

```

```

ggplot(data = RecAct) +
  geom_density(aes(Fishing), fill = "lightblue") # Density plot for Fishing

```

```

ggplot(data = RecAct) +
  geom_density(aes(Ice_Fishing), fill = "lightblue") # Density plot for Ice Fishing

```

```

ggplot(data = RecAct) +
  geom_density(aes(Hunting), fill = "lightblue") # Density plot for Hunting

```

```

ggplot(data = RecAct) +
  geom_density(aes(Shooting_Sports), fill = "lightblue") # Density plot for Shooting Sports

```

```

ggplot(data = RecAct) +
  geom_density(aes(Camping), fill = "lightblue") # Density plot for Camping

```

```

ggplot(data = RecAct) +
  geom_density(aes(Wildlife_Viewing), fill = "lightblue") # Density plot for Wildlife Viewing

```

```
ggplot(data = RecAct) +  
  geom_density(aes(Bicycling), fill = "lightblue") # Density plot for Bicycling
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Adventure_Sports), fill = "lightblue") # Density plot for Adventure Sports
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Paddlesports), fill = "lightblue") # Density plot for Paddlesports
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Boating), fill = "lightblue") # Density plot for Boating
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Winter_Sports), fill = "lightblue") # Density plot for Winter Sports
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Swimming), fill = "lightblue") # Density plot for Swimming
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Hiking), fill = "lightblue") # Density plot for Hiking
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Photography), fill = "lightblue") # Density plot for Photography
```

```
ggplot(data = RecAct) +  
  geom_density(aes(Gardening), fill = "lightblue") # Density plot for Gardening
```

```
ggplot(data = RecAct) +
```

```
geom_density(aes(Sewing), fill = "lightblue") # Density plot for Sewing
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Woodworking), fill = "lightblue") # Density plot for Woodworking
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Cultural_Sites), fill = "lightblue") # Density plot for Cultural Sites
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Driving), fill = "lightblue") # Density plot for Driving
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Watching_TV), fill = "lightblue") # Density plot for Watching TV
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Attending_Sports), fill = "lightblue") # Density plot for Attending Sports
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Art), fill = "lightblue") # Density plot for Art
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Golf), fill = "lightblue") # Density plot for Golf
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Coaching), fill = "lightblue") # Density plot for Coaching
```

```
ggplot(data = RecAct) +
```

```
  geom_density(aes(Team_Sports), fill = "lightblue") # Density plot for Team Sports
```

```
ggplot(data = RecAct) +
  geom_density(aes(Recreational_Sports), fill = "lightblue") # Density plot for Recreational Sports
```

```
ggplot(data = RecAct) +
  geom_density(aes(Fitness), fill = "lightblue") # Density plot for Fitness
```

```
# Log Transformed PCA -----
```

```
summary(RecAct)
```

```
RecAct %>%
```

```
  mutate(Fishing = log(Fishing + 1),
         Ice_Fishing = log(Ice_Fishing + 1),
         Hunting = log(Hunting + 1),
         Shooting_Sports = log(Shooting_Sports + 1),
         Camping = log(Camping + 1),
         Wildlife_Viewing = log(Wildlife_Viewing + 1),
         Bicycling = log(Bicycling + 1),
         Adventure_Sports = log(Adventure_Sports + 1),
         Paddlesports = log(Paddlesports + 1),
         Boating = log(Boating + 1),
         Winter_Sports = log(Winter_Sports + 1),
         Swimming = log(Swimming + 1),
         Hiking = log(Hiking + 1),
         Photography = log(Photography + 1),
         Gardening = log(Gardening + 1),
         Sewing = log(Sewing + 1),
         Woodworking = log(Woodworking + 1),
         Art = log(Art + 1),
```

```

Cultural_Sites = log(Cultural_Sites + 1),
Driving = log(Driving + 1),
Watching_TV = log(Watching_TV + 1),
Golf = log(Golf + 1),
Attending_Sports = log(Attending_Sports + 1),
Coaching = log(Coaching + 1),
Team_Sports = log(Team_Sports + 1),
Recreational_Sports = log(Recreational_Sports + 1),
Fitness = log(Fitness + 1)) -> logRecAct # Transformed the days spent recreated to a base
log format

```

```
logRecAct %>%
```

```
select(-Watching_TV) -> logRecAct # Watching TV removed from the log transformed PCA data.
```

```
logRecAct %>%
```

```

rename(Fsh = Fishing,
       IcF = Ice_Fishing,
       Hnt = Hunting,
       ShS = Shooting_Sports,
       Cmp = Camping,
       WIV = Wildlife_Viewing,
       Bcy = Bicycling,
       AdS = Adventure_Sports,
       Pdd = Paddlesports,
       Btn = Boating,
       WnS = Winter_Sports,
       Swm = Swimming,
       Hkn = Hiking,
       Pht = Photography,

```

Grd = Gardening,

Swn = Sewing,

Wdw = Woodworking,

CIS = Cultural_Sites,

Drv = Driving,

AtS = Attending_Sports,

Cch = Coaching,

TmS = Team_Sports,

RcS = Recreational_Sports,

Ftn = Fitness) -> logRecAct # Renamed the recreational activities with the abbreviations provided by R

```
summary(logRecAct)
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Fshn), fill = "lightblue") # Density plot for Fishing
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(IcFs), fill = "lightblue") # Density plot for Ice Fishing
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Hntn), fill = "lightblue") # Density plot for Hunting
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(ShtS), fill = "lightblue") # Density plot for Shooting Sports
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Cmpn), fill = "lightblue") # Density plot for Camping
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(WldV), fill = "lightblue") # Density plot for Wildlife Viewing
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Bcyc), fill = "lightblue") # Density plot for Bicycling
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(AdvS), fill = "lightblue") # Density plot for Adventure Sports
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Pddl), fill = "lightblue") # Density plot for Paddlesports
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Btng), fill = "lightblue") # Density plot for Boating
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(WntS), fill = "lightblue") # Density plot for Winter Sports
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Swmm), fill = "lightblue") # Density plot for Swimming
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Hkng), fill = "lightblue") # Density plot for Hiking
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Phtg), fill = "lightblue") # Density plot for Photography
```

```
ggplot(data = logRecAct) +  
  geom_density(aes(Grdn), fill = "lightblue") # Density plot for Gardening
```

```

ggplot(data = logRecAct) +
  geom_density(aes(Swng), fill = "lightblue") # Density plot for Sewing

ggplot(data = logRecAct) +
  geom_density(aes(Wdwr), fill = "lightblue") # Density plot for Woodworking

ggplot(data = logRecAct) +
  geom_density(aes(CltS), fill = "lightblue") # Density plot for Cultural Sites

ggplot(data = logRecAct) +
  geom_density(aes(Drvn), fill = "lightblue") # Density plot for Driving

# ggplot(data = logRecAct) +
#   geom_density(aes(WtTV), fill = "lightblue") # Density plot for Watching TV

ggplot(data = logRecAct) +
  geom_density(aes(AttS), fill = "lightblue") # Density plot for Attending Sports

ggplot(data = logRecAct) +
  geom_density(aes(Art), fill = "lightblue") # Density plot for Art

ggplot(data = logRecAct) +
  geom_density(aes(Golf), fill = "lightblue") # Density plot for Golf

ggplot(data = logRecAct) +
  geom_density(aes(Cchn), fill = "lightblue") # Density plot for Coaching

ggplot(data = logRecAct) +

```

```
geom_density(aes(TmSp), fill = "lightblue") # Density plot for Team Sports
```

```
ggplot(data = logRecAct) +
```

```
  geom_density(aes(RcrS), fill = "lightblue") # Density plot for Recreational Sports
```

```
ggplot(data = logRecAct) +
```

```
  geom_density(aes(Ftns), fill = "lightblue") # Density plot for Fitness
```

```
res.pca_log <- prcomp(logRecAct, scale = TRUE) # Compute PCA, with log transformed data all
rec
```

```
fviz_eig(res.pca_log) -> ReclogScreePlot
```

```
fviz_pca_ind(res.pca_log,
```

```
  col.ind = "cos2", # Color by the quality of representation
```

```
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
```

```
  repel = TRUE # Avoid text overlapping
```

```
)
```

```
fviz_pca_var(res.pca_log,
```

```
  col.var = "contrib", # Color by contributions to the PC
```

```
  gradient.cols = c("black", "black", "black"),
```

```
  repel = TRUE # Avoid text overlapping
```

```
) -> RecPCA
```

```
ggsave(RecPCA, filename = "RecPCA.png", path = "C:/Users/k4han/OneDrive/Desktop/Master
Project Data", width = 9, height = 6, units = "in", dpi = 600)
```

```
eig.val_log <- get_eigenvalue(res.pca_log) # Eigen values for the PCA
```

```
eig.val_log
```

```
# Results for Variables
```

```
res.var_log <- get_pca_var(res.pca_log)
```

```
res.var_log$coord      # Coordinates
```

```
res.var_log$contrib     # Contributions to the Principal Components
```

```
res.var_log$cos2        # Quality of representation
```

```
# Results for individuals
```

```
res.ind_log <- get_pca_ind(res.pca_log)
```

```
res.ind_log$coord      # Coordinates
```

```
res.ind_log$contrib     # Contributions to the Principal Components
```

```
res.ind_log$cos2        # Quality of representation
```

```
logRecAct %>%
```

```
  select(-TmSp, -Art, -Swng, -Phtg, -WntS,
```

```
    -AdvS, -ShtS, -Hntn,
```

```
    -lCFs) -> logRecAct2
```

```
res.pca_log2 <- prcomp(logRecAct2, scale = TRUE) # Compute PCA, with log transformed data
3rd Quart
```

```
fviz_eig(res.pca_log2)
```

```
fviz_pca_ind(res.pca_log2,
```

```
  col.ind = "cos2", # Color by the quality of representation
```

```
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
```

```
  repel = TRUE    # Avoid text overlapping
```

```
)
```

```
fviz_pca_var(res.pca_log2,
```

```
  col.var = "contrib", # Color by contributions to the PC
```

```
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
```

```

        repel = TRUE    # Avoid text overlapping
    )

    eig.val_log2 <- get_eigenvalue(res.pca_log2) # Eigen values for the PCA
    eig.val_log2

# Results for Variables
res.var_log2 <- get_pca_var(res.pca_log2)
res.var_log2$coord      # Coordinates
res.var_log2$contrib     # Contributions to the Principal Components
res.var_log2$cos2       # Quality of representation

# Results for individuals
res.ind_log2 <- get_pca_ind(res.pca_log2)
res.ind_log2$coord      # Coordinates
res.ind_log2$contrib    # Contributions to the Principal Components
res.ind_log2$cos2       # Quality of representation

logRecAct %>%
  select(-TmS, -Art, -Swn, -Pht, -WnS,
         -AtS, -ShS, -Hnt,
         -IcF, -WIV, -Cch, -Bcy, -Pdd,
         -Btn, -Swm, -RcS, -Drv, -GlF,
         -Wdw) -> logRecAct3

res.pca_log3 <- prcomp(logRecAct3, scale = TRUE) # Compute PCA, with log transformed data
median
fviz_eig(res.pca_log3) -> MedianReclogScreePlot
fviz_pca_ind(res.pca_log3,

```

```

col.ind = "cos2", # Color by the quality of representation
gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
repel = TRUE    # Avoid text overlapping
)

fviz_pca_var(res.pca_log3,
  col.var = "contrib", # Color by contributions to the PC
  gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),
  repel = TRUE    # Avoid text overlapping
) -> MedianRecPCA

ggsave(MedianRecPCA, filename = "MedianRecPCA.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

eig.val_log3 <- get_eigenvalue(res.pca_log3) # Eigen values for the PCA
eig.val_log3

# Results for Variables
res.var_log3 <- get_pca_var(res.pca_log3)
res.var_log3$coord      # Coordinates
res.var_log3$contrib     # Contributions to the Principal Components
res.var_log3$cos2       # Quality of representation

# Results for individuals
res.ind_log3 <- get_pca_ind(res.pca_log3)
res.ind_log3$coord      # Coordinates
res.ind_log3$contrib     # Contributions to the Principal Components
res.ind_log3$cos2       # Quality of representation

```

```
ReclogScreePlot + labs(x = NULL, y = NULL, title = "All Recreational Activities") +
coord_cartesian(expand = FALSE, ylim = c(0,30)) + theme_classic() -> ReclogScreePlot
```

```
MedianReclogScreePlot + labs(x = NULL, y = NULL, title = "Median Participated Recreational
Activities") + coord_cartesian(expand = FALSE, xlim = c(0.55,10)) + theme_classic() ->
MedianReclogScreePlot
```

```
ScreePlotComb <- grid.arrange(ReclogScreePlot, MedianReclogScreePlot, ncol = 1,
                              left = yScree,
                              bottom = xScree) # Combined scree plots from the 26 rec activity PCA and
median rec PCA - log transformed.
xScree = textGrob("Dimensions", gp = gpar(fontface = "bold", col = "black", fontsize = 12))
yScree = textGrob("Explained Variance", gp = gpar(fontface = "bold", col = "black", fontsize =
12), rot = 90)
```

```
ggsave(ScreePlotComb, filename = "ScreePlotComb.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
# Revised AIC Analysis -----
```

```
AICdat3$Tapestry <- factor(AICdat3$Tapestry, levels = Esri_custom_order)
```

```
mod1_1 <- glm(Fishing ~ Tapestry, data = AICdat3) # Esri Urbanization Group model for days
fished
```

```
summary(mod1_1)
```

```
tapply(AICdat3$Fishing, AICdat3$Tapestry, median) # Median values for urbanization groups of
anglers for the boxplots. Met median = 2.772589, Pri median = 2.397895, Sub median =
2.564949, and Urb = 3.044522
```

```
ggplot(data = mod1_1) + # Days spent fishing box plot for each urbanization group
  geom_boxplot(aes(x = Tapestry, y = Fishing)) +
```

```
labs(x = "Urbanization Group", y = "Avidity(log(days fished))") +
annotate("text", x = "Met", y = 6, label = 14) +
annotate("text", x = "Pri", y = 6, label = 10) +
annotate("text", x = "Sub", y = 6, label = 15) +
annotate("text", x = "Urb", y = 6, label = 18) +
theme_pubr() -> Avidity_Esri_box_thesis
```

```
ggsave(Avidity_Esri_box_thesis, filename = "Avidity_Esri_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod2_1 <- glm(Fishing ~ sex, data = AICdat3) # Sex model for days fished
summary(mod2_1)
```

```
tapply(AICdat3$Fishing, AICdat3$sex, median) # Median values for sex of anglers for the
boxplots. Female median = 24.99741, male median = 59.23645
```

```
ggplot(data = mod2_1) + # Days spent fishing box plot for sex.
  geom_boxplot(aes(x = sex, y = Fishing)) +
  labs(x = "Sex", y = "Avidity (log(days fished))") +
  annotate("text", x = "Female", y = 6, label = 10) +
  annotate("text", x = "Male", y = 6, label = 15) +
  theme_pubr() -> Avidity_sex_box_thesis
```

```
ggsave(Avidity_sex_box_thesis, filename = "Avidity_sex_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod3_1 <- glm(Fishing ~ Age + Employment + Q27, data = AICdat3) # Life stage model for days
fished containing age, employment, and household size
summary(mod3_1)
```

```
as.data.frame(tapply(AICdat3$Fishing, AICdat3$Age, median)) -> Median_Age_Numbers_1 #
Median values for age of anglers for the boxplots.
```

```
Median_Age_Numbers_1 %>%
  rename("Median" = "tapply(AICdat3$Fishing, AICdat3$Age, median)") %>%
  mutate(Median = exp(Median)-1) -> Median_Age_Numbers_1
```

```
tapply(AICdat3$Fishing, AICdat3$Employment, median) # Median values for employment of
anglers for the boxplots.
```

```
tapply(AICdat3$Fishing, AICdat3$Q27, median) # Median values for household size of anglers for
the boxplots.
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Employment, x = Employment, y = Fishing)) +
  labs(x = "Employment Status", y = "Avidity (log(days fished))") +
  annotate("text", x = 0, y = 6, label = 10) +
  annotate("text", x = 1, y = 6, label = 10) +
  annotate("text", x = 2, y = 6, label = 10) +
  annotate("text", x = 4, y = 6, label = 15) +
  annotate("text", x = 5, y = 6, label = 45) +
  annotate("text", x = 6, y = 6, label = 3) +
  theme_pubr() -> Avidity_employment_box_thesis # Box plot representing days fished with
employment status.
```

```
ggsave(Avidity_employment_box_thesis, filename = "Avidity_employment_box_thesis.png",
path = "C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units =
"in")
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Q27, x = Q27, y = Fishing)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6, 7, 8, 11), y = 6,
```

```

    label = c(15, 12, 12, 20, 14, 10, 10, 3, 0, 1)) +
  labs(x = "Additional Household Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_household_box_thesis

ggsave(Avidity_household_box_thesis, filename = "Avidity_household_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Age, x = Age, y = Fishing)) +
  annotate("text", x = c(20, 25, 30,
    35, 40, 45, 50, 55, 60, 65,
    70, 75), y = 6,
    label = c(7, 20, 20, 10, 24, 6, 30, 11, 20, 6, 4, 40)) +
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
  theme_pubr() -> Avidity_age_box_thesis

ggsave(Avidity_age_box_thesis, filename = "Avidity_age_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

mod4_1 <- glm(Fishing ~ Q33TOTAL + Q30, data = AICdat3) # Socioeconomic model for days
fished containing household gross income and education.

summary(mod4_1)

tapply(AICdat3$Fishing, AICdat3$Q33TOTAL, median)
tapply(AICdat3$Fishing, AICdat3$Q30, median)

ggplot(data = mod4) +
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL), color = "black", fill =
"springgreen4") +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,

```

```

label = c(7, 30, 14, 15, 20, 16, 12, 10, 14, 10, 6)) +
labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
theme_mine() -> Avidity_income_box # Box plot representing days fished with household gross
income.

```

```

ggsave(Avidity_income_box, filename = "Avidity_income_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

```

```

ggplot(data = mod4_1) +
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL)) +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
    label = c(9, 30, 14, 15, 20, 15, 12, 10, 14, 10, 6)) +
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_income_box_thesis

```

```

ggsave(Avidity_income_box_thesis, filename = "Avidity_income_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

```

```

ggplot(data = mod4) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30), color = "black", fill = "springgreen4") +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(35, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_mine() -> Avidity_education_box # Box plot representing the days fished with education
status.

```

```

ggsave(Avidity_education_box, filename = "Avidity_education_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

```

```
ggplot(data = mod4_1) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30)) +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(40, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_education_box_thesis
```

```
ggsave(Avidity_education_box_thesis, filename = "Avidity_education_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod5_1 <- glm(Fishing ~ permit_type_comb + Q28 + R3_Type, data = AICdat3)# Participation
model containing license purchase history, license bought, and fishing members in household
summary(mod5_1)
```

```
tapply(AICdat3$Fishing, AICdat3$permit_type_comb, median)
tapply(AICdat3$Fishing, AICdat3$Q28, median)
tapply(AICdat3$Fishing, AICdat3$R3_Type, median)
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = permit_type_comb, y = Fishing, group = permit_type_comb)) +
  annotate("text", x = c("Day", "Annual", "Multi Year"), y = 6,
    label = c(3, 15, 20)) +
  labs(x = "Fishing Permit Purchased", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_permit_box_thesis
```

```
ggsave(Avidity_permit_box_thesis, filename = "Avidity_permit_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28), color = "black", fill = "springgreen4") +
```

```
labs(x = "Family Fishing Members", y = "Avidity (log(days fished))") +
theme_mine_presentation() -> Avidity_fishingmember_box
```

```
ggsave(Avidity_fishingmember_box, filename = "Avidity_fishingmember_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6), y = 6,
    label = c(10, 12, 20, 15, 17, 5, 12)) +
  labs(x = "Additional Family Fishing Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_fishingmember_box_thesis
```

```
ggsave(Avidity_fishingmember_box_thesis, filename =
"Avidity_fishingmember_box_thesis.png", path = "C:/Users/k4han/OneDrive/Desktop/Master
Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = R3_Type, y = Fishing, group = R3_Type)) +
  annotate("text", x = c("Recruit", "Retained", "Reactivated"), y = 6,
    label = c(6, 20, 12)) +
  labs(x = "R3 Type", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_R3_box_thesis
```

```
ggsave(Avidity_R3_box_thesis, filename = "Avidity_R3_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod6_1 <- glm(Fishing ~ Urban_Area, data = AICdat3) # Urban area as defined by NGPC fisheries
biologists.
```

```
summary(mod6_1)
```

```
tapply(AICdat3$Fishing, AICdat3$Urban_Area, median)
```

```
ggplot(data = mod6_1) +
  geom_boxplot(aes(x = Urban_Area, y = Fishing, group = Urban_Area)) +
  annotate("text", x = c("Central", "North", "South", "Southeast", "Southwest", "West"), y = 6,
    label = c(13, 20, 15, 20, 10, 10)) +
  labs(x = "Urban Area", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_Urban_box_thesis
```

```
ggsave(Avidity_Urban_box_thesis, filename = "Avidity_Urban_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod7_1 <- glm(Fishing ~ sex + Age + Employment + Q27 +
  Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28 + Urban_Area, data = AICdat3,
na.action = na.pass) # Global model without urbanization group
summary(mod7_1)
```

```
mod8_1 <- glm(Fishing ~ 1, data = AICdat3) # Null model
summary(mod8_1)
```

```
models <- list(mod1_1, mod2_1, mod3_1, mod4_1, mod5_1, mod6_1, mod8_1)
mod.names <- c('Urbanization Groups', 'Sex', 'Life Stage', 'Socioeconomic', 'Participation', 'Urban
Area', "Null")
aictab(cand.set = models, modnames = mod.names) -> AIC_Table1_1
```

```
write.csv(AIC_Table1_1, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table1_1.csv", row.names = FALSE, )
```

```
dredge(mod7_1) -> Globalmod
```

```
model.sel(Globalmod) -> AIC_Table2_1 # Parsimonious AIC with all groups except Urbanization
Groups
```

```
write.csv(AIC_Table2_1, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table2_1.csv", sep = " ", row.names = FALSE, )
```

```
model_performance(mod7_1)
```

```
model_performance(mod5_1)
```

```
modA <- glm(Fishing ~ sex + Q27 +
            Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action = na.pass)
```

```
summary(modA)
```

```
modB <- glm(Fishing ~ sex + Age + Q27 +
            Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action = na.pass)
```

```
summary(modB)
```

```
modC <- glm(Fishing ~ sex + Q27 +
            Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action =
na.pass)
```

```
summary(modC)
```

```
modD <- glm(Fishing ~ sex + Employment + Q27 +
            Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action =
na.pass)
```

```
summary(modD)
```

```
modE <- glm(Fishing ~ sex + Employment + Q27 +
            Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action = na.pass)
```

```
summary(modE)
```

```
modF <- glm(Fishing ~ sex + Age + Q27 +
            Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action =
            na.pass)
summary(modF)
```

```
modG <- glm(Fishing ~ sex + Age + Employment + Q27 +
            Q30 + R3_Type + permit_type_comb + Q28, data = AICdat3, na.action = na.pass)
summary(modG)
```

```
models_1 <- list(modA, modB, modC, modD, modE, modF, modG)
mod.names_1 <- c('A', 'B', 'C', 'D', 'E', 'F', "G")
aictab(cand.set = models_1, modnames = mod.names_1) -> AIC_Table3

#
# aic_values <- c(2081.92, 2082.36, 2082.38, 2082.47, 2082.72, 2083.08, 2083.31)
# delta_aic <- aic_values - min(aic_values)
# akaike_weights <- exp(-0.5 * delta_aic) / sum(exp(-0.5 * delta_aic))
# weighted_avg_model <- lapply(models_1, function(models_1){
#   coef(models_1) * akaike_weights
# })
# final_weighted_avg_model <- do.call("+", weighted_avg_model)
#
# fits <- map(models_1, glm, data = AICdat3)
# aic <- map_dbl(fits, AIC)
# npars <- map_dbl(fits, "rank") + 1
# tibble(AIC = aic, k = npars, deltas = delta_aic, weights = akaike_weights)
#
# aic.table4 <- tibble(models = 1:7, AIC = aic, k = npars, deltas = delta_aic, weights =
  akaike_weights)
```

```

# aic.table4$models <- as.character(aic.table4$models)

# at2 <- aic.table4 %>%

# arrange(AIC) %>%

# mutate(cumw = cumsum(weights))

# pander(model.sel(fits), split.tables = Inf)

#

# intercepts <- map_df(fits, tidy) %>%

# filter(term == "(Intercept)") %>%

# mutate(model = models_1)

#

# mavg.intercept <- sum(weights * intercepts$estimate)


modavg(parm = c("(Intercept)"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgIntercept

modavg(parm = c("Employment"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgEmployment

modavg(parm = c("Q27"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgHousehold

modavg(parm = c("Q33TOTAL"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgIncome

modavg(parm = c("Q30"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgEducation

modavg(parm = c("R3_TypeRetained"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgR3Retained

modavg(parm = c("R3_TypeReactivated"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgR3Reactivated

modavg(parm = c("permit_type_combDay"), cand.set = models_1, modnames = mod.names_1)
-> Mod_avgPermitDay

modavg(parm = c("permit_type_combMulti_Year"), cand.set = models_1, modnames =
mod.names_1) -> Mod_avgPermitMulti

modavg(parm = c("Q28"), cand.set = models_1, modnames = mod.names_1) ->
Mod_avgFishMember

```

```
modavg(parm = c("Age"), cand.set = models_1, modnames = mod.names_1) -> Mod_avgAge
modavg(parm = c("sexMale"), cand.set = models_1, modnames = mod.names_1) -> Mod_avgSex
```

```
# Omaha Heat Maps -----
```

```
data(fips_codes)
```

```
# Sarpy code is 153
```

```
# Douglas code is 055
```

```
options(tigris_use_cache = TRUE)
```

```
Omaha_pop <- get_estimates(
  geography = "county",
  product = "characteristics",
  breakdown = c("SEX"),
  breakdown_labels = TRUE,
  state = "NE",
  year = 2020) %>%
  group_by(NAME) %>%
  summarise(TTL = sum(value))
```

```
plot(omaha_zip_anglers_prop)
```

```
ggplot(omaha_zip_anglers_prop) +
  geom_sf(data = prop_of_prop) +
  geom_sf(data = DougSarpy, color = "red", fill = NA, linewidth = 1)
```

```
# AIC Avidity Model Fitness -----
```

```

#sample_n(AICdat3, 647) -> Build_Model

x <- 1:681

set.seed(47)

filter_set <- sample(x, 34)

AICdat3 %>%
  filter(row_number() %in% filter_set) -> ModelTest

AICdat3 %>%
  filter(!row_number() %in% filter_set) -> ModelBuild

ModelBuild$Tapestry <- factor(ModelBuild$Tapestry, levels = Esri_custom_order)

modB_1 <- glm(Fishing ~ Tapestry, data = ModelBuild) # Esri Urbanization Group model for days
fished

summary(modB_1)

tapply(AICdat3$Fishing, AICdat3$Tapestry, median) # Median values for urbanization groups of
anglers for the boxplots. Met median = 2.772589, Pri median = 2.397895, Sub median =
2.564949, and Urb = 3.044522

ggplot(data = mod1_1) + # Days spent fishing box plot for each urbanization group
  geom_boxplot(aes(x = Tapestry, y = Fishing)) +
  labs(x = "Urbanization Group", y = "Avidity(log(days fished))") +
  annotate("text", x = "Met", y = 6, label = 14) +
  annotate("text", x = "Pri", y = 6, label = 10) +
  annotate("text", x = "Sub", y = 6, label = 15) +
  annotate("text", x = "Urb", y = 6, label = 18) +
  theme_pubr() -> Avidity_Esri_box_thesis

```

```
ggsave(Avidity_Esri_box_thesis, filename = "Avidity_Esri_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
modB_2 <- glm(Fishing ~ sex, data = ModelBuild) # Sex model for days fished
summary(modB_2)
```

```
tapply(AICdat3$Fishing, AICdat3$sex, median) # Median values for sex of anglers for the
boxplots. Female median = 24.99741, male median = 59.23645
```

```
ggplot(data = mod2_1) + # Days spent fishing box plot for sex.
  geom_boxplot(aes(x = sex, y = Fishing)) +
  labs(x = "Sex", y = "Avidity (log(days fished))") +
  annotate("text", x = "Female", y = 6, label = 10) +
  annotate("text", x = "Male", y = 6, label = 15) +
  theme_pubr() -> Avidity_sex_box_thesis
```

```
ggsave(Avidity_sex_box_thesis, filename = "Avidity_sex_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
modB_3 <- glm(Fishing ~ Age + Employment + Q27, data = ModelBuild) # Life stage model for
days fished containing age, employment, and household size
summary(modB_3)
```

```
as.data.frame(tapply(AICdat3$Fishing, AICdat3$Age, median)) -> Median_Age_Numbers_1 #
Median values for age of anglers for the boxplots.
```

```
Median_Age_Numbers_1 %>%
  rename("Median" = "tapply(AICdat3$Fishing, AICdat3$Age, median)") %>%
  mutate(Median = exp(Median)-1) -> Median_Age_Numbers_1
```

```
tapply(AICdat3$Fishing, AICdat3$Employment, median) # Median values for employment of
anglers for the boxplots.
```

```
tapply(AICdat3$Fishing, AICdat3$Q27, median) # Median values for household size of anglers for
the boxplots.
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Employment, x = Employment, y = Fishing)) +
  labs(x = "Employment Status", y = "Avidity (log(days fished))") +
  annotate("text", x = 0, y = 6, label = 10) +
  annotate("text", x = 1, y = 6, label = 10) +
  annotate("text", x = 2, y = 6, label = 10) +
  annotate("text", x = 4, y = 6, label = 15) +
  annotate("text", x = 5, y = 6, label = 45) +
  annotate("text", x = 6, y = 6, label = 3) +
  theme_pubr() -> Avidity_employment_box_thesis # Box plot representing days fished with
employment status.
```

```
ggsave(Avidity_employment_box_thesis, filename = "Avidity_employment_box_thesis.png",
path = "C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units =
"in")
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Q27, x = Q27, y = Fishing)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6, 7, 8, 11), y = 6,
          label = c(15, 12, 12, 20, 14, 10, 10, 3, 0, 1)) +
  labs(x = "Additional Household Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_household_box_thesis
```

```
ggsave(Avidity_household_box_thesis, filename = "Avidity_household_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Age, x = Age, y = Fishing)) +
  annotate("text", x = c(20, 25, 30,
                        35, 40, 45, 50, 55, 60, 65,
                        70, 75), y = 6,
          label = c(7, 20, 20, 10, 24, 6, 30, 11, 20, 6, 4, 40)) +
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
  theme_pubr() -> Avidity_age_box_thesis
```

```
ggsave(Avidity_age_box_thesis, filename = "Avidity_age_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
modB_4 <- glm(Fishing ~ Q33TOTAL + Q30, data = ModelBuild) # Socioeconomic model for days
fished containing household gross income and education.
```

```
summary(modB_4)
```

```
tapply(AICdat3$Fishing, AICdat3$Q33TOTAL, median)
```

```
tapply(AICdat3$Fishing, AICdat3$Q30, median)
```

```
ggplot(data = mod4) +
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL), color = "black", fill =
"springgreen4") +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
          label = c(7, 30, 14, 15, 20, 16, 12, 10, 14, 10, 6)) +
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
  theme_mine() -> Avidity_income_box # Box plot representing days fished with household gross
income.
```

```
ggsave(Avidity_income_box, filename = "Avidity_income_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4_1) +
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL)) +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
    label = c(9, 30, 14, 15, 20, 15, 12, 10, 14, 10, 6)) +
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_income_box_thesis
```

```
ggsave(Avidity_income_box_thesis, filename = "Avidity_income_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30), color = "black", fill = "springgreen4") +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(35, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_mine() -> Avidity_education_box # Box plot representing the days fished with education
status.
```

```
ggsave(Avidity_education_box, filename = "Avidity_education_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4_1) +
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30)) +
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
    label = c(40, 20, 20, 20, 10, 10, 3)) +
  labs(x = "Education Status", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_education_box_thesis
```

```
ggsave(Avidity_education_box_thesis, filename = "Avidity_education_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
modB_5 <- glm(Fishing ~ permit_type_comb + Q28 + R3_Type, data = ModelBuild)#
Participation model containing license purchase history, license bought, and fishing members in
household
```

```
summary(modB_5)
```

```
tapply(AICdat3$Fishing, AICdat3$permit_type_comb, median)
```

```
tapply(AICdat3$Fishing, AICdat3$Q28, median)
```

```
tapply(AICdat3$Fishing, AICdat3$R3_Type, median)
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = permit_type_comb, y = Fishing, group = permit_type_comb)) +
  annotate("text", x = c("Day", "Annual", "Multi Year"), y = 6,
    label = c(3, 15, 20)) +
  labs(x = "Fishing Permit Purchased", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_permit_box_thesis
```

```
ggsave(Avidity_permit_box_thesis, filename = "Avidity_permit_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28), color = "black", fill = "springgreen4") +
  labs(x = "Family Fishing Members", y = "Avidity (log(days fished))") +
  theme_mine_presentation() -> Avidity_fishingmember_box
```

```
ggsave(Avidity_fishingmember_box, filename = "Avidity_fishingmember_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```

ggplot(data = mod5_1) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6), y = 6,
    label = c(10, 12, 20, 15, 17, 5, 12)) +
  labs(x = "Additional Family Fishing Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_fishingmember_box_thesis

ggsave(Avidity_fishingmember_box_thesis, filename =
"Avidity_fishingmember_box_thesis.png", path = "C:/Users/k4han/OneDrive/Desktop/Master
Project Data", width = 9, height = 6, units = "in")

ggplot(data = mod5_1) +
  geom_boxplot(aes(x = R3_Type, y = Fishing, group = R3_Type)) +
  annotate("text", x = c("Recruit", "Retained", "Reactivated"), y = 6,
    label = c(6, 20, 12)) +
  labs(x = "R3 Type", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_R3_box_thesis

ggsave(Avidity_R3_box_thesis, filename = "Avidity_R3_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

modB_6 <- glm(Fishing ~ Urban_Area, data = ModelBuild) # Urban area as defined by NGPC
fisheries biologists.

summary(modB_6)

tapply(AICdat3$Fishing, AICdat3$Urban_Area, median)

ggplot(data = mod6_1) +
  geom_boxplot(aes(x = Urban_Area, y = Fishing, group = Urban_Area)) +
  annotate("text", x = c("Central", "North", "South", "Southeast", "Southwest", "West"), y = 6,

```

```

label = c(13, 20, 15, 20, 10, 10)) +

labs(x = "Urban Area", y = "Avidity (log(days fished))" ) +

theme_pubr() -> Avidity_Urban_box_thesis

ggsave(Avidity_Urban_box_thesis, filename = "Avidity_Urban_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")

modB_7 <- glm(Fishing ~ sex + Age + Employment + Q27 +
              Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28 + Urban_Area, data =
ModelBuild, na.action = na.pass) # Global model without urbanization group

summary(mod7_1)

modB_8 <- glm(Fishing ~ 1, data = ModelBuild) # Null model

summary(modB_8)

modelsB <- list(modB_1, modB_2, modB_3, modB_4, modB_5, modB_6, modB_8)

mod.namesB <- c('Urbanization Groups', 'Sex', 'Life Stage', 'Socioeconomic', 'Participation',
'Urban Area', "Null")

aictab(cand.set = modelsB, modnames = mod.namesB) -> AIC_TableB

write.csv(AIC_Table1_1, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table1_1.csv", row.names = FALSE, )

dredge(modB_7) -> GlobalmodB

model.sel(GlobalmodB) -> AIC_Table2B # Parsimonious AIC with all groups except Urbanization
Groups

write.csv(AIC_Table2_1, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_Table2_1.csv", sep = " ", row.names = FALSE, )

model_performance(mod7_1)

```

```
model_performance(mod5_1)
```

```
modB_A <- glm(Fishing ~ sex + Q27 +
              Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_A)
```

```
modB_B <- glm(Fishing ~ sex + Q27 +
              Q30 + R3_Type + permit_type_comb + Q28 + Q33TOTAL, data = ModelBuild, na.action =
na.pass)
summary(modB_B)
```

```
modB_C <- glm(Fishing ~ sex + Q27 + Age +
              Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_C)
```

```
modB_D <- glm(Fishing ~ sex + Employment + Q27 +
              Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action =
na.pass)
summary(modB_D)
```

```
modB_E <- glm(Fishing ~ sex + Age + Q27 + Q33TOTAL +
              Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_E)
```

```
modB_F <- glm(Fishing ~ sex + Q27 + Employment +
              Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_F)
```

```
modB_G <- glm(Fishing ~ sex + Age + Employment + Q27 + Q33TOTAL +
```

```

      Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_G)

modB_H <- glm(Fishing ~ sex + Age + Employment + Q27 + Q30 + R3_Type +
      permit_type_comb + Q28, data = ModelBuild, na.action = na.pass)
summary(modB_H)

modelsB_1 <- list(modB_A, modB_B, modB_C, modB_D, modB_E, modB_F, modB_G, modB_H)
mod.namesB_1 <- c('B_A', 'B_B', 'B_C', 'B_D', 'B_E', 'B_F', "B_G", "B_H")
aictab(cand.set = modelsB_1, modnames = mod.namesB_1) -> AIC_Table3B

modavg(parm = c("(Intercept)"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgIntercept_B

modavg(parm = c("Employment"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgEmployment_B

modavg(parm = c("Q27"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgHousehold_B

modavg(parm = c("Q33TOTAL"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgIncome_B

modavg(parm = c("Q30"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgEducation_B

modavg(parm = c("R3_TypeRetained"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgR3Retained_B

modavg(parm = c("R3_TypeRecruit"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgR3Recruit_B

modavg(parm = c("permit_type_combDay"), cand.set = modelsB_1, modnames =
mod.namesB_1) -> Mod_avgPermitDay_B

modavg(parm = c("permit_type_combMulti_Year"), cand.set = modelsB_1, modnames =
mod.namesB_1) -> Mod_avgPermitMulti_B

modavg(parm = c("Q28"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgFishMember_B

modavg(parm = c("Age"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgAge_B

```

```
modavg(parm = c("sexMale"), cand.set = modelsB_1, modnames = mod.namesB_1) ->
Mod_avgSex_B
```

```
ModelTest |>
```

```
  mutate(retained = ifelse(R3_Type == "Retained", 1, 0),
         recruited = ifelse(R3_Type == "Recruit", 1, 0),
         day = ifelse(permit_type_comb == "Day", 1, 0),
         MY = ifelse(permit_type_comb == "Multi_Year", 1, 0),
         M = ifelse(sex == "Male", 1, 0),
         Emp_pred = 0.03 * Employment,
         HS_pred = -0.12 * Q27,
         GI_pred = -0.04 * Q33TOTAL,
         Edu_pred = -0.15 * Q30,
         Ret_pred = 0.26 * retained,
         Rec_pred = -0.28 * recruited,
         Day_pred = -0.87 * day,
         MY_pred = 0.41 * MY,
         FM_pred = 0.25 * Q28,
         Age_pred = -0.004 * Age,
         M_pred = 0.24 * M,
         Intercept = 3.13) -> ModelTest1
```

```
ModelTest1 %>%
```

```
  mutate(Expected = rowSums(ModelTest1[,46:57])) -> ModelTest2
```

```
ggplot(data = ModelTest2) +
```

```
  geom_point(aes(x = Fishing, y = Expected)) +
```

```

scale_x_continuous(limits = c(0,5)) +
scale_y_continuous(limits = c(0,5)) +
geom_abline(slope = 1) +
geom_smooth(method = "lm", aes(x = Fishing, y = Expected), se = FALSE) +
theme_pubr()

```

Revised AIC After Defense -----

```
df_filtered %>%
```

```
  mutate(Age = 2019 - Q32) -> dat # Converted the year born column in the survey to a new
column for the anglers age.
```

Employment status will be on a scale of 0 to 7, due to anglers being in multiple categories

```
dat %>%
```

```
  mutate(Q29A = ifelse(Q29A == 1, 4, Q29A)) -> dat # Converted the full time employee to a rank
of 4
```

```
dat %>%
```

```
  mutate(Q29B = ifelse(Q29B == 1, 2, Q29B)) -> dat # Converted the part time employee to a
rank of 2
```

```
dat %>%
```

```
  mutate(Q29C = ifelse(Q29C == 1, 0, Q29C)) -> dat # Converted the retired employee to a rank
of 0
```

```
dat %>%
```

```
  mutate(Q29E = ifelse(Q29E == 1, 1, Q29E)) -> dat # Converted the student employee to a rank
of 1
```

```
dat %>%
```

```
mutate(Q29E = ifelse(Q29D == 1, 0, Q29D)) -> dat # Converted the unemployed to a rank of 0
```

```
dat %>%
```

```
  rowwise() %>%
```

```
    mutate(Employment = sum(across(Q29A: Q29E))) -> dat # Combined the employment status
    questions from the survey data into a new column called Employment and summed the total
  summary(dat$Employment)
```

```
dat %>%
```

```
  mutate(Generation = case_when(
    Q32 >= 1995 ~ "Gen Z",
    Q32 >= 1980 ~ "Millennial",
    Q32 >= 1965 ~ "Gen X",
    Q32 >= 1946 ~ "Baby Boomer",
    Q32 >= 1925 ~ "Silent Gen")) -> dat
```

```
dat %>%
```

```
  select(-Q1A: -Q1B, -Q6A: -Q20, -Ice_Fishing: -Q26OTH, -urbanization_groups, -permit_year,
    -complete_survey) -> AICdatRev
```

```
AICdatRev %>%
```

```
  mutate(Fishing = log(Fishing + 1)) -> AICdatRev # Transformed the days spent fishing into a
  base log format. Natural log. To complete inverse equation is exp(log fishing) - 1.
```

```
AICdatRev <- AICdatRev %>%
```

```
  mutate(permit_type_comb = case_match(permit_type,
    "2019 Resident 1-Day Fish" ~ "Day",
    "2019 Resident 3-Day Fish" ~ "Day",
    "2019 Resident Annual Fish" ~ "Annual",
```

```

    "2019 Resident Lifetime (age 46+) Fish" ~ "Multi_Year",
    "3YR 2019-21 Resident Fish" ~ "Multi_Year",
    "5YR 2019-23 Resident Fish" ~ "Multi_Year",
    "2019 Non-Resident 1-Day Fish" ~ "Non-Resident",
    "2019 Non-Resident Annual Fish" ~ "Non-Resident",
    .default = permit_type)) %>%

  filter(permit_type_comb != "Non-Resident")# Combined the permit types into different
  categories. Non resident license holders removed.

unique(AICdat$permit_type_comb)

# AICdat <- AICdat %>%

# mutate(fish_history = ifelse(fish_history == 0, NA, fish_history)) %>%

# mutate(License_history = ifelse(License_history == 0, NA, License_history)) # There were 0
values in the license history and those values got turned to NA

AICdatRev <- AICdatRev %>%

mutate(Urban_Area = case_when(
  Q31 == 68022 ~ "West",
  Q31 == 68116 ~ "West",
  Q31 == 68164 ~ "West",
  Q31 == 68134 ~ "North",
  Q31 == 68142 ~ "West",
  Q31 == 68122 ~ "North",
  Q31 == 68152 ~ "North",
  Q31 == 68112 ~ "North",
  Q31 == 68104 ~ "North",
  Q31 == 68111 ~ "North",
  Q31 == 68110 ~ "North",

```

Q31 == 68132 ~ "Central",
 Q31 == 68131 ~ "Central",
 Q31 == 68102 ~ "Central",
 Q31 == 68106 ~ "Central",
 Q31 == 68105 ~ "Central",
 Q31 == 68108 ~ "Central",
 Q31 == 68118 ~ "West",
 Q31 == 68154 ~ "West",
 Q31 == 68114 ~ "Central",
 Q31 == 68130 ~ "Southwest",
 Q31 == 68144 ~ "Southwest",
 Q31 == 68124 ~ "Central",
 Q31 == 68135 ~ "Southwest",
 Q31 == 68137 ~ "Southwest",
 Q31 == 68127 ~ "Central",
 Q31 == 68136 ~ "Southwest",
 Q31 == 68138 ~ "Southwest",
 Q31 == 68128 ~ "South",
 Q31 == 68046 ~ "South",
 Q31 == 68117 ~ "Central",
 Q31 == 68107 ~ "Southeast",
 Q31 == 68157 ~ "Southeast",
 Q31 == 68133 ~ "South",
 Q31 == 68147 ~ "Southeast",
 Q31 == 68123 ~ "Southeast",
 Q31 == 68005 ~ "Southeast",
 Q31 == 68113 ~ "Southeast",

)) # Groups zip codes into groups for the urban area as described by Game and Parks

```

AICdatRev %>%
  select(ID, p2015: p2019) %>%
  pivot_longer(p2015: p2019, names_to = "year", values_to = "value") %>%
  mutate(year = gsub("p", "", year),
         year = as.numeric(year)) %>%
  filter(value != 0) %>%
  group_by(ID) %>%
  summarise(minyear = min(year),
            nyears = length(year)) %>%
  ungroup() %>%
  mutate(R3_Type = case_when(minyear == 2019 & nyears == 1 ~ "Recruit",
                             minyear != 2019 & nyears == 5 ~ "Retained",
                             minyear != 2019 & nyears < 5 ~ "Reactivated")) %>%
  select(ID, R3_Type) %>%
  inner_join(AICdatRev, join_by("ID")) -> AICdatRev # R3 coding for license history

```

```

AICdatRev %>%
  mutate(Q27 = replace(Q27, ID == 32250, 7),
         Q27 = replace(Q27, ID == 33015, 6),
         Q27 = replace(Q27, ID == 33265, 6),
         Q27 = replace(Q27, ID == 34240, 6),
         Q27 = replace(Q27, ID == 36158, 6),
         Q27 = replace(Q27, ID == 38097, 6),
         Q27 = replace(Q27, ID == 31209, 5),
         Q27 = replace(Q27, ID == 31227, 5),
         Q27 = replace(Q27, ID == 33124, 5),
         Q27 = replace(Q27, ID == 35198, 5),
         Q27 = replace(Q27, ID == 35378, 5),
         Q27 = replace(Q27, ID == 36338, 5),

```

```
Q27 = replace(Q27, ID == 37328, 5),  
Q27 = replace(Q27, ID == 38013, 5),  
Q27 = replace(Q27, ID == 38382, 5),  
Q27 = replace(Q27, ID == 31239, 4),  
Q27 = replace(Q27, ID == 31279, 4),  
Q27 = replace(Q27, ID == 32038, 4),  
Q27 = replace(Q27, ID == 32091, 4),  
Q27 = replace(Q27, ID == 32257, 4),  
Q27 = replace(Q27, ID == 33182, 4),  
Q27 = replace(Q27, ID == 33216, 4),  
Q27 = replace(Q27, ID == 33242, 4),  
Q27 = replace(Q27, ID == 33380, 4),  
Q27 = replace(Q27, ID == 34040, 4),  
Q27 = replace(Q27, ID == 34362, 4),  
Q27 = replace(Q27, ID == 37311, 4),  
Q27 = replace(Q27, ID == 37340, 4),  
Q27 = replace(Q27, ID == 31159, 3),  
Q27 = replace(Q27, ID == 31324, 3),  
Q27 = replace(Q27, ID == 32021, 3),  
Q27 = replace(Q27, ID == 32033, 3),  
Q27 = replace(Q27, ID == 32239, 3),  
Q27 = replace(Q27, ID == 32260, 3),  
Q27 = replace(Q27, ID == 33049, 3),  
Q27 = replace(Q27, ID == 33386, 3),  
Q27 = replace(Q27, ID == 34082, 3),  
Q27 = replace(Q27, ID == 34230, 3),  
Q27 = replace(Q27, ID == 35021, 3),  
Q27 = replace(Q27, ID == 35042, 3),  
Q27 = replace(Q27, ID == 35232, 3),
```

```
Q27 = replace(Q27, ID == 35238, 3),
Q27 = replace(Q27, ID == 35300, 3),
Q27 = replace(Q27, ID == 35366, 3),
Q27 = replace(Q27, ID == 36041, 3),
Q27 = replace(Q27, ID == 37072, 3),
Q27 = replace(Q27, ID == 37156, 3),
Q27 = replace(Q27, ID == 37193, 3),
Q27 = replace(Q27, ID == 37302, 3),
Q27 = replace(Q27, ID == 37314, 3),
Q27 = replace(Q27, ID == 38046, 3),
Q27 = replace(Q27, ID == 38182, 3),
Q27 = replace(Q27, ID == 31026, 2),
Q27 = replace(Q27, ID == 31359, 2),
Q27 = replace(Q27, ID == 32299, 2),
Q27 = replace(Q27, ID == 33091, 2),
Q27 = replace(Q27, ID == 33179, 2),
Q27 = replace(Q27, ID == 33197, 2),
Q27 = replace(Q27, ID == 33266, 2),
Q27 = replace(Q27, ID == 34067, 2),
Q27 = replace(Q27, ID == 34161, 2),
Q27 = replace(Q27, ID == 34163, 2),
Q27 = replace(Q27, ID == 34188, 2),
Q27 = replace(Q27, ID == 34214, 2),
Q27 = replace(Q27, ID == 34313, 2),
Q27 = replace(Q27, ID == 34323, 2),
Q27 = replace(Q27, ID == 34377, 2),
Q27 = replace(Q27, ID == 35092, 2),
Q27 = replace(Q27, ID == 35109, 2),
Q27 = replace(Q27, ID == 35281, 2),
```

```
Q27 = replace(Q27, ID == 35358, 2),
```

```
Q27 = replace(Q27, ID == 35369, 2),
```

```
Q27 = replace(Q27, ID == 37227, 2),
```

```
Q27 = replace(Q27, ID == 37334, 2),
```

```
Q27 = replace(Q27, ID == 38132, 2),
```

```
Q27 = replace(Q27, ID == 38140, 2),
```

```
Q27 = replace(Q27, ID == 38157, 2),
```

```
Q27 = replace(Q27, ID == 38258, 2)) -> AICdatRev # Adjusting values within household size  
due to swaps with Q27OTH
```

```
AICdatRev %>%
```

```
mutate(Q27OTH = replace(Q27OTH, ID == 32250, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 33015, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 33265, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 34240, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 36158, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 38097, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 31209, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 31227, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 33124, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 35198, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 35378, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 36338, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 37328, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 38013, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 38382, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 31239, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 31279, 0),
```

```
  Q27OTH = replace(Q27OTH, ID == 32038, 0),
```

Q27OTH = replace(Q27OTH, ID == 32091, 0),
Q27OTH = replace(Q27OTH, ID == 32257, 0),
Q27OTH = replace(Q27OTH, ID == 33182, 0),
Q27OTH = replace(Q27OTH, ID == 33216, 0),
Q27OTH = replace(Q27OTH, ID == 33242, 0),
Q27OTH = replace(Q27OTH, ID == 33380, 0),
Q27OTH = replace(Q27OTH, ID == 34040, 0),
Q27OTH = replace(Q27OTH, ID == 34362, 0),
Q27OTH = replace(Q27OTH, ID == 37311, 0),
Q27OTH = replace(Q27OTH, ID == 37340, 0),
Q27OTH = replace(Q27OTH, ID == 31159, 0),
Q27OTH = replace(Q27OTH, ID == 31324, 0),
Q27OTH = replace(Q27OTH, ID == 32021, 0),
Q27OTH = replace(Q27OTH, ID == 32033, 0),
Q27OTH = replace(Q27OTH, ID == 32239, 0),
Q27OTH = replace(Q27OTH, ID == 32260, 0),
Q27OTH = replace(Q27OTH, ID == 33049, 0),
Q27OTH = replace(Q27OTH, ID == 33386, 0),
Q27OTH = replace(Q27OTH, ID == 34082, 0),
Q27OTH = replace(Q27OTH, ID == 34230, 0),
Q27OTH = replace(Q27OTH, ID == 35021, 0),
Q27OTH = replace(Q27OTH, ID == 35042, 0),
Q27OTH = replace(Q27OTH, ID == 35232, 0),
Q27OTH = replace(Q27OTH, ID == 35238, 0),
Q27OTH = replace(Q27OTH, ID == 35300, 0),
Q27OTH = replace(Q27OTH, ID == 35366, 0),
Q27OTH = replace(Q27OTH, ID == 36041, 0),
Q27OTH = replace(Q27OTH, ID == 37072, 0),
Q27OTH = replace(Q27OTH, ID == 37156, 0),

Q27OTH = replace(Q27OTH, ID == 37193, 0),
Q27OTH = replace(Q27OTH, ID == 37302, 0),
Q27OTH = replace(Q27OTH, ID == 37314, 0),
Q27OTH = replace(Q27OTH, ID == 38046, 0),
Q27OTH = replace(Q27OTH, ID == 38182, 0),
Q27OTH = replace(Q27OTH, ID == 31026, 0),
Q27OTH = replace(Q27OTH, ID == 31359, 0),
Q27OTH = replace(Q27OTH, ID == 32299, 0),
Q27OTH = replace(Q27OTH, ID == 33091, 0),
Q27OTH = replace(Q27OTH, ID == 33179, 0),
Q27OTH = replace(Q27OTH, ID == 33197, 0),
Q27OTH = replace(Q27OTH, ID == 33266, 0),
Q27OTH = replace(Q27OTH, ID == 34067, 0),
Q27OTH = replace(Q27OTH, ID == 34161, 0),
Q27OTH = replace(Q27OTH, ID == 34163, 0),
Q27OTH = replace(Q27OTH, ID == 34188, 0),
Q27OTH = replace(Q27OTH, ID == 34214, 0),
Q27OTH = replace(Q27OTH, ID == 34313, 0),
Q27OTH = replace(Q27OTH, ID == 34323, 0),
Q27OTH = replace(Q27OTH, ID == 34377, 0),
Q27OTH = replace(Q27OTH, ID == 35092, 0),
Q27OTH = replace(Q27OTH, ID == 35109, 0),
Q27OTH = replace(Q27OTH, ID == 35281, 0),
Q27OTH = replace(Q27OTH, ID == 35358, 0),
Q27OTH = replace(Q27OTH, ID == 35369, 0),
Q27OTH = replace(Q27OTH, ID == 37227, 0),
Q27OTH = replace(Q27OTH, ID == 37334, 0),
Q27OTH = replace(Q27OTH, ID == 38132, 0),
Q27OTH = replace(Q27OTH, ID == 38140, 0),

```

Q27OTH = replace(Q27OTH, ID == 38157, 0),

Q27OTH = replace(Q27OTH, ID == 38258, 0)) -> AICdatRev # Adjusting values within
Q27OTH to equal 0

AICdatRev %>%

  filter(zip != 51503) %>%

  filter(zip != 51510) %>%

  filter(zip != 57367) %>%

  filter(zip != 66207) %>%

  filter(zip != 68003) -> AICdatRev # Removed respondents with a zip code outside of our survey
frame.

AICdatRev %>%

  mutate(Q33TOTAL = ifelse(Q33TOTAL == 0, NA, Q33TOTAL)) %>%

  mutate(Q30 = ifelse(Q30 == 0, NA, Q30)) -> AICdatRev # Made non response values from 0 to
NA

AICdatRev %>%

  filter(!is.na(Q30)) %>%

  filter(!is.na(Q33TOTAL)) -> AICdatRev # Removed NA angler responses from the Education and
Income variables.

AICdatRev %>%

  dplyr::mutate(permit_type_comb = str_replace(permit_type_comb, "Multi Year",
"Multi_Year")) -> AICdatRev

AICdatRev$Tapestry <- factor(AICdatRev$Tapestry, levels = Esri_custom_order)

mod1rev <- glm(Fishing ~ Tapestry, data = AICdatRev) # Esri Urbanization Group model for days
fished

summary(mod1rev)

```

```
tapply(AICdatRev$Fishing, AICdatRev$Tapestry, median) # Median values for urbanization
groups of anglers for the boxplots. Met median = 2.772589, Pri median = 2.397895, Sub median
= 2.564949, and Urb = 3.044522
```

```
ggplot(data = mod1_1) + # Days spent fishing box plot for each urbanization group
  geom_boxplot(aes(x = Tapestry, y = Fishing)) +
  labs(x = "Urbanization Group", y = "Avidity(log(days fished))") +
  annotate("text", x = "Met", y = 6, label = 14) +
  annotate("text", x = "Pri", y = 6, label = 10) +
  annotate("text", x = "Sub", y = 6, label = 15) +
  annotate("text", x = "Urb", y = 6, label = 18) +
  theme_pubr() -> Avidity_Esri_box_thesis
```

```
ggsave(Avidity_Esri_box_thesis, filename = "Avidity_Esri_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod2rev <- glm(Fishing ~ sex, data = AICdatRev) # Sex model for days fished
summary(mod2rev)
```

```
tapply(AICdatRev$Fishing, AICdatRev$sex, median) # Median values for sex of anglers for the
boxplots. Female median = 24.99741, male median = 59.23645
```

```
ggplot(data = mod2_1) + # Days spent fishing box plot for sex.
  geom_boxplot(aes(x = sex, y = Fishing)) +
  labs(x = "Sex", y = "Avidity (log(days fished))") +
  annotate("text", x = "Female", y = 6, label = 10) +
  annotate("text", x = "Male", y = 6, label = 15) +
  theme_pubr() -> Avidity_sex_box_thesis
```

```
ggsave(Avidity_sex_box_thesis, filename = "Avidity_sex_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod3rev <- glm(Fishing ~ Age + Employment + Q27, data = AICdatRev) # Life stage model for
days fished containing age, employment, and household size
```

```
summary(mod3rev)
```

```
as.data.frame(tapply(AICdatRev$Fishing, AICdatRev$Age, median)) -> Median_Age_Numbers_1
# Median values for age of anglers for the boxplots.
```

```
Median_Age_Numbers_1 %>%
```

```
  rename("Median" = "tapply(AICdatRev$Fishing, AICdatRev$Age, median)") %>%
```

```
  mutate(Median = exp(Median)-1) -> Median_Age_Numbers_1
```

```
tapply(AICdatRev$Fishing, AICdatRev$Employment, median) # Median values for employment
of anglers for the boxplots.
```

```
tapply(AICdatRev$Fishing, AICdatRev$Q27, median) # Median values for household size of
anglers for the boxplots.
```

```
ggplot(data = mod3_1) +
```

```
  geom_boxplot(aes(group = Employment, x = Employment, y = Fishing)) +
```

```
  labs(x = "Employment Status", y = "Avidity (log(days fished))") +
```

```
  annotate("text", x = 0, y = 6, label = 10) +
```

```
  annotate("text", x = 1, y = 6, label = 10) +
```

```
  annotate("text", x = 2, y = 6, label = 10) +
```

```
  annotate("text", x = 4, y = 6, label = 15) +
```

```
  annotate("text", x = 5, y = 6, label = 45) +
```

```
  annotate("text", x = 6, y = 6, label = 3) +
```

```
  theme_pubr() -> Avidity_employment_box_thesis # Box plot representing days fished with
employment status.
```

```
ggsave(Avidity_employment_box_thesis, filename = "Avidity_employment_box_thesis.png",
path = "C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units =
"in")
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Q27, x = Q27, y = Fishing)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6, 7, 8, 11), y = 6,
          label = c(15, 12, 12, 20, 14, 10, 10, 3, 0, 1)) +
  labs(x = "Additional Household Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_household_box_thesis
```

```
ggsave(Avidity_household_box_thesis, filename = "Avidity_household_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod3_1) +
  geom_boxplot(aes(group = Age, x = Age, y = Fishing)) +
  annotate("text", x = c(20, 25, 30,
                        35, 40, 45, 50, 55, 60, 65,
                        70, 75), y = 6,
          label = c(7, 20, 20, 10, 24, 6, 30, 11, 20, 6, 4, 40)) +
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
  theme_pubr() -> Avidity_age_box_thesis
```

```
ggsave(Avidity_age_box_thesis, filename = "Avidity_age_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod4rev <- glm(Fishing ~ Q33TOTAL + Q30, data = AICdatRev) # Socioeconomic model for days
fished containing household gross income and education.
```

```
summary(mod4rev)
```

```
tapply(AICdatRev$Fishing, AICdatRev$Q33TOTAL, median)
```

```
tapply(AICdatRev$Fishing, AICdatRev$Q30, median)
```

```
ggplot(data = mod4) +
```

```
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL), color = "black", fill =  
  "springgreen4") +
```

```
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
```

```
    label = c(7, 30, 14, 15, 20, 16, 12, 10, 14, 10, 6)) +
```

```
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
```

```
  theme_mine() -> Avidity_income_box # Box plot representing days fished with household gross  
income.
```

```
ggsave(Avidity_income_box, filename = "Avidity_income_box.png", path =
```

```
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4_1) +
```

```
  geom_boxplot(aes(x = Q33TOTAL, y = Fishing, group = Q33TOTAL)) +
```

```
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11), y = 6,
```

```
    label = c(9, 30, 14, 15, 20, 15, 12, 10, 14, 10, 6)) +
```

```
  labs(x = "Age", y = "Avidity (log(days fished + 1))") +
```

```
  labs(x = "Household Gross Income", y = "Avidity (log(days fished))") +
```

```
  theme_pubr() -> Avidity_income_box_thesis
```

```
ggsave(Avidity_income_box_thesis, filename = "Avidity_income_box_thesis.png", path =
```

```
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4) +
```

```
  geom_boxplot(aes(x = Q30, y = Fishing, group = Q30), color = "black", fill = "springgreen4") +
```

```
  annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,
```

```
    label = c(35, 20, 20, 20, 10, 10, 3)) +
```

```
labs(x = "Education Status", y = "Avidity (log(days fished))") +  
theme_mine() -> Avidity_education_box # Box plot representing the days fished with education  
status.
```

```
ggsave(Avidity_education_box, filename = "Avidity_education_box.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod4_1) +  
geom_boxplot(aes(x = Q30, y = Fishing, group = Q30)) +  
annotate("text", x = c(1, 2, 3, 4, 5, 6, 7), y = 6,  
label = c(40, 20, 20, 20, 10, 10, 3)) +  
labs(x = "Education Status", y = "Avidity (log(days fished))") +  
theme_pubr() -> Avidity_education_box_thesis
```

```
ggsave(Avidity_education_box_thesis, filename = "Avidity_education_box_thesis.png", path =  
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod5rev <- glm(Fishing ~ permit_type_comb + Q28 + R3_Type, data = AICdatRev)# Participation  
model containing license purchase history, license bought, and fishing members in household  
summary(mod5rev)
```

```
tapply(AICdatRev$Fishing, AICdatRev$permit_type_comb, median)  
tapply(AICdatRev$Fishing, AICdatRev$Q28, median)  
tapply(AICdatRev$Fishing, AICdatRev$R3_Type, median)
```

```
ggplot(data = mod5_1) +  
geom_boxplot(aes(x = permit_type_comb, y = Fishing, group = permit_type_comb)) +  
annotate("text", x = c("Day", "Annual", "Multi Year"), y = 6,  
label = c(3, 15, 20)) +  
labs(x = "Fishing Permit Purchased", y = "Avidity (log(days fished))") +
```

```
theme_pubr() -> Avidity_permit_box_thesis
```

```
ggsave(Avidity_permit_box_thesis, filename = "Avidity_permit_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28), color = "black", fill = "springgreen4") +
  labs(x = "Family Fishing Members", y = "Avidity (log(days fished))") +
  theme_mine_presentation() -> Avidity_fishingmember_box
```

```
ggsave(Avidity_fishingmember_box, filename = "Avidity_fishingmember_box.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = Q28, y = Fishing, group = Q28)) +
  annotate("text", x = c(0, 1, 2, 3, 4, 5, 6), y = 6,
    label = c(10, 12, 20, 15, 17, 5, 12)) +
  labs(x = "Additional Family Fishing Members", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_fishingmember_box_thesis
```

```
ggsave(Avidity_fishingmember_box_thesis, filename =
"Avidity_fishingmember_box_thesis.png", path = "C:/Users/k4han/OneDrive/Desktop/Master
Project Data", width = 9, height = 6, units = "in")
```

```
ggplot(data = mod5_1) +
  geom_boxplot(aes(x = R3_Type, y = Fishing, group = R3_Type)) +
  annotate("text", x = c("Recruit", "Retained", "Reactivated"), y = 6,
    label = c(6, 20, 12)) +
  labs(x = "R3 Type", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_R3_box_thesis
```

```
ggsave(Avidity_R3_box_thesis, filename = "Avidity_R3_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod6rev <- glm(Fishing ~ Urban_Area, data = AICdatRev) # Urban area as defined by NGPC
fisheries biologists.
```

```
summary(mod6rev)
```

```
tapply(AICdatRev$Fishing, AICdatRev$Urban_Area, median)
```

```
ggplot(data = mod6_1) +
  geom_boxplot(aes(x = Urban_Area, y = Fishing, group = Urban_Area)) +
  annotate("text", x = c("Central", "North", "South", "Southeast", "Southwest", "West"), y = 6,
    label = c(13, 20, 15, 20, 10, 10)) +
  labs(x = "Urban Area", y = "Avidity (log(days fished))") +
  theme_pubr() -> Avidity_Urban_box_thesis
```

```
ggsave(Avidity_Urban_box_thesis, filename = "Avidity_Urban_box_thesis.png", path =
"C:/Users/k4han/OneDrive/Desktop/Master Project Data", width = 9, height = 6, units = "in")
```

```
mod7rev <- glm(Fishing ~ sex + Age + Employment + Q27 +
  Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28 + Urban_Area, data =
AICdatRev, na.action = na.pass) # Global model without urbanization group
summary(mod7rev)
```

```
mod8rev <- glm(Fishing ~ 1, data = AICdatRev) # Null model
summary(mod8rev)
```

```
modelsRev <- list(mod1rev, mod2rev, mod3rev, mod4rev, mod5rev, mod6rev, mod8rev)
```

```
mod.names <- c('Urbanization Groups', 'Sex', 'Life Stage', 'Socioeconomic', 'Participation', 'Urban
Area', "Null")
```

```
aictab(cand.set = modelsRev, modnames = mod.names) -> AIC_TableRev
```

```
write.csv(AIC_TableRev, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_TableRev.csv", row.names = FALSE, )
```

```
dredge(mod7rev) -> Globalmodrev
```

```
model.sel(Globalmodrev) -> AIC_TableRev2 # Parsimonious AIC with all groups except
Urbanization Groups
```

```
write.csv(AIC_TableRev2, "C:/Users/k4han/OneDrive/Desktop/Master Project
Data/AIC_TableRev2.csv", sep = " ", row.names = FALSE, )
```

```
model_performance(mod7_1)
```

```
model_performance(mod5_1)
```

```
modArev <- glm(Fishing ~ sex + Q27 +
               Q30 + R3_Type + permit_type_comb + Q28, data = AICdatRev, na.action = na.pass)
summary(modArev)
```

```
modBrev <- glm(Fishing ~ sex + Q27 +
               Q30 + R3_Type + permit_type_comb + Q28 + Q33TOTAL, data = AICdatRev, na.action =
na.pass)
summary(modBrev)
```

```
modCrev <- glm(Fishing ~ sex + Q27 + Employment +
               Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = AICdatRev, na.action =
na.pass)
summary(modCrev)
```

```
modDrev <- glm(Fishing ~ sex + Age + Q27 +
               Q30 + R3_Type + permit_type_comb + Q28, data = AICdatRev, na.action = na.pass)
summary(modDrev)
```

```
modErev <- glm(Fishing ~ sex + Employment + Q27 +
               Q30 + R3_Type + permit_type_comb + Q28, data = AICdatRev, na.action = na.pass)
summary(modErev)
```

```
modFrev <- glm(Fishing ~ sex + Age + Q27 +
               Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28, data = AICdatRev, na.action =
na.pass)
summary(modFrev)
```

```
models_1rev <- list(modArev, modBrev, modCrev, modDrev, modErev, modFrev)
mod.names_1rev <- c('A', 'B', 'C', 'D', 'E', 'F')
aictab(cand.set = models_1rev, modnames = mod.names_1rev) -> AIC_Tablerev3
```

```
modavg(parm = c("Intercept"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevIntercept
```

```
modavg(parm = c("Employment"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevEmployment
```

```
modavg(parm = c("Q27"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevHousehold
```

```
modavg(parm = c("Q33TOTAL"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevIncome
```

```
modavg(parm = c("Q30"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevEducation
```

```
modavg(parm = c("R3_TypeRetained"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevR3Retained
```

```
modavg(parm = c("R3_TypeRecruit"), cand.set = models_1rev, modnames = mod.names_1rev) -
> Mod_avgrevR3Recruit
```

```

modavg(parm = c("permit_type_combDay"), cand.set = models_1rev, modnames =
mod.names_1rev) -> Mod_avgrevPermitDay

modavg(parm = c("permit_type_combMulti_Year"), cand.set = models_1rev, modnames =
mod.names_1rev) -> Mod_avgrevPermitMulti

modavg(parm = c("Q28"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevFishMember

modavg(parm = c("Age"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevAge

modavg(parm = c("sexMale"), cand.set = models_1rev, modnames = mod.names_1rev) ->
Mod_avgrevSex

# Revised Avidity Fitness Test Defense -----

#sample_n(AICdat3, 647) -> Build_Model

xrev <- 1:694 # Total sample size. 555 anglers will be used to build the model (80%), 139 (20%)
anglers used to validate

set.seed(47)

filter_setRev <- sample(x, 139)

AICdatRev %>%
  filter(row_number() %in% filter_setRev) -> ModelTestRev

AICdatRev %>%
  filter(!row_number() %in% filter_setRev) -> ModelBuildRev

ModelBuildRev$Tapestry <- factor(ModelBuildRev$Tapestry, levels = Esri_custom_order)

modB_1rev <- glm(Fishing ~ Tapestry, data = ModelBuildRev) # Esri Urbanization Group model
for days fished

summary(modB_1rev)

```

```
modB_2rev <- glm(Fishing ~ sex, data = ModelBuildRev) # Sex model for days fished
summary(modB_2rev)
```

```
modB_3rev <- glm(Fishing ~ Age + Employment + Q27, data = ModelBuildRev) # Life stage model
for days fished containing age, employment, and household size
summary(modB_3rev)
```

```
modB_4rev <- glm(Fishing ~ Q33TOTAL + Q30, data = ModelBuildRev) # Socioeconomic model
for days fished containing household gross income and education.
summary(modB_4rev)
```

```
modB_5rev <- glm(Fishing ~ permit_type_comb + Q28 + R3_Type, data = ModelBuildRev)#
Participation model containing license purchase history, license bought, and fishing members in
household
summary(modB_5rev)
```

```
modB_6rev <- glm(Fishing ~ Urban_Area, data = ModelBuildRev) # Urban area as defined by
NGPC fisheries biologists.
summary(modB_6rev)
```

```
modB_7rev <- glm(Fishing ~ sex + Age + Employment + Q27 +
                Q33TOTAL + Q30 + R3_Type + permit_type_comb + Q28 + Urban_Area, data =
ModelBuildRev, na.action = na.pass) # Global model without urbanization group
summary(modB_7rev)
```

```
modB_8rev <- glm(Fishing ~ 1, data = ModelBuildRev) # Null model
summary(modB_8rev)
```

```
modelsBrev <- list(modB_1rev, modB_2rev, modB_3rev, modB_4rev, modB_5rev, modB_6rev,
modB_8rev)
```

```
mod.namesBrev <- c('Urbanization Groups', 'Sex', 'Life Stage', 'Socioeconomic', 'Participation',
'Urban Area', "Null")
```

```
aictab(cand.set = modelsBrev, modnames = mod.namesBrev) -> AIC_TableBrev
```

```
write.csv(AIC_Table1_1, "C:/Users/k4han/OneDrive/Desktop/Master Project  
Data/AIC_Table1_1.csv", row.names = FALSE, )
```

```
dredge(modB_7rev) -> GlobalmodBrev
```

```
model.sel(GlobalmodBrev) -> AIC_Table2Brev # Parsimonious AIC with all groups except  
Urbanization Groups
```

```
write.csv(AIC_Table2_1, "C:/Users/k4han/OneDrive/Desktop/Master Project  
Data/AIC_Table2_1.csv", sep = " ", row.names = FALSE, )
```

```
model_performance(mod7_1)
```

```
model_performance(mod5_1)
```

```
modB_Arev <- glm(Fishing ~ sex + Q27 + Q33TOTAL +  
                 Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuildRev, na.action = na.pass)  
summary(modB_Arev)
```

```
modB_Brev <- glm(Fishing ~ sex + Q27 + Employment +  
                 Q30 + R3_Type + permit_type_comb + Q28 + Q33TOTAL, data = ModelBuildRev,  
                 na.action = na.pass)  
summary(modB_Brev)
```

```
modB_Crev <- glm(Fishing ~ sex + Q27 + Age + Q33TOTAL +  
                 Q30 + R3_Type + permit_type_comb + Q28, data = ModelBuildRev, na.action = na.pass)  
summary(modB_Crev)
```

```
modelsB_1rev <- list(modB_Arev, modB_Brev, modB_Crev)
```

```
mod.namesB_1rev <- c('B_A', 'B_B', 'B_C')
```

```
aictab(cand.set = modelsB_1rev, modnames = mod.namesB_1rev) -> AIC_Table3Brev
```

```
modavg(parm = c("(Intercept)"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgIntercept_Brev
```

```
modavg(parm = c("Employment"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) -
> Mod_avgEmployment_Brev
```

```
modavg(parm = c("Q27"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgHousehold_Brev
```

```
modavg(parm = c("Q33TOTAL"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgIncome_Brev
```

```
modavg(parm = c("Q30"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgEducation_Brev
```

```
modavg(parm = c("R3_TypeRetained"), cand.set = modelsB_1rev, modnames =
mod.namesB_1rev) -> Mod_avgR3Retained_Brev
```

```
modavg(parm = c("R3_TypeRecruit"), cand.set = modelsB_1rev, modnames =
mod.namesB_1rev) -> Mod_avgR3Recruit_Brev
```

```
modavg(parm = c("permit_type_combDay"), cand.set = modelsB_1rev, modnames =
mod.namesB_1rev) -> Mod_avgPermitDay_Brev
```

```
modavg(parm = c("permit_type_combMulti_Year"), cand.set = modelsB_1rev, modnames =
mod.namesB_1rev) -> Mod_avgPermitMulti_Brev
```

```
modavg(parm = c("Q28"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgFishMember_Brev
```

```
modavg(parm = c("Age"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgAge_Brev
```

```
modavg(parm = c("sexMale"), cand.set = modelsB_1rev, modnames = mod.namesB_1rev) ->
Mod_avgSex_Brev
```

```
ModelTestRev |>
```

```
  mutate(retained = ifelse(R3_Type == "Retained", 1, 0),
         recruited = ifelse(R3_Type == "Recruit", 1, 0),
         day = ifelse(permit_type_comb == "Day", 1, 0),
         MY = ifelse(permit_type_comb == "Multi_Year", 1, 0),
```

```

M = ifelse(sex == "Male", 1, 0),
Emp_pred = 0.02 * Employment,
HS_pred = -0.12 * Q27,
GI_pred = -0.07 * Q33TOTAL,
Edu_pred = -0.1 * Q30,
Ret_pred = 0.27 * retained,
Rec_pred = -0.46 * recruited,
Day_pred = -0.8 * day,
MY_pred = 0.53 * MY,
FM_pred = 0.29 * Q28,
Age_pred = 0 * Age,
M_pred = 0.3 * M,
Intercept = 3.12) -> ModelTestRev1

```

```
ModelTestRev1 %>%
```

```
  mutate(Expected = rowSums(ModelTestRev1[,46:57])) -> ModelTestRev2
```

```

ggplot(data = ModelTestRev2) +
  geom_point(aes(x = Fishing, y = Expected)) +
  scale_x_continuous(limits = c(0,5)) +
  scale_y_continuous(limits = c(0,5)) +
  geom_abline(slope = 1) +
  geom_smooth(method = "lm", aes(x = Fishing, y = Expected), se = FALSE) +
  labs(x = "Responded (log(days fished))", y = "Expected (log(days fished))") +
  theme_pubr()

```