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Do changing resource conditions displace anglers? A study of contingent travel behaviors and substitution patterns on Minnesota's North Shore

by

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A thesis submitted in fulfillment of the requirements for the degree of Master of Science

Recreation Resource Management

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Abstract

Angling in Minnesota's North Shore faces unique threats from the impacts of climate change. These impacts, such as changes in the presence and/or abundance of specific species, present management challenges which might also influence the demand for recreational angling throughout the region. Anglers' adaptations to climate change in the North Shore region could shift densities, timing, and spatial use of the region's fish populations, increasing the stress on ecological systems. Developing an empirically-grounded understanding of the contingent behaviors of anglers is imperative if the region's fish populations are to be managed sustainably. Using a travel cost model, we measured the demand for angling under current conditions and a range of future climate and environmental conditions. Our research also explores the adaptive and coping behaviors of anglers. We tested the substitution of anglers against non-anglers to determine if anglers exhibit sensitivities in their contingent behaviors. Results imply anglers to the North Shore would not alter their trip-taking behavior under any of the future climate and environmental conditions presented. However, anglers are willing to substitute recreation settings, and even their participation in the activity, in response to future climate and environmental conditions. These substitution patterns are significantly different than those reported by non-anglers. This study provides empirical evidence of substitution behavior amongst anglers in response to shifts in environmental and climatic conditions. Further research is needed to understand why anglers' future trip-taking behaviors are not responsive to changes in climate and environmental conditions, though their substitution behaviors are. Our findings can be used to help managers maintain the satisfaction, experiences, and participation of future generations of anglers.

1. Introduction

Uncertainty about the effects of global climate change on local environmental conditions presents numerous challenges to both outdoor recreation professionals and fisheries managers (Arent et al., 2014; Gössling et al., 2012; Gössling and Hall, 2006; Nicholls, 2006; Scott and Lemieux, 2010). Climate-altered resource conditions pose particularly notable challenges for outdoor recreation activities, such as angling, that are dependent upon the quality and/or quantity of those resources. Research on how anglers will respond to climate-altered environmental conditions can provide a better understanding of how, or if, managers need to prepare themselves for future shifts in the demand for angling. In this research, we use downscaled climate change projections, (a statistical procedure to localize climate predictions from global climate models) to describe varying scenarios of future climate and environmental conditions likely to be experienced across Minnesota's North Shore. We use these scenarios to elicit North Shore anglers' contingent trip taking behavior (i.e., stated behavior), comparing seasonal trip counts with anglers' current trip taking behavior (i.e., revealed behavior). Our investigation attempts to discern if North Shore anglers are likely to change their trip taking behavior under altered climate and environmental conditions. Our research also uses anglers' responses to several Likert-type question to ascertain more specifically *how* North Shore anglers' trip taking behavior will be altered.

Specifically, there is a notable gap in the fisheries management literatures focused on quantifying the behavioral responses of anglers to climate change (Hunt et al., 2016). This is perhaps surprising given climate change is expected to bring dramatic changes to North American fisheries. Inland recreational fisheries are certain to experience impacts from changing climatic conditions. Hunt et al. (2016) identified three major pathways in which climate change

can impact inland angling: (1) altered environmental conditions that affect fish and thus, fishers; (2) altered environmental conditions that directly affect fish; and (3) changes to environmental policies that influence fishers. Generally, research in inland fisheries has focused on the first of these pathways – the impacts of climate change to fish populations and habitat (Lamborn and Smith, 2019). For example, numerous analyses have suggested a relationship between climate change and the distribution of species in freshwater environments. In North America, climate change is projected to have severe impacts on temperature sensitive species, with temperature tolerant species affected less so (Alofs and Jackson, 2015; Eby et al., 2014; Johnson and Evans, 1990; Lynch et al., 2016; Whitney et al., 2016). Cold water species more tolerant to temperature increases, as well as warm water species less tolerant to temperature increases may shift their distribution to relatively cooler environments, replacing and in some cases displacing sensitive native species. Little research to date has examined the complete impact that resource conditions, altered by climate change, can have on angling behavior (Hunt et al., 2016; Jones et al., 2013; Lamborn and Smith, 2019; Pendleton and Mendelsohn, 1998). By investigating changes in angling participation as a result of climate-altered environmental conditions, our investigation can begin to build the literature base on how climate change impacts anglers directly.

Looking beyond the fisheries management literature, research from the broader outdoor recreation management literature has demonstrated the demand for outdoor recreation and tourism is sensitive to both weather and climate (Maddison, 2001). Several studies have found outdoor recreationists' adaptations to climate change include substituting the location, timing, and even the preferred activity of outdoor recreation trips (Amelung et al., 2007; Bigano et al., 2006; Hamilton et al., 2005). Anglers may incur additional costs in adapting their behaviors as a result of the effects of climate change on ecosystems. For example, the substitution of locations

may introduce additional costs to anglers through increased drive times to reach angling streams with coldwater fish species (DeWeber and Wagner, 2015).

Climate-induced ecological stresses on fisheries, coupled with the potential for the altered behaviors of anglers, results in unique challenges to fisheries managers. An important step in mitigating and managing the potential impacts of climate change in communities with robust recreational fishing industries is to understand the behavioral adaptations and responses of anglers. The purpose of our research is to develop a better understanding of the demand for angling under current conditions and a range of potential future climate and environmental conditions in an area with a robust recreational fishing industry – Minnesota's North Shore. Additionally, we investigate the adaption/coping behaviors of anglers under altered climate and environmental conditions. Specifically, we investigate three types of substitution behaviors anglers can take in response to altered climate and environmental conditions; these are: (1) site substitution; (2) activity substitution; and (3) temporal substitution. By understanding the responses of North Shore anglers to changes in climate and environmental conditions, we hope to offer guidance in the management, development, and sustainability of the region's fisheries.

2. Literature Review

2.1 Travel Behavior Responses to Climate Change

Within the outdoor recreation behavior literature, contingent behavior refers to the stated behaviors that individuals make in response to hypothetical scenarios describing the future conditions of a recreation setting. Previous research on anglers' contingent behaviors has explored behavioral responses to shifting costs and environmental quality (Eiswerth et al., 2008; Englin and Cameron, 1996). Eiswerth, Kashian, and Skidmore (2008) used data collected from surveys given to anglers on-site to analyze the benefit of changing water quality on a Wisconsin

Lake. Utilizing a travel cost model, the authors found deterioration to the site's water quality, measured as a reduction in water clarity, lead to dramatic losses in anglers' consumer surplus (net economic value). Englin and Cameron (1996) conducted a survey of Nevada anglers that combined actual angling trips with stated trips given changes in the expense of the angling trip. The authors tested the validity and response of consumer surplus estimates to variations in model specifications (e.g., fixed effects vs. non-fixed effects models, and a pooled revealed and stated preference model vs. a panel model). The research suggests using panel model specifications with fixed effects for the repeated measures of the respondent's reported trips provide robust estimates by controlling for the potential unobserved heterogeneity of individual anglers (i.e., preferences and demographics) and by reducing omitted variable bias.

Englin and Camerson (1996) go on to note interpretations of individuals' contingent trip-taking behaviors are best understood and more robust when grounded in data on their actual travel behaviors; these data are known as individuals' *revealed* preferences. The combination of *revealed* and *stated* preferences has previously been utilized to capture the benefits anglers receive from changes in site conditions. Specifically, Eiswerth et al. (2000) collected both revealed preference data and stated preference data to assess the impact of alternate water levels on trips to Walker Lake in Northwestern Nevada. A large proportion of their survey sample was comprised of anglers. Respondents were provided with information on baseline conditions and one randomly-selected scenario describing a rise in water levels at the lake. The authors found higher water levels were associated with an increase in intended trip-taking behavior. More recently, revealed and stated trip-taking data have been used to quantify the benefits of changes in fish quality to anglers. Deely, Hynes, and Curtis (2019) combined data on actual trip counts with stated trip-taking behaviors, collected via surveys, to understand the effects of changes in

the presence of fish species on the average consumer surplus of anglers to a lake in Ireland. The study found increases in the presence of fish species increased anglers' marginal benefits between 25% and 50%.

A small, but growing, body of work has elicited individuals' stated trip-taking behaviors in response to projected climate and environmental conditions, in combination with data on past trips (Hestetune et al., 2018; Loomis and Richardson, 2006; Perry et al., 2018; Richardson and Loomis, 2004; Smith et al., 2016).

The first of these studies were conducted by Richardson and Loomis (2004) and Loomis and Richardson (2006), who estimated changes in park visitors' trip-taking behaviors due to changes in the park's climate and subsequent changes in resource conditions (e.g., the presence of wildlife). Of particular interest to our work is the researchers' 2006 study which combined revealed preference data in the form of monthly park visitation, with a survey assessing visitors' reported annual visitation and intended visitation under several hypothetical scenarios, to estimate changes in future visitation attributable to the changes described in the scenarios. More specifically, visitors were presented with a description of typical summer conditions (derived from historical average temperatures, precipitation, and snow depth in Rocky Mountain National Park) and two hypothetical scenarios describing potential future conditions (derived from the Colorado Climate Center and Hadley global climate change scenarios). The hypothetical scenarios described a greater numbers of days with temperatures above 26.7°C (80°F) and a greater number of days with more than 0.635 cm (0.25 in.) of precipitation, relative to current conditions. Respondents were asked about how many trips they would take to Rocky Mountain National Park under the hypothetical conditions (visit more often, visit less often, or make no change to their number of trips) and about the intended length of their stay during future visits

(stay longer, stay shorter, or no change to trip duration). Under the hypothetical scenarios, visitors indicated they would take more trips and stay longer in the Park. A regression model of historical visitation responses to past climatic fluctuations in conjunction with estimates from stated visitation under forecasted climatic fluctuations demonstrated intended behavior for the two scenarios fell within the 95% confidence interval of actual behavioral responses to climatic shifts. The research suggests potential increases in visitation to northern latitude, high elevation, parks as a response to increasing temperatures; it also suggests data on stated trip-taking behaviors can be a reasonable surrogate for revealed preference data.

More recent work by Perry et al. (2018) has explored the impacts of climate change on the travel behavior of visitors to three Vermont State Parks. The researchers used a range of climatic conditions (average high temperatures, average low temperatures, number of days above 90°F degrees, and number of rainy days per week) and environmental conditions (increases in biting insects and pest species) projected through the year 2100 to elicit changes in trip-taking behavior relative to observed behaviors of park visitors. Respondents were surveyed about their spatial and temporal adaptive behaviors. Given projected conditions described in the survey, individuals were asked to indicate whether they would shift their visitation to different locations (cooler northern parks, warmer southern parks, or would no change), shift their visitation to higher elevations (parks at cooler/higher elevations, parks at warmer/lower elevation, or no change), and/or if they would visit state parks at different times of the year (earlier in the season, later in the season, or no change). The study found warmer high temperatures, colder low temperatures, increases in rainy days per week, and increases in biting insects resulted in estimates of decreased visitation. Additionally, changing climate and environmental conditions contributed to visitors' intention to change the location and timing of their trips as well as the

activities they participated in during the trip. The researchers concluded future demand would shift to more northerly parks and parks at higher elevations in the region and shift participation away from some recreational activities towards others. The impact of increased daytime temperatures, increased nighttime temperatures, and more days with a temperature greater than 32.2°C (90°F) were found to have no impact on angling. However, increases in the number of rainy days per week and increases in the number of biting insects were found to decrease participation in angling.

Most directly related to this study are two pieces of analysis specifically focused on contingent trip-taking behavior of outdoor recreationists on the North Shore. Smith et al. (2016) and Hestetune et al. (2018) collected data on contingent trip-taking behavior using scientifically-grounded projections of the region's future climate and environmental conditions (projected through the year 2035). Visitors were presented with both recent and forecasted climate and environmental conditions (e.g., average daily temperatures, average daily wind chill, average daily precipitation, etc.) and environmental conditions (e.g., average snow depth, average daily ice thickness of inland lakes, fire risk, and fish presence in inland streams, etc.) and asked how many total trips they had made over the most recent winter (December 1, 2014 to February 28, 2015) and summer (June 1 to August 31, 2015) seasons and how many trips they would make under forecasted conditions presented in the survey. For both studies, the researchers found visitors to the North Shore would take similar numbers of trips under projected climate and environmental conditions as they currently do. The results of Hestetune and his colleagues' work on summer visitation in conjunction with Smith and his colleagues' work on winter visitation suggest altered conditions affected visitation similarly across different seasons for the same year. This analysis goes beyond the work of Hestetune et al. (2018) and Smith et al. (2016) by taking a

focused look at just the contingent trip-taking behavior of anglers; both previous studies did not discriminate between different types of outdoor recreation activities occurring within the region.

2.2 Survey Date Temperature

Our investigation also examines if anglers experience additional sensitivities to survey date temperature that may influence their contingent trip-taking behaviors. Climate change opinion research suggests the temperature on the date an individual takes a survey is positively correlated with their beliefs in global warming (Deryugina, 2013; Egan and Mullin, 2012; Hamilton and Stampone, 2013; Joireman et al., 2010; Li et al., 2011; Zaval et al., 2014). Building on this research, Hestetune and his colleagues (2018) introduced a survey date temperature variable into a study of visitors to Minnesota’s North Shore to test what influence the variable had on respondents’ contingent trip-taking behavior; a hypothesis that had not previously been explored in contingent behavior research. Despite the empirical evidence from numerous climate change opinion studies that survey date temperature influences beliefs in global warming, Hestetune et al. found no relationship between survey date temperature and contingent trip-taking behavior. Our investigation extends the work of Hestetune et al. (2018) by disaggregating anglers from other types of outdoor recreationists to determine if they are more sensitive to survey date temperature effects.

2.3 Place Meanings

Our investigation also examines the influence that anglers’ cognitive bonds to a specific place, the North Shore, affect their contingent behaviors under a climate-altered future. “Place” is a multi-faceted perception of the significance of a location along a combination of emotional, psychological, spiritual, functional, and physical bonds; these perceptions influence the attitudes, preferences, behaviors, and experiences of outdoor recreationists (Manning, 2011). In the

outdoor recreation literature, the concept of place attachment has commonly been used; it is most often measured along two primary dimensions, place identity and place dependence (Budruk et al., 2008; Williams and Roggenbuck, 1989; Williams and Vaske, 2003). Place identity is “the emotional and symbolic aspect” of an individual’s relationship to a place; while place dependence describes the “functional attachment” to a location as it relates to goals and needs (Manning, 2011). The meanings individuals ascribe to a place are considered the foundation of place attachment (Davenport and Anderson, 2005; Stedman, 2003). The concept of place attachment has expanded to include a broader set of affective meanings individuals associate with a place; these range from functional meanings (e.g., the place provides the only available activity resource) to intangible meanings (e.g., the place provides a sense of belonging). These broader characterizations of place attachment have been measured through robust psychometric scales that contextualize place meanings into multiple dimensions including, family identity, individual identity, community identity, ecological meanings, economic meanings, self-efficacy, and self-expression. Research has shown that these place meanings are both valid and generalizable over diverse social and geographic extents (Smith et al., 2011).

A number of studies have explored the degree to which anglers’ emotional attachments to a setting (e.g., a river) influence their behaviors (Hammitt et al., 2006, 2004; Oh et al., 2013). Broadly, recreation research suggests that place attachment has a moderating impact on the substitution behaviors of recreationists, where greater place attachment decreases the willingness to substitute sites (Oh et al., 2013). Gentner and Sutton (2008) proposed that the willingness of anglers to substitute sites is influenced by not only by the perceptions of similarity between the substitute site and their preferred site but also by their psychological attachment to their preferred site. Further supporting the theory, Oh and colleagues (2013) demonstrated a relationship

between place attachment and anglers’ perceptions of site substitutability in a study of freshwater anglers in Texas where both place dependence and place identity were found to influence anglers’ perceptions of site substitution via specialization. Additionally, the researchers found place identity directly and negatively influenced the willingness of anglers to substitute sites.

Previous research has explored the effect of place attachment on anglers’ visitation related behaviors, specifically their ‘experience use history’ (Budruk et al., 2008; Hammitt et al., 2009, 2004)[1]. The influence of place attachment has further been utilized to understand visitation behaviors in recreation demand models where support has been found for a relationship between an individual’s place attachment and revealed (Hailu et al., 2005) and stated (Smith et al., 2010) trip-taking behaviors. Hailu et al. (2005) and Smith et al. (2010) both found evidence for place identity as a strong, positive predictor of an individual’s trip-taking behavior. Two studies of summer visitation (Hestetune et al., 2018) and winter visitation (Smith et al., 2016) to Minnesota’s North Shore found support for the moderating influence of various place meanings on the contingent trip-taking behaviors of visitors to the region. Both studies found a positive relationship between individual identity and the intended number of trips a recreationist said they would take in the future. Past research has suggested place identity to be a stronger and more dominating predictor than most other dimensions of place (Hammitt et al., 2009). Current results from recreation demand models incorporating dimensions of place meanings also seem to suggest place identity has a stronger and more consistent influence on recreation behavior

[1] Experience use history is a multidimensional concept that includes dimensions of past visitation and levels of participation in an activity or/and at a site. The theory proposes that an individual’s exposure to a place positively corresponds with the attachments that individual develops for the place (Hammitt et al., 2004). Research has shown mixed to weak relationships between place attachment and experience use history (Budruk et al., 2008; Hammitt et al., 2009).

relative to the other dimensions of place meanings (e.g., place dependence, family meanings, etc.).

2.4 Substitution

The concept of substitution in the outdoor recreation literature refers to the extent to which one recreation setting or activity could be a comparable substitute for another recreation setting or activity (Manning, 2011, p. 231). Substitution has been broadly developed to include substitution along dimensions of location, activity, and time. Current research suggests outdoor recreationists may substitute where, when, and what activities they participate in to achieve comparable recreation experiences (Aas and Onstad, 2013; Brunson and Shelby, 1993; Miller and McCool, 2003; Schneider and Wynveen, 2015). Individuals typically choose to substitute when opportunities are constrained (e.g., through changes in site conditions, crowding, or conflict among other recreationists). Our investigation specifically focuses on three types of substitution: (1) spatial substitution; (2) activity substitution; and (3) temporal substitution.

2.4.1 Spatial Substitution

Recreationists make spatial substitution decisions when their preferences for desired settings are constrained (Brunson and Shelby, 1993). Originally developed in recreation planning to conceptualize the allocation of recreation resources, where the demand for recreation settings exceeds the supply (Cordell, 1976), the theory has been more broadly constructed to capture substitution behaviors resulting from site conditions unrelated to the density of users (i.e., environmental conditions). Spatial substitution among anglers has received specific attention in the outdoor recreation literature (Hammitt et al., 2004). Research on fly-anglers in Oregon along the Metolious river investigated what anglers would do if they could not participate in angling on that particular river (Manfredo and Anderson, 1987). Intended to elicit the willingness of anglers

to substitute activities, 95% percent of the anglers revealed they would simply continue to fish but choose another river. Shelby and Vaske (1991), in a study of salmon anglers in New Zealand, explored the willingness of anglers to substitute sites on a nearby river for their preferred sites on another river. The respondents indicated travel distance, expenses, and lower presence of salmon decreased the potential substitutability of nearby sites. Decisions made about whether sites closer to anglers' preferred sites were likely substitutes were related to angling conditions and the presence of their target species, salmon. Based on the tradeoffs of potential site substitutes, the authors suggest substitute sites did not provide an equivalent value to anglers. These decisions may be unrelated to resource conditions and a function of the attachments anglers develop with the habitual use of a site (Hammitt et al., 2004). Thus, the willingness of anglers to substitute an alternative site over a preferred one is likely related to both their attachment to the original site and their perception of the equivalence of the substitute site (Gentner and Sutton, 2008). Hammitt, Backland, and Bixler (2006) postulated the importance of attributes for site substitution among trout anglers along the Chattooga National Wild and Scenic River was a function of angler heterogeneity, specifically experience in terms of time and frequency of use of substitute sites. The authors found the most important quality when choosing a substitute site for anglers was related to water quality, with anglers choosing to substitute to higher quality rivers. Anglers also rated scenery, number of other anglers, and number of fish, as important considerations when choosing a substitute site.

2.4.2 Activity Substitution

Activity substitution has received significant attention in the outdoor recreation literature, with initial research dating back to the mid-1970s (Hendee and Burdge, 1974; Iso-Ahola, 1986; Manning, 2011). The earliest literature focused on the comparability of outdoor recreation

activities and how different activities may be related. Contemporarily, activity substitution is understood as the interchangeability between outdoor recreation activities as it relates to individuals' avoidance of constraints on their preferred activity. Research on activity substitution has identified many factors which influence a recreationists intention to substitute activities; these include place attachment, experience use history, and specialization (Manning, 2011).

Research on activity substitution specifically focused on anglers has explored if there are any outdoor recreation activities which provide the same benefits as a fishing experience (Ditton and Sutton, 2004; Manfredo and Anderson, 1987; Shelby and Vaske, 1991). Ditton and Sutton (2004), in a study of anglers in Florida and Texas, explored the extent to which anglers were likely to substitute for other activities that would provide equivalent satisfaction and enjoyment as angling. The researchers also identified variables that contributed to anglers' substitution decisions; these included motivations (i.e., experience preferences), demographics, and participation variables. The results of Ditton and Sutton's study revealed anglers were nearly evenly split on their likelihood of substituting for other recreation activities that provided equivalent activity-general benefits, with 51% suggesting a willingness to substitute other activities for angling. The authors found stronger motivations were negatively related to a willingness to substitute other activities for angling. The authors also found a negative relationship between the importance anglers placed on the activity and their willingness to substitute in other activities. The results of this research suggest commitment to angling is an important factor that is likely negatively related to the willingness to engage in alternative activities.

2.4.3 Temporal Substitution

Temporal substitution is the process of shifting the timing of engagement in an outdoor recreation activity to avoid undesirable social or environmental conditions (Gentner and Sutton, 2008). Temporal substitution has been observed as a response to both crowding (Hall and Shelby, 2000) and degraded resource quality. Aas and Onstad (2013) examined the influence of streamflow, as a result of damming a river for hydroelectric power generation, on possible temporal substitution behaviors of salmon anglers in Central Norway. Anglers indicated periods of minimum flow impacted the availability of high-quality pools suitable for fishing. Anglers engaged in ad-hoc as well as planned temporal substitution behaviors, selecting for times on the river where conditions were favorable to their experience. The concept of temporal substitution has not received as much research as other dimensions of substitution and warrants further study to understand how and why temporal substitution occurs (Aas and Onstad, 2013).

3. Methods

3.1 Study Area

Minnesota's North Shore is located along the coast of Lake Superior; spanning an area between the city of Two Harbors and the Canadian border. The region is comprised of small communities surrounded by public lands. The local economies of these communities can be characterized as resource dependent, either through mining or nature-based tourism. Businesses, largely locally-owned, have developed to support the region's tourism, which sees significant visitation in the winter and summer seasons. Recreational opportunities are abundant throughout the region. These opportunities are provided by eight state parks, the Superior National Forest, a National Scenic Byway, 255 continuous miles of the 310-mile Lake Superior Hiking Trail, Grand Portage National Monument (managed by the National Park Service), and the Boundary Waters Canoe Area Wilderness. The eight state parks have averaged 1.6 to 1.8 million visitors

annually over the last 20 years (Kanazawa et al., 2018). For this study we have designated the North Shore as the area defined by the HUC-8 watersheds between the cities of Two Harbors and Grand Portage (Figure 1) (i.e., the Baptism-Brule and Beaver-Lester watersheds). The populations of human communities in our study area range from 176 to 3,666 residents.

The North Shore is located in the North Woods, a forested ecoregion spanning the northern Great Lakes. The ecology of the region is characterized by temperate broadleaf and mixed forests comprised of deciduous aspens, oaks, paper birches, mountain ash, maples as well as coniferous pines, spruces, firs, and junipers. Forest cover extends from the pebble beaches of Lake Superior (at 184 meters above sea level) to the rolling terrain of the Sawtooth Mountains in the North Shore Highlands, with the highest point along the coast reaching 515 meters above sea level at Moose Mountain. The climate of the region is typically warm and humid over the summer months and cold and snowy during winters.

The North Shore offers many angling opportunities ranging from Lake Superior to the region's many inland streams, rivers, and lakes. There are 34 species of fish native to the Lake Superior region, including the sport fisher's prized Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), Brook Trout (*Salvelinus fontinalis*), and Smallmouth Bass (*Micropterus dolomieui*). Introduced species present in the area include Coho Salmon (*Oncorhynchus kisutch*), Brown Trout (*Salmo trutta*), Rainbow Trout (*Oncorhynchus mykiss*), and White Perch (*Morone americana*).

3.2 Data Collection

Surveys were conducted at 22 locations along the North Shore. Survey sites included state parks, historic sites, scenic waysides, and local businesses. Locations for surveying were selected based on their accessibility (open for the season), representativeness spatially (locations

in the northern, middle, and southern regions of the shoreline) and recreationally (sites that draw both active and passive recreationists). Surveying for the summer season occurred between July 15 and August 3, 2015. Respondents intercepted at sampling locations were administered questionnaires using tablet computers loaded with off-line surveys. A total of 2,453 visitors were intercepted over the summer season; of these, 1,398 completed the questionnaire for a response rate of 57%.

3.3 Angler Characteristics

The questionnaire asked about anglers' sociodemographic characteristics, the strength of personal meanings they attach to the North Shore (i.e., place meanings), and their trip-taking behavior to the region. Sociodemographic data included age, gender, education, income, and home zip code. Home zip codes were used in the calculation of travel cost (computed by calculating the geodetic distance between an angler's zip code of origin and the sampling location where the survey occurred (Picard, 2012)). Place meanings were measured using nine statement items intended to measure three types of meaning (individual identity, family identity, and place dependence) an angler may ascribe to the North Shore. The specific statement items used were drawn from larger psychometric scales which have proved to be invariant across a diverse set of recreational activities and settings (Smith et al., 2011). Data on anglers' trip-taking behavior included the length (number of nights) of their current trip, additional recreational activities they have/or planned to participate in during the trip, their trip-related expenditures, and information on how long in advance they planned their current trip.

3.4 Revealed and Stated Trip-taking Behavior

Past trip-taking behavior was elicited by asking anglers about the number of trips they took, or planned to take, to the North Shore during the summer season of 2015. The

questionnaire described the summer season as the three-month period between June 1st and August 31st.

Contingent trip-taking behavior was elicited by asking anglers how many trips they would make to the North Shore given a specific set of future climate and environmental conditions. Each angler was presented with one randomly-chosen scenario (out of four total scenarios) that described different future climate and environmental conditions. They were asked to indicate the number of trips they would take to the North Shore region during the summer months under these hypothetical future conditions.

The four scenarios describing future climate and environmental conditions on the North Shore described the percent of days in a summer month where, the temperature was above the average high for the season (71°F), the percent of days in a summer month where the heat index was above 80°F, and the percent of days in a summer month where there was a ‘high’, ‘very high’, or ‘extreme’ fire risk. Importantly, they were also given information about the percent of streams in which Brook Trout and Smallmouth Bass would be present. The values used to characterize the future scenarios are shown in Table 1.

Future climate conditions were derived using a 10-model ensemble of Coupled Model Intercomparison Project Phase 5 (CMIP5) projections. The CMIP5 projections use a range of Representative Concentration Pathways (RCPs) that serve as potential future Greenhouse Gas emission trajectories. For the summer season, two scenarios were calculated using emissions under low trajectories (RCP2.6) and emissions under high trajectories (RCP8.5). Low and high scenarios were projected to the year 2035. Future fire risk was based on future levels of either: (1) ‘high’, ‘very high’, or ‘extreme’, fire risk; or (2) only ‘very high’, or ‘extreme’ fire risk.

Changes to the percent of inland streams with Brook Trout (57% reduction) and Smallmouth Bass (5% increase) present were constant across all four scenarios.

The questionnaire was designed so that anglers could see recent (2010-2014) climate and environmental conditions alongside future conditions. Because conditions presented in the future scenarios were not randomly generated, but developed from climate models, respondents were only shown one future scenario to reduce response bias. Figure 2 provides a sample questionnaire instrument for the contingent trip-taking question for one randomly generated future scenario.

3.5 Substitution

After being presented with altered climatic and environmental conditions, anglers were asked how likely they would be to substitute their behaviors given the future conditions presented in the hypothetical scenario. We specifically asked about site substitution ('Travel elsewhere on the North Shore to participate in the planned summer activity', 'Travel outside of the North Shore to participate in the planned summer activity'), activity substitution ('Stay on the North Shore but do something else'), and temporal substitution ('Cancel your trip, but reschedule during the summer season', 'Cancel your trip for the full summer season'). Anglers were also asked how likely they were to keep their plans the same under the future conditions (i.e., abstain from substitution behaviors) presented in the hypothetical scenario. Substitution questions from the survey were not mutually exclusive. Anglers were asked to respond to each substitution behavior question independently, without considering responses to other substitution behavior questions or by selecting questions that best characterized their responses to projected conditions. Responses were measured using a 5-point Likert-type scale ranging from '*Not at all likely*' to substitute, to '*Extremely likely*' to substitute.

3.6 Data Alterations

Of the 1,398 surveys completed by visitors, 182 (21%) were from outdoor recreationists who indicated on the questionnaire they had or would fish during the trip in which they were contacted. We use data from these 182 respondents in our analysis. We removed all responses from visitors who indicated the purpose of their trip was non-recreational given the assumption that recreation is the primary purpose of a respondent's trip in travel cost models (McConnell, 1985; Siderelis, 2001). We also removed individuals who had travelled from outside the country; did not complete the portions of the questionnaire asking about either the place of origin for their trip or report their income (used in the model travel cost calculation).

We truncated the trip counts variables at 3-standard deviations above the mean to remove respondents who reported taking excessive numbers of trips. The same threshold was used to truncate travel distance; a conservative approach to analysis of count data used in recreation economics (Blaine et al., 2015) which has been used in previous research on winter visitation to the North Shore region (Smith et al., 2016).

3.7 Data Analysis

We performed a factor analysis of a correlation matrix for the 9-item place meanings scale along three types of place meaning (individual identity, family identity, and place dependence) to produce principal factor scores for each dimension.

Data were organized into a panel format with five panels, the first panel indicating current (i.e., revealed) trip-taking behavior and panels two through five corresponding to anglers' contingent (i.e., stated) trip-taking responses under the altered climate and environmental scenarios. A travel cost model was constructed in which anglers' current and future trip counts served as the dependent variable. Five dummy variables were created to indicate each panel, four

dummy variables for the trip-taking behavior under future scenarios and one dummy variable for trip-taking behavior under current conditions. The dummy variable for anglers' revealed trip-taking behavior was the reference (i.e., omitted) category of the model. The panel structure allowed for the combination of revealed and stated trip-taking behavior, enabling us to analyze contingent behavioral responses while grounding them in observable (i.e., revealed) behaviors (Train, 2009).

After checking the distribution of the revealed and stated trip-taking variable we selected a Poisson distribution. One concern in using Poisson distributions (where the mean and variance are assumed to be equal) for count data is failing to account for overdispersion (where the variance is greater than the mean). In these cases, the negative binomial distribution is applied to account for the overdispersion. Incorrectly applying a Poisson distribution for overdispersed data will underestimate standard errors and increase the likelihood of a Type-1 error (Palmer et al., 2007). We tested both the revealed and stated trip-taking counts for overdispersion. Summary statistics suggest the counts of stated trips (M = 1.65, SD = 1.39) were overdispersed when compared with revealed trips (M = 1.64, SD = 1.02). However, a more robust test of overdispersion was conducted by regressing the trip-taking variables on the covariates to acquire the predicted number of trips ($\hat{y}$), generating $y^* = \frac{((y-\hat{y})^2-y)}{\hat{y}}$, and regressing y^*on $\hat{y}$ without a constant. The results of this test suggest our trip count variable was not overdispersed (Coef.. = -0.0934, S.E. = 0.1507, t = -0.62, p = 0.536). Consequently, we used the Poisson distribution.

Equation 1 gives the full formulation of the travel cost model.

Equation 1. Travel cost model of angler trips to Minnesota's North Shore

$$Y_{ij} = \mu + \beta_{1-4} climate\_scenario_{ij} + \beta_{5-7} place\_meanings_i + \beta_8 high\_temperature_i + \beta_9 income_i + \beta_{10} travel\_cost_i + \varepsilon_{ij}$$

The dependent variable Y_{ij} represents each individual angler's revealed and stated trip-taking counts. Independent variables include: dummy variables corresponding to the four projected future climatic and environmental conditions ($climate\_scenario_{ij}$); the principal factor scores for each of the three types of place meanings ($place\_meanings_i$); the maximum temperature for the day when the survey occurred ($high\_temperature_i$); the angler's income ($income_i$) and their travel cost ($travel\_cost_i$). Income is included in the model to control for the potential that individuals with different incomes make different travel choices, an appropriate assumption in travel cost modeling (Mendelsohn et al., 1994). The high temperature variable was used to test the hypothesis that temperature influences responses to surveys dealing with climate change. The travel cost model was fit with a population averaged Poisson model specification using the xtpoisson command in Stata 14.0 (StataCorp, 2015).

Responses to substitution questions were summarized and compared with non-anglers. A Pearson's χ^2-test was produced to empirically test if angler substitution was significantly different than non-anglers on the North Shore. A contingency table analysis indicated where angler substitution responses varied from non-anglers along five levels of likelihood to substitute behaviors (Cox, 2016). An alpha value of 0.05 was used to determine significant differences in responses (Beasley and Schumacker, 1995). A two-tailed t-test was also run to test if current and future trip-taking behaviors for anglers and non-anglers were significantly different.

4. Results

4.1 Angler Characteristics

Descriptive statistics of the explanatory variables are provided in Table 2. On average, North Shore anglers took between one and two trips to the region in the summer months of 2015 (M = 1.64, SD = 1.22). Across all four scenarios describing potential future climate and environmental conditions, anglers indicated a marginal increase in the amount of trips they would take to the region (M = 1.65, SD = 1.39).

North Shore anglers' socioeconomic and trip characteristics are provided in Table 3. Over 90% of anglers reported spending more than one night on the North Shore during visits over the summer season. The average angler spends 4.5 nights on the North Shore (SD = 3.64). Day trip anglers make up only a small proportion of overall anglers (4.95%). The average distance a day trip angler travels to the North Shore is significantly lower (M = 249.88 km (155.27 mi.), SD = 148.69 km (92.39 mi) than overnight anglers (M = 437.56 km (271.89 mi.), SD = 238.60 km (148.26 mi.)) (t = 2.33, p = 0.02). The shorter average distance day trip anglers travel to reach the North Shore suggests they are likely to come from communities adjacent to the region. Additionally, day trip anglers do not report significant differences in their current trip-taking behavior (M = 1.67, SD = 0.70) when compared with overnight anglers (M = 1.64, SD = 1.04) (t = -0.09, p = 0.93).

On average, anglers travelled 428.3 km (266.1 miles) to the North Shore (SD = 238.2 km), with an average individual travel cost (calculated as a function of the transportation costs plus the value of an anglers' time[2]) of USD $389.42 (SD = $256.55). The high travel cost values are indicative of the longer distances anglers travelled to reach the North Shore.

[2] Travel cost is calculated as

$$P = [(d \times 0.56) + (w \times h \times 0.33)] \times 2 \text{ , where}$$

A majority of anglers reported planning their trip more than a week in advance (79.12%). Just under a quarter (23.1%) of anglers spent between eight days and one month planning their trips to the North Shore, while a majority of anglers spent more than a month planning their trips (56.0%). The average total trip-related expenditures[3] of anglers were $955.43 (SD = $980.50).

4.2 Trip-Taking Behavior

A two-sample t-test of anglers' trip-taking behavior revealed no difference in trip-taking behavior from non-anglers. No significant differences were found between anglers and non-anglers' current trip taking behavior (t = -0.05, p = 0.96), or future trip-taking behavior (t = 0.83, p = 0.41). However, non-anglers did take significantly shorter trips to the North Shore (t = -4.28, p = 0.00). On average, non-anglers spent a total of 3.45 nights in the region while anglers spent an average of one additional night (M = 4.48). The results of the two-sample t-test for trip length suggests anglers on the North Shore spend a greater amount of time in the region during their stay.

Further exploration of the data showed significant differences in the distance anglers and non-anglers travelled to reach the North Shore (t = -2.49, p = 0.01). On average, anglers travelled

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d = the one distance from the centroid of an angler's home zip code to the point where the angler was intercepted; the value is multiplied by the by a per mile transportation cost of $0.56 (IRS, 2013).

w = hourly wage rate of a respondent; per Cesario (1976), income is divided by an annual 2080 work hours and multiplied by a fraction of wage rate to time of 0.33. 11 categories of median income values were presented to anglers. Categories for under $10,000 and more than $100,000 were assigned values of $10,000 and $100,000 respectively.

h = the hours of travel time to reach the site where anglers were intercepted, calculated as $(\frac{d}{54\ miles\ per\ hour} + 30\ minutes)$ where the addition of 30 minutes accounts for in-city driving.

[3] Total trip-related expenditures are calculated as the summation of trip expenditures (i.e., transportation, food and beverage, lodging, sporting goods, entertainment, retail, and other) divided by total anglers (n = 182).

a greater distance (M = 266.13) to reach the North Shore than non-anglers (M = 238.29). Anglers also had significantly larger group sizes relative to non-anglers ($t = -3.47$, $p \leq 0.001$). Non-anglers had an average of 3.16 members in their party while anglers reported marginally larger group sizes, with an average of 3.75 members.

Given the results of the difference in group size and distance, an additional two-sample t-test was conducted for travel cost as group sizes and distance are used in the calculation of an individual's travel cost. As expected, the results of this test revealed a significant difference between the travel costs of anglers versus non-anglers ($t = 2.06$, $p = 0.04$). Non-anglers had a greater average travel cost (M = $434.99 USD) than anglers (M = $389.43 USD). However, a Pearson's χ^2-test demonstrated no relationship between the income of anglers and non-anglers ($\chi^2 = 16.12$, $p = 0.09$). Additionally, there were no significant differences in trip purpose ('Recreation in this area', 'Recreation at a different area', 'Recreation at multiple locations') between anglers and non-anglers ($\chi^2 = 2.11$, $p = 0.35$).

4.3 Demand Model

The results of our analysis of contingent trip-taking behavior amongst anglers are presented in Table 5. Contingent trip-taking behavior was not significantly different than past trip-taking behavior at the 0.05 level for any of the future climate scenarios. These results are similar to those reported in previous research for contingent trip-taking behavior of all outdoor recreationists visiting the North Shore in winter (Smith et al., 2016) and summer (Hestetune et al., 2018).

Though previous research has found place meanings associated with the North Shore are significantly correlated with contingent trip-taking behavior, our analysis of anglers suggests these beliefs are not significant determinants of contingent trip-taking behaviors under current or

projected climate and environmental conditions. Hestetune et al. (2018) found contingent trip-taking behavior for aggregated summer visitation to the North Shore was strongly associated with individuals whose personal identities were more strongly tied to the region. Similarly, Smith et al. (2016) found several of the place meanings winter visitors' attach to the North Shore (specifically place dependence and family identity) were significantly and positively related to individuals' contingent trip-taking behavior.

Our analysis also revealed income was negatively associated with contingent trip-taking behavior amongst anglers (Coef. = -3.69e-06, S.E. = 1.66e-06, p = 0.026). These results suggest anglers with more disposable income are more likely to travel to areas outside the North Shore for angling opportunities given changes to the region's climate and environmental conditions.

The maximum daily high temperature on the day an angler was surveyed had no significant influence on their contingent travel behavior (Coef. = 0.013, S.E. = 0.007, p = 0.057). These results are consistent with those found for aggregated summer visitation to the North Shore (Hestetune et al., 2018). Both the conclusions of Hestetune and his colleagues and the findings of our study counter the body of previous research conducted on the influence of outdoor temperature on the day an individual completed a survey and their beliefs in global warming.

4.4 Substitution

The results of angler and non-angler substitution patterns given changes to the region's climate and environmental conditions are presented in Table 4. For the dimension of spatial substitution, 34.6% of anglers indicated they were not at all likely to travel elsewhere on the North Shore for their planned activity and 42.9% indicated they were not at all likely to travel outside of the North Shore for their planned activity as a result of the projected climate and

environmental conditions they were presented with. Anglers expressed a greater willingness to travel elsewhere on the North Shore than travelling outside the North Shore for their planned activities with 65.4% of anglers indicating they were *slightly* to *extremely* likely to engage in spatial substitution within the region.

Regarding activity substitution, a majority of anglers did indicate they were likely to substitute for a different activity on the North Shore with 68.7% indicating they were *slightly likely* to *extremely likely* to participate in different activities.

By comparison, anglers do not appear likely to engage in temporal substitution. Nearly two-thirds (64.3%) of anglers indicated they were *not at all likely* to cancel and reschedule future trips during the summer season and nearly three-fourths (74.7%) of anglers indicated they were *not at all likely* to cancel their trip for the full summer season.

We conducted Pearson's χ^2-tests and a contingency table analysis to determine if substitution behaviors of anglers differed significantly from non-anglers; results of the tests are shown in Table 5. Contingency table analysis tests whether the observations within a cell are statistically different than would be expected given a null hypothesis of no relationship between the groups being compared (anglers and non-anglers). Adjusted Standardized Residuals (ASRs) are assumed to have a standard deviation of 1 when no relationship (the null hypothesis) exists between groups (Lamborn et al., 2017). As a result, ASRs greater than 1.96 suggest the observed count within a cell is different than the expected count under the null hypothesis at the 0.05 level of significance. The results of the contingency table suggest there is a relationship between whether an individual is an angler and responses in two of the three substitution questions presented in the survey. For the dimension of spatial substitution, a relationship was found between anglers and non-anglers' stated substitution behaviors for whether they were willing to

travel elsewhere on the North Shore for their planned summer activity (χ^2 = 14.89, p = 0.01). A higher percentage of non-anglers indicated that they were *not at all likely* to travel elsewhere on the North Shore for their planned summer activities (ASR = ±2.15, p = 0.01). The percentage of anglers (17.6%) who were *very likely* to substitute spatially within the North Shore was more than twice as high as non-anglers (8.5%)(ASR = ±3.55, p = 0.01). In total, anglers expressed they were 8.9% more likely (summed total between *slightly* to *extremely likely* responses) to travel elsewhere on the North Shore for their planned summer activity.

Additionally, a relationship was found between anglers and non-anglers' stated temporal substitution behaviors for whether they would cancel their trip for the season (χ^2 = 14.89, p = 0.01). A marginally larger proportion of anglers (1.7%) were *extremely* likely to cancel their trip for the full summer season when compared with non-anglers (0.0%) (ASR = ±3.3, p = 0.01). Overall, anglers indicated they were more likely to engage in this type of temporal substitution, with anglers 6.1% more likely to cancel for the full summer season when compared with non-anglers.

The dimension of activity substitution showed no statistical differences between anglers and non-anglers.

5. Discussion

The purpose of our research was to understand the characteristics of anglers' trip-taking behavior and to identify how projected climate and environmental conditions would impact the demand for summer angling on the North Shore of Lake Superior. Additionally, we sought to develop a better understanding of North Shore anglers' substitution patterns given projected changes in climate and environmental conditions.

5.1 Trip-Taking Behavior

We found North Shore anglers' trip-taking behavior did not significantly differ from non-anglers. Anglers took a similar number of trips to the region during the summer of 2015 as non-anglers. Similarly, anglers reported they would take a comparable number of trips to the region under projected climate and environmental conditions when compared to non-anglers. The latter result suggests anglers do not exhibit additional sensitivity from changes in projected climate and environmental conditions relative to non-anglers.

One of the limitations in the study is that we cannot be certain about specific preferences of anglers or their motivations that may influence trip-taking behavior. Travel behaviors of anglers have been found to be variable given their heterogenous preferences. There is no average angler. Paudyal et al. (2015) demonstrated in a study of trout anglers in Georgia that trip-taking responses to a range of declines in trout presence from climate change varied along value orientations of anglers. Anglers who expressed greater protection (e.g., protection of resources is more important than providing fishing opportunities) and utilitarian (e.g., fishing is important for human well-being) values were found to have higher willingness to reduce or stop angling at sites with substantial reductions in trout presence than those with no or low value orientations. While a majority of anglers in our study indicated the presence of Brook Trout (63.7%) and the presence of Smallmouth Bass (65.9%) were not influential in their contingent trip-taking behavior under altered conditions, further research may identify heterogenous groups of anglers that respond differently to changes in the presence or abundance of target species. Smith et al. (2016) used a finite-mixture model of all recreationists visiting the North Shore region over the winter season to identify heterogeneous preferences in visitation patterns. The authors found a two-component solution that identified variations in trip-taking response along frequency of visitation to the North Shore and the directionality of future trip-taking behavior. Individuals

who made less frequent trips to the North Shore reported fewer future trips under altered conditions. Further research could work to identify heterogenous preferences amongst North Shore anglers.

Identifying different preferences amongst North Shore anglers could yield some insights into whether or not specific groups of anglers will respond to altered climatic and environmental conditions. For example, Arlinghaus et al. (2019) identified three classes of anglers in a choice experiment by asking anglers to allocate angling days among three fishing alternatives. The three classes of anglers varied along characteristics related to catch orientation (e.g., angler characteristics and attitudes), specialization (i.e., a multidimensional measurement encompassing behavioral commitment, skill, and psychological attachment to the activity), satisfaction, and behavioral commitment (e.g., enthusiasm). The three classes were broken out by level of commitment (most committed, intermediately committed, and least committed). The most committed groups were found to benefit from the size of fish. Intermediately committed groups were found to benefit from size and catch numbers. The least committed group were mostly indifferent to catch related aspects of the fishing experience. The design of our survey, by comparison to Arlinghaus' (2019) work, was meant to capture a wide array of activity types across the North Shore and not anglers specifically. Future research on angling across the North Shore may provide additional insight by tailoring surveys to anglers' values, preferences, and tastes, to identify heterogeneity. Identifying heterogeneous preferences are a valuable tool in management decisions.

5.2 Travel Behavior Responses to Climate Change

Our results revealed projected climate and environmental conditions on the North Shore are not likely to influence anglers' future trip-taking behavior. Estimates of future trips were not

significantly different than the number of trips anglers took during the summer of 2015. These results suggest that in the near term, anglers will take a similar number of trips under altered conditions than under current conditions. In conjunction with our analysis of anglers' temporal substitution responses to climate change scenarios these results show that both frequency and timing of visitation to the North Shore will remain relatively stable through 2035.

These results are similar to those found from previous research for all outdoor recreation activities across the North Shore for both winter (Smith et al., 2016) and summer seasons (Hestetune et al., 2018).

A limitation in our study of anglers in the North Shore is that the data is composed of individuals who indicated they participated or planned to participate in angling during their trip, but specific angling trips cannot be obtained from trip counts aggregated across an entire season. We only know respondents are anglers, not the proportion of their trips that constitute angling trips. Trip counts for angler participants may include counts of trips for other recreation activities. These activities encompass different motivations and preferences, which may contribute to their adaptive responses and trip-taking behavior where angling may not be their primary activity on the North Shore. Further research should investigate angling-specific trips to test for differences in sensitivities among primary activities.

Another possible limitation is that presence of Brook Trout and Smallmouth Bass had no variation over the four climate scenarios we presented to survey respondents. Variations in species presence could have identified tipping points where changes in the presence of a species could have produced significant changes in anglers' contingent trip-taking behavior. Though the presence of Smallmouth Bass increased slightly across the 4 scenarios, from 53% of inland streams currently having bass, to 58% having Bass under projected conditions, the presence of

Brook Trout decreased notably, from 77% percent under current conditions to 20% under future conditions. The large decreases in Brook Trout and marginal increases in Smallmouth Bass illustrate a shift from cold water species to warmer water species as the region's climate and environment begins to change, a consequence of rising temperatures. Even though the presence of Brook Trout experienced dramatic reductions under altered conditions (of over 50%), anglers may have felt the increase in the presence of Smallmouth Bass offset these changes when considering their visitation to the North Shore. The influence of both the presence of Brook Trout and Smallmouth Bass had little influence on anglers' future trip-taking behavior, suggesting a majority of anglers' visitation to the North Shore may not be motivated by these species.

We cannot be certain about what the impact of variable species presence may be on anglers without knowing how, or if, North Shore anglers value specific target species. Anglers may also be more concerned about catch rates, which they may not have realized are substantially diminished by changes in fish presence within inland streams. Historically, research has concluded non-catch motivations are more important than catch motivations of anglers. Recent research has indicated variations of these motivations along target species where large, trophy sized, species of fish elicited catch motivations among anglers (Beardmore et al., 2011). Future research could employ more tangible general impacts to anglers, such as catch rates per hour or other general experience quality metrics (e.g., fish size).

Future climatic and environmental conditions were also only projected through the year 2035; projections beyond 2035 would produce larger changes in both environmental and climatic conditions to the region. These more dramatic changes would have likely elicited greater changes in contingent trip-taking behavior to the North Shore. Anglers may not have believed the

climatic and environmental conditions presented (e.g., % days above the average high temperature, % of days with greater than .25 in. of rain, etc.) reached significant levels to influence their future plans to visit the region. Future research is needed to identify if critical thresholds from changes in conditions, specifically variations in species composition, would obtain changes in trip-taking behaviors of anglers.

5.3 On-site Temperature Effects

Previous research has tested if weather conditions on the day of the survey influenced recreationists responses regarding their future trip-taking behavior to the North Shore for all summer outdoor recreation activities (Hestetune et al., 2018). This work found no significant relationship between survey date temperature and contingent trip-taking behavior. This result ran counter to a body of research which suggests a positive correlation between outdoor temperature on the day an individual completes a survey and their beliefs in global warming (Deryugina, 2013; Egan and Mullin, 2012; Hamilton and Stampone, 2013; Joireman et al., 2010; Li et al., 2011; Zaval et al., 2014). The inclusion of this variable in our model was exploratory; though we expected sample date temperature would be negatively correlated with contingent trip-taking behavior. One potential explanation for the non-finding could be the temperatures recorded over the study period. The North Shore is a temperate, northern latitude climate that does not experience significantly warm temperatures during the summer months. Over the study period, the average temperature recorded in our data was 22.4°C (72.4°F) and maximum temperatures did not exceed 26.7°C (80°F). The vast majority (90%) of sampled days during the summer experienced temperatures below 25.6°C (78.1°F). Differences in temperature over the study period may not have been large enough to negatively influence anglers' contingent trip-taking behavior.

5.4 Substitution

Our analysis of substitution behaviors suggests the greatest willingness to substitute along two dimensions, spatial substitution and activity substitution. A greater proportion of anglers indicated they were *slightly likely* to *somewhat likely* to both travel elsewhere within (44%), and outside of (45.1%), the North Shore to participate in their planned activities than to not engage in spatial substitution within (34.6%) and outside (42.9%) the region. Further, a fifth of anglers indicated they were *very likely* (17.6%) to *extremely likely* (3.8%) to substitute for sites within the North Shore while 12.1% indicated they were *very likely* (10.4%) to *extremely likely* (1.6%) to substitute for sites outside of the North Shore. The substantial percentage of anglers willing to substitute sites suggest anglers on the North Shore consider site substitution a reasonable strategy for coping with changes in climate and environmental conditions. Considering the changes of fish composition for inland streams to the region, shifts from the cold-water guild Brook Trout to the more prevalent warm-water guild Smallmouth Bass, anglers may select for sites inside or outside of the North Shore where they feel opportunities for target species may not be significantly impacted. Shelby and Vaske (1991) found decisions about spatial substitution were likely to occur when alternate sites presented equivalent angling conditions to the preferred site and also held target species. Research has also shown site substitution is most common amongst anglers who are highly skilled or committed to their activities and do not place a lot of emphasis on where those activities occur (Aas and Onstad, 2013; Hammitt et al., 2004).

Our analysis also suggests anglers are willing to substitute for different activities on the North Shore. Only 31.3% of anglers indicated they would not engage in activity substitution on the North Shore. In total, a greater percentage of anglers suggested they were *slightly likely*

(15.4%) to *somewhat likely* (33%) to substitute activities, with a fifth of anglers indicating they were *very likely* (14.8%) to *extremely likely* (5.5%) to engage in activity substitution. Individuals generally select for substitute activities similar to their preferred activity (Vaske et al., 1983). However, the perceived number of available substitutes is negatively correlated with the importance placed on the attributes of the activity (Manfredo and Anderson, 1987). Shelby and Vaske (1991) demonstrated the benefits anglers receive from substitute activities are not equivalent to those of angling. The authors found that 38% of salmon anglers believe there is no substitute for salmon fishing; this suggests important consideration should be given to the satisfaction individuals receive from preferred outdoor recreation opportunities when considering alternatives. Though anglers may be willing to participate in other recreation activities on the North Shore under projected climate and environmental conditions, they may likely experience potential losses in satisfaction as opportunities for their preferred angling experience diminish.

Anglers did not indicate any willingness to engage in temporal substitution. Potential explanations are that anglers did not believe projected climate and environmental conditions would significantly impact their angling opportunities for the summer season in the region or that temporal shifts would not increase their potential opportunities. Given weather and climatic conditions in the region, anglers may also feel the preferred timing of their trip during the summer season provides the best window for angling whereas trips earlier or later in the year may provide less favorable conditions. Additionally, timing outside of summer may coincide with impacts to “ideal” times of the year to target specific species. Stream closures for Brook Trout on the North Shore occur between September 30th and April 13th. The summer visitation period occurred between June 1st and August 31st, a three-month period spanning the majority of the inland trout season. Anglers may be constrained by not only managerial decisions such as

stream closures, they may also be limited by the practicality of temporal substitution (Aas and Onstad, 2013). Many anglers first select when they are going to take a trip and then, based upon that decision, choose the setting which best allows them to achieve their goals (e.g., targeting specific species).

Our analysis revealed significant differences for site and temporal substitution patterns between anglers and non-anglers. A significantly greater proportion of non-anglers indicated they were *not at all likely* to travel elsewhere on the North Shore for their planned activity (+9%) while a significantly greater proportion of anglers indicated they were *very likely* to engage in spatial substitution within the North Shore (+9%) when compared with non-anglers. A significant though marginally larger proportion of anglers were also more *extremely likely* to temporally substitute by cancelling for the full summer season (+2%) when compared with non-anglers. Considering site substitution, angling is by nature a resource-dependent activity when compared to many other activities on the North Shore (e.g., hiking, biking). Anglers are limited by the presence of species and were presented with simple descriptions of likely changes in species presence. Anglers with catch-oriented motivations who are unconcerned with where they fish would be more likely to explore better opportunities to achieve their motivations. Non-anglers' willingness to engage in site substitution is not as necessary, given changes in the presence of trout or bass are less likely to impact their outdoor recreation experiences.

One potential explanation for anglers' greater willingness to engage in substitution behaviors when compared with non-anglers may be a result of differences found in the demographics of anglers and non-anglers. We found North Shore anglers were significantly younger than non-anglers. Around a quarter of anglers (25.8%) were between the ages of 25 to 34 in comparison to 15% of non-anglers (ASR = ±3.42, $p = 0.00$), while around a fifth of non-

anglers (21.4%) were between the ages of 55 and 64 in comparison with 8.8% of anglers (ASR = ±3.86, $p = 0.00$). The younger skew in angler demographics could indicate differences in experience use history with the North Shore; a variable which has been found to influence substitution behaviors (Manning, 2011). Experience use history is a function of past experiences which includes the total years of use for a site. Research has shown that experience use history negatively correlates with an individual's willingness to engage in substitution (Wynveen et al., 2008). Further, research has also found age is negatively related to an individual's willingness to engage in substitution behaviors (Ditton and Sutton, 2004; Tseng and Ditton, 2007). Anglers in our sample may demonstrate greater willingness to engage in substitution as a result of their generally younger age when compared with non-anglers. This may indicate lower levels of experience use history (a function of an individual's exposure to a site found to positively correlate to their place attachment) with specific sites along the North Shore for anglers. Further research could identify anglers' experience use history to understand the influence of experience on substitution behaviors; this research could capture vulnerable classes of anglers for targeted education and outreach efforts.

Additionally, our results revealed anglers travel a greater average distance to reach their destination when compared with non-anglers. This may suggest a greater ability to travel for anglers than non-anglers, where non-anglers could find the closest opportunities for their preferred activities are the only logistical option. Site substitution is common amongst individuals who are both highly committed to their activity and do not care where those activities take place (Aas and Onstad, 2013; Hammitt et al., 2004). Anglers may demonstrate higher levels of commitment to their activity, placing greater emphasis on factors such as species presence and catch rates, which they perceive as important to their experience.

6. Conclusion

In this research, we sought to increase our understanding of anglers' contingent trip-taking behavior in response to scientifically-based projections of future climate and environmental conditions on the North Shore. Our analysis builds upon previous analysis developed for general recreationists during the winter and summer seasons along the North Shore (Hestetune et al., 2018; Smith et al., 2016). Similar to these previous investigations, we found anglers' contingent trip-taking behavior was not significantly different from their revealed trip-taking behavior. This result was unexpected given the small body of research that has elicited contingent trip-taking behavior in response to projected climate and environmental conditions (Loomis and Richardson, 2006; Perry et al., 2018; Richardson and Loomis, 2004). One unique aspect of our research was the ability to test the sensitivity of North Shore anglers to changes in the presence of specific target species in the region. Our results indicate anglers do not experience any additional sensitivity to changing conditions than non-anglers.

In concurrence with the results reported by Hestetune et al. (2018) we also found the temperature on the day a survey was administered was not significantly related to anglers' contingent travel behavior. We theorize that because the North Shore is a generally mild and temperate climate during summer months, any potential threshold at which survey date temperatures begins to influence contingent travel behaviors for respondents was not reached.

Additionally, our research sought to understand how individuals cope, in this case substitute their behaviors, in response to projected conditions. A unique aspect of this research, that builds upon previous studies of winter and summer tourism on the North Shore, was that it sought to identify sensitivities of a specific user group to future climate and environmental

conditions. In our study we identified individuals who had participated or planned to participate in angling on the North Shore and compared their adaptive behaviors with non-anglers. We also constructed a demand model of angling on the North Shore. For substitution behaviors, we found anglers were more likely to travel elsewhere on the North Shore in response to future climate and environmental conditions; they were also more likely to cancel their plans for the full summer season in response to future climate and environmental conditions when compared with non-anglers. However, no difference in activity substitution behaviors were found between anglers and non-anglers. Overall, a majority of anglers indicated some level of willingness to engage in substitution for two of the dimensions of substitution, spatial substitution and activity substitution. However, a majority of anglers demonstrated they would not engage in temporal substitution given future climate and environmental conditions.

For managers, it is important to understand how visitor behavior changes in response to projected climate and environmental conditions. Anglers on the North Shore indicated they might engage in spatial and activity substitution in response to future conditions; however, they are unlikely to engage in temporal substitution. This result suggests anglers' perceptions of future climate and environmental conditions will not alter their intentions to visit the North Shore during the summer but could potentially lead to shifts in where and how they recreate along the North Shore. This raises potential concerns about crowding and conflict as visitation increases and anglers continue to disperse along or adjacent to the region to fish. A majority of anglers also expressed some level of willingness to participate in activities other than angling if projected conditions were to alter their angling opportunities. This suggests managers provide alternative outdoor recreation opportunities for displaced anglers where conditions may not promote continued angling in the region. Substituting other activities for angling may not provide the

same benefits for anglers. Changes to the presence of sensitive cold-water species like Brook Trout may impact the experiences of trout anglers in the North Shore. However, biophysical functions of other species of trout, such as Brown Trout may be more robust to changes in climatic and environmental conditions (Flebbe, 1994; Jensen et al., 2008; Raleigh, 1982a, 1982b; Waters, 1983). Managers may consider stocking temperature-tolerant cold-water species of trout in the North Shore to maintain the opportunities for trout angling in the region as the presence of less tolerant cold-water species continues to decrease with changing conditions.

One potential result of warming conditions is extended shoulder seasons where angling is possible. The current season for Smallmouth Bass in the region is from May 11th to February 23rd, a 10-month window twice as long as the Brook Trout season. Given the shift from Brook Trout to Smallmouth Bass, anglers targeting this species may find greater opportunities for success in the region with future conditions projected to increase both the presence of Smallmouth Bass in inland streams and shoulder seasons of more favorable conditions. However, increased use over longer periods of the year under projected conditions presents challenges to fisheries experiencing the stresses of climate change. Fisheries and outdoor recreation managers should strive to maintain both resilient fish populations and high-quality angling experiences. These goals are not mutually exclusive, but are likely to require shifts from current actions on the part of both managers (i.e., choosing to stock more temperature-tolerant species) and anglers (choosing to fish in different locations or for different species) across the North Shore.

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8. Tables and Figures

Figure 1. North Shore study area (map)

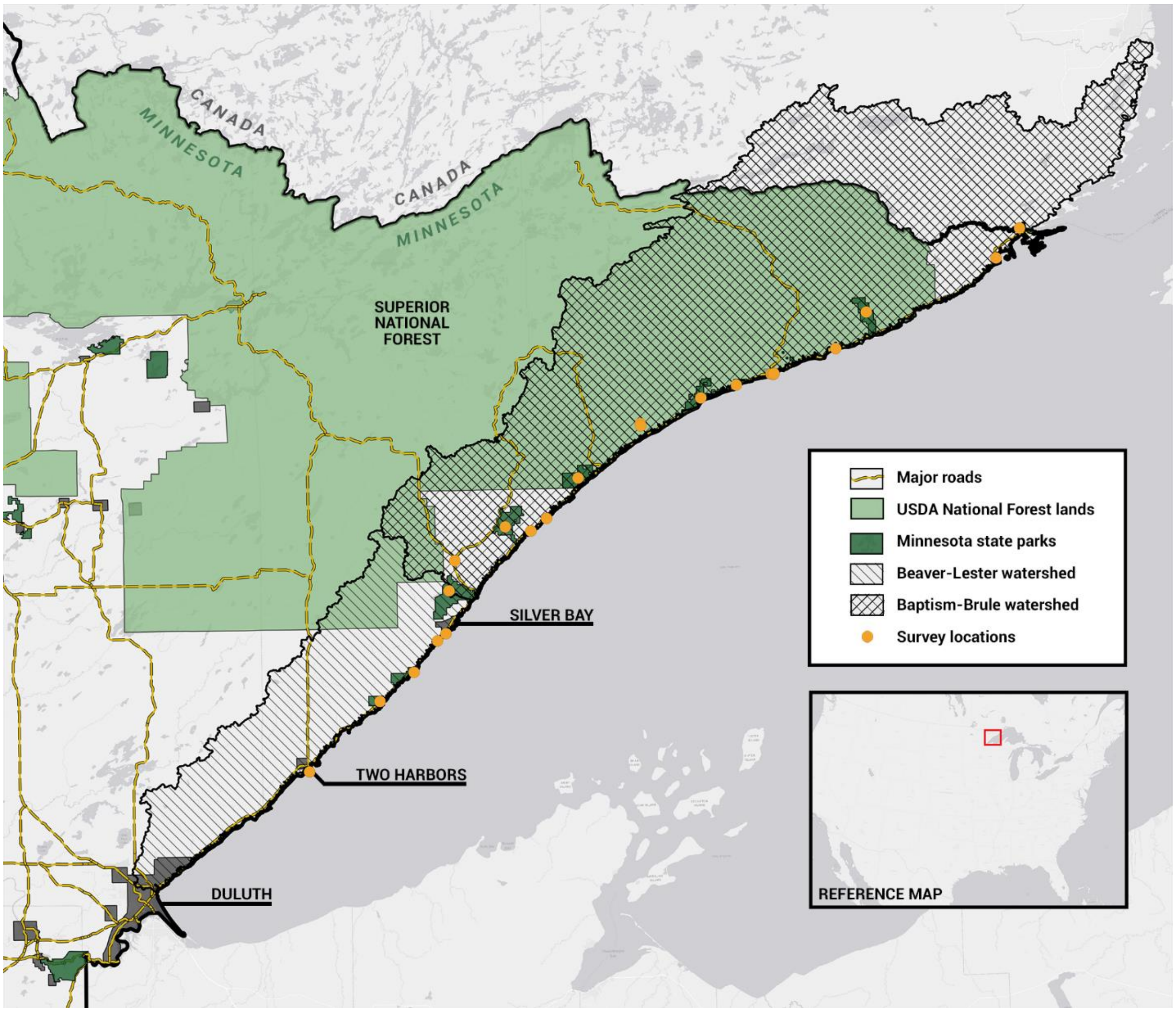

Figure 2. Sample of the survey instrument contingent trip-taking question

Please consider the possible future ***conditions described in the last column in relation to the recent conditions*** *and indicate* ***how many summer recreational trips*** *you would take on the North Shore given those conditions.*

% of days in a month	Recent	Future
above the **avg. high temperature** (71°F)	60% (**18** of 30 days)	63% (**19** of 30 days)
above **80°F heat index**	5% (**2** of 30 days)	17% (**5** of 30 days)
with a **'high,' 'very high,' or 'extreme' fire risk**	18% (**6** of 30 days)	37% (**11** of 30 days)
with **greater than ¼" rainfall**	14% (**5** of 30 days)	12% (**4** of 30 days)
% of inland streams	**Recent**	**Future**
with brook trout	**77%**	**20%**
with small mouth bass	**53%**	**58%**

Below is some additional information about fire danger and the heat index for your reference.

Under Very High Fire Danger, *fires will start easily, spread rapidly, and become large and long-standing fires; no burning permits are issued to private landowners.*
Under Extreme Fire Danger, *fires last for several days; no burning permits are issued to private landowners; campfires are prohibited on all public and private lands.*

Also, please keep in mind that the National Weather Service advises the following likelihoods of heat disorders with prolonged exposure or strenuous activity at the following ranges of the ***HEAT INDEX***:

Caution	80˚F to 91˚F	Fatigue possible
Extreme Caution	91˚F to 103˚F	Sunstroke, muscle cramps, and/or heat exhaustion possible
Danger	103˚F to 115 ˚F	Sunstroke, muscle cramps, and/or heat exhaustion likely
Extreme Danger	> 115 ˚F	Heat stroke or sunstroke highly likely

Table 1

Attribute table of survey climate scenarios

	Survey version			
Attribute	**1** (RCP4.5; H, VH, and E Fire Risk)	**2** (RCP4.5; VH, and E Fire Risk)	**3** (RCP8.5; H, VH, and E Fire Risk)	**4** (RCP8.5; VH, and E Fire Risk)
Percent of days with …				
Average high temperature (71F)	63	63	67	67
80F heat index	17	17	19	19
Fire risk	37	22	35	22
Rainfall greater than 1/4"	12	12	11	11
Percent of inland streams with …				
Brook Trout	20	20	20	20
Smallmouth Bass	58	58	58	58

Table 2

Descriptive statistics of demand model variables

Variables	Mean	Std. Dev.
Current trips	1.61	1.00
Future trips		
Scenario 1	1.58	0.75
Scenario 2	1.71	0.83
Scenario 3	1.56	1.13
Scenario 4	1.72	1.12
Place meanings		
Individual identity	0.02	0.89
Self-efficacy/place dependence	0.11	0.92
Family identity	0.05	0.92
High temperature	72.82	5.31
Income	70,439.56	28,911.84
Travel cost	155.16	126.53

Table 3

Sociodemographic characteristics of anglers to the North Shore

Characteristic	**n**	**%**
Gender		
Male	91	50.0
Female	90	49.5
Age		
18-24	23	12.6
25-34	47	25.8
35-44	42	23.1
45-54	41	22.5
55-64	16	8.8
65+	13	7.1
Education		
< High school	0	0.0
High school	10	5.5
Some college	41	22.5
Associates degree	19	10.4
Bachelors degree	66	36.3
Masters degree	44	24.2
Doctorate	2	1.1
Income		
< 10k	6	3.3
10k-20k	7	3.8
20k-30k	7	3.8
30k-40k	15	8.2
40k-50k	18	9.9
50k-60k	10	5.5
60k-70k	16	8.8
70k-80k	18	9.9
80k-90k	12	6.6
90k-100k	23	12.6
> 100k	50	27.5

Table 4

Results of population averaged Poisson regression: dependent variable is angling trips to the North Shore

Independent Variables	Coef.	Std. Err.	z	p
Climate scenario 1	0.042	0.064	0.66	0.508
Climate scenario 2	0.053	0.172	0.31	0.760
Climate scenario 3	-0.105	0.069	-1.5	0.133
Climate scenario 4	0.047	0.069	0.68	0.495
Individual identity	0.139	0.099	1.39	0.165
Self-efficacy/place dependence	0.017	0.066	0.25	0.799
Family identity	0.017	0.08	0.21	0.833
High temperature	0.013	0.007	1.91	0.057
Income	-3.69E-06	1.66E-06	-2.23	0.026
Travel cost	-.0004	0.0003	-1.74	0.081
Constant	-0.154	0.519	-0.3	0.767

Wald $\chi^2(10) = 51.91$
prob. > χ^2 = .0000

Table 5

Chi-square test and contingency table analysis comparing angler and non-angler substitution responses (n = 842)

Substitution			Percentage of respondents					
Dimension	Question		Not at all likely	Slightly likely	Somewhat likely	Very likely	Extremely likely	χ^2
Spatial	Travel elsewhere on the North Shore to participate in the planned summer activity	Angler	34.6**	19.2	24.7	17.6**	3.9	14.89**
		Non-angler	43.5**	20.3	25.1	8.5**	2.6	
	Travel outside the North Shore to participate in the planned summer activity	Angler	42.9	20.3	24.7	10.4	1.7	6.76
		Non-angler	51.7	20.4	19.7	7.4	0.8	
Activity	Stay on the North Shore but do something else	Angler	31.3	15.4	33.0	14.8	5.5	7.85
		Non-angler	32.6	23.3	25.9	14.4	3.8	
Temporal	Cancel your trip, but reschedule during the summer season	Angler	64.3	22.5	9.9	2.2	1.1	7.68
		Non-angler	71.5	14.4	11.4	2.1	0.6	
	Cancel your trip for the full summer season	Angler	74.7	13.7	7.7	2.2	1.7**	14.26**
		Non-angler	80.8	9.4	8.0	1.8	0.0**	

Angler (n = 182)

Non-angler (n = 660)

** $p < 0.05$