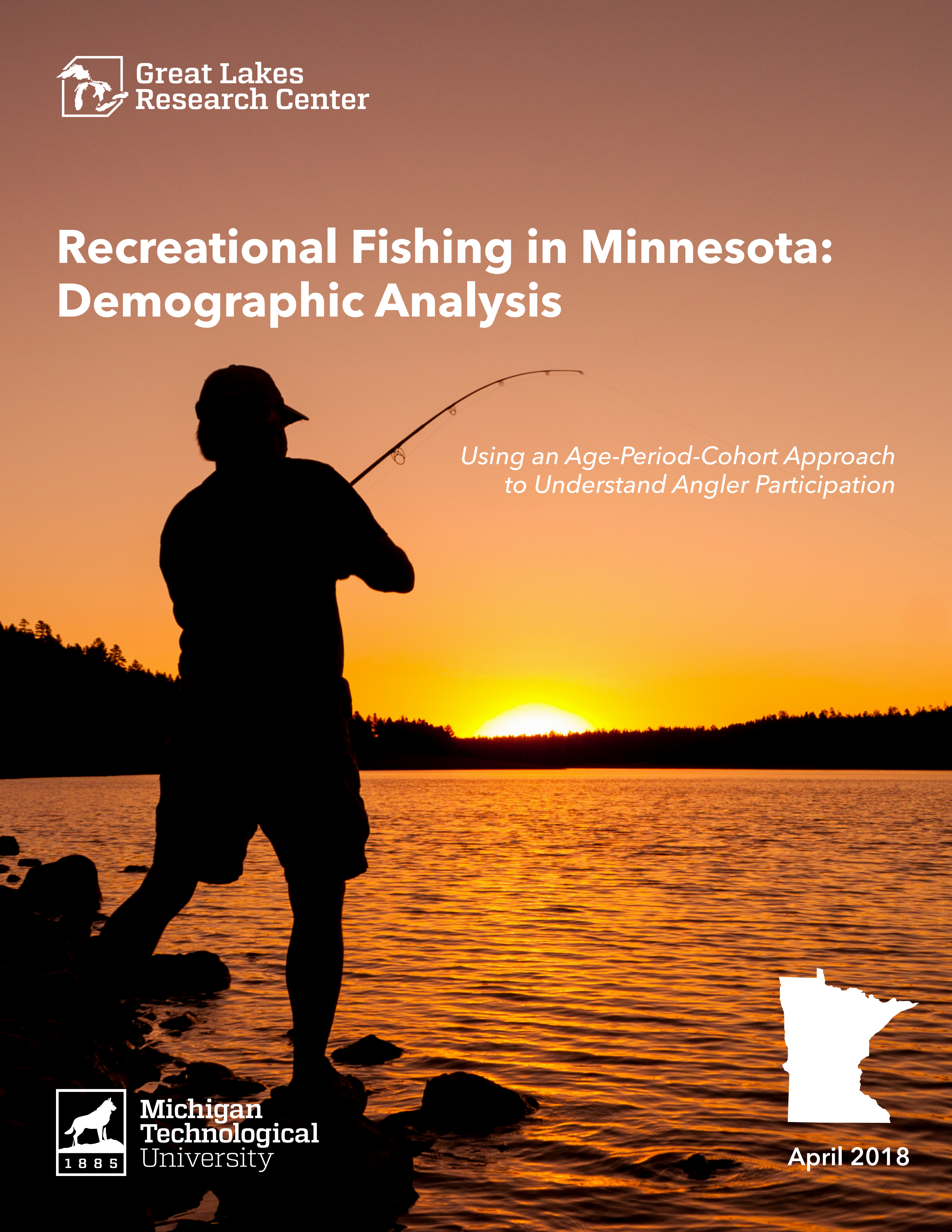
Great Lakes Research Center



# Recreational Fishing in Minnesota: Demographic Analysis

*Using an Age-Period-Cohort Approach to Understand Angler Participation*

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Michigan Technological University
1885

# Acknowledgements

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## Executive Summary

The number of Minnesota residents (ages 16-79) who purchased a fishing license in the state of Minnesota increased from 1,164,015 in 2000 to 1,203,769 in 2009, but then declined to 1,130,172 in 2016. Between 2000 and 2016, the proportion of Minnesota residents who purchased a fishing license declined from 32.3% in 2000 to 27.2% in 2016. Male anglers continue to make up the majority of Minnesota's anglers (64% in 2016), but females comprise approximately 36%.

In order to understand change in Minnesota's anglers over time, researchers at Michigan Technological University partnered with the Great Lakes Fishery Commission and the Minnesota Department of Natural Resources (DNR) to analyze demographic patterns in the fishing population and to use those results to project future numbers of anglers in Minnesota. We used an age-period-cohort regression model to analyze 17 years of Minnesota resident fishing license sales data from 2000 to 2016. We specifically looked at differences by gender, age, and birth cohort among both total anglers and more specifically at Lake Superior salmon/trout anglers. The results show that age, time period, and birth cohort all impact fishing participation independently. Among total anglers, generational differences (cohort effects) are not extreme, but evidence shows that males and females born 1942-1965 have generally been more likely to fish over the last several years than prior or more recent generations. Female patterns are very similar to male patterns, likely because on average across these 17 years of data approximately 62% of all female anglers are licensed to fish as a secondary holder under a combination (married couple) license. Age effects also matter. Both men and women between the ages of 21 and 51 are more likely to fish than other ages. Participation drops off dramatically after age 61 for females and after age 66 for males. Period effects show that participation has been gradually declining across age and birth cohorts. Looking specifically at estimates of male Lake Superior salmon/trout anglers, both cohort and age effects matter more. Recruitment into fishing the "Big Lake" appears to peak for cohorts born 1946-1962. Males ages 25 to 50 and retirement-age (65 years old) males were more likely to fish Lake Superior for salmon/trout than older or younger men. Estimated participation was generally low between 2005 and 2013, but increased in 2015 and 2016.

These results inform projections of future anglers. Assuming patterns from the recent past continue, the number of male anglers could decrease by 55,000 by 2035 to fewer than 675,000 licensed anglers, down from approximately 728,000 in 2016. This decline would primarily be due to aging of Baby Boomers moving through the system. Female anglers are projected to remain fairly stable in number through 2035. Finally, the age structure of anglers is projected to change such that anglers will generally be younger in 2030 than they were in 2016, with a greater proportion under the age of 50 as the current Baby Boom population ages out of the fishing population.

## Introduction

Fishing is an important cultural activity in Minnesota with about 30% of state-resident adults purchasing a fishing license each year. Yet, while the number of Minnesota resident anglers increased from 2000 to 2009, angler numbers and participation rates decreased 2009-2016. Fishing participation decline, coupled with similar decline in hunting license sales, has important implications for fish and wildlife management, conservation funding, restoration efforts, social relationships with nature, and social and cultural ways of life. For recruitment and retention efforts to be successful, it is vital that fisheries planners, policymakers, and managers understand the nuanced social, cultural, and demographic issues behind participation shifts. Moreover, adaptations to smaller future numbers of anglers and different types of anglers (i.e. new generations) may be necessary.

Researchers have explored several explanations for nationwide declines in fishing participation. A myriad of social, cultural, and economic changes over the last several decades typically earn the brunt of the blame – urbanization, population aging, increasing time demands from work and family, new competing activities, and changes in fish populations have all contributed to patterns of decline.[i,ii,iii,iv]

This brief focuses on understanding demographic drivers of fishing participation in the state of Minnesota, particularly the effects of age and birth cohort, and how these vary by gender. In doing so, we use techniques well-known in demography including the age-period-cohort (APC) analytical approach. This approach is useful because we have access to administrative records on the full universe of anglers who purchase licenses, virtually eliminating the possibility of sampling or reporting error. The study cannot address the detailed causes of why people of different ages or birth cohorts may or may not fish, but it can describe the ways that age and birth cohort (by gender) impact angler participation over time. The APC approach is also extraordinarily useful for projecting future numbers of anglers.

This report is part of a larger project examining angler participation and demographic change among the upper Great Lakes states (Illinois, Indiana, Michigan, Minnesota, and Wisconsin) and particularly among anglers who fish the upper Great Lakes for salmon/trout. Here, we focus specifically on results among Minnesota resident anglers with the following objectives:

1. Summarize annual participation rates of Minnesota resident anglers and Lake Superior salmon/trout anglers from 2000-2016 (by age and sex).
2. Analyze the relative importance of age, period, and cohort effects on Minnesota angler participation.
3. Generate population projections of the future number of Minnesota anglers and Lake Superior salmon/trout anglers by age and sex.
4. Describe geographic differences in angler participation across Minnesota at the county level.

### Data and Methods

The primary data come from the fishing license sales records database for fishing licenses purchased between 2000 and 2016, provided in aggregate and absent any identifying information by the Minnesota Department of Natural Resources (DNR). Licenses are coded by year of purchase, single year of age, sex, and county of residence. We also explored the importance of the combination (married couple) license in driving female fishing participation. Analysis was restricted to Minnesota residents ages 16 and older. Because of a license structure rule that exempted people over age 65 from license requirements prior to 2003, we had to estimate the number of anglers age 65 and older in 2000-2002 based on observed age-specific participation rates 2004-2016. Rates show the proportion of the state-resident population that bought a fishing license in any particular year. Males and females were analyzed separately because prior research shows they have somewhat different pathways into fishing[v,vi] and hunting[vi,viii], and the effects of age, period, and cohort may also show gender differences that would be obscured by looking at the entire population.[ix]

**Estimating Lake Superior salmon/trout anglers** required additional steps because while Minnesota requires a general trout stamp in addition to the basic fishing license, this stamp does not exclude inland waters, and our larger research project goal is aimed at summarizing participation trends for Great Lakes salmon/trout anglers specifically. The State of Wisconsin requires anglers to purchase a Great Lakes Salmon/Trout Stamp in order to fish the Great Lakes or their tributaries up to the first barrier for salmon or trout. We used these Wisconsin data to develop and apply a model that estimates the number of Lake Superior salmon/trout anglers resident in Minnesota.

First, we developed a logistic regression model using Wisconsin data. The model predicts the likelihood of any angler to fish the Great Lakes for salmon/trout (dependent variable) based on individual demographics (age and sex) and county characteristics, including metro/nonmetro status (defined by the Federal Office of Management and Budget definition 2013), distance from the nearest Great Lake (measured continuously as distance from county centroid to the nearest lake shore), and whether the county borders a Great Lake (measured categorically as 0 or 1). This model fit the data well and, when compared to observed data, was found to predict Great Lakes salmon/trout fishing in Wisconsin reasonably well, but with a general underestimate.[1]

Next, we applied the Wisconsin regression coefficients to Minnesota anglers, now using Minnesota county characteristics. This process generated a predicted probability of whether any Minnesota angler would fish for salmon/trout in Lake Superior or its tributaries. Those individual values were then aggregated by county, sex, and single-year of age in 2010 (census year when the most accurate data are available) to estimate the proportion of Minnesota resident anglers who fished Lake Superior for salmon/trout. Predicted proportions were next multiplied by the matching known Minnesota resident license sales aggregations in 2010 to estimate the number of Lake Superior salmon/trout anglers in 2010.

In the final steps, we control these estimates to observed Minnesota Trout Stamp sales data. For 2010, we divided the estimated number of Minnesota resident Lake Superior salmon/trout anglers (found using the process described above) by the known 2010 Trout Stamp anglers (by county, age, and sex) to estimate the proportion of trout anglers that are specific to the Great Lakes (Lake Superior). Aggregating to the county level, this proportion ranged from 18% of trout stamp holders in Cook County and Lake County to less than 1% of trout stamp sales in Rock County, where trout stamp sales were low and where distance from Lake Superior is high. This proportion can then simply be multiplied by the number of trout stamps sold in 2010 (always by single-year of age, sex, and county) to generate the estimate of Lake Superior salmon/trout anglers in 2010. Finally, to estimate Lake Superior salmon/trout anglers in the remaining years (annually 2000-2016), we assumed that the proportion of trout stamp holders who fish Lake Superior for salmon/trout in 2010 remains constant over time. We then multiplied the 2010 rates by the observed trout stamps sales for each additional year 2000-2016 to generate annual estimates.[2] We believe the resulting estimates to represent reality reasonably well, but that they likely underestimate the number of Lake Superior salmon/trout anglers.

**Age-period-cohort analysis** is a statistical method that estimates the independent impacts of age, time period, and birth cohort on angler participation.[x] Age affects our ability to participate in many kinds of outdoor recreation, including fishing. Individuals at different ages are more or less likely to fish based on life events, career, family, and, at later ages, physical ability.[xi] True **age effects**,however, are complicated by the fact that they are easily confounded by changes over time and by differences among birth cohorts.[xii] For example, other studies of fishing participation find that age is a significant factor predicting participation,[xiii] but without considering birth cohort, it is impossible to say whether participation is determined by current age or if participation is determined by being born during a certain era.

**Period effects** (time period) refer to social, environmental, policy, and economic changes that impact the conditions under which fishing takes place over time. These might be specific and discrete events (such as a dramatic reduction in stocking a popular target species) or incremental change over time (such as slow changes in species composition). Changes in rules and regulations, decreasing access to fishing areas, and changes in fish abundance are other examples that could lead to period effects in fishing participation.

**Cohort effects** refer to the impact of the environmental, social, and historical factors that shape the experiences and worldviews of those born in a particular year. Each birth cohort experiences significant events at the same point in the life course. Those experiences influence individuals' behavior throughout their lives and contribute to lasting social change as each successive generation replaces the previous one. A good example is cigarette smoking and its dramatically different participation rates by different generations of people born over the course of the twentieth century.

[1] Great Lakes salmon/trout fishing license data from the Wisconsin DNR does not include Two-Day Salmon/Trout Stamps issued on charter boats so these data are omitted from the logistic regression model we used to estimate Minnesota's Lake Superior salmon/trout anglers, meaning that individuals who fish from charters may not be included in the Minnesota estimate.

[2] Before applying the logistic regression model to the Minnesota license sales data we adjusted the county centroid distance to Lake Superior to 10 km for three northeastern counties in Minnesota (St. Louis, Lake, and Cook county) because their populations are mainly distributed along the Lake Superior shoreline and northern reaches of these counties are very unpopulated which makes the true county centroid a misleading measure of the overall population's distance to Lake Superior.

Resulting age-period-cohort estimates then provide key information to build **projections of future angler populations.** We used two demographic methods to generate projections of the future number of Minnesota anglers by age and sex and Lake Superior salmon/trout anglers (combined males and females) by age. The APC approach uses the age-period-cohort results to predict future participation rates. The cohort survival approach advances current anglers forward in time assuming average recruitment/retention by age each year. Both models generally assume that patterns observed in the recent past will continue into the future.

Lastly, this report includes **maps of fishing participation rates and changes over time for Minnesota counties** Reviewing geographic differences in angler participation is useful for hypothesizing about causes of change and for considering where to focus recruitment and retention efforts.

## Angler Participation Rates

Figure 1 shows the changes between 2000 and 2016 in the number of anglers (ages 16-79) in bars (shown on left axis) and corresponding participation rates in a line (right axis). The total number of unique anglers varied over this 17-year period, peaking in 2009. Participation rates generally declined between 2000 (32.2%) and 2016 (27.2%). Lake Superior salmon/trout anglers are shown in a lighter colored bar at the bottom. Estimates suggest that they make up a small share of the total number of anglers (2.6% in 2016) and their numbers increased from 23,693 in 2000 to 29,861 in 2016.

Figure 2 shows the age structure of Minnesota anglers in 2016 transposed on top of the general age structure for Minnesota's entire population in 2016, by sex. The chart makes it possible to identify birth cohorts that may be over- or under-represented in the angler population. The orange bulge at ages 31-60 indicates that female anglers are over-represented at these ages, whereas females at older and younger ages are underrepresented. Females ages 31-60 are more likely to be included as an addition to a combination (married couple) license than younger or older women, who are less likely to be currently married, so the observed overrepresentation at these ages is likely related to combination (married couple) licenses rather than women seeking their own individual fishing licenses. Looking at males, anglers generally represent the population well, with the exception of underrepresentation of anglers under age 26. This suggests that across ages and generations of males, participation rates are fairly uniform, except for lower participation among those under age 26.

**Figure 1. Minnesota Resident Anglers and Fishing Participation Rates (2000-2016)**

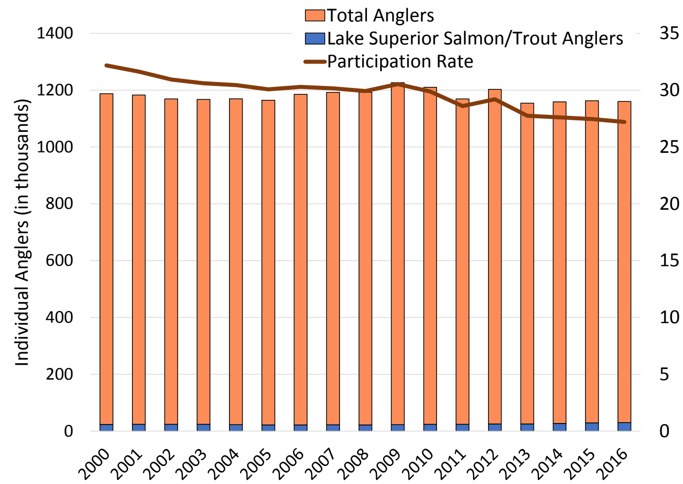



Figure 1 shows the estimated number of individual Lake Superior salmon/trout anglers (in blue), the number of total anglers (in orange), and total fishing participation rate (the brown line) for Minnesota residents from 2000-2016.

*Data sources: Minnesota Fishing License Database, provided by the Minnesota Department of Natural Resources; U.S. Census 2000, U.S. Census 2010, and U.S. Census Bureau, Intercensal Estimates.*

**Figure 2. Age Structure of Minnesota Anglers vs. Total Population, by Sex (2016)**

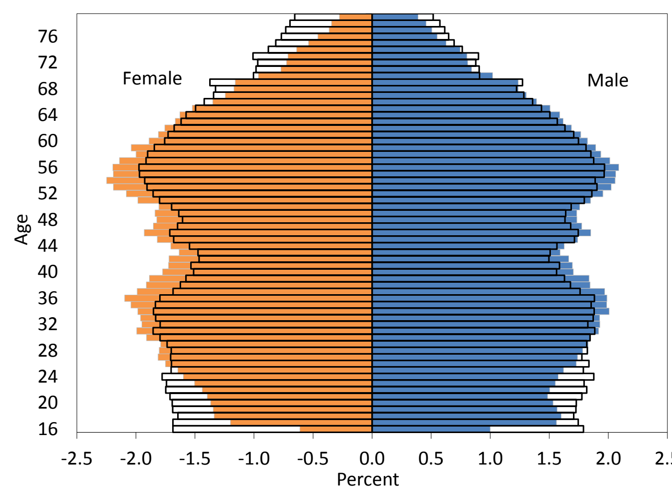



Figure 2 shows the age distribution of the total Minnesota population (in hollow black bars) compared to the age distribution of Minnesota anglers (orange and blue bars) in 2016. For each single year of age between 16 and 79, it shows the proportion of all anglers (or people in total) who are at that age.

*Data sources: Minnesota Fishing License Database, provided by the Minnesota Department of Natural Resources; U.S. Census Bureau, Intercensal Estimates, 2016.*

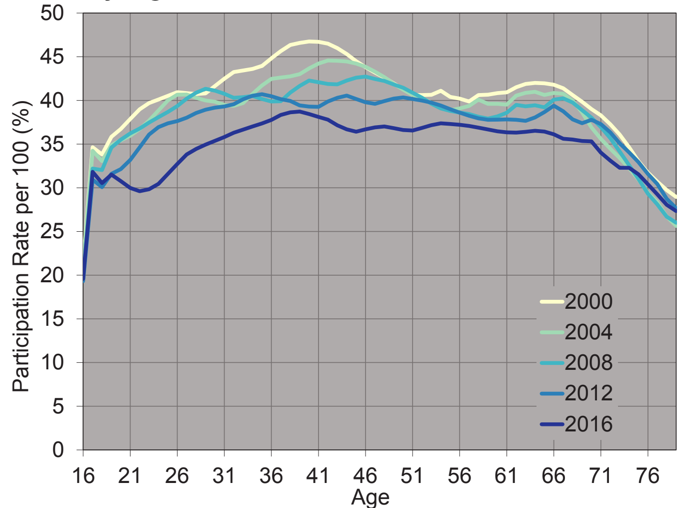
Figures 3A-3C show age-specific fishing participation rates for total male and female anglers and estimates of male Lake Superior salmon/trout anglers (referred to as Great Lakes/GL anglers). Note the scale is different for different groups. Female GL fishing rates are not included because the numbers are small and estimates unreliable. Lighter colors represent earlier time periods and become darker in more recent years. The rates are "smoothed" to account for the fact that birthdays fall at various times over the course of the year and don't match perfectly with the age reported by the US Census Bureau (age on April 1 of each year), which may suffer from age heaping and other classification errors. Smoothing is a common demographic technique when dealing with rates by single year of age. Here, we report participation rates by age calculated from the reported data for that single year of age plus borrowing from participation at the ages directly before and after each single year of age.

In the figures, following any particular curve from left to right shows variation in participation across different ages. Among males, participation rates are fairly even by age (horizontally flat), except for somewhat lower participation among younger males and then declining participation at the oldest ages. Reading the graph vertically shows a general decline over time in male participation across most age groups. Female participation rates are lower, and the age-specific participation rate trends are somewhat different. Female participation rates are highest for women between the ages of 30 and 60, again the most likely ages that women are licensed under a male partner with a combination license. Rates declined at these ages between 2000 and 2016 (likely due to declining participation among male anglers), but increased for the youngest and oldest females, who are more likely to be primary license purchasers.

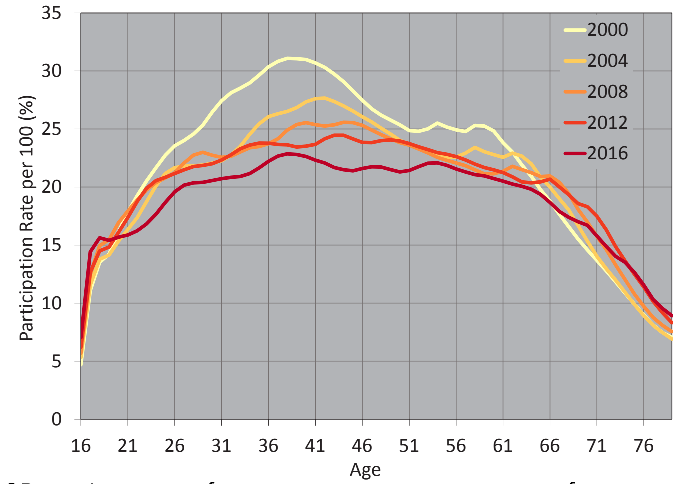
Participation rates for male GL anglers are much lower than total angler participation rates. Age-based participation appears to peak in the mid and late thirties and then at about retirement age (around 65). We don't see a clear pattern of change over time in participation rates, but participation at retirement ages looks to have increased in recent years.

*Data sources: Minnesota Fishing License Database, provided by the Minnesota Department of Natural Resources; U.S. Census 2000, U.S. Census 2010, and U.S. Census Bureau, Intercensal Estimates. Estimates of Lake Superior salmon/trout anglers were generated by the authors.*

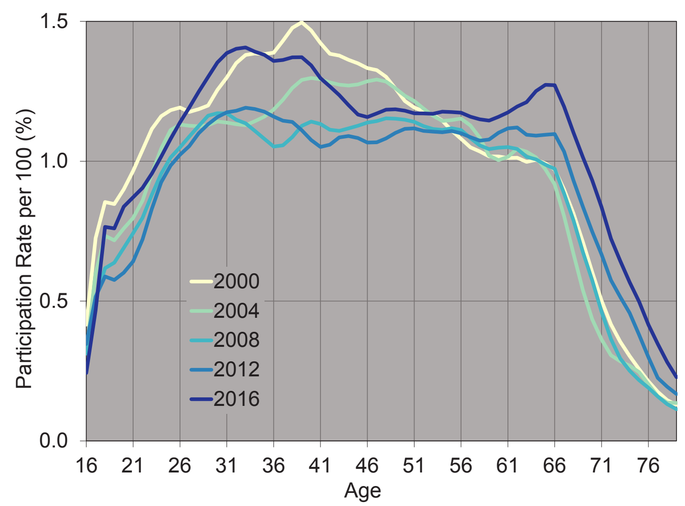
**Figure 3. Minnesota Angler Participation Rates by Age (2000-2016)**




3A. Age-specific participation rates for total male anglers




3B. Age-specific participation rates for total female anglers




3C. Age-specific participation rates for male Lake Superior salmon/trout anglers

*Figures 3A-3C show the proportion of Minnesota residents who purchased a license to fish (3A & 3B) & the estimated proportion of Minnesota resident male Lake Superior salmon/trout anglers (3C) by age for a set of years between 2000 and 2016. Lighter colors represent earlier time periods and become darker in more recent years.*

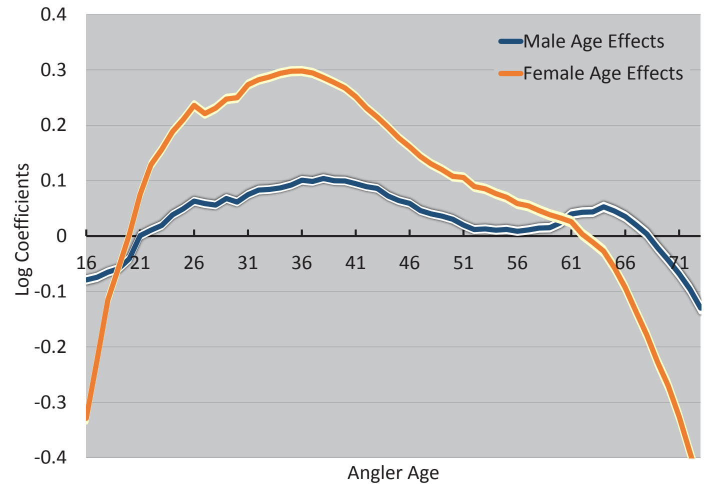
## Estimating Age, Period, and Cohort Effects

This section reviews estimates of the independent effects of age, time period, and birth cohort on the likelihood of individuals to purchase a fishing license. To make these estimates, we fit a log linear regression model using Stata statistical software and an approach developed by Yang et al. (2008) that incorporates an "intrinsic estimator." Independent estimates of age, period, and cohort are complicated because they are perfect linear functions of one another: cohort = period - age. This is referred to as the "identification problem" whereby common statistical and demographic models cannot uniquely identify the effects of age, period, and cohort.[xiv] The intrinsic estimator is a principal components regression estimator that is designed to circumvent the collinearity problem. Its purpose is to control for any two variables (age, period, or cohort) in order to accurately see the magnitude of the effect of the third, bypassing the problem of collinearity. The intrinsic estimator approach has been shown to produce unbiased, efficient, and asymptotically consistent estimates and to perform well in simulations.[xv]

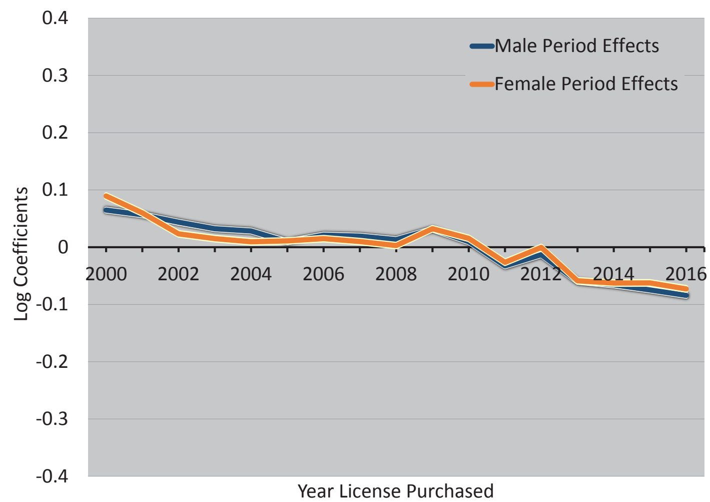
We assume that the data follow a Poisson distribution, modeling angler participation rates as the count of anglers at each age, sex, and year, divided by the total population of Minnesota by age and sex in each year. Total population data are from the U.S. Census 2000 and 2010, and from U.S. Census Bureau population estimates for intercensal years. The process estimates the independent effects of age, period, and cohort, and shows the log likelihood of an individual to purchase a fishing license for any particular age, birth year, and annual time period.

Results show that age, period, and cohort all significantly influence fishing participation rates in Minnesota. Figures 4A-4C illustrate the model results showing estimates of the independent impacts of age, period, and cohort on male and female total anglers. Figures 4D-4F show the estimates for male Lake Superior salmon/trout anglers. Estimates for female Lake Superior salmon/trout anglers are not shown, because numbers of participants are too small to produce reliable estimates. The Y-axis is a log likelihood coefficient, meaning that the bigger the difference from zero (positive or negative) a value is, the larger its effect on the likelihood of an individual to purchase a fishing license. Values above zero indicate an increased likelihood, while values below zero indicate a decreased likelihood. Note that likelihoods should be compared to other points on the same line (e.g. among males at different ages) rather than between groups (e.g. female to male).

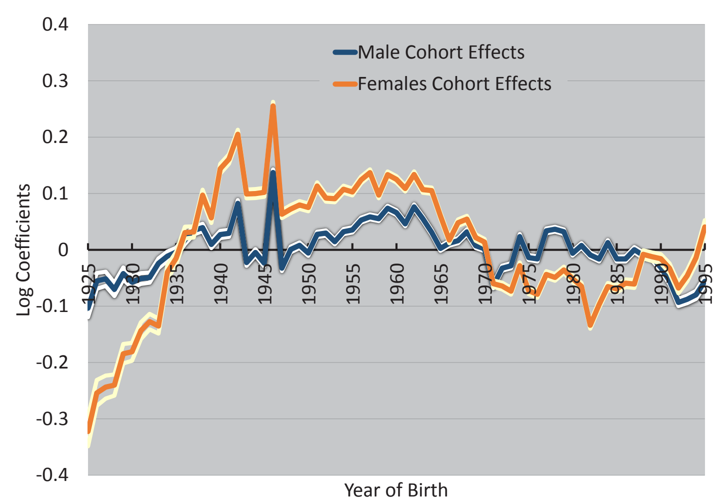
**Figure 4: Age-Period-Cohort Estimates for Total Minnesota Anglers (2000-2016)**




4A: Age Effects, Total Anglers by Sex




4B: Period Effects, Total Anglers by Sex




4C. Cohort Effects, Total Anglers by Sex

*Figures 4A-4C show the age effects, period effects, and cohort effects for total male (blue lines) and total female (orange lines) Minnesota resident anglers for ages 16-79. Lighter lines surrounding the estimates show 95% confidence intervals.*

Males and females across age groups and birth cohorts experienced gradual participation decline over time between 2000 and 2016. Still, there are significant differences in participation by both age and birth cohort. Males ages 25-50 and around retirement (ages 61-66) show increased likelihood to fish than older or younger men. For females, age effects are particularly strong with those between ages 20-50 being much more likely to fish than other ages, again this is related to the fact that most females are licensed under a combination license and women at these ages are more likely to be married and to be included as a secondary holder under a combination license. Among males and especially females, likelihood to participate declines dramatically at older ages (after age 61 for females and after age 66 for males). This late life decline could be related to decreased mobility or competition for other retirement-age activities.

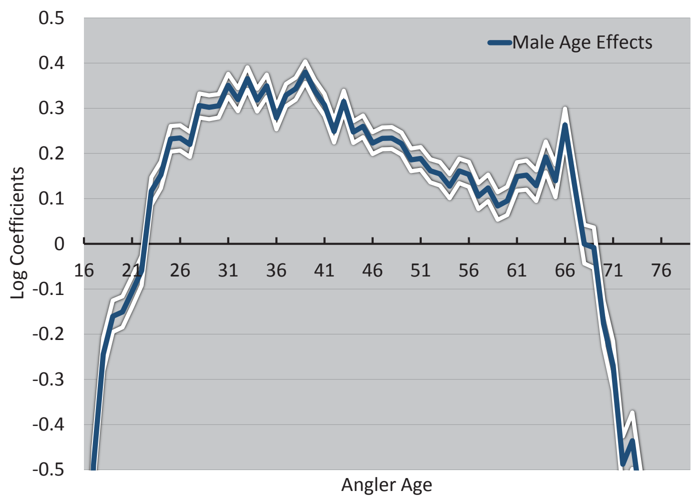
Controlling for age and time period, male cohort effects are statistically significant and impactful. Males born 1956-1964 have an increased likelihood to fish and males born in the early 1970s and after 1980 generally show a decreased likelihood to fish in comparison to other generations. To illustrate these impacts, it helps to convert the log likelihoods shown below to probabilities and to play out some hypothetical examples. For instance, if we hold age constant at 40-years and apply average time period effects, the difference between the predicted probability of a hypothetical cohort of men to fish varies by birth year. For every 100 hypothetical 40-year old males born in 1952, 42.7 would purchase a fishing license in a given year. If a similar group was born in 1962 and exposed to the associated birth cohort effects, 44.5% would purchase a fishing license. If the group were subject to the birth cohort effects of 1982, 41.2% would fish and if exposed to the effects of 1992, only 38.5% would fish.

Among females, cohort effects are similar to those seen for males, but somewhat stronger. The similarities with males are likely due, at least in part, to combination (married couple) license sales. Cohorts born between 1940 and 1964 show higher likelihood to participate in comparison to prior generations, while cohorts born between 1970 and 1987 show decreased participation. There is some indication that cohorts born since about 1990 may have somewhat increased participation, but the pattern is not yet particularly clear. This is in contrast to other states where more recent cohorts of females show a sometimes dramatically increased likelihood to participate. The difference in Minnesota is likely related to the fact that older generations of females are more likely to participate in Minnesota than they are elsewhere, in part due to the combination (married couple) license option. To illustrate female cohort effects with more clear examples, the model predicts that for a hypothetical group of 30-year old females born in 1940, 26% would fish in any given year. This compares to 30-year old females exposed to cohort effects from 1955 where 25% would fish, from 1970 where 24% would fish, and to those exposed to 1985 cohort effects where only 23% would fish.

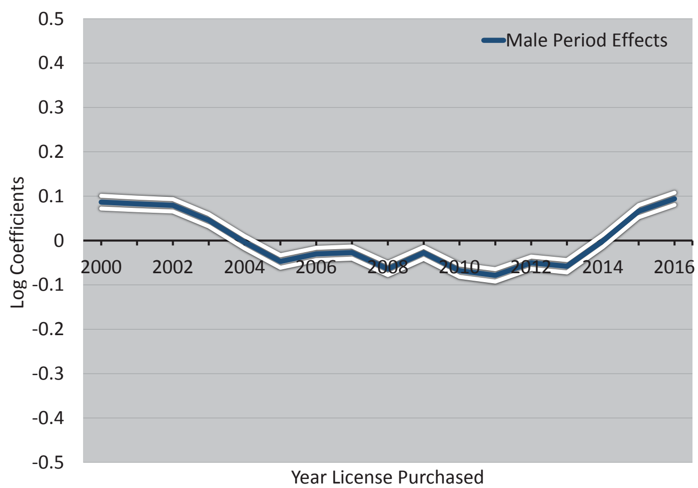
The APC effects we estimated for female anglers and show here are heavily influenced by female residents fishing with their spouses. On average, 62% of female anglers are licensed to fish as a secondary license holder under a spousal license. Because these are the majority of female anglers, female APC patterns generally reflect male patterns. Analysis (not shown here) comparing primary female license holders to secondary license holders shows opposing patterns. Among primary female anglers, recent generations are more likely to fish than those born prior to 1978. Younger women more likely to fish, and participation is generally increasing over time. This means that while secondary female license holders closely mimic the broader APC patterns observed for males and described above, primary female license holders have different patterns. The patterns estimated for primary female license holders point more toward increasing participation over the long term, while the secondary female license holder patterns point more towards decline.

Among male Lake Superior salmon/trout anglers, both age and birth cohort look to have a substantial impact on participation (see Figure 5 on the following page). Period effects were weak in comparison but showed statistically significantly lower participation between 2005 and 2013 and greater participation in 2015 and 2016. Males between the ages of 25-46 and around retirement age (65-66) showed an increased likelihood to participate than other ages. Estimated cohort effects among male Lake Superior salmon/trout anglers are stronger than they were for total male anglers. Cohorts born 1945 to 1967 (roughly the Baby Boom generation) show an increased likelihood to participate, as do cohorts born 1976-1985 (potentially children of the early Baby Boomers). Cohorts born prior to 1942 and since 1985 show a reduced likelihood to participate in comparison to other generations. The model predicts that on average for every 1,000 40-year old Minnesota males born in 1940, 7 of them would fish Lake Superior for salmon/trout in any given year. This is in comparison to the probability of 40-year old males born in 1960 which is predicted at 9 per 1,000, and to 40-year old males born in 1985, predicted at 7 per 1,000.

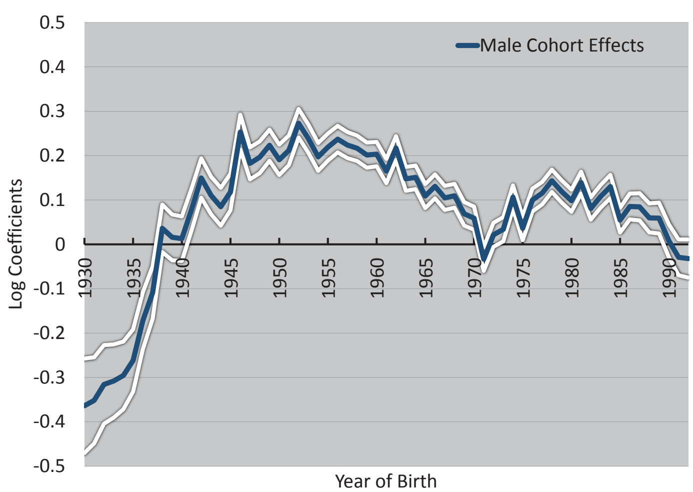
**Figure 5: Age-Period-Cohort Estimates for Minnesota Lake Superior Salmon/Trout Anglers (2000-2016)**




5A: Age Effects, Male Lake Superior Salmon Anglers




5B. Period Effects, Male Lake Superior Salmon Anglers




5C: Cohort Effects, Male Lake Superior Salmon Anglers

*Figures 5A-5C show the age effects, period effects, and cohort effects for male (blue lines) and female (orange lines) Minnesota resident Lake Superior salmon/trout anglers for ages 16-79. Lighter lines surrounding the estimates show 95% confidence intervals.*

## Projecting Future Anglers

We used the results of the age-period-cohort analysis to project future angler populations employing two different technical approaches. Both models assume that the general patterns of the recent past will continue into the future. One approach (APC model) directly uses the age-period-cohort estimates described above to estimate the proportion of future Minnesotans who will purchase a fishing license. These rates (by age and sex) are then multiplied by the total projected population for the State of Minnesota (from Minnesota Population Projections by Age and Gender, 2016-2065, Minnesota State Demographic Center, December 2016). The APC projection model is a fairly novel approach (better described in Winkler and Warnke 2013[xvi]) that has proven accurate in projecting Wisconsin deer hunters over the last ten years.

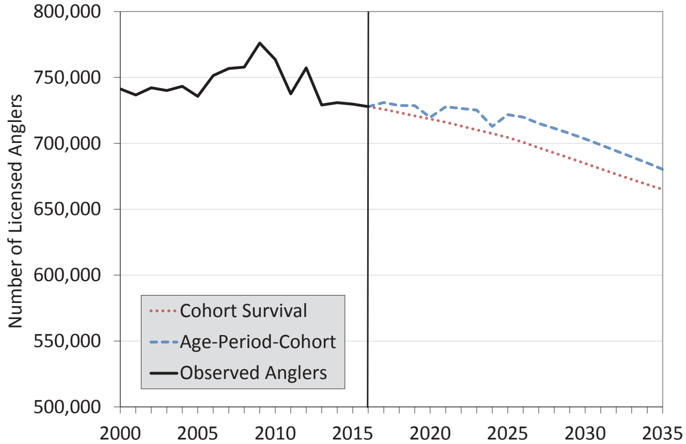
The other approach (Cohort Survival model) begins with the number of anglers observed in 2014 and ages them forward over time, applying a "survival ratio" that accounts for the average annual loss or recruitment/retention of anglers at different ages over time. Cohort survival models are commonly used by demographers to produce population projections. Using both the APC model and the Cohort Survival model acts as a way of checking our work, and comparing a new model (APC) with a well-established one (Cohort Survival).

### Results

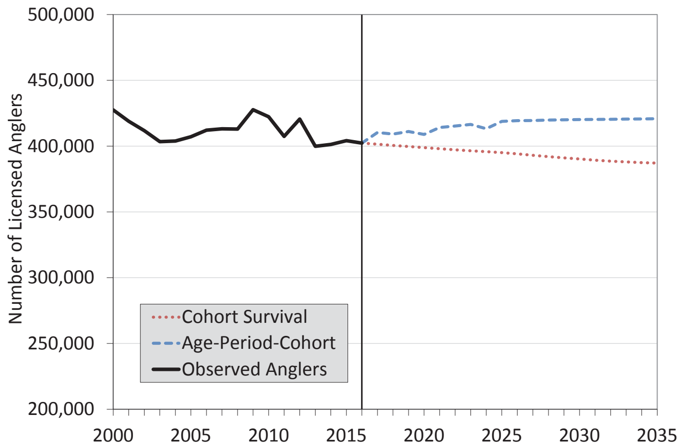
Both the APC and the Cohort Survival models represent a "business-as-usual" approach to recruitment and retention and assume that the general social, environmental, and economic patterns experienced between 2000 and 2016 will continue into the future. They should be expected to be fairly accurate models if policies, programs, and outreach efforts as well as socioeconomic and environmental conditions remain about the same over the next twenty years. Both models generally assume that current and recent patterns of angler participation by age, period, and cohort will continue into the future.

Figures 6A-6C and Table 1 (Appendix A) summarize the projection results for total males, total females, and combined (both sexes) Lake Superior salmon/trout anglers annually through 2035. The results of the two models are very similar for total male anglers, with a projected decline of about 55,000 anglers, down from approximately 728,000 male anglers in 2016 to about 673,000 in 2035.

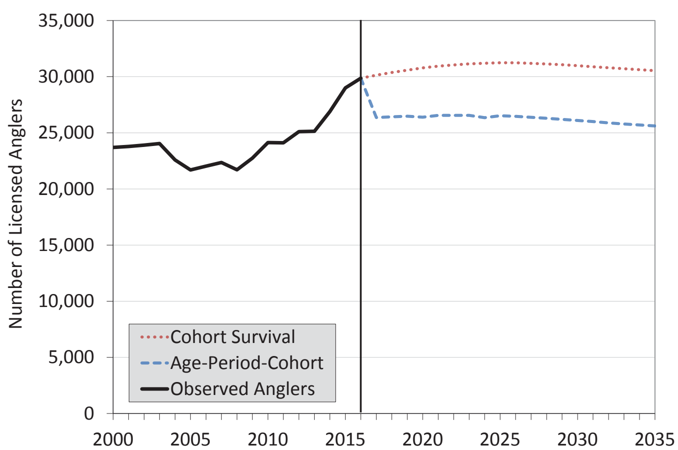
**Figure 6: Modeling Future Angler Projections for Minnesota Anglers**




6A: Projected Minnesota Resident Male Anglers, 2000-2035, Ages 16-79




6B: Projected Minnesota Resident Female Anglers, 2000-2035, Ages 16-79



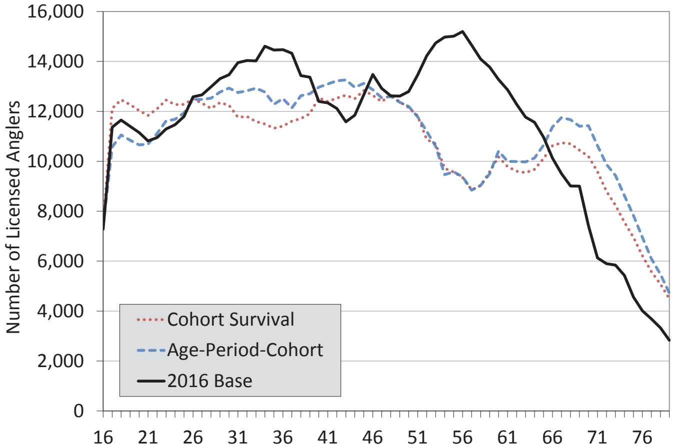

6C: Projected Minnesota Resident Lake Superior Salmon/Trout Anglers, 2000-2035, Ages 17-79

*Figures 6A-6C show the projected male (6A), female (6B), and combined male/female Lake Superior salmon/trout (6C) anglers in 2035. Two model outputs are shown in red and blue.*

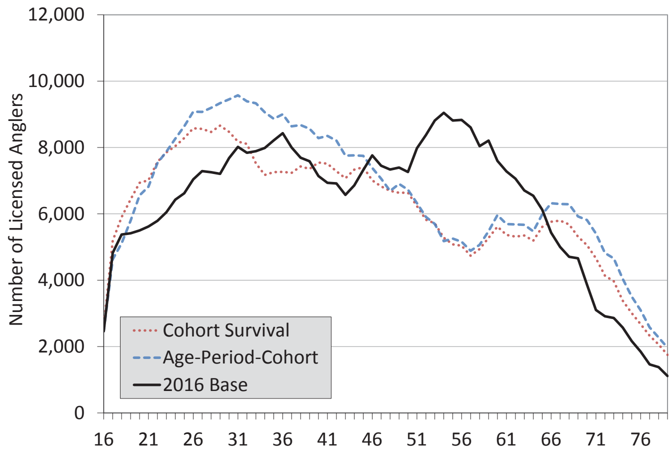
For female anglers, the APC model predicts stable numbers at about 420,000 anglers through 2035, whereas the Cohort Survival model shows moderate decline to fewer than 388,000 anglers in 2035. Female projections reflect a balance of projected decline for secondary license holders (in conjunction with projected male decline) and projected increase for primary license holders among younger women. For Lake Superior salmon/trout anglers, the Cohort Survival model predicts that anglers will remain fairly high (about 30,000 anglers) at levels similar to or slightly greater than their recent peak in 2016. This model is more impacted by observed participation in 2016, taking this recent peak as its starting point. The APC model predicts numbers more similar to the recent average at about 25,000.

Beyond changes in the number of future anglers, the models also predict changes to the age structure of the fishing population. Figures 7A-7C compare the observed age structure of fishing license purchasers in 2016 with projected age structures in 2030. Most noticeable on the male chart is that the large peaks of anglers in their early 30s and ages 50-60 years in 2016 will be dramatically reduced and older by 2030. Among females, the 2016 age structure is similar to males, with most female anglers in their 30s or between ages 50-60 years old. Projecting to 2030 we see the Baby Boomer women growing older and aging out of fishing, similar to the male pattern. But also with women, we see the potential for new cohorts of young female anglers to be recruited into fishing and retained into adulthood. Looking at Lake Superior salmon/trout anglers, in 2016 the peak age groups are in their early 30s or in their 50s. Projections however, show these peaks aging so that high proportions will be in their 40s and a diminished proportion over age 65 in 2030.

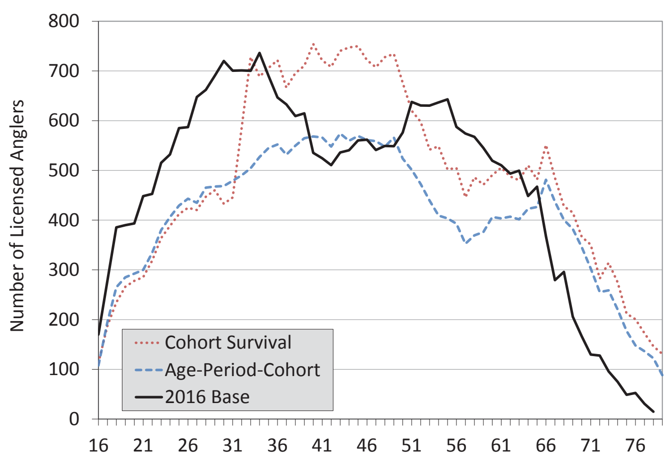
## Figure 7: Modeling Future Age Structure for Minnesota Anglers




7A: Age Structure of Minnesota Resident Male Anglers in 2030, Ages 16-79




7B: Age Structure of Minnesota Resident Female Anglers in 2030, Ages 16-79




7C: Age Structure of Minnesota Resident Lake Superior Salmon/Trout Anglers in 2030, Males and Females, Ages 16-79

*Figures 7A-7C show the predicted age structure of male (7A), female (7B), and combined male/female Lake Superior salmon/trout (7C) anglers in 2030. Two model outputs are shown in red and blue.*

Figure 8 summarizes and compares the results of the total angler projection models to provide a synthesized glimpse into projected changes in the number of Minnesota resident anglers, if age- and cohort-specific patterns from the recent past continue for the next twenty years. The chart compares the 2016 observed fishing population to the projected fishing population in 2035 showing an average projection from the two models. The total number of anglers is projected to decline by about 54,000 anglers between 2016 and 2035. Of the approximately 1,077,000 anglers that might be expected in 2035 about 404,000 of them (38%) should be expected to be women. Because the number of male anglers is projected to decline more than female anglers, this is a slight increase in the female share of the total fishing population from 36% observed in 2016.

## Figure 8: Minnesota Angler Projections Summary


*Figure 8 shows the number of observed Minnesota resident anglers in 2000 (shown in orange) and 2016 (shown in blue), the number of projected anglers in 2035 (shown in gray), and the projected change in the angler population from 2016 to 2035 (shown in red), by sex, ages 16-79.*

*Data sources: Minnesota Fishing License Database, provided by the Minnesota Department of Natural Resources; Projections generated by the authors.*

## Geographic Patterns

To examine differences in angler participation rates across different regions of the state, we used the license sales database on anglers' residence and total population data from the U.S. Census Bureau to calculate and map fishing participation rates and change in participation rates over time for each Minnesota county using ArcGIS. We generated a series of maps designed to showcase spatial variations in angler participation. They show patterns based on where anglers live, rather than where they fish.

All participation rate values reported are per 100 Minnesota residents (percentages). Rates tend to be higher in central and northern Minnesota, especially in counties with an abundance of inland lakes and a strong lake culture. In 2016, the highest male fishing participation rates occurred in Mille Lacs County (73%), Lake of the Woods County (70%), and Roseau County (66%). Hennepin County (22%) and Ramsey County (24%) showed the lowest overall male participation rates. Note that while participation rates are lower in more urban areas, the greatest number of anglers still reside in more urban areas. For instance, Hennepin County was home to the greatest number of anglers (n=99,857 male anglers) in 2016, compared to only 1,160 male anglers in Lake of the Woods County.

We determined change in county participation rates from 2000 to 2016 by calculating the difference in the proportion of residents age 16-79 who purchased a fishing license in 2016 compared to 2000. Change is reported as the simple difference in participation rate in 2016 compared to 2000 (% participating in 2016 minus % participating in 2000). Male fishing participation generally decreased from 2000 to 2016, with more dramatic declines in the central lakes districts (fishing strongholds) and in suburban/exurban counties surrounding Minneapolis/St Paul (which experienced significant population growth and urbanization over this time period). The greatest participation declines for males were in counties with some of the highest participation rates in 2000. In Chisago County male participation declined from 81% in 2000 to 57% in 2016 (a decrease of approximately 24%). Mille Lacs County (-20%) and Sherburne, Wright, and Aitkin Counties (-17%) also experienced considerable decline from 2000 to 2016. These counties experienced significant population change over this time period as more urban people moved into more suburban areas or into lake-district retirement homes. This may lead to a change in culture as increasing numbers urban people (who may be less likely to fish than longer term residents) move to relatively rural areas.

Female fishing participation was highest in Lake of the Woods County (56%) and Roseau County (46%) and lowest in Hennepin County (10%), Ramsey County (11%), and Dakota and Mahnomen counties (14%). Female fishing participation decreased from 2000 to 2016 in the majority of counties, especially in Chisago County and Mille Lacs County (decrease of 14%), but generally the decreases were under a 6% change. Of the counties that showed an increase in female fishing participation from 2000 to 2016, Lake of the Woods County had the greatest increase (8%) in female fishing participation.

As expected, participation in Lake Superior salmon/trout fishing increases as distance to Lake Superior decreases with the highest participation rates (for combined males and females) in 2016 occurring in Lake County (5%), Cook County (5%), and St. Louis County (4%). Participation rates changed very little from 2000 to 2016, with the biggest decreases occurring in Chisago (-0.2%), Scott (-0.1%), and Pennington (-0.1%) counties. Lake Superior salmon/trout fishing participation increased the most in Lake (0.5%), St. Louis (0.5%) and Todd, Aitkin, and Becker counties (0.3%).

## Limitations

The key limiting factor in this analysis that only 17 years of license sales data are available, meaning that we do not have data on the participation rates of generations born before the 1990s when they were young. Despite this, we are confident in our results because they are corroborated by alternative data sources and by alternative methods. For instance, data from the National Survey of Fishing, Hunting, and Wildlife Associated Recreation on age-specific angler participation from and 1980, 1985, 1991, 1996, 2001, 2006, and 2011 confirm the influence of birth cohort on fishing participation rates in a similar pattern to what is shown here.

Second, as with any projection of future populations, assumptions about future social conditions must be made. Here, we specifically make assumptions about future time period effects and new incoming cohort effects for generations not yet old enough to be required to purchase a fishing license or even born. We base these assumptions on what has been experienced in Minnesota in the recent past among the newest cohorts.

Finally, another potential factor that has yet to be explored in depth is that of race and ethnicity. While approximately 80% of anglers nationwide are Caucasian/White[xvii], the proportion of people of color in Minnesota is growing, particularly among younger generations. This shift in the demographic makeup of the state's population will likely have significant impacts on demands for outdoor recreational opportunities, including fishing. It is possible that the age and generational differences described here are related to generational differences in the race/ethnic structure of the Minnesota population. Data on race and ethnicity are not collected in the license sales process, so we cannot exactly measure the impact of race/ethnic shifts on cohort effects.

## Implications for Fisheries Management

The key point that emerges from this study is that Minnesota's fishing population is likely to decline over the next two decades, despite Minnesota's strong fishing culture and high female participation rates, which are higher than we are seeing in other Great Lakes states. Most state fisheries and wildlife management agencies in the U.S. are grappling with the issue of declining hunting and fishing participation. Societal changes throughout the 21st century have altered the social context under which most citizens live, consequently leading to decreasing participation in fishing and hunting. The response by many state agencies has been to focus resources on recruitment and retention efforts to try and boost participation rates.[xviii] Our research suggests that although it will be challenging for these efforts to make up for the projected declines in fishing numbers during the next 20 years, it may be possible to partially address this by paying more attention to women as primary anglers.

While female fishing participation is already high in Minnesota, most of the current female anglers are secondary license holders added to a spouse's combination license. As male anglers decline in number, women (especially younger women) could play an increasingly active role in the fishing population. Women currently make up a high proportion (36%) of total anglers in Minnesota. This portion is higher than that observed in neighboring states (29% in Wisconsin, 24% in Michigan, and only 21% in Illinois). Still, it is unclear how active in fishing many of Minnesota's female fishing license holders are, given that a large share are secondary license holders added to a license purchased by a male spouse. Our projections show potential for increased recruitment and retention of young women, and if these female anglers can be retained, women could play an even more active role in Minnesota's fishing culture in the coming years. Outreach and education efforts targeted toward women have the potential to pay off and may even contribute to also recruiting more children in the long run if mothers (as well as fathers) increasingly fish with their children. As gender norms have changed, so too has the role of women in fishing.

Along with similar evidence from other states,[xix,xx] the findings presented here indicate that while participation patterns do vary by state, age and cohort effects on hunting and fishing participation are generally operating in similar ways across the Upper Midwest and the broader nation. An understanding of the contribution of cohort effects shows that, beyond the effects of age, participation has been declining because of generational differences, and it will continue to decline as the Baby Boom generation ages. Although cohort effects and projected participation declines appear to be more severe among hunters than among anglers, the general patterns are broad and will be difficult to change. Further research and planning strategies would benefit from incorporating an understanding of age and cohort effects when considering future policy changes.

Agencies will require better understanding of differences in the mix of environmental, fisheries/wildlife, social, and food-related values between different generations of stakeholders. Our projections indicate the, although the future fishing population of Minnesota will likely be smaller, female participation remains strong and could be the key to recruiting future generations. This could mean that future fishing stakeholders may have different values, interests, and expectations than past and present fishing populations.[xxi] Moreover, anglers should be expected to produce less agency revenue if license purchases decline as projected. We encourage agencies to use projections such as ours to explicitly plan how to meet conservation goals and to engage diverse fishing and non- fishing publics in the face of these changes.

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[xi.] Fedler, A. J., and R. B. Ditton. 2001. "Dropping out and dropping in: a study of factors for changing recreational fishing participation." *North American Journal of Fisheries Management* 21(2): 283-292.

[xii.] Yang, Y., W. J. Fu, S. Schulhofer-Wohl, and K. C. Land. 2008. "The intrinsic estimator for age-period-cohort analysis: What it is and how to use it." *American Journal of Sociology* 113:1697-1736.

[xiii.] Floyd, M. F., L. Nicholas, I. Lee, J. H. Lee, and D. Scott. 2006. "Social stratification in recreational fishing participation: Research and policy implications." *Leisure Sciences* 28(4):351-368.

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[xv.] Yang, Y., W. J. Fu, S. Schulhofer-Wohl, and K. C. Land. 2008. "The intrinsic estimator for age-period-cohort analysis: What it is and how to use it." *American Journal of Sociology* 113:1697-1736.

[xvi.] Winkler, R. and K. Warnke. 2013. "The future of hunting: An age-period-cohort analysis of deer hunter decline." *Population and Environment* 34(4):460-480.

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# Appendix A

## Table 1: Minnesota Resident Angler Projection Results

### Minnesota Male Resident Angler Projections

| Year | Observed | Age-Period-Cohort Projection | Cohort Survival Projection |
|---|---|---|---|
| 2000 | 741,293 | | |
| 2001 | 736,646 | | |
| 2002 | 742,176 | | |
| 2003 | 740,054 | | |
| 2004 | 743,301 | | |
| 2005 | 735,655 | | |
| 2006 | 751,424 | | |
| 2007 | 756,781 | | |
| 2008 | 757,805 | | |
| 2009 | 776,104 | | |
| 2010 | 763,522 | | |
| 2011 | 737,571 | | |
| 2012 | 757,264 | | |
| 2013 | 729,117 | | |
| 2014 | 730,854 | | |
| 2015 | 729,735 | | |
| 2016 | 727,881 | 727,881 | 727,881 |
| 2017 | | 730,938 | 725,764 |
| 2018 | | 728,691 | 723,310 |
| 2019 | | 728,618 | 720,837 |
| 2020 | | 719,652 | 718,510 |
| 2021 | | 727,797 | 715,995 |
| 2022 | | 726,486 | 713,088 |
| 2023 | | 725,193 | 710,247 |
| 2024 | | 712,855 | 707,463 |
| 2025 | | 721,722 | 704,468 |
| 2026 | | 719,874 | 700,820 |
| 2027 | | 715,074 | 696,632 |
| 2028 | | 711,437 | 692,710 |
| 2029 | | 707,495 | 688,766 |
| 2030 | | 703,340 | 684,760 |
| 2031 | | 698,822 | 680,630 |
| 2032 | | 694,227 | 676,540 |
| 2033 | | 689,767 | 672,635 |
| 2034 | | 685,132 | 668,789 |
| 2035 | | 680,283 | 664,976 |

### Minnesota Female Resident Angler Projections

| Year | Observed | Age-Period-Cohort Projection | Cohort Survival Projection |
|---|---|---|---|
| 2000 | 427,475 | | |
| 2001 | 418,869 | | |
| 2002 | 411,724 | | |
| 2003 | 403,381 | | |
| 2004 | 403,872 | | |
| 2005 | 407,084 | | |
| 2006 | 412,070 | | |
| 2007 | 413,115 | | |
| 2008 | 412,926 | | |
| 2009 | 427,665 | | |
| 2010 | 422,315 | | |
| 2011 | 407,370 | | |
| 2012 | 420,533 | | |
| 2013 | 399,865 | | |
| 2014 | 401,216 | | |
| 2015 | 404,097 | | |
| 2016 | 402,291 | 402,291 | 402,291 |
| 2017 | | 410,342 | 401,416 |
| 2018 | | 409,105 | 400,497 |
| 2019 | | 411,082 | 399,668 |
| 2020 | | 408,828 | 398,843 |
| 2021 | | 414,191 | 398,049 |
| 2022 | | 415,285 | 397,187 |
| 2023 | | 416,511 | 396,408 |
| 2024 | | 413,185 | 395,790 |
| 2025 | | 418,758 | 395,089 |
| 2026 | | 419,390 | 394,133 |
| 2027 | | 419,426 | 393,029 |
| 2028 | | 419,804 | 392,030 |
| 2029 | | 420,038 | 391,075 |
| 2030 | | 420,211 | 390,188 |
| 2031 | | 420,227 | 389,330 |
| 2032 | | 420,357 | 388,573 |
| 2033 | | 420,543 | 387,977 |
| 2034 | | 420,681 | 387,476 |
| 2035 | | 420,827 | 387,092 |

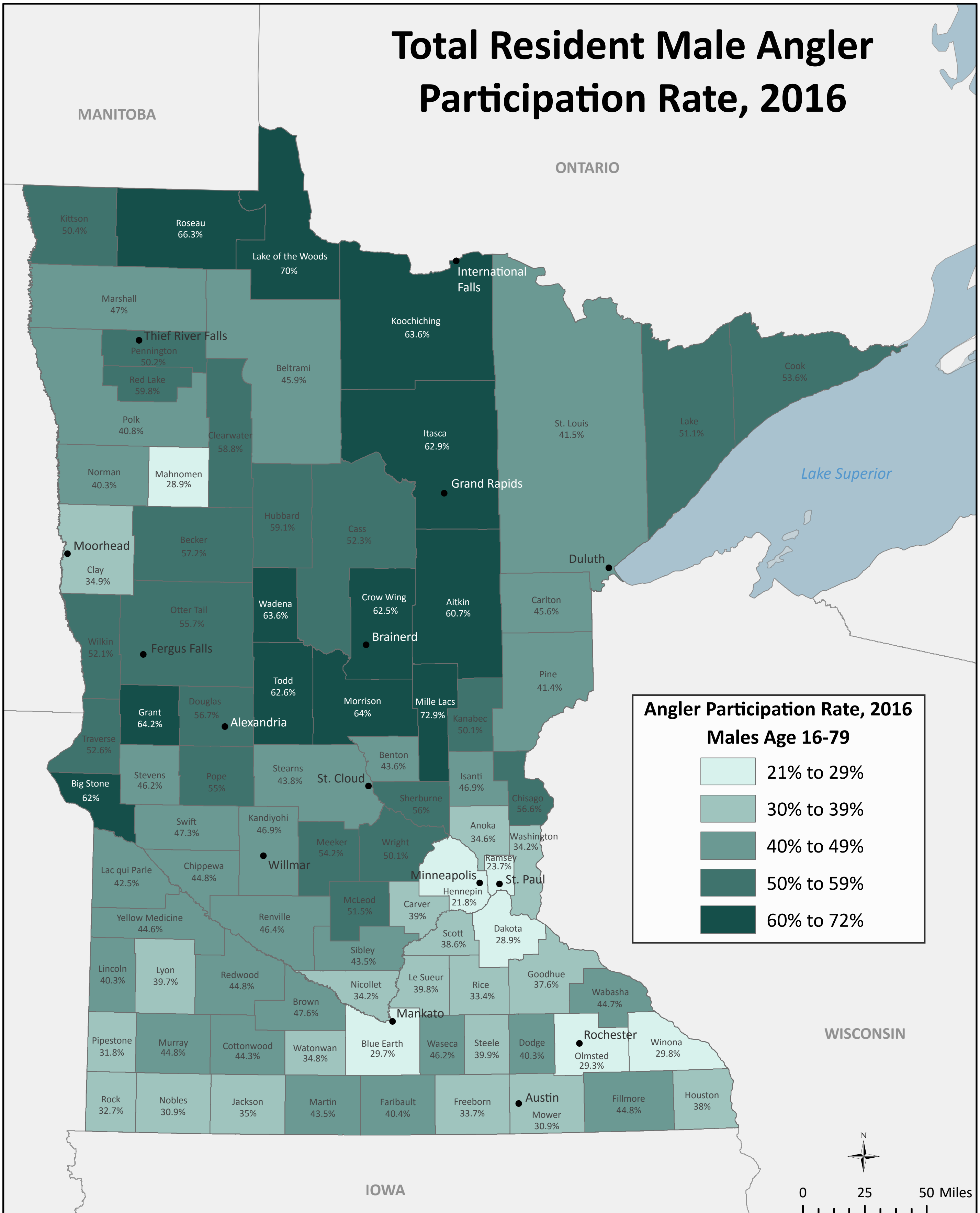
### Minnesota Lake Superior Salmon/Trout Resident Angler Projections

| Year | Observed | Age-Period-Cohort Projection | Cohort Survival Projection |
|---|---|---|---|
| 2000 | 23,693 | | |
| 2001 | 23,784 | | |
| 2002 | 23,905 | | |
| 2003 | 24,043 | | |
| 2004 | 22,582 | | |
| 2005 | 21,692 | | |
| 2006 | 22,026 | | |
| 2007 | 22,360 | | |
| 2008 | 21,703 | | |
| 2009 | 22,748 | | |
| 2010 | 24,133 | | |
| 2011 | 24,103 | | |
| 2012 | 25,103 | | |
| 2013 | 25,135 | | |
| 2014 | 26,888 | | |
| 2015 | 28,996 | | |
| 2016 | 29,862 | 29,862 | 29,862 |
| 2017 | | 26,359 | 30,136 |
| 2018 | | 26,425 | 30,372 |
| 2019 | | 26,476 | 30,580 |
| 2020 | | 26,395 | 30,782 |
| 2021 | | 26,550 | 30,933 |
| 2022 | | 26,557 | 31,048 |
| 2023 | | 26,555 | 31,142 |
| 2024 | | 26,344 | 31,197 |
| 2025 | | 26,523 | 31,240 |
| 2026 | | 26,467 | 31,233 |
| 2027 | | 26,382 | 31,188 |
| 2028 | | 26,297 | 31,135 |
| 2029 | | 26,201 | 31,068 |
| 2030 | | 26,102 | 30,975 |
| 2031 | | 26,002 | 30,883 |
| 2032 | | 25,887 | 30,794 |
| 2033 | | 25,786 | 30,712 |
| 2034 | | 25,700 | 30,621 |
| 2035 | | 25,612 | 30,532 |

*Table 1 shows observed and projected numbers of Minnesota resident male, female, and combined total anglers for ages 16-79.*

*Data sources: Minnesota Fishing License Database, provided by the Minnesota Department of Natural Resources; Projections generated by the authors.*

# Appendix B




*Authors: Data analysis by Richelle Winkler and Erin Burkett, Michigan Technological University. Cartography by Roz Klaas, Applied Population Lab, UW- Madison*
*Sources: Rates constructed by dividing Minnesota DNR resident license sales data by total population age 16-79 from US Census Bureau*
*Project supported by the Great Lakes Fishery Commission. Project ID - 2015 WIN 44044*

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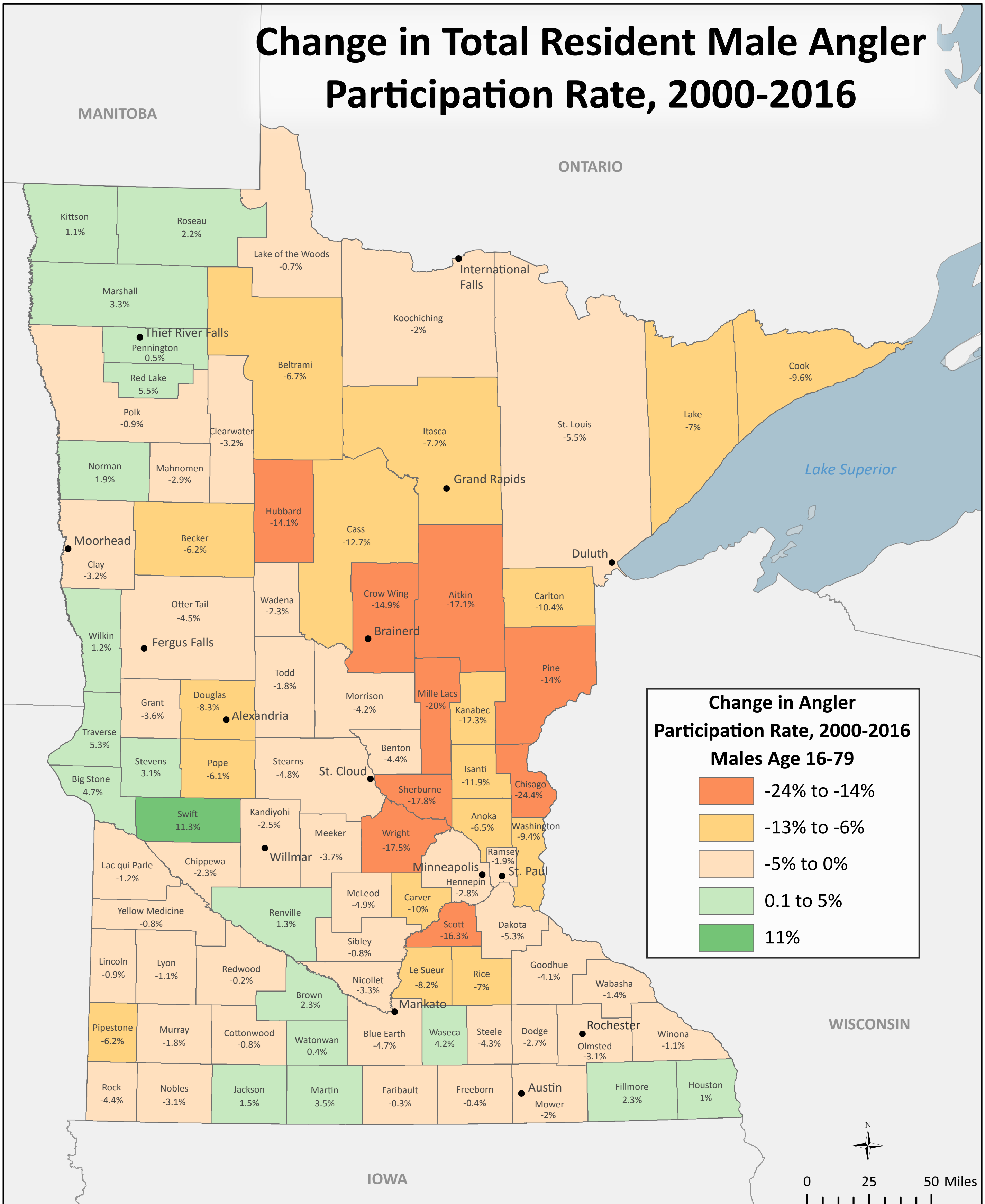
# Change in Total Resident Male Angler Participation Rate, 2000-2016

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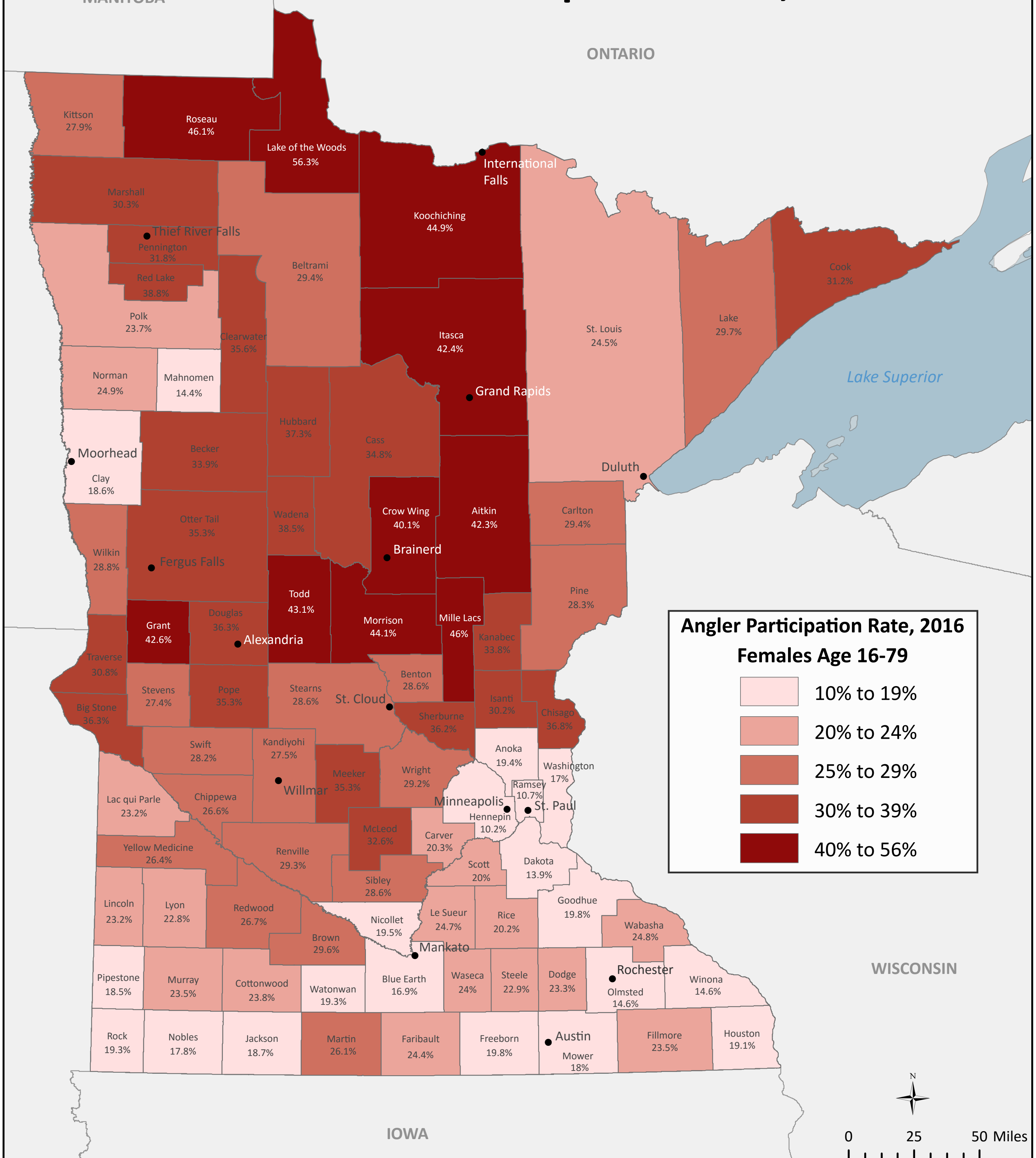
*Sources: Rates constructed by dividing Minnesota DNR resident license sales data by total population age 16-79 from US Census Bureau*
*Project supported by the Great Lakes Fishery Commission. Project ID - 2015 WIN 44044*

# Total Resident Female Angler Participation Rate, 2016




*Authors: Data analysis by Richelle Winkler and Erin Burkett, Michigan Technological University. Cartography by Roz Klaas, Applied Population Lab, UW- Madison*
*Sources: Rates constructed by dividing Minnesota DNR resident license sales data by total population age 16-79 from US Census Bureau*
*Project supported by the Great Lakes Fishery Commission. Project ID - 2015 WIN 44044*

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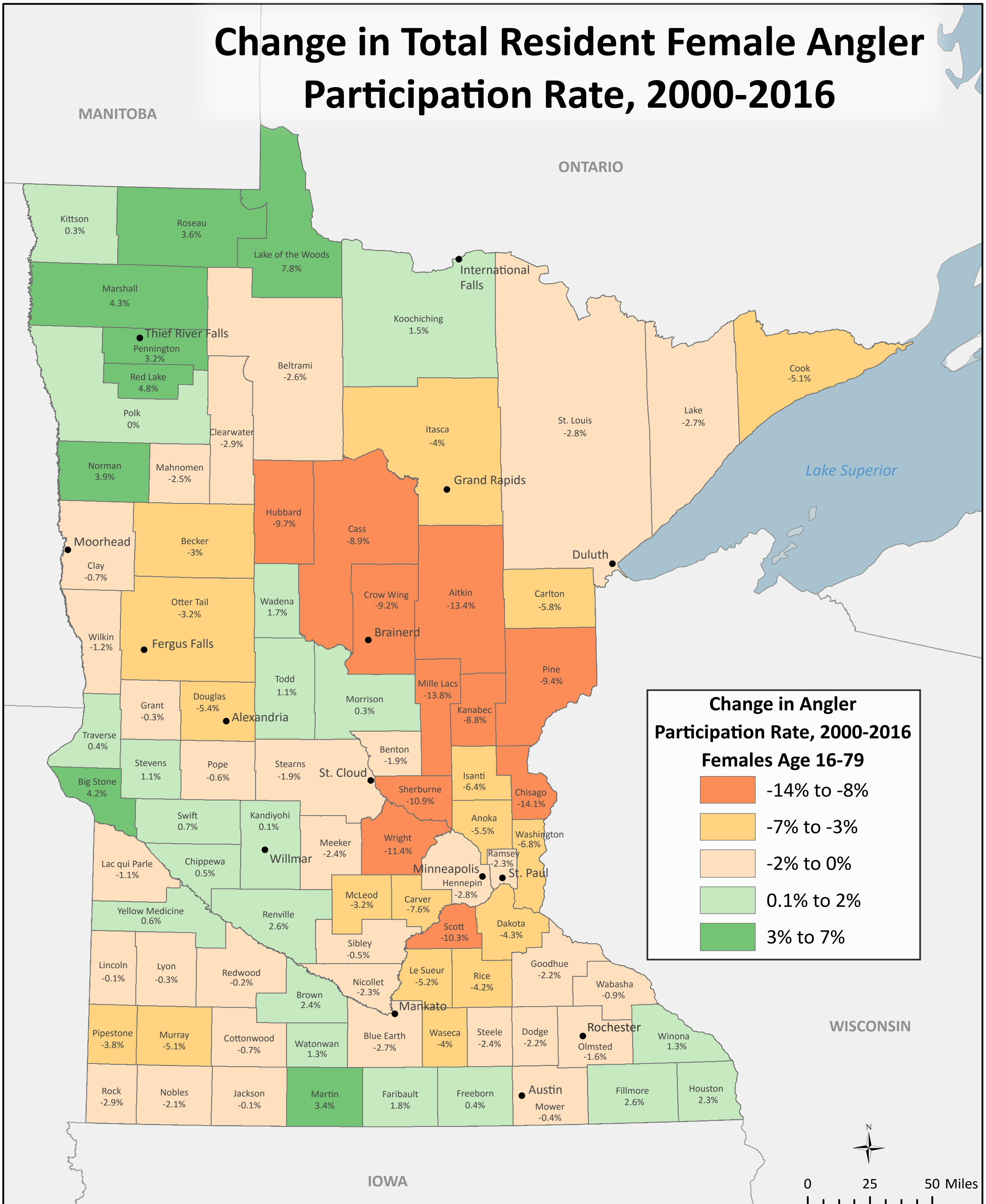
# Change in Total Resident Female Angler Participation Rate, 2000-2016

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*Sources: Rates constructed by dividing Minnesota DNR resident license sales data by total population age 16-79 from US Census Bureau*

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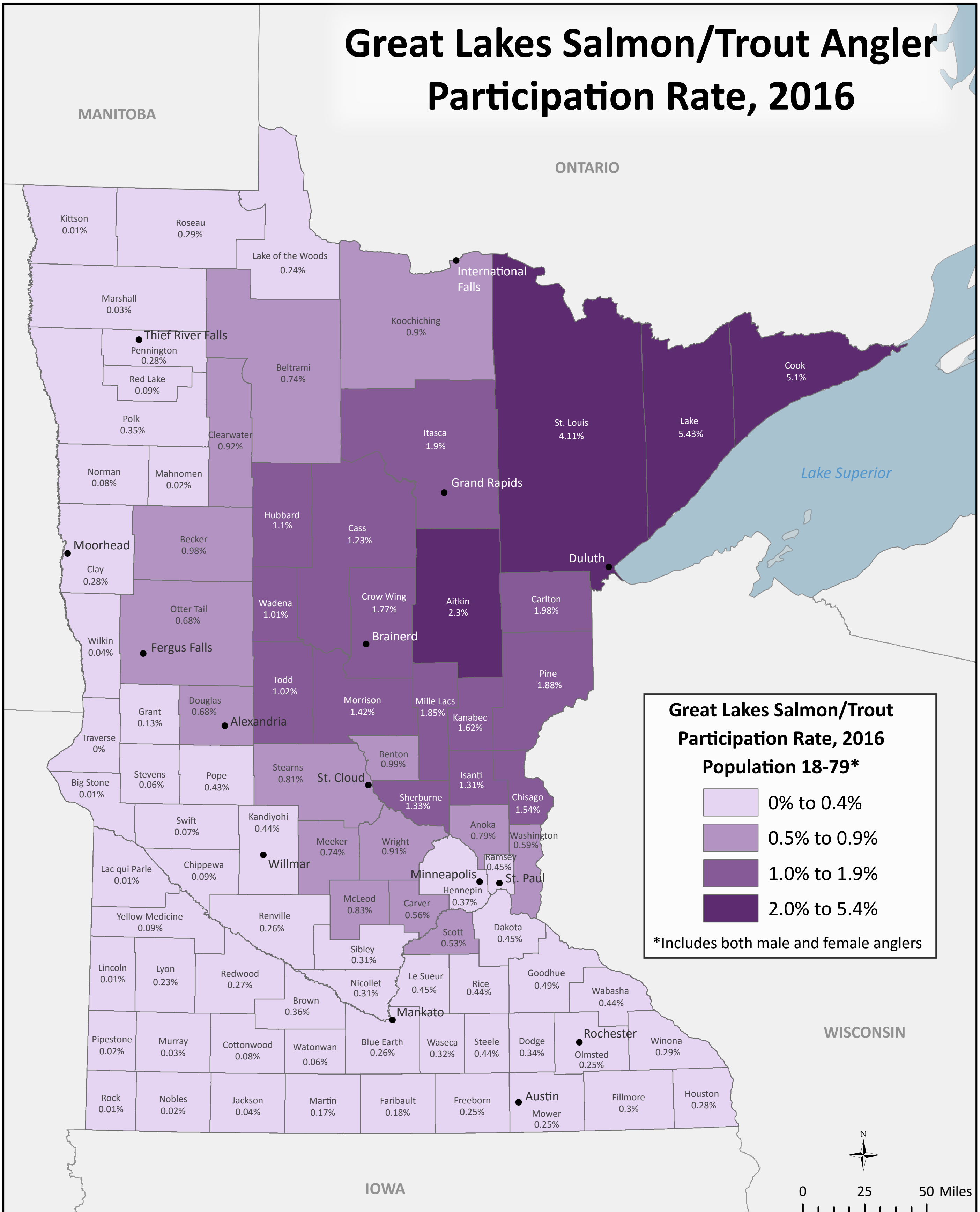


*Authors: Data analysis by Richelle Winkler and Erin Burkett, Michigan Technological University. Cartography by Roz Klaas, Applied Population Lab, UW- Madison*
*Sources: Rates estimated based on GL salmon/trout stamp sales (using WI as model for MN & MI) divided by total population age 18-79*
*Project supported by the Great Lakes Fishery Commission. Project ID - 2015 WIN 44044*

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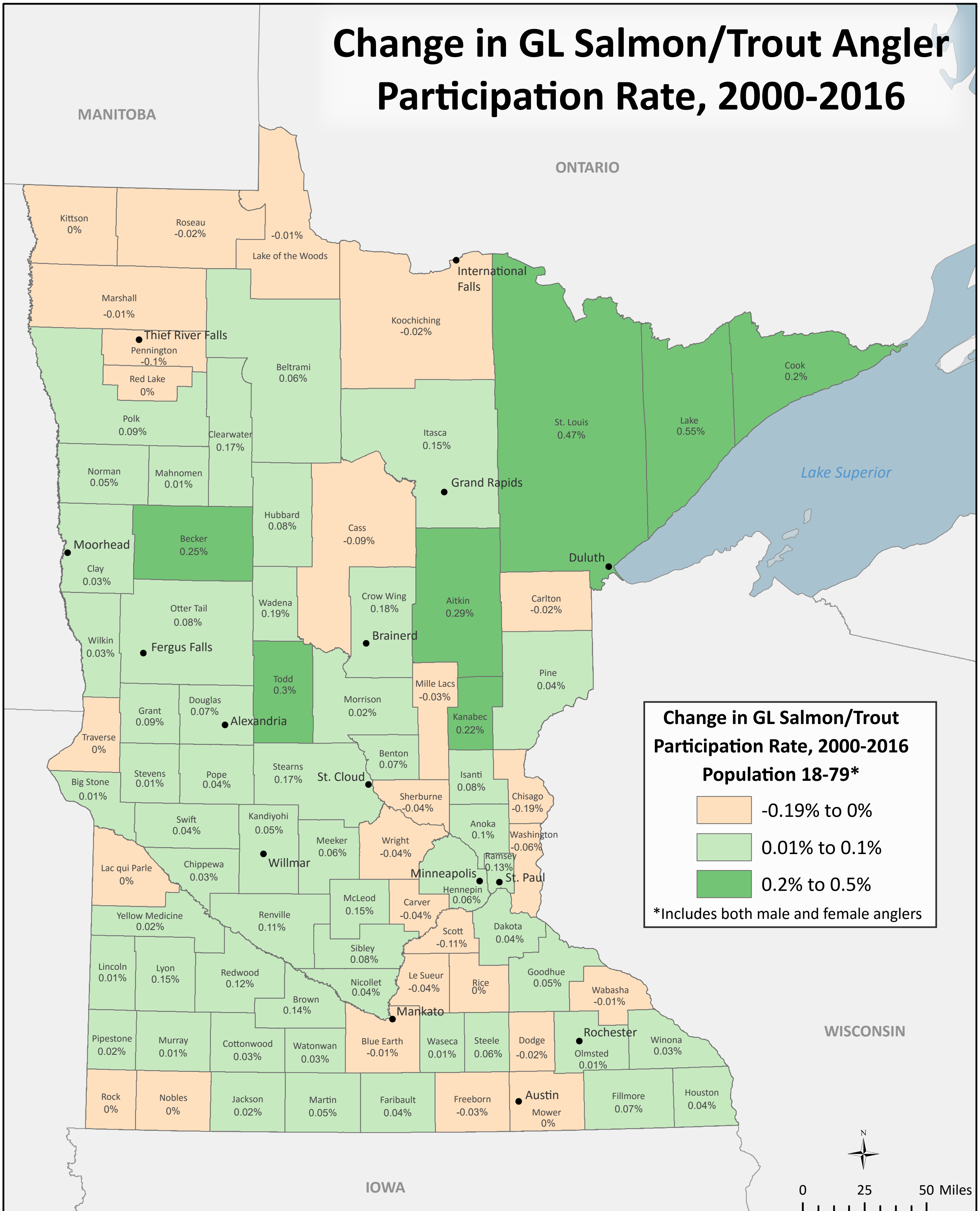
# Change in GL Salmon/Trout Angler Participation Rate, 2000-2016




*Authors: Data analysis by Richelle Winkler and Erin Burkett, Michigan Technological University. Cartography by Roz Klaas, Applied Population Lab, UW- Madison*
*Sources: Rates estimated based on GL salmon/trout stamp sales (using WI as model for MN & MI) divided by total population age 18-79*
*Project supported by the Great Lakes Fishery Commission. Project ID - 2015 WIN 44044*

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