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## The Aggregate Economic Value of Great Lakes Recreational Fishing Trips

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**Abstract.** We use the contingent valuation method in a survey of Great Lakes anglers to estimate the willingness to pay for a Great Lakes recreational fishing trip. Employing various assumptions and models, we find that the willingness to pay for a trip ranges from $54 to $101 ($2020). We then combine the willingness to pay per trip estimates with an estimate of the number of trips and find that the aggregate economic value of Great Lakes fishing trips in the U.S. is $611 million. We conduct a sensitivity analysis over the estimates of willingness to pay and the number of trips and estimate that the 90% confidence interval around the mean estimate of $632 million is ($182.5, $1,553) million.

**Key words**: Economics, Recreational fishing, Willingness to pay

## Introduction

The intersection of human social systems and fisheries management is a complex relationship that must be considered if fisheries policies are to receive wide acceptance among the populations who utilize, value, and support the resource. However, the human dimension does not always receive the attention required to generate the information that should be part of management decisions. Regarding economic considerations, Heck, Stedman and Gaden (2014) outline several reasons as to why that is the case including the lack of formal training in the application of economic information by decision-makers, managers' distrust of social sciences, and a lack of actionable economic information on which to base decisions. This study addresses the lack of current economic information about the recreational value of the Great Lakes system.

The management of fisheries systems is complex, dynamic, and often contested. Fisheries resources and the anthropogenic activities that rely on them, whether free or at a cost, contain significant economic values. However, at the core of fisheries management lies economic issues of valuation, incentives and user-rights. Understanding the economic role that recreational fisheries play is crucial to shaping successful international, national, regional, and local fisheries policies. However, different policy contexts will require the application of different approaches.

The Great Lakes are a finite resource with multiple uses and multiple users. Policy makers at various levels must make allocation decisions regarding the Great Lakes (e.g., providing water for agricultural, industrial, or recreational uses). Economic use value is of particular importance to these policy makers as it provides a clear measure of the broader societal effects of resource allocation. Maximizing social welfare requires the efficient allocation of public resources, and an efficient allocation is possible only if we clearly understand the values that society places on its resources. Specific to the Great Lakes fisheries, managers are faced with allocating specific fisheries to recreational versus commercial uses. Such decisions require estimates of economic use value of the fisheries that are as accurate and timely as possible.

Measuring the socio-economic contributions of fisheries has taken the form of a variety of frameworks dependent on the type of aspects being explored. These methods generally fit into the categories of market valuation, non-market valuation, or a combination of the two. The total economic value of resources is the net social benefit that comprises both consumer surplus and producer surplus. Producer surplus relates to the real market economy and represents market value, while consumer surplus refers to the non-market benefits derived from activities and is measured by the additional amount an individual would be willing to pay over and above their market expenditures. Market and non-market values can be further deconstructed into use and non-use values. Use value is typically comprised of direct use values, which involve the economic or social values of tangible goods or benefits used directly by a consumer; indirect use values which relate to tangible benefits provided indirectly by resources; and non-use values which refer to the value of resource preservation and their future availability for use.

Generally, the values relating to direct use value are easiest to estimate, since they usually involve measured quantities of products which have observable market prices. For instance, we can look at transactional data of recreational fishing gear or license sales to understand certain components of direct values. However, assessing the benefits received by recreational anglers from indirect use require a slightly more complex assessment. Nevertheless, a large literature has been developed to tackle this problem. The most common ways to assess these values has been through the use of surveys that measure fishery participants revealed and/or stated preferences. In this study, we estimate the indirect use value of recreational fishing using a stated preference survey.

Poe et al. (2013) review travel cost method, contingent valuation method and other studies that estimate the economic value (i.e., willingness to pay) of a Great Lakes fishing trip and find that the range is between $20 and $75 per day ($2012). Combined with estimates of the number of fishing days, Poe et al. estimate that the aggregate value of recreational fishing in the Great Lakes is between $393 million to $1.47 billion ($2012). There have only been a few Great Lakes recreation valuation studies since the Poe et al. review. For example, Ready et al. (2018) use the travel cost method to estimate the value of recreational fishing when aquatic nuisance species are prevented from spreading. Three studies have used stated preference choice experiments to value attributes of recreational fishing trips in the Great Lakes. Knoche and Lupi (2016) estimate the value of changes in regulations that catch rates for Michigan trout anglers. Raynor and Phaneuf (2020) estimate the value of species-specific catch rate changes in Lake Michigan. Hunt, et al. (2021) estimate how the value of a trip with changes with changes in target species for Ontario anglers.

Given that no recent study has estimated the aggregate recreational fishing value for the entire Great Lakes system, we use the contingent valuation method (CVM) in a survey of Great Lakes anglers (Boyle, 2017; Haab et al. 2020). Our survey design builds on the traditional dichotomous choice CVM approach to valuing a recreation trip. The first such study with a trip cost payment vehicle may be Cameron and James (1987). In this question format, survey respondents who had already taken a trip were asked about their trip costs and then a counterfactual about higher trip costs. A large number of studies have since used this approach to value outdoor recreation trips. Recently, for example, Neher et al. (2017) asks river rafting participants four separate questions with changes in trip costs at different river flow levels.

We conduct an analysis that estimates willingness to pay for the most recent Great Lakes fishing trip. Employing various assumptions and models, we find that the willingness to pay for a trip ranges from $54 to $101 ($2020). We then combine the willingness to pay per trip estimates with an estimate of the number of trips and find that the aggregate economic value of Great Lakes fishing trips in the U.S. is $611 million. We conduct a sensitivity analysis over the estimates of willingness to pay and the number of trips and estimate that the 90% confidence interval around the mean estimate of $632 million is ($182.5, $1,553) million.

**Survey Method**

Our sampling frame was all individuals aged 18 and older who were licensed to fish in at least one Great Lake state. In total, we identified 8.9 million individuals; however, we recognize this is an imperfect number given our data request fell while the 2020 fishing season was still open. The survey was designed to collect demographic information, fishing behavior, expenditures, and stated preferences of Great Lakes anglers during the 2020 fishing season (Cornicelli et al. 2022). We divided our sample into three treatment groups: 1) email, 2) advance email notification (recipient received a postcard notifying them of a future email survey), and web push (recipient was given an access code and directed to the website).

Our intent was to compile state license data at one time and stratify the sample to include 25,000 anglers from each state aged 18 and over; half the sample was comprised of individuals with zip codes within 25 miles of a Great Lake and half from outside that area. Although we successfully obtained data from all 8 Great Lakes states, we encountered several delays and database issues that resulted in uneven survey timelines and variable outgoing sample sizes. In brief, Indiana (IN), Michigan (MI), Minnesota (MN), Ohio (OH), Pennsylvania (PA), and Wisconsin (WI) sent us data by mid-December, 2020. Concurrently, we were in discussion with Illinois (IL) and New York (NY) and hoped to obtain those data in time to do one survey in mid-January. Unfortunately, NY and IL confirmed they would not meet our survey timelines and we adjusted survey delivery. We received NY data on February 4, 2021 and IL on March 4, 2021. Consequently, survey campaigns began on January $18^{th}$ (IN, MI, MN, OH, PA, WI), February $4^{th}$ (NY), and March $8^{th}$ (IL). In total, we attempted to contact recipients 4 times and concluded primary data collection in mid-April 2021.

In total, we emailed 209,645 survey invitations across the eight Great Lakes states. Of those, 17,482 invitations either bounced or were undeliverable. This yielded 186,074 surveys that were presumably delivered to recipients. For the web push component, we mailed 4,750 postcards and 397 were returned as undeliverable.

We subsequently developed an abbreviated 17 question survey to demographically weight the main dataset, or ideally, obtain information that could be incorporated into the final dataset. To enhance response, we opted to implement the survey via both paper (mail) and email delivery. In total, we mailed 6,400 paper surveys (400 per state/strata) and sent 28,000 email invitations (2,000 per state/strata) to non-respondents. Abbreviated survey data collection started in early May and concluded at the end of April 2021.

We emailed 209,645 survey invitations across the eight Great Lakes states and received

18,514 completed replies. In most cases, recipients who lived within 25 miles of a Great Lake and received an advance notification postcard responded at higher rates. We received an additional 1,479 responses (979 email, 500 paper) from the shortened survey, which resulted in an adjusted response rate of 10.6% (12.7% inside 25 miles, 8.7% outside 25 miles). We found no meaningful differences among the five modes of contact, so we combined the primary and abbreviated survey samples into one dataset (n = 19,993).

Our sample was comprised of 82% male and 18% female respondents, which was skewed slightly towards males as compared to the population (77%M/23%F). Average age of respondents was 49.9 years (males = 51.1, females = 44.4), which was slightly older than the population (46.2M/42.5F). Consequently, we applied a rake weighting procedure to reflect those differences. Overall, 54.5% (n = 10,821) indicated they fished at least one of the Great Lakes during the 2020 season. Of those, 78% had a resident annual license, 2% resident daily, and 9.9% each had a non-resident annual or non-resident daily license. These proportions were not different from the license population ($\chi2 = 0.998$, $P = 0.802$).

The average angler started fishing at 9.7 years old, has fished for 31.4 years, and fished for 38.5 days in 2020. Great Lakes-specific anglers started at a slightly younger age (9.2), have fished for 32.9 years, and spent 45 days fishing in 2020. A majority of Great Lakes anglers indicated they had intermediate (34%) or fairly advanced (44%) fishing skills. Only 3.4% of respondents self-identified as beginners.

To estimate lake level participation and effort, we only used individuals who fished one lake within that respective state. To drill down into lake level activity, respondents were asked if they fished a Great Lake, the species and number of days they fished, the Great Lake(s) they fished (e.g., Lake Superior), and the number of days they fished from that state/lake (e.g., Michigan-Lake Superior, Michigan-Lake St. Clair). Anglers fished multiple Great Lakes both within and outside their own state, overall participation and effort results would be aggregated for states with more than one Great Lake. Using the state of Michigan as an example (up to 5 locations), if an individual fished for salmonids in Lake Superior and bass in Lake St. Clair, salmon effort would inadvertently be aggregated with Lake St. Clair (where salmon fishing is limited). Thus, we would produce misleading lake-level results, especially for Lake St. Clair and the St. Lawrence River. Consequently, we decided to constrain the results to individuals who only fished one lake, recognizing sample sizes would be smaller. In the case of large lakes with multiple species, the results did not vary among people who fished one lake or more than one lake. However, for Lake St. Clair and the St. Lawrence River, results indicated significant effort for species that are otherwise lightly fished.

The average time that individuals fished the Great Lakes ranged from 15.9 to 27.2 days. St. Lawrence River (15.9) and Lake St. Clair (16.3) anglers fished the fewest number of days, and Lake Erie anglers the greatest (27.2), followed by Lake Michigan (25.3). For species targeted, apart from bass on the St. Lawrence River (72%), anglers most often fished for either walleye/sauger or salmon. Anglers also indicated they spent the most days fishing for ‘anything that bites’, regardless of location. Other species were infrequently fished and generally included sturgeon, catfish, and rough fish.

**Contingent Valuation Method**

We focus the willingness to pay analysis on a sample 8,425 anglers who answered the willingness to pay and the related follow-up questions. We included several questions in the angler survey related to the anglers' most recent trip to fish the Great Lakes. Respondents were first asked about the distance traveled on their most recent Great Lakes fishing trip (excluding distance traveled on the water). The average distance was 118 miles with a minimum of zero and a maximum of 980. The most recent trip was a day trip for 69% of the respondents who answered the question. Of those who took an overnight trip, the average number of nights spent away from home is 6.7 with a minimum of 1 and a maximum of 80.

The average number of people in the travel party was 3.07. The average number of people in the fishing party was 3.13. Sixty-two percent of respondents fished with members of their immediate family, 21% fished with their extended family, 57% fished with friends and colleagues, 6% fished with pets, and 1% fished with an organized group (such as a club or church group). Forty-six percent of respondents fished from a private boat and 12% fished from a charter boat. Twenty-five percent fished from the shore and 8% fished from a pier. Six percent took an ice fishing trip. September was the most common month of the most recent fishing trip (21%) with 17% in August and 16% in October. The average amount of time spent fishing on the trip is 10 hours. Overall, 88% of respondents stated that the most recent trip was a typical trip.

The willingness to pay question section began by asking respondents for the cost of the most recent fishing trip to help frame the willingness to pay question. The average reported trip cost is $278 with a minimum of $0 and a maximum of $3,000. Two-hundred seventy-nine respondents answered 0 and 1,835 respondents did not answer the question. Since this is a large fraction of the respondents who answered the willingness to pay question (22%), we investigated the differences in willingness to pay responses between those who answered the trip cost question and those who did not. We first considered the effect of item nonresponse on the cost of the most recent trip variable on willingness to pay responses. In a logit model analyzing the factors that explain item nonresponse we find that males, those with higher incomes, those who hold nonresident licenses and who fish with more people are more likely to report their cost per trip. Beginner skill level anglers are less likely to report the cost for the most recent trip. It is tempting to conduct a complete case analysis with these data, dropping willingness to pay responses with missing cost per trip information assuming that those who consider and report their costs per trip provide better answers. But, complete case analysis would impose a sample selection rule and potentially bias the WTP estimates due to an unrepresentative sample. The percentage of "yes" responses is 57% for those who report their cost per trip and 53% for those who do not. The difference is seemingly small but statistically significant ($\chi^2 = 12.5(1\ df)$). In split sample logit models, we find that both models are statistically reliable and there are no statistically significant difference in the willingness to pay estimates. Considering these results, we proceed with analysis of the full data below (n = 8,425).

Next, respondents are presented with a hypothetical situation: "Fishing expenses change over time. For example, gas prices rise and fall. Would you have taken this trip if the cost were $A more than the amount you just reported?" Respondents could answer "yes", "no" or "I don't know". The randomly assigned cost amounts, $A, were developed from a review of the literature conducted by Poe et al. (2013). Poe et al. review 22 studies that estimate the economic value (i.e., willingness to pay) of a Great Lakes fishing trip. The average value is $53.9 with a standard deviation of 23.4 ($2019). The values range from $24.9 to $123.2. We use six values from this distribution as dollar values in the willingness to pay question. The six values are the mean, the mean minus 1 and 2 standard deviations and the mean plus 1, 2, and 3 standard deviations (rounded to the first digit). The randomly assigned additional cost amounts are $7, $31, $54, $77,

$101, and $124. The average additional cost amount presented to respondents is $65 which is 23% of the stated cost of the most recent trip.

Overall, 56% of the respondents answered “yes” to the willingness to pay question, 20% answered” no” and 23% answered “I don’t know” (Table 1). The percentage of respondents who state that they would still have taken the fishing trip with the higher cost amount is 81% at the lowest additional cost amount and declines monotonically to 40% at the highest cost amount. The differences in proportions are statistically significant when each of the response categories is considered separately and when the “no” and “I don’t know” responses are combined according to the chi-square statistic ($p<0.05$).

Respondents who answered “yes” were asked a qualitative certainty question: “How sure are you that you would still have taken this trip?” The answer options were 1-very sure, 2-somewhat sure, and 3 -not very sure. Eighty-four percent of respondents who answered “yes” stated that they were “very sure” that they would still take the trip. Fourteen percent stated that they were somewhat sure and less than 1% stated that they were not very sure. The proportion of those who were very sure about still taking the trip is 90% at a cost of $7 and decreases monotonically to 82% at $124.

Hypothetical bias exists when responses to hypothetical behavior questions in surveys does not match actual behavior. There is much past research to suggest that respondents who answer “very sure” in willingness to pay follow-up questions are more likely to actually behave that way in a real situation (Penn and Hu, 2018). A common technique to mitigate hypothetical bias is to recode “yes” responses to responses if the respondent is not “very sure” about their answer. Following this recode, 48% of the respondents would still take the trip. The percentage of respondents who state that they are very sure that they would still have taken the fishing trip with the higher cost amount is 73% at $7 and declines non-monotonically to 33% at $124. The differences in proportions are statistically significant when the "no" and "I don't know" responses are combined and considered separately, as above.

**Results**

Simple willingness to pay binary logit models with "I don't know" responses recoded to no responses are estimated, $\Pr(yes = 1) = \Pr(\alpha - \beta A + e)$. See the appendix for a description of the economic theory that leads to this model. The probability function is operationalized with the logistic regression model: $\Pr(\Delta v \geq 0) = \frac{1}{1+e^{-(\alpha-\beta A+e)}}$. With a linear functional form for utility the mean (and median) WTP estimate is the cost amount that makes the probability that the change in utility is equal to 0.50 (Hanemann, 1984). In other words, the angler is indifferent between paying more and taking the trip and not taking the trip (and paying nothing). Setting $Pr(\cdot) = 0.5$ yields $WTP = -\frac{\alpha}{\beta}$. The standard errors of WTP are estimated with the Delta method (Cameron 1991).

Another welfare measure described in Hanemann (1989) is the truncated WTP. The WTP estimate in (9) allows for negative WTP when the probability of a "yes" response at a cost amount of zero is less than one. The truncated WTP welfare measure is: $WTP' = -\frac{1}{\beta}\ln(1 + \exp(\alpha))$. Hanemann (1989) shows that $WTP'/WTP$ increases from close to 1 when the probability of a "yes" response when the cost amount is zero is 0.95 to almost 4 when the probability is 0.55. Note that the probability of a "yes" response should be equal to one when the cost amount is zero unless the object of valuation is a bad (instead of a good). When the probability of a yes response is less than 0.50 ($\alpha < 0$), $WTP < 0$.

We present two willingness to pay models (Table 2). One set is with the two dependent variables: the raw willingness to pay responses (Yes1) and the yes1 responses recoded for respondent certainty (Yes2) to mitigate for potential hypothetical bias. For each of these we estimate weighted models which provide an improved statistical fit with higher model chi-squared values. In each of the logit models the constant ($\alpha$) is positive and the slope ($\beta$) coefficient is negative and statistically significant. The raw Yes1 model provides a better statistical fit relative to the model using the recoded Yes2 responses. This is a typical result since the dependent variable in the recoded Yes2 model contains an additional source of variation.

The willingness to pay estimates are presented in Table 3. The mean willingness to pay estimate without hypothetical bias mitigation is $82 with a tight 95% confidence interval of [78, 85]. The probability of a yes1 response when the cost amount is zero is 76% and the truncated willingness to pay is $101 [96, 105], 1.2 times greater than that the willingness to pay estimate that allows negative values. The mean willingness to pay estimate with hypothetical bias mitigation is $54 [51, 58]. The probability of a yes response when the cost amount is zero is 68% and the truncated willingness to pay is $85 [80, 89], 1.6 times greater than that which allows negative values.

In addition, we examined other factors that explain the willingness to pay responses (Cornicelli, et al. 2022). In choosing these variables we focus on those that have a sample size greater than 8,000 to avoid significant sample attrition and that produce statistically significant coefficient estimates. The average income is $96.8 thousand and suffers from significant, 23%, item nonresponse. We include the income variable and avoid a reduced sample size by setting the income for those who do not report income equal to zero and include a dummy variable for income item non-response. The coefficient on the income variable is no different than the coefficient on income with the sample reduced by income item non-response. Two variables are related to the cost for the most recent trip, whether the respondent took a day trip and the miles driven to the fishing location. In order to parameterize the constant, we include angler age, dummy variables for angler skill, dummy variables for fishing mode, dummy variables for target species and angler age and state of residence.

The marginal effect of each independent variable is equal to the coefficient on the variable divided by the negative of the coefficient on the cost amount. As before, as the cost amount increases the respondent is less likely to take the most recent trip. As income increases the respondent is more likely to continue taking the most recent trip. Each $10,000 increase in income leads to an increase of $2.83 in willingness to pay. For the variables that capture the baseline trip cost, as the miles traveled increases willingness to pay increases. The willingness to pay for a day trip is $53 lower than the willingness to pay for an overnight night trip.

Anglers who target perch and do not target any specific species are willing to pay $6 less per trip than the baseline. Anglers who target Northern pike, pickerel, and muskie are willing to pay $12 more per trip than the baseline. Anglers with advanced skill level are willing to pay $7 more for the most recent trip. Anglers with expert skill level are willing to pay $14 more. Relative to the private boat mode, charter boat anglers are willing to pay $14 more, shore and pier anglers would pay $23 less and ice fishing anglers would pay $15 less. Minnesota, Pennsylvania, and Wisconsin resident anglers are willing to pay $11, $8, and $10 less per trip than residents of other Great Lakes states.

**Discussion**

The aggregate economic value of Great Lakes recreational fishing trips can be estimated by aggregating the willingness to pay for the most recent trip over the number of trips. Recall that 88% of the survey respondents stated that the most recent trip was a typical trip. Therefore, we assume that the willingness to pay estimates are unbiased estimates of the value of a typical trip. The aggregate economic value of Great Lakes fishing trips is $AEV = \sum_{i=1}^{n} \sum_{t=1}^{m} WTP\,'$, where $n$ is the number of anglers and $m$ is the number of fishing trips.

As our base case estimate of the willingness to pay for a fishing trip we use the truncated willingness to pay, $WTP'$, with the hypothetical bias adjustment, $85. The truncated willingness to pay may be most appropriate since it is difficult to imagine an angler trip being a bad (instead of a good) since it is a choice variable. Since the additional cost of a fishing trip could potentially be spread out over the entire travel party, we divide the willingness to pay by the average travel party size, 3.06, from the angler survey. Our baseline estimate of the value of a recreational fishing trip per person is $27.78. Note that this is a conservative adjustment since the average size of the fishing party may be lower than the average size of the travel party.

Estimating the number of recreational anglers is foundational to estimating the aggregate economic value of the system. This proved challenging because each Great Lake state has different requirements for licensing (e.g., age, military status) and permitting (e.g., stamp requirement). Four states (IN, MI, NY, OH) had no special requirement to fish the Great Lakes or their tributaries. We used a variety of data sources to create our estimates, recognizing that different methods must be applied, depending on the state. Where applicable, we used estimates derived by Richelle Winkler (personal communication) as a foundation; however, that project (Burkett and Winkler, 2019) was constrained to resident, trout/salmon anglers in the Upper Great Lakes (Huron, Michigan, Superior). In other cases, we used a combination of stamp sales, creel data, proportion of survey respondents not fishing for trout/salmon, or other state-derived research. Simply, it was not possible to estimate the number of Great Lakes anglers using a standardized process; thus, the estimate derived from this project is the best number we could generate given the inherent regulatory differences among the states. We acknowledge the uncertainty surrounding our angler estimates, and the fact they could be biased both low and high.

Overall, we estimated that 1.1 million unique licensed anglers fished at least one of the Great lakes (or their tributaries) in 2020. Because individuals fished multiple lakes within a state, we estimated that during the 2020 fishing season, just over 1.4 million licensed anglers fished a Great Lake or tributary. The most popular lake was Erie (566,511), followed by Michigan (353,790), and Ontario (228,488).

To estimate the number of trips we used the estimate of total Great Lakes fishing days from the angler survey data and divide this by the number of days fished on each trip. Our estimate of the number of days fished on each trip is the number of nights away on each trip plus 1 (assuming conservatively that the angler fishes on both travel days). With these estimates, the mean and median number of trips per unique angler is 33 and 20, respectively. The product of the number of anglers and the median number of angler trips is 22 million angler trips. The product of the number of angler trips and willingness to pay per trip per angler is $611 million ($2019).

A number of assumptions were made to develop the aggregate benefit estimate so we conduct sensitivity analysis to develop a more rigorous estimate of the aggregate economic value and its 90% confidence interval. Earlier we presented a range of willingness to pay estimates and above we chose one of these for welfare analysis. However, it is clear from the economics literature that the true willingness to pay can be found over a wide range of estimates. So, we assume a triangular distribution of willingness to pay and use a lower bound estimate, $54, from the weighted model that employs the hypothetical bias adjustment but does not exclude negative willingness to pay values. The upper bound is the truncated willingness to pay from the model without the hypothetical bias adjustment, $101. The mode of the distribution is the base case estimate of willingness to pay and $WTP \sim T(54, 101, 85)$.

We employ a normal distribution of travel party size with a standard deviation of 2.79 and random draws from this distribution truncated below at 1. For the number of trips by each angler we use a triangular distribution with the minimum equal to the 25% percentile of the distribution (6.67 trips) and a maximum equal to the 75$^{th}$ percentile, 40 trips. We took 100,000 random draws from each distribution and take the products implied by aggregation equation. The mean aggregate economic value from the Monte Carlo simulation is $623.2 million and the median is $490.6. The 90% confidence interval around the mean is ($182.5, $1,553) million.

**Conclusions**

In this paper we use the contingent valuation method in a survey of Great Lakes anglers to estimate the willingness to pay for a Great Lakes recreational fishing trip. Employing various assumptions and models, we find that the willingness to pay for a trip ranges from $54 to $101 ($2019). We then combine the willingness to pay per trip estimates with an estimate of the number of trips and find that the aggregate economic value of Great Lakes fishing trips in the U.S. is $611 million. We conduct a sensitivity analysis over the estimates of willingness to pay and the number of trips and estimate that the 90% confidence interval around the mean estimate of $632 million is ($182.5, $1,553) million.

These estimates can be used in two ways. First, the estimate of aggregate economic recreational value illustrates the economic importance of the Great Lakes Recreational fishery over and above market expenditures. Second, they can be used for policy analysis. For example, suppose a policy is proposed to combat an aquatic invasive species that is expected to decrease the number of recreational fishing trips by 10%. The recreational value of this policy would be 10% of the aggregate economic valuation estimate, $61 million. This number could be compared to the cost of the policy to determine if it is economically efficient.

Future research should focus on extending this analysis to broader economic questions. Our approach focused on estimating the status quo value of recreational fishing trips. But, the contingent valuation method can be used to estimate the valuation of trip attributes when additional questions are presented (e.g., Neher et al. 2017). A potential extension with this question format would be to ask respondents if they would still have taken the trip if their catch rate had increased. Combining these responses in a single model would allow for an estimate of the value of catch per trip.

Table 1. "Yes" response of anglers for willingness to pay question related to whether they would take their trip, based on increased cost.

| | Survey Response | | | | |
|---|---|---|---|---|---|
| Cost | No | Maybe | Yes1 | Total | % Yes1 |
| $7 | 70 | 187 | 1,089 | 1,346 | 81% |
| $31 | 176 | 332 | 931 | 1,439 | 65% |
| $54 | 261 | 347 | 828 | 1,436 | 58% |
| $77 | 351 | 384 | 681 | 1,416 | 48% |
| $101 | 412 | 344 | 669 | 1,425 | 47% |
| $124 | 435 | 380 | 548 | 1,363 | 40% |
| Total | 1,705 | 1,974 | 4,746 | 8,425 | 56% |
| $\chi^2$ [yes vs. no, I don't know] (df) = 606.60 (5) | | | | | |
| $\chi^2$ [yes vs. no vs I don't know] (df) = 695.90 (10) | | | | | |

Table 2. Willingness to pay logistic regression models

| | Yes1 | | | Yes2 | | |
|---|---|---|---|---|---|---|
| | Coefficient | SE | t-value | Coefficient | SE | t-value |
| Constant | 1.163 | 0.046 | 25.16 | 0.710 | 0.044 | 16.20 |
| Cost | -0.014 | 0.00059 | -24.08 | -0.013 | 0.00058 | -22.40 |
| Sample size | 8,425 | | | 8,245 | | |
| Model $\chi^2$ (df) | 620.53 (1) | | | 531.53 (1) | | |
| Note: | Yes1 is yes vs. no/I don't know | | | | | |
| | Yes2 is certain yes vs. no/I don't know/uncertain yes | | | | | |

Table 3. Willingness to pay estimates

| | Yes1 | | | Yes2 | | |
|---|---|---|---|---|---|---|
| | WTP | SE | t-value | WTP | SE | t-value |
| Base | 81.50 | 1.69 | 48.21 | 54.18 | 1.78 | 30.46 |
| Truncated | 100.56 | 2.36 | 42.56 | 84.71 | 2.19 | 38.72 |
| Note: | Yes1 is yes vs. no/I don't know | | | | | |
| | Yes2 is certain yes vs. no/I don't know/uncertain yes | | | | | |

**Appendix. Willingness to pay model**

The economic theory behind the willingness to pay estimation begins with the utility function, $v(y \mid x)$, where $y$ is income, $x = 1$ indicates the trip was taken and $x = 0$ indicates the trip was not taken. Each respondent in the sample indicates by revealed preference that taking the most recent fishing trip would yield expected utility greater with the trip than without:

(1) $$v(y - c \mid x = 1) > v(y \mid x = 0)$$

where $c$ is the cost of the trip.

Each respondent in the sample is put in the counterfactual situation of considering whether they would have still taken the most recent trip if the cost was higher, where $A$ is the additional cost amount. The respondent would have taken the trip if utility with the additional costs and a fishing trip is greater than utility with no trip and no trip cost:

(2) $$v(y - c - A \mid x = 1) \geq v(y \mid x = 0)$$

If the utility with the trip is less than the utility without the trip the respondent would not have taken the trip:

(3) $$v(y - c - A \mid x = 1) < v(y \mid x = 0)$$

Willingness to pay ($WTP$) for the trip is the dollar amount that equates utility with and without the fishing trip

(4) $$v(y - c - WTP \mid x = 1) = v(y \mid x = 0)$$

To estimate $WTP$ with a dichotomous choice regression model (e.g., logit, probit) first suppose that respondents have a linear in parameters utility function, $v = \alpha + \beta y$, where $\alpha$ is the utility from a fishing trip and $\beta$ is the marginal utility of income (Hanemann 1984). Since $\alpha = 0$ when $x = 0$The change in utility for which we observe trips is

(5) $$\Delta v = \left(\alpha + \beta(y - c - A)\right) - (\beta_0 y)$$

and

$$\Delta v = \alpha + (\beta - \beta_0)y - \beta c - \beta A$$

The probability that the respondent would take the trip is

(6) $$\Pr(\Delta v \geq 0) = \Pr(\alpha + (\beta - \beta_0)y - \beta c - \beta A + e)$$

where $e$ is an error term. The model can be simplified by assuming that the marginal utility of income is constant across utilities with and without the fishing trip so that $\beta - \beta_0 = 0$. Theoretically the coefficients on cost per trip and the change in the cost per trip should be equal. But, the actual cost per trip is endogenous (and measured with error) so its inclusion in the model is econometrically difficult. If $c$ is omitted from the model it will not affect estimation of the marginal utility of income since the randomly assigned cost amount, $A$, is exogenous and not correlated with $c$, which is captured by the error term.

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