Journal of Great Lakes Research 49 (2023) 545–553

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/ijglr

Angler preferences for management of aquatic invasive species in the USA and Canada: A discrete choice experiment

North Joffe-Nelson [a], Carena J. van Riper [a,*], Elizabeth Golebie [a], Dana N. Johnson [a,b], Max Eriksson [c], Cory Suski [a], Richard Stedman [d], Len M. Hunt [e]

[a] Department of Natural Resources and Environmental Sciences, University of Illinois Urbana-Champaign, 1102 S. Goodwin Ave, Urbana, IL 61801, USA
[b] Institute for Resources, Environment and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, British Columbia V6T 1Z4, Canada
[c] Vrije Universiteit Brussel. Brussel School of Governance, Centre for Environment, Economy and Energy, Bd de la Plaine 5/1st floor, 1050 Bruxelles, Belgium
[d] Department of Natural Resources and the Environment, Cornell University, 111-B Fernow Hall, Ithaca, NY 14853, USA
[e] Ontario Ministry of Natural Resources and Forestry, Centre for Northern Forest Ecosystem Research, 103-421 James St. S, Thunder Bay, Ontario P7E 2V6, Canada

ARTICLE INFO

Article history:
Received 21 December 2021
Accepted 5 December 2022
Available online 7 January 2023
Communicated by Marc Gaden

Keywords:
Recreation
Anglers
Stated choice model
Aquatic invasive species
Fisheries management

ABSTRACT

Aquatic invasive species (AIS) management in the Great Lakes region of North America requires coordination between multiple agencies and stakeholder groups. Because the Great Lakes are an internationally managed entity, an understanding of policy preferences among stakeholders across borders is crucial for making both comprehensive and evidence-based decisions about fishery resources. We evaluated angler preferences for how future fishing scenarios are affected by aquatic invasive species in the Great Lakes region. Using a mixed-mode survey of anglers in Illinois, Michigan, Wisconsin, New York, and the Canadian province of Ontario, we conducted a stated choice experiment to understand and compare American and Canadian anglers. Results from a mixed multinomial logit model suggested fish habitat quality, amount of native fish species, impact of invasive species, availability of wash stations, and cost significantly influenced hypothetical scenarios chosen by survey respondents. Fish habitat and increased availability of boat wash stations had the greatest influence on the likelihood that a given scenario would be chosen by a survey respondent. We observed predominantly similar patterns across the border but did find that Canadians had stronger preferences for limiting AIS impacts and improving habitat quality. Our research thus suggests that an internationally consistent management approach would likely be well received among the anglers engaged in this study.

Introduction

Resource management agencies invest billions of dollars each year in the United States (USA) to minimize the spread of aquatic invasive species (AIS) (Pimentel et al., 2005; Lovell et al., 2006). Biological invasions also cause substantial alterations to freshwater ecosystems that are exacerbated by pollution and impaired flow regimes, all of which warrant research attention (Williams et al., 1993; Poff et al., 1997; Ricciardi et al., 1998). The Great Lakes region in particular, presents fishery managers with complex challenges due to its combined commercial and recreational uses, geographic scale, and the range of state, national and international agencies that have jurisdiction over the provision of its resources. In addition to costly invasions from sea lamprey (*Petromyzon marinus*) (Christie and Goddard, 2003), zebra mussel (*Dreissena polymorpha*) (Griffiths et al., 2011), and species of Asiatic carps (Cuddington et al., 2014), the Great Lakes are also subject to novel AIS invasions, with the threat of new alien aquatic species being ever present and increasing (Ricciardi, 2006). These ecological and political dynamics necessitate decisions that are supported by multi-state and multi-national research questions.

Recreational anglers are an important stakeholder group for fishery managers to consider, because these individuals experience the effects of AIS damage firsthand and can be partially responsible for spreading organisms through inadvertent transmission in bilge water, fishing gear, and live bait disposal (Drake et al., 2015; Johnson et al., 2001; Kemp et al., 2017; Kilian et al., 2012; Pradhananga et al., 2015; Seekamp et al., 2016; McEachran et al., 2022). Effective mitigation of biological invasions therefore requires insights on how angler preferences influence behaviors related to AIS spread (Arlinghaus, 2004; Arlinghaus et al., 2017; Beardmore et al., 2015; Hunt et al., 2013; van Riper et al., 2019). Although the social sciences have received some research attention

* Corresponding author.
E-mail address: cvanripe@illinois.edu (C.J. van Riper).

https://doi.org/10.1016/j.jglr.2022.12.012
0380-1330/

in aquatic ecosystems (Haapasaari et al., 2012; Kaplan and McCay, 2004), these disciplines are underrepresented in research that is conducted to inform fisheries management decision making (Golebie et al., 2021). Moreover, individual motivations often transcend simple economic considerations (Manning et al., 2022) and are influenced by a complex array of contextual and psychological factors, which calls for the integration of multiple disciplinary perspectives (Heck et al., 2015; Hunt et al., 2013). Understanding how anglers are likely to react to changes in regulations across the Great Lakes region will also help fishery managers tailor policies and communication strategies to different audiences, while minimizing impacts on aquatic ecosystems (Aas et al., 2000; Gaden et al., 2021a; Hunt et al., 2019).

There are multiple competing considerations that need to be weighed in the process of managing fisheries in the Great Lakes region. Habitat quality to support a variety of fish species, recreational opportunities, and the spread of AIS are all priorities that warrant managerial attention. However, these conditions cannot be optimized simultaneously and require an understanding of tradeoffs (Lawson and Manning, 2002; Foelske et al., 2019). Limitations on the availability of infrastructure further complicate the allocation of scarce resources in the face of change. For example, AIS are commonly spread at boat ramps (Rothlisberger et al., 2010), and there is a continued risk of further spread from this vector (Cole et al., 2019), which affects recreational opportunities, ecosystem health, and native fish species. Yet not all points to access waterways are equipped with tools like boat washing stations or on-site personnel. Redirecting resources to improve these sites would help to combat biological invasions, but introduce substantial costs. An understanding of stakeholder willingness to support policy changes (e.g., accepting added costs to fishing trips) is thus needed for agencies to respond to how anglers view the relative importance of competing conditions. Addressing the evolution of threats from AIS while encouraging negotiation and collective decisions that acknowledge tradeoffs about how to manage fisheries is particularly challenging in an international context like the Great Lakes region. Stakeholder engagement in the USA and Canada therefore requires coordination across multiple states, provincial, tribal, and national governments (Gaden et al., 2008).

Tradeoffs that anglers are willing to make among competing conditions can be better understood using discrete choice experiments (DCE) (Dabrowksa et al., 2017; Pröbstl-Haider et al., 2020). This technique first arose in transportation planning to discern individual preferences for travel (McFadden, 1974) and has since been applied in a diverse array of fields (Louviere et al., 2000). For example, Adamowicz et al. (1994) applied this technique in an environmental context to understand preferences for recreational sites in Canada. Studies of moose hunting (Boxall et al., 1996; Hunt et al., 2005), soil erosion programs (Colombo et al., 2006), and recreational fisheries (Aas et al., 2000; Oh et al., 2005; Dorow et al., 2010) have also been conducted using DCEs. Despite receiving increased research attention (Hunt et al., 2021) and considering the wealth of knowledge that has already been generated using DCEs involving invasive species (Rolfe and Windle, 2014; Adams et al., 2011; Adams et al., 2020), no studies to date have examined how anglers evaluate combinations of conditions surrounding AIS in a fisheries context. Research in this vein has the potential to provide fishery managers with useful insights on angler preferences for future fishing scenarios and conditions that are not currently in place, but may offer an alternative that is better than the status quo.

A DCE involves survey respondents being presented with sets of hypothetical scenarios that include different combinations of conditions and then being asked to choose which they would prefer in the future. The attributes in a series of hypothetical scenarios are developed to reflect a range of realistic conditions that respondents may encounter in the future. When one attribute is represented using monetary units, the marginal rate of substitution can be derived from a ratio of two factors to estimate willingness-to-pay (WTP) (Levers and Pradhananga, 2021; Louviere et al., 2000). Respondent selections can then be aggregated across multiple respondents to collectively portray the relative impact of each attribute and its intensity on the chosen scenario. These data are analyzed using a type of logit model, with the multinomial logit being most traditional (Hensher and Greene, 2003). However, the random parameters logit model has gained traction because of its ability to assess preference heterogeneity and sophistication compared to earlier, simpler models (Colombo et al., 2009; Hensher et al., 2005; Hunt et al., 2019). Another recent development in DCE research is the use of bayesian prior estimates to improve efficiency in the experimental designs that populate DCE scenarios. Rather than using orthogonal experimental designs (Louviere et al., 2000), "D-efficiency" designs are increasingly used to minimize the standard error of parameter estimates (Arlinghaus et al., 2014; Johnston et al., 2017) by generating a measure of efficiency called "D-error" through pilot testing. This approach can reduce the sample size needed to obtain the fixed level of reliability for a given design.

In response to the gaps and priorities identified in previous research, this study was guided by two objectives. First, we weighed the relative importance of five DCE attributes that characterized hypothetical fishing scenarios. Second, we conducted this research across the USA-Canada border to test for differences based on country of residence. Our study therefore aimed to enhance multi-national coordination in the face of growing threats from AIS, as well as ameliorate the kinds of resource-based conflicts that characterize fisheries relations worldwide.

Methods

Data collection

Data were collected through a mixed mode survey administered to license holding anglers in 2019. Different sampling methods were used to optimize data collection across states and a national border. In the USA, anglers from New York, Illinois, Michigan, and Wisconsin were invited to participate in the study through a mail-back survey that included a $1 incentive and an online option (see Fig. 1). Within each state, state fishing license data were used to draw an independent random sample of 1,200 anglers who had purchased a non-commercial license in 2017 and lived in a county adjacent to Lake Michigan or Lake Ontario. Licensing data were unavailable in Indiana so an on-site survey was administered along the Lake Michigan shoreline to learn about these anglers' perspectives, but not incorporated into the present results (see van Riper et al., 2020). Mail-back surveys were administered from June through August 2019 using a standard survey methodology with six points of contact including an introductory letter, two reminders, and three survey waves (Dillman et al., 2014).

Canadian anglers were engaged in this research through an online survey administered to all registered users of a smartphone app called "Angler's Atlas." This Canadian company offers free membership and resources such as bathymetric maps to its users. With over 220,000 members in total, this app was used to reach a convenience sample of anglers in the province of Ontario in 2019 at the same time of the mailback survey administered in the USA. This research approach was taken because the research team was not able to access a database of licensed Canadian anglers given the challenges of sharing information across an international border. Moreover, we responded to previous research that has highlighted the utility in fishing apps as a new platform for reaching

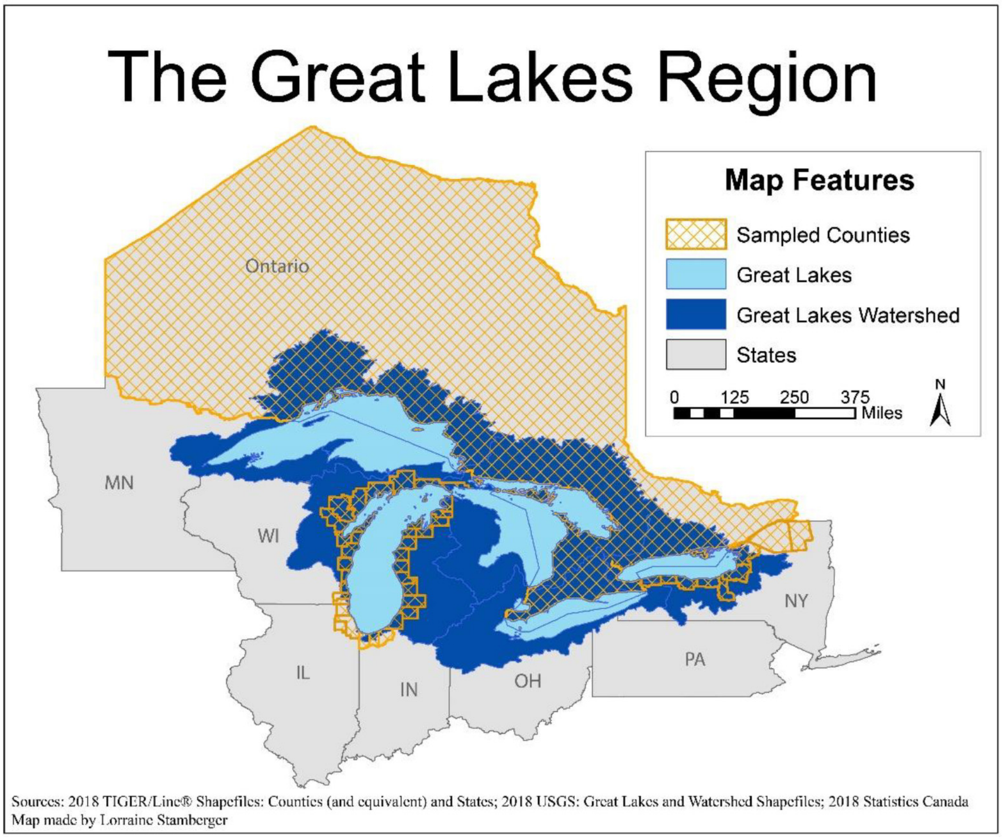

Fig. 1. Map of the study area within the Great Lakes region.

large audiences (Venturelli et al., 2017). A two-contact protocol was used, consisting of an introductory email and reminder. All individuals who completed the survey were presented with an opportunity to win one of ten $50 CAD gift cards to Canadian Tire. The same questionnaire was used in the USA and Canadian surveys, though the cover letters were changed and survey items such as socio-demographic characteristics were tailored to local customary standards. Prior to data collection in both countries, the survey instrument was pilot tested on two occasions to ensure conceptual and empirical validity (Johnston et al., 2017; Rose and Bliemer, 2013). Specifically, a focus group of graduate students at the University of Illinois at Urbana-Champaign was first engaged using verbal protocol procedures (n = 6) (Cahill et al., 2007), followed by an online survey of American Fisheries Society chapter members in New York and Illinois (n = 121). The data collected during our online pilot test were analyzed and used to build a "D-efficiency" experimental design (Arlinghaus et al., 2014). The final databases that were generated for this research were manually coded and 5 % of the data were quality controlled to ensure inter-coder reliability.

Experimental design

We measured angler preferences for future fishing scenarios by asking respondents to choose between two competing hypothetical scenarios in relation to a "same as today" option (see Fig. 2). Our experimental design included 18 paired comparisons, and respondents were presented with six options. Our design was blocked into three different survey versions such that each individual evaluated six combinations of attributes. Our scenarios included five attributes developed in consultation with members of the Lake Michigan and Lake Ontario Lake Committees through the Great Lakes Fishery Commission. Each attribute had either three or five levels that reflected a realistic range of potential conditions (see Table 1). First, we evaluated *wash stations,* which were areas where anglers could clean their boating and/or fishing equipment to minimize the unintentional spread of AIS. Second, we measured preferences for *added cost per fishing trip* to understand the amount of money anglers would be willing to accept as a cost to improve fisheries management. This factor ranged from $0 to $20 in increments of 5, with Canadian dollar figures adjusted to equal US dollars. Third, we measured preferences for *amount of fish* present in the Great Lakes defined as total native fish species. This attribute had five levels ranging from 20 % decrease to 20 % increase, in increments of 10. Fourth, we measured preferences for *impact from invasive species,* which were defined as organisms such as zebra mussels and sea lamprey that were outside of their historic range and harming the environment by changing nutrients, water clarity, and habitat in the Great Lakes. There were three levels of this attribute that ranged from minimal to moderate, and then severe degrees of impact. Our fifth factor was *fish habitat,* which referred to the quality of the environment that supported fish species, including support for successful reproduction and growth of sportfish communities such as salmon (*Salmonidae*) and yellow perch (*Perca flavescens*), as well as prey fish such as rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus*).

Analysis approach

A random parameters (mixed) multinomial logit model was estimated with individual specific variables included. Use of such a model allowed for the estimation of heterogeneity by relaxing the assumption that respondents were homogenous in their pref-

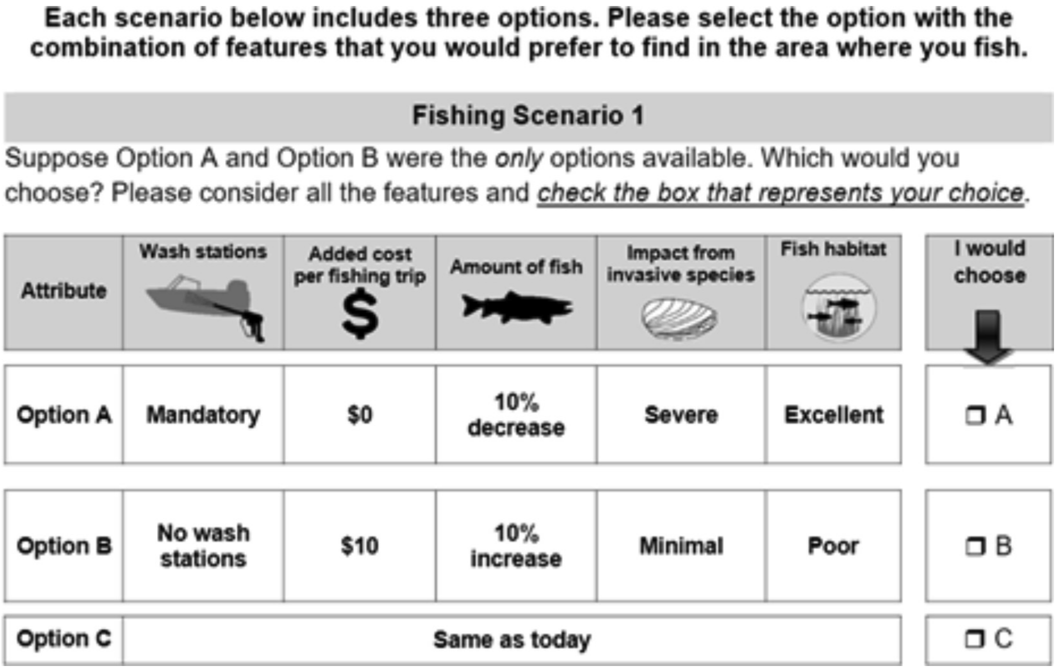

Fig. 2. Example paired comparison for the discrete choice experiment included in the survey questionnaire.

Table 1
The definitions and levels for all attributes estimated in the stated choice experiment.

Attribute	Definition	Levels
Wash stations	Locations near boat ramps where anglers can disinfect and pressure-wash boats to stop invasive species from spreading.	1. No wash stations 2. Voluntary wash stations 3. Mandatory wash station
Added cost per fishing trip	Cost per fishing trip that could be voluntarily added for invasive species control and prevention efforts in the Great Lakes.	1. $0 2. $5 3. $10 4. $15 5. $20
Amount of fish	Total amount of native fish species found in the Great Lakes	1. 20 % decrease 2. 10 % decrease 3. No change 4. 10 % increase 5. 20 % increase
Impact from invasive species	Degradation caused by organisms that are outside of their historic range and harming the environment	1. Minimal impact 2. Moderate impact 3. Severe impact
Fish habitat	The quality of the environment for supporting fish species	1. Poor 2. Good 3. Excellent

erences for the future (Dissanayake and Ando, 2014). This analysis approach enabled us to estimate standard deviations and better understand variation in preferences by quantifying differences among respondents. Three alternatives were accommodated in the model including two options that displayed a configured set of attribute levels and a third option that represented the current set of conditions that was treated as a constant. Marginal WTP was calculated for the non-cost attributes that were normally distributed whereas a triangular parameter distribution was applied to our cost attribute to ensure theoretically consistent signs (Zhang and Sohngen, 2018). First, main effects were estimated, and then main effects with interaction terms based on country of residence – USA or Canada. Respondents who selected the "same as current condition" option for all six sets were considered protest responses, and thus, were excluded from analysis (Greiner et al., 2014). Our analysis was conducted using Nlogit Version 6.

Results

Descriptive results

In the USA, a total of 1,086 questionnaires were returned. After accounting for 478 incorrect addresses or deceased individuals and removing protest respondents, 940 individuals were included in our sample and our response rate was 25 %. Response rates varied little across states, in that New York had the lowest response rate (21 %), followed by Illinois (25 %), Michigan (27 %) and Wisconsin (28 %). On the Canadian side, 31,299 users from Angler's Atlas were contacted, 24,357 of whom never opened the email and were excluded from the sample. This left 6,942 who we considered to be invited to participate in the study, 801 of whom agreed to participate, resulting in a response rate of 12 %. A total of 537 individuals were entered into the analysis after data cleaning and the

Table 2
Respondent socio-demographic characteristics of the survey sample.

Variable	*Pooled*	*United States*	*Canada*
	N(%)	N (%)	N (%)
Gender			
Female	184 (12.9)	134 (14.3)	50 (10.1)
Male	1235 (86.4)	799 (85.5)	435 (88.1)
Other	10 (0.7)	1 (0.1)	9 (1.8)
Education[a]			
Some high school	318 (22.8)	227(24.9)	91 (18.9)
High school graduate or GED	196 (14.0)	150 (16.4)	46 (9.5)
Two-year college degree	397 (28.4)	295 (32.1)	102 (21.2)
Bachelor's degree	147 (10.5)	79 (8.6)	68 (14.1)
Professional certificate	46 (3.1)	23 (2.5)	23 (4.8)
Graduate degree	293 (21.0)	141 (15.4)	152 (31.5)
Annual Household Income			
Less than $20,000	58 (4.2)	45 (5.0)	13 (2.6)
$20,000 to $39,999	142 (10.2)	111 (12.5)	31 (6.2)
$40,000 to $59,999	152 (10.9)	114 (12.7)	38 (7.6)
$60,000 to $79,999	117 (8.4)	60 (6.7)	57 (11.4)
$80,000 to $99,999	173 (12.4)	106 (11.8)	67 (13.5)
$100,000 to $124,999	195 (14.0)	122 (13.6)	73 (14.7)
$125,000 to $149,999	176 (12.6)	134 (14.8)	42 (8.4)
$150,000 or more	191 (13.7)	108 (12.0)	83 (16.7)
Prefer not to answer	193 (13.8)	99 (11.0)	94 (18.9)
Race[b]			
White	1284 (87.2)	844 (89.8)	440 (82.7)
Asian	30 (2.1)	9 (1.0)	21 (4.2)
Black or African American	23 (1.6)	17 (1.8)	6 (1.1)
Native Hawaiian or Pacific Islander	3 (0.2)	2 (0.2)	1 (0.2)
American Indian or Alaska Native	48 (3.3)	26 (2.8)	22 (4.1)
Other	47 (3.2)	0(0)	47 (9.0
Age [M, SD]	[53.95, 14.95]	[55.58, 15.44]	[50.55, 13.24]
18–34 years	180 (13.0)	115 (12.3)	65 (14.5)
35–50 years	334 (24.1)	196 (21.0)	138 (30.7)
51–60 years	351 (25.4)	215 (23.0)	136 (30.3)
61–70 years	346 (25.0)	254 (27.2)	92 (20.5)
71 years or more	173 (12.5)	155 (16.6)	18 (4.0)
Knowledge[c]	3.50	3.46	3.53
Total years fishing[c] [M,SD]	[39.37, 17.32]	[40.25, 17.88]	[37.82, 16.17]
Total days fishing/year [M,SD]	[30.26, 36.93]	[28.45, 36.46]	[33.24, 37.51]

[a] Different educational categories were presented to respondents in the US and Canada.
[b] Respondents could check all that applied so column totals may not equal 100%.
[c] Score was created by adding the number of correct responses where 1 = no correct responses and 5 = all correct responses
[d] Estimate included fishing activities in 2018.

removal of protest respondents. Demographic information was compared between the two countries to assess the validity of each group given the different sampling methods (see Table 2). Canadians were slightly younger, more racially diverse and had higher levels of household income.

We tested for potential non-response bias by comparing our samples to previous research. In the USA, respondents in Michigan, New York, Wisconsin, and Illinois were not significantly different in gender compared to respondents engaged by Connelly et al. (2014) (χ^2 = 0.167; p = 0.682). We also assessed days fished between our sample and a study of anglers in the broader Great Lakes region (Ready et al., 2012), and found no significant differences in days fished in the previous year (*t*-stat (df = 2636) = 0.2 60; p = 0.795). In Canada, we compared respondents to Ontario anglers from two different general angler surveys (see OMNRF (2015) and Hunt et al. (2021) for more information). One sample t-tests (continuous variables) and chi-square tests (categorical variables) were performed to compare age, gender, license type, days fished, and years fished. We found significant differences in years fished between the Hunt et al. (2021) respondents and our sample (*t*-stat = 7.007; df = 4363; p < 0.001). Gender differences existed as well, in that OMNRF (2015) respondents were 78 % male (χ^2 = 11.203, p < 0.001). No significant difference was found based on the license type purchased (χ^2 = 0.0202; p = 0.887).

In our pooled sample, most respondents identified as male (86.4 %) and White (87.2 %), with 63 % holding at least a two-year college degree and 54.1 % reporting a household income of $100,000 or more. Respondents were mostly older with an average age of 53.95 (*SD* = 14.95). Respondents were also asked about their total years fishing (*M* = 39.37, *SD* = 17.32) and number of days fishing out of the year (*M* = 30.26, *SD* = 36.93). Respondents were quizzed on their knowledge of AIS with four questions pertaining to the number of non-native species present in the Great Lakes, the agency primarily responsible for fishery management in said region, whether or not sea lamprey are considered invasive, and whether or not AIS can be spread through the dumping of bait buckets. Respondents scored an average of 3.50 out of 4.0 on these questions.

Discrete choice modeling results

A total of 8,862 individual scenarios were chosen by respondents, including 5,640 in the USA and 3,222 in Canada. These numbers corresponded to the number of respondents multiplied by the scenarios chosen in each of the six sets. The relative impact of each attribute on the chosen scenario was illustrated by regression coefficients (see Table 3). Each attribute had a statistically significant

Table 3
Estimated results from random parameters logit model.

Variables	**Coeff. (Std. Err)**	**Std. Dev. (Std. Err)**
Wash stations	0.509*** (0.119)	0.730*** (0.064)
Added cost per fishing trip	−0.069*** (0.011)	0.187*** (0.014)
Amount of fish	0.025*** (0.006)	0.002 (0.005)
Impact from invasive species	−0.437*** (0.110)	0.708*** (0.059)
Fish habitat	0.535*** (0.100)	0.516*** (0.055)
Constant	−1.578*** (0.110)	2.353*** (0.100)
*Country * wash stations ++*	−0.006 (0.083)	
*Country * added cost per fishing trip*	0.014* (0.008)	
*Country * amount of fish*	0.007* (0.004)	
*Country * impact from invasive species*	−0.186** (0.077)	
*Country * fish habitat*	0.256*** (0.070)	

LL = -6143; AIC = 12,320.8; N = 8160; Pseudo R^2 = 0.3147; *** = p < 0.0001; ** = p < 0.001; * = p < 0.01.
++ Binary-coded site-specific variable where 1 = respondent from USA and 2 = respondent from Canada.

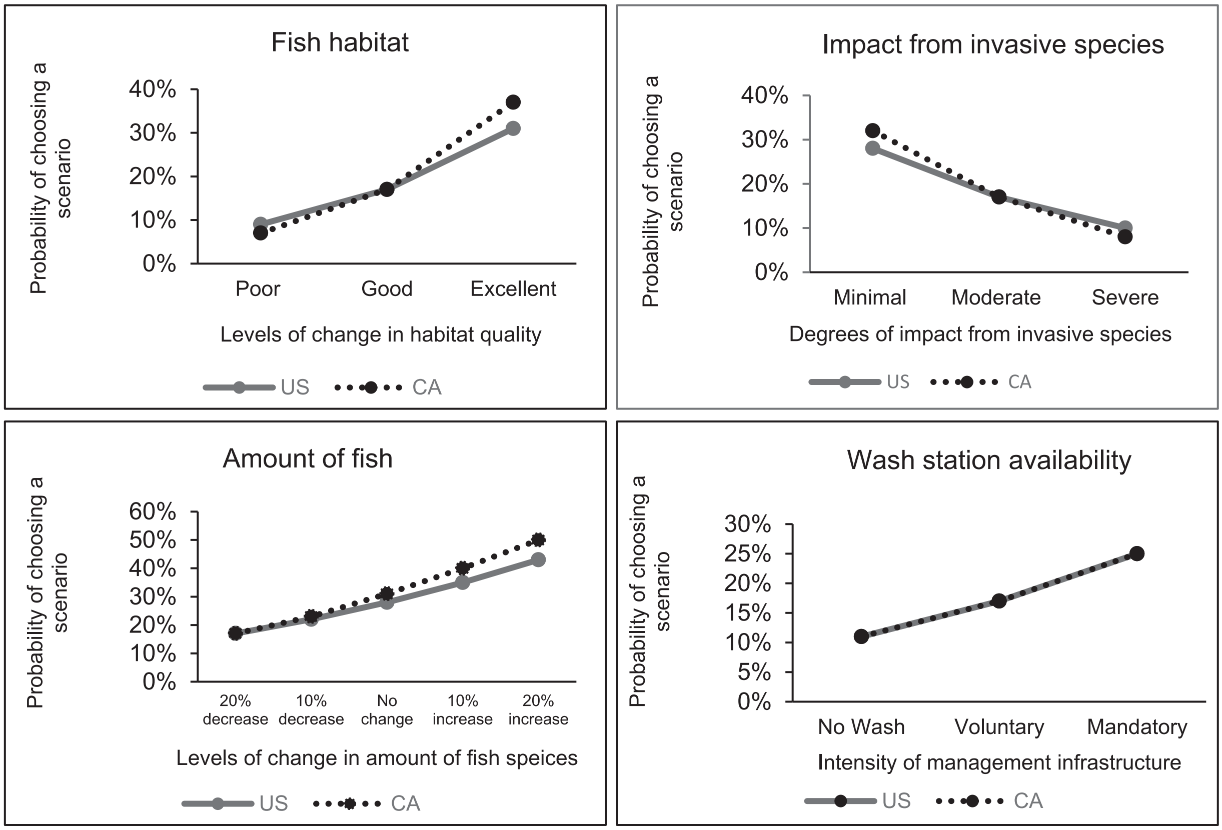

Fig. 3. Rate of change for the probabilities of choosing a scenario within the discrete choice experiment.

effect on the scenario chosen by respondents ($p < 0.0001$), resulting in a McFadden's R^2 value of 0.315. Standard deviations were also statistically significant ($p < 0.0001$) for each attribute except for *amount of fish,* demonstrating heterogeneity within the samples for all but one attribute. The strongest predictors of the chosen scenarios were improvements to *fish habitat* (β = 0.535, *SD* = 0.516), followed by the implementation of *wash stations* (β = 0.509, *SD* = 0.730), limiting *impact from invasive species* (β = -0.437, *SD* = 0.708), limiting *added cost per fishing trip* (β = -0.069, *SD* = 0.187), and increasing the *amount of fish* (β = 0.025, *SD* = 0.002). Interaction terms were then estimated to test for differences between anglers in each respective country, with preferences for *added cost per fishing trip* (β = 0.014), and *amount of fish* (β = 0.007) significant at $p < 0.01$, while *impacts from invasive species* (β = -0.186) and *fish habitat* (β = 0.256) were significant at $p < 0.0001$. Differences regarding preferences for *wash stations* (β = -0.006) were non-significant. Interactions reflected differences in the impact of attributes on choices made by Canadians versus Americans.

Coefficients and interaction terms were converted into probabilities for ease of interpretation (see Fig. 3). The resulting graphs showed the probability that a scenario including an attribute at each level would be chosen, as well as the rate at which higher intensities of that attribute were chosen compared to the lower levels. This approach illustrated the impact of each attribute as the levels changed. Marginal willingness-to-pay (WTP) was calculated for both Americans and Canadians using the added cost per fishing trip attribute (see Table 4). These figures represented the average amount of money anglers would be willing to pay per trip to upgrade from one attribute level to the next in US dollars. For instance, concerning *wash stations,* American and Canadian anglers were willing to pay $7.37 and $7.01, respectively, per trip to upgrade from *no wash stations* to *voluntary wash stations*, and from *voluntary wash stations* to *mandatory wash stations*. The highest WTP amount, which corresponds to the trends reflected in the coefficients, was for improvements to *fish habitat* ($7.74, US; $10.9, CA). Canadians were willing to pay more to reduce *impacts from invasive species*, ($6.33, US; $8.72, CA), and both groups had low willingness to pay for increases in *amount of fish* ($0.36, US; $0.44, CA).

Table 4
Marginal willingness-to-pay for changes to each study attribute.

Variable	US WTP (USD)	CA WTP (USD)*
Wash stations	$7.37	$7.01
Amount of fish	$0.36	$0.44
Impact from invasive species	$6.33	$8.72
Fish habitat	$7.74	$10.9

*Conversion rate of 0.758 (CAD to USD) as of 08/01/2019.

Discussion

We examined the tradeoffs anglers would be willing to make to obtain their desired fishing experiences in the Great Lakes region, particularly around Lake Michigan and Lake Ontario. This research is important because of the urgency of AIS issues and relevance of recreational anglers in shaping associated policy outcomes (Birdsong et al., 2021; Heck et al., 2016; van Riper et al., 2019). We provide a new, international perspective to advance theoretical knowledge of the drivers of behavioral decisions and address ongoing challenges for fishery management agencies to communicate across the USA-Canada border (Kerr and Kamke, 2011; Landon et al., 2018). Given the history of collaborative management in North American freshwater ecosystems, a more universal understanding of angler preferences for AIS management fills a crucial gap for comparative research that is needed to create opportunities for knowledge exchange between countries (Johnson et al., 2019) and decrease the likelihood of fragmented co-management over shared resources (Gaden et al., 2021b).

We observed relative uniformity in USA and Canadian angler preferences for the attributes that characterized our fishing scenarios, as well as significant levels of standard deviations suggesting there was heterogeneity present within our samples. Because levels of heterogeneity were not strongly correlated with our interaction terms, country of origin did not account for much of this variation, but rather, diversity in preferences spanned the international border. It could be that the similarities in demographics, previous experience, and knowledge reported by anglers in both countries contributed to the patterns observed, despite our different sampling methods. Understanding preference heterogeneity at a regional scale is a crucially important area of future research to support evidence-based decisions about how best to engage recreational anglers in AIS management (Foelske and van Riper, 2020; Matsumura et al., 2019).

Explanations for heterogeneity surrounding preferences for our discrete choice attributes are relevant for fishery management agencies in both countries. First, in the case of *wash stations*, there were high levels of deviation from the mean and low levels of differences based on country of residence. It could be that these differences were attributable to fishing mode, in that some anglers fished from the shore whereas others fished from a boat. Indeed, different equipment used by anglers requires different levels of commitment to be adequately cleaned (Vander Zanden and Olden, 2008). Second, the differences in preferred *impact from invasive species* may have been influenced by variation in prior experience among recreational anglers engaged in this study (White et al., 2008). Given the importance of ecological variation (Matsumura et al., 2021) and fishing locations (Golebie et al., 2021) for understanding recreational angling, more research is needed to understand how exposure to different species influences sensitivity to environmental impacts. Third, stronger preferences for improving *fish habitat* among Canadian anglers may have differed based on catch rates in the two countries (Arlinghaus et al., 2014; Schroeder et al., 2018) or our sampling methods, particularly the use of a fishing app (Venturelli et al., 2017). Although differences in angler knowledge and reported levels of experience were not detected, it could be that anglers who used Angler's Atlas were more specialized because they subscribed to a fishing application. This could result in greater sensitivity to the importance of habitat for sustaining fish populations, as well as Canadians' stronger preferences for native fish species (Beardmore et al., 2013).

Results showed that anglers were willing to pay relatively high amounts to see improvements in habitat quality, fewer AIS impacts and the construction of new wash stations. Our WTP figures were estimated relative to each fishing trip, which corresponds to a high number of fishing trips taken on average by anglers. Other studies on WTP for invasive species management have shown similar values for increases to catch rates (Cantrell et al., 2004) and relaxed harvest bans (Shideler et al., 2015). Our results reflect an interest among anglers in improving the quality of their fishing experience via the improvement of fish habitat, mitigation of AIS and increases in boat ramp infrastructure, specifically wash stations. Also noteworthy is that anglers were not willing to pay much in additional costs to their fishing trips for an increase in the total number of native fish species. This may be because some anglers in the Great Lakes region value introduced fish like rainbow trout / steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) more than native species (Melstrom and Lupi, 2013). Given relatively high values for our WTP estimates, it could be anglers were making rational investments because the improvement of fisheries can save them money in travel costs to visit fishing sites and upgrades in equipment (Zalejska-Jonsson, 2014). These results may also signal an ascription of responsibility among anglers in stewarding shared resources (Landon et al., 2021). As such, fishery managers would be well advised to connect the damages from AIS to the capacity of anglers to inadvertently assist in their spread (Levers and Pradhananga, 2021). These findings comport with the recent rise of research using contingent valuation methods to address challenges posed by AIS. Our study also provides decision support for managers seeking to rationalize consensus-based decisions with available evidence (Jones et al., 2010; Smith, 2021; Stensland et al., 2021).

Due to the complexity associated with engaging recreational anglers across jurisdictional boundaries, we relied on multiple sampling methods. Although this can be viewed as a limitation, our databases largely mirrored one another and generated intuitive results that aligned with the extant literature. The overall similarities between our two samples thus instilled confidence in our decision to empirically compare anglers from different countries. In other words, the similarities observed despite the two populations being sampled in different ways reinforced the conclusion that recreational anglers across the USA and Canadian border expressed similar preferences for AIS management priorities.

Conclusion

This study reports on results from a valuation of fishery characteristics and the associated experiences of recreational anglers at a regional scale spanning Lake Michigan and Lake Ontario. An international perspective on fisheries management is presented, as part of discrete choice experiment that includes interaction terms to compare two different countries of residence. Our findings suggest that fish habitat, impacts from AIS, and infrastructure to aid in the disposal and cleaning of equipment are drivers of the behavioral decisions made by recreational anglers. We also show that there are relatively similar preferences for Great Lakes fishery management across the USA-Canada border. This study supports a process for multinational cooperation and provides insights on how anglers believe fishery managers should prioritize their efforts in the future. Further research to address the evolving nature of biological invasions in the Great Lakes region will require continual consideration of social science research to account for the centrality of people in the inadvertent spread of AIS.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements:

This paper is part of the first author's MS thesis from the University of Illinois at Urbana-Champaign. Funding was provided by the Great Lakes Fishery Commission (contract: 2018_VAN_44076), and USDA National Institute of Food and Agriculture Hatch program (accession #: 7000939). This work was also supported in part through National Great Rivers Research & Education Center internships for Claire Bailey (#NGRREC-IP2018-09) and Megan Gaddy (#NGRREC-IP2019-12). We would like to thank the Great Lakes Fishery Commission Lake Committee managers for feedback during various phases of this research. We are also grateful for conceptual contributions from Seunguk Shin and Nate

Shipley, as well as data collection and entry performed by undergraduate research assistants David Nguyen, Delta Zhang, Venus Apantenco, and Yen-Hsuan Chang.

References

Aas, Ø., Haider, W., Hunt, L., 2000. Angler responses to potential harvest regulations in a norwegian sport fishery: a conjoint-based choice modeling approach. N. Am. J. Fish Manag. 20, 940–950.

Adamowicz, W., Louviere, J., Williams, M., 1994. Combining revealed and stated preference methods for valuing environmental amenities. J. Environ. Manage. 26, 271–292.

Adams, D.C., Bwenge, A.N., Lee, D.J., Larkin, S.L., Alavalapati, J.R.R., 2011. Public preferences for controlling upland invasive plants in state parks: Application of a choice model. Forest Policy Economics 13, 465–472.

Adams, D.C., Soto, J.R., Lai, J., Escobedo, F.J., Alvarez, S., Kibria, A.S.M.G., 2020. Public preferences and willingness to pay for invasive forest pest prevention programs in urban areas. Forests 11, 1056.

Arlinghaus, R., 2004. A human dimensions approach towards sustainable recreational fisheries management. Turnshare Limited. - Publisher.

Arlinghaus, R., Beardmore, B., Riepe, C., Meyerhoff, J., Pagel, T., 2014. Species-specific preferences of German recreational anglers for freshwater fishing experiences, with emphasis on the intrinsic utilities of fish stocking and wild fishes. J. Fish Biol. 85, 1843–1867.

Arlinghaus, R., Alós, J., Beardmore, B., Daedlow, K., Dorow, M., Fujitani, M., Hühn, D., Haider, W., Hunt, L.M., Johnson, B.M., Johnston, F., Klefoth, T., Matsumura, S., Monk, C., Pagel, T., Post, J.R., Rapp, T., Riepe, C., Ward, H., Wolter, C., 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. Rev. Fish. Sci. Aquacult. 25, 1–41.

Beardmore, B., Haider, W., Hunt, L.M., Arlinghaus, R., 2013. Evaluating the ability of specialization indicators to explain fishing preferences. Leis. Sci. 35 (3), 273–292.

Beardmore, B., Hunt, L.M., Haider, W., Dorow, M., Arlinghaus, R., 2015. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and the anglers. Can. J. Fish. Aquat. Sci. 72, 500–513.

Birdsong, M., Hunt, L.M., Arlinghaus, R., 2021. Recreational angler satisfaction: What drives it? Fish Fish. 22, 682–706.

Boxall, P.C., Adamowicz, W.L., Swait, J., Williams, M., Louviere, J., 1996. A comparison of stated preference methods for environmental valuation. Ecol. Econ. 18, 243–253.

Cahill, K.L., Marion, J.L., Lawson, S.R., 2007. Enhancing the interpretation of stated choice analysis through the application of a verbal protocol assessment. J. Leis. Res. 39 (2), 201–221.

Cantrell, R.N., Garcia, M., Leung, P., Ziemann, D., 2004. Recreational anglers' willingness to pay for increased catch rates of Pacific threadfin (*Polydactylus sexfilis*) in Hawaii. Fish. Res. 68, 149–158.

Christie, G.C., Goddard, C.I., 2003. Sea Lamprey International Symposium (SLIS II): advances in the integrated management of sea lamprey in the Great Lakes. J. Great Lakes Res. 29, 1–14.

Cole, E., Keller, R.P., Garbach, K., 2019. Risk of invasive species spread by recreational boaters remains high despite widespread adoption of conservation behaviors. J. Environ. Manage. 229, 112–119.

Colombo, S., Calatrava-Requena, J., Hanley, N., 2006. Analysing the social benefits of soil conservation measures using stated preference methods. Ecol. Econ. 58, 850–861.

Colombo, S., Hanley, N., Louviere, J., 2009. Modeling preference heterogeneity in stated choice data: an analysis for public goods generated by agriculture. Agric. Econ. 40, 307–322.

Connelly, N.A., Lauber, T.B., Stedman, R.C., 2014. Reducing the spread of aquatic invasive species and fish pathogens in the Great Lakes: the role of anglers 14–7, 36 pp.,. Department of Natural Resources, Human Dimensions Research Unit HDRU Series.

Cuddington, K., Currie, W.J.S., Koops, M.A., 2014. Could an asian carp population establish in the great lakes from a small introduction? Biol. Invasions 16, 903–917.

Dabrowksa, K., Hunt, L.M., Haider, W., 2017. Understanding how angler characteristics and context influence angler preferences for fishing sites. N. Am. J. Fish Manag. 37, 1350–1361.

Dillman, D.A., Smyth, J.D., Christian, L.M., 2014. Internet, phone, mail, and mixed mode surveys: the tailored design method. John Wiley & Sons Inc, Hoboken, NJ, US.

Dissanayake, S.T., Ando, A.W., 2014. Valuing grassland restoration: proximity to substitutes and trade-offs among conservation attributes. Land Econ. 90 (2), 237–259.

Dorow, M., Beardmore, B., Haider, W., Arlinghaus, R., 2010. Winners and losers of conservation policies for European eel, anguilla anguilla: an economic welfare analysis for differently specialised eel anglers. Fish. Manag. Ecol. 17, 106–125.

Drake, D.A.R., Mercader, R., Dobson, T., Mandrak, N.E., 2015. Can we predict risky human behaviour involving invasive species? a case study of the release of fishes to the wild. Biol. Invasions 17, 309–326.

Foelske, L., van Riper, C.J., 2020. Assessing spatial preference heterogeneity in a mixed-use landscape. Appl. Geogr. 125, 102355.

Foelske, L., van Riper, C.J., Stewart, W., Ando, A., Gobster, P., Hunt, L., 2019. Assessing preferences for growth on the rural-urban fringe using a stated choice analysis. Landsc. Urban Plan. 189, 396–407.

Gaden, M., Krueger, C., Goddard, C., Barnhart, G., 2008. A joint strategic plan for management of great lakes fisheries: A cooperative regime in a multi-jurisdictional setting. Aquat. Ecosyst. Health Manag. 11, 50–60.

Gaden, M., Brant, C., Stedman, R.C., Cooke, S.J., Young, N., Lauber, T.B., Nguyen, V.M., Connelly, N.A., Knuth, B., 2021a. Shifting baselines and social license to operate: Challenges in communicating sea lamprey control. J. Great Lakes Res. 47, S800–S808.

Gaden, M., O. Brant, C., Lambe, R., 2021b. Why a Great Lakes Fishery Commission? the seven-decade pursuit of a Canada-U.S. fishery treaty. *Journal of Great Lakes Research,* S11-S23.

Golebie, E., van Riper, C.J., Suski, C., Stedman, R., 2021. Reducing invasive species transport among recreational anglers: the importance of values and risk perceptions. N. Am. J. Fish Manag. 41 (6), 1812–1825.

Great Lakes Fishery Commission, 2021. Strategic Vision 2021–2025 Retrieved 12/17/21 http://www.glfc.org/pubs/misc/StrategicVision2021.pdf, .

Greiner, R., Bliemer, M., Ballweg, J., 2014. Design considerations of a choice experiment to estimate likely participation by north Australian pastoralists in contractual biodiversity conservation. J. Choice Model. 10, 34–45.

Griffiths, R.W., Schloesser, D.W., Leach, J.H., Kovalak, W.P., 2011. Distribution and dispersal of the zebra mussel (*dreissena polymorpha*) in the Great Lakes Region. Can. J. Fish. Aquat. Sci. 48 (8), 1381–1388.

Haapasaari, P., Kulmala, S., Kuikka, S., 2012. growing into interdisciplinarity: how to converge biology, economics, and social science in fisheries research? Ecol. Soc. 17 (1).

Heck, N., Stedman, R.C., Gaden, M., 2015. The integration of social science information into Great Lakes fishery management: opportunities and challenges. Fish. Res. 167, 30–37.

Heck, N., Stedman, R.C., Gaden, M., 2016. Indicators to evaluate the social dimensions of the recreational fishery in the Great Lakes. N. Am. J. Fish Manag. 36, 477–484.

Hensher, D.A., Greene, W.H., 2003. The mixed logit model: the state of practice. Transportation 30, 133–176.

Hensher, D.A., Rose, J.M., Rose, J.M., Greene, W.H., 2005. Applied choice analysis: a primer. Cambridge University Press.

Hunt, L.M., Haider, W., Bottan, B., 2005. Accounting for varying setting preferences among moose hunters. Leisure Science 27, 297–314.

Hunt, L.M., Sutton, S.G., Arlinghaus, R., 2013. Illustrating the critical role of human dimensions research for understanding and managing recreational fisheries within a social-ecological system framework. Fish. Manag. Ecol. 20, 111–124.

Hunt, L.M., Camp, E., van Poorten, B., Arlinghaus, R., 2019. Catch and non-catch-related determinants of where anglers fish: a review of three decades of site choice research in recreational fisheries. Rev. Fish. Sci. Aquacult. 27, 261–286.

Hunt, L.M., Phaneuf, D.J., Abbott, J.K., Fenichel, E.P., Rodgers, J.A., Buckley, J.D., Drake, D.A.R., Johnson, T.B., 2021. The influence of human population change and aquatic invasive species establishment on future recreational fishing activities to the Canadian portion of the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. 78, 232–244.

Johnson, L.E., Ricciardi, A., Carlton, J.T., 2001. Overland dispersal of aquatic invasive species: a risk assessment of transient recreational boating. Ecol. Appl. 11, 1789–1799.

Johnson, D.N., van Riper, C.J., Chu, M., Winkler-Schor, S., 2019. Comparing the social values of ecosystem services in US and Australian marine protected areas. Ecosyst. Serv. 37, 100919.

Johnston, R. J., Boyle, K. J., Adamowicz, W. (Vic), Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W. M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C. A., 2017. Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists* 4, 319–405.

Jones, N., Evangelinos, K., Halvadakis, C.P., Iosifides, T., Sophoulis, C.M., 2010. Social factors influencing perceptions and willingness to pay for a market-based policy aiming on solid waste management. Resour. Conserv. Recycl. 54, 533–540.

Kaplan, I. M., McCay, B. J., 2004. Cooperative research, co-management and the social dimension of fisheries science and management. *Marine Policy* 28, 257–258.

Kemp, C., van Riper, C. J., BouFajreldin, L., P. Stewart, W., Scheunemann, J., van den Born, R. J. G., 2017. Connecting human–nature relationships to environmental behaviors that minimize the spread of aquatic invasive species. *Biological Invasions* 19, 2059–2074.

Kerr, S. J., Kamke, K. K., 2003. Competitive fishing in freshwaters of North America: A survey of Canadian and US jurisdictions. *Fisheries* 28(3), 26-31.

Kilian, J. V., Klauda, R. J., Widman, S., Kashiwagi, M., Bourquin, R., Weglein, S., Schuster, J., 2012. An assessment of a bait industry and angler behavior as a vector of invasive species. *Biological Invasions* 14, 1469–1481.

Landon, A. C., Kyle, G. T., van Riper, C. J., Schuett, M. A., Park, J., 2018. Exploring the psychological dimensions of stewardship in recreational fisheries. *North American Journal of Fisheries Management 38*(3), 579-591.

Landon, A. C., Fulton, D. C., Pradhananga, A. K., Cornicelli, L., Davenport, M. A., 2021. Community attachment and stewardship identity influence responsibility to manage wildlife. *Society and Natural Resources 34*(5), 571-584.

Lawson, S.R., Manning, R.E., 2002. Tradeoffs among social, resource, and management attributes of the Denali wilderness experience: A contextual approach to normative research. Leis. Sci. 24 (3–4), 297–312.

Levers, L.R., Pradhananga, A.K., 2021. Recreationist willingness to pay for aquatic invasive species management. PLoS One 16 (4), e0246860.
Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. Stated choice methods: analysis and applications. Cambridge University Press, Cambridge.
Lovell, S.J., Stone, S.F., Fernandez, L., 2006. The economic impacts of aquatic invasive species: a review of the literature. Agricultural and Resource Economics Review 35, 195–208.
Manning, R., Budruk, M., Goonan, K., Hallo, J., Laven, D., Lawson, S., Stanfield McCown. R., Anderson McIntyre, L., Minteer, B., Newman, P., Perry, E., Pettengill, P., Reigner, N., Valliere, W., van Riper, C.J., Xiao, X., 2022. *Studies in outdoor recreation: Search and research for satisfaction.* Fourth Edition. Oregon State University Press.
Matsumura, S., Beardmore, B., Haider, W., Dieckmann, U., Arlinghaus, R., 2019. Ecological, angler, and spatial heterogeneity drive social and ecological outcomes in an integrated landscape model of freshwater recreational fisheries. Rev. Fish. Sci. Aquacult. 27 (2), 170–197.
McEachran, M.C., Hofelich Mohr, A., Lindsay, T., Fulton, D.C., Phelps, N.B.D., 2022. Patterns of live baitfish use and release among recreational anglers in a regulated landscape. N. Am. J. Fish Manag. 42, 295–306.
McFadden, D., 1974. The measurement of urban travel demand. J. Public Econ. 3, 303–328.
Melstrom, R.T., Lupi, F., 2013. Valuing recreational fishing in the Great Lakes. North American Journal of Fisheries Management 33 (6), 1184–1193.
Oh, C.O., Ditton, R.B., Gentner, B., Riechers, R., 2005. A stated preference choice approach to understanding angler preferences for management options. Hum. Dimens. Wildl. 10, 173–186.
Ontario Ministry of Natural Resources and Forestry (OMNRF), 2015. 2010 survey of recreational fishing in Canada: Results for fisheries management zones of Ontario. Ontario Ministry of Natural Resources and Forestry, Peterborough, ON.
Pimentel, D., Zuniga, R., Morrison, D., 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol. Econ. 52, 273–288.
Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C., 1997. The natural flow regime. Bioscience 47, 769–784.
Pradhananga, A., Davenport, M.A., Seekamp, E., Bundy, D., 2015. Preventing the spread of aquatic invasive species: boater concerns, habits, and future behaviors. Hum. Dimens. Wildl. 20, 381–393.
Pröbstl-Haider, U., Hunt, L.M., Rupf, R., Haegeli, P., 2020. Choice experiments in outdoor recreation. Journal Outdoor Recreation and Tourism 32, 100321.
Ready, R. C., Poe, G. L., Lauber, T. B., Creamer, S., Connelly, N. A., Stedman, R. C., 2012. Net benefits of recreational fishing in the Great Lakes, Upper Mississippi River, and Ohio River Basin. Department of Natural Resources, College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.S
Ricciardi, A., 2006. patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. Divers. Distrib. 12, 425–433.
Ricciardi, A., Neves, R.J., Rasmussen, J.B., 1998. Impending extinctions of north american freshwater mussels (*unionoida*) following the zebra mussel (*dreissena polymorpha*) invasion. J. Anim. Ecol. 67, 613–619.
Rolfe, J., Windle, J., 2014. Public preferences for controlling an invasive species in public and private spaces. Land Use Policy 41, 1–10.
Rose, J.M., Bliemer, M.C.J., 2013. Sample size requirements for stated choice experiments. Transportation 40, 1021–1041.
Rothlisberger, J.D., Chadderton, W.L., McNulty, J., Lodge, D.M., 2010. Aquatic invasive species transport via trailered boats: what is being moved, who is moving it, and what can be done. Fisheries 35, 121–132.
Schroeder, S.A., Fulton, D.C., Altena, E., Baird, H., Dieterman, D., Jennings, M., 2018. The influence of angler values, involvement, catch orientation, satisfaction, agency trust, and demographics on support for habitat protection and restoration versus stocking in publicly managed waters. Environ. Manag. 62, 665–677.
Seekamp, E., McCreary, A., Mayer, J., Zack, S., Charlebois, P., Pasternak, L., 2016. Exploring the efficacy of an aquatic invasive species prevention campaign among water recreationists. Biol. Invasions 18, 1745–1758.
Shideler, G.S., Carter, D.W., Liese, C., Serafy, J.E., 2015. Lifting the goliath grouper harvest ban: angler perspectives and willingness to pay. Fish. Res. 161, 156–165.
Smith, C., 2021. Eliciting willingness-to-pay from Canadian recreational anglers to fish on watersheds adopting novel eDNA toolkits: a contingent valuation approach. University of Guelph). Doctoral dissertation,.
Stensland, S., Dugstad, A., Navrud, S., 2021. The Recreational value of Atlantic salmon angling under different fishing regulations. Fish. Manag. Ecol. 28, 362–372.
van Riper, C.J., Browning, M.H., Becker, D., Stewart, W., Suski, C.D., Browning, L., Golebie, E., 2019. Human-nature relationships and normative beliefs influence behaviors that reduce the spread of aquatic invasive species. Environ. Manag. 63 (1), 69–79.
van Riper, C.J., Golebie, E.J., Shin, S., Eriksson, M., Smith, A., Suski, C., Stedman, R., 2020. A study of angler behavior and the spread of aquatic invasive species in the Great Lakes region. Series 20–7 Department of Natural Resources, College of Agriculture and Life Sciences. Cornell University, Ithaca, New York.
Vander Zanden, M.J., Olden, J.D., 2008. A management framework for preventing the secondary spread of aquatic invasive species. Can. J. Fish. Aquat. Sci. 65 (7), 1512–1522.
Venturelli, P.A., Hyder, K., Skov, C., 2017. Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. Fish and fisheries 18 (3), 578–595.
White, D. D., Virden, R. J., van Riper, C. J., 2008. Effects of place identity, place dependence, and experience-use history on perceptions of recreation impacts in a natural setting. *Environmental Management 42*(4), 647-657.
Williams, J.D., Warren, M.L., Cummings, K.S., Harris, J.L., Neves, R.J., 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18 (9), 6–22.
Zalejska-Jonsson, A., 2014. Stated WTP and rational WTP: willingness to pay for green apartments in Sweden. Sustain. Cities Soc. 13, 46–56.
Zhang, W., Sohngen, B., 2018. Do US anglers care about harmful algal blooms? A discrete choice experiment of Lake Erie recreational anglers. Am. J. Agric. Econ. 100 (3), 868–888.