North American Journal of Fisheries Management 41:1812–1825, 2021

ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1002/nafm.10696

ARTICLE

Reducing Invasive Species Transport among Recreational Anglers: The Importance of Values and Risk Perceptions

Elizabeth Golebie,* Carena J. van Riper, and Cory Suski
Department of Natural Resources and Environmental Sciences, University of Illinois Urbana–Champaign, 1102 South Goodwin Avenue, Urbana, Illinois 61801, USA

Richard Stedman
Department of Natural Resources, Cornell University, 104 Fernow Hall, Ithaca, New York 14853, USA

Abstract
The behavioral patterns of recreational anglers are an increasingly common focus of fishery management agencies, particularly due to the unintentional spread of aquatic invasive species. Previous research in this area has focused on understanding stakeholder awareness, use patterns, and beliefs. Although informative, these drivers of behavior are easily shifted by new information and are thus potentially less influential for encouraging long-term behavior change. There is a pressing need to account for the effects of human values in management of aquatic invasive species because values are a fundamental driver of behavior that changes slowly over time and represents a core basis for angler decision making. Therefore, this study assessed the relationships among values, risk perceptions, and reported aquatic invasive species prevention behavior to inform management decisions aimed at minimizing angler transport of aquatic invasive species. We generated a data set from a mixed-mode survey of license-holding recreational anglers from counties adjacent to the Great Lakes in three U.S. states ($n = 788$). Results from a structural equation model revealed that biospheric values positively predicted social and personal risk perceptions. Personal risk perceptions in turn positively predicted private and public dimensions of reported behaviors related to reducing the spread of aquatic invasive species. Efforts to reduce the spread of aquatic invasive species within the study context would be best served by emphasizing the personal impacts rather than broader social and ecological consequences from biological invasions. Agencies should also shift their attention to thinking about the role of values in explaining how people process and respond to environmental threats and degradation from aquatic invasive species.

As one of the strongest drivers of environmental change (Pyšek and Richardson 2010), aquatic invasive species are organisms that have been introduced outside of their native range and survived, reproduced, and started spreading beyond the initial point of introduction, often causing negative effects throughout the process (Blackburn et al. 2011). These negative impacts range from altering habitat to outcompeting native species for food and interfering with human activity (Gallardo et al. 2016). The Great Lakes are a hot spot for species invasions due to international shipping, which brings organisms from places around the world in ships' ballast water that is discharged upon arrival into a port (Keller et al. 2011; Escobar et al. 2018). Once species have become established in new ecosystems, reversing an invasion is virtually impossible (Vander Zanden and Olden 2008); thus, preventing the spread of aquatic invasive species is a crucial priority for fishery management agencies (Heck et al. 2016).

While regulations have been designed to minimize future biological invasions from shipping (Firestone and Corbett 2005), as well as from the bait trade (Kilian et al. 2012; Nathan et al. 2014), resource managers in the Great

*Corresponding author: golebie2@illinois.edu
Received March 24, 2021; accepted September 8, 2021

Lakes region have also been concerned about individual angler behavior that is exacerbating the spread of aquatic invasive species (Heck et al. 2015; Pradhananga et al. 2015). In particular, recreational anglers pose a risk of unintentionally transporting aquatic invasive species as they travel between water bodies (Kilian et al. 2012; Ready et al. 2018). For instance, the spread of zebra mussels *Dreissena polymorpha* and quagga mussels *Dreissena bugensis* across the United States has been attributed to recreational boaters and anglers (Hickey 2010) as well as the secondary spread of Great Lakes invaders, such as Rainbow Smelt *Osmerus mordax* and spiny waterflea *Bythotrephes longimanus*, as anglers move from the Great Lakes to inland water bodies (vander Zanden and Olden 2008). Consequently, resource management agencies have increasingly directed attention to environmental education that encourages anglers to take precautions (e.g., cleaning boats and/or equipment) after leaving bodies of water to reduce the likelihood of aquatic invasive species transport.

Outreach campaigns have been developed and implemented to encourage aquatic recreationists to check their equipment before entering new waterways and remove any plants, mussels, or other organisms they find (Funnell et al. 2009; Cole et al. 2016; Seekamp et al. 2016b). The "Stop Aquatic Hitchhikers!" (stopaquatichitchhikers.org) campaign sponsored by the Aquatic Nuisance Species Task Force, for example, encourages anglers to "clean, drain, dry" their boats to prevent the spread of aquatic invasive species and uses slogans such as "protect our natural state" and "be a good steward." On the state level, the "Be a Hero, Transport Zero" campaign (transportzero.org) in Illinois offers similar instructions for anglers to "remove, drain, dry." The Be a Hero campaign produced informational materials, including brochures that are disseminated at fishing events, and constructed boat-washing stations at lakes in northern Illinois. Previous research has evaluated the efficacy of these campaigns (Kemp et al. 2017) and indicated that they have successfully raised awareness of aquatic invasive species among anglers (Eiswerth et al. 2011). Slogans associated with these campaigns were recognized by 59% (Stop Aquatic Hitchhikers) and 25% (Be a Hero) of boaters who responded to one aquatic invasive species survey (Cole et al. 2016), indicating that outreach was successfully reaching a large proportion of the boating population. Likewise, respondents to another angler survey reported agreement with the statements that aquatic invasive species "are easily transferred from one lake to another" and "can interfere with water-based recreation like swimming, fishing, and boating" (Eiswerth et al. 2011). These findings suggest that there is relatively high awareness of how aquatic invasive species have spread and why they are problematic.

Although awareness of aquatic invasive species is increasing among anglers, their adoption of actions to prevent the spread of aquatic invasive species has not followed suit. Research has shown that engagement in aquatic invasive species prevention behaviors was the same across regions that had different levels of investment in aquatic invasive species outreach (Cole et al. 2016), which calls into question the efficacy of information campaigns on behavioral performance. Additionally, inconsistencies of angler participation in prevention behaviors can further exacerbate the risk of transporting aquatic invasive species. Specifically, there are multiple required steps in angler prevention of aquatic invasive species transport (e.g., cleaning the boat, draining it of water, and allowing it to dry), and many anglers report performing one, but not all, necessary step. For instance, one study in the Great Lakes region found that a majority of anglers completed the simplest step of draining their boat after each fishing trip; however, only 5% also completed the four other recommended actions: inspecting their boat for attached animals; removing any plants, animals, or mud; washing with hot water or disinfecting; and allowing their boat to dry before traveling to a different water body (Connelly et al. 2016). A similar study of anglers in Illinois found that although many anglers reported always taking at least one step to prevent aquatic invasive species spread, 62% had at least occasional fishing trips where they did not take any steps, leading to a high risk of aquatic invasive species transport (Cole et al. 2019). In other words, many anglers have become aware of aquatic invasive species and realized that there are preventative steps they should be taking but are not completing all of the steps or are not completing them on a regular basis. This phenomenon, referred to as the "knowledge–action gap" (Kollmuss and Agyeman 2002), has sparked calls for research investigating deeper psychological processes that affect behavior relevant to preventing the spread of aquatic invasive species (Cole et al. 2019), including values (Estévez et al. 2015) and risk perceptions (Hart and Larson 2014).

Values are a key element in understanding behavior that benefits the environment (Steg and Vlek 2009) and thus have been studied across disciplines, with guidance from numerous theoretical frameworks (Steg et al. 2014; Chan et al. 2018; van Riper et al. 2018; Kenter et al. 2019). Values, defined as guiding principles in life (Rokeach 1973), inform the study of environmentally relevant behaviors on a deep level (Stern et al. 1999; Steg and de Groot 2012). People with strong biospheric, altruistic, and egoistic values hold guiding principles around nature preservation, social equality, and self-interest, respectively (Schwartz 1992). Past work has shown that biospheric values, in particular, play a prominent role in predicting behavior, in that people who are driven by environmental concern are more likely to participate in behaviors that benefit the environment (Schultz et al. 2005; Liobikiene and Juknys 2016). Altruistic values also lead to pro-environmental and pro-social beliefs, whereas egoistic values decrease the likelihood of environmental outcomes (de Groot and Steg 2008). Human values have received limited attention within the study of recreational angling despite their potential to provide insights on the underlying reasons why behavioral patterns exist (van Riper et al. 2020).

The study of ecological risk in fisheries management has received widespread attention given the difficulties of implementing strategies that reduce threats from species invasions (Drake and Mandrak 2014; Gallardo and Aldridge 2018). Risk perceptions represent beliefs about the severity of possible harms to an entity (Rogers 1975), such as beliefs about the severity of food web disruptions that could be caused by a new aquatic invasive species within the Great Lakes fishery. Higher perceived risks have been shown to positively predict engagement in environmental behavior in a variety of contexts (O'Connor et al. 1999; Kothe et al. 2019). People tend to respond differently to risks that may affect themselves versus risks that affect the broader world, including social and environmental concerns (Smith and Leiserowitz 2012), generally perceving risks to others (i.e., social risks) to be higher than risks to themseleves (i.e., personal risks) (van der Linden 2015; van Riper et al. 2016). Risk perceptions specifically focused on preferences for aquatic invasive species management have received previous research attention (e.g., Estévez et al. 2015); however, the effects of different types of risk perceptions on angler behavior have yet to be determined.

The goal of this study was to define the roles of individual values and perceived risks of biological invasions on the behaviors of recreational anglers related to the spread of aquatic invasive species. Specifically, we addressed three research questions: (1) What are the relationships between values and risk perceptions among Great Lakes anglers? (2) What are the relationships between risk perceptions and reported behavior related to the spread of aquatic invasive species for Great Lakes anglers? and (3) How do the relationships among values, risk perceptions, and reported behavior vary by fishing site within the Great Lakes? To respond to these research questions, we tested a manifest variable path model including multiple hypotheses informed by previous research (Figure 1). When combined, answers to our three research questions can aid in the goal of encouraging long-term behavior change to curb angler spread of aquatic invasive species within the Great Lakes and beyond.

METHODS

Context of recreational angling in the Great Lakes region.— In the Great Lakes region, fishing environments can broadly be categorized as the Great Lakes themselves and their tributaries or as inland waterways that include smaller lakes, rivers, and streams. Past work has highlighted differences among anglers according to fishing site (Ward et al. 2013; Dabrowksa et al. 2017). Anglers fishing in different types of environments may have different beliefs and behavior related to aquatic invasive species given variation in regulations observed, outreach efforts, and social-ecological conditions experienced. For instance, anglers who fish exclusively in the Great Lakes and its tributaries may be aware of existing degradation from aquatic invasive species (Escobar et al. 2018) and thus perceive more risk than anglers who exclusively fish in inland waterways that have not been invaded by aquatic invasive species. Additionally, anglers who frequent both Great

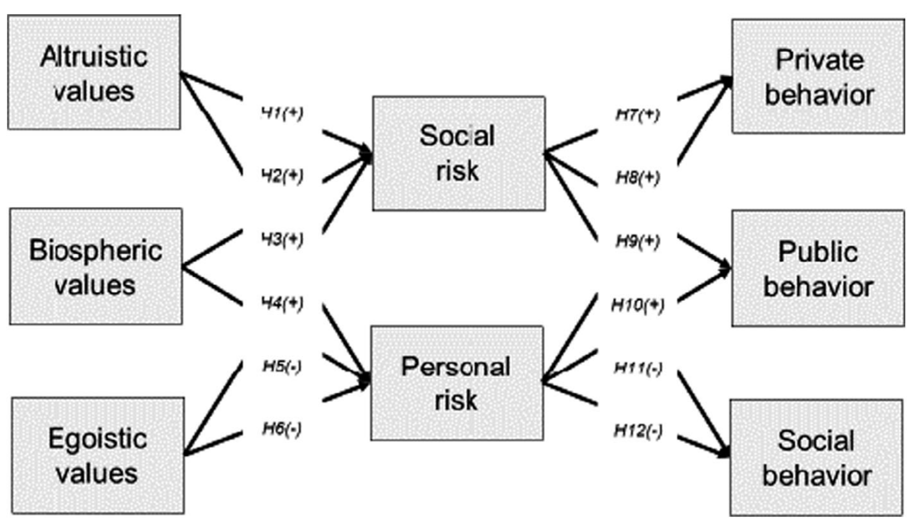

FIGURE 1. Hypothesized model showing predicted relationships between values, risk perceptions, and three dimensions of reported angler behavior. Twelve hypothesized paths were tested between values and risk perceptions (H1–H6) and risk perceptions and reported behavior (H7–H12). Plus (+) and minus (−) signs indicate positive and negative hypothesized relationships.

Lakes and inland waterways are a particularly important group; boaters moving between multiple water bodies in short time frames, referred to as "transient boaters," pose the most risk for transporting aquatic invasive species (Witzling et al. 2016), even if they take some preventative measures (Cole et al. 2019). However, avid transient boaters may also be aware of the issue given more exposure to a variety of aquatic invasive species messages posted at different sites or through different mediums (Seekamp et al. 2016a). Because signage at fishing sites is a common method for communicating about aquatic invasive species, message design can be validated or enhanced by understanding the beliefs and actions of anglers who fish in inland waterways versus the Great Lakes. Thus, understanding differences among anglers who fish different environments allows managers to better understand the risks of aquatic invasive species transport as well as the messaging needs at Great Lakes and inland waterways fishing sites.

Data collection.— Data were collected through a mail-back survey of anglers in the Great Lakes region conducted May–October 2019. The target population was U.S. anglers who fish on Lake Michigan, Lake Ontario (and associated tributary streams and rivers), and nearby inland waterways. Survey recipients were randomly selected from lists of licensed anglers in counties adjacent to Lake Michigan or Lake Ontario. A sample of 1,200 anglers were randomly selected from each of three license lists—Illinois, Michigan, and New York—for a total of 3,600 anglers that were invited to participate. The survey was administered over the course of 14 weeks and included an introductory letter, three mailings of the survey, and two reminder postcards, in line with standard guidelines by Dillman et al. (2014). In addition to the hard-copy questionnaire and postage-paid envelope, participants also had the option to access the survey via an online link that was shared in each mailing. Respondents were each provided a unique numerical code to enter on the survey home page, which allowed us to track response rates and avoid duplicate responses from the same individual. A total of 788 anglers completed the survey via mail ($n = 669$) or Internet ($n = 119$), resulting in a response rate of 22%. To assess potential sampling bias, we compared our sample with anglers from Michigan, New York, and Illinois in a past study (Connelly et al. 2014) and found no difference in gender ($\chi^2 = 2.1942$, $P = 0.139$). We also assessed days fished between our sample and a study of anglers in the Great Lakes region (Ready et al. 2012) and found no significant difference (t-statistic = 0.7186, df = 4,296, $P = 0.472$). Survey items were drawn from past research and finalized through two rounds of pilot testing, including a verbal protocol assessment ($n = 6$) and an online pilot test ($n = 102$).

Measures.— We measured three types of values, including biospheric, altruistic, and egoistic, established in previous research (Stern et al. 1999) and positioned as predictors of risk perceptions in environmental contexts (Slimak and Dietz 2006). Three items reflected each type of value, and responses were measured on a nine-point scale ranging from "opposed to my values" (1) to "of supreme importance" (9).

We measured both personal and social risk perceptions (Leiserowitz 2006; Brody et al. 2008; van der Linden 2015). Past work has characterized personal risk perceptions as the seriousness of a threat to one's own health, financial well-being, and local environment and social risk perceptions as seriousness of threat to the health, economy, and environment in broader society (Bord et al. 2000; Brody et al. 2008; Kellstedt et al. 2008; Milfont 2012). We tailored these items to the context of aquatic invasive species. Specifically, personal risk perceptions were measured as the seriousness of threat from aquatic invasive species to the respondent's fishing experience and financial well-being and the environment where they fished. Social risk perceptions were measured as the seriousness of threat from aquatic invasive species to the Great Lakes fishery, the economy in the Great Lakes region, and the environment in the Great Lakes region. Respondents were asked to report the level of threat from aquatic invasive species to each survey item on a five-point scale ranging from "low threat" (1) to "high threat" (5).

We examined three types of reported behavior established in previous research (Stern 2000; Larson et al. 2015) and tailored to the topic of aquatic invasive species. First, "private sphere" behaviors included activities that affect one's own impact on the environment, such as cleaning one's boat to minimize risk of aquatic invasive species transport. Second, behaviors in the "public sphere" were considered to have an impact beyond the individual, generally by aiming to affect policy, such as writing letters to government officials in support of aquatic invasive species control policies. Third, behaviors in the "social sphere" involved others through actions like telling community members about the risks of invasive species and encouraging friends to attend events related to aquatic invasive species. Private sphere behaviors such as boat washing have received the most attention in previous research given their tangible impact (Pradhananga et al. 2015; Kemp et al. 2017), though public and social sphere behaviors may have far-reaching impacts by affecting environmental policy and increasing participation in aquatic invasive species prevention by other people (Ertz et al. 2016). Thus, all three dimensions were measured. Survey items asked respondents to consider their behavior over the past 12 months and report their frequency of engagement in each behavior on a five-point Likert scale from "never" (1) to "very often" (5).

Fishing site was assessed by asking respondents to select where they spent most of their time fishing from a list of the Great Lakes and descriptions of Great Lakes tributaries, inland lakes, and inland rivers and streams. Respondents who selected at least one Great Lake and/or Great Lakes tributary were categorized as "Great Lakes and tributaries" anglers ($n = 172$), respondents who selected inland lakes and/or inland rivers and streams were categorized as "inland waterways" anglers ($n = 203$), and respondents who selected from both categories of answers were categorized as "mixed-site" anglers ($n = 382$). Respondents who did not respond to the fishing site question ($n = 31$) were removed from further analysis.

Analysis.— Structural equation modeling (Kline 2011) was used to test relationships among values, risk perceptions, and reported behavior. Specifically, a two-step structural regression modeling procedure outlined by Anderson and Gerbing (1988) was used. First, the validity and reliability of survey scales were evaluated using confirmatory factor analysis with a maximum likelihood estimation procedure. We assessed factor loading scores on each dimension, retaining items with standardized factor loading scores above 0.40 and ensuring no cross-loading of items (Hair et al. 2011). To test for internal consistency, we examined Cronbach's alpha as a measure of scale reliability; coefficients greater than 0.60 were accepted (Cortina 1993). Past work has emphasized the importance of including multiple measures of reliability because Cronbach's alpha relies on assumptions such as uncorrelated errors and tau-equivalence (Trizano-Hermosilla and Alvarado 2016). Therefore, we also assessed composite reliability, which was considered acceptable given values exceeding 0.60 (Bagozzi and Yi 1988). All final scales met these two thresholds (Table 1).

Our hypothesized reported behavior scale with a three-dimensional configuration demonstrated good model fit but poor reliability. Therefore, we used exploratory factor analysis to improve our hypothesized factor structure. We chose principal axis factoring because it corrected for measurement error and varimax rotation because it minimized the correlation among the latent variables. This analysis resulted in a two-factor solution that accounted for 54% of the total variance: private behavior ($\alpha = 0.657$; $\Omega = 0.642$) and public behavior ($\alpha = 0.726$; $\Omega = 0.731$). One item ("worked with others to minimize impacts from aquatic invasive species") did not load onto either dimension and was therefore dropped from the final model.

After defining the measurement model, we estimated a structural model to test our hypotheses (Figure 1). Specifically, we tested 12 hypothesized paths between values and risk perceptions (H1–H6) and risk perceptions and reported behavior (H7–H12). The model was identified given seven constructs and 15 hypothesized paths and correlations; however, due to the sample size of subgroups in relation to model complexity, parceling was conducted (Matsunaga 2008). A manifest model, including the mean value scores for each construct, was then run in RStudio 1.4.1717 (R Core Team 2020) using lavaan and semTools packages. The full information maximum likelihood (FIML) method was used to account for missing data (von Hippel 2016). Model fit was assessed using a chi-square test of significance, root mean square error approximation (RMSEA), comparative fit index (CFI), the Tucker–Lewis index (TLI), and standardized root mean square residual (SRMR) (Kline 2011). Our models were estimated, and fit was assessed separately for the pooled sample and each of the three fishing-site subgroups. Nonsignificant paths were dropped from the final analysis. To compare subgroup models with the pooled sample model, we used an invariance constraints procedure and analyzed differences using a chi-square difference test (Bollen 1989)[1].

RESULTS

Our sample was primarily white (88.0%) and male (85.6%), with an average age of 56 years (Table 2), which is consistent with past aquatic invasive species survey research conducted in the Great Lakes region (Connelly et al. 2014). On average, survey participants had fished 29 days in the past year and had 41 years of fishing experience. Representation of anglers from the three sampled states was roughly even (Illinois = 34.5%, Michigan = 28.7%, New York = 36.9%). Fishing effort was split across types of species, including salmonids (22.3%), warmwater game species such as bass *Micropterus* spp. and Walleye *Sander vitreus* (51.1%), and panfish and other species (26.6%).

Our analysis revealed partial support for the hypothesized relationships in the manifest path model (Figure 2). The chi-square test was significant ($\chi^2 = 33.511$, df = 9, $P < 0.001$); thus, other fit statistics were referenced, each of which fell within acceptable ranges and demonstrated a good fit of the model to the sample data (CFI = 0.981; TLI = 0.956; RMSEA = 0.060; SRMR = 0.044). In the pooled sample, biospheric values positively predicted social ($\beta = 0.326$; H3) and personal risk perceptions ($\beta = 0.271$; H4). Personal risk perceptions also increased egoistic values ($\beta = 0.091$), contrary to our hypothesis (H6). Finally, higher personal risk perceptions led to both private ($\beta = 0.323$; H10) and public behaviors ($\beta = 0.251$; H11).

We compared models between three fishing-site subgroups, including Great Lakes and tributaries ($n = 172$),

[1]The FIML method "repeatedly auditions different combinations of population parameter values" to identify the best model fit (Enders 2010: 61). This method estimates parameters based on all available data, whether or not each case is completed. This method is thus considered more efficient and less biased than deleting incomplete cases or imputation.

TABLE 1. Means (SDs in parentheses) for recreational anglers in the pooled sample and three fishing-site subgroups; measures of internal consistency including Cronbach's alpha (α) and composite reliability (Ω); and factor loading scores (λ) for scale items measuring reported behavior, risk perceptions, and values. Abbreviations are as follows: AIS = aquatic invasive species.

Scale items	λ	All anglers	Great Lakes and tributaries anglers	Inland waterways anglers	Mixed-site anglers
	Reported behavior[a]				
Private sphere behaviors (α = 0.657; Ω = 0.642)					
Looked up information about AIS	0.665	2.03 (1.06)	2.07 (1.11)	1.82 (0.97)	2.13 (1.06)
Avoided purchasing products that contribute to the spread of AIS	0.540	2.91 (1.80)	2.94 (1.80)	2.66 (1.74)	3.03 (1.65)
Took measures (e.g., washed boat or equipment) to personally reduce the spread of AIS	0.435	2.99 (1.66)	2.91 (1.64)	2.64 (1.64)	3.19 (1.65)
Talked to other people in my community about AIS	0.695	2.22 (1.25)	2.16 (1.19)	1.89 (1.15)	2.43 (1.29)
Public sphere behaviors (α = 0.726; Ω = 0.731)					
Participated in a policy process (e.g., voting) related to AIS	0.649	1.67 (1.20)	1.69 (1.18)	1.47 (1.02)	1.77 (1.28)
Donated money with the intention of reducing impacts from AIS	0.570	1.56 (0.98)	1.64 (1.04)	1.50 (0.97)	1.56 (0.97)
Wrote a letter, sent an email, or signed a petition about AIS	0.664	1.29 (0.77)	1.26 (0.72)	1.17 (0.63)	1.36 (0.85)
Encouraged other people to attend an event related to AIS	0.706	1.32 (0.79)	1.32 (0.82)	1.23 (0.67)	1.37 (0.82)
	Risk perceptions[b]				
Personal risk (α = 0.734; Ω = 0.748)					
Your fishing experience	0.768	3.92 (1.24)	3.87 (1.27)	3.75 (1.33)	4.04 (1.17)
Your financial well-being	0.472	2.29 (1.33)	2.46 (1.42)	2.19 (1.30)	2.26 (1.30)
The environment where you fish	0.878	3.96 (1.20)	3.98 (1.14)	3.66 (1.28)	4.10 (1.15)
Social risk (α = 0.882; Ω = 0.885)					
The Great Lakes fishery	0.815	4.39 (0.99)	4.31 (1.07)	4.24 (1.10)	4.50 (0.87)
The economy in the Great Lakes region	0.825	4.09 (1.13)	4.05 (1.18)	3.95 (1.16)	4.17 (1.07)
The environment in the Great Lakes region	0.905	4.24 (1.03)	4.17 (1.09)	4.13 (1.06)	4.34 (0.98)
	Values[c]				
Biospheric values (α = 0.887; Ω = 0.891)					
Protecting the environment: preserving nature	0.838	7.55 (1.60)	7.46 (1.69)	7.38 (1.64)	7.68 (1.53)
Unity with nature: fitting into nature	0.887	7.02 (1.86)	6.94 (1.96)	6.95 (1.91)	7.09 (1.79)
A world of beauty: beauty of nature and the arts	0.839	7.15 (1.87)	6.94 (2.06)	7.09 (1.93)	7.28 (1.74)
Altruistic values (α = 0.858; Ω = 0.863)					
Equality: equal opportunity for all	0.839	7.12 (2.02)	6.94 (2.14)	7.04 (2.08)	7.25 (1.93)
Social justice: correcting injustice, care for others	0.885	6.89 (2.12)	6.66 (2.20)	6.84 (2.16)	7.02 (2.05)
A world at peace: free of war and conflict	0.741	7.12 (2.12)	6.96 (2.24)	7.26 (2.07)	7.13 (2.08)
Egoistic values (α = 0.730; Ω = 0.727)					
Authority: the right to lead or command	0.760	5.90 (2.06)	5.82 (2.15)	5.83 (2.13)	5.98 (1.99)
Social power: control over others, dominance	0.555	3.38 (2.27)	3.58 (2.43)	3.49 (2.21)	3.23 (2.22)

TABLE 1. Continued.

Scale items	λ	All anglers	Great Lakes and tributaries anglers	Inland waterways anglers	Mixed-site anglers
Influential: having an impact on people and events	0.750	5.40 (2.09)	5.36 (2.19)	5.25 (2.10)	5.51 (2.04)

[a]Scales ranged from 1 (never) to 5 (very often); confirmatory factor analysis indicated good model fit (χ^2 = 73.557, df = 19, $P < 0.001$; RMSEA = 0.062 [90% CI = 0.048–0.077]; CFI = 0.958; TLI = 0.938; SRMR = 0.035).

[b]Scales ranged from 1 (low threat) to 5 (high threat) and reflect the perceived seriousness of threat that invasive species are to each of the six items; confirmatory factor analysis indicated good model fit (χ^2 = 51.668, df = 8, $P < 0.001$; RMSEA = 0.086 [90% CI = 0.065–0.109]; CFI = 0.980; TLI = 0.963; SRMR = 0.023).

[c]Scales ranged from 1 (opposed to my values) to 9 (of supreme importance); confirmatory factor analysis indicated good model fit (χ^2 = 90.679, df = 24, $P < 0.001$; RMSEA = 0.062 [90% CI = 0.048–0.075]; CFI = 0.980; TLI = 0.970; SRMR = 0.039).

TABLE 2. Characteristics of recreational anglers in the Great Lakes regions of Illinois, Michigan, and New York in the pooled sample and three fishing-site subgroups.

Variable	All anglers	Great Lakes and tributaries anglers	Inland waterways anglers	Mixed-site anglers
Gender (%)				
Male	88.0	88.2	84.9	89.5
Female	12.0	11.8	15.1	10.5
Other	0.0	0.0	0.0	0.0
Race[a] (%)				
White	85.6	85.5	89.7	83.5
State (%)				
Illinois	34.5	18.0	54.2	31.4
Michigan	28.7	36.0	22.2	45.0
New York	36.9	45.9	23.6	23.6
Target species (%)				
Salmonids	22.3	38.3	8.2	22.5
Warm- or coolwater game	51.1	48.1	55.5	50.1
Panfish and other	26.6	13.6	36.3	27.4
Fishing method (%)				
Shore	36.1	40.6	39.6	32.3
Boat	44.2	46.5	46.0	42.3
Boat and shore	19.7	12.9	14.4	25.5
Age (years; mean ± SD)	56.31 ± 15.68	56.67 ± 14.76	55.78 ± 16.43	56.43 ± 15.70
Days fished in past year (mean ± SD)	29.15 ± 38.81	28.17 ± 35.18	21.29 ± 22.22	33.76 ± 46.01
Years fished (mean ± SD)	40.82 ± 17.99	40.28 ± 17.56	38.39 ± 19.62	42.31 ± 17.19
Self-reported fishing skill[b] (mean ± SD)	3.72 ± 1.44	3.63 ± 1.48	3.54 ± 1.55	3.85 ± 1.36

[a]Less than 10% of respondents selected American Indian, Asian, Black, or Pacific Islander.

[b]Self-reported fishing skill was measured on a five-point scale ranging from 1 = much lower than average to 5 = much higher than average.

inland waterways ($n = 203$), and mixed-site ($n = 382$) anglers (Figure 3). First, we compared factor means across the three subgroups; anglers who frequented both Great Lakes and tributaries and inland waterways tended to have higher levels of reported behavior related to aquatic invasive species and perceived greater risk than those who exclusively fished either Great Lakes and tributaries or inland waterways (Table 3). Second, we compared regression coefficients among the three groups ($\Delta\chi^2$ = 31.029, Δdf = 22, P = 0.096; Table 4). A strong positive relationship between biospheric values and both social risk and personal risk perceptions was observed for all three groups. Relationships between risk perceptions and reported behavior varied among the groups. For the inland waterways subgroup, only the relationship between personal risk perceptions and private behavior was significant ($\beta = 0.243$). For mixed-site

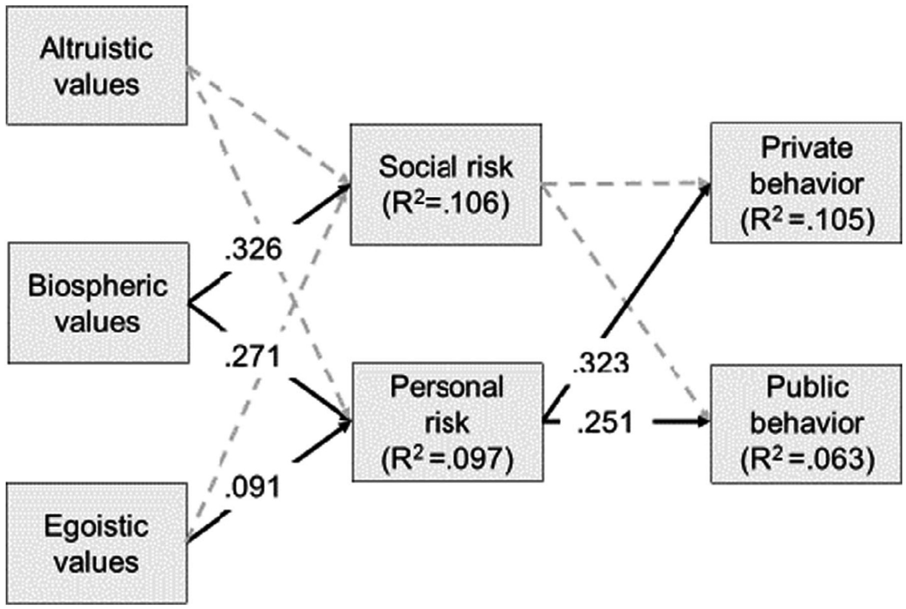

FIGURE 2. Drivers of behavior reported by anglers residing in Illinois, Michigan, and New York counties bordering Lake Michigan or Lake Ontario ($N = 757$). Fit statistics are as follows: χ^2 = 33.511, df = 9, $P < 0.001$; CFI = 0.981; TLI = 0.956; RMSEA = 0.060; and SRMR = 0.044. Standardized path coefficients (β) are indicated on the solid black lines. Hypothesized paths that were nonsignificant are shown as gray dashed lines.

anglers, personal risk strongly predicted both public ($\beta = 0.298$) and private ($\beta = 0.360$) behaviors. For Great Lakes and tributaries anglers, personal risk perceptions predicted public behaviors ($\beta = 0.252$) and social risk perceptions predicted private behaviors ($\beta = 0.318$).

DISCUSSION

We investigated multiple drivers of angler behavior with the goal of informing management strategies that reduce angler transport of aquatic invasive species in the Great Lakes region. Results revealed that values for environmental protection as a guiding principle in life were fundamentally important for explaining why individuals perceived risks and, in turn, reported engaging in behaviors related to the spread of aquatic invasive species. A comparison between Great Lakes and tributaries, inland waterways, and mixed-site anglers revealed consistency in values, as expected, but variation in risk perceptions and behavior. These findings provide insight on individual, small-scale behaviors that can have large-scale impacts on environmental sustainability by curbing the effects of unintentionally transported invasive species.

Public behaviors (e.g., talking to others about aquatic invasive species or engaging in local politics) were not as frequent as private behaviors (e.g., draining a boat after fishing) among all subgroups of recreational anglers engaged in this research. While private behaviors were reported “rarely” to “sometimes,” public behaviors were reported “never” to “rarely.” Although there is room for improvement with both types of behavior, there is a particular need to highlight public-sphere behaviors, which are largely absent from current outreach initiatives that focus on private behaviors, such as boat washing (Seekamp et al. 2016b). Angler interest in public sphere behaviors can be initiated through in-depth discussions with anglers that recognize and embrace their values regarding aquatic invasive species (Barclay et al. 2017; Kemp et al. 2017) and encourage further group action to prevent aquatic invasive species spread. Thus, campaigns to promote public behaviors, such as encouraging anglers to contact a political representative about an aquatic invasive species issue or to bring a friend to an upcoming aquatic invasive species event, may be helpful in generating wider-reaching effects.

Personal risk perceptions were shown to be more influential than social risk perceptions in encouraging behaviors that curb the spread of aquatic invasive species. Specifically, there was a significant, positive relationship between personal risk perceptions and behavior preventing aquatic invasive species for all angler subgroups in this study, whereas the relationship between social risk perceptions and reported behavior was not significant. Thus, for most anglers, regardless of their perceptions of general risks of aquatic invasive species, they are unlikely to take preventative action until they believe that those risks will impact their own lives. These findings extend past work on the importance of risk perceptions in behavior change

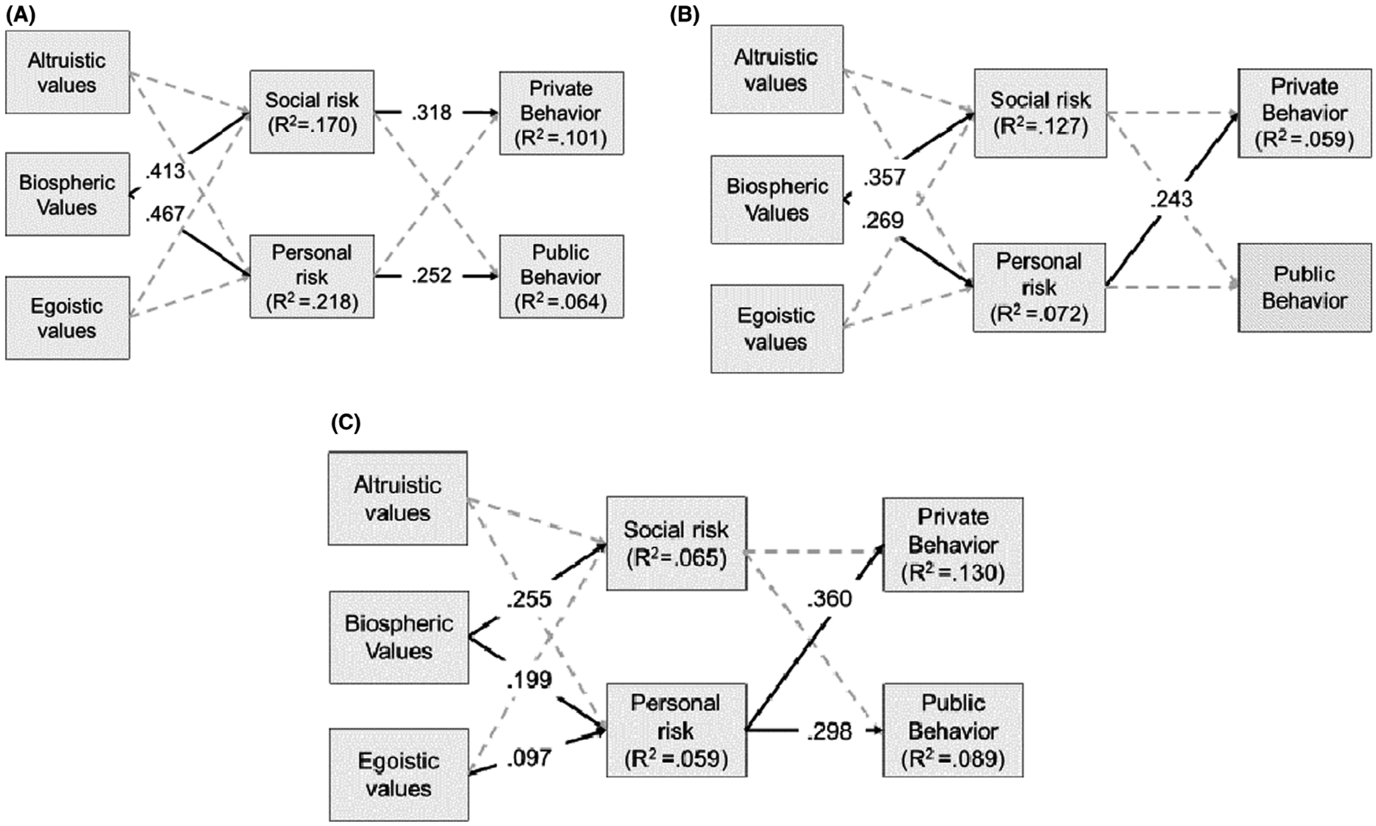

FIGURE 3. Drivers of angler behavior for anglers fishing in the following environments: **(A)** Great Lakes and tributaries (model fit: χ^2 = 17.447, df = 12, $P = 0.134$; CFI = 0.983; TLI = 0.971; RMSEA = 0.052; SRMR = 0.051), **(B)** inland waterways (model fit: χ^2 = 11.588, df = 7, $P = 0.115$; CFI = 0.984; TLI = 0.967; RMSEA = 0.057; SRMR = 0.058), and **(C)** mixed sites (model fit: χ^2 = 23.680, df = 9, $P = 0.005$; CFI = 0.976; TLI = 0.945; RMSEA = 0.066; SRMR = 0.043). Standardized path coefficients (β) are indicated on the solid black lines. Hypothesized paths that were nonsignificant are shown as gray dashed lines.

TABLE 3. Means (SDs in parentheses) for recreational anglers in the pooled sample and three fishing-site subgroups and ANOVA results for each construct. Within each row, means followed by different lowercase letters are significantly different at $P < 0.05$, based on Tukey's honestly significant difference comparison. Eta squared (η^2) provides a measure of effect size (i.e., the ratio of variance explained by the independent variable) and ranges from 0 to 1.

Construct	All anglers	Great Lakes and tributaries anglers	Inland waterways anglers	Mixed-site anglers	*F*-value	*P*-value	η^2
			Behavior				
Private	2.51 (1.04)	2.49 (1.04) z	2.21 (0.96) y	2.68 (1.04) z	14.012	0.000	0.037
Public	1.46 (0.71)	1.47 (0.73) zy	1.36 (0.67) y	1.52 (0.72) z	3.298	0.038	0.009
			Risk				
Personal	3.39 (1.02)	3.44 (1.04) z	3.21 (1.07) y	3.47 (0.97) z	4.663	0.010	0.013
Social	4.24 (0.95)	4.18 (1.00) zy	4.10 (1.04) y	4.34 (0.86) z	4.527	0.011	0.012
			Values				
Biospheric	7.24 (1.61)	7.12 (1.75)	7.13 (1.70)	7.35 (1.49)	1.767	0.171	0.005
Altruistic	7.04 (1.84)	6.85 (1.96)	7.04 (1.90)	7.14 (1.75)	1.413	0.244	0.004
Egoistic	4.90 (1.74)	4.93 (1.86)	4.85 (1.78)	4.91 (1.67)	0.111	0.895	0.000

(O'Connor et al. 1999; Kothe et al. 2019) by highlighting the particular importance of personal risk perceptions. Past work assessing multiple dimensions of risk has argued that social risk perceptions are higher than personal risk perceptions (van der Linden 2015; van Riper et al. 2016); we both corroborate this finding and extend it by noting

TABLE 4. Results from a manifest variable path model of the predictors of private and public behavior among recreational anglers. Variables that were nonsignificant and thus not retained in the final model are noted as "ns" in the table.

		All anglers		Great Lakes and tributaries anglers		Inland waterways anglers		Mixed-site anglers	
Dependent variable	Predictor variable	β	R^2	β	R^2	β	R^2	β	R^2
Private behavior	Personal risk (H10)	0.323	0.105	ns	0.101	0.243	0.059	0.360	0.130
	Social risk (H7)	ns		0.318		ns		ns	
Public behavior	Personal risk (H11)	0.251	0.063	0.252	0.064	ns	ns	0.298	0.089
Social risk	Biospheric (H3)	0.326	0.106	0.413	0.170	0.357	0.127	0.255	0.065
Personal risk	Biospheric (H4)	0.271	0.097	0.467	0.218	0.269	0.072	0.199	0.059
	Egoistic (H6)	0.091		ns		ns		0.097	

that while personal risk perceptions may be lower, they may also be more influential in predicting behavior. Thus, the current study offers a new perspective on how risk perceptions can aid in encouraging aquatic invasive species prevention and understanding angler behavior more broadly.

Reported behavior and risk perceptions varied among Great Lakes anglers, inland waterways anglers, and those who frequented both types of fishing environments. Inland waterways anglers had lower personal risk perceptions, as well as lower engagement in private-sphere behaviors than both Great Lakes and mixed-site anglers. Additionally, the relationship between social risk perceptions and behavior related to deterring the spread of aquatic invasive species was significant only for Great Lakes anglers. It could be that educational campaigns targeted at Great Lakes anglers have successfully communicated the severity of impacts from invasive species on the Great Lakes fishery and the region's economy, whereas inland waterways anglers have had more limited exposure to outreach messages. In support of this argument, aquatic invasive species messages are rarely presented at inland sites as compared with Great Lakes access points (e.g., Be a Hero's boat wash stations are only found in northern Illinois near Lake Michigan: see transportzero.org), and there are large differences in outreach investment across the state (Cole et al. 2016). Given that exposure to aquatic invasive species messages increases awareness (Seekamp et al. 2016a), groups outside of the Great Lakes region should be targeted by future outreach initiatives. These findings highlight the importance of considering distinguishable segments of recreational anglers defined by fishing location (Witzling et al. 2016; Dabrowksa et al. 2017). Together, results from the current study clearly show that angler risk perceptions vary across locations and need to be considered when designing strategies to control the spread of aquatic invasive species.

Biospheric values were stronger predictors of aquatic invasive species risk perceptions than egoistic or altruistic values. Across all subgroups tested, biospheric values significantly predicted both personal and social risk perceptions, whereas egoistic values only weakly predicted personal risk perceptions, and the relationship between altruistic values and risk perceptions was not significant. These results suggest that value systems driven by self-worth and achievement result in concerns about personal impacts from aquatic invasive species, rather than impacts on the environment or community outside of an individual's experience. This finding lies in contrast to past work suggesting that egoistic values should be negatively correlated with environmental beliefs (de Groot and Steg 2008). Additionally, we suggest that anglers who strongly value the environment will be more concerned with the impacts of aquatic invasive species both to their local fishing site and to the environment more broadly given that biospheric values were far stronger predictors of risk perceptions. As guiding principles in life (Rokeach 1973), values are one of the most fundamental influences on environmental behavior that remain unchanged throughout the lifespan and could be incorporated in future fisheries research to complement the large body of work focused on angler satisfaction (Birdsong et al. 2021).

Several message design guidelines can be derived from this study to help close the knowledge–action gap (Kollmuss and Agyeman 2002) and encourage anglers to reduce the spread of aquatic invasive species. To activate personal risk perceptions, managers can encourage anglers to consider how aquatic invasive species affect their everyday lives. Angler-relevant topics at risk of being impacted by aquatic invasive species could include angler's appreciation of the beauty of the landscape, access to favorite water bodies, ability to catch desired fish species, and damage to personal fishing equipment. To share information about the personal relevance of biological invasions, managers may recruit anglers to serve as spokespersons to share personal narratives about aquatic invasive species. The spokespersons could be highlighted within brochures or other printed material by including an image of the spokesperson alongside a quotation of that angler's personal reasons for their concern about aquatic invasive species and decision to take action. Personal anecdotes about how aquatic invasive species have changed a favorite fishing site may resonate with anglers who can identify with the spokesperson; past work in other contexts has found a strong relationship between identification with the speaker and intentions to engage in recommended behaviors (Brown et al. 2003; Kosenko et al. 2015). Related research has shown that print newspapers and other anglers are the most common sources of information regarding aquatic invasive species in this region (van Riper et al. 2020); thus, these sources present opportunities to convey risk information through personal narratives, enabling anglers to think about how they will be personally impacted by aquatic invasive species. Finally, although messaging on social risks (e.g., threats to the economy or fishery more broadly) is unlikely to encourage behavior change for inland waterways anglers, social risk perceptions significantly predicted behavior for anglers fishing on the Great Lakes and thus we recommend continuing messaging on broad impacts specifically at Great Lakes outreach sites.

For both Great Lakes and inland anglers, the strong influence of biospheric values on risk perceptions presents an opportunity to frame risk messages in line with these values. Past work on invasive species communication has highlighted the importance of engaging "deep frames," such as values that may result in long-term behavior change (Hine et al. 2014). The Be a Hero and Stop Aquatic Hitchhikers campaigns generally draw on the biospheric theme of protecting natural environments, such as through Stop Aquatic Hitchhiker's "protect your waterways" slogan. Our results provide support for this messaging choice but also suggest that the broader definition of biospheric values should be considered. Messages that emphasize the concepts of unity with nature and appreciating the beauty of natural areas, in addition to protecting the environment, would more completely reflect biospheric values and therefore be more likely to influence risk perceptions. Given the nonsignificance of altruistic values detected in this study, emphasizing benefits to the community of preventing aquatic invasive species spread is unlikely to encourage angler participation in prevention behaviors. Thus, complementing existing campaigns with messages that highlight the personal relevance of aquatic invasive species and adding additional themes related to biospheric values beyond generally protecting the environment may result in higher risk perceptions and ultimately higher participation in aquatic invasive species prevention among recreational anglers.

Limitations

Results from our study should be interpreted knowing that there were limitations that emerged throughout the research process. As documented in a growing body of previous research (Stedman et al. 2019; Coon et al. 2020), our low response rate was of concern. It could be that important differences between our sample and the target population may have influenced responses. We were not able to assess nonresponse bias because we had mailing addresses without an alternative method for contacting nonrespondents. That is, we could not confirm whether there were any trends among anglers who did or did not complete our survey. However, we did compare our data with past research (Ready et al. 2012; Connelly et al. 2014) on Great Lakes anglers and observed similarities in demographics and specialization. Future research should continue to consider how differences in characteristics, such as levels of specialization, may influence nonresponse bias. This analysis could occur through assessments of license type (Hunt et al. 2021).

Conclusion

Recreational anglers can help prevent the spread of aquatic invasive species by taking steps such as cleaning their equipment before leaving a waterway; however, despite the prevalence of outreach campaigns to raise awareness of aquatic invasive species prevention techniques, the risk of aquatic invasive species transport via anglers remains high. Our study identified relationships among values, risk perceptions, and reported angler behavior in the context of preventing the spread of aquatic invasive species by anglers in the Great Lakes region. Personal risk perceptions (i.e., believing that one's own fishing experience or the specific environment where one prefers to fish may be harmed by aquatic invasive species) were strong predictors of both public and private dimensions of aquatic invasive species prevention behaviors. Two deeper drivers of behavior, particularly biospheric and egoistic values, influenced personal risk perceptions. Future research should further explore the relationship between egoistic values and risk perceptions to understand whether it is rooted in self-interest or a desire for leadership. The messaging implications generated through this research provide a basis for future experiments on how people with different value profiles respond to messages aimed at increasing risk perceptions and ultimately behavior. In practice, managers should consider complementing language about large-scale environmental impacts of aquatic invasive species with language that explains how anglers may be personally affected should aquatic invasive species populations grow or spread. Likewise, outreach campaigns can be supplemented with news articles highlighting personal anecdotes from anglers who have experienced harm caused by aquatic invasive species. Ultimately, educational outreach campaigns in the context of aquatic invasive species and beyond can be enhanced by understanding the drivers of behavior and aligning message design with the psychological processes that shape angler decision making.

ACKNOWLEDGMENTS

Funding for this research was provided by the Great Lakes Fishery Commission (contract 2018_VAN_44076) and the U.S. Department of Agriculture National Institute of Food and Agriculture Hatch program (accession number 1012211). This work was supported in part through internships to Megan Gaddy and Claire Bailey provided by the National Great Rivers Research and Education Center through grants NGRREC-IP2018-09 and 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 guidance by Len Hunt and for the data collection and entry efforts of Max Eriksson as well as undergraduate research assistants David Nguyen, Delta Zhang, Venus Apantenco, and Yen-Hsuan Chang. There is no conflict of interest declared in this article.

ORCID

Elizabeth Golebie https://orcid.org/0000-0002-3238-0162
Cory Suski https://orcid.org/0000-0001-8280-873X

REFERENCES

Anderson, J. C., and D. W. Gerbing. 1988. Structural equation modeling in practice: a review and recommended two-step approach. Psychological Bulletin 103:411–423.

Bagozzi, R. P., and Y. Yi. 1988. On the evaluation of structural equation models. Journal of the Academy of Marketing Science 16:74–94.

Barclay, K., M. Voyer, N. Mazur, A. M. Payne, S. Mauli, J. Kinch, M. Fabinyi, and G. Smith. 2017. The importance of qualitative social research for effective fisheries management. Fisheries Research 186:426–438.

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

Blackburn, T. M., P. Pysek, S. Bacher, J. T. Carlton, R. P. Duncan, V. Jaroski, J. R. U. Wilson, and D. M. Richardson. 2011. A proposed unified framework for biological invasions. Trends in Ecology and Evolution 26:333–339.

Bollen, K. 1989. Structural equations with latent variables. Wiley, Hoboken, New Jersey.

Bord, R., R. O'Connor, and A. Fisher. 2000. In what sense does the public need to understand global climate change? Public Understanding of Science 9:205–218.

Brody, S. D., S. Zahran, H. Grover, and A. Vedlitz. 2008. A spatial analysis of local climate change policy in the United States: risk, stress, and opportunity. Landscape and Urban Planning 87:33–41.

Brown, W. J., M. D. Basil, and M. C. Bocarnea. 2003. The influence of famous athletes on health beliefs and practices: Mark McGwire, child abuse prevention, and androstenedione. Journal of Health Communication 8:41–57.

Chan, K. M., R. K. Gould, and U. Pascual. 2018. Editorial overview: relational values: what are they, and what's the fuss about? Current Opinion in Environmental Sustainability 35:A1–A7.

Cole, E., R. P. Keller, and K. Garbach. 2016. Assessing the success of invasive species prevention efforts at changing the behaviors of recreational boaters. Journal of Environmental Management 184:210–218.

Cole, E., R. P. Keller, and K. Garbach. 2019. Risk of invasive species spread by recreational boaters remains high despite widespread adoption of conservation behaviors. Journal of Environmental Management 229:112–119.

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

Connelly, N. A., T. B. Lauber, R. C. Stedman, and B. A. Knuth. 2016. The role of anglers in preventing the spread of aquatic invasive species in the Great Lakes region. Journal of Great Lakes Research 42:703–707.

Coon, J. J., C. J. van Riper, L. W. Morton, and J. R. Miller. 2020. Evaluating nonresponse bias in survey research conducted in the rural Midwest. Society and Natural Resources 33:968–986.

Cortina, J. M. 1993. What is coefficient alpha? An examination of theory and applications. Journal of Applied Psychology 78:98–104.

Dabrowksa, K., L. M. Hunt, and W. Haider. 2017. Understanding how angler characteristics and context influence angler preferences for fishing sites. North American Journal of Fisheries Management 37:1350–1361.

de Groot, J., and L. Steg. 2008. Value orientations to explain beliefs related to environmental significant behavior. Environment and Behavior 40:330–354.

Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. Internet, phone, mail, and mixed-mode surveys: the tailored design method, 4th edition. Wiley, Hoboken, New Jersey.

Drake, D. A. R., and N. E. Mandrak. 2014. Ecological risk of live bait fisheries: a new angle on selective fishing. Fisheries 39:201–211.

Eiswerth, M. E., S. T. Yen, and G. C. van Kooten. 2011. Factors determining awareness and knowledge of aquatic invasive species. Ecological Economics 70:1672–1679.

Enders, C. K. 2010. Applied missing data analysis. Guilford Press, New York.

Ertz, M., F. Karakas, and E. Sarigöllü. 2016. Exploring pro-environmental behaviors of consumers: an analysis of contextual factors, attitude, and behaviors. Journal of Business Research 69:3971–3980.

Escobar, L. E., S. Mallez, M. McCartney, C. Lee, D. P. Zielinski, R. Ghosal, P. G. Bajer, C. Wagner, B. Nash, M. Tomamichel, P. Venturelli, P. P. Mathai, A. Kokotovich, J. Escobar-Dodero, and N. B. D. Phelps. 2018. Aquatic invasive species in the Great Lakes region: an overview. Reviews in Fisheries Science and Aquaculture 26:121–138.

Estévez, R. A., C. B. Anderson, J. C. Pizarro, and M. A. Burgman. 2015. Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. Conservation Biology 29:19–30.

Firestone, J., and J. J. Corbett. 2005. Coastal and port environments: international legal and policy responses to reduce ballast water introductions of potentially invasive species. Ocean Development and International Law 36:291–316.

Funnell, E., M. Heaton, F. MacDonald, and B. Brownson. 2009. The aquarium and horticultural industry as a pathway for the introduction of aquatic invasive species—outreach initiatives within the Great Lakes Basin. Biodiversity 10:104–112.

Gallardo, B., and D. C. Aldridge. 2018. Inter-basin water transfers and the expansion of aquatic invasive species. Water Research 143:282–291.

Gallardo, B., M. Clavero, M. I. Sánchez, and M. Vilà. 2016. Global ecological impacts of invasive species in aquatic ecosystems. Global Change Biology 22:151–163.

Hair, J. F., C. M. Ringle, and M. Sarstedt. 2011. PLS-SEM: indeed a silver bullet. Journal of Marketing Theory and Practice 19:139–152.

Hart, S. P., and B. M. H. Larson. 2014. Communicating about invasive species: how "driver" and "passenger" models influence public willingness to take action. Conservation Letters 7:545–552.

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

Heck, N., R. C. Stedman, and M. Gaden. 2016. Human dimensions information needs of fishery managers in the Laurentian Great Lakes. Journal of Great Lakes Research 42:319–327.

Hickey, V. 2010. The quagga mussel crisis at Lake Mead national recreation area, Nevada (USA). Conservation Biology 24:931–937.

Hine, D. W., P. M. Please, L. J. McLeod, and A. B. Driver. 2014. Behaviourally effective communications for invasive animals management: a practical guide. Invasive Animals Cooperative Research Centre, Canberra, Australia.

Hunt, L. M., D. J. Phaneuf, J. K. Abbott, and E. P. Fenichel. 2021. Per trip changes to the economic value of Ontario, Canada anglers fishing the Laurentian Great Lakes under target species transitions. Human Dimensions of Wildlife 26:132–147.

Keller, R. P., J. M. Drake, M. B. Drew, and D. M. Lodge. 2011. Linking environmental conditions and ship movements to estimate invasive species transport across the global shipping network. Diversity and Distributions 17:93–102.

Kellstedt, P. M., S. Zahran, and A. Vedlitz. 2008. Personal efficacy, the information environment, and attitudes toward global warming and climate change in the United States. Risk Analysis 28:113–126.

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

Kenter, J. O., C. M. Raymond, C. J. van Riper, E. Azzopardi, M. R. Brear, F. Calcagni, I. Christie, M. Christie, A. Fordham, R. K. Gould, C. D. Ives, A. P. Hejnowicz, R. Gunton, A. I. Horcea-Milcu, D. Kendal, J. Kronenberg, J. R. Massenberg, S. O'Connor, N. Ravenscroft, A. Rawluk, I. J. Raymond, J. Rodríguez-Morales, and S. Thankappan. 2019. Loving the mess: navigating diversity and conflict in social values for sustainability. Sustainability Science 14:1439–1461.

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

Kline, R. B. 2011. Convergence of structural equation modeling and multilevel modeling. Pages 562–589 *in* M. Williams and W. P. Vogt, editors. The SAGE handbook of innovation in social research methods. SAGE Publications, London.

Kollmuss, A., and J. Agyeman. 2002. Mind the gap: why do people behave environmentally and what are the barriers to pro-environmental behaviour. Environmental Education Research 8:239–260.

Kosenko, K., R. Binder, and R. Hurley. 2015. Celebrity influence and identification: a test of the Angelina effect. Journal of Health Communication 21:318–326.

Kothe, E. J., M. Ling, M. North, A. Klas, B. A. Mullan, and L. Novoradovskaya. 2019. Protection motivation theory and pro-environmental behaviour: a systematic mapping review. Australian Journal of Psychology 71:411–432.

Larson, L. R., R. C. Stedman, C. B. Cooper, and D. J. Decker. 2015. Understanding the multi-dimensional structure of pro-environmental behavior. Journal of Environmental Psychology 43:112–124.

Leiserowitz, A. 2006. Climate change risk perception and policy preferences: the role of affect, imagery, and values. Climatic Change 77:45–72.

Liobikiene, G., and R. Juknys. 2016. The role of values, environmental risk perception, awareness of consequences, and willingness to assume responsibility for environmentally-friendly behaviour: the Lithuanian case. Journal of Cleaner Production 112:3413–3422.

Matsunaga, M. 2008. Item parceling in structural equation modeling: a primer. Communication Methods and Measures 2:260–293.

Milfont, T. L. 2012. The interplay between knowledge, perceived efficacy, and concern about global warming and climate change: a one-year longitudinal study. Risk Analysis 32:1003–1020.

Nathan, L. R., C. L. Jerde, M. McVeigh, and A. R. Mahon. 2014. An assessment of angler education and bait trade regulations to prevent invasive species introductions in the Laurentian Great Lakes. Management of Biological Invasions 5:319–326.

O'Connor, R. E., R. J. Bord, and A. Fisher. 1999. Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Analysis 19:461–471.

Pradhananga, A., M. A. Davenport, E. Seekamp, and D. Bundy. 2015. Preventing the spread of aquatic invasive species: boater concerns, habits, and future behaviors. Human Dimensions of Wildlife 20:381–393.

Pyšek, P., and D. M. Richardson. 2010. Invasive species, environmental change and management, and health. Annual Review of Environment and Resources 35:25–55.

R Core Team. 2020. R: a language and environment for statistical computing. R Foundation for Statistical Computing. Available: https://www.r-project.org. (October 2020).

Ready, R. C., G. L. Poe, T. B. Lauber, S. Creamer, N. A. Connelly, and R. C. Stedman. 2012. Net benefits of recreational fishing in the Great Lakes, upper Mississippi River, and Ohio River basins. Cornell University, Department of Natural Resources, Human Dimensions Research Unit, HDRU Series 12-3, Ithaca, New York.

Ready, R., G. Poe, T. B. Lauber, N. A. Connelly, R. C. Stedman, and L. G. Rudstam. 2018. The potential impact of aquatic nuisance species on recreational fishing in the Great Lakes and upper Mississippi and Ohio River basins. Journal of Environmental Management 206:304–318.

Rogers, R. W. 1975. A protection motivation theory of fear appeals and attitude change. The Journal of Psychology 91:93–114.

Rokeach, M. 1973. The nature of human values. Free Press, New York.

Schultz, P. W., V. V. Gouveia, L. D. Cameron, G. Tankha, P. Schmuck, and M. Franek. 2005. Values and their relationship to environmental concern and conservation behavior. Journal of Cross-Cultural Psychology 36:457–475.

Schwartz, S. H. 1992. Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries. Advances in Experimental Social Psychology 25:1–65.

Seekamp, E., J. E. Mayer, P. Charlebois, and G. Hitzroth. 2016a. Effects of outreach on the prevention of aquatic invasive species spread among organism-in-trade hobbyists. Environmental Management 58:797–809.

Seekamp, E., A. McCreary, J. Mayer, S. Zack, P. Charlebois, and L. Pasternak. 2016b. Exploring the efficacy of an aquatic invasive species prevention campaign among water recreationists. Biological Invasions 18:1745–1758.

Slimak, M. W., and T. Dietz. 2006. Personal values, beliefs, and ecological risk perception. Risk Analysis 26:1689–1705.

Smith, N., and A. Leiserowitz. 2012. The rise of global warming skepticism: exploring affective image associations in the United States over time. Risk Analysis 32:1021–1032.

Stedman, R. C., N. A. Connelly, T. A. Heberlein, D. J. Decker, and S. B. Allred. 2019. The end of the (research) world as we know it?

Understanding and coping with declining response rates to mail surveys. Society and Natural Resources 32:1139–1154.

Steg, L., J. W. Bolderdijk, K. Keizer, and G. Perlaviciute. 2014. An integrated framework for encouraging pro-environmental behaviour: the role of values, situational factors and goals. Journal of Environmental Psychology 38:104–115.

Steg, L., and J. de Groot. 2012. Environmental values. Pages 81–92 *in* S. D. Clayton, editor. The Oxford handbook of environmental and conservation psychology. Oxford University Press, Oxford, UK.

Steg, L., and C. Vlek. 2009. Encouraging pro-environmental behaviour: an integrative review and research agenda. Journal of Environmental Psychology 29:309–317.

Stern, P. C. 2000. New environmental theories: toward a coherent theory of environmentally significant behavior. Journal of Social Issues 56:407–424.

Stern, P. C., T. Dietz, T. Abel, G. A. Guagnano, and L. Kalof. 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. Human Ecology Review 6:81–97.

Trizano-Hermosilla, I., and J. M. Alvarado. 2016. Best alternatives to Cronbach's alpha reliability in realistic conditions: congeneric and asymmetrical measurements. Frontiers in Psychology 7:769.

van der Linden, S. 2015. The social-psychological determinants of climate change risk perceptions: towards a comprehensive model. Journal of Environmental Psychology 41:112–124.

van Riper, C. J., E. J. Golebie, S. Shin, M. Eriksson, A. Smith, C. Suski, and R. Stedman. 2020. A study of angler behavior and the spread of aquatic invasive species in the Great Lakes region. Cornell University, Department of Natural Resources, Center for Conservation Social Sciences, CCSS Series 20–7, Ithaca, New York.

van Riper, C. J., A. Thiel, M. Penker, M. Braito, A. C. Landon, J. Thomsen, and C. M. Tucker. 2018. Incorporating multi-level values into the social-ecological systems framework. Ecology and Society 23 (3):article 25.

van Riper, C. J., K. E. Wallen, A. C. Landon, M. A. Petriello, G. T. Kyle, and J. Absher. 2016. Modeling the trust-risk relationship in a wildland recreation setting: a social exchange perspective. Journal of Outdoor Recreation and Tourism 13:23–33.

Vander Zanden, M. J., and J. D. Olden. 2008. A management framework for preventing the secondary spread of aquatic invasive species. Canadian Journal of Fisheries and Aquatic Sciences 65:1512–1522.

Von Hippel, P. T. 2016. New confidence intervals and bias comparisons show that maximum likelihood can beat multiple imputation in small samples. Structural Equation Modeling: A Multidisciplinary Journal 23:422–437.

Ward, H. G., M. S. Quinn, and J. R. Post. 2013. Angler characteristics and management implications in a large, multistock, spatially structured recreational fishery. North American Journal of Fisheries Management 33:576–584.

Witzling, L., B. Shaw, and D. Seiler. 2016. Segmenting boaters based on level of transience: outreach and policy implications for the prevention of aquatic invasive species. Biological Invasions 18:3635–3646.