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Connecting human–nature relationships to environmental behaviors that minimize the spread of aquatic invasive species

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Abstract Management of aquatic invasive species (AIS) is widely recognized as a global conservation concern driven by myriad factors, particularly individual behaviors. A burgeoning literature focused on the human dimensions of AIS has begun to provide insight into the complexities of behavior change; however, most studies are bound to specific geographic locales and have prevented resource management agencies from making regionally valid statements about the anthropogenic factors contributing to biological invasions. We examined stakeholders' awareness and knowledge of AIS transmission in an evaluation of educational outreach campaign logos

and illustrated how human–nature relationships were related to behaviors relevant to AIS reduction at two case study sites. Drawing from a thematic analysis of data from semi-structured interviews with organisms-in-trade hobbyists and recreational water users in the state of Illinois, we observed high awareness of environmental impacts and modes of transmission by the two groups. Both awareness advanced through AIS outreach and a diversity of human–nature relationships were helpful for understanding reported environmental behaviors. Specifically, stakeholders' views of their relationships with nature affected decisions to engage in activities that contributed to social-ecological change. Results also revealed preferences for national rather than state-level outreach campaign logos, which carry implications for designing communication strategies that will minimize the likelihood of biological invasions in freshwater ecosystems.

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Introduction

Aquatic invasive species (AIS) are increasingly changing the face of ecosystems, local economies, and human well-being (Pimentel et al. 2005; Pagnucco et al. 2015). Numerous outreach programs are being

developed at national and state levels to raise awareness of how people influence the spread of organisms such as the invasive zebra mussel (*Dreissena polymorpha*), which has disrupted food chains through competition and inflicted damage on commercial and recreational fisheries. Anglers and recreational boaters are at particularly high risk of unintentionally spreading invasive species in freshwater ecosystems when transferring boats from one body of water to another, as well as aquarists and water garden hobbyists who can improperly dispose of organisms into local waterways. In response to these threats, agencies have enhanced understanding of AIS in recent years (Seekamp et al. 2016); however, greater knowledge does not always translate into behaviors that benefit the environment (Blake 1999; McKenzie-Mohr 2000; Kollmuss and Agyeman 2002). A stronger social scientific understanding of the interplay between anthropogenic and biological factors will provide insight into the reasons why invasive species are released into new environments and help to close the so called “knowledge-action gap” (Humair et al. 2014; Marshall et al. 2011; Selge et al. 2011; Sharp et al. 2011; Stedman et al. 2014). Specifically, research on the social psychological processes that shape stakeholder opinions and behaviors will show how agencies can structure communication in a way that motivates people to act more consistently on their belief systems (Schultz 2011; Manfredo et al. 2017).

Human behaviors relevant to AIS are influenced by factors such as knowledge, concern, and environmental attitudes (Connelly et al. 2016; Lauber et al. 2015). Of particular interest in the present study is the idea of a human–nature relationship (HNR) that bridges streams of research in social psychology (Dunlap et al. 2000), empirical philosophy (van den Born 2007), and natural resources management (Flint et al. 2013). This study defines HNR as an indicator of how people relate to their environments in a way that recognizes, “key linkages to the realm of values, attitudes, concerns, and worldviews dominating contemporary environmental literature” (Flint et al. 2013, p. 209). A number of scholars have advanced the conceptualization of HNR (Kellert 1996; De Groot et al. 2011), as exemplified by the ‘visions of nature’ typology (Van den Born et al. 2001; De Groot and van den Born 2003). However, despite theoretical progress to understand the visions of nature HNR concept, less attention has been devoted to testing empirical

linkages between HNR and reported AIS behaviors (Verbrugge et al. 2013). Also, there remains a limited understanding of how transferable these insights are across regional contexts to inform policy design and management decisions about biological invasions (de Groot and de Groot 2009).

Building on past research, we approached this study from the aforementioned visions of nature perspective (van den Born 2007) to provide insight into the complexities that underlie environmental behaviors that contribute to biological invasions (Kowarik 2003). More specifically, we were guided by the following objectives: (1) examine stakeholder awareness and knowledge of AIS transmission associated with educational campaign logos; (2) assess HNR worldviews reported by stakeholder groups; and (3) explore how awareness and HNR relate to environmental behavior. To minimize potential incongruence that may occur between knowledge and actions relevant to AIS reduction, this paper offers a deeper understanding of HNR reported by stakeholders who are at risk of spreading AIS in Illinois waterways.

Literature review

Raising awareness of AIS through outreach campaigns

Communicating AIS issues in ways that inspire responsible environmental behaviors among people who hold diverse relationships with nature is complex and resource management agencies have responded by developing diverse outreach strategies targeted at an array of stakeholder groups. This study evaluated four campaigns (Fig. 1)—two state and two national-level initiatives, each of which was associated with unique logos and messaging to combat the spread of problematic species such as Asian carp (*Hypophthalmichthys*), zebra mussels (*D. polymorpha*), and water hyacinth (*Eichhornia crassipes*). First, “Be a Hero—Transport Zero” was an outreach campaign developed in 2012 by the Illinois-Indiana Sea Grant and the Illinois Department of Natural Resources to reach water-based recreationists. Outreach materials accompanying this campaign included tactics such as signs at boat ramps, posters in bait shops, and stickers. Secondly, the “Be a Hero—Release Zero” campaign was developed in 2015 by the same two agencies with



Fig. 1 State-level and national-level AIS campaign logos

the organisms-in-trade audience in mind. Third, a group associated with the U.S. Fish and Wildlife Service and other federal agencies, the Aquatic Nuisance Species Task Force, developed the “Stop Aquatic Hitchhikers” campaign in 2001 to educate recreationists about preventing the spread of AIS. Finally, the “Habitattitude” campaign was created by the Aquatic Nuisance Species Task Force in 2004 for organisms-in-trade hobbyists. Thus, there were two state-level and two national-level campaigns aimed at the same audiences; these campaigns were designed for behavior change among recreationists (Connelly et al. 2014) and hobbyists (Lauber et al. 2015).

Human–nature relationships

Environmental worldviews, or human nature relationships, are considered a psychologically stable basis from which other decisions are made, and are useful for segmenting stakeholders into smaller more homogenous subgroups. For example, van Riper and Kyle (2014a) found that HNR (e.g., environmental worldviews) played a role in shaping the perceived qualities of places in marine and terrestrial environments. These authors examined the “social values for ecosystem services” reported by survey respondents who reported neutral and strong environmental worldviews. Pradhananga et al. (2015) also studied the relationship between HNR concepts and behavioral intentions with the goal of gauging the propensity of individuals to engage in

responsible boating activities. Results from this study suggested value orientations were predictors of past behavior and environmental concern, which in turn influenced intentions. More specifically, anthropocentric-oriented boaters who thought nature should be conserved due to its use for society took action to prevent the spread of AIS only if they perceived a threat to human use of a fishery. Biocentric-oriented boaters on the other hand believed the environment should be protected for its intrinsic value (Thompson and Barton 1994) and were likely to act if they felt concerned about the condition of the aquatic environment. This body of past work points to the importance of tailoring outreach to stakeholders based on underlying orientations.

Past research has explored varied human relationships with nature to provide information on the visions of nature concept. For example, van den Born (2007) set out to find an alternative measure of HNR that would account for some of the disadvantages of previous measures such as the New Ecological Paradigm (NEP) (Hawcroft and Milfont 2010). Visions of nature included perceived images of nature (what people regard as being nature), values of nature (the reason why nature is perceived to be important), and images of the HNR. The following four images were developed and tested to determine whether laypeople’s relationships with nature reflected the relationships proposed by environmental philosophers: (1) *Master over Nature*, which offers a highly anthropocentric perspective; (2) *Steward of Nature*, which suggests more benign anthropocentrism that involves a responsibility for preserving nature; (3) *Partner with Nature*, which is a more ecocentric concept in which humans are equal with nature; and (4) *Participant in Nature*, which is a highly ecocentric image in which humans are part of and have a spiritual connection with nature. Several studies have found that Dutch people reject *Master over Nature* and more closely align with the other three HNR concepts (de Groot and van den Born 2007; van den Born 2007). The effects of the visions of nature on human–environment interactions and the explanatory power of reported knowledge have also been explored. Specifically, Verbrugge et al. (2013) suggested that Dutch residents who identified as *Stewards of Nature* were likely to support management of non-native species and relate their knowledge to behavioral engagement.

Environmental behavior

Environmental behaviors include all actions that change the fundamental structures and functions of ecosystems (Stern 2000; Steg and Vlek 2009). This complex concept has been understood using a wide variety of frameworks, several of which posit that a hierarchical relationship exists among centrally held values, beliefs, attitudes, and norms, which can be used to predict more transitory intentions and behaviors (Vaske and Donnelly 1999; van Riper and Kyle 2014b; Pradhananga et al. 2015). These conceptualizations of environmental behavior suggest that HNR concepts such as worldviews are relatively stable in psychological terms, similar to values defined as enduring and guiding principles that transcend specific contexts in life (Rokeach 1973). Though, as researchers move up the hierarchical chain, attitudes and beliefs become less fixed—they are variable and sometimes contradictory, and cause people to respond to environmental information in different ways (Blake 1999). Although theoretically distinct, each of these concepts carries potential to predict intended and/or reported behaviors (Stern et al. 1999; Ajzen and Fishbein 2005; Mastrangelo et al. 2014).

Initial attempts to understand behavior posited that gaining environmental knowledge would promote positive attitudes, and in turn, environmental behavior. However, knowledge has been studied at great length in recent years (Hines et al. 1987; Moscardo et al. 2001; Hunter and Rinner 2004; D'Antonio et al. 2012), and evidence suggests it has only a minor influence on behavior change (Heberlein 2012). Nevertheless, many educational campaigns have continued to focus on increasing awareness of an issue to influence attitudes and thereby promote pro-environmental activity (Kollmuss and Agyeman 2002). There are numerous other factors that have a greater influence on a person's decision to engage in behavior, including but not limited to attitudes (Oskamp and Schultz 2005), values (Schwartz 1994), environmental concern (Schultz 2001), locus of control (Guagnano 1995), and normative processes (Schultz et al. 2007; Heberlein 2012); however, a panacea has yet to be identified. Future research focused on internal *and* external factors can identify mechanisms that bridge the knowledge-action gap and encourage people to engage in minimum-impact activities (van Riper et al. 2017).

Methods

Target stakeholder groups and study context

Our research focused on AIS issues that affected waterways in the state of Illinois. Several of the problematic AIS in Illinois include Asian carp (genus *Hypophthalmichthys*), zebra mussels (*D. polymorpha*), and Eurasian watermilfoil (*Myriophyllum spicatum*). Two stakeholder groups were identified as potential vectors for AIS release. First, we examined recreational water users, including stakeholders engaged in consumptive (e.g., anglers) and non-consumptive (e.g., boaters) activities (van Riper et al. 2012). These individuals were selected owing to their potential for spreading AIS by unintentionally transferring organisms from one body of water to another via boat or other watercraft (Connelly et al. 2014). Secondly, we examined the practices of organisms-in-trade (OIT) hobbyists, including aquarists (e.g., aquarium owners) and water gardeners (e.g., pond owners) (Lauber et al. 2015). These individuals were also at risk of spreading AIS through purposeful or unintentional pathways (Verbrugge et al. 2014). Outlets for recruitment of organisms-in-trade hobbyists included aquarium club meetings and a pond and koi trade show.

We examined environmental behavior in the context of two case study sites, one of which was an access point to the Great Lakes and the other represented an inland waterway in the state. Specifically, recreational water users were invited to participate in this study from North Point Marina located in Winthrop Harbor, IL on the southwest shore of Lake Michigan. The Great Lakes system is a region of high concern because many of the conditions (e.g., food webs) in these lakes have undergone tremendous changes over the past several decades (Allan et al. 2005), and are quickly becoming less diverse and at risk of being dominated by invasive species (Mills et al. 1993). The second case study site was Chain o' Lakes State Park, which is located in northern Illinois and is a segment of the Fox River that runs through a series of mid-sized lakes. This state park is reportedly one of the busiest recreational waterways in the United States and is located in a state that manages a number of major rivers systems such as the Mississippi and Illinois Rivers. Decisions about data collection procedures and the two case study sites were selected in consultation with the Illinois-Indiana Sea Grant AIS Team.

Data collection, recruitment and data analysis

We collected qualitative data to explore the connections between HNR and environmental behavior tied to a series of outreach campaigns aimed at combatting the spread of AIS. Although both quantitative and qualitative methods have been used in past research to evaluate HNR, quantitative studies have focused on distributions of phenomena while qualitative studies have tended to focus on the content of phenomena, such as what people specifically regard as nature (de Groot and van den Born 2007). Given the goal of this research to understand the nuanced relationship between HNR and environmental behaviors learned from AIS outreach campaigns, in-depth techniques and a qualitative research design were deemed most suitable.

To recruit study participants, a purposive “snowball” sampling technique was employed (Heckathorn 1997). This involved developing an initial pool of participants from various sources relevant to the study. The initial sampling frame included participants in a pond and koi trade show, a fishing tournament, local boating clubs, and bait shops. Then, participants were asked for personal referrals for additional people to contact. These steps were taken until reaching a point where additional interviews did not yield new information or lead to distinctly new relationships, also referred to as the point of saturation (Guest et al. 2012). In total, 19 semi-structured interviews were conducted from May–July, 2015 with recreational water users ($N = 10$) and organisms-in-trade hobbyists ($N = 9$). Conversations ranged from 14 to 65 min with an average duration of 32 min. Interviews were audio recorded and transcribed verbatim. ATLAS.ti version 7.1.8 was used to analyze the text by means of open and axial coding (Marshall and Rossman 2006). Meaningful but distinct key words and categories were associated with segments of text, which were subsequently organized into themes, each of which was identified by the authors in a process of co-construction and understanding with their study participants (Guest et al. 2012). The stories shared by participants helped to unveil the complexities of human behaviors that contributed to AIS problems.

Interview questions

Semi-structured interview guides were developed to query the specifics of participants' involvement with either recreational water activities or hobbyists.

Participants were asked questions to gauge familiarity with AIS and modes of transmission. Next, they were asked to evaluate the campaign logos targeted at their particular group (Fig. 1). The campaign logos were sent by email before the phone interviews and participants were asked to reflect on the logos during the in-depth conversation. Participants were also provided with a document that included visual representations of four relationships between people and nature (Fig. 2), were read verbal descriptions of these relationships (Table 1), and asked to choose the relationship that best reflected how they personally related to nature in everyday life. Throughout the interview, participants were asked probing questions to discover more about their connections with the environment and behaviors tied to AIS.

Results

Participant characteristics

All participants reported similar ages and ethnic characteristics. Both hobbyists and recreationists were mostly older than 50 years and were Caucasian. Yet, the two groups maintained differences in gender, educational attainment, and length of involvement in

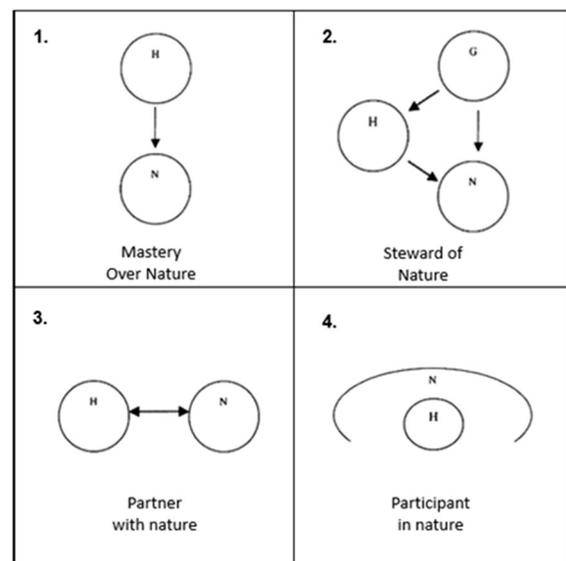


Fig. 2 Images of the human–nature relationship (drawn from Van den Born 2008). *H* humans, *N* nature, *G* God (in religious variant) or next generations (in secular worldview)

Table 1 Descriptions of the human–nature relationship (de Groot and van den Born 2007)

Human–nature relationship	Definition
Master over nature	According to the idea of Mastership, humans stand above nature. Humans are allowed to do with nature whatever they want. Economic growth and technology are expected to provide answers to (environmental) problems that may arise.
Steward of nature	The Steward stands above nature and is responsible for environmental conservation. Nature is not owned by the Steward, but entrusted to him or her. The steward owes responsibility to God or future generations.
Partner with nature	The Partner stands side by side with nature. Humans and nature are considered to be of equal value. Humans should work together with nature in the conviction that this interaction will benefit both.
Participant in nature	The Participant is part of nature, not just biologically, but also on the spiritual level. Although humans are a (small) part of nature, they are active participants. For the Participant, the bond between self and nature is very important; it co-constitutes the self.

respective activities, whereby: (1) more male than female recreationists participated in the study; (2) a larger proportion of recreationists belonged to an organization, a society, or club; and (3) the length of involvement of participants in respective activities was higher among recreationists (Table 2).

Stakeholder awareness and knowledge of AIS

This study assessed stakeholders' awareness and knowledge of the problems with AIS and campaigns to reduce their spread. To assess awareness, participants were asked to list invasive species in the Great Lakes and Illinois waterways. Both groups communicated two distinct lists of AIS. Hobbyists listed names primarily of invasive plants including water hyacinth (*E. crassipes*), water lettuce (*Pistia statiotes*), elodea (genus *Elodea*), and gooseneck loosestrife (*Lysimachia clethroides*), as well as a mollusk called the Chinese mystery snail (*Cipangopaludina chinensis*). Recreationists communicated a wider variety of AIS, including mollusks such as the quagga mussel (*D. bugensis*), fish such as the round goby (*Neogobius melanostomus*), crustaceans such as spiny water fleas (*Bythotrephes longimanus*) and rusty crayfish (*Orconectes rusticus*), and plants such as Eurasian milfoil (*M. spicatum*). A small number of AIS were commonly listed by both hobbyists and recreationists, including alewife (*Alosa (Pomolobus) pseudoharengus*), Asian carp (*Hypophthalmichthys*), and zebra mussels (*D. polymorpha*).

Awareness and knowledge of AIS was also assessed according to the extent to which familiarity

with introductions, associated impacts, and modes of transmission were reported. Familiarity with introductions of AIS varied among participants. For example, one hobbyist talked at length about the history of AIS introductions in Lake Michigan: "The first invasive species that came into Lake Michigan was the [alewife]. Then they added the salmon...that's their unnatural habitat. Of course now they're so huge... Zebra mussels is another serious problem [Participant 17]." Conversely, another hobbyist mentioned only zebra mussels (*D. polymorpha*) and was not aware that the water lettuce (*P. statiotes*) in her garden was considered an invasive species. While hobbyists did not talk at length about specific impacts of invasive species, recreationists demonstrated deeper understandings of biological invasions and commented on the impacts of AIS on fisheries. One stated:

Just about everything's an invasive species in Lake Michigan, starting with the salmon they put in to take care of the alewives that came in during the 1960s through the St. Lawrence Seaway...we're having a huge problem with our fishery right now because of the zebra mussels and the quagga mussels that are actually filtering all of the nutrients out of the water in Lake Michigan. On a clear day I can see 55 feet down on Lake Michigan... it's getting clearer and clearer and pretty sterile [Participant 3].

Participants reported different modes of AIS transmission. Both groups commonly referred to ballast water in large freights as vectors for release, and some believed that the purposeful release of organisms was

Table 2 Sociodemographic characteristics of study participants, including the pooled sample, organism-in-trade hobbyists (N = 9) and recreational water users (N = 10)

	Pooled sample	Hobbyists	Recreationists
Sex: N (%)			
Male	12 (63.2)	4 (44.4)	8 (80.0)
Female	7 (36.8)	5 (55.6)	2 (20.0)
Age: Mean (SD)	58.65 (9.37)	62.29 (7.23)	56.1 (10.19)
Ethnicity: N (%)			
Caucasian	17 (94.4)	7 (87.5)	10 (100.0)
Hispanic	1 (5.6)	1 (12.5)	0 (0)
Completed education: N (%)			
High school	2 (11.1)	1 (12.5)	1 (10.0)
Trade school	1 (5.6)	0 (0)	1 (10.0)
Some college	4 (2.2)	1 (12.5)	3 (30.0)
Bachelor's degree	7 (38.9)	4 (50.0)	3 (30.0)
Graduate degree	4 (22.2)	2 (25.0)	2 (20.0)
Income: N (%)			
\$20,000–\$49,999	3 (17.6)	1 (12.5)	2 (22.2)
\$50,000–\$99,999	5 (29.4)	2 (25.0)	3 (33.3)
\$100,000–\$119,000	1 (5.9)	0 (0)	1 (11.1)
\$120,000–\$149,999	2 (11.8)	2 (25.0)	0 (0)
\$150,000–\$199,999	4 (23.5)	2 (25.0)	2 (22.2)
\$200,000–\$250,000	0 (0)	0 (0)	0 (0)
Greater than \$250,000	2 (11.8)	1 (12.5)	1 (11.1)
Years of experience: N (%)			
Less than 5 years	2 (11.1)	2 (22.2)	0 (0)
5–9 years	2 (11.1)	2 (22.2)	0 (0)
10–19 years	1 (5.6)	1 (11.1)	0 (0)
20–29 years	4 (22.2)	3 (33.3)	1 (11.1)
40–49 years	6 (33.3)	1 (11.1)	5 (55.6)
50 years or more	3 (16.7)	0 (0)	3 (33.3)
Club/society/organization membership		6 (67%)	8 (80%)

a non-issue. All participants identified at least one mode of AIS transmission, which typically related to activity-specific incidents. On one hand, hobbyists mentioned ponds flooding into other waterbodies, disposal of tank water down drains, flushing organisms down toilets, and purposeful release in waterways as transmission modes. Recreationists on the other hand said water in livewells and other parts of the boat, and vegetation and animals clinging to boats and equipment were the most common modes of AIS transmission.

Evaluations of aquatic invasive species campaigns

Two state and two national-level campaigns were evaluated by hobbyists and recreationists. None of the hobbyists had heard of “Be a Hero–Release Zero” or “Habitattitude,” half of the recreational water users had seen the “Be a Hero–Transport Zero” campaign, and all but two were familiar with “Stop Aquatic Hitchhikers.” Most hobbyists preferred the graphics associated with the national-level campaign because they felt its logo was more eye-catching and, with the

blue and green colors, fit with other environmental messages previously encountered. The specificity of the national campaign was also preferred. For instance, one participant said, “Well I don’t understand it. It says ‘Be a Hero–Release Zero’. Release zero what?” [Participant 17]. Suggestions for improvement included adding a visual of fish or plants and using the logo within the context of other information—for example, at the end of a presentation about AIS, as illustrated by the following quote:

I think [Habitattitude] is more effective than the other one because it directly says protect the environment and don’t release fish or aquatic plants... You’ve got the Earth, right, so that kind of conjures up the ecological aspect of it, but then you also have the fish in the bowl, which is a direct relation to aquariums. So that one really popped out to me more than the other [Participant 11].

Similarly, all but one recreationist felt the national-level campaign would be more effective at convincing people to stop the spread of invasive species, because it was “straightforward” and “self-explanatory.” Participants also liked the clear image of a boat ramp, trailer, and water. One participant stated, “Be a Hero–Transport Zero, it might be a little confusing to some people. What are you talking about? The logo on the right, you clearly see a ramp, water, and a boat and clearly see ‘Stop Aquatic Hitchhikers’. Pretty self-explanatory” [Participant 5].

Participants agreed that campaign logos could not stand on their own and needed to be utilized within the context of further information about AIS. As one participant said, “I think it’s a piece of the puzzle...of convincing people that this matters to them and that it impacts them” [Participant 17]. Other suggestions for improvements to the “Be a Hero—Transport Zero” included adding a visual component or text that explained desired behaviors: “The other logo, it has a boat—‘oh, I get the idea. I’ve got things attached to my boat.’ You’re gonna have to show them some type of graphic about how they could be doing it to give them that mental image, in my opinion” [Participant 6]. It is important to note that participants were only asked to evaluate the campaign logos and not consider the messages that are often displayed alongside the state-level logos evaluated in this study.

Participant views on human–nature relationships

Study participants were asked about their worldviews of HNR. None of the participants considered themselves *Masters over Nature*, half of the hobbyists preferred the *Participant in Nature* orientation, and half of the recreationists preferred the *Steward of Nature* orientation (Table 3). This was a challenging task for all participants, because many identified with more than one worldview. For example, one person stated, “I also like interacting with nature and being outside, so I had to pick one, so maybe like number 3. The other two, number 2 and 4 are very good also” [Participant 2].

The *Participant in Nature* orientation was based on the belief that humans were part of their environments. Many associated being a *Participant in Nature* with engaging in outdoor activities and being part of nature physically or biologically. One hobbyist provided spiritual reasoning by saying, “As a *Participant in Nature*, I don’t see the human separate from nature to some extent...Humans are nature, in the same way that a bird or plant is nature” [Participant 8]. Another stated:

I’ve always just felt like everything’s interconnected... There’s just like a force of nature which is in us and trees and plants and frogs and koi and everything. And so I think we’re just a part of it. We may be the most advanced part of it, but that doesn’t mean that we’re better than it or not a part of it. I think if we got rid of nature, we would get rid of ourselves [Participant 18].

When asked which of the four HNR concepts best reflected how they related to and interacted with nature, half of the recreationists answered *Steward of Nature*. Two recreationists answered *Partner with Nature*, two answered *Participant in Nature*, and one believed his relationship was a combination of *Steward of Nature* and *Participant in Nature*.

Engagement in behaviors that minimize the spread of AIS

This study examined reported engagement in behaviors tied to the spread of AIS. Among hobbyists, reported engagement varied. Most could identify multiple behaviors to prevent the spread of AIS, including pouring tank water into the ground, avoiding

Table 3 Distribution of human–nature relationship reported by study participants, including the pooled sample, organism-in-trade hobbyists (N = 8) and recreational water users (N = 10)

	Pooled sample	Hobbyists	Recreationists
Master over nature	0	0	0
Participant in nature	7	5	2
Partner with nature	4	2	2
Steward of nature	6	1	5
A combination	1	0	1

disposal of organisms down the toilet, avoiding purchasing and sharing AIS, avoiding release of organisms into waterways, and rinsing plants before planting. Of the four aquarists who reported their own behaviors, three poured tank water into gardens rather than down the drain, and one reported that she had recently stopped flushing snails down the toilet after learning it could be harmful. For the four aquarists, many of these behaviors were learned from a recent talk from Illinois-Indiana Sea Grant staff at an aquarist club meeting. All aquarists talked about the knowledge exchange that occurred in clubs and two expressed concern that hobbyists not belonging to clubs would never become aware of AIS issues because aquarium shops did not provide sufficient information. Of the water gardeners who reflected on their own behaviors, two stopped purchasing invasive water lettuce and only used native plants, and one rinsed plants and did not share any of their organisms.

Behavioral engagement among recreationists varied depending on the frequency at which vessels were transported. A selection of participants kept their boats in one body of water and believed they were not at risk of spreading AIS because did not switch waterways. Others did move their boats on trailers and all reported engaging in at least one environmental behavior. In some cases, these actions were mandatory. For example, one participant who was a professional angler engaged in certain behaviors because he would otherwise be disqualified from tournaments. A few participants stored their boats at a marina where they were required to wash the boats when they took them out of the water for the season. Thus, the structural constraints imposed on consumptive recreationists such as anglers had bearing on their behavioral engagement.

Connecting human–nature relationships with environmental behavior

We examined the connections between HNR and environmental behaviors related to AIS. Participants' narratives about how they defined nature and their perceived responsibilities to act on nature's behalf were instrumental to addressing this final objective (Table 4). Both hobbyists and recreationists reported mixed sentiments surrounding human use of the environment. Some hobbyists tended to feel that nature was uncontrollable and should only be used by humans in a responsible manner, as one participant stated: "I think that humans are responsible for not screwing up nature, but I do believe that at the end of the day, if you just leave nature alone, it just fixes it all by itself" [Participant 18]. Recreationists reported a deep-seated appreciation for nature and acted in line with that appreciation. One participant shared the following experience:

I enjoy watching how [nature] unfolds, especially early in the morning, and the same holds true for fishing. If I get a big fish, a female fish for example, that's full of eggs, I'm going to release that fish because she's more beneficial back in the water than she is on my plate, so, that's kind of the way I look at nature on its own, I just enjoy being out in it and I don't have to necessarily take an animal or kill an animal or keep a fish to enjoy what I do out there [Participant 10].

Our analysis revealed that perceived responsibility was central to participants' connections with nature, which in turn provided insight into behavioral patterns. This finding indicated that some participants felt compelled to take care of nature while others did not

Table 4 Summary of socio-demographics, previous experience, human–nature relationships, and environmental behaviors reported by all participants, including organism-in-trade hobbyists (OIT) and recreational water users (RWU)

ID	Group	Sex	Completed Education	Previous experience	Human–nature relationship	Reported behavior
1	OIT	F	High school	25 years	Steward	Doesn't buy invasive plants
2	OIT	F	Bachelor's	2 years	Partner	Washes plants before planting them, doesn't share with other water gardeners
3	RWU	M	Some college	62 years	Steward	Empties water from boat and livewell, removes vegetation, sometimes pressure washes boat if there are zebra mussels in the area
4	OIT	M	Master's	15–20 years	Partner	Dumps aquarium water into yard
5	RWU	M	Bachelor's	40 years (9 years professionally)	Steward and partner	Drains water from bilge, runs bleach water through the livewell, removes vegetation from boat
6	RWU	F	Master's	50 years	Steward	Pressure washes sailboat; but doesn't switch water bodies
7	RWU	M	Bachelor's	More than 50 years	Steward	Doesn't currently own a boat, goes with friends who remove vegetation and clean boat
8	OIT	F	Master's	5 years	Participant	Dumps aquarium water into yard
9	RWU	M	Trade school	40 years boating (14 years as charter boat captain)	Steward	Pressure wash charter boat, but doesn't switch water bodies anyway
10	RWU	M	High school	52 years	Steward	Removes vegetation and washes boat and trailer
11	OIT	F	–	4 years	–	Dumps aquarium water into garden
12	RWU	F	Master's	50 years fishing	Participant	Doesn't switch water bodies
13	RWU	M	Bachelor's	30 years	Partner	Removes vegetation from boat trailer
14	RWU	M	Some college	25 years	Participant	Doesn't switch water bodies
15	RWU	M	Some college	50 years canoeing and boating (6 years sailboat captain)	Partner	Pressure wash sailboat at least one time per year, but doesn't switch water bodies anyway
16	OIT	F	Bachelor's	20 years	Participant	Used to flush snails down toilet, stopped after talk from Illinois-Indiana Sea Grant
17	OIT	M	Bachelor's	20 years	Participant	Uses water lilies instead of invasive water hyacinth; properly disposes of unwanted organisms
18	OIT	M	Bachelor's	7 years	Participant	Tries to only use native plants
19	OIT	M	Some college	28 as fish/pond retailer (4 years as pond owner)	Participant	Removes invasive plants when visible in people's ponds; properly disposes of unwanted fish

want to interfere. Many held the belief that humans should play a more active role in conserving nature and mentioned “doing our part” or “doing my part.” For some, the perceived position of humans over nature, a key part of the *Steward* relationship, was this source of responsibility: “We’re the ones that can deplete it but we should be the ones that should take care of it, too” [Participant 10]. One participant attributed this responsibility to God: “I think the basic tenet from the Old Testament is a pretty good one to live by, that we have dominion over nature but that we’re responsible for it...there is a separation” [Participant 7]. Four attributed the responsibility to future generations, as illustrated by the following quote: “We as stewards have to do everything we can to particularly make our environment and our wildlife, whether it be underwater or on the land, take care of them because we’ve got grandchildren coming up behind us and hopefully they’ll be able to enjoy the same things that we have” [Participant 10]. Another claimed, “I think everyone has a strong responsibility for conservation and supporting nature” [Participant 1]. Thus, the notion of responsibility from both religious and secular perspectives was a central theme surrounding the reasons why participants chose to engage in behaviors that affected the spread of AIS.

Distinctions among subgroups such as people who engaged in non-consumptive (e.g., sail boaters, power boater) and consumptive activities (e.g., angling) helped to explain the emergent relationships between HNR and environmental behaviors. Within the recreational group, the non-fishing boaters were referred to as “weekend warriors” and were characterized as power boat users, partiers, people who were out on the water infrequently, and people just going from point A to point B. One participant said: “They’re the ones driving out with big wads of seaweed on their props. They could probably care less about seaweed or invasives and they’re just not into it. They’re just there to go to...a bar in the middle of the lake” [Participant 12]. Another participant further clarified the difference between anglers and recreational boaters:

A fisherman actually pays some attention. I don’t think recreational boaters give a damn, I mean I’ll be honest, I don’t think they care one iota. I mean other than that their boat is clean. Fishermen... we’ve seen what that does to a fishery. I

think that’s why fishermen take it a lot more seriously [Participant 7].

When asked to indicate the relationship of the larger group of recreationists as a whole, some brought even more nuance to the division of subgroups and their associated activities. Six out of eight anglers said that HNR of the larger group of anglers would most likely align with their own concept of *Steward*, *Partner*, or *Participant*. Five participants specifically noted that HNR among non-consumptive recreational boaters was reflected by the *Master over Nature* concept. For example, one noted: “I don’t think they’re near a partnership with nature because a lot of times they don’t seem to care about the destruction that they cause, the litter that they strew” [Participant 17]. Others explained:

Well I think fishermen would be [*Partner*] but just overall boaters, probably [*Master*]...Because fishermen are trying to be in tune with nature, with the fish, and they understand their impact by, whether it’s polluting or just keeping too many fish, they understand how that affects the fishery and nature, whereas the big guy with the big powerboat just wants to go fast, I don’t think really sees that so much [Participant 13].

Discussion

Management of AIS is a critical concern among resource management agencies and scientists aiming to reduce impacts on ecosystem health, local economies, and human well-being. Social science research can provide valuable insights into how best to manage and engage with stakeholders (e.g., recreational water users, organism-in-trade hobbyists) that contribute to social-ecological change by acting as vectors for AIS release (Connelly et al. 2016; Humair et al. 2014; Marshall et al. 2011; Selge et al. 2011; Sharp et al. 2011). This study explored individual responses to outreach campaign logos to provide insight into the efficacy of environmental communications about AIS adopted by national and state-based agencies. Additionally, given the myriad factors—particularly human–nature relationships—that influence human (environmental) behavior, we explored several social psychological processes that influenced how

stakeholders from two case study sites in Illinois engaged with AIS issues. This study aimed to advance the capacity of resource management agencies to make more regionally valid statements about the human dimensions of biological invasions.

We found that awareness and knowledge of AIS varied for recreational water users and organisms-in-trade hobbyists. Recreationists were more familiar and reported higher levels of involvement in their respective activities, which could be attributed to their direct observations of the detrimental impacts of AIS on aquatic ecosystems (Eiswerth et al. 2011). Organisms-in-trade hobbyists were less familiar with AIS and pathways for their introduction. Results from the campaign logo evaluation suggested segments of the population responded differently to environmental communications and thus require different intervention strategies. For example, divisions within the subgroup of recreationists (i.e., consumptive versus non-consumptive users) reported unique viewpoints and were differentially inclined to engage in environmental behavior (van Ripper and Kyle 2014b; Pradhananga et al. 2015). These results reinforce the importance of not assuming stakeholders have similar levels of (limited) knowledge and suggest a “one size fits all” management approach that prioritizes education over tailored outreach strategies will be less likely to succeed (Humair et al. 2014; Fischer et al. 2014).

Recreational water users and organisms-in-trade hobbyists' responses to questions about HNR aligned with past work focused on a vision of nature perspective, in that all rejected the idea of *Master over Nature* (van den Born 2007). Many participants who affiliated with the *Participant in Nature* orientation believed they were part of nature in biological terms or from engagement outdoor activities rather than through spiritual connections. This finding aligned with past research that has suggested people who identify as *Participants in Nature* discuss being part of nature in a physical way (de Groot and de Groot 2009). In a similar vein, recreationists saw themselves as *Stewards of Nature* but not necessarily above it, as the description of the relationship suggests. Additionally, hobbyists who believed *Participants in Nature* best reflected their relationship with nature often mentioned responsibilities for stewardship, even though they were part of the environment. Although counterintuitive (van den Born 2007), this finding does not indicate an inconsistency in an individual's belief

system, rather, a dual tendency in human cognition. In response, De Groot et al. (2011) created a new image of HNR called “*Guardianship*,” which is a more ecocentric version of the *Steward* relationship. Our results endorse this refinement, because it accommodates difficulties in characterizing one relationship and reflects the mixed orientations reported by our study participants.

Variation in perspectives was at the heart of our investigation of HNR and its connection to behaviors affecting the spread of AIS. In line with past research (Flint et al. 2013; Braitto et al. 2017), results indicated that no single relationship could be applied to groups of recreationists and hobbyists. Although consensus would be helpful to provide insight into normative processes as predictors of behavior (Cialdini 2003; Schultz et al. 2007), no clear pattern could be discerned from our study findings. That is, a diversity of perspectives existed across all of our participants, many of whom believed that humans were responsible for taking care of nature on some basic level. Further research focused on individual and group-level norms would help to advance theoretical understanding of HNR and inform the development of solutions for solving conservation problems affected by human behavior (Manfredo et al. 2014).

Both HNR concepts and the outreach campaign logos evaluated in this study influenced awareness and behavioral engagement. Most hobbyists and recreationists were in agreement about their reactions to the AIS campaigns. A connection between participants' personal relationships with nature and their perspectives on AIS management emerged, in that when asked whether HNR influenced their decisions, most replied in the affirmative but did not delve into further detail. Instead, most participants elaborated on activities and behaviors that expressed their underlying orientations. Although a longstanding body of past research affirms that HNR concepts help to explain behavior (e.g., Flint et al. 2013), this relationship was theoretical and not clear in the public eye. Instead of directly asking how HNR affected engagement with AIS issues, as we did, future research should attempt to gauge this relationship by using examples and avoiding academic language.

Study participants believed that humans had the right to use nature, albeit in a responsible manner. In line with past work such as Pradhananga et al.'s (2015) study of boaters, stakeholders who adopted an

anthropocentric orientation believed humans had a right to use nature and were more likely to prevent the spread of AIS if impacts on useful resources were apparent. Conversely, other studies have found that biocentric-oriented stakeholders may believe nature can be valued for its inherent qualities, which can stimulate actions to prevent the spread of AIS so long as awareness is high (van Riper and Kyle 2014b). In a similar vein, the present study indicated that aquarists changed their behavior after learning about proper disposal techniques adopted by other people and became aware of the impacts that could ensue. These results indicated that educational campaigns can be more effective if they activate norms and include information about the consequences of inaction (Stern et al. 1999). To improve understanding of the relationship between HNR concepts and environmental behavior, researchers should: (a) develop specific questions about correlates of behaviors and associated actions; (b) examine AIS behaviors through on-site surveys at boat ramps or hobbyist stores, coupled with on-ground observations; and (d) adopt a broader latitude of acceptance for what constitutes data and information about human–environment interactions. Thus, future research can help to close the knowledge-action gap by identifying creative and interdisciplinary solutions to complex problems such as biological invasions.

Management options

This study provided insight into awareness and knowledge of AIS advanced through environmental communication, HNR concepts, and reported environmental behavior to assist in the development of strategies for reaching people who may be responsible for spreading invasive species. Results shed light on the aesthetic appeal of logos and messaging in state and national-level campaigns (Francis 2014), and indicated that agencies should ensure materials are specific and directly related to how stakeholders can prevent the spread of AIS (Seekamp et al. 2016). In the opinion of participants, the logos evaluated in this study could not stand alone without the context of further information. In other words, logos should be used to enhance educational messages rather than replace them, especially when engaging audiences that have limited previous experiences. Additionally, public presentations to aquarist and water gardener

clubs was an effective avenue for communication—knowledge-sharing was instrumental to these organizations and participants felt inclined to continue supporting one another in this context. Future outreach might also establish stronger linkages between national and state-initiated campaigns, and engage with vendors who provide goods and services. Organizations in the public and private sectors provide key sources of product information for stakeholders such as aquarists and water gardeners.

Management agencies should consider tailoring outreach to diverse populations such as the subgroups identified in this study. Through free listing activities during semi-structured interviews, we gained a preliminary understanding of behavioral engagement (Guest et al. 2012) and generated dialogue with individuals who adopted multiple identities. Distinctions between consumptive and non-consumptive water users were particularly meaningful and should be considered by agencies (Hobson 2000; Cottrell et al. 2004). For example, aquarists and water gardeners utilized different species in their hobbies and AIS mitigation practices, as did an array of recreational water users (e.g., boaters, kayakers, anglers). Each of these subgroups may perceive different degrees of risk when considering behaviors that minimize the spread of AIS, which will in turn affect their decisions. Given variation in responses to how information was presented, resource management agencies should frame messages in a way that resonates with stakeholders' existing belief systems (Gallagher and Updegraff 2012; Lauber et al. 2015).

Identifying appropriate spaces for engaging stakeholders and disseminating information will increase the efficacy of AIS education (Seekamp et al. 2016). Many participants were familiar with AIS logos from boat launches and other public spaces such as bait and tackle shops. Future efforts might consider targeting places used by non-consumptive recreationists. Given that constituencies such as anglers are required to clean their boats during tournaments, less specialized users may be at higher risk to unintentionally spread AIS. Although outreach to recreational boaters or the “weekend warrior” demographic identified in this study may be difficult due in part to their HNR, lack of community structure, and the nature of their recreational pursuits, information could be provided with boater registration. Other potential barriers that may

be faced in reaching this subgroup include lower dependence on particular environments, less exposure to environmental hazards, and limited histories with water-based settings (Hobson 2000).

Future outreach to hobbyists should target aquarists and water gardeners separately, and messaging should be specifically focused on their respective AIS prevention practices (i.e. proper disposal of aquarium tank water vs. proper plant selection for a water garden). On one hand, engaged hobbyists may be more likely to seek advice from fellow hobbyists instead of professional retailers so disseminating materials through existing networks is advised (Seekamp et al. 2016). However, on the other hand, less engaged hobbyists are less likely to belong to a group or club that disseminates educational materials so outreach efforts should be extended to hobbyist shops in an effort to reach all relevant stakeholder groups. Given study participants relied on biological resources for improving their quality of life, many will likely be receptive to adopting low impact practices. Consequently, communication strategies should emphasize the importance of natural resources for maintaining human wellbeing and abundance of societal norms for engaging in environmental behavior to activate these users' vested interests in sustainable resource use and development.

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