The Role of Anglers in Preventing the Spread of Aquatic Invasive Species in the Great Lakes Region

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Abstract: The spread of aquatic invasive species (AIS) is an ongoing challenge in the Great Lakes region. Anglers play a pivotal role in preventing or contributing to the spread of these organisms. Anglers in the Great Lakes region were surveyed by mail during fall 2013 to assess their AIS-related awareness, knowledge, and concern as well as the actions they took to prevent the spread of AIS. Many anglers were aware of AIS, knowledgeable and concerned about them, and taking some actions to prevent their spread. However, certain actions, such as drying and disinfecting or rinsing equipment with hot water, were more difficult and were reported less frequently. Because many anglers already recognize the importance of taking action to prevent the spread of AIS, future outreach efforts may be able to deemphasize communication about the importance of taking action and focus more on strategies that will enable anglers to take these actions.

Keywords: anglers, aquatic invasive species, beliefs, Great Lakes, human dimensions, outreach.

Introduction

The spread of aquatic invasive species (AIS) is an ongoing challenge in many places in North America, including the Great Lakes region. Large freshwater lake systems are particularly susceptible to AIS invasions because there are multiple pathways for introduction, including ballast water from large ships, disposal of unwanted baitfish, and movement of equipment by recreational users.

Recreational users can distribute AIS in multiple ways. For example, Jacobs and MacIsaac (2007) found that fishing line fouled with diapausing eggs of fishhook waterflea *Cercopagis pengoi*, which can remain viable for weeks, was a potential source of introduction of this species to non-invaded lakes if the fishing line was not cleaned. Kelly et al. (2013) found that recreational boaters traveling into Lake Simcoe, Ontario, Canada could transport zooplankton (both native and invasive) in water-holding compartments in their boats as they moved to different locations within this large lake. They recommended frequent drainage of standing water in the boat to prevent AIS movement from one part of a waterway to another. Leung et al. (2006) developed models to show how movement of recreational boaters between lakes could result in the transport of AIS between invaded and non-invaded lakes.

Given the potential for AIS to be moved via recreational equipment, anglers can play a major role in the spread of AIS. For example, about half of the anglers surveyed in a southwestern Montana study reported that they only occasionally, rarely, or never cleaned their boots or waders between uses (Gates et al., 2009). In a recent survey in the United Kingdom, Anderson et al. (2014) found that 12% of anglers and 50% of canoeists who move their equipment, including boats, between basins did not either clean or dry them adequately between

uses. In Michigan and Wisconsin, mail and in-person surveys of boaters found that more than two-thirds do not always clean their boats when going from one water body to another (Rothlisberger et al., 2010).

Educational efforts have been undertaken throughout the United States, and in some states regulations have been put in place, to encourage anglers to take additional actions to prevent the spread of AIS. The most notable educational program in the Great Lakes region has been the “Stop Aquatic Hitchhikers” campaign (Jensen, 2008; Wildlife Forever, 2013). However, little information is available about the level of awareness generated by multiple efforts across the Great Lakes region and subsequent compliance with AIS recommendations and regulations.

This paper examines anglers’ AIS-related awareness, knowledge, concerns, and the actions they take in the Great Lakes region to prevent the spread of AIS. Factors that could influence actions are also examined to assess what factors and messages are most likely to increase angler compliance with the AIS recommendations. Results by state are examined to assess differences in the level of consistency in awareness, knowledge and actions across the region. Based on the research results, recommendations for managers and educators are made about how to refine outreach efforts to increase actions that will help to prevent the spread of AIS.

The factors explored in this paper that could influence actions were developed based on the Integrated Model of Behavioral Prediction (Fishbein and Ajzen, 2010; Fishbein and Yzer, 2003), which postulates that behavioral, normative, and control beliefs can influence behavior. A series of belief statements was included in the questionnaire on the basis of their potential

contribution to compliance with AIS recommendations. A fully executed test of the model was not possible due to questionnaire space constraints, but relationships between each type of belief and AIS-related actions were examined. The behavioral beliefs included in the questionnaire focused on the importance of compliance in order to limit the spread of AIS and protect the resource for future generations of anglers. Normative beliefs assessed the importance of fishing companions in motivating compliance. Control beliefs focused on the presence or absence of situational factors that could enhance or impede compliance with the recommendations. In this case, anglers were asked about the ease, cost, and time required to comply with the recommendations.

Methods

A sample of 1,000 licensed anglers likely to have fished the Great Lakes was obtained from each of the six states selected for the study (Illinois, Indiana, Michigan, New York, Ohio, and Wisconsin). Funding constraints limited the survey to six of the nine states/provinces bordering the Great Lakes. Selected states/provinces were chosen to represent diverse regulatory responses to AIS, including fish pathogens. These anglers were defined as any state resident who: (1) bought an annual or short-term (of more than one-day) license that permitted fishing in the most recently completed license year; (2) was 18 years old or older as of Sept. 1, 2013; and (3) resided in a county (or grouping of zip codes covering the majority of the county, if the state did not keep data on counties) bordering the Great Lakes. In Michigan, all adult anglers who resided in the state were included because Great Lakes waters are accessible throughout the state.

The questionnaire included items measuring awareness and knowledge about AIS, including fish pathogens, such as the viral hemorrhagic septicemia virus. Items also measured

awareness of AIS regulations and recommendations, concern about AIS, factors potentially influencing compliance with the regulations and recommendations, and actions taken to respond to AIS.

A behavioral response score was created for anglers based on their self-reported frequency of taking five actions to prevent the spread of AIS. These actions included inspecting their fishing and boating equipment, removing plant or animal material, draining water holding compartments on boats, drying equipment, and disinfecting or rinsing equipment with hot water. The AIS behavioral response score summed each angler's response to all items where 0=never engaged in the action, 1=engaged some of the time, 2=engaged most of the time, and 3=always engaged in the action, and ranged from 0 to 15.

The mail survey was implemented in September 2013. After the initial mailing, up to three follow-up mailings were sent to non-respondents over the course of the next four weeks to encourage their response.

Telephone follow-up surveys of 300 non-respondents (50 per state) were implemented approximately two months after the first survey mailing to assess how and to what degree non-respondents differed from respondents. Only key questions from the mail survey were asked over the telephone. The questions most relevant to the analysis presented here focused on awareness of AIS and concerns about AIS within the Great Lakes region. Respondents and non-respondents were also compared using information available from their fishing licenses, including year of birth (for five of the six states) and gender (for two of the six states).

Data from returned mail questionnaires were analyzed using SPSS (IBM SPSS Statistics 20). Chi-square, ANOVA and Scheffe's tests were used to test for statistically significant differences at the $P \leq 0.05$ level. All reported differences were significant at this level.

Data reported by state are unweighted and reflect the number of people who responded to the survey from that state. However, because equal sample sizes were drawn from each state, respondent data were weighted proportionate to the population of licensed anglers in the portions of each state from which the sample was drawn to make statements about the population of anglers in the 6-state region as a whole.

Results

Mail survey response and non-response bias analysis

Of the 6,000 questionnaires mailed to anglers, 532 were undeliverable, and 1,487 completed questionnaires were returned, for an adjusted response rate of 27%. The response rate varied from 31% in Michigan to 20% in Indiana. Although respondents were more likely to know something about AIS than non-respondents (74% versus 62%), the two groups did not differ in level of concern about AIS in the Great Lakes region. Respondents did not differ from non-respondents based on gender in the two states where this information was available from the fishing license. However, respondents were on average nine years older than non-respondents in the five states where this information was available.

Awareness, knowledge, and concern about AIS

Three-quarters (74%) of responding anglers indicated they had both heard of AIS and knew something about them, 21% indicated they had heard of AIS but did not know much, and

fewer than 5% had never heard of them. The level of awareness is likely somewhat lower across the entire angler population in the Great Lakes region based on the non-respondent analysis, in which 62% of non-respondents indicated they knew something about AIS.

Respondents were concerned about AIS. Almost all anglers who were aware of AIS thought AIS could hurt native fish populations (95%) and reduce the number of fish available for them to catch (90%). In addition, more than 90% of the anglers who were aware of AIS were moderately or very concerned about having AIS in the Great Lakes region. Nearly two-thirds (65%) of them were very concerned.

Actions taken in response to the presence of AIS

Anglers can take action to prevent the spread of AIS by following regulations and recommendations for inspecting and cleaning their fishing and boating equipment. The survey asked about five actions anglers could take to prevent the spread of AIS (Table 1). The action most likely to be taken by anglers was draining all water-holding compartments including live wells, bait wells, and bilge areas. Almost three-quarters of anglers indicated they always took this action when moving from one water body to another. Roughly half of all anglers reported that they always inspected fishing and boating equipment for attached aquatic plants and animals, and removed any visible mud, plants, fish or animals before transporting fishing or boating equipment. Fewer anglers always dried their boats, trailers and all fishing or boating equipment before use in another water body. One-quarter never engaged in this activity. Even fewer anglers disinfected or rinsed with hot water anything that came into contact with water before reuse; three-quarters of anglers never took this action. Some recommendations suggest taking one but not both of these actions (i.e., either dry or disinfect/rinse), so the proportion who

always took at least one of these actions was calculated. This proportion was still less than 50%. Ten percent of anglers never took any of the five actions, and 5% always took every action.

A behavioral response score was calculated by summing the frequency with which the actions were taken. The average score was 8.3, with a range of 0 to 15. Moderate to high scores could indicate anglers were taking all of the actions some of the time, or several actions most or all of the time. Middle-aged anglers (aged 51 to 65) had a significantly higher score than older anglers (8.7 versus 7.3).

Factors Associated with Compliance with the Regulations and Recommendations

Awareness and concern about AIS were related to taking more actions and taking specific actions more frequently. Anglers who were more aware of AIS had significantly higher AIS behavioral response scores, suggesting they were taking more actions or taking them more frequently than those who were not aware (Table 2). Those who were moderately or very concerned about AIS also had a higher behavioral response score than those who were not at all or only slightly concerned.

Over 80% of anglers indicated they were aware of the rules and recommendations intended to prevent the spread of AIS. However, far fewer (45%) indicated a familiarity beyond basic awareness. Awareness of the rules or recommendations was strongly correlated with taking actions to prevent the spread of AIS. Those who were familiar with the rules and recommendations scored significantly higher on the AIS behavioral response scale than those who were aware of the regulations but did not know much about them (Table 2). Furthermore, those who were aware but didn't know much about the rules and recommendations had a higher

score than those who were not at all aware. A score of 9.6 among those who were most familiar suggests that they were taking several actions most or all of the time.

Anglers who were aware of the rules and recommendations were also asked if they agreed or disagreed with a series of statements designed to measure their behavioral, normative, and control beliefs related to following the rules and recommendations (Table 3). Most anglers agreed or strongly agreed with each of the behavioral belief statements. The proportions who strongly agreed ranged from 46% who strongly agreed that following the rules and recommendations will help protect the waters they fish for future generations of anglers, to 24% who strongly agreed that following the rules and recommendations could limit the damage to their boat or fishing equipment. There was no relationship between behavioral beliefs and behavioral response scores. Most anglers agreed with the behavioral belief statements; little variation existed in these variables.

Most anglers agreed, but did not necessarily strongly agree, with each of the normative belief statements (Table 3). Anglers thought most of the people they go fishing with followed the rules and recommendations and that their fishing companions thought it was important for them to do so too. Those who agreed with these two statements had higher AIS behavioral response scores compared with those who disagreed with each statement (Table 2). Most anglers also trusted the opinions of the people they fished with about the importance of following the rules and recommendations.

With regard to the control beliefs, most anglers found it easy to follow the rules and recommendations (Table 3), they did not think it took too much time or cost too much money. Those who thought it was easy or did not cost too much money had higher AIS behavioral

response scores than those who did not think it was easy or cost too much (Table 2). Middle-aged anglers, who as a group had higher behavioral response scores, were more likely than other age groups to think following the rules and recommendations did not take too much time or cost too much. In addition, those who thought it was easy or did not cost too much were more likely to always engage in the actions of disinfecting, rinsing with hot water, or drying their equipment (50% vs. 34% [agree it was easy vs. others], 51% vs. 36% [doesn't cost too much vs. others]). These are the actions that generally require more effort to undertake.

Some anglers agreed that they did not know enough about the rules and recommendations to follow them, but the majority disagreed, implying that they had sufficient knowledge to follow the rules and recommendations (Table 3). Such anglers had a higher AIS behavioral response score than those who were neutral or agreed (Table 2). Those who believed they knew enough were more likely to always disinfect, rinse with hot water or dry their equipment (54% vs. 38% [know enough vs. others]).

Between State Comparisons

Angler awareness, knowledge, and beliefs regarding AIS were similar across the states surveyed. However, awareness of the rules and recommendations intended to prevent the spread of AIS varied somewhat by state. Anglers in Wisconsin (66%), and to a slightly lesser extent in New York (52%), Michigan (49%), and Indiana (46%), were more likely than anglers in the other states to indicate that they were familiar with the rules and recommendations. One-third (35%) of anglers in Ohio said they were not aware of any rules or recommendations for preventing the spread of AIS.

Actions taken to prevent the spread of AIS varied somewhat by state, with the strongest differences occurring between Wisconsin and Ohio (Table 1). Wisconsin anglers were more likely to always inspect their fishing and boating equipment and remove all plant or animal material than Ohio anglers. They were also somewhat more likely to always dry or disinfect/rinse their equipment. Consequently, anglers from Wisconsin had a significantly higher average behavioral response score (9.8), indicating they took more of the actions more of the time, than Ohio anglers (7.4).

Discussion

Most anglers in the Great Lakes region have some general awareness of AIS and their potential impact on native fish populations. This is similar to findings of other studies within the Great Lakes region (e.g., Michigan anglers [Vollmar et al., 2014], New York anglers [Connelly et al., 2015]). It is also similar to findings in other regions of North America (e.g., anglers using boats in southern Manitoba [Lindgren 2006], and for anglers in southwestern Montana [Gates et al., 2009]). Given the prevalence of programs such as “Stop Aquatic Hitchhikers,” this finding was expected.

Many anglers were generally aware of the regulations or recommendations to prevent the spread of AIS, and were concerned about having AIS in the Great Lakes region. Their agreement with behavioral belief statements such as “following the recommendations will help protect the waters I fish for future generations of anglers” and “will help limit the spread of AIS” further suggests some level of knowledge about AIS. They were also influenced by their friends and family, who they believe are following the regulations and recommendations (i.e., normative beliefs).

Given that anglers were aware, knowledgeable, and concerned about AIS, it appears they do not have to be convinced of the value of taking actions to prevent the spread of invasive species. However, while many were taking actions such as inspecting their equipment and draining water-holding compartments before moving to a new water, there were other actions that were not taken by as many people nor as consistently. These actions include disinfecting, rinsing with hot water, or drying their equipment, which are actions that require more time and equipment, and, at least in New York State, recommendations about the best way to perform these actions differ (Lauber et al., 2014). Those who found these actions easier to take and not too costly (i.e., had positive control beliefs) were more likely to always take them. Therefore, it appears that constraints such as time, money, and equipment are likely limiting factors.

The findings were generally consistent across the six Great Lakes states included in this study, suggesting a homogenous group of anglers in terms of awareness, knowledge, beliefs, and action, with one exception. Wisconsin anglers were more likely to be aware of the recommended actions and more likely to be taking them than Ohio anglers. Personal communication with managers knowledgeable about their AIS outreach programs in these states at the time of the survey suggested that the difference was likely attributable to the amount of resources (financial, personnel, etc.) expended by each state on outreach (Workshop on the Management of AIS and Fish Pathogens: The Roles of Anglers and Bait Dealers, Ann Arbor, MI, May 2014).

The generalizability of the findings of this study to the entire Great Lakes region is somewhat limited by the low response rate to the mail survey. However, the non-respondent telephone follow-up survey provided insight into the potential effect of the low response rate, suggesting that awareness of AIS may be lower among the entire population of Great Lakes

anglers than reported for mail survey respondents, but—crucially—not their level of concern. Older anglers were also found to be more likely to respond to the survey, as expected based on results from other mail surveys of anglers (e.g., Connelly and Knuth, 2013). However, older anglers were less likely to take action than their middle-aged counterparts.

Conclusions and Management Implications

This study has implications for the future management of AIS in the Great Lakes region and beyond. The results show that most anglers are taking at least some action to prevent the spread of AIS. But is it enough? Drake and Mandrak (2014) modeled the probability of spread of live bait by anglers using round gobies as a test species in Ontario, Canada, and found the risk of spread to be very low. However, for waterbodies with many visits by anglers—such as the Great Lakes—even a very low probability of transport per angler could result in introductions. This suggests that near 100% compliance with recommendations may be needed at certain sites to prevent introductions. The results of the current study and others (Fera, 2014; Lauber et al., 2015; Rothlisberger et al., 2010) show high compliance rates with certain actions such as visually inspecting and removing vegetation from boats, and draining water holding compartments before transport, but lower compliance with other recommended actions.

What can fishery managers and outreach educators do to increase the number of anglers always taking appropriate actions? Several Great Lakes states (Wisconsin, Minnesota, and New York) have recently enacted laws regarding the transport of potential AIS on boats as a means to prevent their spread, but the impact of such laws will ultimately depend on angler compliance with the laws. Rothlisberger et al. (2010) suggested that education efforts should be augmented with provision of cleaning and inspection stations to achieve high compliance rates. The results

of this study also lead to the conclusion that outreach campaigns may not need to focus as much on convincing people that certain behaviors are a good idea because that goal seems to have been generally achieved. Rather, outreach programs may be able to focus more on strategies that enable anglers to carry out these desired behaviors. Future research could focus on identifying in more detail what the barriers are to compliance with recommended behaviors and which barriers are most limiting.

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Table 1. Actions taken when changing from one water body to another, overall and by state. * in first column indicates statistically significant difference between states at $p = 0.05$ using ANOVA.

How often action is taken	Percent						
	Overall	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Inspect fishing and boating equipment for attached aquatic plants and animals*							
Never	18.2	18.7	18.9	17.9	15.5	27.6	6.3
Some of the time	13.4	15.4	17.9	13.4	17.8	16.2	4.2
Most of the time	19.0	19.8	23.6	20.1	24.8	17.1	11.9
Always	49.4	46.1	39.6	48.6	41.9	39.1	77.6
Remove any visible mud, plants, fish or animals before transporting fishing or boating equipment*							
Never	11.8	15.1	12.1	10.4	13.7	18.7	4.2
Some of the time	12.7	6.5	15.0	15.4	13.0	11.2	4.2
Most of the time	20.5	16.1	25.2	19.3	29.8	23.4	16.0
Always	55.0	62.3	47.7	54.9	43.5	46.7	75.6
Drain all water holding compartments including live wells, bait wells and bilge areas*							
Never	11.0	14.8	8.3	10.4	12.1	16.2	3.6
Some of the time	3.0	8.6	2.1	2.4	5.6	2.0	2.9
Most of the time	12.6	6.2	10.4	11.6	12.1	16.2	14.6
Always	73.4	70.4	79.2	75.6	70.2	65.6	78.9
Dry boats, trailers and all fishing or boating equipment before use in another water body							
Never	27.2	28.4	32.0	27.8	26.7	28.4	21.3
Some of the time	9.8	12.5	13.6	9.1	10.7	10.8	9.9
Most of the time	18.0	12.5	12.6	19.3	15.3	18.6	15.6
Always	45.0	46.6	41.8	43.8	47.3	42.2	53.2
Disinfect or rinse with hot water anything that came into contact with water before reuse							
Never	74.5	70.3	71.7	78.9	70.1	68.5	69.6
Some of the time	12.6	14.3	16.0	10.0	17.2	14.8	16.2
Most of the time	6.3	3.3	1.9	6.1	5.2	9.3	4.7
Always	6.6	12.1	10.4	5.0	7.5	7.4	9.5
Always dry or disinfect	43.8	48.4	43.5	43.2	44.9	39.1	51.7

Table 2. Mean angler behavioral response score for actions taken that could prevent the spread of aquatic invasive species by factors significantly associated with taking actions. Superscripts ^{a,b} indicate values without a letter in common are significantly different from each other at P=0.05 using Scheffe's test.

Ever heard of AIS?	No	Yes, but don't know much	Yes, and know something about it
	5.8 ^a	7.1 ^{a,b}	8.7 ^b
Concern about AIS	Not at all / slightly concerned	Moderately concerned	Very concerned
	5.0 ^a	8.4 ^b	8.6 ^b
Aware of rules or recommendations for preventing the spread of AIS in Great Lakes region.	No	Yes, but don't know much	Yes, am familiar
	6.0 ^a	7.5 ^b	9.6 ^b
<u>Belief statements</u>	Agree	Neutral	Disagree
Most of the people I go fishing with think it is important that I follow the rules and recommendations	9.2 ^a	7.8 ^{a,b}	6.9 ^b
It is easy for me to follow the rules and recommendations	9.0 ^a	7.3 ^{a,b}	7.1 ^b
It costs too much to follow the rules and recommendations	7.3 ^a	7.7 ^{a,b}	9.1 ^b
I don't know enough about the rules and recommendations to follow them	7.2 ^a	8.0 ^a	9.4 ^b

Table 3. Behavioral, normative, and control beliefs of anglers related to following the rules and recommendations to reduce the spread of aquatic invasive species and fish diseases.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
<u>Behavioral beliefs</u>						
I think following the rules and recommendations will help protect the waters I fish for future generations of anglers	46.2	45.9	4.0	1.3	0.6	2.0
If I follow the rules and recommendations, that will help limit the spread of aquatic invasive species and fish diseases	37.0	49.7	7.9	2.2	1.1	2.1
If I follow the rules and recommendations, I can limit damage to my boat or fishing equipment	23.8	38.6	22.6	4.1	2.1	8.8
I trust my state natural resource agency when it comes to the importance of following the rules and recommendations	29.8	48.2	13.5	4.0	2.5	2.0
<u>Normative beliefs</u>						
Most of the people I go fishing with follow the rules and recommendations	24.4	52.7	11.1	4.9	0.5	6.4
Most of the people I go fishing with think it is important that I follow the rules and recommendations	24.1	46.8	15.9	5.2	1.2	6.8
I trust the opinions of the people I fish with about the importance of following the rules and recommendations	22.2	52.5	17.1	3.8	1.7	2.7
<u>Control beliefs</u>						
It is easy for me to follow the rules and recommendations	37.3	46.6	10.6	2.2	0.5	2.8
It takes too much time to follow the rules and recommendations	1.4	4.1	16.3	45.1	30.2	2.9
It costs too much to follow the rules and recommendations	1.5	2.5	18.0	44.6	29.2	4.2
I don't know enough about the rules and recommendations to follow them	3.4	15.2	22.3	38.6	18.6	1.9