
Reducing the Spread of Aquatic Invasive Species and Fish Pathogens in the Great Lakes: The Role of Anglers



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Prepared by:

Nancy A. Connelly, T. Bruce Lauber,
and Richard C. Stedman
Human Dimensions Research Unit
Department of Natural Resources
Cornell University

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EXECUTIVE SUMMARY

Fish pathogens and aquatic invasive species (AIS) are an ongoing challenge in the Great Lakes region. Their presence and the possibility of their spread have resulted in local, state, and federal responses, including education programs and regulatory actions aimed in part at anglers. These efforts focus on preventing the movement of fish between bodies of water, proper disposal of fish carcasses and byproducts, removal of mud, plants, and animals from gear, boats, motors, and trailers, and draining and disinfecting live wells, bilges, and bait tanks. However, little is known about how target audiences, such as anglers, have responded to these efforts.

Our aim in this study was to assess how anglers in the Great Lakes region have responded to regulations and recommendations intended to reduce the spread of AIS and fish pathogens. Further, we wanted to know how their responses to regulations and recommendations are related to: (a) their knowledge and awareness of and concern about pathogens and AIS; (b) constraints on their compliance; and (c) sources of information they use and their trust in those sources.

We sampled 1,000 licensed anglers from each of the six states selected for the study (Illinois, Indiana, Michigan, New York, Ohio, and Wisconsin) who were likely to have fished the Great Lakes. We sent them a mail questionnaire in September 2013, with up to three follow-up mailings to non-respondents over the next four weeks. The questionnaire included sections on awareness and knowledge of AIS and fish pathogens and the related regulations and recommendations, behavioral responses to the presence of AIS and fish pathogens, concern about AIS and fish pathogens, sources used to obtain information about AIS and VHS (viral hemorrhagic septicemia), factors potentially influencing compliance with the regulations and recommendations, level of fishing activity, and socio-demographic characteristics. A telephone follow-up survey of 300 non-respondents (50 per state) was implemented approximately two months after the first mailing of the questionnaire to assess differences between respondents and non-respondents.

Of the 6,000 questionnaires mailed, 532 were undeliverable, and 1,487 completed questionnaires were returned. The adjusted response rate was 27%. Non-respondents were less likely to have fished the Great Lakes region in the past five years, and among those who had fished in the past five years they were less likely to have fished in the year preceding the study. They were less likely than respondents to be aware of VHS, aware of invasive species, and aware of rules or recommendations to prevent the spread of AIS. These differences suggest that the population as a whole is somewhat less aware than the results below portray. However, respondents and non-respondents did not differ in their level of concern about having AIS in the Great Lakes region.

Results Related to AIS and Preventing Their Spread

Most anglers were aware of AIS in the Great Lakes region, and many indicated they were aware of the recommendations to prevent their spread. It appears that educational campaigns, which include “Stop Aquatic Hitchhikers” (which the majority of anglers in each state were aware of), state fishing regulations guides, media coverage, etc., have been successful in alerting anglers to the concerns. In fact, two-thirds of anglers indicated they were concerned about having AIS in the region.

This awareness has resulted in most anglers (90%) engaging in at least one action recommended for preventing the spread of AIS at least some of the time. The most common actions taken were inspecting and removing aquatic plants and animals attached to fishing and boating equipment and to drain all water holding compartments. However, results indicate that as many as 25% of anglers, view these recommendations as applying only to boating equipment and not fishing equipment. Depending on the importance managers and educators place on the need for applying these actions to fishing equipment, we recommend that increased emphasis be placed on messages concerning the spread of AIS via fishing equipment. Few anglers disinfected their fishing or boating equipment or washed it with hot water. This may be because few facilities exist to facilitate these actions. It is also possible that many different, and sometimes conflicting, messages exist about exactly what needs to be done. For example, Lauber et al. (2014) found that messages for recreationists using the Lake Ontario basin varied in terms of the specific guidelines recommended for washing equipment. If managers and educators consider these actions important, it may help to provide additional facilities and equipment for washing and/or more consistent messages regarding how to wash.

The actions taken by anglers to prevent the spread of AIS varied by state. We found that anglers in Wisconsin were more likely to take more actions more frequently than anglers in Ohio, with the other states being intermediary. Based on discussions with AIS coordinators in the states these differences likely reflect differences in the amount of resources (financial, personnel, etc.) states are able to devote to AIS education.

Anglers who took actions to prevent the spread of AIS more frequently were more likely to: (1) be aware of AIS, and the rules and recommendations for reducing their spread; (2) be concerned about having AIS in the Great Lakes region, (3) use the fishing regulations guide as a source of information; and (4) be aware of the “Stop Aquatic Hitchhikers” phrase. Therefore, we recommend continued emphasis on efforts to raise awareness, especially through materials such as the fishing regulations guide and the “Stop Aquatic Hitchhikers” program, to increase compliance with the recommendations.

We also asked anglers about their beliefs associated with AIS and found that most already thought it was important to take actions to prevent the spread, protect the environment, and protect the fishery for future generations of anglers. Because many of the beliefs associated with taking actions were already held by most anglers, additional emphasis on communicating the importance of these beliefs in an effort to increase the number of anglers or frequency of actions taken by anglers is not likely to be fruitful. We think increased compliance is most likely if: (1) continued emphasis is placed on efforts to raise awareness, as stated before; (2) taking action, such as boat washing, is made more convenient and affordable; (3) messages about how to wash or disinfect are made more consistent; and (4) increased emphasis is placed on messages applying to fishing equipment and how AIS might be transferred by that equipment.

Results Related to Fish Pathogens and Preventing Their Spread

Over half of the anglers in the region use baitfish at least some of the time when they go fishing. The use of bait is especially common among Ohio anglers. Anglers can help to prevent the spread of AIS and fish pathogens by proper baitfish disposal. We found that most anglers dispose of their unwanted baitfish using recommended methods at least some of the time (i.e., dispose of on land or in the trash, return to the same water body where they came from). However, some anglers dispose of them in ways that are not recommended (i.e., return them to a body of water other than the one they came from) and even among those using recommended methods they are not all using the recommended methods all of the time. Therefore, we think more needs to be done to educate anglers about issues related to baitfish and the best methods for disposal. In this vein, Lauber et al. (2014) found fewer organizations involved with AIS outreach to recreational users in the Lake Ontario basin provided information about what to do with unwanted baitfish.

In contrast to awareness of AIS, awareness of VHS among anglers was generally lower and varied much more by state. For example, anglers in Michigan, New York, and Wisconsin were more likely to be aware of VHS and think VHS was a major threat to the health of fish populations in the Great Lakes region than anglers in other states. Anglers who were aware and concerned were more likely to take the recommended actions when disposing of unwanted baitfish.

Anglers' awareness of the rules regarding the transport and disposal of unwanted baitfish varied greatly by state. New York and Wisconsin anglers were more likely to be aware; Ohio anglers were less likely to be aware even though Ohio anglers were the most likely to use baitfish. According to Heck et al. (2013) the messages and regulations concerning baitfish seemed to vary by state, and AIS messages seemed more universal across states. This might explain, in part, the differences in awareness of the rules by state. One recommendation then would be to have more consistent messages and/or regulations.

State fishing regulations guides were a frequently mentioned source of information. Use of this source was associated with anglers taking the recommended actions when disposing of baitfish. Use of newspapers and magazines was also associated with anglers taking the recommended actions when disposing of baitfish. This suggests that in the case of fish pathogens, non-traditional sources of communication like mass media should be considered in educational efforts about the pathogens and how to prevent their spread, in addition to the fishing regulations guide.

Additional Information Needs

Results from this survey provide information about the actions anglers are currently taking that can prevent or contribute to the spread of AIS and fish pathogens. Results also can be used to inform efforts to improve outreach to anglers, as discussed previously. However, the findings also highlight some gaps in information that could be useful to have to further focus outreach efforts. For example, we recommended a variety of actions that could be taken to increase the number of anglers following the recommendations regarding washing their boating and fishing

equipment. But which of these recommendations would be most effective? What are the specific barriers that anglers face?

Anglers are not the only audience that many of the outreach efforts are focused on. Boaters, for example, are another audience that is a primary focus of outreach. While many anglers use boats, not all boaters are anglers, so information on the attitudes and behaviors of boaters is also important. We recommend gathering information on boaters similar to what we collected for anglers.

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INTRODUCTION

Fish pathogens and aquatic invasive species (AIS) are an ongoing challenge in the Great Lakes region. Their presence and the possibility of their spread have resulted in local, state, and federal concerns and responses, including education programs and regulatory actions aimed in part at anglers. These efforts focus on preventing the movement of fish between bodies of water, proper disposal of fish carcasses and byproducts, removal of mud, plants, and animals from gear, boats, motors, and trailers, and draining and disinfecting live wells, bilges, and bait tanks. Regarding AIS for example, Sea Grant Extension programs throughout the Great Lakes are involved in information and outreach, aiming to influence human behaviors related to fish handling, preparation, and harvest. Other programs such as “Stop Aquatic Hitchhikers,” whose materials have been distributed in many states and provinces, have focused heavily on messages aimed at preventing the spread of AIS. However, little is known about how target audiences have responded to these efforts.

Lauber et al. (2009) conducted exploratory research on compliance with VHS (viral hemorrhagic septicemia) regulations and recommendations in the Great Lakes. Based on a series of 45 interviews of representatives of fish and wildlife agencies, extension educators, and stakeholder groups, they reported that the compliance of anglers with the regulations and recommendations was perceived to be low. Interview respondents believed that a variety of factors influenced angler compliance including awareness of and concern about VHS and perceptions about the financial costs of compliance, the feasibility of compliance, the level of enforcement of regulations, the effectiveness of the regulations at addressing VHS, and the fairness of the regulations and the process through which they were developed. This type of information can then be used to focus a quantitative survey of target audiences.

The survey reported on here focused specifically on anglers. (A similar study was conducted with bait dealer (see Connelly et al. 2014.) Our aim in this study was to assess how anglers in the Great Lakes region have responded to regulations and recommendations intended to reduce the spread of AIS and fish pathogens. Further, we wanted to know how their responses to regulations and recommendations are related to: (a) their knowledge and awareness of and concern about pathogens and AIS; (b) constraints on their compliance; and (c) sources of information they use and their trust in those sources.

We applied concepts from the Integrated Model of Behavioral Prediction (IMBP; Fishbein and Yzer 2003; Fishbein and Ajzen 2009) to identify beliefs held by anglers that were related to their compliance or attempted compliance with the regulations and recommendations. We measured specific behavioral, normative, and control beliefs related to compliance with the regulations and recommendations. Behavioral beliefs are beliefs about the consequences of performing relevant behaviors (Fishbein and Ajzen 2009). For example, an angler might believe that following certain recommendations will help limit the spread of AIS and fish diseases. Normative beliefs are beliefs about the degree to which a behavior is being performed by others (e.g., “most of the people I go fishing with follow the recommendations”) and beliefs about the degree to which others think a behavior should be performed (e.g., “most of the people I go fishing with think it is important that I follow the recommendations”). Control beliefs are beliefs about the presence or absence of situational factors that enhance or impede performance of the behavior (e.g., do

anglers perceive it costs too much to follow the regulations and recommendations) and perceptions about whether these factors will make the behavior easier or more difficult (e.g., if anglers find the regulations confusing it might be harder to follow them). Understanding which beliefs are held by the greatest number of people and held most strongly can inform approaches used to try to influence compliance with the regulations and recommendations. For example, if anglers found the recommendations confusing, efforts to simplify them or communicate them more simply might be the best course of action.

The specific objectives of the study were to:

1. Characterize anglers and their fishing activity in the Great Lakes region;
2. Assess their behavioral responses to the presence of AIS and fish pathogens;
3. Assess angler awareness and knowledge of AIS and fish pathogens;
4. Assess sources of information used to learn about AIS and VHS, and trust in those sources;
5. Assess angler level of concern regarding AIS and fish pathogens;
6. Assess angler awareness of the regulations and recommendations intended to reduce the spread of AIS and fish pathogens; and
7. Understand the importance of various factors that could enhance or constrain angler compliance with the regulations and recommendations.

Our study focused on the Great Lakes region, with a particular emphasis on the Great Lakes themselves and connecting waters. The reason for this emphasis was that many of the current concerns about AIS and fish pathogens revolve around introduction to the region through the Great Lakes. A study of anglers in all nine states and provinces surrounding the Great Lakes was not financially feasible. Therefore, we chose to focus on anglers living in six states and provinces using two primary selection criteria. The first criterion was to have states and provinces that have responded in diverse ways to AIS and fish pathogens using regulations and recommendations. We used the earlier work of Heck et al. (2013) to identify states and provinces responding in diverse ways. The second criterion was to choose states and provinces in which we had access to fishing license records (e.g., it was not possible for us to obtain license records of Ontario anglers).

METHODS

Sample Selection

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). These anglers were defined as: (1) any state resident who bought an annual or short-term (of more than one-day) license that permitted fishing in the most recently completed license year; (2) 18 years old or older as of Sept. 1, 2013; and (3) residing in a county (or grouping of zip codes covering the majority of the county, if county was not a variable in the license file) bordering the Great Lakes, with the exception of Michigan where anyone who resided in the state was included because Great Lakes waters are so accessible throughout the state.

Questionnaire Design

The questionnaire included sections on awareness and knowledge of AIS and fish pathogens and the related regulations and recommendations, behavioral responses to the presence of AIS and fish pathogens, concern about AIS and fish pathogens, sources used to obtain information about AIS and VHS, factors potentially influencing compliance with the regulations and recommendations, level of fishing activity, and socio-demographic characteristics. The full text of the questionnaire is available in Appendix A.

Mail Survey Implementation

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

Non-respondent Telephone Follow-up

A telephone follow-up survey of 300 non-respondents (50 per state) was implemented approximately two months after the first mailing of the questionnaire to estimate the degree to which non-respondents differed from respondents. Key questions from the mail survey were asked over the telephone about fishing activity, awareness of AIS and recommendations to prevent their spread, and concerns about having AIS in the Great Lakes region. The list of these questions can be found in Appendix B.

Analysis

Data from returned mail questionnaires were entered into the computer and analysis was done using SPSS (IBM SPSS Statistics 20). Chi-square, t-test, and Scheffe's test were used to test for statistically significant differences between groups of anglers at the $P \leq 0.05$ level.

Data reported by state are unweighted and reflect the number of people who responded to the survey from that state. However, to make statements about anglers in the six states surveyed as a whole, respondent data was weighted in proportion to the population of licensed anglers in the portions of each state from which our sample was drawn.

RESULTS AND DISCUSSION

Survey Response

Of the 6,000 questionnaires mailed, 532 were undeliverable, and 1,487 completed questionnaires were returned. The adjusted response rate was 27%. Response rate differed by state with Michigan being the highest and Indiana the lowest (Table 1).

Table 1. Response rate by state.

State	Initial Sample Size	Responses	Response rate adjusted for undeliverables
Illinois	1,000	215	24.3%
Indiana	1,000	188	20.2%
Michigan	1,000	289	31.0%
New York	1,000	281	30.8%
Ohio	1,000	237	26.6%
Wisconsin	1,000	277	30.1%
Overall	6,000	1,487	27.2%

Non-response Bias Analysis

Results of non-response bias comparisons are consistent with the conclusions of previous research that non-respondents are less likely to be active anglers (Connelly and Knuth 1993, Connelly et al. 2012). In this study they were less likely to have fished the Great Lakes region in the past five years, and among those who had fished in the past five years they were less likely to have fished in the year preceding the study (Appendix Table B-1). However among those who did fish, they did not differ from respondents in their fishing characteristics (i.e., use of artificial lures, baitfish, boats for fishing).

Non-respondents were less likely to be aware of VHS and somewhat less likely to be aware of invasive species than respondents (Appendix Table B-1). They were less likely to be aware of rules or recommendations to prevent the spread of AIS. However, they did not differ in their level of concern about having AIS in the Great Lakes region. Respondents and non-respondents did differ in the frequency that they reported actions to prevent the spread, such as inspecting their boat or fishing equipment. However, the difference was most likely an artifact of the difference in survey method (mail vs. telephone), with mail respondents choosing from the full range of answer choices and telephone respondents choosing primarily from either end of the range. In future sections of the report, when respondent data concerning awareness are discussed in more detail, non-respondent differences are reiterated.

Characteristics of Anglers and Their Fishing Activity in the Great Lakes Region

Although the sample for this study was drawn from people who purchased a fishing license, not everyone had gone fishing in the Great Lakes region in the past five years. The Great Lakes region was defined as the eight states and one province bordering the Great Lakes. Among respondents, 216 people indicated they had not fished in the Great Lakes region and were not asked any further questions. Thus, the results presented below come from the 1,271 people who indicated they fished in the Great Lakes region in the past five years.

Most respondents were male and the proportion of men versus women did not differ by state (Table 2). Anglers from Illinois and Indiana were younger on average and Ohio anglers were older, but the mean age for all states was high compared to the general population, likely as a result of the general aging of the angler population and also the tendency for older people to be more likely to fill out mail surveys (e.g., Connelly and Knuth 2013). Anglers living in Illinois or Michigan were the most likely to have a college degree, and Indiana anglers were least likely. The proportions of respondents living in urban, suburban, and rural areas were consistent with the expected proportions based on the areas of each state from which the sample was drawn. Illinois anglers were mostly from urban/suburban areas, whereas Michigan and New York anglers were more likely from rural areas.

Table 2. Socio-demographic characteristics of respondents by state.

Socio-demographic Characteristics	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Gender						
Male	85.6	88.3	86.4	85.4	85.9	83.4
Female	14.4	11.7	13.6	14.6	14.1	15.6
Education*						
Less than high school	1.1	1.2	3.5	4.6	2.9	1.3
High school diploma/G.E.D.	16.1	26.1	23.0	20.6	27.0	25.4
Some college or technical school	30.0	37.3	30.5	29.8	32.9	31.8
Associate's degree	12.8	10.6	7.4	19.3	8.8	13.6
College degree	30.0	18.0	20.8	14.7	19.1	13.1
Graduate degree	10.0	6.8	14.8	11.0	9.3	14.8
Primary residence*						
Urban	19.6	13.0	10.9	11.5	18.1	30.6
Suburban	75.4	54.1	37.1	44.0	63.8	30.2
Rural	5.0	32.9	52.0	44.5	18.1	39.2
Mean age	51.3 ^a	49.2 ^a	52.4 ^{a,b}	52.4 ^{a,b}	56.4 ^b	52.7 ^{a,b}

*Statistically significant difference between states at P = 0.05 using chi-square test.

^{a,b}Values without a letter in common are significantly different from each other at P = 0.05 using Scheffe's test.

Most anglers had fished in the Great Lakes region between Sept. 1, 2012 and Aug. 31, 2013 (i.e., the year preceding the survey) and had fished an average of 25 to 35 days (Table 3). Almost all anglers in Ohio and New York had fished Great Lakes waters (defined as the five Great Lakes and rivers or streams that run into or connect them), and in the remaining states most had fished Great Lakes waters. The average number of days spent fishing Great Lakes waters varied from 12 to 21 days, but the differences between states were not statistically significant. Most anglers, except those in Ohio also fished non-Great Lakes waters in the past year. The average number of days spent fishing varied across states from 16 to 27 days.

Our sample design was intended to target anglers who had fished Great Lakes waters, where much of the emphasis on the prevention of AIS and disease spread has focused. We were

successful in that effort with over two-thirds of anglers in each state indicating they had fished Great Lakes waters in the past five years.

The majority of anglers who responded to our survey owned a boat they used in the Great Lakes region, except anglers from Illinois and Ohio (Table 4). Among those who owned a boat, most owned a motorized boat and 25-40% owned a non-motorized boat.

Table 3. Fishing activity by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Fished Great Lakes <u>region</u> between Sept. 1, 2012 and Aug. 31, 2013*						
No	7.9	12.3	8.6	16.4	7.2	15.7
Yes	92.1	87.7	91.4	83.6	92.8	84.3
If yes: Mean days	25.7	33.8	29.0	28.8	27.2	28.2
If fished Great Lakes <u>region</u> :						
Fished Great Lakes <u>waters</u> between Sept. 1, 2012 and Aug. 31, 2013*						
No	42.7	31.5	28.9	14.0	8.8	37.9
Yes	57.3	68.5	71.1	86.0	91.2	62.1
If yes: Mean days	12.3	15.0	18.7	20.4	21.5	15.3
Fished non-Great Lakes waters between Sept. 1, 2012 and Aug. 31, 2013*						
No	19.5	14.0	28.9	29.6	54.2	20.2
Yes	80.5	86.0	71.1	70.4	45.8	79.8
If yes: Mean days	22.6	27.4	21.4	16.9	15.9	22.3
Fished Great Lakes <u>waters</u> in past 5 years*						
No	30.6	26.5	19.4	13.9	6.5	28.6
Yes	69.4	73.5	80.6	86.1	93.5	71.4

*Statistically significant difference between states at P = 0.05 using chi-square test.

Table 4. Boat ownership by state.

Boating characteristics	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Own a boat used in Great Lakes Region*						
No	62.4	40.7	36.1	45.6	51.9	40.8
Yes	37.6	59.3	63.9	54.4	48.1	59.2
If yes:						
Own a motorized boat	85.5	89.9	87.8	87.5	85.4	91.3
Own a non-motorized boat	33.9	28.1	40.5	30.4	25.8	27.8

*Statistically significant difference between states at P = 0.05 using chi-square test.

Behavioral Responses to the Presence of AIS and Fish Diseases

Aquatic Invasive Species

Anglers can take action to prevent the spread of AIS by following recommendations for inspecting and cleaning their fishing and boating equipment. We asked about five actions anglers could take to prevent the spread of AIS. Four of the actions applied to both fishing and boating equipment; only one applied to just boating equipment. We expected everyone would answer the four questions applying to fishing and boating equipment. However, 23-26% of anglers indicated that those questions did not pertain because they did not own a boat. This suggests that messages about these actions may not be getting across as intended to anglers because some saw the questions as applying only to boating equipment even though they specifically say fishing equipment.

Responses varied by state in the frequency with which anglers followed recommendations (Table 5). For example in most states, roughly 40% of anglers always inspected their fishing and boating equipment for attached aquatic plants and animals, except in Wisconsin where the percentage was significantly higher (78%). Similarly Wisconsin and Illinois anglers were more likely than anglers in other states to always remove any visible mud, plants, fish or animals before transporting fishing or boating equipment. There were some differences between states in the percentage who always drained all water-holding compartments including live wells, bait wells, and bilge areas (about two-thirds of anglers overall always took this action). 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: over two-thirds of anglers never took this action. Sometimes recommendations suggest doing one but not both of these actions (i.e., either dry or disinfect/rinse), so we calculated the proportion who always do one or the other and found that the proportion is still less than half in every state except Wisconsin, which is just over half. There were no statistically significant differences by state for these last two less frequently taken actions.

Using angler responses to these action items we created an AIS behavioral response scale that 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. The scale ranged from 0 to 15, with 10% of anglers never taking any of the actions and 5% always taking every action. The average scale score was 8.3 (Table 6). Anglers from Wisconsin had a higher scale score indicating they took more of the actions more of the time; Ohio anglers had a lower score.

Table 5. Actions taken when changing from one water to another by state.

How often action is taken	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Inspect fishing and boating equipment for attached aquatic plants and animals*						
Never	18.7	18.9	17.9	15.5	27.6	6.3
Some of the time	15.4	17.9	13.4	17.8	16.2	4.2
Most of the time	19.8	23.6	20.1	24.8	17.1	11.9
Always	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	15.1	12.1	10.4	13.7	18.7	4.2
Some of the time	6.5	15.0	15.4	13.0	11.2	4.2
Most of the time	16.1	25.2	19.3	29.8	23.4	16.0
Always	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	14.8	8.3	10.4	12.1	16.2	3.6
Some of the time	8.6	2.1	2.4	5.6	2.0	2.9
Most of the time	6.2	10.4	11.6	12.1	16.2	14.6
Always	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	28.4	32.0	27.8	26.7	28.4	21.3
Some of the time	12.5	13.6	9.1	10.7	10.8	9.9
Most of the time	12.5	12.6	19.3	15.3	18.6	15.6
Always	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	70.3	71.7	78.9	70.1	68.5	69.6
Some of the time	14.3	16.0	10.0	17.2	14.8	16.2
Most of the time	3.3	1.9	6.1	5.2	9.3	4.7
Always	12.1	10.4	5.0	7.5	7.4	9.5
Always dry or disinfect	48.4	43.5	43.2	44.9	39.1	51.7

*Statistically significant difference between states at P = 0.05 using chi-square test.

Table 6. Angler behavioral responses to AIS and fish diseases, overall and by state.

	Mean response						
	Overall	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
AIS behavioral response score	8.3	8.1 ^{a,b}	8.2 ^{a,b}	8.3 ^{a,b}	8.0 ^{a,b}	7.4 ^a	9.8 ^b
Baitfish behavioral response score	1.1	1.2	1.2	1.1	1.1	1.1	1.4

^{a,b}Values without a letter in common are significantly different from each other at P = 0.05 using Scheffe's test.

Baitfish and Fish Diseases

Anglers who use baitfish have the potential to spread fish diseases and AIS by transporting or releasing unwanted baitfish in waters other than where the baitfish came from. A majority of anglers, especially those in Ohio, used baitfish while fishing in the Great Lakes region (Table 7). However, very few anglers collected their own baitfish; most bought baitfish. Some states promote the sale of “certified” disease-free baitfish as a way to reduce the chance of spreading disease. It is clear this is the case in New York and Michigan where a majority of anglers are familiar with the term “certified” and purchase “certified” baitfish most of the time. In the other states 75% or more of the anglers did not know if they purchased “certified” disease-free baitfish.

Table 7. Use of baitfish by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Uses of baitfish						
Use baitfish*	53.6	63.0	53.3	48.4	73.3	52.3
Use other natural baits	77.3	79.0	77.6	74.9	76.2	77.4
Use artificial lures*	83.4	81.5	87.6	91.3	74.8	85.1
If use baitfish:						
Collect own baitfish	12.9	10.8	17.9	20.8	14.7	7.9
Buy baitfish	92.9	97.8	93.7	98.0	95.6	99.1
If buy baitfish:						
Is it “certified” disease free*						
No	3.9	4.6	0.9	1.1	6.2	0.9
Yes, some of the time	1.3	1.1	5.5	7.9	1.6	2.7
Yes, most of the time	7.8	17.2	45.0	62.9	16.4	21.4
Don't know	87.0	77.1	48.6	28.1	75.8	75.0

*Statistically significant difference between states at P = 0.05 using chi-square test.

Respondents were asked what they did with extra baitfish when they were done fishing, and we found that anglers typically do two to three things at least some of the time from the list of possible actions in Table 8. The most common action for anglers to do at least some of the time was to give extra baitfish to other anglers. This is a little less likely to happen in New York and

more likely to happen in Indiana. Half to three-quarters of anglers also took baitfish home. New York and Wisconsin anglers were more likely to take baitfish home than anglers in other states. Neither taking baitfish home nor giving baitfish to other anglers are in and of themselves harmful to the objective of preventing the spread of disease or AIS. What happens to the baitfish after they are brought home or given to other anglers is the potential concern.

Table 8. What anglers did with extra baitfish when they were done fishing by state.

What is done with extra baitfish	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Take them home*						
Never	48.7	33.4	44.7	28.1	56.5	29.4
Some of the time	35.1	37.9	32.2	36.5	27.4	27.5
Most of the time	16.2	28.7	23.1	35.4	16.1	43.1
Throw them back into the water where I caught them*						
Never	53.1	57.1	48.5	39.3	29.2	82.7
Some of the time	18.8	24.3	23.3	36.9	26.7	13.0
Most of the time	28.1	18.6	28.2	23.8	44.1	4.3
Throw them back into another body of water*						
Never	87.0	82.3	84.2	88.5	82.5	94.9
Some of the time	8.7	13.9	10.2	11.5	9.2	5.1
Most of the time	4.3	3.8	5.6	0.0	8.3	0.0
Dispose of them in the trash*						
Never	47.9	44.3	48.1	58.8	72.0	43.3
Some of the time	35.2	36.7	41.5	27.1	23.3	36.1
Most of the time	16.9	19.0	10.4	14.1	4.7	20.6
Dispose of them on dry land*						
Never	43.1	32.9	45.1	55.8	63.7	17.3
Some of the time	32.3	39.1	39.6	30.2	31.8	48.1
Most of the time	24.6	28.0	15.3	14.0	4.5	34.6
Give them to other anglers to use*						
Never	20.8	8.9	16.0	30.1	19.5	20.5
Some of the time	59.7	76.7	70.6	58.1	59.4	69.7
Most of the time	19.5	14.4	13.4	11.8	21.1	9.8

*Statistically significant difference between states at P = 0.05 using chi-square test.

Some states and organizations recommend that anglers throw extra baitfish back into the water they came from or dispose of them in the trash or on dry land. Overall 90% of anglers who use baitfish take one of these recommended actions at least some of the time. Forty-four percent take at least one of the actions most of the time. Throwing them back into the water where they came from was more frequently done in Ohio and New York. Anglers in the other states were more likely to throw them in the trash or on dry land.

Anglers are advised by a number of states and organizations not to throw the extra baitfish into another body of water from the one where they came from. Very few (<5%) anglers took this action most of the time; 15% took this action some of the time. Anglers in Ohio and Indiana

were the most likely to throw the baitfish into another water; Wisconsin anglers were the least likely (Table 8).

We created a baitfish behavioral response scale that combined the likelihood of doing the three recommended, positive actions (throwing extra baitfish back into the water they came from or disposing of them in the trash or on dry land) with the likelihood of doing the undesirable, negative action (throw the extra baitfish into another body of water from the one where they came from). If an angler never engaged in either recommended or undesirable actions their scale score was zero, indicating he or she was not demonstrably increasing or decreasing the risk of the spread of pathogens. If they engaged in any of the recommended actions some of the time they received a one for the positive actions. If they engaged in any of the positive actions most of the time they received a two for the positive actions. If they engaged in the negative action some of the time they received a negative one, and if they engaged in it most of the time they received a negative two. The positive and negative scores for an individual were added together. The average score for all anglers using baitfish was 1.1 suggesting that on average anglers engaged in positive actions at least some of the time (Table 6). There was no difference in average scores between the states.

Awareness and Knowledge of AIS and Fish Diseases

Most anglers in every state had heard of AIS, and many felt they knew something about them (Table 9). There was no difference between the states in the proportion that were aware of AIS. Non-respondents to the survey were less aware, so the overall level of awareness among all anglers is likely somewhat less than what is reported in Table 9. However, anglers who were more aware of AIS had higher AIS behavioral response scores (5.8 for those who never heard of AIS, 7.1 for those who were aware but didn't know much, and 8.7 for those who knew something about AIS). In other words, those who knew something about AIS took more actions or engaged in actions more frequently than those who had never heard of AIS.

Table 9. Awareness of aquatic invasive species and VHS by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Ever heard of aquatic invasive species?						
No	6.7	2.6	3.0	4.4	4.8	2.8
Yes, but don't know much	23.2	23.2	19.0	20.0	22.2	22.0
Yes, and know something about them	70.1	74.2	78.0	75.6	73.0	75.2
Ever heard of fish disease called VHS?*						
No	62.8	63.6	36.1	46.1	61.4	33.7
Yes, but don't know much	21.3	20.5	36.4	31.6	25.9	32.2
Yes, and know something about it	15.9	15.9	27.5	22.3	12.7	34.1

*Statistically significant difference between states at P = 0.05 using chi-square test.

Anglers living in Wisconsin, Michigan, and New York were more likely than anglers in Illinois, Indiana, and Ohio to indicate that they knew something about VHS (Table 9). Almost two-thirds of anglers in Illinois, Indiana, and Ohio indicated that they had never heard of VHS. The overall

level of awareness is likely a bit less than what is shown in Table 9 because non-respondents to the survey were less aware of VHS. Those who had never heard of VHS had a lower average score on the baitfish behavioral response scale than those who recognized the name but didn't know much about it (1.0 vs. 1.3), indicating that awareness and taking action are related. However, those who said they knew something about VHS were not significantly different in their baitfish behavioral response score (1.2) from either those who were unaware or those who recognized the name but didn't know much, suggesting that the relationship between awareness and taking actions is not that clear cut.

When asked about their knowledge or opinions about AIS and fish diseases, almost all anglers thought AIS could hurt native fish populations or reduce the number of fish available for them to catch, and that fish diseases could hurt the species of fish they'd like to fish for (Table 10). There were no differences between states for these items. There were also no differences between the states for the other questions about AIS. Most anglers thought AIS could prevent the use of some areas for boating or swimming, and about half thought AIS could damage their boat or fishing equipment. Fewer thought the spread of AIS was inevitable.

Anglers in the three states (Wisconsin, Michigan, New York) where anglers were more likely to indicate at least some knowledge about VHS were also the same states where more anglers thought VHS was a major threat to the health of fish populations in the Great Lakes region (Table 10). Anglers in the other states were more likely to indicate they didn't know. About half to two-thirds of the anglers thought fish diseases could harm people.

Sources of Information about AIS and VHS

Anglers were asked where they had gotten information about AIS or VHS, and as is usual for most fishing related topics, over half of the anglers indicated their state fishing regulations guide (Table 11). This was particularly true in the three states (Wisconsin, Michigan, New York) in which the most anglers knew something about VHS. Use of the fishing regulations guide was also related to significantly higher AIS and baitfish behavioral response scores (Table 12). This relationship indicates that anglers who use the guide are more likely to take actions that reduce the spread of AIS and pathogens and less likely to take actions that increase the spread of AIS and pathogens.

Mass media (such as newspapers, TV or radio) are not usually listed as sources of fishing-related information for many anglers in recent surveys we have conducted, but 35-50% of anglers in this survey listed them as a source of AIS and VHS information (Table 11). In the case of newspapers and magazines, they were also related to a positive increase in the baitfish behavioral response score (Table 12).

Posters in Wisconsin, websites in Illinois and Indiana, personnel at launch ramps in Illinois and Wisconsin, and outdoor expos in Indiana were sources of information used more by anglers in those states compared to other states (Table 11). They were also sources of information that were associated with higher AIS behavioral response scores (Table 12).

Table 10. Angler knowledge regarding aquatic invasive species and fish diseases by state.

Knowledge	Percent					
	IL	IN	MI	NY	OH	WI
Aquatic invasive species can hurt native fish populations						
Agree	96.9	94.0	95.3	93.8	94.6	93.4
Neutral	0.6	2.0	3.0	3.6	1.6	3.1
Disagree	0.0	0.7	0.0	0.0	0.0	0.4
Don't know	2.5	3.3	1.7	2.6	3.8	3.1
Aquatic invasive species can reduce the number of fish available for me to catch						
Agree	90.8	89.2	91.1	88.8	90.1	86.6
Neutral	4.3	5.4	4.7	6.6	4.4	7.6
Disagree	0.6	2.0	0.4	1.0	0.0	1.3
Don't know	4.3	3.4	3.8	3.6	5.5	4.5
Aquatic invasive species can prevent use of some areas for boating or swimming						
Agree	72.6	68.5	77.4	76.0	74.4	80.3
Neutral	10.6	11.4	9.0	10.7	7.2	9.9
Disagree	3.1	2.7	3.8	3.6	5.6	3.1
Don't know	13.7	17.4	9.8	9.7	12.8	6.7
Aquatic invasive species can damage my boat or fishing equipment						
Agree	51.5	54.1	56.0	55.1	56.9	50.7
Neutral	16.4	20.9	18.7	20.4	20.4	22.4
Disagree	10.1	9.5	10.3	9.2	7.2	11.2
Don't know	22.0	15.5	15.0	15.3	15.5	15.7
The spread of aquatic invasive species is inevitable						
Agree	45.3	43.3	45.6	46.4	51.7	45.4
Neutral	17.4	15.5	19.0	23.5	12.2	17.6
Disagree	25.5	32.4	26.3	19.9	27.8	30.2
Don't know	11.8	8.8	9.1	10.2	8.3	6.8
Fish diseases can hurt the species of fish I like to fish for						
Agree	96.3	96.0	96.2	94.4	96.1	93.3
Neutral	0.6	0.7	0.8	2.0	1.1	2.7
Disagree	0.0	0.0	0.0	0.0	0.6	0.9
Don't know	3.1	3.3	3.0	3.6	2.2	3.1
VHS is a major threat to the health of fish populations in the Great Lakes region*						
Agree	59.8	61.0	69.4	69.9	61.4	71.3
Neutral	7.5	12.8	9.5	8.2	4.5	10.0
Disagree	0.6	0.0	0.4	1.0	1.1	2.3
Don't know	32.1	26.2	20.7	20.9	33.0	16.4
Fish diseases can harm people*						
Agree	61.2	60.8	56.2	63.4	65.2	46.8
Neutral	14.0	15.5	16.2	15.5	17.4	24.1
Disagree	1.9	3.4	6.1	3.6	2.2	8.2
Don't know	22.9	20.3	21.5	17.5	15.2	20.9

*Statistically significant difference between states at P = 0.05 using chi-square test.

Table 11. Sources of information for anglers about VHS or aquatic invasive species and the percent who would like more information by state.

Sources of information	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Fishing regulations guide*	54.0	63.8	70.5	68.7	54.8	71.8
Newspapers	40.4	41.4	45.6	50.2	54.8	47.1
TV or radio	46.0	34.9	42.3	36.8	49.5	42.3
Magazines	34.2	38.2	41.1	38.3	40.3	43.6
Friends and family	37.3	34.2	41.9	40.3	30.6	37.0
Poster where I was fishing*	39.8	35.5	35.3	22.9	18.8	59.0
Web site*	31.7	32.2	23.7	28.4	29.6	16.3
Brochure	19.9	19.7	16.2	16.9	19.4	22.5
People at the boat launch ramp or marina*	21.1	15.8	13.3	17.9	17.2	29.5
Place where I purchase baitfish	17.4	14.5	18.7	19.9	16.1	19.4
Fishing organizations	14.3	21.1	13.3	13.4	16.7	15.0
Outdoor expos*	15.5	23.0	9.5	19.4	12.4	15.0
Charter boat captains or fishing guides*	14.9	5.3	5.0	6.5	15.6	8.8
Other sources	8.1	5.3	5.8	10.0	5.4	7.9
<u>Percent who would like additional information*</u>	66.7	66.5	59.8	66.8	69.9	46.3

*Statistically significant difference between states at P = 0.05 using chi-square test.

Table 12. Sources of information associated with a significant increase in the AIS or baitfish behavioral response scores, using t-test at P = 0.05.

Sources of information	AIS	Baitfish
	Significant increase in behavioral response score	
Fishing regulations guide	X	X
Newspapers		X
TV or radio		
Magazines		X
Friends and family		
Poster where I was fishing	X	
Web site	X	
Brochure	X	
People at the boat launch ramp or marina	X	
Place where I purchase baitfish	X	
Fishing organizations		
Outdoor expos	X	
Charter boat captains or fishing guides		
Other sources		

About two-thirds of anglers in each state, except Wisconsin, would like more information about AIS or fish diseases and how to reduce their spread (Table 11).

Level of Concern Regarding AIS and Fish Diseases

Almost all anglers in every state were concerned to some degree about having AIS and fish diseases in the Great Lakes region (Table 13). Many were very concerned, especially in Ohio. In Wisconsin, fewer anglers were very concerned and more were moderately concerned than in the other states. Those who were moderately or very concerned had a behavioral response score for AIS higher than those who were not at all/slightly concerned (8.4 and 8.6 vs. 5.0). Similarly for the baitfish behavioral response, those who were not at all/slightly concerned had a lower score than those who were moderately or very concerned (0.8 vs. 1.1, and 1.2).

Table 13. Angler level of concern about aquatic invasive species and fish diseases in the Great Lakes region by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Concern about aquatic invasive species*						
Not at all concerned	0.6	1.3	0.8	1.5	0.5	0.4
Slightly concerned	6.2	4.6	4.6	5.6	3.8	5.8
Moderately concerned	30.6	26.5	29.4	28.7	24.9	41.7
Very concerned	62.6	67.6	65.2	64.2	70.8	52.1
Concern about fish diseases*						
Not at all concerned	1.4	0.8	0.9	1.1	0.0	1.0
Slightly concerned	6.1	9.1	4.5	6.1	9.4	8.6
Moderately concerned	28.4	22.0	28.2	28.2	20.6	38.6
Very concerned	64.1	68.1	66.4	64.6	70.0	51.8

*Statistically significant difference between states at P = 0.05 using chi-square test.

Awareness of Rules and Recommendations Intended to Reduce the Spread of AIS and Fish Diseases

Awareness among anglers of the rules and recommendations intended to prevent the spread of AIS varied by state, despite the fact that the level of awareness of AIS themselves was relatively consistent, as discussed earlier. Anglers in Wisconsin, and to a slightly lesser extent in New York, Michigan, and Indiana, were more likely than anglers in the other states to indicate that they were familiar with the rules and recommendations (Table 14). One-third of anglers in Ohio said they were not aware of any rules or recommendations for preventing the spread of AIS. 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 had recommendations had an AIS behavioral response score significantly higher than those who were aware but don't know much about them (9.6 vs. 7.5). Furthermore those who were aware but didn't know much had a higher score than those who were not at all aware (7.5 vs. 6.0). A score of 9.6 suggests that anglers were taking several actions most or all of the time.

Anglers in Wisconsin and New York were the most likely to be aware of their states' rules about the transport and disposal of unwanted baitfish, with about three-quarters of respondents from each state being aware and 40-44% overall indicating they were familiar with the rules (Table 14). In Ohio half of the anglers indicated they were not aware of any rules. Anglers who were familiar with the rules had a higher baitfish behavioral response score compared to those who were merely aware of the rules but didn't know much about them (1.3 vs. 1.0).

Table 14. Angler awareness of rules and recommendations to reduce the spread of aquatic invasive species and fish diseases by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Awareness of rules or recommendations for preventing the spread of aquatic invasive species in Great Lakes region*						
No	21.6	18.3	17.9	9.5	34.7	3.4
Yes, but don't know much	38.9	35.2	33.3	38.5	39.7	30.8
Yes, am familiar	39.5	46.5	48.8	52.0	25.6	65.8
Awareness of rules about transport and disposal of unwanted baitfish in state where you live*						
No	44.5	41.4	31.8	21.5	51.1	24.2
Yes, but don't know much	32.9	28.6	33.9	38.0	34.0	31.8
Yes, am familiar	22.6	30.0	34.3	40.5	14.9	44.0
Ever heard phrase "Stop Aquatic Hitchhikers"*						
No	37.3	30.8	25.6	25.6	44.1	16.5
Yes	62.7	69.2	74.4	74.4	55.9	83.5

*Statistically significant difference between states at P = 0.05 using chi-square test.

The "Stop Aquatic Hitchhikers" slogan and program of recommendation to prevent the spread of AIS was developed in Minnesota and has been adopted and used by many states and organizations. We asked anglers if they had ever heard of the phrase "Stop Aquatic Hitchhikers," and the majority in each state said yes (Table 14). Most anglers in Wisconsin were familiar with the phrase. Ohio had the fewest number of anglers who had ever heard it. Anglers who had heard the phrase had a higher AIS behavioral response score than anglers who had not heard the phrase (8.7 vs. 7.0). A two point difference on the scale could mean that two actions were taken always as compared to most of the time, or most of the time compared to some of the time.

Factors that Could Enhance or Constrain Compliance with the Rules and Recommendations

Anglers were asked how important it was to them to follow the rules and recommendations to reduce the spread of aquatic invasive species and fish diseases, and most anglers in every state said it was very important (Table 15). There were no differences between states, and no relationship to behavioral response scores, likely because most people thought it was important (i.e., no variation in response).

Anglers 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 16). There were no significant differences between the states for any of the belief statements, except for one control belief discussed below. This suggests that angler beliefs are quite homogeneous across the region.

Most anglers agreed or strongly agreed with each of the behavioral belief statements (Table 16), some more strongly than others. For example 45-50% of anglers strongly agreed that following the rules and recommendations will help protect the waters they fish for future generations of anglers, and that the rules about the transport of baitfish are needed to keep fish diseases from spreading. About one-quarter 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, which is likely because most people agreed with the behavioral belief statements and so very little variation in these variables existed.

Most anglers agreed, but did not necessarily strongly agree, with each of the normative belief statements (Table 16). They thought most of the people they go fishing with followed the rules and recommendations, and thought it was important for them to do so. Those who agreed with these two statements had higher AIS behavioral response scores compared with those who disagreed with each statement (9.1 vs. 6.7 and 9.2 vs. 6.9, respectively). 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 16). They didn't think it took too much time or cost too much money. Those who thought it was easy and didn't cost too much money had higher AIS behavioral response scores than those who did not think it was easy (9.0 vs. 7.1 and 9.2 vs. 7.3, respectively).

Some anglers felt they didn't know enough about the rules and recommendations to follow them, some were neutral, but the majority disagreed with the statement, implying that they did know enough about the rules and recommendations to follow them (Table 16). Such anglers had a higher AIS behavioral response score than those who were neutral or agreed (9.4 vs. 8.0 and 7.2). Those who disagreed or were neutral had a higher baitfish behavioral response score than those who agreed (1.2 and 1.2 vs. 0.9).

A plurality of anglers were neutral regarding the statement that the cost of baitfish was too high because of the rules, and over 10% indicated they didn't know (Table 16). New York anglers were more likely than anglers in other states to agree that the cost was too high because of the rules.

Table 15. Importance of following the rules and recommendations to reduce the spread of aquatic invasive species and fish diseases by state.

	Percent					
	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin
Importance of following rules and recommendations						
Not at all important	1.8	0.7	0.9	0.5	0.0	0.0
Slightly important	1.2	4.3	0.4	4.0	2.2	2.4
Moderately important	16.0	13.5	17.5	21.5	17.4	15.5
Very important	81.0	81.5	81.2	74.0	80.4	82.1

CONCLUSIONS AND RECOMMENDATIONS

The response rate to the mail survey was lower than is desirable, but the sample size per state was sufficiently large for all the statistical tests that we wanted to perform. The low response rate increases the importance of the non-respondent follow-up in determining if meaningful differences exist between respondents and the overall population of anglers. We found differences that suggest respondent results likely overestimate the number of anglers who were aware of AIS, VHS, and the rules and recommendations to prevent their spread.

AIS and Preventing Their Spread

Most anglers were aware of AIS in the Great Lakes region, and many indicated they were aware of the recommendations to prevent their spread. It appears that educational campaigns, which include “Stop Aquatic Hitchhikers” (which the majority of anglers in each state were aware of), state fishing regulations guides, media coverage, etc., have been successful in alerting anglers to the concerns. In fact, two-thirds of anglers indicated they were concerned about having AIS in the region.

This awareness has resulted in most anglers (90%) engaging in at least one of the recommended actions at least some of the time. The most common actions taken were inspecting and removing aquatic plants and animals attached to fishing and boating equipment and to drain all water holding compartments. However, results indicate that as many as 25% of anglers, view these recommendations as applying only to boating equipment and not fishing equipment. Depending on the importance managers and educators place on the need for actions related to fishing equipment, we recommend that, if important, increased emphasis be placed on messages concerning the spread of AIS via fishing equipment. Few anglers disinfected their fishing or boating equipment or washed it with hot water. This may be because few facilities exist to facilitate these actions. It is also possible that many different, and sometimes conflicting, messages exist about exactly what needs to be done. For example, Lauber et al. (2014) found that messages for recreationists using the Lake Ontario basin varied in terms of the specific guidelines recommended for washing equipment. If managers and educators consider these actions important, it may help to provide additional facilities and equipment for washing and/or more consistent messages regarding how to wash.

Table 16. 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
Rules about transport of baitfish are needed to keep fish diseases from spreading	49.6	40.7	5.6	1.6	0.9	1.6
<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
The cost of baitfish is too high because of the rules	6.1	13.9	35.5	23.2	8.0	13.3
New York anglers*	11.5	23.7	27.7	14.7	4.5	17.9
Other anglers	6.3	12.1	35.2	22.3	10.6	13.5

*Statically significant differences between New York anglers and anglers in other states at P = 0.05 using chi-square test.

The number and frequency of actions taken by anglers to prevent the spread of AIS varied by state. We created a score based on the number of actions anglers took and whether they took those actions not at all, some of the time, most of the time, or all of the time. Anglers in Wisconsin had a higher average score than anglers in Ohio, with the other states falling between these extremes. Based on discussions with AIS coordinators in the states these differences likely reflect differences in the amount of resources (financial, personnel, etc.) states are able to devote to AIS education.

The AIS behavioral response score was positively correlated with: (1) angler awareness of AIS, and the rules and recommendations for reducing their spread; (2) concern about having AIS in the Great Lakes region, (3) use of the fishing regulations guide as a source of information; and (4) awareness of the “Stop Aquatic Hitchhikers” phrase. In other words, anglers who were more aware of and concerned about AIS were more likely to take actions to reduce the spread. Therefore, we recommend continued emphasis on efforts to raise awareness, especially through materials such as the fishing regulations guide and the “Stop Aquatic Hitchhikers” program, to increase compliance with the recommendations.

We also asked anglers about their beliefs associated with AIS and found that most already thought it was important to take actions to prevent the spread, protect the environment, and protect the fishery for future generations of anglers. Because many of the beliefs associated with taking actions were already held by most anglers, additional emphasis on communicating the importance of these beliefs in an effort to increase the number of anglers or frequency of actions taken by anglers is not likely to be fruitful. We think increased compliance is most likely if: (1) continued emphasis is placed on efforts to raise awareness, as stated before; (2) taking action, such as boat washing, is made more convenient and affordable; (3) messages about how to wash or disinfect are made more consistent; and (4) increased emphasis is placed on messages applying to fishing equipment and how AIS might be transferred by that equipment.

Fish Pathogens and Preventing Their Spread

Over half of the anglers in the region use baitfish at least some of the time when they go fishing, especially anglers in Ohio. Almost all anglers who use baitfish purchase them, rather than catching their own. Therefore, the risk of introduction of AIS and fish pathogens from acquiring baitfish falls primarily on bait dealers. Results of our survey of bait dealers can be found at Connelly et al. (2014). It suggests that most bait dealers are aware of VHS and AIS and are concerned about having them in the Great Lakes region. Further, most indicate they are aware of the state/provincial regulations regarding the transport and sale of baitfish, think they are important, and are trying to follow them. However, a few anglers collect their own baitfish and they could be carriers/transporters of AIS or fish pathogens. Those who collect baitfish often appear to be concentrated on certain waters, such as a group of New York anglers fishing Lake Erie (Connelly and Knuth, 2014). Education focused at these locations would be a recommendation to reduce the chances of movement of AIS or fish pathogens by those collecting baitfish.

Anglers may also contribute to the spread of AIS and fish pathogens by what they do with their baitfish when they are done fishing. We found that most anglers dispose of their unwanted

baitfish using recommended methods at least some of the time (i.e., dispose of on land or in the trash, return to water where they came from). However, some anglers dispose of them in ways that are not recommended (i.e., return them to a body of water other than the one they came from) and even among those using recommended methods they are not all using the recommended methods all of the time. Therefore, more needs to be done in general to educate anglers about issues related to baitfish and the best methods for disposal. Lauber et al. (2014) found fewer organizations involved with AIS outreach to recreational users in the Lake Ontario basin provided information about what to do with unwanted baitfish, which reinforces our belief that more needs to be done.

In contrast to awareness of AIS, awareness of VHS among anglers was generally lower and varied much more by state. For example, anglers in Michigan, New York, and Wisconsin were more likely to be aware of VHS and think VHS was a major threat to the health of fish populations in the Great Lakes region than anglers in other states. Anglers who were aware and concerned were more likely to take the recommended actions when disposing of unwanted baitfish.

Anglers' awareness of the rules regarding the transport and disposal of unwanted baitfish varied greatly by state. New York and Wisconsin anglers were more likely to be aware; Ohio anglers were less likely to be aware even though Ohio anglers were the most likely to use baitfish. According to Heck et al. (2013) the messages and regulations concerning baitfish seemed to vary by state, and AIS messages seemed more universal across states. This might explain, in part, the differences in awareness of the rules by state. One recommendation then would be to have more consistent messages and/or regulations.

As with other fishing topics, the fishing regulations guide was a frequently mentioned source of information. Use of this source was associated with anglers taking the recommended actions when disposing of baitfish. Unlike other studies of anglers that find little use of mass media sources for fishing information (e.g., Connelly et al. 2012, Connelly and Knuth, 2013), one-third to one-half used various mass media sources for information about VHS and AIS. Use of newspapers and magazines was associated with anglers taking the recommended actions when disposing of baitfish. This suggests that in the case of fish pathogens, non-traditional sources of communication like mass media should be considered in educational efforts about the pathogens and how to prevent their spread.

Additional Information Needs

Results from this survey provide information about the actions anglers are currently taking that can prevent or contribute to the spread of AIS and fish pathogens. Results also can be used to inform efforts to improve outreach to anglers, as discussed previously. However, the findings also highlight some gaps in information that could be useful to have to further focus outreach efforts. For example, we recommended a variety of actions that could be taken to increase the number of anglers following the recommendations regarding washing their boating and fishing equipment. But which of these recommendations would be most effective? What are the specific barriers that anglers face?

Anglers are not the only audience that many of the outreach efforts are focused on. Boaters, for example, are another audience that is a primary focus of outreach. While many anglers use boats, not all boaters are anglers, so information on the attitudes and behaviors of boaters is also important. We recommend gathering information on boaters similar to what we collected for anglers.

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APPENDIX A: MAIL QUESTIONNAIRE

A SURVEY OF ANGLERS IN THE GREAT LAKES REGION



Cornell University
Human Dimensions Research Unit

A SURVEY OF ANGLERS IN THE GREAT LAKES REGION

Research funded by the
Great Lakes Fishery Commission

Research conducted by the
Human Dimensions Research Unit
Department of Natural Resources
Cornell University

The purpose of this survey is to learn about your fishing experiences in the Great Lakes region.

- If you have not gone fishing in any of the states or provinces in the region (see map on front cover) in the past 5 years, please check this box and skip the remaining questions. Return the questionnaire to us so we don't bother you with reminder mailings.

Cornell University is conducting this survey, funded by the Great Lakes Fishery Commission, to provide states and provinces in the region with important information on anglers living and fishing in the area. The Commission, state and provincial agencies, and other organizations will use the results of this survey to provide anglers with better information about aquatic invasive species and fish diseases, and how to prevent their spread.

Your name was selected from a list of people who bought a fishing license in one of the states in the region in the past year. Even if you don't fish very often, or don't feel you know much about aquatic invasive species or fish diseases, there are still important questions we'd like you to answer in this survey.

Please complete this questionnaire as soon as you can, seal it with the white re-sealable label provided, and drop it in any mailbox; return postage has been paid. Your participation in this survey is voluntary, but we sincerely hope you will take just a few minutes to answer our questions. Your identity will be kept confidential and the information you give us will never be associated with your name.

THANK YOU FOR YOUR HELP!

1. Did you go fishing in the Great Lakes region (any of the states or provinces in the map on front cover) between Sept. 1, 2012 and Aug. 31, 2013?

- No (Skip to Question 3)
 Yes (Go to Question 2)

2. About how many days did you fish in the Great Lakes region (both Great Lakes waters and non-Great Lakes waters) between Sept. 1, 2012 and Aug. 31, 2013? (When we say "Great Lakes waters," we mean the 5 Great Lakes and rivers or streams that run into them or connect them, like the St. Mary's River, Niagara River or St. Lawrence River. See map on front cover.)

Water Type	Approximate Number of Days
Great Lakes Waters	
Non-Great Lakes Waters	

3. Have you gone fishing on Great Lakes waters in the past 5 years? (When we say "Great Lakes Waters," we mean the 5 Great Lakes and rivers or streams that run into them or connect them, like the St. Mary's River, Niagara River, or St. Lawrence River. See map on front cover.)

- No
 Yes

For the rest of the survey, please think about your experiences in the Great Lakes region (any of the states or provinces in the map on front cover).

4. Which of the following do you use when you go fishing in the Great Lakes region? (Check all that apply.)

- Artificial lures
 Baitfish (i.e., live fish)
 Other natural baits (e.g., crayfish, leeches, worms)

If you do NOT use baitfish, skip to Question 8.

5. Do you collect your own baitfish?

- No
 Yes

6. Do you buy baitfish?

- No
 Yes → Is it “certified” disease-free?
 No
 Yes, some of the time
 Yes, most of the time
 Don’t know

7. How often do you do each of the following with extra baitfish when you are done fishing? (Check all that apply.)

	Never	Some of the time	Most of the time
Take them home	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Throw them back into the water where I caught them	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Throw them back into another body of water	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dispose of them in the trash	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dispose of them on dry land	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Give them to other anglers to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

8. Do you own one or more boats that you use in the Great Lakes region?

- No
 Yes → (Check all that apply): Motorized
 Non-motorized

9. When you change fishing or boating locations from one water body to another, how often do you do each of the following:
(Check one box for each action.)

	Never	Some of the time	Most of the time	Always	NA, don't own boat
Inspect fishing and boating equipment for attached aquatic plants and animals	<input type="checkbox"/>				
Remove any visible mud, plants, fish or animals before transporting fishing or boating equipment.	<input type="checkbox"/>				
Drain all water holding compartments including live wells, bait wells and bilge areas.	<input type="checkbox"/>				
Dry boats, trailers and all fishing or boating equipment before use in another water body.	<input type="checkbox"/>				
Disinfect or rinse with hot water anything that came into contact with water before reuse.	<input type="checkbox"/>				

10. Have you ever heard of the fish disease called VHS (viral hemorrhagic septicemia)?

- No
- Yes, recognize the name but don't know much about it
- Yes, recognize the name and know something about it

11. Have you ever heard of aquatic invasive species? (By aquatic invasive species, we mean non-native plants and animals such as Asian carp, European water chestnut, hydrilla, and zebra mussels)

- No
- Yes, but I don't know much about them
- Yes, I know something about them

If you have never heard of either VHS or aquatic invasive species, skip to Question 16.

12. Please indicate the sources from which you have gotten information about VHS or aquatic invasive species? (Check all that apply.)

- Fishing regulations guide
- Poster where I was fishing
- Brochure
- Web site
- People at the boat launch ramp or marina
- Place where I purchase baitfish
- Charter boat captains or fishing guides
- Fishing organizations
- Friends and family
- Newspapers
- Magazines
- TV or radio
- Outdoor expos
- Other (please specify): _____

13. How strongly do you agree or disagree with the following statements? (Check one box for each statement.)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
<u>Fish diseases</u> can hurt the species of fish I like to fish for	<input type="checkbox"/>					
Fish diseases can harm people	<input type="checkbox"/>					
VHS is a major threat to the health of fish populations in the Great Lakes region.	<input type="checkbox"/>					
<u>Aquatic invasive species</u> can prevent use of some areas for boating or swimming	<input type="checkbox"/>					
The spread of aquatic invasive species is inevitable	<input type="checkbox"/>					
Aquatic invasive species can reduce the number of fish available for me to catch	<input type="checkbox"/>					
Aquatic invasive species can damage my boat or fishing equipment	<input type="checkbox"/>					
Aquatic invasive species can hurt native fish populations	<input type="checkbox"/>					

14. How concerned are you about having aquatic invasive species in the Great Lakes region?

- Very concerned
- Moderately concerned
- Slightly concerned
- Not at all concerned

15. How concerned are you about having fish diseases in the Great Lakes region?

- Very concerned
- Moderately concerned
- Slightly concerned
- Not at all concerned

16. Some states have rules about the transport of baitfish (i.e., live fish) and what you should do with unwanted baitfish to prevent the spread of fish diseases. Have you ever heard of these types of rules in the state where you live?

- No (Skip to Question 18)
- Yes, but don't know much about them
- Yes, I am familiar with the rules

17. How strongly do you agree or disagree with the following statements? *(Check one box for each statement.)*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
Rules about the transport of baitfish are needed to keep fish diseases from spreading	<input type="checkbox"/>					
The cost of baitfish is too high because of the rules	<input type="checkbox"/>					

18. Have you ever heard the phrase “Stop Aquatic Hitchhikers?”

- No
- Yes

19. Some organizations and states have made rules or recommendations about things you should do to prevent the spread of aquatic invasive species, such as cleaning your boat before moving it to a new body of water, or not dumping unused bait in a body of water it didn't come from. Have you ever heard of these types of rules or recommendations for waters you fish in the Great Lakes region?

- No
- Yes, but don't know much about them
- Yes, I am familiar with the rules and recommendations

20. How important is it to you that you follow the rules and recommendations of states and organizations to reduce the spread of aquatic invasive species and fish diseases?

- Very important
- Moderately important
- Slightly important
- Not at all important

If you have never heard about the rules or recommendations, skip to Question 22.

21. How strongly do you agree or disagree with the following statements about the rules and recommendations of states and organizations to reduce the spread of aquatic invasive species and fish diseases? (Check one box for each statement.)

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Don't know
It is easy for me to follow the rules and recommendations	<input type="checkbox"/>					
It takes too much time to follow the rules and recommendations	<input type="checkbox"/>					
It costs too much to follow the rules and recommendations	<input type="checkbox"/>					
I don't know enough about the rules and recommendations to follow them	<input type="checkbox"/>					
Most of the people I go fishing with think it is important that I follow the rules and recommendations	<input type="checkbox"/>					
Most of the people I go fishing with follow the rules and recommendations	<input type="checkbox"/>					
I trust the opinions of the people I fish with about the importance of following the rules and recommendations	<input type="checkbox"/>					
I trust my state natural resource agency when it comes to the importance of following the rules and recommendations	<input type="checkbox"/>					
If I follow the rules and recommendations, that will help limit the spread of aquatic invasive species and fish diseases	<input type="checkbox"/>					
If I follow the rules and recommendations, I can limit damage to my boat or fishing equipment	<input type="checkbox"/>					
I think following the rules and recommendations will help protect the waters I fish, for future generations of anglers	<input type="checkbox"/>					

22. Would you like to know more about aquatic invasive species or fish diseases and how you can reduce their spread?

No

Yes → What method of communication (such as those listed in Question 12) would be the best way to reach you with that information?

BACKGROUND INFORMATION

23. Are you male or female? (*Check one.*) Male Female

24. In what year were you born? 19_____

25. Is your primary residence: (*Check one.*)

Urban

Suburban

Rural

26. What is the highest level of education you have completed?
(*Check one.*)

Less than high school

High school diploma / G.E.D.

Some college or technical school

Associate's degree

College undergraduate degree (e.g., B.A., B.S.)

Graduate or professional degree (e.g., M.S., Ph.D., M.D., J.D.)

Please use the space below for any comments you wish to make.

Thank you for your time and effort!

To return this questionnaire, simply seal it with the white removable seal, and drop it in the mail (return postage has been paid).

APPENDIX B: ADDITIONAL TABLES

Appendix Table B-1. Tests for non-response bias.

Questions	Percent	
	Respondents	Non-respondents
Gone fishing in any of the Great Lakes states or provinces in past 5 years		
Yes	85.6	75.0
No	14.4	25.0
	($x^2 = 20.4$, $df = 1$, $p < 0.001$)	
Fished Great Lakes region between September 1, 2012 and August 31, 2013		
Yes	88.7	83.7
No	11.3	16.3
	($x^2 = 4.6$, $df = 2$, $p = 0.03$)	
Use artificial lures in the Great Lakes region		
Yes	84.0	80.7
No	16.0	19.3
	NS	
Used baitfish in Great Lakes region		
Yes	57.3	55.8
No	42.7	44.2
	NS	
Use other natural baits in Great Lakes region		
Yes	77.1	77.4
No	22.9	22.6
	NS	
Own a boat used in Great Lakes region		
Yes	53.7	47.4
No	46.3	52.6
	NS	
Own motorized boat used in Great Lakes region		
Yes	88.1	94.9
No	11.9	5.1
	($x^2 = 4.7$, $df = 1$, $p = 0.03$)	
Own a non-motorized boat used in Great Lakes region		
Yes	31.2	12.6
No	68.8	87.4
	($x^2 = 16.0$, $df = 1$, $p < 0.001$)	
When changing location, how often do you: Inspect fishing and boating equipment for attached aquatic plants and animals		
Never	17.3	26.9
Some of the time	14.0	8.0
Most of the time	19.7	12.9
Always	49.0	52.2
	($x^2 = 17.7$, $df = 3$, $p = 0.001$)	

Appendix Table B-1 (cont.)

	Percent	
	Respondents	Non-respondents
Dry boats, trailers, and all fishing or boating equipment before use in another water body		
Never	27.5	38.0
Some of the time	11.0	10.2
Most of the time	15.8	9.3
Always	45.7	42.5
	($\chi^2 = 11.6$, $df = 3$, $p = 0.01$)	
Disinfect or rinse with hot water anything that came into contact with water before reuse		
Never	71.8	68.1
Some of the time	14.7	10.8
Most of the time	5.0	5.9
Always	8.5	15.2
	($\chi^2 = 10.1$, $df = 3$, $p = 0.02$)	
Ever heard of fish disease called VHS		
No	50.6	62.6
Yes, recognize name but don't know much	28.0	23.1
Yes, recognize name and know something	21.4	14.3
	($\chi^2 = 11.7$, $df = 2$, $p = 0.003$)	
Ever heard of aquatic invasive species		
No	4.1	12.1
Yes, but don't know much	21.6	26.2
Yes, I know something about them	74.3	61.7
	($\chi^2 = 28.2$, $df = 2$, $p < 0.001$)	
How concerned are you about having AIS in Great Lakes region		
Very concerned	63.6	64.3
Moderately concerned	30.4	27.3
Slightly concerned	5.1	5.4
Not at all concerned	0.9	3.0
	NS	
Ever heard of rules or recommendations to prevent spread of AIS		
No	17.4	28.9
Yes, but don't know much	36.1	12.5
Yes, I am familiar with rules and recommendations	46.5	58.6
	($\chi^2 = 50.8$, $df = 2$, $p < 0.001$)	
Gender		
Male	85.8	82.5
Female	14.2	17.5
	NS	