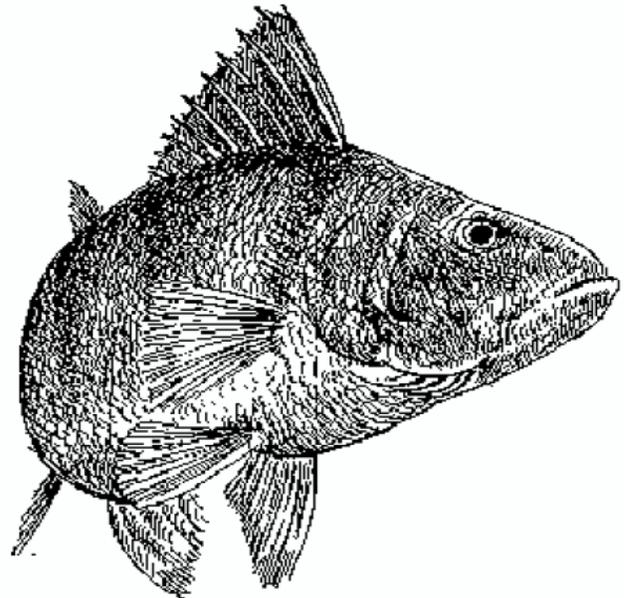


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# **Pathogens and invasive species in the Great Lakes: Understanding manager responses targeting bait dealers and anglers**



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## EXECUTIVE SUMMARY

Fish pathogens and aquatic invasive species (AIS) in the Great Lakes have become an ongoing management concern resulting in local, state, and federal responses. These responses include regulatory and educational efforts to reduce the spread of pathogens and AIS. Through this study, we characterized the strategies used by fisheries professionals, managers, and decision makers to respond to the presence of fish pathogens and AIS with a particular emphasis on strategies targeting bait dealers and anglers. We also identified the factors influencing the adoption of those strategies. In our results, we report on:

- Concerns about fish pathogens and AIS;
- Management responses to pathogens and AIS; and
- Factors that shape management responses.

The research was conducted in two phases: (1) 43 in-depth interviews with fisheries professionals, managers, and decision makers; and (2) a social network survey of 44 professionals, managers, and decision makers. Included in the interviews were respondents from US and Canadian agencies with the ability to influence fisheries management including state and provincial fish and wildlife agencies, federal agencies, tribal authorities, all state Sea Grants in the region, and nongovernmental organizations interested in fisheries management in the Great Lakes. Interview questions covered: (1) key concerns associated with fish pathogens and AIS in the Great Lakes region; (2) existing regulations, education, and communication efforts used to manage pathogens and AIS; (3) how management approaches have changed over time and the reasons for those changes; (4) how learning has contributed to the management of pathogens and invasive species; (5) how collaboration between organizations has contributed to management efforts; and (6) how stakeholders have been engaged in the efforts to manage pathogens and AIS.

The social network survey included all individuals that we attempted to recruit for the interviews. Questions in the survey instrument covered: (1) the organizations respondents worked for or represented; (2) their interactions and collaboration during the past five years with individuals in each of the other organizations; (3) their beliefs about factors contributing to the spread of pathogens and AIS; and (4) their management objectives and activities. We hypothesized that the consistency of regulations and behavioral recommendations adopted by each organization would be correlated with: (1) the degree to which agencies share an understanding of the factors leading to the spread of pathogens and AIS; and (2) the extent of social networks created by working relationships between individuals in different agencies.

We found that many organizations working to reduce the spread of AIS by boaters and anglers adopted similar approaches and had similar perspectives. On average, shipping was perceived to be the most significant contributor to the spread of pathogens and AIS. Anglers and boaters were considered the second most significant contributor. Bait dealers and the trade in live fish were perceived to play a smaller influence in the spread of pathogens and AIS. The agencies and other organizations we interviewed, however, place a priority on reducing the spread of pathogens and AIS by both bait dealers and recreational users.

Many agencies use regulations to try to reduce the risk of the movement of pathogens and AIS caused by the activities of bait dealers (e.g., regulations on the import, export, and movement of

live bait within and between states). However, we found an apparent lack of consistency in the particular regulations adopted. Few regulations regarding the trade, import and movement of bait were reported to be used in 50% or more of the Great Lakes states and provinces. Management activities targeting anglers and boaters relied more on education and outreach than regulations to influence behavior. None of the regulations targeting anglers and boaters were reported to be used in more than 50% of the Great Lakes states and provinces.

In order to learn more about how current management approaches have been developed, we explored the influence of stakeholder engagement, learning, and social networks on the approaches used to influence bait dealers and recreational users. We found that all three factors influenced the development and adoption of regulations and education and outreach efforts to reduce the spread of pathogens and AIS.

Agencies were more likely to engage bait dealers than recreational users as they developed their management approaches to AIS and pathogen management. Most state and provincial fish and wildlife agencies, for example, solicited feedback from bait dealers during the development of regulations on bait movement. This feedback was solicited either directly via mail surveys, contact with individual aquaculture operators, and workshops or more indirectly through efforts to engage the general public during public hearings and open houses. Respondents reported few stakeholder engagement efforts specifically targeting recreational users with regard to the management of pathogens and AIS. The greater emphasis on engaging bait dealers is likely partly attributable to the fact that stakeholder engagement is more frequently used in the development of regulations than education and outreach programs, and bait dealers are more likely to be targeted by regulations. Bait dealers might also be easier to engage since they are a smaller, more well-defined group than boaters and anglers. Regulations also often directly affect the livelihoods of bait dealers, and their engagement might increase acceptance and compliance with bait regulations and help to achieve a balance between the adoption of regulations and the sustainability of bait dealers' livelihoods.

We also found that learning shaped management in a variety of ways. At one level, learning led to recognition of problems that had to be addressed, and this recognition was often stimulated by the appearance or spread of new pathogens and AIS. After the appearance of VHS, many agencies focused particular attention on developing new regulations to control the import, export, and movement of live bait (e.g., implementation of VHS zones, prohibition of import of VHS-susceptible species of live bait, and movement restrictions of live bait within states). As the spread of pathogens and AIS continued, organizations recognized the need to target other stakeholders (anglers and boaters, in particular) and to use education and outreach in addition to regulations.

In addition to these broad conceptual shifts that led to the adoption of new management approaches and target groups, learning has resulted in the refinement of particular approaches as organizations gain experience with the effectiveness of different methods. For example, educational messages and recommendations have been modified over time. Initially, educational efforts focused on increasing awareness of pathogens and AIS, but they gradually shifted towards increasing understanding of how pathogens and AIS are spread and how bait dealers and recreational users can reduce their contribution to that spread. Similarly, as the scientific understanding of pathogens and AIS and the vectors that contribute to their spread has advanced,

regulations have been refined. Import restrictions for live bait, for example, became less strict whereas regulations for boaters and anglers were extended to include more requirements for boat and equipment disinfection. As communication technology has improved, the audience and media for communicating with target groups has changed (e.g., use of new media, more emphasis on visual messaging, etc.).

Most organizations have also concluded that more consistent recommendations across the basin, through the adoption of national campaigns such as “Habitattitude” and “Stop Aquatic Hitchhikers,” are more likely to lead to behavior change because it would expose target groups repeatedly to the same messages.

Much of the evolution and refinement of approaches to managing pathogens and AIS has been influenced by social learning, or learning that improves relationships and interactions between organizations working on these efforts. Agencies and organizations developed a variety of means to facilitate interaction and collaboration: regional panels, committees, and efforts coordinated by the GLFC. These venues offered opportunities to identify common management issues related to pathogens and AIS across the Great Lakes states, identify common management strategies, standardize educational messages, and share information and data across diverse organizations.

Our social network survey showed that interactions and collaboration among organizations was correlated with the adoption of similar approaches to education and outreach, but not to similar regulations. The decision about whether to proceed with the implementation of jointly developed management strategies remains with the individual states and provinces, which could be one of the reasons why interactions and collaboration have not led to more similar regulations. Making changes in state or provincial regulations is often very challenging. Regulations are often influenced by political processes that are driven by people outside of management agencies.

Given the important role that collaboration and dialogue has played in the evolution of approaches to managing pathogens and AIS, we expect that it will continue to play an important role as agencies develop approaches to identify the challenges that they maintained they were facing. On one level respondents argued for management they addressed pathogens and AIS more comprehensively by aiming for the prevention of new pathogens and AIS (rather than just minimizing their spread) and targeting vectors (rather than focusing on single species). Furthermore, collaboration is clearly necessary to address the oft-stated aim of increasing the consistency of both the regulatory and educational approaches being used in the basin.

## **ACKNOWLEDGMENTS**

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## BACKGROUND

Fish pathogens, such as the viral hemorrhagic septicemia (VHS) virus, and aquatic invasive species (AIS) have become an ongoing management concern in the Great Lakes. Managers have relied on similar strategies to respond to pathogens and AIS. Local, state, and federal responses to reduce the spread of VHS and AIS include education programs and regulatory actions to influence the behaviors of key stakeholders, such as bait dealers and anglers, who potentially contribute to the spread. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS), for example, issued an emergency order in 2006 in response to the rapid spread of VHS in the Great Lakes region, targeting the actions of both bait dealers and aquaculture operations. States and provinces in the region have developed regulations and educational campaigns to discourage anglers from taking actions that can lead to the spread of pathogens and AIS. 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. Sea Grant Extension programs throughout the Great Lakes are heavily involved in information and outreach aiming to influence human behaviors related to fish handling, preparation, harvest, and selling.

Understanding the responses of managers to the discovery and management of pathogens and AIS in the Great Lakes can help determine the prospects for success (and the factors that may impede success) of various management approaches, and can help inform future decisions in which fisheries-related risks must be managed under conditions of uncertainty. This study addressed the questions of how resource managers have responded to pathogens and AIS through information campaigns, regulations, and other management actions and how their approaches have evolved over time. We characterized the strategies used by fisheries professionals, managers, and decision makers to try to influence bait dealers and anglers and identified the factors contributing to the adoption of those strategies. In particular, we explored how regulations and education and outreach efforts intended to influence bait dealers' and anglers' behavior were shaped by:

- Managers' and decision makers' understanding of factors leading to the spread of pathogens and AIS;
- The dynamic process of learning in an environment characterized by considerable uncertainty;
- Interactions among managers and decision makers and between managers and decision makers and other stakeholders.

This study is part of a larger project. This report addresses questions of how resource managers respond to pathogen and AIS risks through information campaigns, regulations, and other management actions. Later reports, based on a series of mail surveys of bait dealers and anglers in Great Lakes states and provinces, will explore whether stakeholders adopt the behaviors advocated through information campaigns, including compliance with regulations, and why certain behaviors are more or less likely to be adopted.

## THEORETICAL FOUNDATION

The Great Lakes are a complex and evolving social-ecological system, and the outcomes of management actions intended to reduce the spread of AIS and pathogens will always be somewhat uncertain. In contexts characterized by uncertainty, managers and researchers have long recognized the importance of adaptive approaches to management informed by an ongoing process of learning. Learning can inform management at several different levels. The policy learning literature identifies the variety of types of learning (Bennett & Howlett 1992; Fiorino 2001; Glasbergen 1996; Lauber & Brown 2006; May 1992; Peterson 1997) that occur in policy and management contexts. Schemes for classifying these types of learning overlap conceptually, but use different terminology and distinguish learning types in different ways. Fiorino (2001) and Glasbergen (1996), who provided some of the more expansive views of what is learned in policy and management contexts, identified three basic types of learning. Although he used a slightly different scheme for classifying types of learning, May (1992) described changes that can serve as indicators of these types of learning.

**Technical learning** involves efforts to find new policies to accomplish existing objectives, but does not include reconsideration of the objectives. Although policies change, policy makers tend to rely on a consistent set of strategies. Changes in policies or how policies are operationalized can serve as indicators of technical learning. Developing new regulations and actions to try to accomplish the preexisting objective of limiting the movement of live fish within the Great Lakes system is an example of technical learning. In this scenario, the understanding of the factors leading to the spread of pathogens and AIS (the movement of live fish) does not change, but decision makers try to find more effective approaches for addressing that factor.

**Conceptual learning** consists of the search for new objectives and new ways of defining the problem. As conceptual learning occurs, objectives are debated, the way people think about issues changes, and new concepts are developed. Changes in management objectives can serve as indicators of conceptual learning. Deciding that the movement of fish needs to be regulated to control fish pathogens is an example of conceptual learning, reflecting in this case an improved understanding of factors leading to pathogens' spread. Even more fundamentally, conceptual learning might lead to the recognition that the spread of pathogens needs to be controlled.

**Social learning** focuses on relationships between stakeholders and the quality of dialogue between them. It involves learning about how to promote effective communication and interaction. Changes in the stakeholder groups who are involved in policy making and changes in how they are involved can serve as indicators of social learning. Coalescing a group of representatives of management agencies to decide on a coordinated approach to address pathogens and AIS is an example of social learning. Engaging stakeholders such as anglers or the bait industry to contribute to management decisions is another example.

As management problems evolve, the type of learning that occurs is likely to change (Fiorino 2001; Glasbergen 1996; Lauber & Brown 2006). Technical learning tends to be the most common until problems are encountered that additional technical learning cannot address. Conceptual learning (identifying new ways to define problems or new objectives) then lays the groundwork for additional technical learning. Social learning becomes necessary in situations in

which agreement on objectives or problems that need to be addressed is not straightforward. In these situations, social learning provides the foundation for conceptual and technical learning.

In the management of fish pathogens and AIS, which is characterized by both social and ecological uncertainty, we anticipated that: (1) social learning and conceptual learning would be necessary for technical learning to proceed; and (2) these learning types would then serve as a foundation for periods of technical learning about how to control pathogens and AIS. In particular, we expected that social learning would lead to the development of social networks among management agencies and other organizations in the Great Lakes region.

## METHODS

The research was conducted in two phases: (1) in-depth interviews; and (2) a social network survey.

### **Interviews with Fisheries Professionals, Managers, and Decision-Makers**

During the first phase of the project, we conducted 43 semi-structured, open-ended telephone interviews with decision makers who have worked to address the presence of fish pathogens and AIS in the Great Lakes region through regulations, educational campaigns, or other means. Interviews were completed with respondents from federal US and Canadian agencies, state and provincial fish and wildlife agencies, tribal authorities, all but one of the state Sea Grants in the region, and nongovernmental organizations (NGOs) interested in fisheries management in the Great Lakes.

Interview respondents were identified through snowball sampling. Potential interview respondents were identified initially through recommendations of Great Lakes Fishery Commission staff and researchers with experience in the region. Each potential respondent was then asked about other potential interview respondents until at least one knowledgeable respondent within each federal, state, and provincial agency and Great Lakes Sea Grant was identified and contacted

Interview questions (Appendix A) covered:

- (1) Key concerns associated with fish pathogens and AIS in the Great Lakes region;
- (2) Existing regulations, education, and communication efforts used to manage pathogens and AIS;
- (3) How management approaches have changed over time and the reasons for those changes;
- (4) How learning has contributed to the management of pathogens and invasive species;
- (5) How collaboration between organizations has contributed to management efforts; and
- (6) How stakeholders have been engaged in the efforts to manage pathogens and AIS.

All interviews were recorded and transcribed. Transcripts were analyzed using ATLAS.ti (qualitative data analysis software). A coding system was created that characterized indicators of policy learning that had been used in past studies (Lauber and Brown 2006). This qualitative

data analysis program allowed us to mark/code segments of interviews that described indicators of learning by managers. In specific, we coded:

- (1) Changes in management regulations or behavioral recommendations or how they were being implemented (indicating technical learning);
- (2) Changes in management objectives (indicating conceptual learning); and
- (3) Changes in who was involved in management decision-making or how they were involved (indicating social learning).

In addition, we coded key concerns about fish pathogens and AIS, collaboration efforts between organizations, and stakeholder engagement strategies. Transcript segments with the same code were grouped together, reviewed, and relevant quotes are used in subsequent sections of this report to illustrate the range of perspectives and experiences of interview respondents.

In addition, we coded key concerns about fish pathogens and AIS, collaboration efforts between organizations, and stakeholder engagement strategies. Transcript segments with the same code were grouped together, reviewed, and relevant quotes are used in subsequent sections of this report to illustrate the range of perspectives and experiences of interview respondents.

Each interview excerpt presented is labeled with a code that identifies the interview from which it was drawn (e.g., FP-1) and a particular stakeholder group, such as “state/provincial fish and wildlife agency” (including the Great Lakes Fishery Commission, which is allied with state/provincial agencies), “state agriculture agency,” “APHIS,” “aquaculture,” “bait dealer,” etc.

### **Social Network Survey**

Because we hypothesized that relationships and interactions between fisheries professionals, managers, and decision makers might influence the actions they took to reduce the spread of fish pathogens and AIS, we conducted a social network survey of all individuals we attempted to recruit for the interviews to characterize these relationships and interactions (Appendix B).

The first section of the survey instrument explored interactions and collaboration among organizations working to address pathogens and AIS in the Great Lakes. Prior to the survey, we developed a list of all the organizations represented by our interview respondents. In the survey, we asked respondents about:

- (1) The organization they worked for or represented;
- (2) Interaction and collaboration during the past five years based on :
  - The frequency of their interactions during the past five years with each of the other organizations (never, no more than once a year, several times a year, at least once a month, and at least once a week); and
  - Whether respondents had collaborated with each of the other organizations on projects to address fish pathogens and/or AIS in the Great Lakes region during the past five years.

The second section explored participants’ beliefs about fish pathogens and AIS and their organizations’ activities to minimize the spread of AIS and pathogens including:

- (3) The perceived contribution of 18 different factors to the spread of fish pathogens and/or AIS in the Great Lakes (5-point scale ranging from “no contribution” to “very high contribution”);
- (4) Management objectives and activities:
- Their organization’s emphasis on limiting the spread of pathogens and AIS in the Great Lakes (5-point scale ranging from “not an emphasis” to “very much an emphasis”);
  - The importance of 10 possible objectives in their organizations’ regulatory and/or educational efforts (5-point scale ranging from “not important at all” to “very important”),
  - How frequently their organization had carried out 18 different educational activities targeting bait dealers and anglers to reduce the spread of fish pathogens and/or AIS during the last five years (4-point scale ranging from “never” to “every year”),
  - Whether or not their organization currently had 15 different regulations and/or restrictions in place to reduce the spread of fish pathogens and/or AIS.

We hypothesized that the consistency of regulations and recommendations would be correlated with: (1) the degree to which agencies shared an understanding of the factors leading to the spread of pathogens and AIS; and (2) the degree to which agencies were connected within social networks created by working relationships between individuals in different agencies.

The survey was implemented as a web-based survey using Qualtrics (web-based survey software). Individuals were invited via email to take part in the survey with a link to the survey provided. Individuals who did not respond to the first invitation received up to four additional requests to complete the survey.

Out of 57 people that we contacted, 44 completed the survey (77.2% response rate). All agencies were represented by at least one respondent with the exception of one state Sea Grant and one state fish and wildlife agency.

Survey results were analyzed using IBM SPSS Statistics (statistical analysis software). We calculated means to quantify respondents’ perceptions of: (1) the contribution of different factors to the spread of pathogens and AIS; and (2) the importance of different management objectives in their organizations. We calculated the percentage of organizations that implemented different educational activities and the percentage of state and provincial fishery management agencies that adopted each of a variety of different regulations for managing the spread of pathogens and AIS.

We compared means across federal agencies, state and provincial agencies, tribal organizations, Sea Grant Programs, and NGOs with regard to the perceived contribution of different factors to the spread of pathogens and AIS and the importance of listed management objectives. We calculated the percentage of organizations within each organization type that implemented various educational activities.

To document the characteristics of the social network, UCINET 6 (a software package for the analysis of social network data) was used to calculate the “degree centrality” of each organization and the “geodesic distance” between each pair of organizations. We calculated

these network measures based on both: (1) how frequently organizations interacted with other organizations in the network (in which we defined two organizations as connected if they interacted at least several times a year); and (2) which organizations collaborated with each other.

- Degree centrality is a measure of the activity of actors in the network based on the number of ties they have to other actors (Wassermann and Faust 1994). In the normalized degree centrality measure that we used, the number of ties is reported as a percentage of all possible ties.
- The geodesic distance is the shortest path between two actors in a network. Organizations may be connected either directly (a geodesic distance of 1) or indirectly via other actors in the network (e.g., a geodesic distance of 2 would indicate that two actors are not directly connected, but are both connected with at least one other actor in common).

We anticipated that organizations that were closer to each other in the network (separated by a shorter geodesic distance) would have more similar approaches to managing pathogens and AIS. To test this hypothesis, we calculated how similar organizations were with regard to four variables: their perceptions of factors that contribute to the spread of pathogens and AIS; their management objectives; educational activities they undertake; and regulations they had implemented to combat the spread of pathogens and AIS. We calculated similarity measures for each of these variables for every pair of organizations among the 26 organizations. To calculate the similarity measure for perceptions of factors that contribute to the spread of pathogens and AIS:

- For each pair of organizations, we calculated the difference in the perceived contributions of each of 18 different factors to the spread of pathogens and AIS. (If an organization was represented by more than one respondent, we calculated the mean response for all respondents within the organization.)
- We took the absolute value of these 18 differences.
- We calculated the mean of these absolute values across all 18 factors to get an overall index of how similar their beliefs were (lower values indicated greater similarity).

We did similar calculations to assess similarities in management objectives, educational activities, and regulations.

We then calculated the correlation between the distance between organizations in the network and the similarity in: (1) their beliefs about factors that contribute to the spread of pathogens and AIS; (2) management objectives; (3) educational activities; and (4) regulations.

## **RESULTS**

The results are organized around three main themes: (1) Concerns about fish pathogens and AIS including perceived impacts from pathogens and AIS and factors that contribute to the spread of pathogens and AIS; (2) Management responses to pathogens and AIS; and (3) Factors that shape management responses (including stakeholder engagement strategies, different types of learning, and social networks). Information in the results section combines insights gained from interviews and the survey.

## Concerns about Fish Pathogens and AIS

### Perceived Impacts from Pathogens and AIS

AIS and pathogens were perceived to cause a wide variety of impacts on the Great Lakes ecosystem and fisheries (Table 1).

**Table 1.** Perceived impacts from pathogens and AIS.

| <b>Types of impact</b>    | <b>Perceived impacts</b>  |
|---------------------------|---|
| <b>Ecological impacts</b> | Changes in fish community composition<br>Depletion or significant loss of native species<br>Competition among native and non-native species<br>Loss of biodiversity<br>Impacts on/loss of habitat or reproductive success<br>Disruptions of food webs<br>Fish mortality due to pathogens<br>Spread of pathogens from the wild environment into farmed, cultured fish and vice versa |
| <b>Economic impacts</b>   | Financial impacts on hatcheries (losses due to disease or potentially having to depopulate)<br>Financial costs for agencies for mitigation and for control<br>Decreased income from tourism   |
| <b>Social impacts</b>     | Fewer fish available for recreational fishing<br>Less tourism   |

Perceived ecological impacts ranged from significant loss of certain fish species and competition between native and non-native species to disruptions of existing food webs and impacts on habitats and biodiversity. Economic and social impacts of AIS were also of concern. Hatcheries could suffer economic losses if they experience fish kills caused by pathogens and, as a consequence, fewer fish would be available for recreational fisheries that rely on stocked fish species, which could reduce the number of recreational anglers and their spending. This wide range of concerns was reflected by a number of respondents. For example: Respondents also pointed out there were significant economic impacts for agencies that had to mitigate and control pathogens and AIS. Because some states and provinces are better funded than others, some are more advanced in the management of pathogens and AIS than others. State and provincial funding typically comes from state and provincial legislatures and angler and boating fees, but the amount of funding varies considerably.

### Factors Perceived to Contribute to the Spread of Pathogens and AIS

We asked survey respondents about the contribution they thought a variety of factors made to the spread of pathogens and AIS (0=no contribution to 4=very high contribution) (Table 2).

**Table 2.** Respondents beliefs about the contribution of multiple factors to the spread of pathogens and AIS.

| Factors that contribute to the spread                                      | Respondent's employing organization |                 |             |              |             |              |
|--|-------------------------------------|-----------------|-------------|--------------|-------------|--------------|
|  | Federal                             | State/<br>prov. | Tribal      | Sea<br>Grant | NGO         | All          |
|  | Mean<br>n=6                         | Mean<br>n=18    | Mean<br>n=3 | Mean<br>n=11 | Mean<br>n=4 | Mean<br>n=42 |
| <b>Shipping</b>  |                                     |                 |             |              |             |              |
| Ballast water exchange   | 2.33                                | 3.11            | 3.00        | 3.70         | 3.75        | 3.14         |
| Movement of cargo and ships within and between lakes                       | 3.00                                | 3.11            | 1.33        | 3.30         | 2.00        | 2.86         |
| Open canals  | 2.17                                | 2.76            | 3.33        | 2.90         | 2.25        | 2.66         |
| <b>Boaters and Anglers</b>   |                                     |                 |             |              |             |              |
| Movement of recreational boats between water bodies                        | 2.17                                | 2.89            | 1.00        | 3.10         | 2.50        | 2.67         |
| Insufficient boat drainage and disinfection by anglers before moving boats | 2.17                                | 2.56            | 1.00        | 2.80         | 2.50        | 2.45         |
| Movement of live bait fish by anglers from one body of water to another    | 2.00                                | 2.50            | 1.67        | 2.10         | 2.00        | 2.19         |
| Disposal of bait from contaminated bait                                    | 1.67                                | 2.33            | 1.67        | 2.10         | 1.75        | 2.05         |
| Infected fishing equipment   | 1.33                                | 1.61            | 0.67        | 2.60         | 1.75        | 1.76         |
| <b>Pet trade</b>   |                                     |                 |             |              |             |              |
| Pet and aquarium industry (sale of live)                                   | 1.33                                | 2.33            | 2.33        | 2.00         | 2.25        | 2.05         |
| Intentional release of aquarium by public                                  | 1.17                                | 2.28            | 2.67        | 1.60         | 2.00        | 1.93         |
| <b>Wild fish movement</b>  |                                     |                 |             |              |             |              |
| Wild fish movement within and between                                      | 1.60                                | 1.72            | 3.00        | 2.40         | 1.50        | 1.95         |
| <b>Bait dealers and fish farms</b>   |                                     |                 |             |              |             |              |
| Trade of live fish across state lines                                      | 1.33                                | 2.22            | 2.00        | 1.60         | 1.75        | 1.83         |
| Stocking of invasive species in aquaculture operations                     | 1.00                                | 1.65            | 3.33        | 1.40         | 1.25        | 1.54         |
| Stock contamination in aquaculture   | 1.00                                | 1.39            | 2.33        | 1.10         | 1.25        | 1.29         |
| Infected equipment/facilities in hatcheries and aquaculture operations     | 0.83                                | 1.19            | 1.00        | 1.40         | 1.25        | 1.18         |
| Insufficient testing in hatcheries and aquaculture operations              | 0.83                                | 1.25            | 1.33        | 1.20         | 1.25        | 1.15         |
| <b>Food fish industry</b>  |                                     |                 |             |              |             |              |
| Food fish industry (selling of live fish)                                  | 1.00                                | 2.00            | 2.00        | 1.70         | 2.00        | 1.74         |

0=no contribution, 1=some contribution, 2=moderate contribution, 3=high contribution, 4=very large contribution

Shipping activities within and between the lakes was perceived to make the highest contribution to the spread of pathogens and AIS followed by the activities of boaters and anglers. Anglers and

boaters were believed to contribute to the spread of pathogens and AIS in multiple ways. The movement of recreational boats between water bodies was the most important of these, particularly when the boats were not drained and disinfected sufficiently before they were moved. In addition, anglers also were perceived to contribute to the spread if they move live bait fish from one water body to another.

Bait dealers were perceived contribute less to the spread than anglers and boaters and also less than the pet trade industry and wild fish movement.

Perceptions were very similar among all organizations with a few exceptions (Table 2). Tribal representatives in particular ranked the contribution of anglers and boaters less than all other groups. It needs to be taken into consideration, however, that the number of people within most individual groups of respondents was quite small.

### Management Responses to Pathogens and AIS

We were particularly interested in how agencies and other organizations tried to limit the spread of pathogens and AIS through regulatory efforts and educational activities targeting anglers and bait dealers. Our survey results demonstrate that organizations had multiple management objectives for these educational activities and regulatory efforts (Table 3).

**Table 3.** Importance of management objectives in organizations’ regulatory and educational efforts.

| Management objectives                                   | Respondent’s employing organization |                 |             |              |             |              |
|---|-------------------------------------|-----------------|-------------|--------------|-------------|--------------|
|   | Federal                             | State/<br>prov. | Tribal      | Sea<br>Grant | NGO         | All          |
|   | Mean<br>n=6                         | Mean<br>n=18    | Mean<br>n=3 | Mean<br>n=11 | Mean<br>n=4 | Mean<br>n=42 |
| <b>Overarching objectives</b>                           |                                     |                 |             |              |             |              |
| Increase awareness about AIS & pathogens                | 3.60                                | 3.78            | 3.33        | 3.82         | 3.75        | 3.73         |
| Prevent infestation of additional water                 | 2.80                                | 3.72            | 2.33        | 3.64         | 4.00        | 3.51         |
| <b>Boaters and anglers</b>                              |                                     |                 |             |              |             |              |
| Reduce spread of pathogens and AIS by                   | 2.40                                | 3.56            | 1.33        | 3.55         | 2.50        | 3.15         |
| Promote recreational fishing                            | 2.80                                | 3.72            | 1.00        | 2.91         | 2.50        | 3.07         |
| Prevent movement of live fish between<br>water bodies   | 2.20                                | 3.41            | 1.00        | 2.73         | 2.50        | 2.80         |
| <b>Bait dealers and hatcheries</b>                      |                                     |                 |             |              |             |              |
| Prevent infestation of hatcheries                       | 3.00                                | 3.67            | 3.00        | 2.73         | 2.00        | 3.12         |
| Reduce spread of pathogens and AIS by bait<br>dealers   | 2.60                                | 3.44            | 1.67        | 2.82         | 3.00        | 3.00         |
| Prevent import of infected bait from other<br>countries | 2.20                                | 3.39            | 2.00        | 1.80         | 3.25        | 2.73         |
| Protect livelihood of local bait dealers                | 2.20                                | 2.67            | 0.67        | 2.27         | 1.50        | 2.24         |

0=no importance at all, 1=of little importance, 2=moderately important, 3=important, 4=very important

The most important objectives on average were increasing awareness about pathogens and AIS and the prevention of new infestations of uninfected water bodies.

Organizations tended to focus on reducing the spread of pathogens and AIS by anglers (mean value 3.15) and bait dealers (mean value 3.00) to a similar extent, even though recreational anglers and boaters were perceived to contribute more to the current spread of pathogens and AIS than bait dealers by most respondents as mentioned before (see Table 3).

State and provincial fish and wildlife agencies ranked most management objectives as important to very important, which was higher on average than the other organizations. These results suggest that state and provincial agencies take a more comprehensive approach to managing pathogens and AIS. Tribal and federal organizations place relatively high importance on preventing infestations by bait dealers (e.g., in hatcheries) whereas NGOs and Sea Grant seem to focus more on reducing the spread by anglers and boaters.

State and provincial agencies are more likely than federal agencies to adopt regulations to try to achieve these objectives. Table 4 indicates the range of regulations that respondents reported were currently in place to reduce the spread of pathogens and AIS. Most of these regulations relate to the movement, import, and export of live bait by bait dealers. Regulations targeting anglers and boaters are less common.

**Table 4.** Percentage of state and provincial fish and wildlife agencies that have adopted regulations and restrictions to reduce the spread of fish pathogens and AIS.

| <b>Regulations and Restrictions</b>  | <b>%</b> |
|--|----------|
| <b>Focused on Bait dealers</b>   |          |
| Prohibit possession and trade of listed AIS as bait                              | 94.4     |
| Prohibit movement of bait out of VHS zone  | 72.2     |
| Prohibit import of bait from other states to use in your state                   | 55.6     |
| Require VHS testing before bait is imported                                      | 44.4     |
| Prohibit importation of bait from other states to export to other states         | 33.3     |
| Require bait certification   | 33.3     |
| Require VHS testing before bait from aquaculture operations can be sold          | 27.8     |
| Prohibit the sale of wild fish bait that is not tested                           | 16.7     |
| <b>Focused on Anglers and boaters</b>  |          |
| Require boat drainage before boats can be moved                                  | 44.4     |
| Require anglers to empty their live well before leaving a boat launch            | 44.4     |
| Prohibit movement of live bait from one lake to another                          | 38.9     |
| Require disinfection of docks and boats before they are moved from infested area | 11.1     |
| Prohibit use of wild bait fish that is not tested by anglers                     | 5.6      |

Based on our survey results, the adoption of regulations by state and provincial governments is inconsistent across the basin. Only two regulations targeting bait dealers: (1) prohibiting the possession and trade of listed AIS as bait; and (2) prohibiting the movement of bait out of VHS zones were reported to have been adopted by more than 70% of all state and provincial fish and

wildlife agencies. The majority of regulations were reported to be in place in fewer than half of the fish and wildlife agencies.

Consistency in regulations across the basin, however, does not depend entirely on state and provincial agencies adopting the same regulations. USDA-APHIS, which has the authority to regulate interstate and international trade in the U.S., for example, implemented a federal fish order in 2006. The order was adopted to prevent the spread of VHS into aquaculture facilities by prohibiting the import of VHS-susceptible species of live fish into the US and prohibiting interstate movement of these species of live fish within the eight states bordering the Great Lakes (USDA 2008).

Educational activities in the past five years are more likely to have targeted anglers and boaters rather than bait dealers (Table 5).

**Table 5.** Percentage of organizations carrying out educational activities targeting bait dealers and anglers most years or every year in the past five years.

| Educational activities   | Respondent's employing organization |                 |          |              |          |           |
|--|-------------------------------------|-----------------|----------|--------------|----------|-----------|
|  | Federal                             | State/<br>prov. | Tribal   | Sea<br>Grant | NGO      | All       |
|  | %<br>N=6                            | %<br>N=18       | %<br>N=3 | %<br>N=11    | %<br>N=4 | %<br>N=42 |
| <b>Anglers and boaters</b>   |                                     |                 |          |              |          |           |
| Educate anglers about AIS and their impact on GL fisheries                     | 60.0                                | 93.7            | 33.3     | 100.0        | 100.0    | 86.8      |
| Educate boaters and anglers about how to prevent spread of AIS and pathogens   | 60.0                                | 100.0           | 33.3     | 100.0        | 50.0     | 85.0      |
| Promote Stop Aquatic Hitchhikers <sup>1</sup>                                  | 60.0                                | 92.9            | 33.3     | 90.0         | 0.0      | 75.7      |
| Educate anglers about possible implications of movement of live bait           | 60.0                                | 88.1            | 0.0      | 90.0         | 50.0     | 75.0      |
| Educate anglers and bait dealers about collection and use of wild fish as bait | 60.0                                | 94.1            | 0.0      | 72.7         | 25.0     | 70.0      |
| Promote Habitattitude <sup>2</sup>   | 40.0                                | 66.9            | 33.3     | 80.0         | 0.0      | 55.8      |
| <b>Bait dealers</b>  |                                     |                 |          |              |          |           |
| Educate anglers and bait dealers about collection and use of wild fish as bait | 60.0                                | 94.1            | 0.0      | 72.7         | 25.0     | 70.0      |
| Provide guidelines to hatcheries about pathogen testing/HACCP                  | 40.0                                | 80.0            | 0.0      | 63.6         | 0.0      | 51.5      |
| 'White' list of species that may be used as                                    | 40.0                                | 73.3            | 0.0      | 12.5         | 0.0      | 41.2      |

Note: <sup>1</sup> National public awareness campaign to address AIS designed by the U.S. Fish and Wildlife Service (USFWS) on behalf of the national Aquatic Nuisance Species Task Force.

<sup>2</sup> Campaign focusing on minimize spread of invasive species coordinated by the Pet Industry Joint Advisory Council (PIJAC), U.S. Fish and Wildlife service (USFWS), and the National Oceanic and Atmospheric Administration (NOAA)

The most common activities focus on increasing understanding of pathogens and AIS, their impact on fisheries, and how anglers and bait dealers can reduce their contribution to the spread. State and provincial fish and wildlife agencies and Sea Grants were the organizations most likely to carry out educational activities.

Educational messages targeting anglers and boaters were most often distributed fact sheets and watch cards, information on websites, promotional items that contain educational messages, and news releases (Table 6). Recommendations for bait dealers and hatcheries are frequently conveyed by providing operational guidelines or “white lists” of species to use as bait.

**Table 6.** Organizational mechanisms for distributing recommendations to bait dealers and anglers.

| Means of distribution   | Respondents employing organization |                 |          |              |          |           |
|---|------------------------------------|-----------------|----------|--------------|----------|-----------|
|   | Federal                            | State/<br>prov. | Tribal   | Sea<br>Grant | NGO      | All       |
|   | %<br>N=6                           | %<br>N=18       | %<br>N=3 | %<br>N=11    | %<br>N=4 | %<br>N=42 |
| <b>Anglers and boaters</b>  |                                    |                 |          |              |          |           |
| Distribute factsheets/watch cards   | 60.0                               | 100.0           | 66.6     | 100.0        | 100.0    | 92.4      |
| Information on your organization’s website about pathogens and AIS                          | 60.0                               | 100.0           | 66.6     | 90.9         | 100.0    | 90.0      |
| Distribute promotional items (e.g. stickers, magnets) that have educational message on them | 60.0                               | 100.0           | 33.3     | 90.0         | 50.0     | 82.1      |
| Provide new release (TV, newspaper, magazines)  | 40.0                               | 93.7            | 0.0      | 100.0        | 100.0    | 82.0      |
| Distribute information via new media (e.g. Twitter, Facebook) to raise awareness            | 25.0                               | 75.0            | 0.0      | 72.7         | 100.0    | 64.7      |
| Maintain boat ramp signs describing how anglers can prevent the spread of AIS and pathogens | 0.0                                | 93.3            | 0.0      | 36.4         | 25.0     | 52.8      |
| Distribute information on AIS and pathogens in different languages                          | 25.0                               | 64.2            | 0.0      | 10.0         | 66.7     | 38.3      |
| <b>Bait dealers</b>   |                                    |                 |          |              |          |           |
| Distribute guidelines to hatcheries about pathogen testing/HACCP                            | 40.0                               | 80.0            | 0.0      | 63.6         | 0.0      | 51.5      |
| Distribute ‘white list’ of species that may be used as bait                                 | 40.0                               | 73.3            | 0.0      | 12.5         | 0.0      | 41.2      |
| Online training and certifications  | 25.0                               | 25.0            | 0.0      | 40.0         | 25.0     | 27.3      |
| Facilitate workshops to educate about test protocols in hatcheries                          | 0.0                                | 21.3            | 0.0      | 50.0         | 0.0      | 25.0      |

All groups, with the exception of tribal organizations, have used a variety of means to distribute recommendations in the past five years. NGOs, Sea Grants, and state and provincial fish and

wildlife agencies in particular have utilized a range of new media, such as websites, twitter, and Facebook, besides more traditional media such as TV and newspapers.

## **Factors that Shape Management Responses**

The regulatory and educational management responses to pathogens and AIS outlined above have been shaped by several types of factors. We assessed the influence of: (1) stakeholder engagement; (2) conceptual, technical, and social learning; and (3) interaction and collaboration efforts among agencies based on a social network analysis.

### **Stakeholder Engagement**

Most federal and tribal organizations included in this study do not routinely engage bait dealers and anglers to solicit feedback as they develop regulations and recommendations to address the spread of pathogens and AIS. As interviewees pointed out, provincial and state agencies primarily develop these regulations and recommendations. APHIS, however, seeks input from bait dealers as part of the Subcommittee on Aquatic Animal Health (SAAH) that is made up of representatives from the aquaculture industry, state government, tribal communities, the research community, and the three primary federal agencies (APHIS, NOAA, and FWS). The subcommittee provides opportunities to discuss national issues affecting aquaculture and aquatic animal health. Examples include discussion about the adequacy of state regulations and whether federal regulations are needed to manage pathogens and AIS more consistently across the basin.

Most state and provincial agencies solicit some kind of input from bait dealers and anglers during the development or implementation of regulations and recommendations targeting AIS and pathogens. Input from bait dealers on proposed regulation changes is solicited in multiple ways including mail surveys, workshops, contacts with individual aquaculture operators, and meetings with aquaculture organizations. That input is taken into consideration in the development and amendment of regulations and operational policies related to bait harvest and sale. The Ministry of Natural Resources (MNR) in Ontario, for example, works with bait dealer organizations to discuss policy options for the management of pathogens and AIS on a provincial and local watershed scale. The involvement of the bait industry in these discussions focuses mainly on the development of policies related to bait harvest and sale of bait. Another example is the engagement of bait dealers by the Michigan DNR in collaboration with the Michigan Department of Environmental Quality during the development of a fish order that dealt with the movement of bait. Interviewees mentioned that bait dealers provided crucial information on the movement of bait, “*where it is bought, where it was sold, and how much bait was bought and sold.*” This information was used by the DNR to identify the flow of bait within Michigan and to develop regulations related to bait. Bait dealers and bait shop owners are also able to provide feedback contributing to the development or amendment of new rules and regulations in public events such as public meetings, and public comment sections. While these events are not specifically targeted at bait dealers, bait dealers and bait shop owners are one of the key target groups for these events. While input from bait dealers and bait shop owners is considered valuable, interviewees emphasized that the ultimate goal remains to reduce the spread of pathogens and AIS. If agencies believe that regulations must be stricter than what bait dealers would prefer, the need for stricter regulations takes precedence over bait dealers’ recommendations.

Anglers are the targets of educational messages but are not typically actively engaged in the development of regulations or recommendations to reduce the spread of pathogens and AIS. However, when policies are being revised or new regulations are proposed, public input is solicited during public hearings, and anglers can voice their opinions in these hearings along with other stakeholders such as bait dealers, tourism operators, charter boat captains, and commercial harvesters. This approach for engaging stakeholders, for example, was used during the development of the provincial bait policy in Ontario. In some cases, state fisheries agencies gain information on anglers' opinions from other organizations that collect data on public opinion such as Sea Grant or university extension. Organized groups of anglers, in particular, may be asked by agencies for input on management and policy options to manage pathogens and AIS. These organized groups are also often involved in the implementation of educational efforts (e.g., helping to distribute educational materials and messages). Agencies are also open to suggestions by these organizations on how to increase compliance with regulations.

### **Conceptual Learning: The Evolution of Management Objectives**

Conceptual learning leads to changes in management objectives and new ways of defining the problems management is trying to address. As conceptual learning occurs, objectives are debated, the ways people think about issues changes, and new concepts are developed. For example, conceptual learning might lead to the decision that the movement of fish needs to be regulated to control fish pathogens or, even more fundamentally, that the spread of pathogens needs to be controlled.

Based on our interviews, we found that conceptual learning led to the introduction of new laws and regulations, an increased emphasis on education relative to regulations, and a decision to focus on prevention rather than just reactive management responses.

### **Conceptual Learning: Regulations Development**

One of the primary changes in the management of pathogens and AIS brought about by conceptual learning was a shift in focus from understanding and managing existing pathogens and AIS to understanding and managing the vectors leading to their introduction and spread. The management subsequently evolved from “*simply identifying diseases*” and the life cycles of AIS, to discussions about practices and vectors that lead to the introduction and spread of pathogens and AIS and “*how to reduce some of those risks [and] prevent disease organism[s] being brought in on my fish or in the water*” (FP-1).

This increased emphasis on vectors is evident in new regulations that began to be developed. After pathogens and AIS were widely recognized as a problem in the Great Lakes basin, restrictions on the import and movement of bait were implemented to reduce their spread by the bait industry. This type of regulation is still among the most widely used approaches to reduce the spread of pathogens and AIS (see Table 3 above).

In the US, the emergence of VHS led to the initiation of regulations to restrict movement of water and live fish within states from one water body to another, and restrictions on harvesting and selling certain fish species that could potentially be infected. Subsequently, certain fish

species were not allowed to be sold or moved from one water body to another unless they were tested, from tested waters, or raised within aquaculture operations.

*It was because of VHS and the threat to what we did and didn't know about VHS. We took a very quick and restrictive approach. ...Not only did we want to restrict water from Lake Michigan but throughout our state when it comes to either moving fish or water or both. As far as minnows and bait, we do not allow wild [bait] to be moved or sold unless they're from aquaculture or tested waters. You're allowed to collect them, but they have to be tested before they're distributed or sold. So if someone wants to go fishing on their river they can use the bait there, but they can't transport it off the river. (FP-28)*

In Canada, the emergence of VHS led to the creation of VHS zones. The aim was “to control the bait industry to say where they could harvest and sell their bait.” (FP-36)

*[The VHS zone] was established in April of 2007 and it remains in place now. The VHS management zone is defined as the VHS positive waters up until the first impassable barrier and then the next roadway close to that defines the boundary of the zone. ... Commercial bait operators...have conditions on their license that prohibit them from moving live baitfish out of that zone. (FP-26)*

As state by state regulations alone were not perceived as sufficient to stop the spread of pathogens and AIS and associated severe impacts, such as extensive fish kills, across the basin, a more standardized approach was adopted. In 2006, APHIS released a federal fish order that restricted the import of VHS susceptible species of live fish to the US and movement of these species between the eight Great Lakes states. This approach was viewed by some respondents as an important step towards a more consistent regulatory approach across the whole Great Lakes basin.

*There was an alarm bell raised by the Great Lakes and again by the Great Lakes Fish Health Committee saying that we need to have something standardized... And APHIS since ... we have the jurisdiction in the US to protect animal health, they asked us to step in and place a federal order to regulate the movement of fish... So we were asked by the Great Lakes states to help manage this event. (FP-10)*

State agencies further realized that it was not sufficient to protect local fish stocks from pathogens and AIS by restricting the import of fish and their movement within states, but it was also important to maintain their fish stocks in a healthy condition to ensure and certify that bait for export was not infected. This realization represented a shift in emphasis from the protection of the local bait industry from disease to making sure that Great Lakes bait being exported was not infected and was perceived to be healthy by buyers from outside of the states. Management objectives thus changed from solely ecological objectives of maintaining healthy fish stocks within the state to also include more economic objectives of ensuring “our trading partners that our biosecurity plans are in place and our surveillance plans are in place so that ... those trading partners have confidence in the product that is produced here.” (FP-16)

Another significant conceptual shift by managers was the realization that not just the bait industry contributed to the spread of pathogens and AIS, but that anglers and boaters also did.

Shortly after introducing regulations for the bait industry, some state and provincial fisheries agencies adopted new approaches to reduce the spread of AIS from one lake to another by recreational anglers and boaters. Specifically, anglers were prohibited from moving bait from one water body to another and had to drain their bait buckets before leaving a water body.

*We've passed legislation to minimize the probability that somebody inadvertently transport an undesirable organism from one lake to another. ... We do not allow the movement of bait from one natural water body to another. (FP-18)*

Legislative approaches, however, are seen as only partially effective and challenged by the multi-jurisdictional structure in the Great Lakes and different, sometimes conflicting, goals among the agencies involved in the management of pathogens and AIS. The question of “*whose jurisdiction rules*” becomes important if conflicting regulations are in place. Legislative approaches also usually take a lot of time to implement. Respondents point out that “*it's not something that happens overnight and so you have to be willing to be persistent and accept compromise even where perhaps compromise shouldn't occur because that's part of the political system that we work in*” (FP-12).

### **Conceptual Learning: Education and Outreach**

Regulatory approaches alone were not always considered desirable and sufficient to minimize the spread of pathogens and AIS. Consequently, some agencies realized that regulations need to be accompanied by other approaches, such as education.

When “*management agencies around the Great Lakes ... were going to shut down the bait fish industry in the Great Lakes*” to prevent the spread of pathogens and AIS, which would have seriously affected bait dealers' livelihoods, Sea Grant instead recommended implementing Hazard Analysis Critical Control Point (HACCP) programs to educate hatchery owners about how to maintain healthy hatcheries. The HACCP program for AIS is a self-inspection system for reducing the risk of spreading aquatic invasive species through aquaculture, hatchery, scientific, natural resource, and baitfish harvesting activities. This program not only involved a shift from regulation to education, but to an approach to education that was more integrative than what had been used previously. Instead of just distributing information via factsheets or fishery guidelines, Sea Grant went into fish farms and educated bait fish operators about the principles of AIS HACCP and how to develop AIS HACCP plans that could be applied in their own fish farms or state fisheries agencies.

Agencies also came to recognize that the spread of AIS and pathogens was no longer being caused by fish raised in aquaculture operations and hatcheries to the same degree as previously thought, and so they began to focus on the role of fishing and boating activities. Educational efforts were designed to target boaters and anglers:

*When we realized ... our regulatory authority focusing on the farm populations was not halting the spread of VHS, we started looking at ... other ... scenarios. ... We've decided to focus on ... education activities and seeing how can we educate the public about spreading aquatic animal pathogens through boating and fishing activities. (FP-34)*

It became obvious to managers that educational efforts needed not simply to increase awareness about AIS and pathogens but to increase understanding of vectors and pathways that contribute to the emergence and spread of AIS and communicate how angler and boater behavior needs to change to reduce that spread. Educational efforts thus evolved towards focusing on behavior change in key user groups. For anglers and boaters in particular, agencies have been trying to get “*the public on-board with not introducing, not letting things go, not importing a fish and then releasing it into your lake*” (FP-30).

Besides educating the public about not moving fish around into inland lakes and rivers through bait transfer, the state fisheries agencies also started to educate groups ranging from professional organizations to fishing clubs about the importance of managing AIS and pathogens. Their intention was that these groups would then become advocates for actions that are needed to minimize the spread of pathogens and AIS.

*There [are] a number of different actions besides public education. We can get with professional groups and let them advocate the political realm [as] we can't be advocates. We can get this information on to our administrators and let our administrators deal with the environmental bodies like the Corps of Engineers [to] get that information across. We can tell other professional groups, fishing clubs, all that kind of stuff, the importance of why we need to keep Asian carp out. (FP-31)*

### **Future Directions for Conceptual Learning**

Some respondents argued that more emphasis should be given to the prevention of the introduction of new pathogens and AIS and not just the minimization of the spread of existing species. Especially given the potential invasions of Asian carp and other still unknown species, they believed that more efforts are necessary to identify pathways that contribute to the introduction of pathogens and AIS and how to manage them effectively to prevent new entry.

Respondents also mentioned the need to become more strategic and organized in efforts to control the spread of pathogens and AIS. They maintained there was a need to undertake risk assessment and “*to look at the bigger picture of all introductions of aquatic invasive species*” instead of focusing on the management of single species or vectors. Some argued that it was important to be more proactive and develop action plans and rapid response protocols that indicate how to respond in the future to invasions of new AIS.

Some respondents believed the next step for education and outreach was to not just to educate people and try to change their behavior but to also change their attitude, promote their stewardship role for future generations that might be affected by AIS and pathogens, and instill “*a sense of community*” among recreational users. One interviewee argued that there is still a feeling of “*if I'm doing this but my buddy isn't, why even bother?*” Building a sense of community should ultimately change this attitude towards “*I'm doing my part and I'm going to make sure my buddy is doing his part*” (FP-32). In addition, education of the public could not only point out how to prevent further spread for ecological reasons but also increase awareness of other impacts, such as economic ones.

### **Technical Learning: Refining Management Strategies**

In this study, technical learning, in which managers find new ways to accomplish existing objectives but the objectives themselves do not change, led to the ongoing modification of existing regulations on live bait movement and the cleaning of recreational equipment in the regulatory sphere. In educational efforts, technical learning led to expanding the audiences of educational activities and the use of new approaches and media to distribute information.

### **Technical Learning: Regulations**

Technical learning led to changes in the regulations pertaining to the movement of live bait. As the understanding and knowledge about pathogens and AIS advanced, it became apparent that existing regulations were unnecessarily strict. For example, the federal fish order promulgated by APHIS in 2006 placed restrictions on the movement of 37 fish species, but that order was amended in 2008 and reduced the number of restricted species to 28.

A number of states also revised existing bait import regulations as they recognized the need to better reach certain target groups. At first these states restricted the import of certain live bait fish species for commercial purposes. As it became apparent that these restrictions were not sufficient to stop the spread of pathogens and AIS, some states also extended restrictions on the import of live fish from outside the state by the public.

Learning was also evident in the evolution of regulations requiring boaters and anglers to clean their recreational equipment. Despite regulations in some states requiring anglers to drain their bait buckets before leaving a water body, unintentional or ignorant behavior by anglers and boaters lead to the infestation of new waters with AIS. Consequently, anglers and boaters in some states, such as Minnesota, Michigan, Wisconsin, and Illinois, now are required to completely drain and disinfect their boats to make sure that no bilge water remains. Equipment, docks and boatlifts also need to be completely disinfected if they are to be moved from an infested water body.

### **Technical Learning: Education and Outreach**

As with regulations, education and outreach approaches were modified over time as agencies and other organizations learned about what was necessary to be effective. To begin with, some interviewees came to recognize that state-specific campaigns might confuse “*someone that comes down from Michigan and doesn’t understand ... our own Indiana campaign ... and how that’s different*” (FP-4). Subsequently, many organizations adopted national campaigns such as “Stop Aquatic Hitchhikers” and “Habitattitude” to improve the consistency of messages being communicated.

The target audiences of outreach efforts also were expanded to better reach key users groups, such as recreational anglers and boaters. Initially, outreach efforts mainly targeted organized groups such as the charter boat industry and anglers and boaters that belong to fishing clubs and attend fishing shows. Then outreach efforts were expanded to include the “*casual anglers that have a cottage*” to increase the number of recreational users who were exposed to messages about preventive steps to minimize the spread of AIS and pathogens. Another effort to expand educational efforts was the translation of educational materials into a variety of languages to

reach non-English- and non-French-speaking anglers who otherwise might not understand or be aware of all the recommendations.

In some states, the types of messages being communicated to recreational users also changed in an effort to increase their effectiveness at influencing behavior. Managers came to believe that one of the reasons users were not complying with recommendations was a lack of awareness about pathogens and AIS, how they spread, and what their impacts were. They learned that people were not very likely to pay attention to rules until they “*see how those species can really impact our waters [and are] are a real problem [that] need to be dealt with*” (FP-4).

Consequently, they concluded that it is important “*not only to tell people what the rule is but why that rule is important*” (FP-4).

As communication technologies have advanced, the use of media for education about AIS and pathogens has also changed. In addition to the distribution of information via newspapers and magazines, information is now also distributed via signs at boat ramps and online via websites, Facebook, Twitter, WebEx, and e-newsletters. Another change has been the use of videos to better capture peoples’ attention. Initially, educational videos were produced that showed what AIS looked like, but later videos also demonstrated steps to take to clean boats and other equipment. To reach recreational anglers and boaters, some organizations now emphasize distributing small items such as refrigerator magnets, stickers or carabineers, instead of just pamphlets. The hope is to increase repeated exposure to messages compared to pamphlets that “*are going to get recycled in the first trash can or recycling bin they pass*” (FP-30).

*We tried to do a lot of the fridge magnet type of thing or stickers that anglers can put right on their bait buckets, things like that. We've produced carabineers for backpacks and stuff like that. At very least, the product gets used and therefore the message is there as a reminder. (FP-30)*

In addition, managers learned that it is important to involve people with a background in education in the development of educational messages and outreach efforts. One interviewee commented that educational efforts are otherwise likely to fail, and managers might then conclude the education is not the right way to go, even though it might have been a lack of quality in educational messaging and not education per se that led to unsuccessful results.

*They will launch an education effort and it will fail. They will then conclude that education does not work. It's that negative feedback loop that often suggests to natural resources management agencies that education won't work so they turn to enforcement and regulation unfortunately. (FP-38)*

### **Future Directions for Technical Learning**

While educational messages have become more consistent throughout the Great Lakes due to the adoption of national campaigns and logos, respondents believed that regulations are still inconsistent. APHIS, for example, is currently assessing if state regulations that have been put in place are sufficient, if they are consistent, and whether “*everyone is on the same page,*” or if a federal regulation is needed to achieve some kind of standardization. One respondent even

suggested “*some kind of an international agreement*” (FP-14) that focuses on preventing the spread of pathogens and AIS.

Besides more consistency of regulations, interviewees also saw a need for regulations to become “*strengthened and made more clear*” especially in the area of “*interstate and intrastate transport for fish especially from private entities*” (FP-13). While the movement of some individual species is being regulated, “*there is nothing on regulating the entire vector because there’s a very strong pet trade lobby who have opposed efforts*” (FP-25).

Another suggested change would be more consistency in HACCP protocols across the basin. So far, AIS HACCP protocols are implemented mainly on a voluntary basis in the US whereas they are mandatory for the bait industry in Ontario. Efforts are thus underway to make the protocol mandatory within the private and commercial bait sector in the US as well to create a more consistent approach to testing protocols across the basin.

### **Social Learning: Dialogue and Collaboration**

Social learning has been found to contribute to both technical and conceptual learning. It focuses on improving relationships between stakeholders and the quality of dialogue between them. It involves learning about how to promote effective communication and interaction. Changes in the stakeholder groups who are involved in policy making and changes in how they are involved can serve as indicators of social learning. For example, coalescing a group of representatives of management agencies to decide on a coordinated approach to address pathogens and AIS would be an indicator of social learning.

We found that social learning was important to encourage dialogue among all different organizations involved in the management of pathogens and AIS in the Great Lakes basin and to develop more consistent regulatory and educational approaches.

### **Social Learning: Regulations**

A key lesson learned by managers over time in the management of pathogens and AIS was the realization that more consistent and collaborative efforts across the Great Lakes basin were needed to effectively slow down the spread of pathogens and AIS. Subsequently, various approaches have been adopted to increase the consistency of regulations and recommendations by sharing experience, knowledge, and research results.

The Great Lakes Fishery Commission is a bi-national commission created to develop coordinated research programs on the Great Lakes and make management recommendations based on findings. The commission has provided a critical venue for information sharing among the states in their responses to VHS and for learning from each other “*what each state was going to do and getting advice from other states on how to restrict bait harvest, bait sales, restrictions on bait dealers, restrictions on anglers*” (FP-36). The Great Lakes Fishery Commission also provides the opportunity for government agencies to jointly develop management plans to meet present and future needs, such as preventing the spread of Asian Carp.

Another important means to promote a common understanding of pathogens and AIS and related management issues in the Great Lakes basin is the creation of panels and committees to address

shared problems, like the North American intergovernmental Aquatic Nuisance Species Task Force, and more specialized or regional panels and committees such as the Great Lakes Panel on Aquatic Nuisance Species, the Mississippi River Basin Panel, and the Ruffe Control Committee.

*We are involved, very involved, with these different regional panels so that we can try to ... understand what are the issues throughout a certain region, trying to encourage uniform regulations throughout those regions ... We're working with other agencies throughout the state trying to understand what are the threats coming from other parts of the country.*  
(FP-4)

Councils and panels are also important venues for developing consistent preventive measures in and more uniform regulations for parts of the basin that share the same challenges. These institutions can help state agencies jointly “*develop policy [for the] prevention, early detection, and control of invasive species.*” These joint efforts should ultimately increase consistency across the agencies in their efforts to minimize the spread of AIS and specify in more detail “*who is responsible ... if something shows up, who gets told about it, what is that person responsible to do*”(FP-13). Sharing experience and knowledge in panels is particularly critical for states with limited staff and resources for managing pathogens and AIS. Learning from other states within panels and committees is essential for these states to develop appropriate management actions. One respondent, for example, pointed out that “*When I was the aquatic invasive species coordinator I was the only person doing that. I couldn't get a lot of headway just by myself trying to figure out what are the issues we need to address. So you go to these meetings and you understand more about what are the issues that need to be addressed and you find out that other people are also working on them*” (FP-4).

International collaboration between US and Canadian agencies also was mentioned as playing a role in efforts to develop consistent management strategies across the basin. One example is the Lake Superior Bi-national Program that aims to prevent the spread of AIS in Lake Superior. The program is administered through a four-tiered approach including federal, provincial, state, and tribal agencies. Members of all four levels worked together on strategies and actions to help reduce the spread of AIS throughout Lakes Superior (Superiorforum 2012). The program also stimulated the development of a Lake Superior Aquatic Invasive Species Complete Prevention Program that outlines actions recommended to prevent the entry of new AIS in Lake Superior. In addition to members of the program, “*almost all the agencies around the basin*” and the public had the opportunity to provide feedback on the initial draft in 2010. Agencies’ and stakeholders’ commitment to seek implementation of the plan’s recommendations stimulated more engagement among different actors and increased “*the number of programs and the number of activities that they've undertaken*” (FP-21).

Since responsibilities for addressing pathogens and AIS are often shared among multiple agencies, their management requires collaboration between agencies within individual states as well. The Pennsylvania Fish and Boat Commission, for example, collaborates with the Pennsylvania Department of Agriculture to regulate aquaculture operations and fish dealers. The Pennsylvania Fish and Boat Commission maintains a list of species by watershed for which the Pennsylvania Department of Agriculture may issue permits to use in aquaculture operations.

## **Social Learning: Education and Outreach**

As with regulations, a key lesson learned in the management of pathogens and AIS was the importance of collaboration in developing more consistent messages for use in outreach and education efforts.

Collaboration between different state and federal fish and wildlife agencies and between these agencies and Sea Grant were mentioned as critical means to increase consistency of recommendations and outreach programs. For example, the MNR in Ontario collaborated with Sea Grant in the US to increase consistency in public outreach. The MNR shared some of its material with Sea Grant and in return adopted some Sea Grant messages to ensure greater consistency of messages around the Great Lakes “*so that people aren't hearing different messages from various different agencies.*” (FP-30)

*I think another thing that's going to achieve, too, is the collaboration on some of the messaging for public outreach. We've adopted a lot of the products from the Stop Aquatic Hitchhikers program and some of the Sea Grant programs in the US, some of the watch cards and things like that. We have also shared some of our material back with them and used some of the images ... so I think that that probably helps with the outreach part to be giving a similar message. (FP-30)*

The Pennsylvania Fish and Boat Commission also collaborated with Sea Grant to improve outreach efforts. Both institutions developed outreach materials, which were then distributed by Sea Grant to increase exposure of target audiences because human resources at the Pennsylvania Fish and Boat Commission are limited. The Commission also engaged local governments and visitor bureaus in these education efforts “*to help us get the word out.*”

Collaboration between natural resource agencies and ethnic communities helped to widen the audiences for outreach efforts and reach the non-English speaking public. Since not all anglers have a sufficient understanding of English to follow recommendations written in English, translating information in different languages is valuable to reach a wider audience and potentially increase compliance with rules and recommendations. The MNR in Ontario for example worked with a Chinese organization in Toronto to develop information for Chinese people living in the area that are engaged in fishing activities. Prior to that effort, information was only distributed in English and French, which was seen as insufficient.

*I believe in Toronto there is a Chinese association and we have actually worked with them to develop some of the translated material and to get that out to some of their membership. (FP-30)*

Respondents also described the sharing of information among federal and state agencies. The Pennsylvania Fish and Boat Commission worked with federal agencies such as APHIS for the management of VHS. The Commission attended workshops by APHIS and used information provided by APHIS in their educational efforts targeting anglers. In another example, the New York State Department of Environmental Conservation shared findings from a survey with the DNR in Indiana on how to increase effectiveness of education efforts about AIS.

## **Future Directions for Social Learning**

A challenge of working on inter-organizational collaborative efforts for the management of pathogens and AIS lies in the diversity of issues participants on the panel would like to address. For example, the Pennsylvania Aquatic Invasive Species Council was “*coordinated out of the Department of Agriculture and a lot of the invasive species concerns that they have are with plants and with agriculture, which are terrestrial plants, trees stuff like that, which is different than the concerns that we have*” (FP-13). Developing more effective ways for organizations with different interests and priorities to work together on issues related to AIS and pathogens could be beneficial.

Another challenge collaborative efforts face is the limited authority they have to change regulations or implement actions. Outcomes are often only management recommendations, and the real value of these panels seems to be more in information sharing rather than policy or regulatory change efforts.

*The coordinator doesn't have any real authority... Unless there is authority to put people in place and actually direct them to do something it makes the action plans pretty weak. (FP-13)*

*[In] the panel I use to hear new information about what's happening across the region and I also use it as an opportunity to advance any policy prevention campaigning that I'm working on...It's adequate. There are many parties on the panel who cannot engage in policy prevention but it often has very informative sessions and I appreciate going. (FP-25)*

Addressing this limitation of inter-organizational efforts to effect change may contribute to AIS and pathogen management in the future.

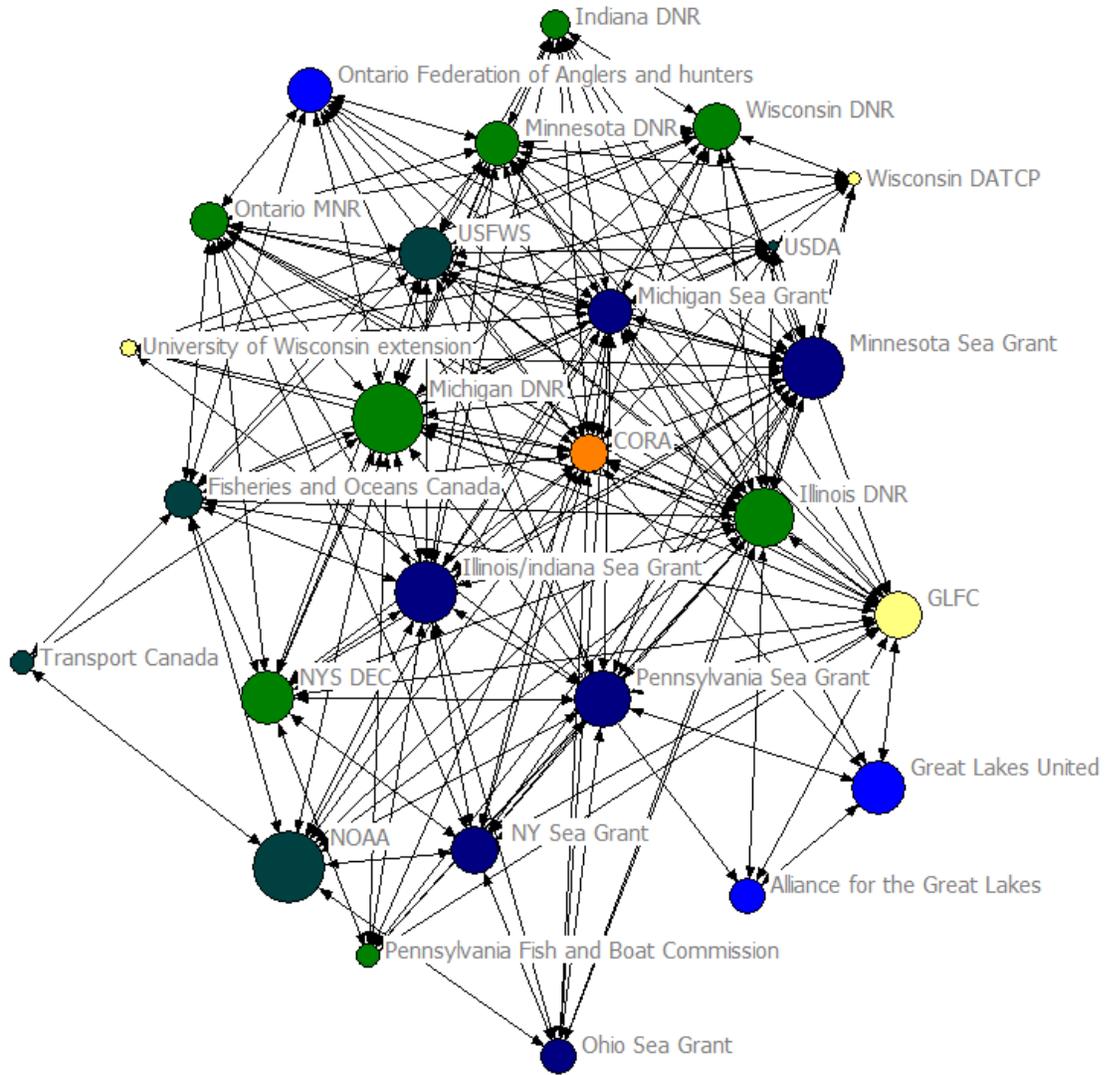
## **Social Networks**

Social network analysis provides a powerful tool for exploring how organizations interact and how those interactions relate to their other activities. For each organization represented by our respondents, we calculated “degree centrality” (a measure of how “central” an organization is in the network based on how much it interacts with the other organizations as a set) and the “geodesic distance” from each other organization (a measure of how much it interacts with other organizations individually). Because we anticipated that consistency in regulations and recommendations would be influenced by the degree to which organizations interact, we assessed whether the degree of interaction and collaboration between organizations was correlated with similarities in their regulations and recommendations. In addition, we investigated whether similarities in beliefs about the importance of factors that contribute to the spread of pathogens and AIS and similarities in management objectives were correlated with similar regulations and recommendations.

### **Degree Centrality of Actors in the Social Network**

We found that some organizations were more central than others in the network based on how frequently they interacted with other organizations in their efforts to address fish pathogens and AIS (Table 7 & Figure 1).

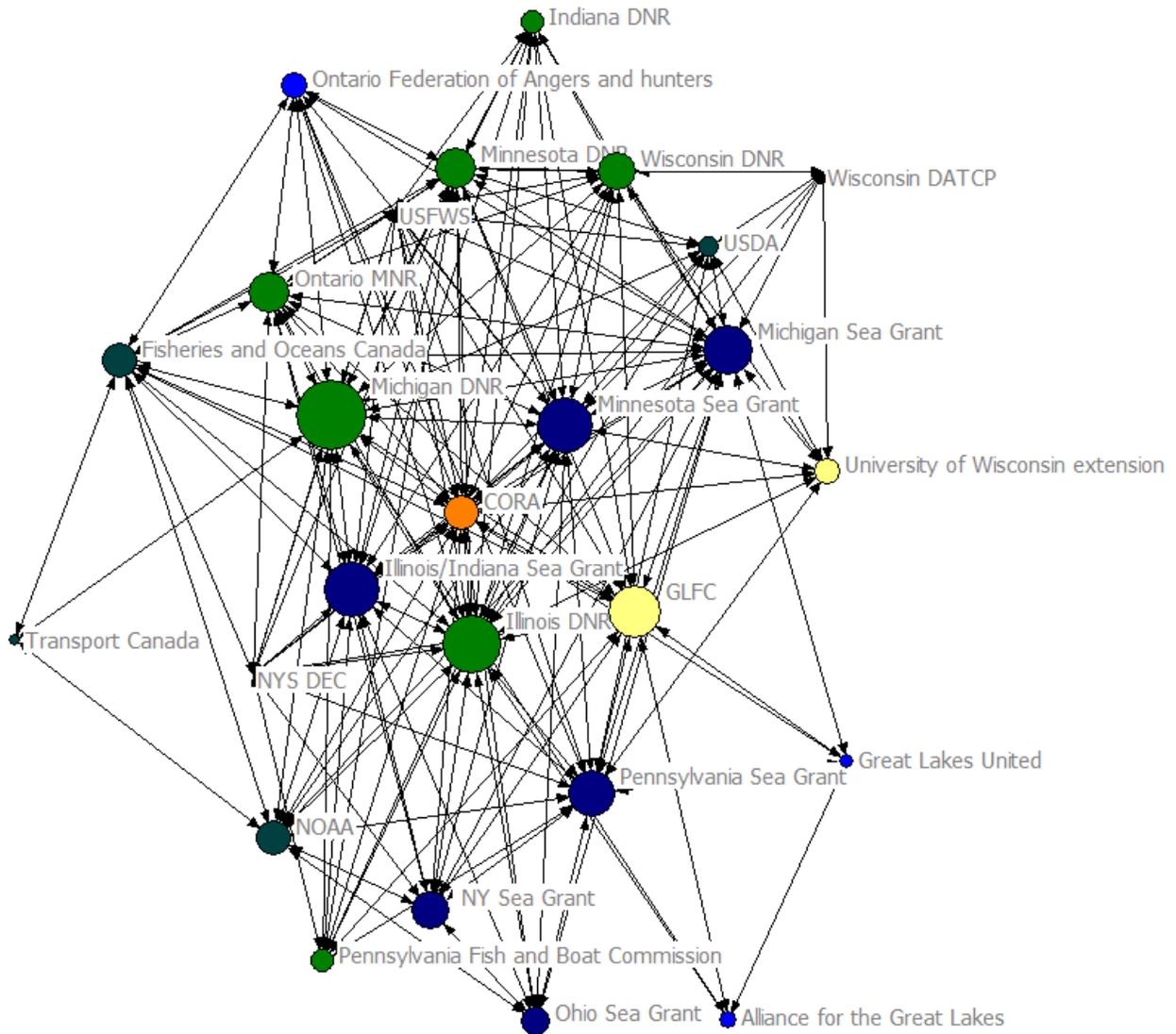
**Figure 1.** Social network map of organizations involved in pathogens/AIS management based on their frequency of interactions<sup>1,2</sup>.



<sup>1</sup> Dark green=federal, green=state fish and wildlife, orange=tribal, yellow=other, dark blue=Sea Grant, blue=NGO.

<sup>2</sup> Size of circle indicates degree of centrality.

**Figure 2.** Social network map of organizations involved in pathogens/AIS management based on their collaboration on specific projects<sup>1,2</sup>.



The 11 most central organizations included a number of state fish and wildlife agencies (Michigan DNR, Illinois DNR, the NYS Department of Environmental Conservation, and Wisconsin DNR), Sea Grants (Illinois/Indiana, Pennsylvania, and Minnesota), NOAA, USFWS, one NGO (Great Lakes United), and the GLFC.

We also calculated the centrality of each organization based on the number of other organizations they had collaborated with on specific projects (which would occur less frequently than “interactions”) (Table 7 & Figure 2). In this case, the most central organizations were some

<sup>1</sup> Dark green=federal, green=state fish and wildlife, orange=tribal, yellow=other, dark blue=Sea Grant, blue=NGO.

<sup>2</sup> Size of circle indicates degree of centrality.

of the natural resource agencies (Michigan and Illinois) and Sea Grants (Illinois/Indiana, Minnesota, and Michigan) in the central and western Great Lakes as well as the GLFC.

**Table 7.** Degree centrality of institutions for interaction and collaboration efforts

| <b>Organization</b>   | <b>Interaction Degree Centrality</b> | <b>Collaboration Degree Centrality</b> |
|---|--------------------------------------|--|
| Michigan DNR  | 52                                   | 56                                     |
| National Oceanic and Atmospheric Administration                             | 51                                   | 26                                     |
| Illinois/Indiana Sea Grant  | 47                                   | 44                                     |
| Minnesota Sea Grant   | 47                                   | 41                                     |
| Illinois DNR  | 45                                   | 48                                     |
| Pennsylvania Sea Grant  | 44                                   | 36                                     |
| NY State Department of Environmental Conservation                           | 42                                   | 26                                     |
| US Fish and Wildlife Service (USFWS)  | 42                                   | 34                                     |
| Great Lakes United  | 41                                   | 8                                      |
| Great Lakes Fishery Commission (GLFC)                                       | 39                                   | 40                                     |
| Wisconsin DNR   | 39                                   | 28                                     |
| NY Sea Grant  | 38                                   | 28                                     |
| Michigan Sea Grant  | 37                                   | 39                                     |
| Minnesota DNR   | 37                                   | 31                                     |
| Ontario Federation of Anglers and Hunters                                   | 36                                   | 18                                     |
| Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) | 36                                   | 14                                     |
| Chippewa Ottawa Resource Authority (CORA)                                   | 34                                   | 26                                     |
| Ontario Ministry of Natural Resources                                       | 34                                   | 30                                     |
| Fisheries and Oceans Canada   | 33                                   | 26                                     |
| Alliance for the Great Lakes  | 31                                   | 10                                     |
| Ohio Sea Grant  | 30                                   | 20                                     |
| Indiana DNR   | 29                                   | 17                                     |
| Transport Canada  | 25                                   | 6                                      |
| Pennsylvania Fish and Boat Commission                                       | 23                                   | 15                                     |
| University of Wisconsin extension   | 22                                   | 19                                     |
| US Department of Agriculture (USDA)   | 18                                   | 15                                     |

**Relationship between Beliefs, Management Objectives and the Adoption of Regulations and Recommendations**

We had hypothesized that the consistency of regulations and recommendations between different pairs of organizations (325 possible pairs among the 25 organizations) would be correlated with

similarities in those organizations’ management objectives and the similarities in organizational representatives’ beliefs about factors leading to the spread of pathogens and AIS. We found highly significant correlations between similarities in behavioral recommendations and similarities in management objectives and beliefs about factors contributing to pathogen/AIS spread. (Table 8). We did not find a significant relationship between similar management objectives and shared beliefs about factors that contribute to the spread and the adoption of regulations.

**Table 8.** Correlation of similarity in regulations and recommendations with similarity in beliefs about factors contributing to the spread of pathogens and AIS and similarity in management objectives.

|  | Regulations <sup>1</sup> |       | Recommendations |       |
|--|--------------------------|-------|-----------------|-------|
|  | r                        | p     | r               | p     |
| Beliefs about factors that contribute to the spread of pathogens and AIS | 0.182                    | 0.102 | 0.196           | 0.000 |
| Management objectives  | 0.172                    | 0.248 | 0.228           | 0.000 |

<sup>1</sup> NGOs and Sea Grants were not included in correlations related to regulations because they have no regulatory power.

### **Relationship between Distance between Organizations within Social Network and the Adoption of Regulations and Recommendations**

We had also hypothesized that organizations that were closer (shorter geodesic distance) within the social network would be more likely to have similar regulations and recommendations. Similarities in behavioral recommendations were indeed correlated with closeness within social networks regardless of whether the social network was based on interactions or collaboration on specific projects (Table 9).

**Table 9.** Correlation of Similarity in Regulations and Recommendations with level of interaction and collaboration within the social network.

|                              | Regulations <sup>1</sup> |       | Recommendations |       |
|------------------------------|--------------------------|-------|-----------------|-------|
|                              | r                        | p     | r               | p     |
| Interaction Social Network   | -0.129                   | 0.105 | 0.192           | 0.000 |
| Collaboration Social Network | -0.153                   | 0.171 | 0.341           | 0.000 |

<sup>1</sup> NGOs and Sea Grants were not included in correlations related to regulations because they have no regulatory power.

The relationship was stronger within the network based on collaboration on specific projects, which is unsurprising given that some of these projects may have contributed to behavioral recommendations. We did not find a correlation between closeness within social networks and similarities in regulations. Because the adoption of regulations is a more involved process than the adoption of recommendations, and likely influenced by the individual politics of each state/province, the lack of a significant correlation could perhaps have been anticipated.

## DISCUSSION AND CONCLUSIONS

We found that many organizations working to reduce the spread of pathogens and AIS by boaters and anglers adopted similar approaches and had similar perspectives. On average, shipping was perceived to be the most significant contributor to the spread of pathogens and AIS. Anglers and boaters were considered the second most significant contributor. Bait dealers and the trade in live fish were perceived to play a smaller influence in the spread of pathogens and AIS. The agencies and other organizations we interviewed, however, place a priority on reducing the spread of pathogens and AIS by both bait dealers and recreational users.

Many agencies use regulations to try to reduce the risk of the movement of pathogens and AIS caused by the activities of bait dealers (e.g., regulations on the import, export, and movement of live bait within and between states). However, we found an apparent lack of consistency in the particular regulations adopted. Few regulations regarding the trade, import and movement of bait were reported to be used in 50% or more of the Great Lakes states. Management activities targeting anglers and boaters relied more on education and outreach than regulations to influence behavior. None of the regulations targeting anglers and boaters were reported to be used in more than 50% of the Great Lakes states.

In order to learn more about how current management approaches have been developed, we explored the influence of stakeholder engagement, learning, and social networks on the approaches used to influence bait dealers and recreational users. We found that all three factors influenced the development and adoption of regulations and education and outreach efforts to reduce the spread of pathogens and AIS.

Agencies were more likely to engage bait dealers than recreational users as they developed their management approaches. Most state and provincial fish and wildlife agencies, for example, solicited feedback from bait dealers during the development of regulations on bait movement. This feedback was solicited either directly via mail surveys, contact with individual aquaculture operators, and workshops or more indirectly through efforts to engage the general public during public hearings and open houses. Respondents reported few stakeholder engagement efforts specifically targeting recreational users with regard to the management of pathogens and AIS. The greater emphasis on engaging bait dealers is likely partly attributable to the fact that stakeholder engagement is more frequently used in the development of regulations than education and outreach programs, and bait dealers are more likely to be targeted by regulations. Bait dealers might also be easier to engage since they are a smaller, more well-defined group than boaters and anglers. Regulations also often directly affect the livelihoods of bait dealers, and their engagement might increase acceptance and compliance with bait regulations and help to achieve a balance between the adoption of regulations and the sustainability of bait dealers' livelihoods.

We also found that learning shaped management in a variety of ways. At one level, learning led to recognition of problems that had to be addressed, and this recognition was often stimulated by the appearance or spread of new pathogens and AIS. After the appearance of VHS, many agencies focused particular attention on developing new regulations to control the import, export, and movement of live bait (e.g., implementation of VHS zones, prohibition of import of VHS-susceptible species of live bait, and movement restrictions of live bait within states). As the

spread of pathogens and AIS continued, organizations recognized the need to target other stakeholders (anglers and boaters, in particular) and to use education and outreach in addition to regulations.

In addition to these broad conceptual shifts that led to the adoption of new management approaches and target groups, learning has resulted in the refinement of particular approaches as organizations gain experience with the effectiveness of different methods. For example, educational messages and recommendations have been modified over time. Initially, educational efforts focused on increasing awareness of pathogens and AIS, but they gradually shifted towards increasing understanding of how pathogens and AIS are spread and how bait dealers and recreational users can reduce their contribution to that spread. Similarly, as the scientific understanding of pathogens and AIS and the vectors that contribute to their spread has advanced, regulations have been refined. Import restrictions for live bait, for example, became less strict whereas regulations for boaters and anglers were extended to include more requirements for boat and equipment disinfection. As communication technology has improved, the audience and media for communicating with target groups has changed (e.g., use of new media, more emphasis on visual messaging, etc.).

Most organizations have also concluded that more consistent recommendations across the basin, through the adoption of national campaigns such as “Habitattitude” and “Stop Aquatic Hitchhikers”, are more likely to lead to behavior change because it would expose target groups repeatedly to the same messages.

Much of the evolution and refinement of approaches to managing pathogens and AIS has been influenced by social learning, or learning that improves relationships and interactions between organizations working on these efforts. Agencies and organizations developed a variety of means to facilitate interaction and collaboration: regional panels, committees, and efforts coordinated by the GLFC. These venues offered opportunities to identify common management issues related to pathogens and AIS across the Great Lakes states, identify common management strategies, standardize educational messages, and share information and data across diverse organizations.

Our social network survey showed that interactions and collaboration among organizations was correlated with the adoption of similar approaches to education and outreach, but not to similar regulations. The decision about whether to proceed with the implementation of jointly developed management strategies remains with the individual states and provinces, which could be one of the reasons why regulations why interactions and collaboration have not led to more similar regulations. Making changes in state or provincial regulations is often very challenging. Regulations are often influenced by political processes that are driven by people outside of management agencies.

Given the important role that collaboration and dialogue has played in the evolution of approaches to managing pathogens and AIS, we expect that it will continue to play an important role as agencies develop approaches to identify the challenges that they maintained they were facing. On one level respondents argued for management they addressed pathogens and AIS more comprehensively by aiming for the prevention of new pathogens and AIS (rather than just minimizing their spread) and targeting vectors (rather than focusing on single species).

Furthermore, collaboration is clearly necessary to address the oft-stated aim of increasing the consistency of both the regulatory and educational approaches being used in the basin.

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## APPENDIX A: INTERVIEW QUESTIONS

1. First, could you tell me what position you hold and how long you've been in that position? How have you been involved with efforts to manage fish pathogens and aquatic invasive species in the Great Lakes region?
2. What are the main management concerns with regard to the spread of fish pathogens and invasive species in the Great Lakes?
3. What do you think are the main factors leading to the spread of fish pathogens and invasive species?
4. I'd like to talk with you now about how your agency's/organization's efforts to combat the spread of fish pathogens and invasive species have changed over time and to learn about the reasons for those changes. When you first became involved in the management of fish pathogens and AIS, what management objectives was your agency/organization trying to achieve?
5. What kind of actions were you taking to address pathogens and invasive species?
6. After that point, how did your efforts to combat fish pathogens and invasive species in the Great Lakes change? How did your management objectives change? How did the actions you were taking to address pathogens and invasive species change? What changes do you think you think will be needed in efforts to combat fish pathogens and invasive species in the future?
7. Is there anything else you would like to add concerning the spread of fish pathogens and aquatic species in the Great Lakes that you think is important for me to know?
8. Who else in your organization/state/province do you think I should interview as part of this study? Who else in other organizations/states/provinces do you think I should interview?
9. Do you have any questions for me before we finish? Are you interested in receiving a copy of the final report? Are there any other individuals or groups you think would benefit from seeing the results of our work?

**APPENDIX B SOCIAL NETWORK SURVEY QUESTIONNAIRE**

1. What organizations do you work for or represent in your efforts to address fish pathogens and/or aquatic species in the Great Lakes region?
2. How frequently have you interacted with the following organizations in your efforts to address fish pathogens and/or aquatic invasive species in the Great Lakes region during the past 5 years? (Circle one number for each item. Skip the question about your own organization.)

- 1=Never interacted
- 2=Rarely interacted (no more than once a year)
- 3=Sometimes interacted (several times a year)
- 4=Frequently interacted (at least once a month)
- 5=Very frequently interacted (at least once a week)

Have you interacted with this organization

|    |  | Never? |   |   |   | Very<br>frequently |
|----|--|--------|---|---|---|--------------------|
| a. | Illinois Department of Natural Resources                   | 1      | 2 | 3 | 4 | 5                  |
| b. | Indiana Department of Natural Resources                    | 1      | 2 | 3 | 4 | 5                  |
| c. | Minnesota Department of Natural Resources                  | 1      | 2 | 3 | 4 | 5                  |
| d. | Michigan Department of Natural Resources                   | 1      | 2 | 3 | 4 | 5                  |
| e. | New York State Department of Environmental<br>Conservation |        |   |   |   |                    |
| f. | Ohio Department of Natural Resources                       | 1      | 2 | 3 | 4 | 5                  |
| g. | Ontario Ministry of Natural Resources                      | 1      | 2 | 3 | 4 | 5                  |
| h. | Pennsylvania Fish and Boat Commission                      | 1      | 2 | 3 | 4 | 5                  |
| i. | Wisconsin Department of Natural Resources                  |        |   |   |   |                    |
| j. | Wisconsin Department of Agriculture                        | 1      | 2 | 3 | 4 | 5                  |
| k. | USDA Animal and Plant Health Inspection<br>Service         | 1      | 2 | 3 | 4 | 5                  |
| l. | Chippewa/Ottawa Resource Authority (CORA)                  | 1      | 2 | 3 | 4 | 5                  |

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(continued from previous page)

|     |   |   |   |   |   |   |
|-----|---|---|---|---|---|---|
| m.  | National Oceanic and Atmospheric Administration | 1 | 2 | 3 | 4 | 5 |
| n.  | US Department of Agriculture                    | 1 | 2 | 3 | 4 | 5 |
| o.  | US Fish and Wildlife Service                    | 1 | 2 | 3 | 4 | 5 |
| p.  | Fisheries and Oceans Canada (DFO)               | 1 | 2 | 3 | 4 | 5 |
| q.  | Transport Canada                                | 1 | 2 | 3 | 4 | 5 |
| r.  | Illinois/Indiana Sea Grant                      | 1 | 2 | 3 | 4 | 5 |
| s.  | Michigan Sea Grant                              | 1 | 2 | 3 | 4 | 5 |
| t.  | Michigan State University Extension             | 1 | 2 | 3 | 4 | 5 |
| u.  | Minnesota Sea Grant                             | 1 | 2 | 3 | 4 | 5 |
| v.  | New York Sea Grant                              | 1 | 2 | 3 | 4 | 5 |
| w.  | Ohio Sea Grant                                  | 1 | 2 | 3 | 4 | 5 |
| x.  | Pennsylvania Sea Grant                          | 1 | 2 | 3 | 4 | 5 |
| y.  | Wisconsin Sea Grant                             | 1 | 2 | 3 | 4 | 5 |
| z.  | University of Wisconsin Extension               | 1 | 2 | 3 | 4 | 5 |
| aa. | Alliance for the Great Lakes                    | 1 | 2 | 3 | 4 | 5 |
| bb. | Great Lakes Fishery Commission                  | 1 | 2 | 3 | 4 | 5 |
| cc. | Great Lakes United                              | 1 | 2 | 3 | 4 | 5 |
| dd. | Ontario Federation of Anglers and Hunters       | 1 | 2 | 3 | 4 | 5 |

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3. Please list any other organization not listed in Question 2 with which you have interacted in your efforts to address fish pathogens and/or aquatic invasive species in the Great Lakes region during the past five years.

4. With which of the following organizations have you collaborated on specific projects to address fish pathogens and/or aquatic invasive species in the Great Lakes region during the past 5 years? Collaborative projects might involve jointly sponsored research, the development of shared goals and objectives, coordination of management actions or evaluation, etc. (*Check all that apply. Skip the item about your own organization.*)

- |    |   |                          |
|----|---|--------------------------|
| a. | Illinois Department of Natural Resources                | <input type="checkbox"/> |
| b. | Indiana Department of Natural Resources                 | <input type="checkbox"/> |
| c. | Minnesota Department of Natural Resources               | <input type="checkbox"/> |
| d. | Michigan Department of Natural Resources                | <input type="checkbox"/> |
| e. | New York State Department of Environmental Conservation | <input type="checkbox"/> |
| f. | Ohio Department of Natural Resources                    | <input type="checkbox"/> |
| g. | Ontario Ministry of Natural Resources                   | <input type="checkbox"/> |
| h. | Pennsylvania Fish and Boat Commission                   | <input type="checkbox"/> |
| i. | Wisconsin Department of Natural Resources               | <input type="checkbox"/> |
| j. | Wisconsin Department of Agriculture                     | <input type="checkbox"/> |
| k. | USDA Animal and Plant Health Inspection Service         | <input type="checkbox"/> |
| l. | Chippewa/Ottawa Resource Authority (CORA)               | <input type="checkbox"/> |
| m. | National Oceanic and Atmospheric Administration         | <input type="checkbox"/> |
| n. | US Department of Agriculture                            | <input type="checkbox"/> |
| o. | US Fish and Wildlife Service                            | <input type="checkbox"/> |
| p. | Fisheries and Oceans Canada (DFO)                       | <input type="checkbox"/> |
| q. | Transport Canada  | <input type="checkbox"/> |
| r. | Illinois/Indiana Sea Grant                              | <input type="checkbox"/> |
| s. | Michigan Sea Grant                                      | <input type="checkbox"/> |
| t. | Michigan State University Extension                     | <input type="checkbox"/> |
| u. | Minnesota Sea Grant                                     | <input type="checkbox"/> |
| v. | New York Sea Grant                                      | <input type="checkbox"/> |

(continued from previous page)

- w. Ohio Sea Grant
- x. Pennsylvania Sea Grant
- y. Wisconsin Sea Grant
- z. University of Wisconsin Extension
- aa. Alliance for the Great Lakes
- bb. Great Lakes Fishery Commission
- cc. Great Lakes United
- dd. Ontario Federation of Anglers and Hunters

5. Please list any other organization not listed in Question 4 with which you have collaborated on projects to address fish pathogens and/or aquatic invasive species in the Great Lakes region during the past five years.

Now we'd like to ask a few questions about your beliefs about factors that lead to the spread of fish pathogens and aquatic invasive species and about the work your organization does to reduce that spread.

6. A variety of factors have been identified that may play a role in the spread of fish pathogens and/or invasive species. Considering all types of fish pathogens and aquatic invasive species, how much do you believe each of the following factors makes to the spread of fish pathogens and/or aquatic invasive species in the Great Lakes?

|   | No contribution | Some contribution | Moderate contribution | High contribution | Very large contribution |
|---|-----------------|-------------------|-----------------------|-------------------|-------------------------|
| a. Ballast water exchange   | 1               | 2                 | 3                     | 4                 | 5                       |
| b. Movement of cargo ships within and between lakes                           | 1               | 2                 | 3                     | 4                 | 5                       |
| c. Open canals  | 1               | 2                 | 3                     | 4                 | 5                       |
| d. Wild fish movement within and between lakes                                | 1               | 2                 | 3                     | 4                 | 5                       |
| e. Food fish industry (selling of live fish)                                  | 1               | 2                 | 3                     | 4                 | 5                       |
| f. Pet and aquarium industry (selling of live fish)                           | 1               | 2                 | 3                     | 4                 | 5                       |
| g. Intentional release of aquarium fish by public                             | 1               | 2                 | 3                     | 4                 | 5                       |
| h. Trade of live fish across state lines                                      |                 |                   |                       |                   |                         |
| i. Stock contamination in aquaculture operations                              | 1               | 2                 | 3                     | 4                 | 5                       |
| j. Stocking of invasive species in aquaculture operations                     | 1               | 2                 | 3                     | 4                 | 5                       |
| k. Insufficient testing in hatcheries and aquaculture operations              | 1               | 2                 | 3                     | 4                 | 5                       |
| l. Infected equipment/facilities in hatcheries and aquaculture operations     | 1               | 2                 | 3                     | 4                 | 5                       |
| m. Insufficient boat drainage and disinfection by anglers before moving boats | 1               | 2                 | 3                     | 4                 | 5                       |
| n. Movement of recreational boats between water bodies                        | 1               | 2                 | 3                     | 4                 | 5                       |
| o. Movement of live bait fish by anglers from one body of water to another    | 1               | 2                 | 3                     | 4                 | 5                       |
| p. Infected fishing equipment   | 1               | 2                 | 3                     | 4                 | 5                       |
| q. Disposal of bait from contaminated bait buckets                            | 1               | 2                 | 3                     | 4                 | 5                       |
| r. Others (please specify)  | 1               | 2                 | 3                     | 4                 | 5                       |

7. Some organizations focus on limiting the spread of pathogens in their work, some focus on limiting the spread of aquatic invasive species, and some focus on both. Please indicate how much emphasis your organization places on limiting the spread of pathogens and aquatic invasive species in its work.

|   | Not an emphasis | Some emphasis | Moderate emphasis | High emphasis | Very much an emphasis |
|---|-----------------|---------------|-------------------|---------------|-----------------------|
| a. Limit spread of pathogens in Great Lakes | 1               | 2             | 3                 | 4             | 5                     |
| b. Limit spread of AIS in Great Lakes       | 1               | 2             | 3                 | 4             | 5                     |

8. Organizations may work to control the spread of pathogens and/or aquatic invasive species by trying to influence the behaviors of anglers and bait dealers. Many of these efforts involve the use of educational activities and/or regulations. How important are each of the following objectives in your organization's regulatory and/or educational effort?

|   | Not important at all | Of little importance | Moderately important | Very important | Don't know |
|---|----------------------|----------------------|----------------------|----------------|------------|
| a. Prevent new infestation of uninfected water bodies   | 1                    | 2                    | 3                    | 4              | 5          |
| b. Prevent import of infected bait from other countries | 1                    | 2                    | 3                    | 4              | 5          |
| c. Prevent trade of live bait fish between states       | 1                    | 2                    | 3                    | 4              | 5          |
| d. Prevent movement of live fish between water bodies   | 1                    | 2                    | 3                    | 4              | 5          |
| e. Protect livelihood of local bait dealers             | 1                    | 2                    | 3                    | 4              | 5          |
| f. Promote recreational fishing                         | 1                    | 2                    | 3                    | 4              | 5          |
| g. Prevent infestation of hatcheries                    | 1                    | 2                    | 3                    | 4              | 5          |
| h. Increase awareness about AIS and Pathogens           | 1                    | 2                    | 3                    | 4              | 5          |
| Reduce spread of pathogens and AIS by bait dealers      | 1                    | 2                    | 3                    | 4              | 5          |
| i. Reduce spread of pathogens and AIS by anglers        | 1                    | 2                    | 3                    | 4              | 5          |
| j. Other (please specify)                               | 1                    | 2                    | 3                    | 4              | 5          |

9. Please identify which of the following educational activities targeting bait dealers and anglers your organization has carried out during the past five years to reduce the spread of fish pathogens and/or AIS .

|    |   | My organization has carried out this action |                       |            |       |            |
|----|---|---|-----------------------|------------|-------|------------|
|    |   | Never                                       | Fewer than most years | Most years | Every | Don't know |
| a. | Educate anglers about aquatic invasive species and their impact on GL fisheries                   | 1   | 2                     | 3          | 4     | 5          |
| b. | Educate boaters and/or anglers about how to prevent the spread of AIS and pathogens               | 1   | 2                     | 3          | 4     | 5          |
| c. | Educate anglers and bait dealers about collection and use of wild fish as bait                    | 1   | 2                     | 3          | 4     | 5          |
| d. | Educate anglers about the possible implications of movement of live bait                          | 1   | 2                     | 3          | 4     | 5          |
| e. | Develop and distribute 'white list' of species that may be used as bait                           | 1   | 2                     | 3          | 4     | 5          |
| f. | Distribute guidelines to hatcheries about pathogen testing/hatchery protocols (HACCP)             | 1   | 2                     | 3          | 4     | 5          |
| g. | Facilitate workshops to educate about test protocols in hatcheries                                | 1   | 2                     | 3          | 4     | 5          |
| h. | Provide online training opportunities and certifications  | 1   | 2                     | 3          | 4     | 5          |
| i. | Promote Habitattitude   | 1   | 2                     | 3          | 4     | 5          |
| j. | Promote Stop aquatic hitchhikers  | 1   | 2                     | 3          | 4     | 5          |
| k. | Provide information on your organization's website about AIS and pathogens                        | 1   | 2                     | 3          | 4     | 5          |
| l. | Distribute factsheets and/or AIS watchcards   | 1   | 2                     | 3          | 4     | 5          |
| m. | Provide new releases (e.g., TV, newspapers, magazines)  | 1   | 2                     | 3          | 4     | 5          |
| n. | Distribute promotional items (e.g., stickers, magnets etc.) that have educational message on them | 1   | 2                     | 3          | 4     | 5          |
| o. | Establish boat ramp signs describing how anglers can prevent the spread of AIS and pathogens      | 1   | 2                     | 3          | 4     | 5          |
| p. | Distribute information via new media (eg Facebook, Twitter) to raise awareness                    | 1   | 2                     | 3          | 4     | 5          |
| q. | Distribute information on AIS and pathogens in different languages                                | 1   | 2                     | 3          | 4     | 5          |
| r. | Other (please specify)  | 1   | 2                     | 3          | 4     | 5          |

10. Please identify which of the following regulations and restrictions your organization currently has in place to reduce the spread of fish pathogens and/or AIS (check all that apply).

- a. Prohibit import of bait from other states to use in your state by bait dealers and anglers
- b. Prohibit importation of bait from other states to export to other states
- c. Prohibit movement of live bait from one lake to another
- d. Prohibit movement of bait out of VHS area/zone
- e. Require VHS testing before bait is imported
- f. Require VHS testing before bait from aquaculture operations can be sold
- g. Require bait certification
- h. Prohibit the sale of wild bait fish that is not tested
- i. Prohibit use of wild bait fish that is not tested by anglers
- j. Prohibit possession and trade of listed aquatic invasive species as bait
- k. Require boat drainage before boats can be moved
- l. Require disinfection of docks and boats before they are moved from an infested water to another lake
- m. Require anglers to empty their live well before leaving a boat launch
- n. Prohibit possession and trade of listed aquatic invasive species as bait
- o. Other (please specify)

**Thank you very much for completing the survey!**