

Research Article

An assessment of angler education and bait trade regulations to prevent invasive species introductions in the Laurentian Great Lakes

Lucas R. Nathan¹, Christopher L. Jerde², Margaret McVeigh² and Andrew R. Mahon^{1*}

¹*Institute for Great Lakes Research, Dept. of Biology, Central Michigan University, Mount Pleasant, MI 48858 USA*

²*Environmental Change Initiative, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556 USA*

*Corresponding author

E-mail: mahon2a@cmich.edu

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Abstract

The commercial bait trade is one pathway for aquatic invasive species (AIS) introductions, as non-target bait species can be accidentally sold to anglers who either inadvertently or intentionally release them while fishing or as excess bait. Prevention of AIS introductions via the bait trade requires a two-tiered management approach, which includes both regulation of the bait industry and angler education. Retail bait shops may offer opportunities for public education regarding AIS, however it is unknown how often shops are targeted for such purposes and how viable this method of angler education is on a temporal scale. The goals of this research were to 1) quantify the current distribution of AIS signage in retail bait shops in the Great Lakes region and 2) estimate the long term viability of using retail bait shops as platform for angler education. Additionally, we present an up-to-date summary of bait industry regulations across the Great Lakes jurisdictions. Of the 525 bait shops visited in 2012 and 2013, 22% displayed some form of AIS educational materials or signage. Additional signs were distributed during initial visits and, during revisits after one calendar year, 54% of shops still displayed the provided signage. The presented summary of bait regulations for Great Lakes jurisdictions indicates multiple discrepancies across the region, which may hinder successful management strategies. Future management goals should consider additional methods of angler education and coordinating regulations across the Great Lakes to improve upon AIS prevention.

Key words: Aquatic Nuisance Species, outreach, education, management, prevention

Introduction

The transportation of aquatic invasive species (AIS) is often facilitated intentionally or unintentionally by anthropogenic activities (Mills et al. 1993). The commercial bait trade represents one potential pathway for AIS introductions as non-target bait species are often sold to anglers as unwanted contaminants (Litvak and Mandrak 1993; LoVullo and Stauffer 1993; Ludwig and Leitch 1996; Nathan et al. 2014). Following in-store purchase, AIS may be transferred within or across watershed boundaries and released by anglers during fishing or as excess bait either inadvertently or intentionally. Although regulations prohibit such actions, over 40% of anglers may regularly dispose of their unwanted bait in surrounding waters based on their misunderstanding of the regulations, apathy or the misconstrued conception that such actions may be beneficial to native ecosystems (Kilian et al. 2012; Litvak and Mandrak 1993).

Preventing invasive species introductions in the bait trade requires a multifaceted approach that encompasses both regulatory control and educational programs (Kerr et al. 2005; Litvak and Mandrak 1993). Currently, regulations are in place in some localities to reduce AIS bait trade introductions by limiting the allowable bait species, bait capture techniques, importation, and transportation of bait stocks. These regulations are designated by the governing state and often vary considerably across jurisdictional boundaries, which have been highlighted by previous summaries (Dunford 2012; Meronek et al. 1995). Regulations are a dynamic entity, however, which justifies the need for repeated updates to region wide summaries.

Despite regulatory efforts, the potential for bait stock contamination remains, thus justifying the need for complementary programs to educate anglers, retailers and wholesalers about AIS issues. Direct handling of bait stocks by wholesalers and retailers is minimized to reduce stress and

mortality of bait organisms, which limits the capacity to detect contaminate species (Drake and Mandrak 2014; Gunderson and Tucker 2000). Therefore, increasing the awareness of anglers to problems associated with invasive species and the general threat of releasing live bait could help reduce unintentional introductions. The lack of angler, retailer, and even wholesaler awareness remains one of the largest barriers to AIS management and is a key component of future management goals (ANSTF 2013; Gunderson 1994). As many as 97% of retailers are unfamiliar with the species identity they are selling, which is a substantial gap in the management of the bait industry (DiStefano et al. 2009). In addition, historical surveys have indicated that over 50% of anglers are unfamiliar with regulations regarding the use and disposal of bait (Litvak and Mandrak 1993). Despite these overwhelming statistics, evidence has demonstrated the effectiveness of educational programs at improving angler awareness of AIS issues and baitfish regulations (Gunderson 1994; Smith 2013).

The most common methods of angler education routinely include signs at boat access points, regulation books, outdoor magazines, or online resources to distribute AIS information (Gunderson 1994; Kulwicky et al. 2003). Over 90% of anglers who use live bait purchase it from retail bait shops, presenting an excellent opportunity for retailers to provide anglers with information regarding AIS awareness and prevention, yet this method of education is highly underutilized (Kulwicky et al. 2003). Although many bait retailers are willing to provide AIS information to customers, very few have the available resources required to do so (Keller et al. 2007; Kulwicky et al. 2003). Such limitations in the education and outreach efforts may hamper successful AIS management objectives. Identifying these informational gaps and targeting specific user groups are among key future AIS management goals (ANSTF 2013).

To produce effective management objectives and strategies related to angler education and outreach, it is imperative to determine the status and practicality of current education methods. To our knowledge there have been no studies that have served to measure the retention rate in retail establishments of AIS educational signage (i.e. signs, posters, stickers, pamphlets, etc.), a common form of angler education. In this study we documented AIS signage and other information material in retail bait shops while distributing our own signage to calculate retention rates after

a calendar year. The objectives of this study were to 1) quantify the current use of bait shops as a platform for angler education and 2) estimate the long-term viability of using retail bait shops for angler education. Additionally, we have compiled an up to date summary of bait industry regulations in the Great Lakes states and Ontario. This research serves to identify key obstacles to successful AIS prevention with a goal of improving upon current management practices.

Methods

Retail bait shops in the Laurentian Great Lakes region (all Great Lakes States; MI, IL, IN, WI, MN, PA, NY) were targeted for AIS signage observation and distribution based on the sale of live minnows (Nathan et al. 2014). A total of 525 unique bait shops were visited during the summer and fall months of 2012 and 2013. During initial visitations, general observations were made regarding the presence or absence of AIS signage or informational material. These included posters, stickers, informational pamphlets, or any other form of AIS angler education. Additionally, during the initial shop visits, AIS Stop Aquatic Hitchhikers (SAH) signs were distributed to all accepting retailers (Appendix 1). The signs offered information to anglers regarding ways to prevent the spread of AIS as well as descriptions of likely bait contaminants specific to the state. In a number of shops, signs were posted immediately, while in others, signs were simply left with the retailer under the assumption that they were subsequently posted.

To estimate the retention of signs, 25% of shops were randomly selected for re-visitations one year after initial visits, stratified by state and whether signs were posted immediately or handed out to retailers. A total of 135 shops were revisited across IL, IN, MI, OH, and WI. During revisits, shops were entered and visible SAH signs were documented to estimate the retention rates of AIS education materials displayed in retail bait shops. Chi squared and Fisher's exact tests were performed in R V3.02 with a significance value of 0.05 to determine if retention rates varied between states and whether signs were posted immediately or handed out to retailers (R Core Team 2013). If voluntarily provided during the revisit, responses from retailers regarding the status of the signs were recorded.

Regulatory control over the Great Lakes region bait trade is an important component of invasive

species prevention and management. We reviewed and summarized multiple bait trade regulations including the allowable bait species, licensing requirements, importation, personal transportation, and disposal of live bait. Regulations were gathered from 2013 fishing regulation handbooks and online resources provided by the governing jurisdictions (Table S1).

Results and discussion

Existing signage

During our initial 525 visits in 2012 and 2013, 116 (22%) shops had some form of signage regarding AIS education (Table 1). Illinois-Indiana Sea Grant's 'Don't dump your bait' stickers, SAH signs and stickers, and Asian carp (*Hypophthalmichthys* sp.) posters were the most common forms of AIS signage (Appendix 1). In particular the IL-IN Sea Grant stickers placed on bait buckets by retailers appeared to be the most common or potentially the most desirable form of outreach materials for retailers because it was an easy method of education and provided them something to distribute to the anglers. This also appeared to be one of the most practical methods of outreach, as anglers would be reminded consistently while using live bait, specifically at the moment when the dumping of bait would occur.

The frequency of AIS signage varied considerably across the region (Table 1; Figure 1). The Western Great Lakes states had the highest percentages of shops with signs on display, as 44% of shops in Minnesota, Wisconsin, and Illinois had AIS signage whereas only 3% of Pennsylvania, New York, Ohio, and Indiana shops displayed some form of AIS education. Such trends in AIS signage are reflective of the emphasis placed on AIS education and outreach campaigns by individual states across the region, with states such as Minnesota and Wisconsin being the fore runners in the development of AIS outreach programs such as the Stop Aquatic Hitchhikers campaign (D. Jensen, MN Sea Grant, personal communication). Specific efforts directed towards retail bait shops have seen increases in recent years in states such as Wisconsin, which has also aided in the statewide distribution of AIS signage (Shaw and Howell 2011).

The types of signage observed also varied considerably across the region, as evidenced by the high occurrences of Asian carp signage in Illinois, where carp are abundant in many areas of the state and where future spread is a pressing

concern. Stop Aquatic Hitchhiker material, on the other hand, was most commonly documented in Minnesota and Wisconsin (Table 1), states known for their SAH campaign efforts (D. Jensen, MN Sea Grant, personal communication). Such variation indicates that individual states have the ability to choose what forms of signage are being distributed in their retail bait shops. Although this type of regional variation can be beneficial because of the localized threats (e.g., Asian carp in Illinois), the inconsistency of total AIS signage across the region as a whole is a concern for region-wide educational goals.

On the region-wide scale, the low percentage of bait shops displaying AIS signage remains a potential obstacle to successful management. Although bait shops represent an ideal setting for direct angler interactions and education opportunities, they remain largely underutilized for improving upon current AIS outreach efforts. Historically, AIS signage programs have focused on introductions of species such as dreissenid mussels and Eurasian water milfoil (*Myriophyllum spicatum*) via recreational watercrafts, however the threat of high-risk invasive species being transported via the bait trade pathway (Nathan et al. 2014) demonstrates the need for increased focus towards retail bait shops.

Sign retention

Of the 135 bait shops that were revisited in 2013, 73 (54%) had the sign displayed that was distributed one year prior (Table 3). On a per state basis most averaged a near 50% sign retention rate, with no significant differences between states (Table 3; $X^2=3.85$, $df=4$, $P=0.426$) or between shops that had signs hung immediately versus those that were handed out to retailers during initial visitations (Table 3; P -value = 0.728, Fisher's exact test). Additionally, there was no significant difference in retention rates between those that had existing signage or a lack thereof (Table 4; P -value = 0.443, Fisher's exact test). Therefore, based on these findings, the retention of signs appears to be heavily dependent on retailer discretion, and the relatively moderate rate indicates that many bait retailers are reluctant to display AIS outreach materials in their shops. Although 90% of retailers have suggested their interest in communicating with anglers regarding AIS information (Kulwicki et al. 2003), our results imply a lower percentage of such retailers, at least in regards to signage display. Some retailers volunteered explanations regarding the missing signs, while almost half of

Figure 1. Percentages of retail bait shops displaying existing AIS signage and educational materials during initial visits in 2012 and 2013.

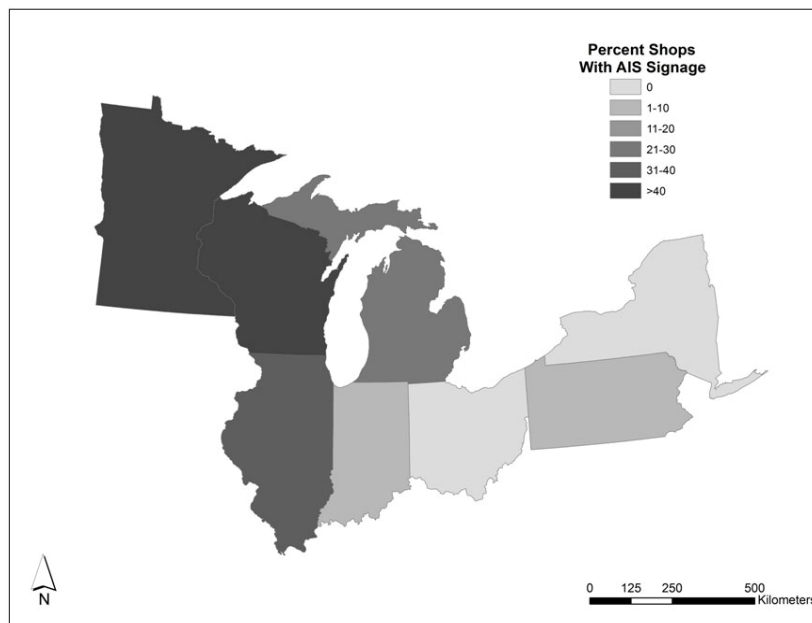


Table 1. Types of signage observed in Great Lakes region retail bait shops during 2012 and 2013 surveys. Some shops had more than one form of signage, making the sum of signage types greater than the total signage.

State (# shops)	Asian Carp (%)	Sea Grant Stickers (%)	Stop Aquatic Hitchhiker (%)	Viral Hemorrhagic Septicemia (%)	Other (%)	Any signage (%)
IL (32)	8 (25.0)	3 (9.4)	3 (9.4)	0 (0.0)	1 (3.1)	12 (37.5)
IN (37)	0 (0.0)	0 (0.0)	1 (2.7)	0 (0.0)	1 (2.7)	2 (5.4)
MI (302)	20 (6.6)	51 (16.9)	4 (1.3)	10 (3.3)	4 (1.3)	66 (21.9)
MN (24)	0 (0.0)	0 (0.0)	11 (45.8)	0 (0.0)	1 (4.2)	12 (50.0)
NY (41)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
OH (43)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
PA (10)	0 (0.0)	0 (0.0)	1 (10.0)	0 (0.0)	0 (0.0)	1 (10.0)
WI (52)	0 (0.0)	2 (3.8)	14 (26.9)	9 (17.3)	7 (13.5)	22 (42.3)
Total (525)	28 (5.33)	56 (10.67)	34 (6.58)	19 (3.62)	14 (2.67)	115 (21.90)

Table 2. Voluntary responses from bait retailers during repeat visitations regarding the missing sign distributed during 2012 and 2013 bait shop initial visitations.

Response	Number (%)
None/Didn't remember receiving sign	27 (43.5)
Business closed/Moved/New owner	8 (12.9)
Didn't remember receiving sign, asked for another in revisit	6 (9.7)
Was posted, removed for unknown reasons	5 (8.1)
Was posted, removed due to wear	5 (8.1)
Already had other signs up or received new AIS signs to post	4 (6.5)
Unsure, handed out stickers	2 (3.2)
No room to display	2 (3.2)
Doesn't like to keep posters	1 (1.6)
Doesn't keep posters over one year	1 (1.6)
Had sign, but not posted	1 (1.6)
Total	62

Table 3. The number and percentages of Stop Aquatic Hitchhikers (SAH) signs that remained posted in 135 revisited shops after one year. Shops were selected for revisits, stratified by state and whether signs were posted immediately during initial visits or handed out to retailers.

State	Sign Posted Immediately		Sign Handed Out		Total Revisited Shops	
	# Revisited shops	Signs posted (%)	# Revisited shops	Signs posted (%)	# Revisited shops	Signs posted (%)
IL	7	5 (71)	13	9 (69)	20	14 (70)
IN	10	3 (30)	10	6 (60)	20	9 (45)
MI	29	18 (62)	31	16 (52)	60	34 (57)
OH	1	0 (0)	12	6 (50)	13	6 (46)
WI	10	6 (60)	12	4 (33)	22	10 (45)
Total	57	32 (56)	78	41 (53)	135	73 (54)

Table 4. Retention rates of Stop Aquatic Hitchhikers (SAH) in Great Lake retail bait shops one year after distribution, grouped based on the presence of existing signage.

	Sign posted (%)	Sign not posted (%)	Total
Had Previous Signage	23 (60)	15 (40)	38
No Previous Signage	50 (52)	47 (48)	97
Total	73	62	135

them simply claimed that they didn't recall receiving the sign. Other reasons for absence of signs included the closing or relocating of businesses, signage wear, or lack of space to display given signs (Table 2). The low retention rates of signage may perhaps suggest that retailers would prefer other methods of angler education that do not require the posting of AIS signage, but additional studies or surveys would be required to support this claim.

The moderate retention rate of shop signage (54%) raises concern over the efficacy of displaying signage at retail bait shops as a method of AIS prevention. In order to maintain signage in bait shops yearly distributions may be required and, although it is an excellent resource for angler education, the cost associated with such signage may not be a long-term solution for management purposes. At an estimated cost of \$150 per day in distribution costs and \$3.50 per sign, yearly costs for delivering 525 signs would be roughly \$9,700 (estimated using 2012 expense data). These estimates are based on our methods of delivery, which consisted of two technicians delivering signage from two central locations in the Great Lakes region. A more time and cost efficient method of delivery could be used if multiple individuals or agencies across the region were involved. Distributing signs via mail shipments would likely be a much more viable method of distribution, but it is uncertain how retention rates may compare to signs that were hand delivered. Regardless of the distribution method, the costs associated with

signage as a form of angler education may not be justifiable if signs do not remain posted for anglers to observe. Additionally, although this work gives insight towards the retention rate of AIS bait shop signage, further research may be required to gauge the true effectiveness of such signage. Although a sign may remain posted over a year's time it does not necessarily mean that anglers took notice of the sign or retained information detailed by the sign. Recent angler surveys have indicated anglers seem to be receptive of bait shop signage, with similar region wide trends observed in our signage observations; in states with higher rates of observed bait shop signage, more anglers reported gaining AIS information from bait shops (D. Jensen, MN Sea Grant, personal communication). Despite these findings, it is still unknown how effective such signage is at improving anglers' awareness of AIS issues and if signage improves their knowledge of bait regulations or regulation compliance.

With questions surrounding the efficacy and effectiveness of bait shop signage, additional outreach strategies may be warranted to increase AIS angler awareness. Interacting with bait retailers on a personal level may improve their commitment to AIS education promotion and thus improve the retention of AIS signage and overall effectiveness of outreach programs (Shaw and Howell 2011). Additionally, providing other educational materials in addition to signs and posters, specifically products that can be taken by anglers (e.g., stickers, keychains, etc.), is one method that has already been recommended and

employed by some Great Lakes states (Shaw and Howell 2011). Placing stickers on bait buckets before selling them to anglers was a technique frequently observed during our retail shop visits and such strategies seem to be advantageous from a methodological standpoint, as anglers would be reminded of bait regulations frequently during use. Other methods, such as online resources, billboards, signs at boat landings, and regulation handbooks remain alternative options for angler education, and the most effective method would most likely be a combination of these strategies which present multiple opportunities for anglers to become aware of AIS related issues. Future emphasis should be placed on strategies that target specific user groups to provide the most appropriate source of information for the given AIS pathway.

Regulations

The species allowed for live bait use varies considerably across the Great Lakes states and Ontario (Tables S2–S4). Each state defines what species constitute legal bait fish, as well as a list of species prohibited from possession or use as bait. Anglers must therefore utilize both resources in order to determine what species are allowed for bait use. Two jurisdictions, New York and Ontario, have adopted specific lists (i.e., white or green lists) of legal bait species, making all others illegal for use as bait (Table S3). Of the 57 total species listed between the two jurisdictions, only 13 (23%) are included on both lists. A notable difference is the listing of threespine stickleback (*Gasterosteus aculeatus*), a species with invasive status in the Great Lakes, on the Ontario permitted species list. In addition to listing legal bait species, states also specify certain species that are illegal to possess or use as bait (Table S4). These are categorized into prohibited species (i.e., illegal to possess, import, purchase, transport, or release), regulated species (i.e., legal to possess, purchase, and transport, but illegal to release in public waters), and those that are specifically illegal for bait use. In total 33 species are prohibited in at least one state, but only nine of them are prohibited across all states. Goldfish (*Carassius auratus auratus*) and common carp (*Cyprinus carpio*) are examples of species not allowed for bait use, as six states prohibit the use of these species as bait, specified in their fishing regulation handbooks. Of concern, however, is that two states allow the use of goldfish as bait

despite its status as a non-native species present in retail bait stocks (Nathan et al. 2014).

With the exception of Ontario and Minnesota, all other Great Lakes jurisdictions allow some importation of live baitfish (Table S5). Importation regulations commonly require health certifications to document that the stocks are free of harmful viruses and diseases, such as Viral Hemorrhagic Septicemia (VHS). Regulations directed towards preventing the transfer of AIS, on the other hand, are much less common. Many states have adapted the Hazard Analysis and Critical Control Point (HACCP) education and training program in an attempt to reduce AIS transportation (Gunderson and Kinnunen 2002), although only Illinois specifically addresses the requirement in their regulations. Importation of bait stocks from areas outside of the Great Lakes basin are of increased concern due to the presence of invasive species not currently established in the basin (i.e., Asian carp in the Mississippi River basin). Such importations have led to detections of invasive species DNA in bait stocks, highlighting the importance of regulatory control to prevent future invasions (Nathan et al. 2014).

The licensing requirements required to become a bait dealer vary across jurisdictional boundaries (Table S6). Many states have particular licenses for retail or wholesale bait dealers and some have additional permit requirements for bait harvest and transportation. The costs associated with a retail bait dealer license ranges from \$2 to \$50 in the US states and up to \$133 (converted to USD) for an Ontario commercial bait license. Over half of bait trade sales may involve interstate exchanges (Meronek et al. 1995), making these inconsistencies problematic for region-wide management.

Angler transportation of live minnows has variable regulations across the Great Lake's jurisdictions (Table S7). Transportation of angler-harvested minnows have more stringent regulations when compared to bait purchased from a retail dealer. Most states do not allow the transportation of minnows away from the waterbody they were harvested if collected by anglers, whereas minnows purchased from certified dealers can often be transported away from a waterbody, if certain stipulations are met. For example, this can require a certain VHS certification status (e.g., Michigan), a receipt is in possession from the retailer (Michigan and New York), no water was added from the surrounding waterbody (Wisconsin), or the water is exchanged with bottled or tap water (Minnesota). Pennsylvania was the only state to

address species-specific regulations, where species may not be transported to a watershed where they are not permanently established. Although this regulation is designed to prevent the further spread of non-native species, it requires anglers to reliably identify all potential species which may not always be possible without sufficient angler knowledge or awareness. These variations in transportation regulations across the jurisdictions may hinder region-wide management and angler compliance, particularly for some anglers that may travel between jurisdictions for recreational fishing opportunities.

Disposal or release of live bait in public waters is prohibited in every Great Lake state and Ontario (Table S8). Information regarding such actions is provided in every regulation handbook. There are still considerable discrepancies across the jurisdictions, as the contexts in which the regulations are presented vary. Some clearly state that it is illegal to release excess bait into the surrounding waterbodies and describe proper disposal methods listed with other bait regulations. Others provide information regarding aquatic invasive species and state that live introductions are prohibited. Although this provides the necessary information, an angler searching for bait regulations may not care to read about invasive species and thus, not read about the release or disposal regulations. Such discrepancies could lead to angler confusion and non-compliance, and further contribute to the already existing problem of anglers disposing of live bait in surrounding waterbodies (Litvak and Mandrak 1993; Kulwicki et al. 2003; Kilian et al. 2012).

Conclusions

Management objectives and strategies often involve both regulatory control and educational programs with the goal of preventing the introduction and spread of AIS (Kerr et al. 2005; Litvak and Mandrak 1993). Although regulations are in place to limit the potential introductions through the bait industry, the potential exists for AIS to be accidentally captured during bait harvests, and, due to imperfect detection capabilities, sold unknowingly to anglers (Litvak and Mandrak 1993; LoVullo and Stauffer 1993; Ludwig and Leitch 1996; Drake and Mandrak 2014; Nathan et al. 2014). These occurrences highlight the need for complementary educational and outreach programs to help raise angler and retailer awareness of the problems associated with AIS. Although such programs are on the rise, many anglers and retailers remain

ill-informed of regulations and AIS issues (DiStefano et al. 2009). The results presented here indicate potential room for improvement of the status quo for management of the Great Lakes bait trade. First, our survey results suggest retail bait shops remain an underutilized opportunity for angler education. This may not necessarily be due to lack of signage distributions, however, as roughly 50% of AIS signage may not remain posted for more than a year. Further consideration should be given to the most appropriate methods of angler education from both a cost and operational standpoint. Addition research may be warranted to evaluate the overall effectiveness of specific strategies at improving angler AIS awareness and regulation compliance. Second, our summary of the bait trade regulations identified multiple discrepancies between jurisdictions, which could potentially weaken region wide management strategies. These inconsistencies may present issues not only in terms of successful AIS prevention, but also by way of angler compliance and comprehension. Interstate coordination to produce cohesive region wide regulations should be considered a high priority to improve upon existing AIS prevention. The results presented here should aid in the development and improvement of future management goals to limit the potential for further introduction and spread of aquatic invasive species.

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Supplementary material

The following supplementary material is available for this article:

Appendix 1. Examples of aquatic invasive species (AIS) signs distributed to retail bait shops during this study (a), signs observed during shop visits (b), and stickers observed during visits (c).

Table S1. References used for Great Lakes bait trade regulation summaries.

Table S2. State specific bait fish definitions, obtained from fishing regulation handbooks and online resources.

Table S3. Fish species allowed for live bait use (x) or allowed for bait use in restricted areas (r) in New York and Ontario. Information obtained from 'white' and 'green' lists in fishing regulation handbooks.

Table S4. Fish species prohibited (x), regulated (r), or illegal for live bait use (b) in the Great Lakes states and Ontario.

Table S5. Regulations regarding the importation of live baitfish in the Great Lakes states and Ontario.

Table S6. Licenses required by Great Lakes states and Ontario to harvest, sell, or distribute live bait.

Table S7. Regulations regarding personal transportation of live baitfish in the Great Lakes states and Ontario, obtained from the 2013 fishing regulation handbooks.

Table S8. Regulations regarding disposal of live baitfish posted in the Great Lakes states and Ontario, obtained from 2013 fishing regulations handbooks.

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