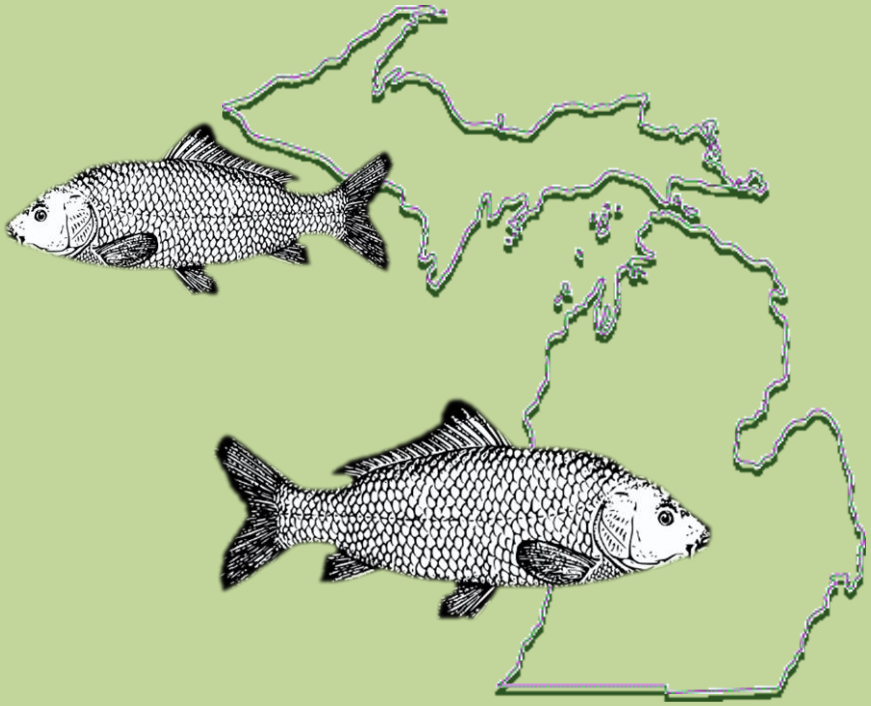
Informing the Debate

Michigan Applied Public Policy Brief

Michigan Citizens' Response to Aquatic Invasive Species Threats



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About the Michigan Applied Public Policy Briefs

Informing the Debate

The paper series, Informing the Debate, is generated out of grant-funded, policy-relevant research sponsored by the Institute for Public Policy and Social Research (IPPSR).

The IPPSR program, Michigan Applied Public Policy Research Program or MAPPR, generates research on current issues held in urban communities with special attention to Michigan. Policy researchers author summary briefs of their research outcomes and their implications. The funded research projects and related policy briefs focus on main headings of discussion being held in the policy arena.

When developing the paper series initiative in 1992, the topics of the papers were submitted following a two-day meeting with leaders from the business sector, nonprofit agencies, foundations, and university faculty and staff. That group evolved into the Urban Research Interest Group.

The Urban Research Interest Group recognized the pressure on urban core leaders to make critical decisions that continue to impact people long into the future. A commitment to generating background research to add to the core of debate on possible solutions to complex, urban problems was made.

The expected outcomes of the paper series include discussion that fosters and strengthens multidimensional connections between the policy, academic, and practitioner community. The series continues to cultivate research interest in policy-relevant issues for consideration of decision makers in urban communities.

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Informing the Debate

MAPPR Policy Research Brief

Michigan Citizens' Response to Aquatic Invasive Species

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ABOUT THE RESEARCH

Abstract

Public opinion about aquatic invasive species can relate to perceptions of those species' impact on human livelihood and recreational activity. This study aimed to identify risk perception and public support for various aquatic invasive species (AIS) management strategies; we conducted an internet-based survey of 500 randomly selected Michigan residents during November 2014. Most respondents believed over the next five years that efforts should be made in Michigan to reduce the population of Asian carp. Risk perceptions were generally high. Responses were varied about how willing an individual would be to take no action, catch and release a carp elsewhere, or call authorities and either file a report, set up a physical barrier or lethally poison the fish. Results indicate opportunity exists to increase Michigan residents' awareness and understanding about AIS policy, particularly policies designed to prevent AIS introductions.

Policy Implications

Four policy implications emerge from this research. First, consensus among the Great Lakes States on Aquatic Invasive Species management is critical. Second, research on the long term impact of AIS on the Great Lakes is imperative given that the Great Lakes contain more than 20 percent of the world's freshwater supply, more than 80 percent of North America's freshwater, and substantial recreational fisheries. Third, public engagement and public understanding of AIS is crucial to any AIS management effort. Finally, research presented here indicates the public's preference for reporting AIS sightings to authorities and erecting

"...public engagement and public understanding of AIS is crucial to any AIS management effort."

physical barriers to AIS entry to the Great Lakes, rather than management by lethal poisoning of the AIS after their introductions.

BACKGROUND

What is an Aquatic Invasive Species (AIS?)

Non-native species are introduced to new ecosystems intentionally or unintentionally. Intentional introductions may be intended for aquaculture, pets, sport fishing, or bait. Other species introductions are accidental, including attachment to vessels moving from one system to another or insufficient barriers to prevent species from entering a new system on their own (Kolar and Lodge, 2002).

"Worldwide, invasive species have substantial ecological and economic impacts."

Introduced species have varying abilities to establish themselves in the new ecosystem, depending on their ability to adapt to new climate, food sources, and other environmental conditions. Once established, these non-native species may have positive and/or negative impacts on their new surroundings. They may compete with native species for scarce food resources, or they may themselves *serve* as new food sources for native species or local human communities (Pejchar and Mooney, 2009).

Worldwide, invasive species have substantial ecological and economic impacts. One study estimated the United States suffers from approximately $120 billion in annual damages from terrestrial and aquatic invasive species (Pimentel et al., 2005); over $5 billion of which is concentrated in Great Lakes aquatic ecosystems (Pimentel, 2005). Great Lakes commercial and sport fishing industries are burdened with $4.5 billion of this total loss (ibid).

The Michigan Department of Natural Resources (MDNR) defines invasive species as "non-native species that have the potential to become established and the potential to spread widely and cause ecological or economic harm or pose a risk to human health." Introduced species are **only** considered to be invasive if they:

- have the ability to establish themselves, and
- cause harm in a new ecosystem.

Therefore, AIS assessments account not only for a species' presence in an ecosystem, but also the suite of potential risks the AIS poses to its "new" surroundings.

Managing AIS-related Risks

Michigan, along with other Great Lakes Basin states and provinces, has a long history living with AIS. Over 180 non-native aquatic species are present in the Great Lakes today (Great Lakes Fishery Commission, 2015). The substantial ecological and economic damages caused by AIS– characterized by some as natural disasters (Ricciardi et al., 2011) – suggest a need for risk assessment and management. Two of the most insidious AIS in the Great Lakes are zebra mussels and sea lamprey. Although eradication, containment, and control – as in the sea lamprey case – may mitigate damages, scientists consider preventing introduction to be a more successful, sustainable, and cost-effective approach to coping with AIS-related risks (Convention on Biological Diversity - Subsidiary Body on Scientific Technical and Technological Advice, 22 October 1999).

As a result, to the extent possible, it is important to block AIS introductions rather than enduring adaptation efforts (Leung et al., 2002; Cudmore et al., 2012).

Numerous techniques have been developed for assessing invasive potential before AIS are introduced and continuing to monitor to ensure that the most threatening species have not invaded a new ecosystem. Although such risk analyses were previously conducted with qualitative expert assessment, statistical studies have more recently been used to identify which species are likely to pose the greatest risk of establishment and harm (Kolar and Lodge, 2002). For example, the Midwest Invasive Species Information Network (www.misin.msu.edu) is a regional effort developed to provide an early detection and rapid response resource for invasive species. The network relies on both experts and citizen science, facilitates online and smart phone invasive species reporting, and utilizes state-of-the-art Geographic Information Systems and spatial statistics to map invasive species spread. Once a species has been identified as posing an ecological or economic risk, various preventive policies and programs can be pursued. MISIN also continues to monitor success at preventing introduction of the most concerning non-native species. These and other techniques are constantly evolving, with environmental DNA detection serving as an important way to identify the spread of particular species within an aquatic range (Jerde et al., 2013).

Non-native aquatic species have a long history in the Great Lakes. Although some introduced species provide more benefit than harm and therefore are not deemed to be "invasive," others like zebra mussels have caused extensive harm and exemplify why people care so much about AIS. The latter are present in every one

of the Laurentian Great Lakes (National Wildlife Federation), competing with native species for plankton resources and clogging intake pipes among other impacts (Pejchar and Mooney, 2009). A food source for some native species, zebra mussels also compete for food with other native species and damage municipal water supplies and treatment facilities (ibid.). Connelly et al. (2007) estimate $267 million in resulting costs to North American electric generation and water treatment facilities during 1989-2004. These costs include lost production and revenues, as well as expenditures for zebra mussel control or prevention.

Sea lampreys have been present in the Great Lakes since the 1800s, expanding beyond Niagara Falls in the early 1900s with the advent of improved canal shipping. In their native Atlantic Ocean, parasitic lampreys do not kill host species that have co-evolved to survive lamprey attacks. Great Lakes species, however, have not evolved to survive such parasitic action. Instead, a wide range of Great Lakes fishes die – or suffer health declines – from sea lamprey bites. As a result, the Great Lakes fish catch declined severely by the late 1940s (Great Lakes Fishery Commission, 2015), dramatically impacting a fishery now valued at $7 billion annually. Today, sea lampreys are controlled through a variety of chemical and physical interventions to reduce their impact on the fishery (Great Lakes Fishery Commission, 2015); Great Lakes lamprey control is estimated to cost over $10 million per year on average (Lovell and Stone, 2005).

ASIAN CARP

Asian carp have been identified as a group of species with the potential to cause extensive harm in the Great Lakes. At least four Asian carp species are AIS of concern to the Great Lakes Basin:

- Bighead Carp *(Hypophthalmichthys nobilis)*,
- Black Carp *(Mylopharyngodon piceus)*,
- Grass Carp *(Ctenopharyngodon idella)*, and
- Silver Carp *(Hypophthalmichthys molitrix)*.

Silver and Bighead Carp, collectively known as the bigheaded carps, have thrived in the Mississippi River system since the 1970s when they were intentionally introduced to control algae in southern aquaculture ponds. The carp then escaped the river and migrated through water channels. These carp now pose concern for future Great Lakes invasion and their impact (Stern et al., 2014). Asian carp's rapid reproduction rate and large size may bring on fast territorial establishment and ecosystem dominance (National Oceanic and Atmospheric Administration; Great Lakes

Fishery Commission, 2012; Cudmore et al., 2012). Today, in some areas of the Mississippi River Basin, these AIS have come to completely dominate their adopted ecosystem, now representing 97% of the fish biomass (Hansen).

If they become established in the Great Lakes, there are concerns that Bighead and Silver Carp would outcompete native fish for access to plankton. Although they are not yet established in the Great Lakes, bigheaded carp DNA has been found in Lake Erie and the Chicago Area Waterway System (CAWS) that feeds into Lake Michigan (Jerde et al., 2013). Various barriers – particularly the CAWS electric barrier system – have thus far prevented their migration into the Great Lakes. However, one dispersal model suggests that Bighead and Silver Carp could establish lake populations with a small initial number of individuals, provided they have access to sufficient rivers for spawning (Cuddington et al., 2014). At least some of the rivers flowing into Lake Erie have conditions that would support such spawning activity (Kocovsky et al., 2012; Cudmore et al., 2012), while other Great Lakes tributaries have not yet been specifically assessed. This model, however, is conditional on reproductive characteristics of the individual animals that are able to circumvent containment barriers (Cuddington et al., 2014), meaning that substantial species establishment would require somewhat ideal conditions. Bays and nearshore habitats may provide the best temperature and food resources for bigheaded carp survival and reproduction (Cudmore et al., 2012).

"If they become established in the Great Lakes, there are concerns that Bighead and Silver Carp would outcompete native fish for access to plankton."

Other models demonstrate that, although Asian carp may establish Great Lakes breeding populations, they may be confined to specific regions of the lakes due to temperature and food supply (Cooke and Hill, 2010; National Oceanic and Atmospheric Administration), limiting their interaction with most native aquatic species. Nonetheless, the potential economic and ecological vulnerability of the Great Lakes to such an invasion is substantial enough to justify action even if the threat of establishment is unlikely (Cooke and Hill, 2010). Furthermore, a new study suggests that algal blooms, such as those in Lake Erie, may provide additional food options for Bighead and Silver Carp, thereby raising the likelihood of establishing and sustaining an invasive population (Anderson et al., 2015).

If Asian carp establish themselves in the Great Lakes, native mussels and other invertebrates may face particular risk (Stern et al., 2014). Planktivorous species – and their predators such as Lake Trout – also may suffer from food shortages because bigheaded carp diets are forecast to result in "dramatic changes in planktonic composition" (Cudmore et al., 2012). Damages also could extend beyond decline in valuable fish populations to

include impacts on recreational boating and degraded habitat for hunted and/or migratory waterfowl (Stern et al., 2014). Finally, although bigheaded carps do not pose a direct predatory threat to humans, Silver Carp are known to leap out of the water when disturbed by nearby vibrations. Boaters in other regions have been physically injured by leaping carp, increasing the dangers of fishing excursions, and taking away from the relaxation and enjoyment of fishing experiences (Michigan Department of Natural Resources (MDNR), 2012).

A 2012 risk assessment found concerns along these lines, with increasing threat over time for the entire fishery, but limited understanding of particular species that would be threatened by food and/or habitat competition with invasive carp species (Cudmore et al., 2012). Another recent study found that Bighead and Silver Carp, if established in Lake Erie, would likely coexist with commercially or recreationally targeted fish despite substantial new populations (Wittmann et al., 2015). Additional research is necessary to refine expected impacts, and therefore respond to possible Asian carp establishment.

POLICY AND PROGRAMATIC RESPONSES TO ASIAN CARP AND OTHER AIS IN THE GREAT LAKES

Michigan Action

The Michigan Legislature has addressed both terrestrial and aquatic invasive species primarily through the Natural Resources and Environmental Protection Act (NREPA) of 1994 (amended multiple times since), Chapter 324, Part 413 of the Michigan Compiled Laws. All four Asian carp species are listed as prohibited under §324.41301. Prohibited species cannot be knowingly possessed (§41303), or introduced (§41305), into state waters. There are exceptions to these rules, with possession allowed for research or assessment purposes, and individual introductions allowed if the MDNR approves a permit application. Furthermore, any species that are not explicitly listed as permitted aquatic species may not be imported, sold, or offered in Michigan (§41305), and boats must be cleaned of aquatic plants – which may include non-native species – before they are allowed in Michigan waters (§41325). Rule violations may be punished by fines and imprisonment, and some intentional introductions may be treated as felonies (§41309), with the intent to deter such actions. Any fines and permit fees collected by the state under Part 413 are to be used for an invasive species fund that may

support public education and other activities related to Michigan invasive species (§41311) (1994 (amended)).

The Michigan NREPA also delegates responsibility for regulating recreational fisheries to the state's Natural Resources Commission, which must address species invasions based on "sound scientific management". This responsibility must reflect the legislature's finding and declaration "that aquatic invasive species, including Asian carp, represent a significant threat to the state's fisheries, aquatic resources, outdoor recreation and tourism economies, and public safety (§48703a, as amended 2015)." Additional proposals include a not-yet-approved Senate bill to allow local ordinances for protecting against invasive species (2015).

Additionally, state agencies have important invasive species management duties. MDNR has primary responsibility over this policy area, and has therefore developed an Asian Carp Management Plan. The Plan requires ongoing surveillance in southern Lake Michigan and tributary rivers within Michigan, as well as outlining a series of actions to be taken if and when Asian carp are found in these areas. Drawing on NREPA requirements, the Plan also includes efforts to prevent accidental or deliberate introductions of Asian carp through ballast water, bait transfer, or pet releases (Clapp et al., 2012).

Despite these extensive state-level efforts, the point of greatest concern for Asian carp entry is outside of Michigan's jurisdiction. Michigan's Attorney General has therefore requested – and subsequently sued to gain – closure of locks on the Chicago Sanitary and Ship Canal (CSSC) and ultimately complete hydrological separation between the Mississippi River system and the Great Lakes. However, this effort has not been successful due to Illinois concerns about the greater cost of overland shipping (Stern et al., 2014). There is agreement in the literature that complete hydrologic separation would be the most effective solution for preventing Asian carp introduction to the Great Lakes (Hansen, 2015; Great Lakes Fishery Commission, 2012). Physical barriers would also have the added benefit of preventing other unexpected species introductions (Wittmann et al., 2014).

"Despite these extensive state-level efforts, the point of greatest concern for Asian carp entry is outside of Michigan's jurisdiction."

Federal Action

Although concerns may be concentrated in Michigan and some other Great Lakes states, preventing the introduction of invasive species – particularly Asian carp species –requires other states' cooperation. Such prevention is dependent upon physical or chemical barriers, or preferably complete separation of hydrological basins, before the species reach Michigan waters. Although Michigan may have clear goals related to Asian carp and

other AIS invasion prevention, some of these efforts must take place through federal legislative and agency actions rather than the state government.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 established a task force to assess aquatic invasive species and also requested voluntary guidelines to avoid introductions through ballast water (US Congress, 1990). Congress subsequently adopted the National Invasive Species Act of 1996 (NISA), which set stricter limits on ballast water exchange. NISA requires vessels to exchange ballast water at sea, with exceptions only for safety reasons. However, even in these emergency situations, ballast cannot legally be discharged in Great Lakes harbors. NISA also requires further research, including assessment of the CSSC as a pathway for species introduction to the Great Lakes (US Congress, 1996).

More recently, Black and Silver Carp (2007), and Bighead Carp (2010) were listed as injurious species under the Lacey Act, meaning that these species may not be imported or traded in the United States (Stern et al., 2014).

Invasive species establishment is constrained by these restrictions on ballast discharge and intentional introduction. However, studies have suggested that the most likely route for Asian carp introductions would go through the CAWS, meaning that foolproof prevention requires separation between the Mississippi River/CAWS system and the Great Lakes. To that end, a series of electrical barriers have been installed. The first electrical barrier (i.e., Barrier I) has been operational since 2002, and has since been upgraded to a stronger and more permanent system. However, officials raised concerns that maintenance or electricity outages might render Barrier I ineffective, leading to species transfers during these periods of vulnerability. As a result, two additional electrical arrays, referred to as Barriers IIA and IIB, were established 800 feet downstream from the original barrier. Furthermore, in 2010, the Army Corps of Engineers completed a network of physical barricades to "deter fish passage" over the Des Plaines River – another possible link between CAWS and Lake Michigan – during flooding events. The Corps also installed fish screens and changed operational procedures to close CSSC locks during certain periods of vulnerability (Stern et al., 2014).

"...full hydrologic separation is deemed to be the only fool-proof method for preventing species introductions from the Mississippi River system to the Great Lakes."

Despite these electrical and construction efforts, full hydrologic separation is deemed to be the only fool-proof method for preventing species introductions from the Mississippi River system to the Great Lakes. As a result, the 2007 Water Resources Development Act (WRDA) required the Corps to examine alternatives for separating the systems. The study was expedited after Congress passed the 2012 Moving Ahead for Progress in the

21st Century Act (MAP-21). The resulting Great Lakes Mississippi River Interbasin Study (GLMRIS) report assessed seven alternatives for hydrologic separation and compared them to the no-action alternative based on cost and likely effectiveness. The Corps did not take a stand on which of these eight possibilities would be most desirable, leading to ongoing political debates about the best option. Michigan and Illinois have supported different strategies because closing CSSC would require transporters to offload shipments to trucks for part of the journey, thus increasing shipping costs. However, the states continue to debate the actual costs of each strategy (Stern et al., 2014).

As a result of the stalemate between Illinois and Michigan, the Asian Carp Regional Coordinating Committee (ACRCC) continues to evaluate options, including the possibility of using water guns and carbon dioxide pumps to deter fish movement at the vulnerable Brandon Road dam site (Asian Carp Regional Coordinating Committee, June 2015). In the meantime, research identified Asian carp DNA near the barrier sites, leading the Illinois Department of Natural Resources – with financial support and agency expertise from MDNR – to treat the area with rotenone, a chemical that would kill any individual fish that had breached the barriers. Similar actions have been taken when barriers are turned off for maintenance (MDNR, 2015).

MDNR and the ACRCC conduct extensive monitoring to ensure that these species have not breached the electrical barrier system. The goal is to identify the leading edge of carp presence and reproduction in order to limit any establishment beyond the barrier system (Asian Carp Regional Coordinating Committee, June 2015). The federal Government employs an annually updated Asian Carp Control Strategy Framework, which has included additional monitoring and assessment, as well as the GLMRIS study noted above. Congress has also authorized the Corps to implement emergency measures for Asian carp exclusion as necessary (Stern et al., 2014).

Other important regulatory actions include those that began in 2014, when Congress authorized a multi-agency effort, led by the US Fish & Wildlife Service, to implement measures recommended in the GLMRIS report as well as any necessary emergency actions (US Congress, 2014). Other recent proposals, including the 2011 Stop Asian Carp Act (H.R. 892 and S. 471) and a series of bills in 2013, have proposed to finally implement the proposed hydrologic separation between the two water basins. However, none of these bills have passed (www.congress.gov). The Defending Our Great Lakes Act of 2015 (H.R. 1135 and S. 589) has been referred to Congressional committees, but has not moved beyond that stage. This bill is intended to "provide an immediate measure" for

"The goal is to identify the leading edge of carp presence and reproduction in order to limit any establishment beyond the barrier system (Asian Carp Regional Coordinating Committee, June 2015)."

control of species movements and "inform long-term measures" that would prevent such transfers between the Mississippi River basin and the Great Lakes. The bill would require the Corps to complete construction – including a strengthened lock and dam at the Brandon Road site (option 4 from the GLMRIS report) – that would completely prevent Asian carp and other species from entering the Great Lakes through the CAWS (US Congress, 2015a). The Great Lakes Restoration Initiative Act, also currently in committee, would fund additional research on these topics (US Congress, 2015b).

CURRENT STUDY

Public opinion about AIS can relate to perceptions of those species' impact on human livelihood and recreational activity. In particular, opinion shifts as people identify a specific species as "perpetrator" of harm against humans, ecosystems or other animals (Muter, Gore, and Riley 2009). These changes in public opinion can have direct bearing on support or opposition to management strategies, especially those involving lethal control, but the predictive relationship is not well understood. Thus, managers are limited in their ability to anticipate public support for or opposition to management activities and engaging stakeholders as part of the management process.

"In Michigan, AIS such as Asian carp are viewed as perpetrators of harm to Great Lakes fisheries."

In Michigan, AIS such as Asian carp are viewed as perpetrators of harm to Great Lakes fisheries. Currently, various management agencies consider lethal control of AIS as acceptable and necessary responses to fisheries threats. However, no studies have examined broad scale public preferences or how the broader policy context affects public perceptions. Exploring answers to these questions can help identify factors that predict public support for particular policies and programs. This study, therefore, addresses a key research objective: identify risk perception and public support for various AIS management strategies.

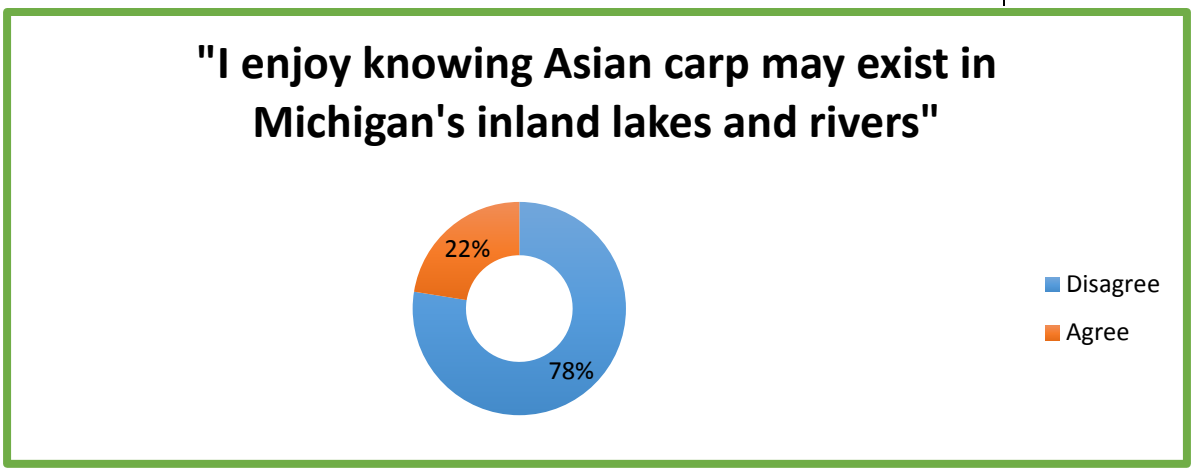
To achieve our objective, we conducted an internet-based survey of 500 randomly selected Michigan residents during November 2014. The sample was stratified to ensure that coastal communities – who may be most affected by aquatic invasive species – were overrepresented, with 40% of respondents hailing from counties that border Lakes Michigan, Superior, Huron, and/or Erie. Therefore, some descriptive statistics may overestimate public opinion about knowledge of, and threats from, invasive species. For this reason, we differentiate the levels of concern statewide from those in coastal counties. Approximately three-quarters of respondents were female (72%) or owned their own home (73%). Slightly more respondents self-identified as

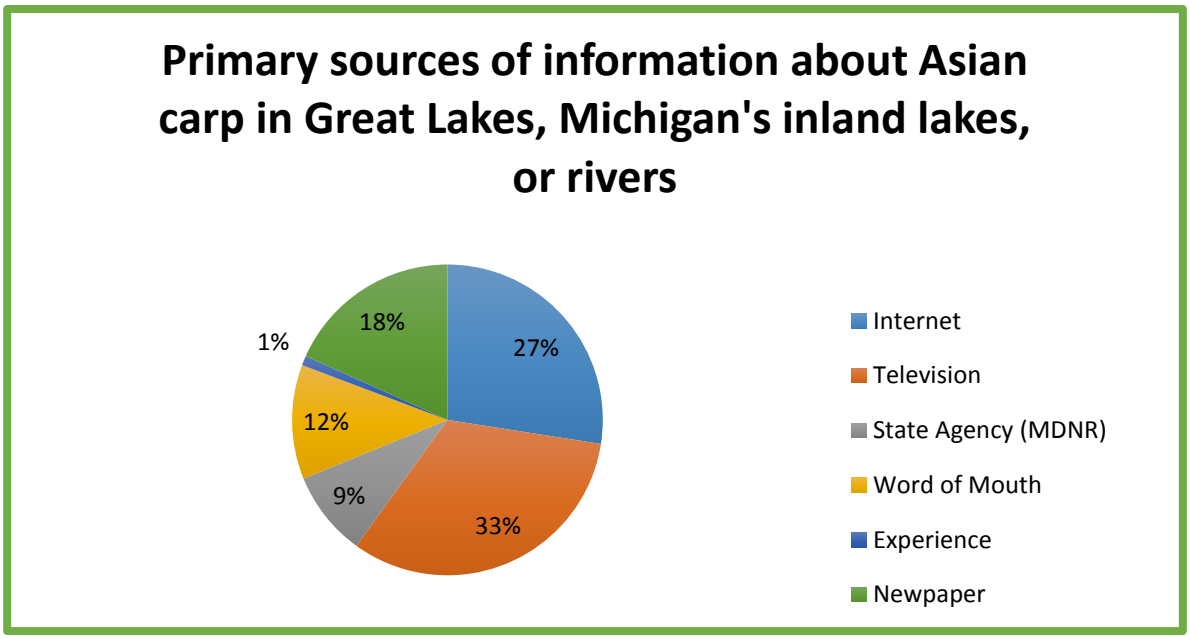
conservative (54%) rather than liberal (46%) in their political orientation. We controlled for these factors in all multivariate regression analyses.

The survey asked participants about their knowledge of Asian carp species and policies that have been directed towards aquatic invasive species in general or Asian carp in particular. Participants were then asked about their preferred policies for Asian carp management in the Great Lakes, as well as which actors (state or federal agencies, legislature, scientific panels, or public vote) should have responsibility for selecting these policies. They were then asked about their perception of the threats posed by invasive Asian carp species, and any actions they – as individuals – may have taken to support management efforts. All relevant survey data are publically available electronically on Figshare.com, and regression analyses are available from the authors. The questions are in the Appendix at the end of this report.

PUBLIC OPINION ABOUT ASIAN CARP AND THEIR MANAGEMENT

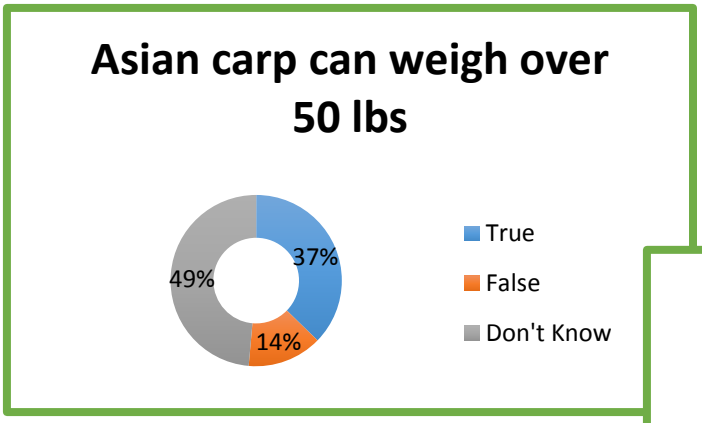
Myriad public policies have been proposed to deter the introduction of Asian carp and other species into the Great Lakes. Such policies depend on citizen participation to support enactment, and also to bring about compliance once in place. Therefore, it is important to understand public opinion on this topic to determine which types of interventions have a chance of success. In addition, by understanding public knowledge and opinions, policy makers and educators can craft effective risk communication and educational programs. Overall, most respondents (73%) believed over the next five years that efforts should be made in Michigan to reduce the population of Asian carp. This population change was very important to over two-thirds of respondents.

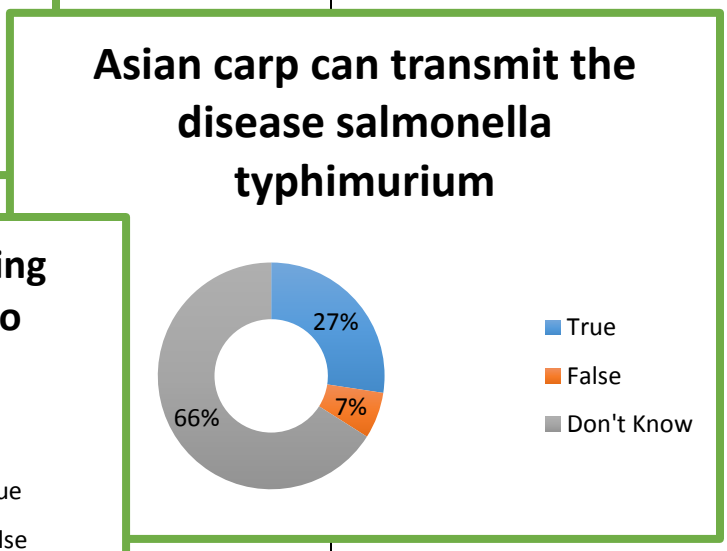


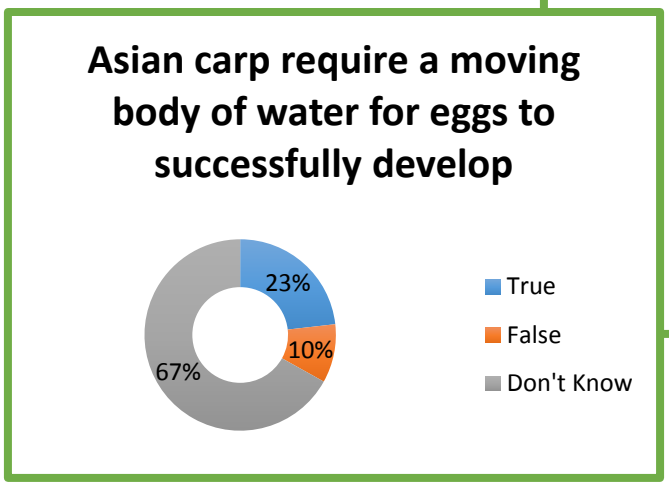


We posed survey questions focused on Michigan residents' knowledge of Asian carp ecology, behavior, and distribution. Some questions asked respondents to assess the validity of statements about Asian carp ecology and behavior, with at least 25% of respondents answering "Unsure" for each question. For those providing an answer, many participants hold misconceptions about Asian carp species. Responses indicated that there are multiple entry points for increasing awareness and understanding about Asian carp among Michigan residents. Approximately one-quarter of respondents overall (24%) and one-fifth of respondents from coastal communities (22%) believe Asian carp reached Michigan's rivers and lakes in the 1990s via the Mississippi River.

- Over two-thirds of respondents overall (69%) and from coastal communities (70%) noted that Asian carp compete with native species for food in Michigan lakes and rivers; however there are not currently established breeding populations of carp in the Great Lakes Basin.
- A majority of respondents overall (59%) indicated they had a direct encounter with an Asian carp in a Michigan Great Lake, inland lake, or river including catching or touching an Asian carp with hands, body, or fishing gear. Paradoxically, Asian carp are not currently established in Michigan.
- A majority of respondents overall (55%) and from coastal communities (53%) correctly noted that Asian carp have a habit of leaping out of the water when disturbed. Approximately 40% of respondents were unsure.







Knowledge of AIS policies

We posed a suite of questions focused on state and federal AIS management policies, permitting, and management authority. Results indicate opportunity exists to increase Michigan residents' awareness and understanding about AIS policy, particularly policies designed to prevent AIS introductions. Although a majority of respondents overall (69%) and in coastal communities (70%) correctly acknowledged individuals can be sanctioned for intentionally releasing AIS into Michigan waters, over one-quarter (28% overall respondents, 27% coastal community respondents) were unsure about sanctions.

- A large majority of respondents overall (71%) and in coastal communities (75%) were aware that Asian carp are designated as AIS and therefore banned in Michigan waters.
- Over 50% of respondents were unsure about the physical barrier between the Mississippi River and Lake Michigan designed to prevent an Asian carp invasion. Approximately one-quarter of respondents (27% among both overall and coastal respondents) believed, incorrectly, that such a barrier is present.

Attitudes about risks associated with Asian carp

Risk perceptions are intuitive judgments about risks as opposed to technical assessments made by experts. We posed a number of questions regarding perceptions of risk associated with Asian carp in general as well with their future potential invasion into the Great Lakes Basin. Risk perceptions were generally high. A majority of respondents overall (63%), particularly in coastal counties (66%), agreed that Asian carp related risks will increase over time.

"Approximately half of respondents in both coastal and landlocked counties believed Asian carp related risks are new and unknown to Michigan residents."

- Approximately half of respondents in both coastal and landlocked counties believed Asian carp related risks are new and unknown to Michigan residents.
- Just under half of respondents (45%) perceived AIS management in general is changing because of Asian carp-related risks.

Attitudes about policy responses

To assess what kinds of behaviors Michigan residents might take in response to different Asian carp scenarios, we posed a number of questions querying how willing an individual would be to take no action, catch and release a carp elsewhere, or call authorities and either file a report, set up a physical barrier or lethally poison the fish. Responses were highly varied.

- If a *single* Asian carp is seen in a Michigan river or lake, the majority of respondents overall (47%; 48% in coastal counties) said they would call authorities and file a report, 22% (20% coastal) would call authorities to set up a physical barrier, and 14% (16% coastal) would catch and release the fish elsewhere.
- If a *school* of Asian carp was seen in a Michigan river or lake, approximately one-third of respondents (38% overall; 37% coastal) said they would call authorities to set up a barrier and 36% (38% coastal) would call authorities to file a report.
- More respondents (42% overall; 44% coastal) would be willing to call authorities to lethally poison Asian carp if the fish were found to be carrying *disease* harmful to other aquatic species than if a single fish was threatening a *commercially* valuable fish species (23% overall; 24% coastal) or threatening someone's *way of life* (29% overall; 26% coastal).
- Individuals believing Asian carp harm other aquatic animal species were significantly more likely than others to support poisoning Asian carp. These individuals were also significantly more likely to support poisoning Asian carp if spotted in Michigan, even if there is no evidence of a specific disease or commercial threat.

- If commercial species were threatened by an individual Asian carp, there was more support for lethal management among respondents who believed that Asian carp risks are easy to understand, among those who mentioned television as one of their top two sources of Asian carp information, and among male respondents.
- Approximately two-thirds of respondents overall (63%) and in coastal counties (60%) strongly or somewhat believed *state agency* scientists' recommendations should guide Asian carp management decisions.
- Reliance on *state agency scientists* was particularly strong among those who believed Asian carp harm other aquatic animal species, among those who believed risks are hard to understand, among males, and among more conservative respondents.
- Less than half of respondents overall (45%) and in coastal counties (46%) felt *university scientists* should inform management decisions. University science was supported in similar proportions, as well as those who relied on newspapers for their information on Asian carp. Slightly more than one-third of respondents overall (34%), but less in coastal counties (30%), supported a role for the state legislature, 31% (33% coastal) supported decision-making by public vote, and only 29% (24% coastal) agreed that federal agencies should be involved.
- A large majority of respondents overall (77%) and in coastal counties (79%) expressed a clear preference for preventing Asian carp establishment in Michigan waters. This preference was stronger among respondents who believed that Asian carp harm other aquatic animal species, as well as older residents and those who participated in recreational fishing.

POLICY IMPLICATIONS

Asian carp management is likely to remain a pressing natural resource policy in Michigan and the Great Lakes Basin in the future. Insights about Michigan residents' public opinion can inform policy design, implementation, and evaluation. Policy impacts will be highly dependent on the Great Lakes states' collective activity as Asian carp management confined to Michigan's borders will be ineffective in the long run. For example, the state of Illinois has not demonstrated substantial interest in carrying out preventive measures, primarily due to costs, despite a common desire to protect Great Lakes fisheries. The efficacy of future solutions will require, at a minimum, reconciliation between those who benefit most from these policy actions and those who will bear the greatest cost for their implementation.

"Policy impacts will be highly dependent on the Great Lakes states' collective activity as Asian carp management confined to Michigan's borders will be ineffective in the long run."

"...further research is needed to gain a clearer understanding of likely Asian carp impacts on the Great Lakes."

Acknowledging this broader policy context exists, we note the following policy implications from this research.

First, further research is needed to gain a clearer understanding of likely Asian carp impacts on the Great Lakes. Although high-level effects have been modeled, findings do not yet pinpoint which specific fish and human populations would bear the brunt of the impacts or identify what the valence of those effects might be. Broadening the knowledge base would increase agencies' abilities to direct their interventions to establishment of Asian carp in particular Great Lakes locations that are likely to need the most support.

Second, multiple opportunities exist for AIS education in general and for policy development and implementation specifically (Pejchar and Mooney, 2009). Although there is some awareness and understanding of Asian carp ecology, behavior, and distribution, not all Michigan residents demonstrate sufficient understanding that may be needed to facilitate early detection and rapid response efforts. This is important because citizens are able to play a key role in detection and prevention of AIS invasions. Educational efforts need not be limited to Asian carp biology, ecology, or distribution; *education about state and federal policy processes can also facilitate more effective AIS management*. For example, coordinated responses would benefit from citizens' increased understanding about the role of federal agencies in effective AIS management, as well as the need for multiple sectors to collaborate in support of Great Lakes Basin AIS management.

Third, respondents' willingness to support lethal control of Asian carp (e.g., call authorities to report sighting, call authorities to erect physical barrier etc.) differed according to the nature of the risk posed by Asian carp. Disease threats to other aquatic species elicited the greatest willingness to lethally poison Asian carp. It is noteworthy that regardless of the nature of the risk posed by Asian carp, the majority of respondents opined they were not likely to contact authorities to lethally poison Asian carp. Programs that prevent the spread of Asian carp into the Great Lakes Basin have greater public support than programs that reactively and lethally poison an established population, regardless of the risks the AIS pose to ecosystems, economies, or livelihoods.

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APPENDIX: Asian Carp Survey Questions, November 2014

Note: ("Likert") indicates 5-point Likert-scale-type question, with options Strongly Agree (1), Somewhat Agree (2), Neither Agree or Disagree (3), Somewhat Disagree (4), Strongly Disagree (5)

- How many years have you lived in Michigan?
- In which Michigan county do you currently reside?
- Before receiving this survey, did you know that there was the potential for Asian carp to move into the Great Lakes and Michigan's inland lakes and rivers? (Yes/No/Unsure)
- I enjoy knowing Asian carp may exist in Michigan's inland lakes and rivers (Likert)
- I enjoy knowing Asian carp may exist in Michigan's Great Lakes. (Likert)
- Have you ever seen Asian carp in a Michigan river or lake, including the Great Lakes? (Yes/No/Unsure)
- Have any of your friends or family ever told you that they have seen Asian carp in a Michigan river or lake, including the Great Lakes? (Yes/No/Unsure)
- Have you ever had a direct encounter with Asian carp in a Michigan Great Lake, inland lake, or river? By a direct encounter we mean caught or touched an Asian carp with your hands, body, or fishing gear. (Yes/No/Unsure)
- Have any of your friends or family ever told you that they had a direct encounter with Asian carp in a Michigan Great Lake, inland lake, or river? By a direct encounter we mean caught or touched an Asian carp with your hands, body, or fishing gear. (Yes/No/Unsure)
- Have you ever read or heard about the DNA of Asian carp being found in a Michigan Great Lake, inland lake, or river? (Yes/No/Unsure)
- Have you ever read or heard of Asian carp being caught by authorities in a Michigan Great Lake, inland lake, or river? (Yes/No/Unsure)
- Have you ever seen authorities testing or searching for Asian carp in a Michigan Great Lake, inland lake, or river? (Yes/No/Unsure)
- What is your primary source of information about Asian carp or other aquatic invasive species in the Great Lakes, Michigan's inland lakes, or rivers? (open-ended)
- In Michigan's rivers and lakes, Asian carp compete with native species for food. (Ture/False/Unsure)
- Asian carp live in large groups of fish, called schools. (Ture/False/Unsure)
- Asian carp reached Michigan's rivers and lakes in the 1990's via the Mississippi River. (Ture/False/Unsure)
- Asian carp can weigh over 50 pounds. (Ture/False/Unsure)
- Asian carp have been known to carry and transmit the disease *Salmonella typhimurium*. (Ture/False/Unsure)
- According to State and Federal government agencies, Asian carp do not currently live in Michigan's rivers and lakes. (Ture/False/Unsure)
- Asian carp are used by some people for religious and cultural purposes. (Ture/False/Unsure)
- Asian carp are known as "big eaters".(Ture/False/Unsure)

- Asian carp require a moving body of water for their eggs to successfully develop. (Ture/False/Unsure)
- Asian carp have a habit of leaping out of the water when disturbed. (Ture/False/Unsure)
- Individuals may be punished for catching Asian carp in Michigan's rivers and lakes. (Ture/False/Unsure)
- Individuals may be punished for knowingly releasing a banned aquatic species into Michigan's rivers and lakes. (Ture/False/Unsure)
- In Michigan's rivers and lakes, Asian carp are considered an aquatic invasive species. (Ture/False/Unsure)
- Individuals may catch Asian carp in Michigan's rivers and lakes, but only if they have obtained a permit. (Ture/False/Unsure)
- Asian carp are considered an invasive species by the US Aquatic Nuisance Species Task Force. (Ture/False/Unsure)
- Asian carp are currently kept out of Michigan by a physical barrier between the Mississippi River and Lake Michigan. (Ture/False/Unsure)
- In the Great Lakes, Asian carp management is conducted by the United States Federal government. (Ture/False/Unsure)
- Michigan officials collaborate with officials from neighboring states on Asian Carp management. (Ture/False/Unsure)
- Decisions about Asian carp management should be made by public vote. (Likert)
- The decision to lethally control Asian carp should be made according to state agency scientist's recommendations. (Likert)
- Asian carp should be lethally controlled even if there is scientific evidence that it will also harm native species from Michigan's rivers or lakes. (Likert)
- Decisions about Asian carp management in Michigan should be made by the state legislature. (Likert)
- Decisions about Asian carp management in Michigan should be made by federal agencies. (Likert)
- Decisions about Asian carp management should be based on university-generated science. (Likert)
- If a public vote on Asian carp management differs from scientific recommendations, the public vote should be given priority. (Likert)
- If scientific recommendations for Asian carp management differ from the legislature's recommendation, scientific recommendations should be given priority. (Likert)
- If the legislature's recommendations on Asian carp management differ from a public vote, the legislature's recommendations should be given priority. (Likert)
- Asian carp should be prevented from establishing themselves in Michigan's rivers and lakes. (Likert)
- Asian carp harm other aquatic animal species. (Likert)
- Asian carp pose risks that cannot be reversed. (Likert)
- I fear Asian carp coming to Michigan's lakes and rivers. (Likert)
- The presence of Asian carp makes it a burden to live near a Michigan river or lake. (Likert)

- Humans should learn to live with some risks from Asian carp. (Likert)
- Asian carp have a right to exist in the Michigan's rivers and lakes. (Likert)
- The risks Asian carp could pose to Michigan lakes and rivers are increased because of human activities that harm nature. (Likert)
- Asian carp-related risks are hard to understand for people living in Michigan. (Likert)
- Asian carp-related risks are hard for scientists to measure. (Likert)
- Asian carp-related risks are unfair to humans. (Likert)
- Asian carp-related risks are the result of human arrogance. (Likert)
- Asian carp-related risks will have effects that increase over time. (Likert)
- Asian carp-related risks are a warning that much worse risks will happen. (Likert)
- Asian carp-related risks, such as direct injury, are ignored by aquatic species managers. (Likert)
- Asian carp-related risks are deterred by aquatic species managers. (Likert)
- Asian carp-related risks are welcomed as a challenge to be solved by aquatic species managers. (Likert)
- Aquatic species management is changing because of Asian carp-related risks. (Likert)
- Asian carp-related risks are new and unknown to people living in Michigan. (Likert)
- Which action would you take in each of the following situations: [Options are: Take no action (1), Catch and release the fish elsewhere (2), Call authorities and file a report (3), Call authorities to set up a physical barrier (4), or Call authorities to lethally poison the Asian carp (5)]
    - A single Asian carp is seen in a river or lake.
    - A school of Asian carp are seen in a river or lake.
    - A single Asian carp is damaging the sport fishing industry.
    - A school of Asian carp are damaging the sport fishing industry.
    - A single Asian carp is found to be carrying a disease that is harmful to other aquatic species.
    - A school of Asian carp are found to be carrying a disease that is harmful to other aquatic species.
    - A single Asian carp is threatening a commercially valuable fish species.
    - A school of Asian carp is threatening a commercially valuable fish species.
    - A single Asian carp is physically threatening a human.
    - A school of Asian carp are physically threatening a human.
    - A single Asian carp is threatening your way of life.
    - A school of Asian carp are threatening your way of life.
- Which of the following actions have you taken?
    - Tried to address a problem with Asian carp myself.
    - Hired a private fishery control agent to address a problem with Asian carp.
    - Asked the state government to use lethal methods to prevent Asian carp from coming into Michigan's rivers and lakes.
    - Asked the federal government to use lethal methods to prevent Asian carp from coming into Michigan's rivers and lakes.
    - Given a presentation about Asian carp.

    - Supported in some way an organization that is involved with Asian carp management.
    - Donated money to an organization that is involved with Asian carp management.
    - Taken some other action related to Asian carp in Michigan in the last year. (please specify)
    - Taken no action.
    - Contacted the Michigan Department of Natural Resources (MDNR) or Michigan Department of Environmental Quality (MDRQ) for information.
    - Contacted the Michigan Department of Natural Resources for a removal permit.
    - Asked the state or federal government agent to establish a barrier that prevents Asian carp from entering Michigan's lakes and rivers.
- In the next five years, should efforts be made in Michigan to increase the Asian carp population, decrease the Asian carp population, or should the Asian carp population remain the same as it is currently? (Increase/Decrease/Remain the same)
- How important is it to you that the Asian carp population in Michigan [insert response from previous question] over the next five years? (Very important, Somewhat important, Neither important or unimportant, Somewhat unimportant, Very unimportant)
- How characteristic of your approach to life are each of the following statements? (Please rate from Not at all like you (1) to Very much like you (5))
    - I believe the things I do today can affect me later.
    - Sacrificing now is not necessary since future outcomes can be dealt with later.
    - I generally ignore warnings about problems that may come up in the future, because I think that they will be taken care of before they reach crisis level.
    - I think it is more important to do things that get bigger results in the future, than to do things that get less important results right now.
    - Sometimes it is better to enjoy less today so you can enjoy more tomorrow.
    - My convenience is a big factor in the decisions I make or the actions I take.
    - I think it is important to take warnings about bad things seriously even if the bad things will not happen for several years.
    - I deal with problems when they appear.
    - Since my day- to-day work has quick results, it is more important to me than behavior that has far off results.
    - I act now even if the results are years away.
    - I must satisfy my needs now; I believe the future will take care of itself.
    - How I act is determined by the immediate results of my behavior.
- Demographic questions
    - Are you Male or Female?
    - What is your age?
    - How many children age 17 and under currently live in your household?
    - What is your marital status?
    - What is the highest level of education you have completed?
    - Are you of Hispanic, Latino, or Spanish origin?

- Are you of Arab or Chaldean origin?
- Which one or more of the following describes your race?
    - White or Caucasian
    - African American or Black
    - Hawaiian or other Pacific Islander
    - Asian
    - American Indian or Alaska Native
    - Other
- What is the religious group which you feel most closely represents your religious views?
- Generally speaking, do you think of yourself as a Republican, a Democrat, an Independent or something else?
- Would you call yourself a strong Republican, or not a very strong [insert response from previous question if Republican or Democrat]?
- Do you generally think of yourself as closer to the Democratic Party or the Republican Party?
- Generally speaking, do you think of yourself as a conservative, a moderate, or a liberal?
    - [If previous answer is Conservative] Would you consider yourself very Conservative, or somewhat Conservative?
    - [If previous answer is Liberal] Would you consider yourself very Liberal or somewhat Liberal?
    - [If previous answer is moderate] Do you generally think of yourself as closer to the conservative side or the liberal side?
- We are interested in learning about the different ways people may earn their living. Which one of the following best describes your employment situation last week. Were you: (Working full-time; Working part-time; Have a job, but I was not at work last week; Working and going to school; School full-time; Homemaker; Serving in the Armed Forces; Disabled; Unemployed, laid off, looking for work; Other (please specify); Retired)
- In which industry are you currently employed? (Forestry, fishing, hunting or agriculture; Mining; Utilities; Construction; Manufacturing; Wholesale trade; Retail trade; Transportation or warehousing; Information; Finance or insurance; Real estate or rental and leasing; Professional, scientific or technical services; Management of companies or enterprises; Admin, support, waste management or remediation; Educational services; Health care or social assistance; Arts, entertainment or recreation; Accommodation or food services; Other services (except public administration); Other
- Is your primary employment associated with commercial fishing? (Yes/No)
- Do you participate in any of the following activities?
    - Hunting
    - Trapping
    - Watching wildlife
    - Fishing
- Do you own or rent your home?

- Would you say you live in a rural community, a small city or town, a suburb, or an urban community?
- What is your zip code?
- To get a picture of people's financial situations, we'd like to know the general range of incomes of all people we interview. Thinking about your household's total annual income from all sources (including your job), what was your household's total annual income in 2013?
    - Less than $10,000
    - $10,000 - $19,999
    - $20,000 - $29,999
    - $30,000 - $39,999
    - $40,000 - $49,999
    - $50,000 - $59,999
    - $60,000 - $69,999
    - $70,000 - $79,999
    - $80,000 - $89,999
    - $90,000 - $99,999
    - $100,000 - $150,000
    - More than $150,000

Informing the Debate

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