Exploring tensions and conflicts in invasive species management: The case of Asian carp

A working paper by the Minnesota Aquatic Invasive Species Research Center

January 8th, 2016 – v.1

Adam E. Kokotovich, PhD
Postdoctoral Research Associate
Minnesota Aquatic Invasive Species Research Center
University of Minnesota

David A. Andow, PhD
Professor, Department of Entomology
University of Minnesota

Introduction

As the fields of invasion biology and invasive species management continue to develop, there have been calls for them to become "more nuanced and less intellectually isolated" through a "growing recognition of complexity and ambiguity" (Davis 2009, 10). An increasing appreciation for nuance, complexity, and ambiguity can be seen in different realms of invasive species scholarship. First, studies on the biological impacts of invasive species are more nuanced. There is a growing appreciation that an invasive species can have both positive and negative effects on native species and ecosystems. Especially in altered landscapes, invasive species can serve as functional, structural, and compositional parts of transformed ecosystems, and can benefit certain native species – even while causing other types of harm (Tassin and Kull 2015). Second, there is a more nuanced understanding of the effects of invasive species management, which can itself cause unintended harm to native species and ecosystems (Buckley and Han 2014). Acknowledgment of this potential has increased the importance of assessing non-target impacts of management efforts (Lampert et al. 2014). Third, the simple narrative that native species are good and exotic species are bad is being challenged by one that acknowledges that both native species and exotic species can be ecologically harmful or ecologically benign (Davis et al. 2011).

The scholarly literature on the social aspects of invasive species decision making, including the role of human values and political influence, is a second area of scholarship showing greater nuance. Much of the existing literature on the social aspects of invasive species has focused on preventing human mediated spread by seeking to understand how people engage in behavior that facilitates the spread of invasive species and how that behavior can be prevented (Clout and Williams 2009). One area of literature broadening the social aspects considered builds on the idea that science alone is inadequate for determining what invasive species are of greatest concern and what management actions are desirable. A first point from this literature is that human values are essential to the judgment of whether the change caused by a particular invasive species is deemed harmful (Sagoff 2009; Hattingh 2011). Science can often be used to examine whether an invasive species is likely to have an impact on

the environment, but it is fundamentally a values-based judgment whether that change is harmful. Such values-based judgments can be made explicitly and deliberately or in less transparent ways, but they are unavoidable in invasive species management. Second, conflict can exist over the values-based judgments in invasive species management, such as those concerning the desired state of nature, the harm caused by an invasive species, or the severity of non-target consequences of management actions (Estévez et al. 2015; Buckley and Han 2014; Larson et al. 2011). Best practices can be used to avoid this conflict over management (Larson et al. 2011), but there remains a need for further scholarship to explore the types of conflict that exist surrounding invasive species management and ways to address them (Estévez et al. 2015).

While existing literature points to the importance of exploring complexity and conflict in invasive species management, there remains a lack of work examining how these issues emerge in empirical case studies. Furthermore, there has yet to be a detailed exploration of how biological and social conflicts and complexities influence each other. Such case studies can improve understandings of the challenges facing invasive species management and indicate ways to address these challenges. The research presented here explores the conflicts facing invasive species management via a case study of Asian carp management in Minnesota. Using in-depth interviews with managers, researchers, and stakeholders active with Asian carp management, we explore the conflicts that currently plague Asian carp management as well as possible ways to address these conflicts. These findings will help improve Asian carp management and shed light on some of the challenges facing invasive species management.

Asian carp management

Silver, bighead, grass and black carp, often referred to as "Asian carp" are four species of invasive fish that have been spreading to and impacting waterways across large portions of the United States. Asian carp were purposefully released into waterways of the United States in the mid-20th century for a variety of reasons including for their use in aquaculture. Silver and bighead carp, specifically, were released to help clean aquaculture ponds and wastewater

treatment lagoons in the southern US and are thought to have escaped into the Mississippi River system in the 1970s (Kolar et al. 2005). Since then they have been making their way upward and outward, with established populations in many river systems of the central and southern United States (Asian Carp Regional Coordinating Committee 2014). Silver and bighead carp have the ability to cause a variety of ecological and recreational impacts, from disrupting the aquatic food change by consuming large amounts of plankton to, in the case of silver carp, jumping up to 10 feet in the air when startled (Kolar et al. 2005).

As a result of the potential threats posed by Asian carp and because Asian carp cross both state and agency jurisdictional boundaries, state and federal agencies have been actively managing invasive Asian carp across the central and southern United States (Conover, Simmonds, and Whalen 2007). In Minnesota, a diversity of agencies work on Asian carp management including the Minnesota Department of Natural Resources, the US Fish and Wildlife Service, the National Park Service, the US Geological Survey, the US Army Corps of Engineers. These agencies have different core responsibilities determined by their legal mandates, and need to find ways to work across these differences when collaborating with other agencies. States can also have differing management priorities based on where along the invasion front they are located, which creates challenges for establishing basin-wide management priorities.

Of the four Asian carp species, silver and bighead are of particular concern in Minnesota because of the proximity of the breeding populations to the state and because of the negative effects they have caused in nearby areas where large populations are present. Although individual silver and bighead carp have been captured in Minnesota each year for almost the last two decades, including 5 bighead carp near Stillwater, MN on the St. Croix river in April 2015, the nearest reproducing population on the Mississippi River is thought to be in southern Iowa. State and federal agencies continue to conduct a variety of management and research efforts for Asian carp in Minnesota including, for example, monitoring, control measures, and deterrents to prevent spread. In 2015, the Upper Saint Anthony Falls Lock in Minneapolis was

closed as the result of federal legislation to prevent Asian carp from being able to swim further north on the Mississippi River.

Asian carp management in Minnesota is a useful case study to examine the tensions and conflicts facing contemporary invasive species management. In addition to representing a complex contemporary invasive species management issue, our previous research (Kokotovich and Andow 2015) and informational interviews revealed that although there is broad agreement on the management goal of minimizing the impacts from Asian carp while protecting native fish and ecosystems, there remains consequential tensions surrounding Asian carp management that warrant further study. Our goal for this research was to examine the tensions and conflicts that exist around Asian carp management in Minnesota to help better understand them, their implications, and how they can be addressed. After outlining the methodology, we present the findings from this research and conclude with a discussion of their implications and importance for invasive species management.

Methodology

To study these tensions, we conducted 16 in-depth interviews with individuals who have been involved with Asian carp management in Minnesota. We chose in-depth interviews because speaking individually with an interviewee helps provide the anonymity needed for interviewees to speak openly about the conflicts they perceive. In addition, in-depth interviews allow for follow-up questions and discussions where interviewees can elaborate upon key nuances. We used two main criteria to prioritize interviewees who had been involved with Asian carp management in Minnesota. First, in order to obtain a breadth of views, we selected interviewees from state and federal agencies (e.g., Minnesota Department of Natural Resources, National Park Service, US Army Corps of Engineers, US Fish and Wildlife Service, US Geological Survey), academia, and non-governmental organizations. Second, we selected individuals who had been most actively involved in management, as we judged by attending state-level Asian carp meetings, such as the Invasion Carp Forum, and as stated by other

interviewees. Interviews lasted, on average, between 1 and 2 hours each and were conducted in person and by phone. Interviews took place from March to May 2015.

During the interviews, interviewees discussed the tensions and conflicts they saw as important to Asian carp management, including tensions that were complicating and impeding management. Interviewees also discussed the implications of these tensions and how they thought the tensions could be addressed. Once the discussion of tensions was complete, we concluded the interview by discussing the actions and strategies that were facilitating what interviewees thought was beneficial for Asian carp management.

The analysis of the interviews took place in two parts. First, notes were taken during the interviews to capture the main points articulated by interviewees, including basic descriptions of the tensions and their implications, what could be done to address the tensions, and what actions and strategies were facilitating management. These notes were used during the interviews to inform follow-up questions and discussions that ensured interviewees' views were comprehensively understood. Second, the interviews were transcribed and qualitatively analyzed using the qualitative analysis software Atlas.ti. This analysis was used to confirm the accuracy of the notes, to apprehend additional nuance in interviewee responses, and to identify quotations that were illustrative of key points.

Findings

Our interviews with individuals involved with Asian carp management in Minnesota revealed three key areas of tension and conflict that provide insights on the challenges facing Asian carp management, and invasive species management more broadly: scientific uncertainty, social uncertainty, and the approach to research and management. In particular, we explore how scientific and social uncertainties complicate efforts to determine the direction of research and management. By examining these tensions, we elucidate their implications as well as the factors that contribute to them. Lastly, we describe the ways that interviewees believed these tensions and conflicts should be addressed.

Scientific uncertainty

Two consequential scientific questions were frequently mentioned as being plagued by significant scientific uncertainty: 1) what are the likely ecological impacts from Asian carp in Minnesota? and 2) what are the likely ecological impacts of barriers and other deterrents on both Asian carp and native fish species? These two questions are important for Asian carp management because there is no simple management solution and there is no agreement on a management strategy for Asian carp. As a result, a host of potential management options must be considered and weighed. For example, with regards to preventing spread, although there is deterrent technology being used to try to slow or stop Asian carp advancing into or around Minnesota, it has been shown to be less than 100% effective. And even though management actions, such as the closing the Upper Saint Anthony Falls Locks, are expected to prevent Asian carp from swimming further north than Minneapolis on the Mississippi River (Lager 2015), this will not stop the natural spread to areas downstream and will not stop human mediated spread above the locks, such as through accidental transfer in bait.

With regards to control efforts, there are a variety of research efforts taking place – involving, for example, biobullets and pheromone attractants (Little et al. 2014) – yet there remain no definitive control solutions. Since there are currently no simple, straight forward solutions – and many interviewees stated that there are unlikely to be any in the future – a host of management and research efforts continue to be needed. And in this context it is important to weigh the likely impact from Asian carp in Minnesota against the likely impacts of the management efforts. Management decision making, therefore, is hampered by uncertainty around these questions.

Interviewees stated that although there have been documented adverse effects of Asian carp in waterbodies further south of Minnesota, there remain questions about where and under what conditions such adverse effects could be experienced in Minnesota's waterways if Asian carp were to establish. This is a result of both the diversity of waterways present in

Minnesota and uncertainty about the conditions that are associated with and essential for the harmful impacts of Asian carp where they have already established. Without a good understanding of where and under what conditions adverse effects are likely to take place within the state, it is hard to create reasoned management priorities.

In addition, there is uncertainty around the efficacy and ecological impacts of management options. For example, the effectiveness of certain barriers, such as acoustic or bubble barriers, at slowing or stopping the spread of Asian carp remains uncertain. In addition, barriers, depending on how they are designed, can impede native fish passage and, as a result, cause harm to native fish populations. It is difficult, therefore, to decide when and how a barrier should be deployed under such uncertainty about their effectiveness at preventing the spread of Asian carp and their negative impacts on native fish populations. Interviewees also articulated uncertainty about the extent that biotic resistance – the ability of ecological communities to avoid negative impacts from Asian carp – could be enhanced by promoting healthy native fish populations. For example, could promoting healthy native fish communities serve as a way of increasing predation on Asian carp and reducing the adverse effects they might cause. As interviewees stated, if that was the case, then it would be more important to look for ways to promote native fish health and to be wary of the negative impacts on native fish communities from barriers. If, however, existing and currently unalterable landscape level river pollution and stresses on native fish communities make it unlikely that they could be restored to a level that would achieve biotic resistance, it could make more sense to pursue barriers. One interviewee summarized these overlapping issues this way:

> *"It is a challenge because it's difficult to predict what exactly is going be the outcome of Asian carp expansion. Where they're going to end up and what the level of impact on the native communities is going to be. Obviously when you see the huge numbers of fish that are found in some areas [further south], it is alarming. Even in those areas, though, the actual impacts on the native species in those locations aren't always clear. And so to predict if Asian carp make their way up the Minnesota in reproducing populations, how far are they really going to expand to, and what are those aquatic areas going look like when Asian carp replace them, that's difficult to predict.*
>
> *So, too, is our understanding of what the ultimate benefits are from implementing fish passage [or deterrent and barriers]… Trying to tease all that out and make a judgment*

call on what's better, blocking Asian carp or promoting our natives moving around. It's something that's going to take a lot more research to get a better understanding before we can really, from a scientific standpoint, tease out what's better for our native species. And it could be very species-specific."

These uncertainties have several implications for management efforts. First, they make it difficult to determine when and under what conditions barriers should be used. There is a need to better understand the fundamental questions of where Asian carp are likely to cause adverse effects in Minnesota and under what conditions. And even if it is determined that Asian carp will likely cause adverse effects in a particular area, the uncertainties surrounding the impacts of barriers on Asian carp and native species make it unclear whether barriers do more harm than good. The second way they complicate management efforts is through making it difficult to establish easy narratives about what needs to be done to address Asian carp. Interviewees expressed how it can be difficult to explain these uncertainties and their implications to politicians and the public.

Social uncertainty - Apathy/Fear

Social uncertainty emerged as a key area of conflict in the interviews in two main ways: 1) the lack of agreement concerning the desired societal response to Asian carp, and 2) the tension created by the need to avoid the undesirable extreme societal responses of apathy and fear. Although interviewees believed that there was general societal agreement on the undesirable nature of Asian carp and their negative effects, interviewees also believed there is a lack of agreement about the appropriate societal response to Asian carp. The lack of societal agreement about what should be done in response to Asian carp was seen as contributing to a conflictual management environment, one where the societal response was likely to drift towards the extremes of apathy and fear.

In discussing this area of conflict, interviewees mentioned: the problems with an apathetic societal response to Asian carp, the problems with a fear-based societal response to Asian carp, and the difficulties of navigating between the extremes of apathy and fear. Societal response, in this case, usually referred to the thinking and actions of people (the general public,

individual stakeholders, politicians, state and federal agency personnel) as well as institutions (state and federal agencies, NGOs, and state and federal legislatures). In other words, apathy and fear were seen as ways of relating to Asian carp and Asian carp management that could be expressed and experienced at many organizational levels. None of our interviewees, those who have been actively involved in Asian carp management, believed that they themselves related to Asian carp from a place of apathy or fear; rather, it was a concern they had about others. Here we examine how interviewees conceived of the conflicts involving apathy, fear, and the relationship between the two.

Interviewees described the apathetic response to Asian carp as the general questioning of the need for any management, resulting from the belief that there is nothing that can be done, that even if something can be done it is not worth the resources, or that any impacts from Asian carp would not be significant. As one interviewee put it,

> *"Some people feel that invasive species are not that much of a threat or are the inevitable, so why fight it… there are people who say you are panicking, that it is a long ways off… It's just the sort of pulling the wool over your eyes, head in the sand, kind of attitude that you always run into when there is a crisis that is coming because there are always crises in place. To many minds, 'we have job issues, we have disparities issues, we have other [environmental] issues that are more important, so stop talking about carp.'"*

Interviewees believed that an apathetic response to Asian carp is undesirable because it leads to a lack of urgency or a feeling that management actions are unimportant. Whether impacting agency decision making or politicians, apathy was seen as a dangerous response because it leads to inaction. More often, interviewee concerns about apathy were aimed at the general public, who were seen as influencing politicians and agency decision makers. If the public cares and speaks out, then priorities are established and actions are taken. An apathetic response to Asian carp was often seen by interviewees as being the result of not knowing enough about Asian carp.

While an apathetic response was seen as undesirable, many interviewees also articulated how a fear-based response is also undesirable. They expressed concerns about

addressing apathy by fueling fearful responses to Asian carp, especially given the uncertainty that exists around their likely impact in Minnesota. A fear-based response was seen as being based on the assumption that Asian carp establishment will lead to potentially catastrophic consequences and, as a result, it is of the utmost importance to prevent their establishment. One interviewee articulated such concerns in the following way,

> *"I think there is a mindset that we need to stop these things at all costs. That certainly is something that needs unpacking, in terms of what we are willing to do or give up to try to control them. The primary concern is that if we are willing to do anything, including poisons or barriers, then you have to think, well what is the underlying mission to what we are doing? Is it to protect native species from this invasive species or is it solely to keep this invasive species out?"*

A fear-based response was seen as having at least two unproductive implications. First, it leads to a strong desire for management irrespective of how likely significant adverse effects are. A fear-based response is grounded in the belief that Asian carp will cause significant consequences, regardless of how likely their establishment is and how likely consequential adverse effects would be even if they do establish. Those holding such a view are seen to be already convinced that it is extremely important to take action to keep Asian carp from establishing, no matter the evidence about where and under what conditions adverse effects are likely to occur. Second, this belief leads to a reduced concern about potential unintended and non-target consequences of management actions. A fear-based response is likely to align with the view that any negative impact on native species from management actions will pale in comparison to the catastrophic anticipated impacts of Asian carp, so the consequences from management actions become unimportant. In other words, if you think that Asian carp would decimate native fisheries and recreation, you will be more likely to support management actions regardless of their negative impacts and without considering where and under what conditions adverse effects from Asian carp are likely to occur.

Finally, interviewees also discussed difficulties in navigating apathy and fear when working on Asian carp issues, especially with the public and politicians. Interviewees expressed that in navigating this tension between apathy and fear it was difficult not to lean too much to

one extreme or the other. One interviewee discussed this in the context of press releases for Asian carp captures in Minnesota,

> *"[Some] would like a press release on every single carp caught, every time. [Many in the DNR then ask], why is this newsworthy? We caught them before. If we put a press release every time we've caught one [it will lead to] oversaturation of the public which leads to apathy: 'they are here who cares, I've heard this before'… The flip side is, say maybe it's not oversaturation, but overemphasis on the issue, and people go down the road of Armageddon. We keep putting these out, so they must be horrible, so we must do something to stop them at any cost no matter what."*

The interviewee highlights how decisions about communication are informed by and have implications for how society responds to Asian carp. Frequent press releases on Asian carp findings could lead to both apathy and fear, depending on how they are understood. As other interviewees discussed, however, avoiding press releases and societal discussion about Asian carp can also support an apathetic response to Asian carp, as it can keep the issue from emerging on the societal radar.

Management and research: "Political need vs. biological reality"

These two broad areas of uncertainty contributed to a third area of conflict that emerged from our interviews: the approach to management and research. Interviewees discussed the conflicts involving the direction of management and research in different ways, but one interviewee aptly summarized the main conflict as being between "political need" and "biological reality". Others elaborated that the conflict was about whether management and research priorities were chosen based on "political expediency" or "ecological soundness." In other words, many interviewees identified a disjuncture between what they thought should be done (identified as "ecological soundness" and being based on "biological reality") and what many decision makers and the public were willing and wanting to do (based on "political need" or "political expediency"). Interviewees generally thought that the "political need" was privileged more in the current context, and thought that ideas from the alternative "biological reality" approach needed to be promoted. Interviewees' own views did not necessarily fall neatly into one of these approaches. These approaches are a way of highlighting the key differences between two sets of logic interviewees saw influencing management and research.

In this section we explore the approaches to management and research characterized by both "political need" and "biological reality," highlighting how they each relate differently to scientific uncertainty and social uncertainty.

Political need

Interviewees described the approach to management and research informed by "political need" as supporting quick fixes and easily justifiable, control-based management actions. This approach was seen as resulting from too much concern about social uncertainty, specifically apathy and fear, and from an underappreciation of scientific uncertainty. Although interviewees were most concerned with when politicians and decision makers – those making management and funding decisions – acted from a place of "political need", such ideas were seen as something that anyone, including the public or stakeholders, could support.

When informed by "political need," management and research were seen as responsive to the pressures of both apathy and fear. Responding to apathy required justifying the management and research taking place, and responding to fear required showing that something was being done. In both research and management, these factors were seen as leading to short-term, control-based management and research. Funders and politicians were also seen as likely to support short-term, quick-fixes that align with political and funding cycles. Yet this focus on doing something in a straight-forward, short-term nature has its limitations, as one interviewee explained:

> *"So, I think there's this tension between science [which] takes time and people wanting direct outcomes. I could almost compare it to throwing criminals in jail versus trying to solve the problems in society that address why they became criminals. The easiest solution, the quickest solution is just to throw someone in jail, and it's cheaper than trying to get at all the background behind it. So, a quick-fix mentality really is in tension versus what's really required by science."*

Another interviewee also said,

> *"I think, well first of all, the politicians want a silver bullet. And, yeah, I think that has impeded the funding going towards ecologically-based solutions."*

So the sentiments expressed here are that the simple, short-term fix mentality prevents a discussion about what could be long-term, more foundational fixes – instead of trying to understand and address the causes of the problem, being happy to just address its symptoms.

Research that looks at more foundational issues and holistic fixes can be systematically excluded when funders and politicians desire short-term fixes. Instead of exploring the basic biology and ecology of Asian carp to help narrow in on a potential 'Achilles heel' to exploit in management, there is a focus solely on short-term, control-based research. Often, though, this control based research bears more explicit and predictable results than basic research or even high-risk, high-reward research. One interviewee shared how this type of ecological or high-risk, high reward research can be hard to get sustained support for because "legislators want sure things. They want… fish killed." Many interviewees felt, however, that this type of control-based management can potentially be used to show the public and decision makers something is being done, without it having significant effects on Asian carp populations. One interviewee expressed these limitations in the context of management issues in states further south with established Asian carp populations,

> *"It's like the commercial catch. It's nice to be able to see that there's fish on the deck and the public likes to see that, but does it actually have an impact on the population? It may not at all. Because you're not having an impact on the population you're really not doing anything. You're spending a lot of money to do nothing. What the public is seeing is; okay, you're doing something. The scientist is saying; wait a second, you're not really doing anything."*

An underappreciation of scientific uncertainty can also contribute to a solely short-term, quick-fix focus. Short-term, control-based management options become the obvious solution only by downplaying the uncertainties concerning: where Asian carp will establish and with what effect, the efficacy of control-based efforts on Asian carp, and the consequences of control-based efforts for native fish species. These uncertainties are more explicitly acknowledged and addressed in the "biological reality" approach.

<u>Biological reality</u>

The approach to management and research that was placed in opposition to "political need" was identified by one interviewee as "biological reality". This direction for management and research was seen by interviewees as being based on a keen understanding of the biological reality of the scientific uncertainties surrounding Asian carp. In describing this approach to management and research, interviewees countered many of the problems they associated with the "political need" approach and focused on reducing uncertainty through research, pursuing biological, long-term management, and addressing rather than reacting to apathy and fear. The "biological reality" approach was seen as not currently influential, but as useful and needed for decision makers, politicians, and the public.

One key part of the "biological reality" approach is acknowledging and engaging productively with scientific uncertainty. This involves understanding the implications of scientific uncertainty for current management actions as well as in determining research priorities that can help reduce scientific uncertainty to inform future management actions. As one interviewee stated,

> *"The public, I don't think, quite understands that we know a lot but we don't know enough to be able to make really well-informed decisions or be able to just throw some sort of control tool at them [Asian carp]. In other words, you don't want to put a control out there and then find out the next year that you've basically wiped out an entire walleye population. You've got to be able to do the test to be able to evaluate the effects of a control on native species to be able to make an informed decision."*

This interviewee believes that research is needed not just to create control tools, but also to assess the potential non-target impacts of control tools on native species. Within this view, control tools cannot be responsibly used in management without reducing to a reasonable level the uncertainty surrounding their non-target impacts. This sentiment makes clear the inadequacies of only prioritizing control efforts for Asian carp.

In addition to research on the non-target impacts of management actions, this approach calls for more biological and ecological research on Asian carp, such as research on Asian carp life history and the conditions under which they thrive. Instead of seeing biological research as less vital than research on control measures, this approach highlights the potential implications

of biological research for control efforts. One interviewee described the beneficial interactions between these two types of research:

> *"And there's a lot of money being spent on development of controls so that the managers have a tool to work with. A lot less money is being spent on understanding the fish's biology: so where are the fish when they're juvenile? What exactly cues them to spawn? Where do they hang out around Locks and Dams? … The managers say that 'I need to control and I don't really need to know where the fish are around a dam.' Yet if you know where the fish are at around the dam, you then can apply it to control. They go hand-in-hand. The unfortunate thing is that some of the folks who are providing funds for it don't understand that, which can end up creating a tension between those who are actually doing the research."*

This interviewee challenges the dichotomy between control and biological research, seeing the potential of biological research to contribute to control. The interviewee also points to the potential tension between those conducting biological and control based research, when control research is seen as more fundamental to management. Another justification for more biological, ecological, and non-target impact research involved seeing Asian carp as one invasive species issue in a broader set of environmental concerns, and wanting to avoid too narrow a focus:

> *"Invasive species is part of a broader issue. It's part of how we abuse the environment in general, whether it be overfishing, overdevelopment, eutrophication… I think that's the big picture. I think we're losing track of it. It's not about walleye, it's not about [keeping Asian carp out of] Pool 2… It should be about trying to save what we have for as long as we can."*

By bringing attention to the broader environmental context that Asian carp issues are taking place within, this interviewee argues that landscape level stresses help create the conditions for Asian carp to thrive and that preventing negative impacts from Asian carp should not hurt efforts to maintain broader environmental health.

The relationship to social uncertainty, and specifically apathy and fear also differed in the "biological reality" approach. Instead of seeking to navigate apathy and fear, it sought to address social uncertainty and influence the societal reaction to Asian carp. That is, it sought to reduce the uncertainty around the societal reaction to Asian carp by reducing the uncertainty around scientific questions. By directing research toward understanding the likely impact of

Asian carp in Minnesota and the efficacy and non-target impacts of management efforts, this approach seeks to develop insights that could make it easier to decide on the desired path for management. Such an approach requires having research priorities based not on apathy or fear, but on addressing questions that are hampering management decision making. This approach assumes that more information about the likely impact of Asian carp and on the efficacy and non-target impacts of management efforts will make the desired path for management more obvious.

How to address tensions and conflicts – The right relationship to uncertainty

Interviewees also shared how they thought these conflicts and tensions could start to be addressed. One sentiment mentioned by some interviewees was the distinction between: 1) acknowledging and addressing scientific uncertainty and 2) wanting to eliminate uncertainty before pursuing management actions. There was an awareness of the need to prevent "paralysis by analysis;" that is, avoiding action by continually saying that further analysis is needed. As one interviewee said, *"If we wait for the day when we are fully certain, all hell will break loose."* In other words, it may be too late to take meaningful action if no management actions are taken until there is full certainty about how Asian carp will impact Minnesota's waterways and how management actions will impact Asian carp and native species. This view points to the limits of only seeking to reduce scientific uncertainty, and highlights how there can be a need to take management actions in the face of undesired levels of scientific uncertainty. Yet what counts as an acceptable level of uncertainty when making management decisions is both a scientific and values-based judgment.

Specific suggestions provided by interviewees for addressing these tensions and conflicts embraced a deliberative approach that fosters the right relationship to scientific and social uncertainty. One interviewee described how this approach would look,

> *"Yeah, well, it would really entail embracing the conflict, embracing the dialogue and different opinions so that there was this open exchange of views and empirical data so that everyone gets on the same page."*

Another echoed the call for dialogue, and articulated it in terms of managers and researchers,

"When you go to solve a problem you need managers and researchers in the same room. If you don't have that, researchers are going to run off and do their thing, and managers are going to run off and do their thing, and there is no consensus on what we need to be doing."

These statements point to the need to better understand the complexities involving values-based ("views" and "managers") and science-based ("empirical data" and "researchers") aspects of uncertainty, as well as how they intersect in determining research and management priorities. The goal, here, is not to eliminate scientific or social uncertainty, but to explicitly, deliberately, and justifiably make Asian carp research and management decisions in the context of that uncertainty. Such a process would acknowledge uncertainty, the potential importance of reducing uncertainty, and the potential need to act despite uncertainty. It also emphasizes the importance of providing researchers and managers an opportunity to deliberate at the intersection of the values-based and science-based aspects of the Asian carp issue.

Discussion

The findings from this study provide insights on the challenges facing Asian carp management and invasive species management, more broadly. We used in-depth interviews with managers to reveal three consequential areas of conflict and tension that hinder Asian carp management: scientific uncertainty, social uncertainty, and the direction of management and research. We found that these three areas of conflict influence and potentially reinforce each other. For example, scientific uncertainty concerning the potential impact of Asian carp in Minnesota reinforces the societal responses of apathy and fear. If the likely impacts of Asian carp in Minnesota were better known, it would be easier to move people from the type of apathy and fear described in this study. Similarly, neither an apathetic nor fear-based societal response to Asian carp will contribute to reducing scientific uncertainty. An apathetic societal response is likely to deem Asian carp inconsequential or unavoidable, thereby making it unimportant to support research to reduce scientific uncertainty concerning Asian carp impacts or non-target impacts of management options. A fear-based societal response is likely to assume the consequences from Asian carp will be severe and to demand control-based management actions, such as barriers, with little concern for their non-target impacts – also

making it unimportant to reduce such scientific uncertainty. Finally, both scientific uncertainty and social uncertainty make determining the appropriate direction of research and management more difficult, and lacking a direction for research and management does little to address scientific and social uncertainty.

One possible way to address this challenging situation emerged in the discussion of the "biological reality" approach to management and research. This approach was based on reducing scientific uncertainty through research on pertinent questions. It was seen as not responsive to social uncertainty, apathy, and fear, but able to address them by narrowing in on what the likely impacts from Asian carp are and what management options are most effective and least harmful. Three points should be considered with regards to this approach. First, what counts as a pertinent question in need of further study is itself a values-based judgment, prone to disagreement. If there was broad agreement on research priorities and the level of certainty needed to advance with management actions, then many of the tensions and conflicts described in this paper would be avoidable and there would be no concern about "paralysis by analysis". Given that agreement does not exist on what constitutes pertinent questions, attention should be paid to the process used to arrive at them. An explicit, inclusive, and deliberative process can help ensure that such decisions are substantively sound and trusted (Stern and Fineberg 1996).

Second, even when decreasing scientific uncertainty around the impacts of Asian carp and management actions reduces social uncertainty, it will not completely remove the potential for social uncertainty or social conflict around management. Even with perfect information about the impact of Asian carp and the efficacy and non-target impacts of management options, there would still be the potential for values-based differences concerning management, such as over the desired state of the waterways and over what management is worth the investment. One could imagine, for example, a variety of views concerning what amount of management is worthwhile to address a small established population of Asian carp that causes no significant ecological harm but that occasionally causes certain recreational

hazards. The persistence of the potential for values-based differences means that there will always be a need to pursue deliberative engagement processes to productively address these value-based issues (Dietz and Stern 2008).

Third, in describing the "biological reality" approach, interviewees did not often describe the essential role of the public, stakeholders, and politicians in supporting research. Even if this approach wished to address and not react to social uncertainty, apathy, and fear, the research such an approach would pursue is at least partially dependent upon broader societal support. It will be hard to continue with research that is not supported by public, stakeholders, or politicians. Here is where the nuance around the type of support becomes important. Without support the research is likely not to be pursued. Yet if the public, stakeholders, or politicians give the wrong type of support that leans towards immediate control-based research and management, research on the key scientific uncertainties also won't be supported. So it is only with the right type of support that this "biological reality" approach to management can advance.

References

Asian Carp Regional Coordinating Committee. 2014. “Asian Carp Control Strategy Framework.”

Buckley, Yvonne M., and Yi Han. 2014. “Managing the Side Effects of Invasion Control.” *Science* 344 (6187): 975–76.

Clout, M.N., and P.A. Williams. 2009. *Invasive Species Management : A Handbook of Techniques*. Techniques in Ecology and Conservation Series. Oxford: Oxford University Press.

Conover, G., R. Simmonds, and M. Whalen, eds. 2007. *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States*. Washington, D.C.: Aquatic Nuisance Species Task Force.

Davis, Mark A. 2009. *Invasion Biology*. Oxford: Oxford University Press.

Davis, Mark A., Matthew K. Chew, Richard J. Hobbs, Ariel E. Lugo, John J. Ewel, Geerat J. Vermeij, James H. Brown, et al. 2011. “Don’t Judge Species on Their Origins.” *Nature* 474 (7350): 153–54. doi:10.1038/474153a.

Dietz, Thomas, and Paul C. Stern. 2008. *Public Participation in Environmental Assessment and Decision Making*. Washington, D.C.: The National Academies Press.

Estévez, Rodrigo A., Christopher B. Anderson, J. Cristobal Pizarro, and Mark A. Burgman. 2015. “Clarifying Values, Risk Perceptions, and Attitudes to Resolve or Avoid Social Conflicts in Invasive Species Management.” *Conservation Biology* 29 (1): 19–30.

Hattingh, Johan. 2011. “Conceptual Clarity, Scientific Rigour and ‘the Stories We Are’: Engaging with Two Challenges to the Objectivity of Invasion Biology.” In *Fifty Years of Invasion Ecology: The Legacy of Charles Elton*, edited by David Richardson M., 359–75. Blackwell.

Kokotovich, Adam E., and David A. Andow. 2015. “Potential Adverse Effects and Management of Silver & Bighead Carp in Minnesota: Findings from Focus Groups.” Working Paper #2015-01. St. Paul, MN: Minnesota Aquatic Invasive Species Research Center.

Kolar, Cindy S., Duane C. Chapman, Walter R. Courtenay Jr, Christine M. Housel, James D. Williams, and Dawn P. Jennings. 2005. “Asian Carps of the Genus Hypophthalmichthys (Pisces, Cyprinidae)—a Biological Synopsis and Environmental Risk Assessment.” US Fish and Wildlife Service.

Lager, William. 2015. “Upper St. Anthony Lock Closing after Half a Century; Blame the Carp.” *Minnesota Public Radio*, June 8. http://www.mprnews.org/story/2015/06/08/upper-st-anthony-lock.

Lampert, Adam, Alan Hastings, Edwin D. Grosholz, Sunny L. Jardine, and James N. Sanchirico. 2014. “Optimal Approaches for Balancing Invasive Species Eradication and Endangered Species Management.” *Science* 344 (6187): 1028–31. doi:10.1126/science.1250763.

Larson, Diane L., Laura Phillips-Mao, Gina Quiram, Leah Sharpe, Rebecca Stark, Shinya Sugita, and Annie Weiler. 2011. “A Framework for Sustainable Invasive Species Management: Environmental, Social and Economic Objectives.” *Journal of Environmantal Management* 92: 14–22.

Little, Edward E., Robin D. Calfee, Holly Puglis, Peter W. Sorensen, Aaron Claus, and Hangkyo Lim. 2014. “Field Evaluation of Sex Pheromone Attractants to Control Asian Carp and Development of Protocols for Field Verification of Response.” In . Quebec, Canada.

Sagoff, Mark. 2009. “Environmental Harm: Political Not Biological.” *Journal of Agricultural and Environmental Ethics* 22: 81–88.

Stern, Paul C., and Harvey V. Fineberg. 1996. *Understanding Risk : Informing Decisions in a Democratic Society*. Washington, D.C.: National Academy Press.

Tassin, Jacques, and Christian Kull. 2015. “Facing the Broader Dimensions of Biological Invasions.” *Land Use Policy* 42: 165–69.