



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



Adam E. Kokotovich*, David A. Andow

Department of Entomology and Minnesota Aquatic Invasive Species Research Center, University of Minnesota, 1980 Folwell Avenue, St. Paul, MN 55108, United States

ARTICLE INFO

Article history:

Received 12 May 2016

Received in revised form 21 December 2016

Accepted 21 December 2016

Available online xxx

Keywords:

Scientific uncertainty

Social uncertainty

Apathy/fear

Participation

Invasive species management

Asian carp

ABSTRACT

There is a growing recognition that scientific and social conflict pervades invasive species management, but there is a need for empirical work that can help better understand these conflicts and how they can be addressed. We examined the tensions and conflicts facing invasive Asian carp management in Minnesota by conducting 16 in-depth interviews with state and federal agency officials, academics, and stakeholders. Interviewees discussed the tensions and conflicts they saw impacting management, their implications, and what could be done to address them. We found three key areas of conflict and tension in Asian carp management: 1) scientific uncertainty concerning the impacts of Asian carp and the efficacy and non-target effects of possible management actions; 2) social uncertainty concerning both the lack of societal agreement on how to respond to Asian carp and the need to avoid acting from apathy and/or fear; and 3) the desired approach to research and management – whether it is informed by “political need” or “biological reality”. Our study of these tensions and conflicts reveals their importance to Asian carp management and to invasive species management, more broadly. We conclude with a discussion of possible ways to address these areas of tension and conflict, including the potential of deliberative, participatory approaches to risk-related decision making and the need to productively engage with apathy and fear.

© 2016 Elsevier Ltd. All rights reserved.

1. 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). This increasing appreciation for nuance, complexity, and ambiguity can be seen in different realms of invasive species scholarship. First, 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 has held little sway for some time in scientific discourse and is becoming more questioned in popular discussions about invasive species (Goode, 2016).

The scholarly literature on the social aspects of invasive species management, including the role of human values and political judgments, also shows considerable nuance. Much of this literature 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). Recently, this focus has broadened by building on the idea that science alone is inadequate for determining what invasive species are of greatest concern and what management actions are desirable. One conclusion 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 determine whether an invasive species is likely to have an impact on the environment, but it is fundamentally a value judgment whether that change is harmful. Such value judgments can be made explicitly and deliberately or in

* Corresponding author.

E-mail address: koko0013@umn.edu (A.E. Kokotovich).

less transparent ways, but they are unavoidable in invasive species management. Second, conflict can exist over the value judgments in invasive species management, such as those concerning the desired state of nature, what constitutes harm from a non-native species, when management is worthwhile, or what non-target consequences of management actions are acceptable (Estévez et al., 2015; Buckley and Han, 2014; Larson et al., 2011). Some practices exist to avoid 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 what form these issues take in empirical case studies. In addition, there is a need to better understand how scientific and social conflicts influence each other in invasive species management. Such case studies can improve understandings of the challenges facing invasive species management and explore possible ways to address these challenges. The research presented here explores the tensions and 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 tensions and conflicts that currently affect Asian carp management as well as possible ways to address these conflicts. These findings provide insights for Asian carp management and shed light on some of the broader challenges facing invasive species management.

1.1. 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 affecting 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 carp (*Hypophthalmichthys molitrix*) and Bighead carp (*Hypophthalmichthys nobilis*), specifically, were promoted by state and federal agencies as a nonchemical and environmentally friendly way to improve water quality in retention ponds and sewage lagoons (Kelly et al., 2011). Subsequent unintentional release and large flood events are thought to have facilitated the escape of Asian carp into the Mississippi River system in the 1970s (Kelly et al., 2011). 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 chain by consuming large amounts of plankton to, in the case of Silver carp, jumping up to 10 feet in the air when disturbed (Kolar et al., 2005).

As a result of the potential and realized threats posed by Asian carp, state and federal agencies have been actively managing invasive Asian carp across the central and southern United States (Conover et al., 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 US 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 must find ways to work across these differences when collaborating with other agencies. States can also have differing management priorities based on where they are located relative to the invasion front, 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 self-sustaining breeding populations to the state and because of the negative effects they have caused in nearby areas where large populations are present. Individual Silver and Bighead carp have been captured in Minnesota each year since 2007, excluding 2010, and as far back as 1996, including 5 Bighead carp in the St. Croix river near Stillwater, MN in April 2015. The nearest reproducing population of Bighead and Silver carp, however, is thought to be in the Mississippi River 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 remain 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.

2. Methodology

To study these tensions, we conducted 16 in-depth interviews with individuals who have been actively 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 that can help reveal key nuances. We used three main criteria to select interviewees who had been involved with Asian carp management in Minnesota. First, in order to obtain a breadth of views, we selected interviewees from the breadth of organizations involved with management, including state and federal agencies (e.g., Minnesota Department of Natural Resources, US 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 through our attendance of state-level Asian carp meetings, such as the Invasion Carp Forum, and as identified by other interviewees. Third, we took steps to make sure we gathered the diversity of views present, by, for example, asking all interviewees for other important people to talk to and by continuing to conduct interviews until we reached a saturation point. After 16 interviews we reached a saturation point, both in terms of having talked to all key individuals mentioned by interviewees and in terms of no longer revealing novel understandings of the tensions and conflicts surrounding Asian carp management. Interviews lasted, on average, between 1 and 2 h each and were conducted in person and by phone. Interviews took place from March to May 2015.

A semi-structured interview process was followed where interviewees were all asked the same initial questions, but

follow-up questions and conversations differed based on the specific responses of interviewees (Bernard, 2013). Interviewees were asked three main questions: 1) what are the tensions and conflicts you see as consequential for Asian carp management; 2) what are the implications of those tensions and conflicts; and 3) how could these tensions and conflicts be addressed or navigated? Follow-up questions sought to clarify the answers to each question and to explore the factors influencing them. 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 conflicts, their implications, and what could be done to address them. 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 involved thematic coding of the interviews to confirm the accuracy of the notes, apprehend additional nuance in interviewee responses, and identify quotations that were illustrative of key points. This analysis resulted in a set of described tensions and conflicts, including what contributed to them, their implications, how they related to one another, and how they could be addressed.

3. 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. Given our desire to understand the breadth of tensions and conflicts influencing management, we looked across all of the interviews to identify these areas of tension or conflict. This means that all three areas were not mentioned by every interviewee. However, all interviewees mentioned at least one area and all areas of tension and conflict were mentioned in each of the groups we interviewed: state agencies, federal agencies, academia, and NGOs. The awareness of these issues was shared across groups, even if interviewees differed in their exact articulations based on how they were situated in the management context. In these results, we first describe each area of tension or conflict in detail, including their implications and the factors that contribute to them. We conclude by discussing some of the ways that interviewees believed these tensions and conflicts could be addressed.

3.1. Scientific uncertainty

Two consequential scientific questions were frequently mentioned as being plagued by significant uncertainty: 1) what are the likely impacts from Asian carp in Minnesota? and 2) what are the likely impacts of management actions, such as deterrents, on both Asian carp and native fish species? Even though there are a variety of research efforts taking place – involving, for example, biobullets and pheromone attractants (Little et al., 2014) – there remain no definitive control solutions for Asian carp. Since there are currently no simple, straight forward solutions to Asian carp, and many interviewees stated that there are unlikely to be any in the future, a host of management and research efforts need to be considered. Interviewees believed that these two questions plagued by uncertainty are vital for determining a reasoned approach to decision making for a particular management action. Such a reasoned approach would need to weigh the following: 1) how will Asian carp likely harm Minnesota and how effective is the proposed management action at preventing harm from Asian

carp? and 2) how does the proposed management action impact native species and how important is the health of native species for preventing harm from Asian carp? Without weighing these points it is impossible to determine if management is even warranted and if management actions do more good (in preventing adverse effects from Asian carp) than harm (in terms of non-target damage to native species).

First, 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, an important part of the decision making equation remains lacking.

Second, there is also significant uncertainty around the effectiveness and non-target impacts of management options. The effectiveness of certain deterrents, such as acoustic or bubble barriers, at slowing or stopping the spread of Asian carp remains poorly known, and although deterrent technology is already being used to try to slow or stop Asian carp spread, it is known to be less than 100% effective. In addition, 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 of juvenile Asian carp in bait. The use of deterrents, depending on how they are designed, can impede native fish passage and, as a result, cause harm to native fish populations. Many interviewees mentioned how such uncertainties can make it challenging to decide when and how a deterrent should be deployed.

Interviewees also articulated uncertainty about the extent that biotic resistance – the ability of ecological communities to resist 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 to increase predation on Asian carp and reduce the severity of 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 deterrents. If, however, existing pollution and stresses on native fish communities make it unlikely that these communities could be restored to a level that would achieve effective biotic resistance, it could make more sense to pursue deterrents.

These scientific uncertainties have several implications for management efforts. First, they make it difficult to determine when and under what conditions deterrents 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 deterrents on Asian carp and native species make it unclear whether they 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.

3.2. Social uncertainty – Apathy/Fear

Social uncertainty emerged as a key area of tension and 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 trying to avoid undesirable societal responses based on apathy and fear. All interviewees believed that there was general societal agreement on the undesirable nature of Asian carp and their negative effects, in that nobody was arguing in favor of their introduction. Yet interviewees also believed that there was a lack of agreement about the appropriate societal response to Asian carp. The lack of agreement on the appropriate societal response was seen as making it more likely that the societal response would drift towards the extremes of apathy and fear.

In discussing this area of conflict, interviewees identified the problems associated with an apathy- or fear-based societal response to Asian carp and the difficulties of navigating between these extremes. Societal response, in this case, usually referred to the thinking and actions of people (e.g., the general public, individual stakeholders, politicians, state and federal agency personnel) as well as institutions (e.g., 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 and fear, and the relationship between the two.

Interviewees described an 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 will 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 will establish and 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 from Asian carp actually 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 lack of 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, many interviewees also discussed difficulties in navigating apathy and fear when working on Asian carp issues, especially with the public and politicians. In particular, interviewees expressed how difficult it was to avoid a societal reaction based on apathy or fear. 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 either or both apathy and fear depending on how they are understood, making clear the nuance needed in communication efforts. 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.

3.3. 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 achieved (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” approach was privileged more in the current context, and thought that ideas from the alternative “biological reality” approach needed to be promoted. The views of all interviewees 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 these two approaches to management and research, highlighting how they each relate differently to scientific uncertainty and social uncertainty.

3.3.1. 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 straightforward, 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.”

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 support for ecological or high-risk, high reward research can be difficult to sustain because “legislators want sure things. They

want . . . fish killed.” Many interviewees felt, however, that control-based management research can potentially be used to show the public and decision makers something is being done, even if it has no significant effects on Asian carp populations. One interviewee expressed these limitations in the context of management issues occurring in more southerly states 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 short-term, quick-fix focus. Short-term, control-based management options emerge as neatly and clearly desirable 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.

3.3.2. Biological reality

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. First, this involves understanding the implications of scientific uncertainty for current management actions and determining research priorities that can help reduce scientific uncertainty to inform future management actions. This includes, for example, acknowledging when little is known about the potential non-target impacts of a management action, and recognizing the importance of this information for reasoned decision making. 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 emphasizes how biological research could help inform control efforts. The strict division between biological and control research is challenged, and there is a recognition that a better understanding of life history and their interactions with other organisms could help inform and create new management actions.

The relationship to social uncertainty, and specifically apathy and fear also differed in the “biological reality” approach. Instead of reacting to 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 effects of Asian carp and on the efficacy and non-target impacts of management efforts will make the desired path for management more obvious.

3.4. 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, to avoid making a decision 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 the need to take management actions in the face of 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 science-based (“empirical data”) 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, as we discuss further in the discussion. 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.

4. Discussion

The findings from this study provide insights into the challenges facing Asian carp management and invasive species management, more broadly. The in-depth interviews revealed three consequential areas of conflict and tension that hinder Asian carp management: scientific uncertainty, social uncertainty, and

the desired approach to management and research. We found that these three areas of tension and conflict influence and potentially reinforce each other. For example, when the likely impacts of Asian carp and management actions are not well known, it is more likely that people will diverge to extreme responses, including those based on apathy or fear. Similarly, neither an apathy- nor fear-based societal response to Asian carp will support efforts to reduce scientific uncertainty. An apathetic societal response is likely to lead to Asian carp being deemed inconsequential or unavoidable, thereby making it unimportant to support research to reduce scientific uncertainty concerning impacts of Asian carp or non-target impacts of management options. A fear-based societal response is likely to lead to the assumption that consequences from Asian carp will be severe and to increase demand for control-based management actions, such as deterrents, 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 such lack of direction stalls efforts 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 and social uncertainty through research on pertinent questions – in this case, the likely impacts of Asian carp and management actions in Minnesota. Three points about the limitations of, and problems facing, this approach should be considered. First, what counts as a pertinent question is itself a value judgment, prone to disagreement (Nelson and Banker, 2007; Machamer and Wolters, 2004). As we discuss in more detail below, attention should be paid to the process used to arrive at these questions, and an explicit, inclusive, and deliberative process can help ensure that such decisions are substantively sound and trusted (Stern and Fineberg, 1996).

Second, although decreasing scientific uncertainty may reduce social uncertainty, it will not completely eliminate social uncertainty or the potential for social conflict around management (Sarewitz, 2004; Boertje et al., 2010). Even with perfect information about the impacts 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. 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 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 values-based issues (Dietz and Stern, 2008).

Third, in describing the “biological reality” approach, interviewees did not often describe the role of the public, stakeholders, and politicians in supporting research. Even if this approach were to conduct research to address proactively social uncertainty, apathy, and fear, such research is at least partially dependent upon broader societal support. It would be difficult to continue with any research that is not supported by the public, stakeholders, or politicians (Clout and Williams, 2009). Here is where the nuance around the type of support becomes important. Without support the research is unlikely to be pursued. Yet if the public, stakeholders, or politicians give the kind of support that leans towards immediate control-based research and management, research on the key scientific uncertainties won’t be fostered. So it is only with the right type of support that the desired form of research and management within the “biological reality” approach can advance.

4.1. Confronting contemporary invasive species management

The findings presented in this paper highlight some of the challenges facing contemporary invasive species management. We conclude by suggesting two areas of literature that may be helpful in addressing these challenges: the literature on risk-related decision making and the literature on apathy and fear. The first area of literature includes the well-established scholarship on using deliberative and participatory methods to inform risk-related decision making in the face of uncertainty (Jasanoff, 1993; Stern and Fineberg, 1996; Renn, 2008; Nelson et al., 2009). Risk assessment is recognized as an important tool to help synthesize science to inform invasive species management (Anderson et al., 2004), and the use of risk governance approaches that explicitly recognize the importance of value judgments and broad participation are particularly useful for the challenges revealed here.

First, explicitly recognizing value judgments is the first step in making sure that they are addressed in appropriate ways. There are many value judgments relevant to the tensions and conflicts discussed here, including: what type of change from an invasive species constitutes significant harm; how to evaluate and compare the benefits, costs, and non-target impacts of management actions; and what levels of certainty are necessary to move forward with management decisions. Recognizing the role of value judgments within these questions makes evident the need for involvement by a broad set of individuals (Stern and Fineberg, 1996; Hartley and Kokotovich *In Press*). Deliberative and inclusive participatory processes, then, can be used to help address these value judgements. Broad participation helps ensure that the assumptions and implications of value judgments are better comprehended, improving the basis for decision making (Stirling, 2008). Such involvement can also help: increase the local knowledge informing decisions, improve the participants' understanding of the decision making context, and increase the trust in decisions (Dietz and Stern, 2008). These insights could inform, as discussed in Section 3.4, a deliberative process with agency managers and researchers, and ideally stakeholders and academics, to identify key areas of uncertainty within the current management context and to deliberate on and decide what levels of uncertainty are acceptable for moving forward with decisions.

While our results indicate that reducing scientific uncertainty is one way to decrease apathy and fear, an over-emphasis on reducing scientific uncertainty can lead to undesirable outcomes such as policy stagnation or oversimplification of the problem (Pe'er et al., 2014). The second area of literature builds on the idea that apathy and fear can also be avoided by understanding their sources, their limitations, and how to address them. The use of fear can be an effective way of seizing the attention of the public or decision makers and can convey a sense of urgency (Gobster, 2005). It can also backfire, however, by overemphasizing the most immediate options. Especially in instances where people feel like they have little control over the situation, fear-based messages can cause people to react to the unpleasant feelings that come up through apathy, denial, or avoidance, thereby preventing a productive engagement with the issue (O'Neill and Nicholson-Cole, 2009). From our results we can add that fear may also lead to calling for immediate management action, regardless of its efficacy or collateral damage. Seeking to address apathy and fear should not involve attempting to remove emotion from invasive species management; rather, it should involve productively engaging with the emotions that are present in a particular context (Roeser and Pesch, 2016; Doherty and Clayton, 2011; Gobster, 2005). Trying to dismiss apathy or fear-based reactions as irrational or illegitimate without actually listening to what informs them will likely only reinforce them and make it even more difficult to have a broader discussion (Roeser and Pesch, 2016, 287). These insights can be

used to design open and transparent conversations between stakeholders, the public, researchers, and managers that could at once: 1) seek to better understand, and not dismiss, existing views and emotions surrounding an invasive species management issue (including those based on apathy and fear) and the assumptions they are based, and 2) present, in a non-condescending or pressuring way, existing evidence about the invasive species and decision-making context that could help individuals reflect upon the assumptions behind their views and emotions.

This study contributes to the growing literature exploring the tensions and conflicts facing invasive species management. Our findings help better understand the challenges posed by the intersection of scientific uncertainty, social uncertainty, and invasive species research and management. These findings support the argument that value judgments are essential to invasive species management and need to be reflected on (Estévez et al., 2015). More broadly, they also contribute to efforts to more explicitly and productively engage with the role of values in environmental issues (Fernandez, 2016; Sarewitz, 2004).

Acknowledgements

We would like to thank the interviewees who took part in this research for their time and thoughtful insights. Funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources [M.L. 2013, Chp. 52, Sec. 2, Subd. 06a, Subproject 11].

References

- Anderson, Mark C., Adams, Heather, Hope, Bruce, Powell, Mark, 2004. Risk assessment for invasive species. *Risk Anal.* 24 (4), 787–793.
- Asian Carp Regional Coordinating Committee, 2014. Asian Carp Control Strategy Framework. .
- Bernard, Harvey Russell, 2013. *Social Research Methods: Qualitative and Quantitative Approaches*, 2nd ed. SAGE Publications, Thousand Oaks.
- Boertje, Rodney D., Keech, Mark, Paragi, Thomas F., 2010. Science and values influencing predator control for alaska moose management. *J. Wildl. Manage.* 74 (5), 917–928.
- Buckley, Yvonne M., Han, Yi, 2014. Managing the side effects of invasion control. *Science* 344 (6187), 975–976.
- Clout, M.N., Williams, P.A., 2009. *Invasive species management: a handbook of techniques*. Techniques in Ecology and Conservation Series. Oxford University Press, Oxford.
- Conover, G., 2007. In: Simmonds, R., Whalen, M. (Eds.), *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States*. Aquatic Nuisance Species Task Force, Washington, D.C.
- Davis, Mark A., 2009. *Invasion Biology*. Oxford University Press, Oxford.
- Dietz, Thomas, Stern, Paul C., 2008. *Public Participation in Environmental Assessment and Decision Making*. The National Academies Press, Washington, D.C.
- Doherty, Thomas J., Clayton, Susan, 2011. The psychological impacts of global climate change. *Am. Psychol.* 66 (4), 265–276.
- Estévez, Rodrigo A., Anderson, Christopher B., Pizarro, J. Cristobal, Burgman, Mark A., 2015. Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. *Conserv. Biol.* 29 (1), 19–30.
- Fernandez, Roberto, 2016. How to Be a more effective environmental scientist in management and policy contexts. *Environ. Sci. Policy* 64, 171–176.
- Gobster, Paul H., 2005. Invasive species as ecological threat: is restoration an alternative to fear-based resource management. *Ecol. Restor.* 23 (4), 261–270.
- Goode, Erica, 2016. Invasive Species Aren't Always Unwanted. *New York Times*, February 29. <http://www.nytimes.com/2016/03/01/science/invasive-species.html>.
- Hartley, S., Kokotovich, A., 2017. Disentangling risk assessment: new roles for experts and publics. In: Nerlich, B., Hartley, S., Raman, S. (Eds.), *Science and the Politics of Openness: Here Be Monsters*. Manchester University Press, Manchester, England in press.
- Hattingh, J., 2011. Conceptual clarity, scientific rigour and 'the stories we are': engaging with two challenges to the objectivity of invasion biology. In: Richardson, David M. (Ed.), *Fifty Years of Invasion Ecology: The Legacy of Charles Elton*. Blackwell, pp. 359–375.
- Jasanoff, Sheila, 1993. Bridging the two cultures of risk analysis. *Risk Anal.* 13 (2), 123–129.
- Kelly, A.M., Engle, C.R., Armstrong, M.L., Freeze, Mike, Mitchell, A.J., 2011. History of introductions and governmental involvement in promoting the use of grass,

- silver, and bighead carps. American Fisheries Society, Symposium Invasive Asian Carps in North America, 74, pp. 163–174.
- Kokotovich, Adam E., Andow, David A., 2015. Potential adverse effects and management of silver & bighead carp in minnesota: findings from focus groups. Working Paper #2015-01. Aquatic Invasive Species Research Center, St. Paul, MN: Minnesota.
- 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, W., 2015. Upper St. Anthony lock closing after half a century; blame the carp. Minnesota Public Radio News, Retrieved from: <http://www.mprnews.org/story/2015/06/08/upper-st-anthony-lock>.
- Lampert, Adam, Hastings, Alan, Grosholz, Edwin D., Jardine, Sunny L., Sanchirico, James N., 2014. Optimal approaches for balancing invasive species eradication and endangered species management. *Science* 344 (6187), 1028–1031. doi: <http://dx.doi.org/10.1126/science.1250763>.
- Larson, Diane L., Phillips-Mao, Laura, Quiram, Gina, Sharpe, Leah, Stark, Rebecca, Sugita, Shinya, Weiler, Annie, 2011. A framework for sustainable invasive species management: environmental, social and economic objectives. *J. Environ. Manage.* 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.
- Machamer, Peter, Wolters, Gereon (Eds.), 2004. *Science, Values, and Objectivity*. University of Pittsburgh Press, Pittsburgh, PA.
- Nelson, K.C., Banker, M., 2007. Problem Formulation and Options Assessment Handbook. International Project on GMO Environmental Risk Assessment Methodologies.
- Nelson, K.C., Andow, D.A., Banker, M.J., 2009. Problem formulation and option assessment (PFOA) linking governance and environmental risk assessment for technologies: a methodology for problem analysis of nanotechnologies and genetically engineered organisms. *J. Law Med. Ethics* 37 (4), 732–748.
- O'Neill, Saffron, Nicholson-Cole, Sophie, 2009. Fear won't do it: promoting positive engagement with climate change through visual and iconic representations. *Sci. Commun.* 30 (3), 355–379.
- Pe'er, G., Mihoub, Jean-Baptiste, Dislich, Claudia, Matsinos, Yiannis, 2014. Towards a different attitude to uncertainty. *Nat. Conserv.* 8, 95–114.
- Renn, Ortwin, 2008. *Risk Governance: Coping with Uncertainty in a Complex World*. Earthscan, London.
- Roeser, Sabine, Pesch, Udo, 2016. An emotional deliberation approach to risk. *Sci. Technol. Hum. Values* 41 (2), 274–297.
- Sagoff, Mark, 2009. Environmental harm: political not biological. *J. Agric. Environ. Ethics* 22, 81–88.
- Sarewitz, Daniel, 2004. How science makes environmental controversies worse. *Environ. Sci. Policy* 7, 385–403.
- Stern, Paul C., Fineberg, Harvey V., 1996. *Understanding Risk: Informing Decisions in a Democratic Society*. National Academy Press, Washington, D.C.
- Stirling, Andy, 2008. 'Opening up' and 'Closing down': power, participation, and pluralism in the social appraisal of technology. *Sci. Technol. Hum. Values* 33 (2), 262–294.
- Tassin, Jacques, Kull, Christian, 2015. Facing the broader dimensions of biological invasions. *Land Use Policy* 42, 165–169.

Adam E. Kokotovich is a postdoctoral research associate with the University of Minnesota's Minnesota Aquatic Invasive Species Research Center, where his current work focuses on the risk assessment and management of invasive Asian carp. An interdisciplinary social scientist with expertise in risk analysis, responsible research and innovation, and science and technology studies, he is particularly interested in opening to reflexive scrutiny the assumptions that inform science, technology, and environment-related decision making. His dissertation research explored contestations of risk and risk assessment involving plant genetic engineering.

David A. Andow is an ecologist with expertise on invasive species, genetically engineered organisms, environmental risk analysis, and science policy in relation to the environment.