

The Journal of Science Policy & Governance



POLICY ANALYSIS:

PREVENTING THE INVASION OF ASIAN CARPS:

**AN ANALYSIS OF ISSUES IN GOVERNANCE
AND MANAGEMENT FOR THE UPPER
MISSISSIPPI RIVER BASIN**

BY

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Abstract:

A group of four non-indigenous cyprinid fishes (of the genera *Hypophthalmichthys*, *Ctenopharyngodon*, and *Mylopharyngodon*), collectively referred to as Asian carps, have agencies and organizations in charge of managing aquatic resources in the Upper Mississippi River Basin on high alert. These fishes, a subset of aquatic invasive species, threaten to alter the ecological and economic landscape of this historically important national waterway by disrupting sensitive life systems.

Aquatic resource managers in the Upper Mississippi system identified the need to illustrate the cooperating networks of agencies and organizations that are shaping efforts to control an Asian carps invasion for this region and provide a synthesis of the economic ramifications, risks, legal frameworks, and policy instruments currently being considered to mitigate the effects these animals have on aquatic ecosystems. The purpose of this paper is to provide a useful guide for analyzing public policy dilemmas that exhibit elevated degrees of managerial complexity and varying stakeholder interests.

Methods for analyzing the problem of an Asian carps invasion begin with identifying suspected pathways of *Hypophthalmichthys*, *Ctenopharyngodon*, and *Mylopharyngodon* introduction and assessing their risk levels, developing of a matrix of legal tools and gap analysis, proceeding to surveys of expert-stakeholders to gauge preferred alternatives for the region, and concluding with a makeup of the federal and state response to the issue area.

Results of the surveys and subsequent analysis conclude that efforts to manage Asian carps in the Upper Mississippi River are significant but barriers prevail in the form of unclear jurisdictional authority for agencies, lack of robust funding to contain the invasion threat, and divergent interests in how to proceed. The recommended course of action combines biological, physical, and/or behavioral deterrents as subsets of a larger integrated pest management model, incorporating these tools into a focused and individualized regional management plan.

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List of acronyms

AHACTF – Ad Hoc Asian Carp Task Force

AIS – Aquatic invasive species

ACRCC- Asian Carp Regional Coordinating Committee

BAFF- Bio-acoustic fish fence

CARPACT- Close All Routes and Prevent Asian Carp Today Act of 2010

CAWS- Chicago Area Waterway System

CEQ- White House Council on Environmental Quality

CSSC- Chicago Sanitary and Ship Canal

GLMRIS- Great Lakes Mississippi River Interbasin Study

GLRI- Great Lakes Restoration Initiative

IPM- Integrated pest management

MNDNR- Minnesota Department of Natural Resources

MNDOT- Minnesota Department of Transportation

NEPA- National Environmental Policy Act

NGO- Non-governmental organization

NISC- National Invasive Species Council

NPS- National Park Service

UMRB- Upper Mississippi River Basin

USACE- United States Army Corps of Engineers

USEPA- United States Environmental Protection Agency

USFWS- United States Fish and Wildlife Service

USGS- United States Geological Survey

WIDNR- Wisconsin Department of Natural Resources

1. Introduction

Managing the threat of aquatic invasive species, or AIS, is one of the most pressing challenges of the 21st century for natural resource managers in the United States. Foreign invaders are capable of significantly altering an aquatic ecosystem and disrupting life systems that are in a constant state of equilibrium and balance. Next to habitat loss, invasive species are considered by many leading scientists to be the single greatest known threat to biodiversity (Wilcove et al., 1998). Introducing unknown variables into natural processes can prove consequential both ecologically as well as economically, as repairing damaged aquatic resources requires substantial private and public investment to solve. In addition to altering sensitive ecosystem processes, invasives displace native species and transport pathogens and disease to animals or humans. Reasons such as these dictate the extent that invasive species are of national concern (NISC, 2008).

An emerging invader to streams throughout the United States is a group of non-indigenous cyprinid (of the carp family) fishes collectively referred to as Asian carps (Aitkin et al., 2008). These carps, more specifically of the genera *Hypophthalmichthys*, *Ctenopharyngodon*, and *Mylopharyngodon* (Kolar et al., 2005; Conover et al., 2007), cause extensive changes to the aquatic environments where they are introduced. Conover et al. noted in the 2007 National Management and Control Plan for Asian carps that these dramatic changes “jeopardize the long-term sustainability of native aquatic fishes, most notably to imperiled, threatened, and endangered species” (Conover et al., 2007). Fifty-one native fish species in the Upper Mississippi River Basin (UMRB) are listed on state and federal threatened and endangered lists (FishPro, 2004). Populations of these carps in parts of the Lower Mississippi, Missouri, and Illinois Rivers are increasing exponentially,

potentially leaving a legacy that could affect the survival of native fish populations within the Mississippi River Basin for decades to come (Kolar et al., 2005).

Resource managers across the Upper Midwest, encompassing multiple sectors and constituent bases, are striving to contain threats of aquatic invasion by Asian carps through aggressive control measures aimed at targeting specific genetic characteristics, behavioral elements, or reproductive capacities through advanced fisheries research and engineering. In addition to learning more of the potential threat through science, agencies charged with protecting the Mississippi River and Great Lakes are working to shape federal and state policy. The intent is to design a comprehensive managerial approach to Asian carps that is unique to the area and allocate funding to meet the invasion threat.

For the purposes of this paper, an invasive species is a category of non-indigenous species that is defined as: 1) non-native to the ecosystem under review and 2) whose introduction may cause economic, environmental, or human health harm (NISC, 2008). It is beyond the scope of the research presented in this document to effectively address the entirety of the national policy landscape for AIS. Instead, this study will reflect the policy priorities and challenges of agencies and organizations tasked with managing



Figure 1. Upper Mississippi River System. Source: U.S. Army Corps of Engineers. <<http://www.mvr.usace.army.mil/Brochures/MeetingTheChallenge.asp>>

aquatic resources, and specifically Asian carps, for greater Minnesota and Wisconsin.

Of principal concern is the potential damage populations of Asian carps may cause to the Upper Mississippi River Basin, which represents 10% of the third largest drainage basin in the world, beginning as a first order stream in Lake Itasca and later joining the Ohio River to form the largest river in North America (See Figure 1). In particular, the Upper Mississippi River System exhibits an impressive range of physical, chemical, and biological diversity that is vital to aquatic and ecological heterogeneity (DeLong, 2005). Encompassing five states in the Upper Midwest, the UMRB is home to 485 species of fish, mammals, birds, amphibians, and reptiles. Precisely 260 species of fish have been surveyed in the UMRB, which represents 25% of all fish species in North America (FishPro, 2004). This river system also provides habitat for 62 species of freshwater mussels, 45 species of amphibians and is an established flyway for 326 species of birds (FishPro, 2004). A study funded by the Minnesota Department of Natural Resources (MNDNR) in 2004 to assess the likelihood of invasion by Asian carps in the Upper Mississippi concluded “the balance of the UMRB as a system depends greatly upon the interactions of both terrestrial and aquatic species. Disruption to this balance by the addition of non-indigenous species or extirpation of key native species could alter the ecosystem” (FishPro, 2004).

Asian carps threaten the UMRB through their ability to adapt to trophic dynamics, food sources, and habitat characteristics of the Mississippi River and are likely to cause a variety of environmental effects including harm to native populations of aquatic organisms (Kolar et al., 2005). The four species discussed herein may alter the ecological integrity of this historically important national waterway resulting in a biomass

homogenized by carps.

This paper utilizes field observations and semi-structured interviews with expert-stakeholders as tools to investigate the makeup, involvement, and challenges present in the effort to prevent the invasion of Asian carps in the UMRB. Additionally, this paper evaluates several alternatives, in both the short- and long-term, that the actors in charge of providing recommendations to policymakers are considering for mitigating the risks of ecological or economic damage to the UMRB.

Initial research questions include:

- What is the composition of the state and federal response effort to the Asian carps UMRB threat?
- Which agencies or actors are vital in organizing and/or leading any actions against the status quo?
- What are the most effective short and long-term policies for prevention of an Asian carps invasion as indicated by the scientific community, resource principals, and non-governmental organizations (NGOs)?
- Which research strategies for managing or eradicating nuisance cyprinids have high levels of initial effectiveness and short timeframes to implementation? Which strategies are more suitable in the long term?
- Which AIS management options are the state and/or federal agencies considering as top candidates to prevent establishment of Asian carps in the UMRB and which barriers to governance are omnipresent?
- What are points of agreement or contention among expert stakeholders involved in Asian carps management?

Review of the literature revealed two conclusions:

1. No analysis of the cooperating networks of agencies and organizations as well as their role in shaping management goals or policy outcomes specifically for the UMRB has been articulated.
2. No comprehensive strategic framework for Asian carps management in the UMRB has been authorized. While national plans do exist, how specific plan elements can be tailored to address a waterway with an inherently unique set of conditions and characteristics has yet to be adopted or finalized.

This paper addresses these two areas so that resource managers and policymakers have sufficient tools and knowledge to make informed decisions that uphold the interests of agencies and the citizens they represent, while subsequently understanding the barriers and complexity of this issue. Also included is a description of the ecological risks associated with these fishes, encompassing life history, population distribution, food sources, behavioral and reproductive patterns, impacts to native species, and economic considerations for greater Minnesota and Wisconsin. Next, methods for analyzing the Asian carps problem are introduced and the paper examines the risks of existing and potential pathways of introduction and outlines the current threat of invasion for the Great Lakes by way of the Chicago Area Waterway System (CAWS) and Lake Michigan. The CAWS, which connects Lake Michigan with the Upper Mississippi by way of the Illinois River, acts as a case study for implementing policies when the threat of an Asian carps invasion is imminent (examples include the Water Resources Development Act of 2007 and the corresponding Electric Dispersal Barriers Project designed to restrict fish passage through Chicago and into Lake Michigan). This paper documents substantial

resource deployment to the Great Lakes region. Furthermore, a policy gap analysis of existing and proposed federal and state law gives context to the regulatory environment, and available tools, of resource managers. The paper also presents a stakeholder analysis derived from interviews with industry leaders and peer-reviewed literature, examines policy priorities in both the short and long-term, describes the role actors play in shaping policy, and concludes with a discussion of possible paths to manage the Asian carps problem for the UMRB.

2. Background of the problem: Invasives in the U.S.

Threats of invasive species are not a recent occurrence. Pimentel et al. have indicated that approximately 50,000 foreign species of plant and animal communities in the U.S. have been introduced over time, and that number is steadily increasing, also noting that about 42% of native species listed as endangered or threatened are at risk due to prevalence of alien-invasives (Pimentel et al. 2005). While many resource managers are aware of the effects aquatic invasive species have on sensitive ecosystems, the sense of urgency has been significantly heightened for the case of Asian carps in the UMRB and Great Lakes areas. This is due in part to the carps' capacity for rapid growth and reproduction, extensive consumption of microorganisms and aquatic plant life, and potential declines to sportfishing revenues.

2.1 Life history and introduction into the United States

Of the numerous species of carps native to Asia, seven have been introduced to the United States. Common usage of the term "Asian carps" in the United States has come to describe four carp species in particular. These include: grass carp

(*Ctenopharyngodon idella*), black carp (*Mylopharyngodon piceus*), bighead carp (*Hypophthalmichthys nobilis*), and silver carp (*H. molitrix*) [Conover et al., 2007]. For the purposes of this document, Asian carps will refer to these four distinct species of fishes (Refer to Figure 2).

Asian carps were originally introduced into the southern United States in 1973 by a private fish farmer in Arkansas for the purpose of improving fish production in aquaculture and enhancing water quality, due to their ability to reproduce rapidly and consume plankton (Conover et al., 2007). Benefits became apparent

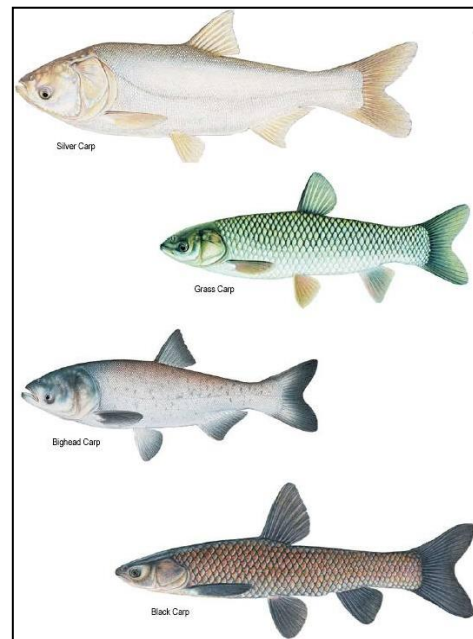


Figure 2. Asian carps species of concern (Source: US Geological Survey (USGS) <http://fl.biology.usgs.gov/Carp_ID/html/spawning_requirements.html>

for fish farmers from nearby states and Asian carps, particularly bighead carp, began being propagated as food fish and sold to ethnic markets. While the time and place of their introduction to public waters is not confirmed or widely known, Kolar et al. (2005) suggests that carps escaped into nearby streams from sewage overflows or floods in the early 1980s. Around this time, regulation was spearheaded by the U.S. Fish and Wildlife Service (USFWS) to restrict stocking of Asian carps in the aquaculture industry and avoid accidental introductions into nearby tributaries, but the mandate proved ineffective as carps quickly became established in Arkansas streams and eventually the Missouri River.

By 1981, confirmed populations of Asian carps existed at seven locations in three different rivers in Arkansas (ACRCC, 2011). The first scientific evidence of Asian carp reproduction occurred in the Missouri River in 1989 (Kolar et al., 2005). From these areas, the fish spread rapidly through the Mississippi/Missouri watersheds, altering food and habitat paradigms for sport fish populations as they migrated in search of adequate sustenance. By the mid-1990s, Asian carps were appearing in large numbers at the interface of the Lower and Upper Mississippi River Systems even appearing as far north as the Saint Croix River in 1996 when an individual bighead carp specimen was caught (MNDNR, 2007). In 1999, the USFWS applied rotenone (a fish toxin) into a pool of the Mississippi River near St. Louis, Missouri to prevent the upstream migration of Asian carps. Among the deceased animals, only four specimens were native fish species. The remaining 97% were Asian carps (primarily bighead and silver carps) [Conover et al., 2007]. Four years later, in 2003, a 23-pound bighead carp was caught in Lake Pepin in the UMRB near Red Wing, Minnesota. Commercial fishermen produced a large grass carp from the Saint Croix River in 2006 (MNDNR, 2007) and as recently as March of 2012, individual bighead, grass, and silver carp specimens were netted near Winona, Minnesota. In light of the confirmed evidence of at least three species of Asian carps within the boundaries of Minnesota, the urgency to act has become more pronounced.

Aquatic resource managers have expressed concern regarding the rate of maturation for these fishes as well as their adult size and long life cycle. Asian carps can grow at a rate of 5-6 pounds per year, are capable of consuming 5-20% of their body weight in a single day (ACRCC, 2011), and have no known natural predators in the country (Kolar et al., 2005). Of note is the fact that grass carp can consume up to 40% of

their body weight in aquatic vegetation in a single day (MNDNR, 2007). At maturity, bighead carp can weigh up to 110 pounds and grow to 60 inches in length. In aquaculture facilities, silver carp have grown to 12 pounds in one year, and may grow to a maximum of 39 inches and 60 pounds. Grass carp grow to a maximum of 59 inches, 99 pounds, and have a 21-year lifespan. Black carp can grow to a maximum of 48 inches and 71 pounds (Conover et al., 2007; Kolar et al., 2005).

Further confounding the problems associated with the growth potential and size of these fishes at maturity is the risk to citizens who use the rivers for recreation. Silver carp are well known for their habit of leaping up to ten feet out of the water when disturbed by boats or other river traffic and colliding with humans, causing injury or harm (MNDNR, 2007).

In certain areas of the Illinois, Ohio, and Lower Mississippi Rivers, Asian carps constitute as much as 95% of the sampled biomass (ACRCC, 2011). The Upper Mississippi system is similar in its trophic and ecological attributes to the aforementioned rivers, therefore it can be deduced that UMRB aquatic resource managers will be challenged in preventing a biomass homogenized by Asian carps if they become established.

2.2 Food sources and threats to native fishes

Asian carps exhibit highly opportunistic feeding habits, although relying almost continually on the base of the food web including: zooplankton, phytoplankton, aquatic vegetation, bacteria, and detritus (MNDNR, 2007). Their eating voracity is largely associated with a lack of a true stomach, which spurs continuous consumption (MNDNR, 2007). Bighead and silver carps, more specifically, are fast-growing, high-volume filter

feeders with a diverse and adaptive diet encompassing primarily plankton (Kolar et al., 2005). Grass and black carps also consume plankton in addition to aquatic vegetation and mollusks.

Evidence suggests that Asian carps profoundly affect food sources for planktivorous fishes such as the gizzard shad, bigmouth buffalo, cisco, bloater, or yellow perch as a result of their dietary needs and preferences (Cooke and Hill, 2010). There is also concern for fisheries and resource managers about the effects these carps have on native invertebrates, vertebrates, and freshwater mussels as competition for limited food sources becomes fierce for native juvenile sport fish that depend on the base of the food web for their growth and survival (Cooke and Hill, 2010). Highly sought after sport fish are dependent on a steady stream of juvenile baitfish to grow and mature. The MNDNR has indicated their commitment to habitat improvement in the UMRB corridor as a means to improving outcomes for indigenous and sport fishes. How native/sport fishes respond to habitat strengthening and whether they can coexist with Asian carps remains to be researched or published.

2.3 Reproductive patterns and fecundity

Table 1 illustrates the respective Asian carps species and their preferred food sources, optimal spawning temperatures, and fecundity. Fecundity is defined as species fertility level, or the capacity of that particular fish to produce abundant offspring given desirable conditions for reproduction. Spawning temperatures for Asian carp species are well within the typical range for seasonal reproduction in the UMRB. Worth noting is that Kolar et al. (2005) determined all four species of Asian carps are capable of dietary overlap with indigenous species.

Table 1. Diet type and fecundity of Asian carps

Species	Food Source	Spawning Temp. (F)	Fecundity
<i>Ctenopharyngodon idella</i> (Grass carp)	Aquatic vegetation	59-86	500,000 to 1 million
<i>Mylopharyngodon piceus</i> (Black carp)	Zooplankton, mollusks	62-86	1.3 to 3.4 million depending on female size
<i>Hypophthalmichthys nobilis</i> (Bighead carp)	Primarily phytoplankton, zooplankton	64-86	478,000 to 1.1 million
<i>H. molitrix</i> (Silver carp)	Phytoplankton, zooplankton and detritus	64-86	50,000 to 5 million depending on female size

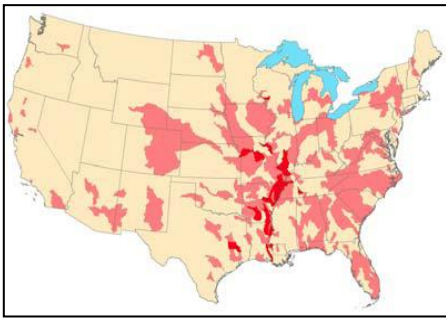
(Data derived from Kolar et al., 2005 and MNDNR, 2007)

It has been reported in the literature that these species exhibit hardiness and adaptive behavioral characteristics pertaining to food sources and reproductive capacity (Kolar et al., 2005). Resource managers are particularly concerned with locating the reproductive front of the four species' geographic distribution and northward migration, as this is typically associated with a population explosion once fish become established (MNDNR, 2007). This has proved challenging in part because the fish are difficult to catch, are leery of human encroachment, are easily rattled by boat and motor traffic, and evade commercial nets.

2.4 Population distribution – 1997-2004

Figure 3 on page 18 illustrates the changes in distribution for the four carp species of concern between 1997-2004. Two colors are highlighted in the images. Light red represents areas where populations of respective Asian carp species are non-reproducing. Dark red indicates areas where reproduction has been documented by the U.S. Fish and Wildlife Service (USFWS). Notable are the changes in reproductive distribution for grass, bighead, and silver carps over a seven-year time frame. Images in Figure 3 also show the northward concentration of fishes near the Wisconsin and Minnesota borders.

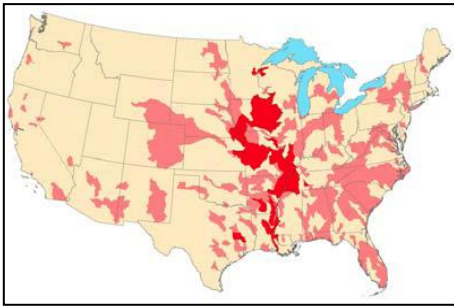
Figure 3. Changes in Asian carp species distribution 1997-2004



Grass carp 1997



Black carp 1997



Grass carp 2004



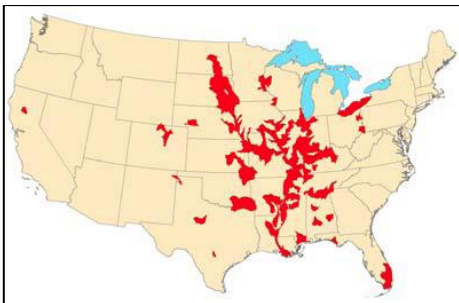
Black carp 2004



Bighead carp 1997



Silver carp 1997



Bighead carp 2004



Silver carp 2004

(Source: USFWS. <http://www.fws.gov/midwest/Fisheries/library/fact-asiancarp.pdf>)

2.5 Economic considerations for Minnesota and Wisconsin

While some non-indigenous fish species have been associated with positive economic benefits, the majority of nuisance or exotic fish species are linked to an estimated \$1 billion per year in economic losses in the United States, ranging from decreased property values and fishing revenues to increased costs associated with impacts to water quality and habitat (Pimentel, et al. 2005). Should breeding populations of Asian carps become established in Minnesota and Wisconsin, agencies and organizations can expect losses consistent with national estimates for alien-invasives from the Pimentel et al. (2005) study but more localized in these two states. Of particular concern for the regional economies of Minnesota and Wisconsin are the sport fishing revenues that could be put in jeopardy should Asian carps diminish fishing resource capacity. The four species mentioned are considered undesirable game species and not targeted by anglers for sport. Therefore, valuable tourism dollars that support many lake and river communities could be diminished as anglers travel elsewhere to fish.

A recent report issued by the American Sportfishing Association (ASA) concluded that annual expenditure for anglers in Minnesota and Wisconsin amounted to approximately \$2.8 billion and \$1.7 billion and supported 43,812 and 30,164 jobs, respectively (Allen and Southwick, 2008). An aggregate figure for other Great Lakes states was significantly higher, at slightly above \$7 billion in reported revenue. As the ASA report demonstrates, the economic incentive of sport fishing for regional states is significant and valuable to communities who depend on consistent revenue streams for their livelihood. Table 2 supplies the ASA figures.

Table 2. Annual revenue and jobs supported by sport fishing

State	Annual revenue \$	Jobs supported by fishing	Federal tax revenue \$	State and local tax revenue \$
Minnesota	\$2.8 billion	43,812	\$350 million	\$342 million
Wisconsin	\$1.7 billion	30,164	\$183 million	\$195 million
Other Great Lakes States (aggregated)	\$7.1 billion	58,291	\$508 million	\$401 million

(Allen and Southwick, 2008)

In summary, concerns for agency managers of a possible carps invasion include:

- Risks to human safety
- Habitat alteration or destruction
- Declines in native fish stocks from direct competition
- Reductions or exhaustion of native plant species that provide spawning, forage, and nursing areas for native fishes
- Baseline stress of the food web
- Potential revenue/job loss for regional recreational economies due to Asian carp prevalence and lack of biodiversity

3. Analytical Methodology

The methods for this paper are broken down into multiple parts. First, a qualitative risk assessment of introductory pathways for Asian carps is presented to illustrate corresponding levels of risk for both the UMRB and national landscapes. Following is a gap analysis and policy matrix of existing and proposed law to assess how these pathways are being addressed. Next, results from expert-stakeholder interviews (refer to interview questionnaire in Appendix A) are shown to display actors' level of

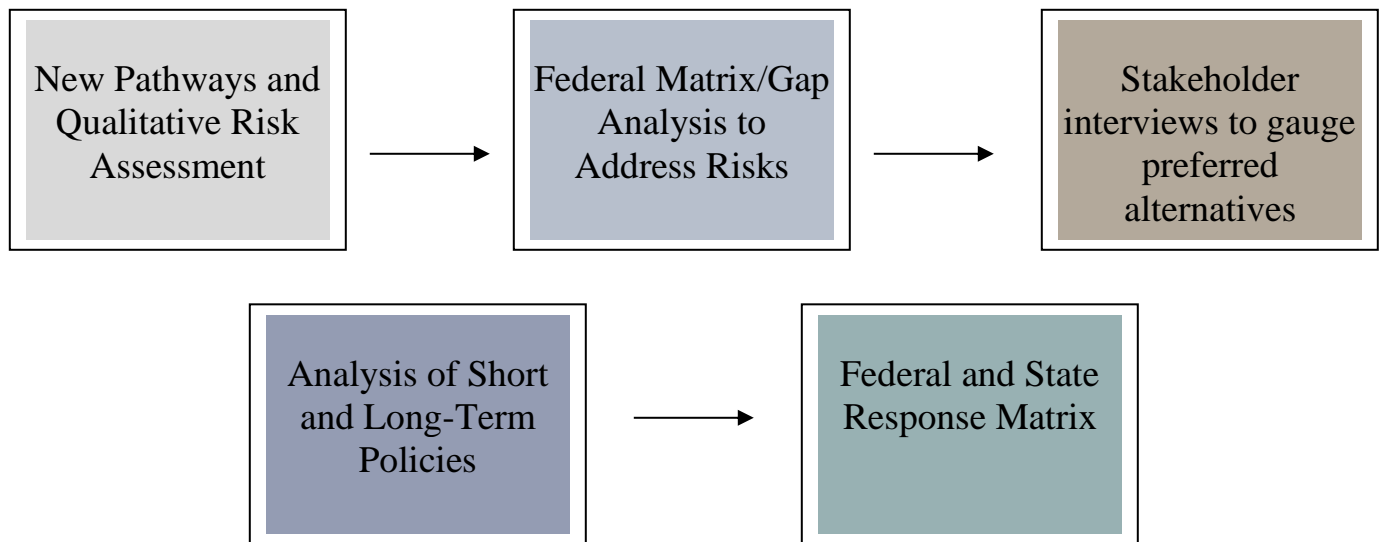
involvement, interest, influence, and position in the issue area. Results from these interviews identify influential actors in the Asian carps control and prevention effort for the UMRB as well as preferred management alternatives in both the short and long-term. Furthermore, an analysis of the federal and state response is provided, detailing leadership, intent, and output. Closing the paper is a discussion of results and research limitations.

As a complement to the analytical methods put forth in this paper, field notes gathered from regional meetings of the Asian Carp Regional Coordinating Committee (ACRCC) and the Ad Hoc Asian Carp Task Force (AHACTF) from November 2011 to April of 2012 are utilized to inform the analysis and fill in gaps that are not addressed in publications. Thirteen interviews with expert-stakeholders were conducted in a semi-structured format, either over the phone or in person, between March 26 and March 30, 2012. The questionnaire was carefully tailored to eliminate bias during delivery. Questions varied from a structured format with three potential responses to those designed with an open dialogue in mind.

As a secondary measure to define the methodology utilized in this paper, a logic model was constructed (refer to Figure 4 below). This flow chart represents substantive areas that needed to be researched in order to make an accurate assessment of which pathways of Asian carps introduction are most likely for the UMRB, which laws are enacted or pending that might subdue an invasion, which alternatives are preferred by stakeholders, how effective these alternatives are in both the short and long-term, and the complexion of federal and state responses. Each box represents broad categories that are

expanded throughout the paper to inform the overall analysis and ultimately make cogent recommendations.

Figure 4. Analytical logic model



4. Suspected pathways of new introduction

Introduction of Asian carps into the UMRB is most likely from multiple sources. The 2007 Federal Management and Control Plan cited the following possibilities: a university research facility, state agency custody, private aquaculture facilities, ceremonial release, juvenile carps mixing with domestic bait, and illegal introduction from interstate transport of live animals (Conover et al., 2007; Cook and Hill, 2010). The literature also suggests bighead and silver carps are sold as seafood illegally in Toronto, Ontario. Moreover, the USACE has confirmed evidence of all four species of carps sold at seafood markets in Chicago, Illinois (ACRCC field notes April 5, 2012). What remains

important to acknowledge is that U.S. federal law has difficulty controlling illegal transport of Asian carps across state and international boundaries as well as their sale.

To combat the potential establishment of illegal markets in the U.S., S. 1421, also known as the Asian Carp Prevention and Control Act of 2010, successfully listed bighead carp to the federal injurious list, granting USFWS regulatory authority. This listing means that under the Lacey Act, it is prohibited to transport bighead carp across state lines by penalty of law. To date, bighead, black, and silver carps are the only species of nuisance cyprinids listed on the federal injurious list. Black and silver carps were listed in 2007 (Conover et al., 2007). While the USFWS inspects all incoming shipping and commercial traffic for invasives at various entry points across the U.S., the regulations become difficult once Asian carps are brought inland. Although S. 1421 sets a legal precedent through the Lacey Act, it does little to control possession across jurisdictional boundaries or state lines, even though this is the intent of the Act. As an act of solidarity between Canada and the United States, both the Ontario Ministry of Natural Resources and the International Joint Commission banned cross-border transport or importation of live Asian carps as a regulatory measure to prevent the fish from entering Lake Superior or other Great Lakes by intentional or unintentional release (Dupre, 2011). These issues are explored in greater depth in Sections 5.1.1 and 5.1.3.

Table 3 below illustrates several of the most notable pathways and corresponding likelihood of introduction of Asian carps both in the UMRB and the comparative national landscape as evaluated by the Asian Carp Working Group in Conover et al. (2007). Risk level was assessed qualitatively, on a low to high scale, from review of Conover et al. (2007), Aitken et al. (2008), and Kolar et al. (2005). The methodology for evaluating

risks of introduction into waterways through suspected pathways was also adapted from Conover et al. (2007). Of the 21 pathways identified in the National Management and Control Plan, the following eight were chosen for their relevance to the UMRB:

Table 3. List of notable pathways and risks of Asian carps introduction

Pathway of Introduction	UMRB Risk Level *	National Plan Risk Level *
<i>1. Illegal distribution to supply exotic markets</i>	High	High
<i>2. Accidental and deliberate unauthorized release by individuals</i>	Moderate	High
<i>3. Inclusion of Asian carps in domestic shipments</i>	Moderate	Low
<i>4. Ceremonial release</i>	High	Moderate
<i>5. Live transport of wild-caught fish</i>	High	High
<i>6. Research and education facilities</i>	Low	Moderate
<i>7. Inclusion and release in farm-raised baitfish</i>	Moderately high	Low
<i>8. Inclusion in aquaculture shipments</i>	Moderate	Moderate

{ Sources: National Plan Risk Level and pathways were adapted from Conover et al., (2007) and Aitkin et al., (2008). UMRB Risk Level was assessed using National Plan Risk Level guidelines elicited Conover et. al., (2007); Aitken et al., (2008); Kolar et al., (2005)}. * Low: introduction is unlikely; Moderate: introduction is probable; High: introduction is likely.

Of considerable concern is the prevalence of illegal markets, since Asian carps are sold internationally in Asia for premium prices, or other international markets where the fish are considered a commodity. Many of these fishes are abundant in some areas of the

lower and middle Mississippi basins, are of large size and weight and can bring premium prices at sale. Illegal distribution will remain until strict regulation and enforcement is put into place. Specific to the UMRB, a vibrant Asian community exists throughout the Upper Midwest and these fishes are considered sacred animals. Intentional release into streams for ceremonial purposes is a pathway that provides consternation for resource managers and policymakers because of the inherent cultural and religious implications.

5. Policy climate: Existing and Proposed Law

At present, political, legal, and scientific challenges abound for Asian carps mitigation in the UMRB. While there seems to be consensus from expert stakeholders and agency actors that something must be done to prevent an invasion, there is no agreement as to what it is and who should do it (state government interview March 26, 2012). As demonstrated in this paper, numerous agencies involved with different levels of authority causes confusion and lapses in authority. Since the UMRB covers the interests of multiple states, any action by one has implications for the others. For example, a federally navigable waterway (such as the Upper Mississippi) is under the control of the USACE. The USACE is under authority from the U.S. Army, and the mandate of interstate commerce, to keep navigable channels open for shipping, dredging, and recreation in the form of locks and dams.

The concern for resource managers in the UMRB is that seasonal lock operation permits unimpeded upstream access during lockages (opening and closing of locks), allowing fishes (such as Asian carps) to migrate freely. Changes that affect commerce or commodities transport are met with resistance from the USACE in addition to requiring Congressional authorization for approval (AHACTF field notes December 2, 2011).

Federal guidelines stipulate that management of aquatic resources is controlled by the states where the navigable waterway is located. In the case of the UMRB, agencies that manage resource districts throughout Minnesota and Wisconsin are ready to respond to eradicating the carp advance, but are halted by pushback from the USACE. This has proved challenging for those actors who wish to respond aggressively to the issue but are limited in their reach by institutionalized structure (federal government interview March 27, 2012). Even though the more flexible agencies (e.g. USFWS, NPS) and their respective proactive management goals collide with pushback from institutions carrying rigid federal mandates, several policy tools remain for agencies and organizations to implement with regards to invasive species in general, and Asian carps specifically. Sections 5.1.1-5.1.4 outline laws that are current and enforceable for Asian carps. Sections 5.2.1-5.2.3 outline proposed bills that have yet to become law.

Existing Law

5.1.1 National Environmental Policy Act (NEPA)

NEPA, authorized in 1969, is the first significant law written for environmental protection. NEPA ensures all branches of government give proper consideration to the environment before undertaking any federal measure that may affect it (U.S. EPA. <http://www.epa.gov/region1/nepa/>). Its purpose is "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality (CEQ)" (U.S. EPA. <http://www.epa.gov/region1/nepa/>).

This law is significant for Asian carps management because NEPA requires funding or permitting decisions [through environmental assessment (EA) or environmental impact statements (EIS)] to be made with full consideration as to their impact to the natural and human environment. However, the resource and time demands to conduct an EA or EIS are substantial and can have the undesirable effect of lengthening the time to implementation when a policy change is immediately needed. In the case of Asian carps, the agencies or cabinet departments that administer NEPA (such as the CEQ and U.S. Environmental Protection Agency) rely on assessments to determine efficacy and environmental impacts. When an environmental problem is identified, such as the Asian carp advance in the UMRB, the response of government appears to be too deliberate, even though it is precisely this type of deliberation that typically achieves more desirable environmental outcomes. A balance must be struck between proceeding accordingly through the protocols of environmental review and responding swiftly to an impending threat. These themes are explored in greater depth in section 5.1.2.

5.1.2 Water Resources Development Act (WRDA) and the CAWS

The WRDA of 2007 authorizes the USACE to conduct studies and water resource developments for flood control, navigation, and environmental restoration (H.R. 1495) along the Upper Mississippi and Illinois River corridors. Specific to the Chicago Area Waterway System (CAWS), which is a man-made channel that connects the Mississippi River to Lake Michigan through the Illinois River, the USACE was funded to complete the Great Lakes and Mississippi Interbasin Study (GLMRIS) which provides comprehensive analysis of alternatives to prevent interbasin transfer of invasive fishes through aquatic pathways (GLMRIS, 2011). GLMRIS was authorized by Congress under

Section 3061(d) of the WRDA of 2007 (GLMRIS, 2011). The centerpiece of the study is to monitor the effectiveness of the Electric Dispersal Barriers Project, operational since 2002 (GLMRIS, 2011). This barrier system is an infrastructure project, operated by the USACE, consisting of three strategically placed electric restraints, secured to the channel bottom along the run of the Chicago Sanitary and Ship Canal (a small navigation canal that is part of the larger CAWS) that feeds Lake Michigan, as a means to restrict fish passage by water-borne electric current (Refer to Figure 5). More specifically, these barriers are steel electrodes that emit an underwater direct current electrical field, fed from a nearby control station with the sole intent of preventing movement of Asian carps northward to the



Figure 5. CSSC and CAWS (Source: Great Lakes Commission. < <http://sierraclubillinois.wordpress.com/>>)

Calumet River and out into Chicago Bay. The GLMRIS study is slated for completion in 2015, which will accompany an EIS in compliance with NEPA protocol. In addition to

studying the effectiveness of the electric barrier system as a deterrent for carps, GLMRIS will also study options and feasibility of hydrologic separation of the Great Lakes and the Mississippi River (GLRMIS, 2011). The study is a significant development in Asian carps management strategy for both the Great Lakes and the UMRB.

The Great Lakes Commission recently conducted an independent study to examine the costs of hydrologic separation of the Mississippi and the CAWS to provide the USACE and GLMRIS with an objective assessment. The study concluded that costs ranged from \$3.4 to \$9.5 billion with partial separation in 2022 and complete separation in 2029 (ACRCC field notes April 5, 2012). GLMRIS is in the process of evaluating the full range of options and technologies to prevent the spread, including hydrologic separation.

5.1.3 Lacey Act

Under the Lacey Act, the Secretary of the Interior is authorized to prohibit the importation and interstate transportation of species designated as injurious. Injurious wildlife are those species, offspring, and eggs that are injurious to wildlife or wildlife resources, to human beings, or to the interests of forestry, horticulture, or agriculture of the United States (H.R. 6124; Lacey Act, 2004). An injurious wildlife designation prohibits the importation and interstate transport of the species, including offspring and eggs, without a permit. Permits may be granted by the USFWS for bona fide scientific, medical, educational, or zoological purposes only. Any person deemed in violation of any chapters of the Lacey Act are subject to a \$5,000 fine and six months in prison (H.R. 6124; Lacey Act, 2004).

On March 22, 2011, the USFWS successfully added the bighead carp to the federal list of injurious wildlife. Both silver and black carps were listed in 2007. Therefore, under national amendment, it is unlawful to transport live bighead, silver, or black carps across state lines in order to contain any spread of the species. As of April 2013, no other species of Asian carps has been listed as federally injurious under the provisions of the Lacey Act. While this is an important first step to controlling the invasion, until all four species are listed by the USFWS the regulatory enforcement for Asian carps seems far from certain.

5.1.4 Asian Carp Prevention and Control Act

S. 1421, commonly known as the Asian Carp Prevention and Control Act of 2010, “amends the Lacey Act to add the bighead carp of the species *Hypophthalmichthys nobilis* to the list of injurious species that are prohibited from being shipped or imported into the United States” (S. 1421). This Act, signed by President Obama on December 14, 2010, grants permission to the USFWS to list the bighead carp as an injurious species and prohibit its live transport between states by penalty of law. This was in direct response to a bighead carp being netted on June 22, 2010 beyond the electric barrier restraint system in the CAWS just five miles from Lake Michigan. The aforementioned amendment and accompanying Act functioned as a reaction to this discovery. While this Act does list the bighead carp as injurious (together with black and silver carps), grass carp remain largely unregulated at this time by federal statute.

Proposed law

5.2.1 Upper Mississippi CARP Act of 2012

On March 6, 2012, the Upper Mississippi Conservation and River Protection Act (Upper Mississippi CARP Act) was introduced in both the U.S. Senate and House of Representatives for consideration (S. 2164 and H.R. 4146, respectively). The bills require the USACE to conduct feasibility studies on both the temporary and permanent closure of Upper Saint Anthony Falls Dam in Minneapolis within a six-month to one-year timeframe. The provisions of the Act authorizes the USACE to close this particular dam in Minneapolis (which would block all northward fish migration) if Asian carps are detected within select areas close to the lock and dam entrance. Essentially, this bill becoming law would grant Congressional authorization for closure to the USACE. Presently, the Corps is only allowed to close locks when an emergency is enacted or an impediment to navigation is identified. One consequence of lock closure is that shipping traffic by barge would have to be re-routed by truck or rail freight.

Both S. 2164 and H.R. 4146 call for the Upper Mississippi, Minnesota, and Saint Croix rivers to be included in the Asian Carp Control Strategy Framework. Currently, this federal framework is focused solely on protecting the economic and ecological resources of the Great Lakes and not the UMRB. Passage of this bill would be significant, as it would allow for lock closure as well as direct funding resources to the UMRB effort. However, the likelihood of these bills becoming law is uncertain. As of April of 2013, both have been submitted to Senate and House subcommittee and no major actions have been reported. The House version of the bill was reintroduced as H.R.

709 on February 14, 2013 after failing to proceed to law (S. 2164, 2012; H.R. 4146, 2012).

5.2.2 CARPACT of 2010

The Close All Routes and Prevent Asian Carp Today Act (CARPACT) of 2010 “directs the Secretary of the Army, and therefore the USACE, to take action with respect to the Chicago waterway system to prevent the migration of bighead and silver carps into Lake Michigan” (H.R. 4472, 2010). The CARPACT outlines several authorities it would grant the Corps should the bill become law including:

1. Implement measures recommended in the efficacy study authorized under the WRDA of 2007.
2. Implement emergency measures to prevent introduction of Asian carps into the Great Lakes.
3. Immediately close the O’Brien lock and dam system, near the city of Chicago and Lake Michigan, in order to prevent fish passage.

Although the CARPACT is specific to governance and response in the Great Lakes region, it becoming law could directly benefit the UMRB effort. Granting the USACE authority to close locks ushers in a new degree of flexibility for this agency in dealing with aquatic invasive species threats. The primary barrier is political, as policymakers are hesitant to support a zero-tolerance response to AIS that will close a navigable waterway used for commodities transport. Should the CARPACT find its way to passage, this could positively affect the ability of the Upper Mississippi CARP Act to make it through subcommittee and reach the legislative floor for a vote. This bill, along

with the Senate version S. 2946, are still in committee and yet to be enacted into law as of 2013.

5.2.3 Stop Asian Carp Act of 2011

H.R. 892, or the Stop Asian Carp Act of 2011, directs the USACE to complete the GLMRIS study in eighteen months, ahead of its 2015 completion target. As discussed in section 5.1.2, the GLMRIS feasibility study investigates hydrologic separation of the Great Lakes and Mississippi River as an alternative to halting the advance of Asian carps. A distinct separation of the two hydrologic systems has been considered by many resource managers to be uniquely effective. However, criticism of severing the channel that feeds the Great Lakes is widespread. There is concern that costs of a capital project of this magnitude could far exceed the benefits associated with its completion (ACRCC field notes April 5, 2012). Although H.R. 892 has a broad base of support from Great Lakes Congressional districts, the bill is currently in subcommittee and no major actions have been approved.

Discussion of gap analysis

Table 4 below provides a concise depiction of the federal tools for resource managers in Minnesota and Wisconsin. This matrix explores the goals of each law, its strengths, any gaps that appear in the law reaching its intended outcome and effectiveness at controlling or preventing Asian carps in the UMRB. Metrics for effectiveness were adapted from BRDTAC (2007) and rated on a four-part qualitative scale ranging from unknown to effective.

Table 4. Asian Carps Policy Matrix {*E=effective; P=partially effective; I= ineffective; U= unknown. Source: Policy Gap Analysis was adapted from BRDTAC (2007)}

Bill or policy identity	Status	Goals	Strengths	Gaps	Policy effectiveness for UMRB *
<i>NEPA</i>	Law	Prevent or eliminate environmental damage. Establish CEQ.	-First law specifying environmental protection -Understand natural systems	-Lengthy timeframes to completion -Little flexibility for emergency response	P
<i>WRDA</i>	Law	Conduct studies and water resource development projects (GLMRIS)	-Authorizes funding and resources for capital projects	-Feasibility studies are lengthy and complex -Compliance with NEPA protocol is arduous and expensive	E
<i>Asian Carp Prevention and Control Act</i>	Law	List bighead carp as injurious	-Prohibits live interstate transport	-Does not list grass carp as injurious	P – as only bighead, black, and silver carps are listed
<i>Lacey Act</i>	Law	Prohibit importation and interstate transport of injurious wildlife	-Grants authority to USFWS to prohibit border entry -Criminal penalties	-Lists only bighead, black, and silver as injurious -Enforcement has jurisdictional barriers	I – for grass carp P – for bighead, black, and silver carps
<i>Upper Mississippi CARP Act</i>	Subcommittee (House bill reintroduced as H.R. 709 on February 14, 2013 and currently in subcommittee)	Authorize Upper St. Anthony closure. Include UMRB streams in the Federal framework	-Effective as a 100% barrier to upstream migration -Allocates funding to augment management efforts	-Little support thus far -Long time frame for feasibility study -Political uncertainty	U – but very promising
<i>CARPACT</i>	Subcommittee	Prevent migration of bighead and silver carps into Lake Michigan	-Establish 100% effective barrier -Emergency measures adopted	-Great Lakes specific -Economic ramifications unclear	U- trickle down to UMRB could be evident. Political barriers widespread
<i>Stop Asian Carp Act</i>	Subcommittee	Complete GLMRIS before 2015 date	-Determines the efficacy of hydrologic separation	-Costs to implement have high projections	I

Analysis of this table concludes that while the efforts on the part of lawmakers to bring bills to the floors of Congress is admirable, most laws are partially effective in addressing the needs of the UMRB or lack specificity in their provisions. For example, the Asian Carp Prevention and Control Act amends the Lacey Act to list bighead carp as an injurious species but fails to include grass carp in this regulatory framework. Listing only three of the four species as injurious wildlife (bighead, black, and silver carps) will do little to limit introduction of grass carp through the identified risk pathways. Secondly, the WRDA authorizes funding for projects to address environmental concerns but requires lengthy feasibility studies to investigate action efficacy. In the case of Asian carps in both the Great Lakes and UMRB, project studies with extended completion timelines are counterproductive to halting the advance. The Upper Mississippi CARP Act, although recently introduced, shows the most amount of promise in terms of effectiveness for all the Acts listed. Removing the lock and dam system at Upper Saint Anthony Falls, while restoring the falls to its historic gradient, creates a natural fish impasse. This Act is the only proposed legislation that investigates returning Upper Saint Anthony Falls Lock and Dam to a natural river barrier and includes the UMRB in the federal framework for management, which would deploy substantial funding and planning resources for control and prevention.

6. Funding challenges for State and Federal Partners

Appropriated funding to control or prevent Asian carps from entering the Great Lakes has been substantial – more than \$1 billion through the Great Lakes Restoration Initiative (GLRI) since 2010 (ACRCC field notes April 5, 2012). The priority for the CEQ and the USEPA, the two administrators of the fund, is to protect the Great Lakes

fishery from an Asian carps invasion. The GLRI funds focus on habitat restoration, toxic site clean-up, point source pollution, and combating invasive species (GLRI, 2010). CEQ coordinates control, monitoring, and response efforts for the region and assembled the ACRCC to develop a strategic framework for management of the Great Lakes Asian carps problem (ACRCC, 2011).

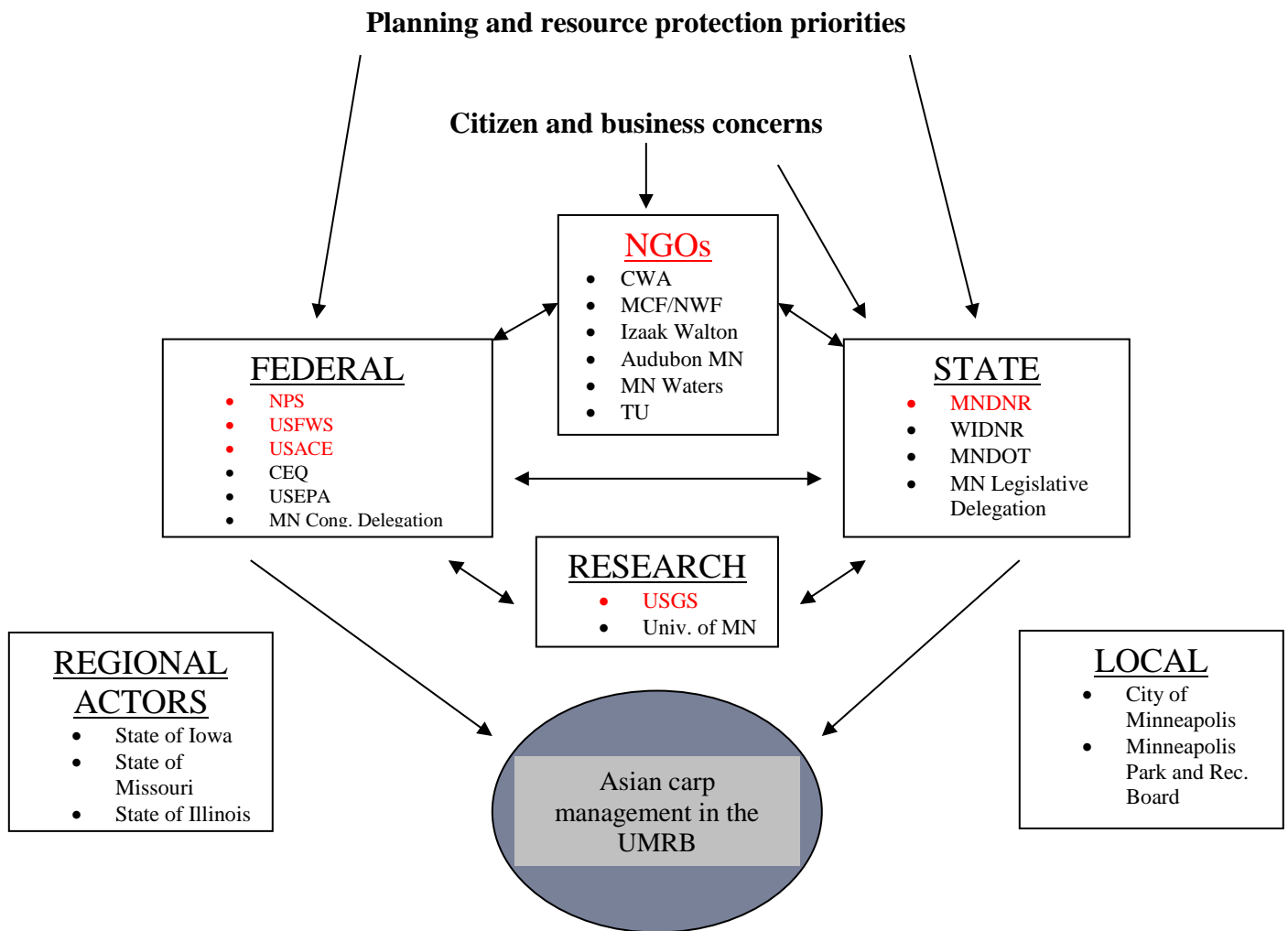
Passage of the Upper Mississippi CARP Act would allow important streams (such as the Upper Mississippi, Saint Croix, and Minnesota Rivers) to be included in the federal management framework authored by the ACRCC. This would grant managers in the UMRB region access to deployed resources for Asian carp control and prevention in Minnesota and Wisconsin through GLRI funding. However, at present most of the monitoring and prevention efforts at the state level are coming from base agency funding for stream sampling, commercial fishing, electrofishing, and netting. Expert-stakeholders have indicated that this approach is simply unsustainable for agencies that have many resources to manage and limited budgets or discretionary funds from which to draw from (federal government interview March 30, 2012).

7. Stakeholder data

Data about actors, agencies, and organizations was collected over a period of five months by attending regional meetings of the AHACTF from December of 2011 to April of 2012. This task force consists of a collection of regional and national partners co-led by the MNDNR and the NPS and is tasked with organizing the response effort for the UMRB as well as briefing Minnesota Governor Mark Dayton on matters of policy and priority. The map of stakeholders in Figure 6 was derived by qualitative assessment and observation of these meetings and other summits involving the ACRCC. High impact

actors are highlighted in red. These agencies/organizations were selected as significant by way of their recent efforts to halt the Asian carp advance in the UMRB and their leadership in finding concrete solutions.

Figure 6. Stakeholder map of UMRB



7.1 Results from expert-stakeholder interviews

From March 26 to March 30, 2012 thirteen stakeholders were interviewed as a secondary way of gauging level of involvement, interest, and influence in preventing an Asian carps invasion in the UMRB (refer to Appendix A to view the interview

questionnaire). Individuals were selected through their participation in the Ad Hoc Asian Carp Task Force or the ACRCC, shown in Table 5 below. These actors possess leading expertise and/or knowledge in the issue area. Methods were adapted from Varvasovszky et al. (2000). Briefly, interviewees were asked two qualitative questions on a low to high scale, with low indicating little or no interest and high indicating significant interest. A third question assessed agency position on the alternatives Minnesota and Wisconsin are considering for Asian carps management in the UMRB. The responses were rated on an opposed to supportive scale, with opposed indicating actors are against action contrary to the status quo and supportive favoring action. Non-mobilized indicates their position to be neutral.

Table 5. Qualitative data from expert-stakeholder interviews (*Not applicable (N/A) was chosen by scientists at USGS for these questions because even though interest in the issue is high for the agency, they conduct unbiased research and cannot take positions nor measure their influence sufficiently.)

Expert-stakeholder	Interest in issue	Influence/power	Position
1. NPS	High	High	Supportive
2. NPS	High	Medium	Supportive
3. MNDNR	High	High	Supportive
4. MNDNR	High	Medium	Supportive
5. MNDNR	High	Low	Supportive
6. USFWS	High	Low	Supportive
7. USFWS	High	Low	Non-mobilized
8. USACE	High	High	Opposed
9. USGS	High	Medium	Supportive
10. USGS	High	N/A*	N/A*
11. NGO	High	Medium	Supportive
12. NGO	High	Medium	Supportive
13. NGO	High	Low	Non-mobilized

Key findings from qualitative questions include:

- All thirteen expert-stakeholders indicated a high level of interest in the issue area.
- Influence varied across sectors and even within each group of federal/state/NGO actors.
- Nine of thirteen interviewees indicated their agency or organization is supportive of action against the status quo.
- Four interviewees were either opposed to action, non-mobilized, or had no opinion.

8. Preferred alternatives

Following qualitative questions explained in Section 7.1, expert-stakeholders were asked to indicate preferable alternatives to the status quo, in both the short and long-term, for the UMRB through a series of three open-ended questions that provided policy examples currently under consideration (Refer to Appendix A). The questions provide a structure and dialogue for the purposes of investigating singular instruments of policy that resource managers could find actionable. Most interviewees indicated that there is no simple solution to preventing establishment of Asian carps in the UMRB, as the problem is complex and multiple interests need to be considered before action can take place. Several respondents indicated that the priority for their agency or organization is to incorporate the best-known science and take the proper amount of time to engineer an effective solution (federal government interviews March 28 and 30, 2012; NGO interview March 26, 2012). Responses were highly variable, but several alternatives were identified for implementation. Alternatives for Asian carps management in both the short and long-term for the UMRB are explored in Sections 8.1-8.6.

Short-term alternatives: new technology and policy

8.1 Pass the Upper Mississippi CARP Act

As explained in Section 5.2.1, returning Upper Saint Anthony Falls Dam in Minneapolis to a natural barrier is a way to construct an effective fish impasse and limit northward carps migration. This navigation channel, built in 1963 and operated by the USACE, functioned for generations as a natural waterfall and spillway (federal government interview March 28, 2012). This bill would give the Corps authority to close the dam when Asian carps are detected. It would also list the aforementioned tributaries into the Asian Carp Control Strategy Framework (the guidelines proposed by the ACRCC), allowing new funding deployment to control or prevent an Asian carps invasion.

There is broad support from resource agencies (including NPS, USFWS, MNDNR), the MN Congressional Delegation, and NGOs for the Upper Mississippi CARP Act. Closure of Upper Saint Anthony Falls creates a migratory endpoint for Asian carps and therefore facilitates enhanced control or extirpation measures by identifying the reproductive front. Some citizen and business groups have indicated their disapproval, as it would likely displace those who wish to use the lock and dam for recreation upstream (AHACTF field notes March 19, 2012). Push back is also significant from the few remaining businesses along the Upper Mississippi corridor that utilize Upper Saint Anthony Falls for moving material by barge. The remaining materials moved by barge are primarily aggregate and scrap metal and would have to be shipped by truck or rail (AHACTF field notes March 19, 2012).

8.2 Fund, install and maintain an electric dispersal barrier

Similar to the existing structure in the CSSC explained in Section 5.1.2, an electrified deterrent would act as a physical impediment to carp movement upstream. The preferred location for this installation will be the Ford Dam in Minneapolis, also known as Lock and Dam #1 (FishPro, 2004). Scientists that conducted the FishPro (2004) feasibility study for the UMRB concluded that initial cost range is \$8-10

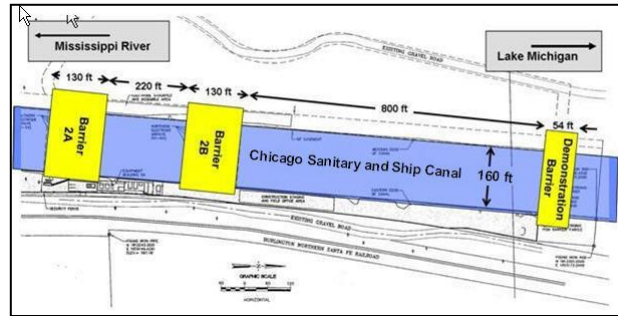


Figure 7. Electric dispersal barriers in the CSSC (Source: USACE. <<http://www.lrc.usace.army.mil/AsianCarp/barrier.htm>>)

million (in 2004 dollars) and effectiveness at deterring carp is in the area of 90-99%. FishPro (2004) also concluded that technical feasibility is likely for a river of similar flow rates to the Mississippi and that navigational impacts are minimal. A visual representation of how this technology would appear is displayed above in Figure 7.

8.3 Fund, install and maintain a BAFF

A BAFF, also known as a bio-acoustic fish fence or bubble barrier, is a behavioral control technology used to guide nuisance species away from lock entrances. These systems function by concentrating sound in bubble plumes with the intent of producing a wall of sound suitable for deterring movement through the lock and dam system. Air bubble curtains are created by pumping compressed air through a diffuser to create a continuous dense curtain of bubbles, which can cause an avoidance response in fish.

Laboratory tests have concluded that Asian carps are sensitive to sounds at frequencies above 2000 hertz and indigenous fish scarcely hear above 400 hertz. The

high pitch induces the carps to turn away from the barrier. Therefore frequency delivery can be customized to deter carps and allow natives to pass through the barrier and into the lock channel (FishPro, 2004). A BAFF can also be modified to incorporate fish trap mechanisms, having the effect of guiding nuisance fishes by acoustical variation into catchments, where they are subsequently collected and processed. Stakeholders from government and NGOs have indicated BAFFs as a prioritized alternative (AHACTF field notes March 19, 2012). Lock and Dam #1 is the most suitable site for this type of impediment, because of its construction type and design (FishPro, 2004). Similar to an electric barrier project, the challenges for supporting BAFFs are primarily economic.

8.4 Revise schedule of lockages

A recent development, initiated in March of 2012, was proposed by the Ad Hoc Asian Carp Task Force to organize an awareness campaign through public outreach to limit commercial and recreation traffic in the locks, thereby reducing lockages and upstream fish passage. Consolidating the schedule, therefore by design reducing the number of times a particular lock opens and closes every day, requires USACE approval and voluntary acceptance by the public who may use the locks for recreation. A revised schedule could be delivered through a digital application or flyer at landings and businesses that use the lock system would be sent a finalized schedule (AHACTF field notes March 19, 2012).

Long-term alternatives: new research

8.5 Develop pheromone technology and integrated pest management (IPM)

Research led by the University of Minnesota on nuisance cyprinids concludes that using naturally released chemical signals is an effective tool to control social behaviors of

fish. Sorensen and Stacey (2004) indicated that, “pheromone potency and specificity makes them ideal candidates for use in control of unwanted (non-indigenous) fish species. Similar in desired effect to the sea lamprey control in the Great Lakes, these potent chemical cues could be part of a larger integrated pest program of control for invasives” (Sorensen and Stacey, 2004). On March 8, 2012, the Minnesota State Legislature authorized \$3.8 million in appropriated funds to initiate a new Minnesota Aquatic Invasive Species Research Center at the University of Minnesota and further explore research into this, and other, developing biological technologies. Funding will come from the Legislative-Citizen Commission on Minnesota Resources (LCCMR), Clean Water Legacy and general obligation bonds (AHACTF field notes March 8, 2012).

The central idea of integrated pest management is to incorporate a variety of pheromones for the purpose of augmenting efficiency targets for removing aquatic pests, and combine this technology with environmental toxins (such as rotenone or Antimycin A), sterilization, and behavior/physical barriers. Integrated pest management, combined with pheromone delivery to encourage desirable behavioral response, would therefore encompass a multi-faceted portfolio of management and extirpation (Kolar et al., 2005; Sorensen and Stacey, 2004; USGS, 2004; Dawson and Kolar, 2003). This technology does carry some risk, however, as introducing physiological or behavioral manipulation has unknown environmental effects outside of laboratory experiments. IPM will take time and additional financial commitments to test its efficacy in the field.

8.6 Oral toxicant delivery

Scientists at USGS are developing an innovative new biological technology to extirpate Asian carps from the UMRB. Rather than synthesize a new chemical and wait

for approval from the proper authorities for use, USGS is utilizing a proven general fish toxicant (Antimycin A) and incorporating it into a new matrix. The result will be an oral-delivered pharmaceutical capable of targeting specific aspects of cyprinid gut physiology. Coupled with IPM or pheromone behavioral manipulation, this technology could be a powerful control mechanism. The product is currently being finalized through private/pharmaceutical partnership and field-testing has commenced. The timeline to implementation could be as short as 2-3 years (federal government interview March 27, 2012; field notes April 5, 2012). Inherent risks of this yet to be proven fisheries technology include the ability of scientists to limit pharmaceutical consumption by desirable species and to discover a way to engineer Antimycin A as inert in aquatic environments.

Summary of Stakeholder Interviews

Interviews with expert-stakeholders all but confirmed that, while there may be alternatives that stand out in terms of political feasibility and effectiveness, no singular policy instrument is going to prevent an Asian carps invasion in the UMRB. Success in suppressing the advance of these four species will take a combination of options, working in tandem, to harness the most efficient solution. To illustrate the range of complexity exhibited by the short and long-term alternatives, a qualitative assessment was constructed. Alternatives were scoped for diversion efficiency, navigational impacts, implementation complexity, and public safety concerns. Cost estimates were included for three of the six alternatives. The remaining three are unknown because the technology is new or a study is ongoing. Scoping was performed on a four-part scale from none to high. The results of this assessment appear in Table 6 (Appendix B).

Key discoveries

- An electric dispersal barrier, while high in effectiveness (estimated 90-99% effective for carps), carries public safety concern and high cost. Impacts to commercial and recreational navigation within the river corridor are forecasted to be moderate but this type of deterrent has never been tested under high flow conditions.
- BAFFs have moderate effectiveness (estimated 60-90% effective for carps), low cost, and no public safety issues. This technology is largely proprietary and unproven for high flow rates.
- Support for pheromone technology has been authorized at a minimum of \$3.8 million by the Minnesota Legislature. Thorough laboratory and field-testing will be required to determine efficacy and suitability for Asian carps.
- USGS oral toxicant has reached the testing phase and is nearing deployment. Costs are unknown at this time but the technology shows a lot of initial promise to target nuisance aquatic animals.
- IPM has a broad base of support from expert-stakeholders.

9. Efforts to plan and mobilize a response

The makeup and involvement of federal, state, and NGO partners involved in the UMRB Asian carps control effort is a complicated and ever-evolving dynamic process. At the interface of policy, many groups with divergent interests find multiple points of contention. These may include the challenges of pushback from rigid federal mandate, incorporating the opinions and priorities of local business, battling funding scarcity, or

finding agreeable solutions to a problem that does not adhere to jurisdictional or institutional boundaries.

As Figure 6 on page 37 demonstrates, planning and resource protection priorities for the UMRB flow through the federal and state agencies with citizen and business concerns directed to state and NGO actors. Research organizations cooperate with state and federal agencies to address research needs and communicate progress. Local municipalities and regional states are on the fringe of this effort but do exert a small degree of influence and presence. Federal and state actors are primarily responsible for carrying out final managerial priorities for the UMRB. Table 7 displays the federal and state response in terms of level of influence, leadership, intent, and final product (refer to Appendix C).

9.1 Federal actions

For the UMRB, management and planning for a possible Asian carps invasion is being led by the NPS, USFWS, and USACE. The USGS is primarily focusing on research and applying the best available scientific principles to guide policy. They do not advocate nor take positions. Although dictated by strict federal guidelines, the USACE has displayed some degree of flexibility in the region. This agency is continuing to evaluate the potential of electric dispersal barriers in Chicago, Illinois and the full range of interbasin options in the GLMRIS study. The criticism of the USACE is that while their engagement in localized efforts for the UMRB is supportive, their institutionalized structure and Congressional mandate are creating undue barriers to progress (NGO interview March 27, 2012). For example, installing physical or behavioral deterrents in a river channel or near a lock will first require a feasibility study and accompanying EIS

before any action can take place. This is to fulfill the requirements of NEPA.

Furthermore, the Corps does not have the discretion to close locks for the control of invasive species, nor does current law allow them to. They are required to keep navigation channels open in the Upper Mississippi (AHACTF field notes March 8, 2012).

The NPS and USFWS, also at the federal level, have been the face of the effort to prevent Asian carps from becoming established in Minnesota and Wisconsin for more than two years. Consistent planning and engagement on the part of the NPS has created a wealth of new knowledge and ideas about how to attack this issue with vigor and influence. While not directly tied to the federal management plans or frameworks, their leadership of the Ad Hoc Asian Carp Task Force has facilitated new dialogue among stakeholders, heightened engagement from the community, press coverage, and a general forum to present new initiatives. Their methods are extensive and highly regarded by the private, state, and NGO communities.

9.2 State actions

The MNDNR, together with the NPS, chairs the Ad Hoc Asian Carp Task Force. This collection of federal, state, and non-governmental organizations works together to shape policy and brief Minnesota Governor Mark Dayton on the preferable course of action to subdue Asian carps from becoming established in Minnesota and Wisconsin. The effort on the part of the MNDNR for Asian carps control has been extensive. Clearly, the actors in charge of the MNDNR's Invasive Species Program are committed to finding a solution that protects the resources they are tasked with managing. However, agency personnel have limited funding with which to organize and plan a response.

The MNDNR Invasive Species Program (which manages AIS across Minnesota) \$2 million annual budget is largely depleted through efforts in prevention, early detection, control, and outreach. These activities include environmental DNA sampling with federal partners to discover potential locations of Asian carps, funding commercial fishing for the purposes of detection and/or removal, soliciting public support for cooperation, and investigating preventative policies as a whole. This leaves little remaining appropriations, through the state general fund or other sources, to pursue various strategies to manage carp invasion. MNDNR's capacity is conclusively extended (AHACTF field notes March 13, 2012). For Minnesota, as well as Wisconsin, listing streams that are vulnerable to invasion in the Asian Carp Control Strategy Framework, and securing GLRI funding for the UMRB that is currently directed towards the Great Lakes basin, will do much in the way of increasing flexibility and reach.

MNDNR has been instrumental in constructing goals and strategies in the 2007 National Management and Control Plan and is a member of the USFWS-led Asian Carp Working Group, which designed the plan. Contributing members are valued for their expertise at developing a comprehensive portfolio of options. MNDNR is also involved with the ACRCC, which has successfully authored a comprehensive framework (the 2011 Asian Carp Control Strategy Framework) for managing aquatic resources in Great Lakes states (refer to Appendix C).

10. Discussion of results and recommendations

Halting the advance of Asian carps is neither simple nor rapid. Scientific evidence cited in this paper suggests that population establishment of these animals jeopardizes sensitive ecological processes and the services these processes provide, putting

indigenous or desirable species at a competitive disadvantage. While the logic supporting control or extirpation of nuisance cyprinids is strong and support is widespread, planning, funding, and execution problems remain. The barriers to implementing an effective strategy consist of uncertain jurisdictional authority, lack of inclusion of the UMRB in the Asian Carp Control Strategy Framework, absence of robust funding through the GLRI, difficulty in appeasing divergent interests across sectors, and devising ways to address gaps in policy. The situation is extremely complex, but solvable.

Leadership and support from federal and state agencies in the region is evident, but effectiveness is uncertain due to a lack of authorized or initiated procedures. Moving forward, natural resource managers in the UMRB need to develop comprehensive managerial guidelines regardless of federal appropriations. Since the UMRB is home to a unique set of economic and environmental conditions, Asian carps control and management should reflect an individualized structure. Consensus views from expert-stakeholder interviews were such that interest in the issue is high and position is supportive. Highly variable responses to open-ended questions demonstrated no singular alternative in either the short- or long-term.

Based on the results from the analysis in this paper, the most desirable method for aquatic resource protection is a systems model designed around instruments of policy and integrated pest management. This could take the shape of biological technologies (pheromone attractant and oral toxicant delivery) being coupled with physical/behavioral barriers (such as lock closure, an electric deterrent, or BAFF) as a way of unifying an entire suite of applications for control and extirpation. The following actions are recommended for natural resource managers and NGO leaders throughout the UMRB.

These recommendations are derived from the analysis in this paper as well as expert-stakeholder interviews.

Recommended short-term actions:

1. Increase enforcement to mitigate juvenile Asian carps from being included in baitfish stocks for recreational fishing (aggressively address pathway #7 in Table 3).
2. Work closely with Asian communities in the region to develop an awareness campaign geared towards preventing ceremonial release of Asian carps into area streams (address pathway #4 in Table 3).
3. Engage with the Minnesota and Wisconsin Congressional Delegations to write amendments to the Lacey Act that successfully list all four species as injurious wildlife. This would provide federal statute for governance.
4. Develop a broad base of support for, and passage of, the Upper Mississippi CARP Act. Not only will this Act examine the costs and likelihood of closing the Upper Saint Anthony Falls Lock and Dam as a 100% effective upstream barrier, but will successfully list the Minnesota, Saint Croix, and Upper Mississippi Rivers as part of the federal framework and secure GLRI funding.
5. While support for the Upper Mississippi CARP Act is expedited, install a BAFF at Lock and Dam #1 (Ford Dam). Group this behavioral technology with a revised schedule of lockages proposed by the NPS in March of 2012. Together, these two alternatives can limit fish passage while a solution is engineered and approved.

Recommended long-term actions (IPM):

6. Further research the efficacy and field implementation of harnessing pheromones from Asian carps as a biological control mechanism at the Minnesota Aquatic Invasive Species Research Center at the University of Minnesota. While it may take time to execute, this research is an essential cog in controlling or extirpating targeted species.
7. Together with pheromones, expand integrated pest management to encompass a two-part attack. This would include corralling nuisance cyprinids into catchments by way of their own chemical signals and delivering oral piscicides (Antimycin A) in the form of impregnated bait.

Research Limitations

The analytical methodology introduced in Figure 6 lends itself to further exploration. However, timelines for completion of this project prohibited any further depth of analysis in this model. To accomplish this degree of research, or to thoroughly tackle one aspect that the paper advances (such as substantive risk analysis) would require a team of researchers and many months to complete. This feat is simply beyond the intentions of this investigation.

Great care was taken in designing the survey instrument and selecting expert-stakeholders for interviews, but bias may have been introduced by the nature of having contact with several interviewees by telephone or personal interviews. Depending on the survey subject's level of comfort with the interviewer, responses may not have been as accurately retrieved as may have been with a more generic mailer that was consistent throughout the range of interviewees. While there were some abnormalities in the survey

data, most responses were indicative of preliminary research projections. Drawing from a larger sample size would have given the results more statistical deference but this was simply not possible within the interest of time constraints.

Much of the latter half of this paper is supported by expert-stakeholder interviews, meeting minutes from summits, and some grey literature. This was due to the fact that this paper advances original thought, manipulation of established concepts, or research that has yet to reach publication and was only retrieved from expert-stakeholder interviews.

Acknowledgements

The author would like to thank Drs. Deborah Swackhamer and Jennifer Kuzma for their commitment, professionalism, and support throughout this research project and for two exceptional years of graduate tutelage. Your guidance is tremendously appreciated.

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Appendices

A. Interview Questionnaire

Introduction:

My name is Scott Haugen and I am a graduate student in Public Policy at the Hubert H. Humphrey School of Public Affairs at the University of Minnesota. I am conducting a study to determine the relationship between stakeholders involved in preventing or managing the advance of Asian carps in the Upper Mississippi River Basin (UMRB), which programs or efforts select stakeholders are participating in or leading, and which management or preventative efforts they see as the most likely and effective, in both the short and long term for the UMRB. To this end and with your permission, I wish to conduct a semi-structured interview process that will take about 10-15 minutes of your time. This interview will be informal and not legally binding in any way. No demographic information (including your name or department) will be shared or published. Information deemed relevant or of value will be paraphrased and considered off the record and not directly cited. Will you agree to a brief interview? (If not now, when would be a convenient time for you to be contacted?)

1. Briefly describe your involvement in the ongoing Asian carps prevention effort for the UMRB.

A. More specifically, which programs, efforts, task forces, frameworks, etc. are you or your agency/organization involved with?

B. For each of these efforts you mention, would you describe which agency is responsible for leadership and coordination, logistics, planning, briefings,

etc.? In other words, who is in charge for each effort you are participating in or is it more of a collaborative approach?

C. How would you characterize you agency's/organization's interest with this potential problem at the current time?

* low

* medium

* high

D. How would you characterize your agency's/organization's influence or power with this problem at the current time?

* low

* medium

* high

E. How would you characterize your agency's/organization's position on the alternatives Minnesota and Wisconsin are considering for Asian carps management? In other words, is your organization supportive, non-mobilized or opposed to action against the status quo?

* supportive

* non-mobilized

* opposed

2. What are some barriers you can identify as blocking progress towards finding an agreeable solution to this problem?

Examples:

- A. The deliberative pace of government
 - B. Inherent difficulty of multiple agencies finding common ground
 - C. Budget constraints
 - D. Misallocated resources or priorities
 - E. Potential confusion about the threat itself and scarce knowledge of economic and/or ecological effects
 - F. Another barrier not mentioned?
3. Now that the State has confirmed evidence of Asian carps in the Upper Mississippi River, in your personal opinion, which option of the following makes the most economic sense, has the highest effectiveness level for deterring carps, and is deliverable in the short-term?
- A. Lock closure for both recreation and industry – starting with Ford Dam
 - B. Return St. Anthony Falls Dam to a natural barrier
 - C. Develop a revised schedule for lockages to mitigate fish passage risks associated with on-demand lock usage
 - D. Install an electric dispersal barrier at the lock aperture
 - E. Install a bio-acoustic fish fence (BAFF) or a sound projector array (SPA) to deter carps
 - F. Ramp up commercial fishing effort
 - G. Use of toxicants such as rotenone or Antimycin A
 - H. Another option that was not mentioned?

4. In your opinion, which of the following options currently in development is deliverable in the long-term and has the potential for sustained success?
- A. Controlled harvesting or removal
 - B. Development of a species-specific toxicant by oral delivery
 - C. Bio-bullets or another encapsulated toxicant
 - D. Pheromone technology coupled with harvesting
 - E. Prevention by education, regulation and enforcement
 - F. Development of an attractant through known food sources (e.g. plankton)
 - G. Another option that was not mentioned?
5. Which management option is your agency/organization considering as its top candidate for questions #3 and #4?
- #3 – _____
- #4 -- _____
- A. Could you provide approximate annual cost estimates for these options?
- #3 – _____
- #4 -- _____
6. Are there any areas that you would like to address or feel has not been asked or any persons you would suggest worthwhile in contacting?
7. Would you mind being contacted for any follow up questions that may have been overlooked in the interview?

B. Summary of Potential Alternatives

Alternative	Diversion or extirpation efficiency	Navigation impact	Implementation complexity	Public safety concerns	Probable cost range	Comments
Upper Miss. CARP Act	100%	Moderate	High: Capital and resource intensive	None	Unknown	Political feasibility is highly uncertain
Electric dispersal barrier *	90-99% *	Low to moderate *	High: Electrode installation in the channel *	High: Shock or harm *	\$8-10 million (2004 dollars) *	Constant power stream is required; Adaptable to high flows *
BAFF *	60-90% *	Low to moderate *	Moderate: Air piping in various depths *	None *	\$1.0-1.4 million (2004 dollars) *	Shows promise for lock entrance *
Revise lockages	Unknown	Moderate: Few businesses use the channel; Recreation impacts	Low: Public education and voluntary cooperation	None	Low but unknown	Moderate business pushback
IPM	Potentially high	None	Moderate to high: Once perfected, quite simple; Thorough lab and field testing needed	Unknown: Fair degree of uncertainty to how pheromones will behave in the environment	\$3.8 million authorized; Estimates around \$1 million annual expenses	IPM is the most realistic long-term solution
Oral toxicant	Potentially high	None	Moderate: Develop toxicant into new matrix, delivery and field testing needed	Unknown: Uncertainty as to whether product is inert in the environment	Unknown	As a cog in IPM, oral toxicants are very promising long-term

Table 6. Summary of potential alternatives. Adapted from FishPro (2004).

* Data retrieved from FishPro (2004, p. V-2)

C. Federal and state response matrix

Organizing body	Level of influence	Leading participants/ partners	Intent	Product
<i>Aquatic Nuisance Species Task Force (ANS Task Force)</i>	Federal	USACE, USGS, USFWS, USDA, MNDNR, NGOs	Develop comprehensive management and control plan; extirpate Asian carps in the wild	2007 Management and Control Plan for Bighead, Black, Grass and Silver Carps in the U.S.
<i>Asian Carp Regional Coordinating Committee (ACRCC)</i>	Cabinet, Federal	CEQ, USEPA, USGS, NOAA, USFWS; various regional departments of natural resources across the Great Lakes region	Describe actions scheduled to occur in the Great Lakes and reflect the best science available	2011 Asian Carp Control Strategy Framework
<i>National Invasive Species Council (NISC)</i>	Cabinet, Federal	Secretaries of Transportation, State, Defense, Homeland Security, Treasury and Health and Human Services	Issue the first national plan to deal with invasive species	2008-2012 National Invasive Species Management Plan
<i>MNDNR</i>	State	MNDNR	Develop a plan to prevent introduction of Asian carps into MN waters	Preventing the Introduction of Asian carp into Minnesota (2007)
<i>Ad Hoc Asian Carp Task Force</i>	Federal, State	Co-chaired by MNDNR and NPS; Partners include: USACE, USGS, USFWS, USEPA, CEQ, MN Congressional Delegation, NGOs	Confirm evidence of fish presence through environmental DNA sampling (eDNA), investigate alternatives to control, advise Governor Dayton on matters of policy	Briefings, 2011 Asian Carp Action Plan (unpublished)

Table 7. Federal and State Response Matrix. Sources: Conover et al., (2007), ACRCC (2011), NISC (2008), MNDNR (2007), field notes 2011-2012.