# 2016 Annual Report to Congress

# Annual Summary of Activities and Expenditures to Manage the Threat of Asian Carp in the Upper Mississippi and Ohio River Basins

A Report to Congress Pursuant to the Water Resources Reform and Development Act of 2014 (PL 113-121)

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# 2016 Report to Congress on Asian Carp in the Upper Mississippi River and Ohio River Basins

## EXECUTIVE SUMMARY

**Background**

On June 10, 2014, the Water Resources Reform and Development Act of 2014 (WRRDA), Public Law 113-121 was enacted, providing direction on an array of agency actions and public projects in the United States. Section 1039 (b) of WRRDA authorizes the Director of the U.S. Fish and Wildlife Service (USFWS) to coordinate with the Secretary of the Army (through the U.S. Army Corps of Engineers, or USACE), the Director of the National Park Service (NPS), and the Director of the U.S. Geological Survey (USGS) to lead a multiagency effort to address the spread of Asian carp in the Upper Mississippi River Basin (UMRB) and the Ohio River Basin (ORB) and their tributaries. WRRDA also requires development of an annual report to the U.S. Congress (Report) summarizing strategies, expenditures, and progress in addressing the threat of Asian carp in the UMRB and ORB and their tributaries.

The 2016 Report builds on prior versions of the Report to Congress, summarizing actions and expenditures focused on management of the four species of Asian carp addressed in the '*Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States*' (National Plan), the initial national Asian carp strategy developed and approved by the Aquatic Nuisance Species Task Force in 2007.

The USFWS, working in close coordination with the Secretary of the Army and other Federal and State partners, developed this third annual Report to summarize cooperating agency activities that were conducted for Asian carp management in the UMRB and ORB and their tributaries from October 1, 2015 to September 30, 2016. The 2016 Report includes the following information:

- Observed changes in the documented range of Asian carp in the UMRB and ORB, including locations of Asian carp in tributaries of the UMRB and ORB
- A summary of Federal agency efforts, including cooperative efforts with non-federal partners, to control the spread of Asian carp in the UMRB and ORB and their tributaries
- Research being conducted that could improve the ability to control the spread of Asian carp
- An evaluation of effort using quantitative and qualitative measures originally identified in the initial 2014 Report to document progress and effectiveness in controlling the spread of Asian carp
- A cross-cut accounting of Federal and non-federal expenditures in the UMRB and ORB and their tributaries, as reported by individual agencies for their respective 2016 Fiscal Year (FY) reporting periods

Summaries of agency activities being conducted for the benefit of specific basins are organized into three geographically-focused sections, as follows:

1. Ohio River and key tributaries (defined as the Ohio River Basin, or ORB)
2. Upper Mississippi River and key tributaries, excluding the Illinois Waterway and Chicago Sanitary and Ship Canal (defined as the Upper Mississippi River Basin, or UMRB)
3. Illinois Waterway and Chicago Area Waterway System (defined as the IWW/CAWS and located within the UMRB, although projects conducted in the IWW/CAWS often directly benefit the Great Lakes Basin, or GLB)

Reported agency activities are categorized under the following:

- Interagency Coordination (e.g. Strategy Development, Committee Participation)
- Field Monitoring and Early Detection
- Active Prevention/Control (including Physical Removal, Implementation/Operation of Barriers, and Rapid Response)
- Research and Development
- Law Enforcement/Regulatory Actions
- Outreach with Industry, Stakeholders, and the Public

This Report focuses on the Federal and State agency actions conducted within the mainstem rivers and tributaries of the ORB and UMRB to protect those river basins from Asian carp (as directed in WRRDA 2014). A summary of efforts conducted in the IWW/CAWS are included in this Report as the IWW/CAWS is located in the UMRB, yet projects conducted in this area often directly benefit the GLB. As the only permanent hydrologic connection between the Mississippi River Basin (MRB) and the GLB, the IWW/CAWS is considered the primary potential vector for the interbasin transfer of Asian carp and is therefore the geographic focus for Federal and State management efforts associated with the Asian Carp Regional Coordinating Committee (ACRCC). Summarized efforts in the IWW/CAWS in this Report are described in greater detail in the ACRCC's Asian Carp Action Plan (http://asiancarp.us/documents/2016AsianCarpActionPlan.pdf) and 2016 Monitoring and Response Plan (http://asiancarp.us/documents/MRP2016.pdf).

**The Challenge – Addressing the Threat of Asian Carp**

Aquatic invasive species (AIS), including Asian carp, pose significant challenges to the health of aquatic ecosystems. In addition to widespread and longstanding ecological consequences, AIS often result in significant economic losses and cost our nation's economy billions of dollars per year[1]. AIS have resilient and adaptive characteristics that afford them competitive advantages over native species. These characteristics can include the ability to reproduce rapidly or tolerate a wider range of environmental conditions than native species, allowing them to establish self-sustaining populations in areas with few or no natural predators. Developing effective and holistic prevention and control strategies to manage AIS requires in-depth knowledge of life history traits, including feeding ecology and reproductive behavior and potential vectors of species introduction. Acquiring an in-depth knowledge of the life history for all life stages of an AIS and evaluating the effectiveness of management actions requires

1 Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological economics, 52(3), 273-288.

extensive field monitoring and assessment. In the U.S., the challenge is substantial for Asian carp, as assessment involves four different species and multiple basins including the GLB, UMRB, and ORB.

To be effective, Asian carp prevention and control efforts require the use of focused, but comprehensive, strategies implemented through inclusive multi-jurisdictional partnerships. Leveraging scientific expertise, data, technological developments, and strategic planning across the various basin partnerships is a key operating principle for extending the collective ability to contain and control Asian carp and maximize the return on investment.

**Observed Changes in the Documented Range of Asian carp in the UMRB and ORB**

In recent years, Asian carp have steadily increased their range through portions of the UMRB, ORB, and other basins, posing a threat to the rich biodiversity and related economies of these watersheds.

This 2016 Report includes detailed results on the occurrence of Asian carp in U.S. waters, including summaries of historical and new detections and assessments of changes in the observed range of each species. This information is critical for supporting decision making on Asian carp management actions and overall strategy implementation. In the 2016 reporting period, range expansion was documented from a single adult Silver Carp collected at river mile (RM) 280 of the Ohio River, approximately 64 miles upriver from a prior collection near Wheelersburg, Ohio. There was also a range expansion of Bighead Carp and Grass Carp into the Minnesota River, 103 miles from previous capture locations in the Upper Mississippi River. Range expansion of Black Carp was not detected in 2016.

**Agency Prevention and Control Efforts**

State and Federal agencies, universities, non-governmental organizations, and other partners are aggressively implementing a broad portfolio of management actions within the National Plan. Collaborative partnerships have been established and operationalized within the ORB, UMRB, and GLB, reflecting the specific needs and opportunities within the respective watersheds. For example, the *Ohio River Basin Asian Carp Control Strategy Framework* (ORB Framework) developed by the Ohio River Fisheries Management Team (ORFMT) outlines actions for prevention, monitoring and response, population control, research, and communications targeted to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carp. Similar priorities are also included in the *Upper Mississippi River Basin Asian Carp Control Strategy Framework* (UMRB Framework); and the *ACRCC's Action Plan* and *Monitoring and Rapid Response Plan for Asian Carp in the Upper Illinois River and the Chicago Area Waterway (Monitoring and Response Plan)*. Both of these regional plans complement the goals within the National Plan.

Through ongoing and increased coordination and strategic planning, partnerships in the UMRB, ORB, and GLB are supporting implementation of the seven goals of the National Plan:

1. Prevent accidental and deliberate unauthorized introductions of Bighead, Black, Grass, and Silver Carp in the United States
2. Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States
3. Extirpate, or reduce to levels of insignificant effect, feral populations of Bighead, Black, Grass, and Silver Carp in the United States

4. Minimize potential adverse effects of feral Bighead, Black, Grass, and Silver Carp in the United States
5. Provide information to the public, commercial entities, and government agencies to improve effective management and control of Bighead, Black, Grass, and Silver Carp in the United States
6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver Carp in the United States
7. Effectively plan, implement, and evaluate management and control efforts for Bighead, Black, Grass, and Silver Carp in the United States

As a core operating principle, basin partnerships use adaptive management to revise and update key components of strategies based on objective evaluation. Within strategies, performance and effectiveness of individual projects in meeting identified goals for managing Asian carp populations are routinely evaluated to inform any needed revisions.

Examples of ongoing adaptive management efforts that support basinwide Asian carp management strategies and the National Plan include:

- Continued implementation and refinement of an interagency Asian carp early detection monitoring program using both traditional gear and eDNA (genetic) sampling methods
- Development of new and refinement of existing basinwide and statewide Asian carp prevention strategies, tools, and technologies for early detection and control
- Progress on the analysis of potential Asian carp control alternatives that can be deployed in or adjacent to lock and dam structures, yet allow continued commercial and recreational navigation
- Closure of St. Anthony Lock in Minneapolis, Minnesota, as authorized under WRRDA, to prevent further upstream movement of Asian carp in the Mississippi River
- Further development of standardized datasets that track the status of Asian carp populations in U.S. waters, focusing on the UMRB and ORB
- Expanded collaborative interagency partnerships in the UMRB and ORB to manage the threat of Asian carp across multiple jurisdictions, including selection of priority Asian carp partnership projects in the UMRB and ORB
- Enhanced interbasin collaboration between the UMRB, ORB, and GLB

**Conducting Key Research, Transferring Technology, and Applying Lessons-Learned**

A growing number of technologies are currently under development or have been proposed for use in controlling populations and preventing additional spread of Asian carp. Working closely with Federal and State partners, the USGS has taken the lead on research and development of new and emerging technologies to control Asian carp in the U.S. Additionally, the USACE's Engineer Research and Development Center (ERDC) coordinates closely with the USGS and other State and Federal agencies and universities to significantly advance the science and capacity for managing Asian carp, including development and refinement of tools for early detection. A brief description of each agency's work is provided in this Report, with a detailed description in Appendix 2. Current Asian carp research and development projects can be described under one of the following categories:

- Early Detection and Monitoring
- Life History/Behavior

- Feeding Ecology
- Prevention
- Control
- Integrated Pest Management (IPM) Strategies

Additionally, increased coordination on Asian carp management has led to the establishment of interbasin subject matter expert teams or "communities of practice" that collaborate across partnership boundaries on specific highest-priority research or management questions (e.g. Asian carp life history, genetics, pathway assessment, or rapid response planning), and develop consistent monitoring, data collection, and best-management practices.

**Establishing Measures of Effectiveness for Asian Carp Prevention**

WRRDA directs the USFWS to identify measures to document collective progress in controlling spread of Asian carp in the UMRB and ORB and their tributaries. The 2014 Report identified: (1) proposed measures and outcomes for ensuring progress toward the goals of controlling spread of Asian carp in the designated watersheds, and (2) specific critical short-term actions to continue and expand multiagency coordination to achieve common prevention-based goals. The 2015 Report included a review of the long-term utility of the measures proposed in the 2014 Report to track performance and progress, revising the measures as appropriate. This 2016 Report continues use of the revised measures, with some additional modification to facilitate more efficient tracking of annual outcomes and progress toward achieving long-term goals. The use of these measures is intended to increase management efficiency and accountability for implementing Asian carp strategies in the UMRB and ORB. Summaries of accomplishments achieved under each measure will be provided in subsequent reports.

**Federal and Non-federal Expenditures**

This Report summarizes Asian carp management activities within the UMRB and ORB and their tributaries, as reported by State and Federal agencies during their respective FY 2016. In this time period, agencies reported a total of $3,750,705 expended on activities for protection from the threat of Asian carp within the UMRB and ORB and their tributaries (Table 1 in Section 6.0).

Agencies also reported a total of $55,203,807 for actions conducted in the IWW/CAWS to protect the GLB from Asian carp. A significant percentage of these expenditures were for the operation and maintenance of the USACE's Electric Dispersal Barrier (EDB) at Romeoville, Illinois. An additional $3,340,791 was reported to address the Great Lakes and Mississippi River Interbasin Study (GLMRIS) Secondary Pathways, temporary hydrologic connections that form between the ORB and GLB during high water and flooding events. Since these pathway mitigation efforts are focused on protecting the GLB from the movement of Asian carp and are outside of the geographic delineated boundaries of the ORB, they are excluded from the total expenditures calculated for the purposes of this Report. Although excluded from the agency expenditures, this Report includes a brief summary of activities that occurred within the GLB in order to present a complete overview of management activities that work together to protect the mainstem rivers and tributaries of the UMRB and ORB from Asian carp introduction and population expansion.

Since FY2015, additional funding has been provided to the USFWS for Asian carp prevention efforts through its annual agency base appropriations. These resources are used to support an enhanced

multiagency Asian carp response in the UMRB and ORB, as directed by WRRDA, Section 1039 that emphasizes strong Federal/State coordination and collaboration to prevent the further range expansion of Asian carp in the designated basins.

The USFWS, in coordination with the Mississippi Interstate Cooperative Resource Association (MICRA), works cooperatively with State and Federal agencies to address the highest priority implementation needs for the ORB and UMRB Frameworks that support the National Plan. The annual Monitoring and Response Plan for the Mississippi River Basin provides detailed information on the collaborative Asian carp projects supported with these funds each year. Following is a general description of the projects funded in each basin in FY2016.

In the UMRB:

- Monitoring and Assessment:
    - Determine the status of all life stages of Asian carp populations
    - Delineate geographic boundaries of the various stages of the invasion above Lock and Dam 19 (LD19) near Keokuk, Iowa
    - Conduct early detection surveillance monitoring at the invasion front
    - Inform containment and control/removal projects
- Containment:
    - Develop a collaborative process to implement and evaluate the use of complex sound (defined as broadband sounds comprised of multiple frequencies) and single specific high-frequency sounds projected underwater as a potential deterrent mechanism
    - Assess the extent of Asian carp and native species fish passage through LD19
    - Develop a deterrent barrier strategy
- Control/Removal:
    - Determine population abundances of Asian carp in Pools 17, 18, 19
    - Target removal of Asian carp species in Pools 14-19 using contracted commercial fishers and intensive agency netting
    - Assess the feasibility of commercial fishing to reduce Asian carp populations below LD19

In the ORB:

- Monitoring and Assessment:
    - Determine the status of juvenile and adult Asian carp populations
    - Delineate geographic boundaries of the various stages of the invasion
    - Conduct early detection surveillance monitoring and response at the invasion front
    - Inform containment and control/removal projects
    - Determine the extent of Asian carp reproduction and recruitment in the Kentucky and Barkley Reservoirs (Tennessee River)
    - Determine the status and abundance of adult Asian carp in the Kentucky and Pickwick Reservoirs (Tennessee River) and the Barkley and Cheatham Reservoirs (Cumberland River)
    - Assess Asian carp dispersal and invasion dynamics, movement through lock and dam systems, and identify seasonal congregations in the Tennessee River to inform future containment and control management actions
- Containment:
    - Identify opportunities to implement and evaluate the use of complex sound
    - Assess Asian carp passage at Ohio River and Tennessee River locks and dams

    - Develop a deterrent barrier strategy
- Control/Removal:
    - Remove Asian carp from low density areas at the leading edge of invasion of the Ohio River, above RM 606
    - Remove Asian carp from high density areas in the Ohio River below Markland Locks and Dam

A detailed summary of these projects is provided in the *2016 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin*. This document provides a complete compilation of project work plans for the ORB and UMRB projects that received funding from the USFWS in FY2016 and is available at http://asiancarp.us/documents/MRP2016MississippiRiverBasin.pdf.

Moving forward, the collaborative processes used to develop priority projects will be employed to evaluate project effectiveness, report measurable accomplishments, and inform subsequent management strategies and actions.

# 1.0 INTRODUCTION

## 1.1 The Need for Interagency Management of Asian Carp in the Upper Mississippi River and Ohio River Basins – Collaboration under WRRDA 2014

The threat to the natural resources of the U.S. from the introduction and establishment of AIS is well-documented and recognized as one of the primary issues facing resource policymakers and managers, resource users, and other stakeholders. AIS have resilient and adaptive characteristics that afford them competitive advantages over native species. These characteristics can include the ability to reproduce rapidly or tolerate a wider range of environmental conditions than native species, allowing them to establish self-sustaining populations in areas with few or no natural predators. In addition to widespread and longstanding ecological consequences, AIS often result in significant economic losses and cost the Nation's economy billions of dollars annually[1]

On June 10, 2014, the WRRDA (Public Law 113-121) was enacted to provide direction on an array of agency actions and public projects in the U.S. Section 1039 (b) of WRRDA authorizes the Director of the USFWS to coordinate with the Secretary of the Army (through USACE) and the Directors of NPS and USGS to lead a multiagency effort to address the spread of Asian carp in the UMRB and ORB and their tributaries. Those actions include provisions for technical assistance, coordination, best practices as well as support to State and local governments engaged in activities to decrease the threat of Asian carp. Additionally, WRRDA directed the USFWS to develop, in coordination with the Secretary of the Army, an annual report to Congress summarizing strategies, expenditures, progress, and emerging research to address the threat of Asian carp in the UMRB and ORB and their tributaries as well as proposed processes for evaluating the effectiveness of these efforts.

The direction provided in WRRDA Section 1039 complements existing Federal and State authorities that address AIS in U.S. waters, including the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA); reauthorized by the National Invasive Species Act (NISA) in 1996. NANPCA called for the establishment of a comprehensive Federal effort to prevent introduction, establishment, and proliferation of introduced aquatic nuisance species (ANS) with the formation of the Aquatic Nuisance Species Task Force (ANSTF). NANPCA's encouragement of a broad collaborative strategy to prevent, monitor, and control AIS is complemented by other Federal and State laws and regulations that address risks posed by AIS. These laws and regulations include the Lacey Act administered primarily by the USFWS and codified in two separate federal statutes: Title 16 United States Code Section 3372 et al. (Lacey Act Trafficking, False Labeling and Captive Wildlife Safety Act provisions) and Title 18 United States Code Section 42 et al. (Injurious Wildlife). Title 16, among other things, prohibits the import, export, transport, sale, receipt, acquisition or purchase of any fish or wildlife which was taken, possessed, transported, or sold in violation of any law or regulation of any State, Tribal or Foreign Law. Title 18 of the Lacey Act (enacted in 1900), which regulates importation into the U.S. and transport between the continental U.S., the District of Columbia, Hawaii, Puerto Rico, or any possessions of the U.S. of species listed as injurious. Bighead Carp, Silver Carp, and Black Carp are all listed as injurious species under the Lacey Act. Together, Titles 16 and 18 of the Lacey Act, provide an important tool to prevent the introduction and further spread of AIS in the United States.

**Annual Report to Congress**

As stipulated in WRRDA, the USFWS coordinated with the USACE, NPS, USGS, and other Federal and State agency partners to develop the *Third Annual Report to Congress - Summary of Activities and Expenditures to Manage the Threat of Asian Carp in the Upper Mississippi and Ohio River Basins: October 2015 through September 2016* (2016 Report).

This 2016 Report is the third annual report since the enactment of WRRDA in 2014, and includes the following information:

- Observed changes in the documented range of Asian carp in the UMRB and ORB, including further delineation of the location of Asian carp in tributaries of the UMRB and ORB
- A summary of Federal agency efforts, including cooperative efforts with non-federal partners, to control the spread of Asian carp in the UMRB and ORB and their tributaries
- Research being conducted that could improve the ability to control the spread of Asian carp
- An evaluation of effort using quantitative and qualitative measures originally identified in the initial 2014 Report to document progress and effectiveness in controlling the spread of Asian carp
- A cross-cut accounting of Federal and non-federal expenditures in the UMRB and ORB and their tributaries, as reported by individual agencies for their respective FY 2016 FY reporting periods

For this 2016 Report, State and Federal agencies reported all Asian carp management activities conducted in the UMRB and ORB during the reporting timeframe of October 1, 2015 through September 30, 2016. Agency activities conducted in support of the National Plan have been grouped into the following six general categories:

- Interagency Coordination (e.g. Strategy Development, Committee Participation)
- Field Monitoring and Early Detection
- Active Prevention/Control (e.g. Physical Removal, Implementation/Operation of Barriers, and Rapid Response)
- Research and Development
- Law Enforcement/Regulatory Actions
- Outreach with Industry, Stakeholders, and the Public

This 2016 Report also identifies new collaborative prevention and control projects and strategic planning efforts being funded, in whole or in part, through additional appropriated USFWS funds provided for Asian carp prevention in FY 2016. These additional funds are being used to support Asian carp activities in the UMRB, ORB, and other priority locations.

The 2016 Report will be formally transmitted to the Committee on Appropriations and the Committee on Environment and Public Works of the Senate; and the Committee on Appropriations, the Committee on Natural Resources, and the Committee on Transportation and Infrastructure of the House of Representatives. In addition, it will be made available to the public via the Internet at *www.AsianCarp.us*.

## 1.2 Basin Partnership Overviews and Accomplishments

The 2016 Report presents a summary of reported accomplishments and related expenditures conducted to address Asian carp in the ORB and UMRB, two sub-basins within the larger Mississippi River drainage basin (see Figure 1). To clearly describe the agency efforts conducted for the benefit of each specific sub-basin, the 2016 Report is organized into three geographically-focused sections, as follows:

1. Ohio River and tributaries (defined as the Ohio River Basin, or ORB)
2. Upper Mississippi River (defined as the Upper Mississippi River Basin, or UMRB)
3. Illinois Waterway and Chicago Sanitary and Ship Canal (defined as the IWW/CAWS and located within the UMRB, although projects conducted in the IWW/CAWS often directly benefit the Great Lakes Basin, or GLB)

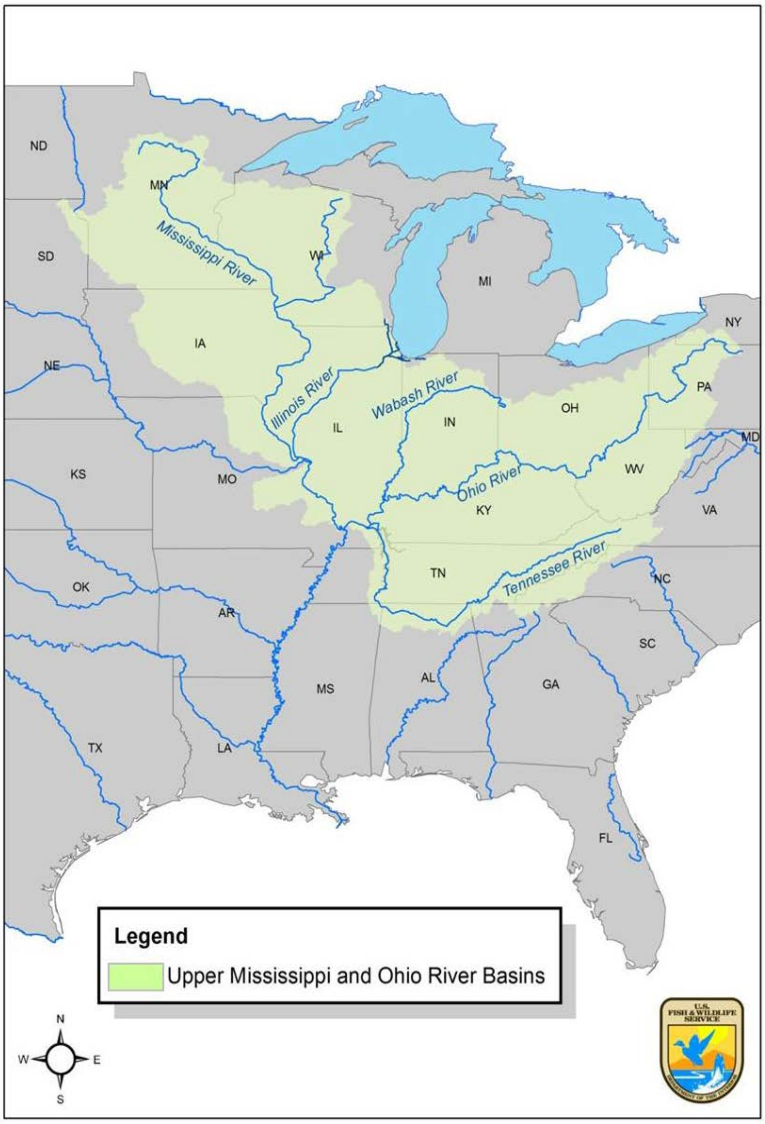


**Figure 1. Upper Mississippi River (including the Illinois Waterway and Chicago Area Waterway System) and Ohio River Basins as defined by the USGS Hydrologic delineations**

The Ohio River flows through or along the border of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia. These six states collaboratively manage fisheries in the mainstem Ohio River through the ORFMT, which was formed in 1990 to develop an inter-jurisdictional perspective to management of Ohio River fisheries. The six ORFMT states initiated development the ORB Framework and requested that the remaining eight states in the drainage basin (Alabama, Maryland, Georgia, Mississippi, New York, North Carolina, Tennessee, and Virginia) participate in its development and implementation. Asian carp are highly abundant in the lower Tennessee River, a major tributary to the Ohio River, and are a threat to the highly valued and imperiled fish and mussel populations that inhabit these waters. Tennessee, Mississippi, Alabama, and Georgia border the Tennessee River and are active participants in the ORB partnership.

The Upper Mississippi River (UMR) flows through or along the border of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. These five states collaboratively manage fisheries in the mainstem UMR through the Upper Mississippi River Conservation Committee (UMRCC). The UMRCC was formed in 1943 for the collaborative management of interjurisdictional fishery resources in the UMR. The five UMRCC member states developed and implement the draft UMRB Framework to manage and control Asian carp populations in the UMR.

The Illinois River is a major tributary to the UMR; however, for the purposes of this Report, actions conducted in the upper Illinois River within the IWW/ CAWS (RM 231 to RM 333) are considered to be conducted for the protection of the GLB. This Report focuses on the Federal and State agency actions conducted within the mainstem rivers and tributaries of the ORB and UMRB (as directed in WRRDA 2014); however, a summary of efforts conducted in the IWW/CAWS are also included. As the only permanent hydrologic connection between the MRB and the GLB, the IWW/CAWS is considered the primary potential vector for the interbasin transfer of Asian carp and is therefore the geographic focus for Federal and State management efforts associated with the Asian Carp Regional Coordinating Committee (ACRCC). Summarized efforts in the IWW/CAWS in this Report are described in greater detail in the ACRCC's Asian Carp Action Plan (http://asiancarp.us/documents/2016AsianCarpActionPlan.pdf) and 2016 Monitoring and Response Plan (http://asiancarp.us/documents/MRP2016.pdf).

## 1.3 The Asian Carp Challenge

During the past two decades, Asian carp have steadily increased their range through portions of the UMRB and ORB, posing a threat to the rich biodiversity and related economies of these watersheds. Bighead Carp (*Hypophthalmichthys nobilis*), Silver Carp (*H. molitrix*), Grass Carp (*Ctenopharyngodon idella*), and Black Carp (*Mylopharyngodon piceus*) have the ability to quickly establish self-sustaining populations following introduction, and can significantly alter entire aquatic ecosystems, negatively impacting native species and habitats. Large portions of America's interior river systems are now occupied by one or more Asian carp species, with populations of at least one species established in 45 states. The impacts from Asian carp establishment are well-documented. For example, studies in the Illinois River demonstrated that the condition of native fish species declined significantly following invasion and establishment by Silver Carp and Bighead Carp. Additional studies documented significant declines in the native species composition in portions of rivers and tributaries in the Midwest United States where Asian carp dominant in numbers and biomass, resulting in negative impacts to commercial and recreational fishing.

The potential expansion of Asian carp populations in the ORB and the UMRB threaten multibillion dollar industries, including recreation, tourism, and sportfishing, that are vital to local and regional economies in the Midwest. Such industries have, for decades, supported thousands of jobs and provided income for communities located on, or adjacent to, rivers and reservoirs. For example, the most recent *National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* (USFWS 2011), estimated the annual economic impact from recreational fishing in the Upper Mississippi River sub-basin as approximately $3.5 billion in retail expenditures and $1.7 billion in job income, supporting 45,730 jobs. In the Ohio River sub-basin, the estimates are approximately $4.4 billion in retail expenditures and $2 billion in job income, supporting 58,338 jobs.

Additional impacts to resource users include compromising the safety of boaters and recreational watercraft users in areas where Silver Carp have become established in high densities, as this large-body species can leap out of the water when stimulated by sound and collide with passing vessels and their occupants.

Acknowledging the need for a coordinated approach to address the growing threat from Asian carp, the ANSTF requested the development of a national management plan for all four species (Bighead, Silver, Black, and Grass Carp) through its Asian Carp Working Group. The USFWS, in collaboration with over 70 State, Federal, non-governmental, and private industry partners, led the development of the *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (National Plan). Approved and released in 2007, the National Plan is built around seven core goals that are operationalized through 48 step-down strategies and 131 recommendations to manage and control Asian carp. The National Plan continues to serve as a blueprint for Federal, State, and non-governmental partnerships on Asian carp management, and as a basis for the subsequent development of geographically-focused basinwide and State management plans (described later in this report). Comprehensive management strategies for Bighead, Black, Grass, and Silver Carp have also been, or are being developed, by state and federal partnerships for large river sub-basins within the Mississippi River watershed. These strategies build upon the seven core goals of the National Plan, listed as follows:

1. Prevent accidental and deliberate unauthorized introductions of Bighead, Black, Grass, and Silver Carp in the United States
2. Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States
3. Extirpate, or reduce to levels of insignificant effect, feral populations of Bighead, Black, Grass, and Silver Carp in the United States
4. Minimize potential adverse effects of feral Bighead, Black, Grass, and Silver Carp in the United States
5. Provide information to the public, commercial entities, and government agencies to improve effective management and control of Bighead, Black, Grass, and Silver Carp in the United States
6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver Carp in the United States
7. Effectively plan, implement, and evaluate management and control efforts for Bighead, Black, Grass, and Silver Carp in the United States

Developing effective, comprehensive prevention and control strategies requires in-depth knowledge of Asian carp occurrence and population status, life history traits (e.g. feeding ecology, reproductive behavior, and preferred habitat), specific tactics for detection, prevention, and control, and potential

vectors of introduction. Strategies have been developed to address these needs and incorporate continued refinement and improvement of tactics and tools targeting key Asian carp vulnerabilities at various life stages within an integrated pest-management approach.

To better inform these efforts, comprehensive databases describing all Asian carp life stages (eggs, larvae, juveniles, and adults) are being developed for each river basin to serve as key decision support tools to strategically place prevention and control projects. Collaborating Federal and State agencies are working to expand and update this body of scientific information, yet data gaps remain in key areas and have been identified as a priority management need. The broad geographic scope of the watersheds with documented occurrences or established populations of one or more Asian carp species require that managers make well-informed, scientifically-based, decisions for the strategic use of available resources. To ensure that each basinwide management approach remains current and robust, partnerships utilize an "adaptive management" approach, which incorporates mechanisms to regularly revise and update key components of their Asian carp strategy based on objective evaluation of performance. Projects are evaluated for their ability to meet identified outcomes and goals for managing Asian carp population, with results used to inform any needed revisions to tactics and management strategies. As new prevention and control technologies are developed and field-tested, fishery management agencies are actively collaborating to identify opportunities for implementation in key locations (e.g. those that afford the greatest ecosystem protection benefits and have highest likelihood of success).

Concurrent with strategic planning of projects, identifying and leveraging available resources to support both research and development, and ongoing operational actions remains critical for effectively preventing future population expansions of Asian carp. Achieving complex long-term management goals can be achieved through annual incremental progress, but will require a sustained, coordinated effort.

## 1.4 Progress in Fiscal Year 2016

Significant progress towards the goals of the National Plan has been made in FY2016. Strong State/Federal agency coordination continues within each basin and supports ongoing collaborative planning, research and development, information exchange, and leveraging and maximizing of agency resources. This section of the Report provides a general overview of progress made during the 2016 reporting period; subsequent sections provide more specific accomplishments for each individual basin.

Progress made in 2016 includes:

- Continued implementation of key strategic actions within the *Ohio River Basin Asian Carp Control Strategy Framework*, the *Minnesota Invasive Carp Action Plan*, and the *2016 Asian Carp Action Plan/Monitoring and Response Plan*, including: use of environmental DNA (eDNA) as a genetic surveillance tool; use of traditional gear for monitoring; use of targeted intensive fishing and other tactics for population reduction; research on new prevention and control tools; law enforcement; and communication and outreach with the public
- Progress in development of an *Action Plan for Management of Asian Carp in the Upper Mississippi River Basin*, a State/Federal interagency Asian carp management plan for the UMRB.
- Advancements in the development and deployment of potential deterrent technologies (e.g. carbon dioxide and complex sound), including the identification of potential sites for pilot project implementation, standard operating procedures, and related environmental planning

- Advancements in the development and deployment of electrical barrier fish deterrent technology, providing examples of technology that could be deployed at appropriate control locations
- Formation of Federal/State/non-governmental collaborative working groups to address specific tactical needs such as the use of complex sound, carbon dioxide, telemetry, and remote-sensing
- Development of new detection tools, including molecular-based techniques, to enhance the ability of agencies to quickly detect and respond to new occurrences of Asian carp
- Development of more robust data sets for assessing the distribution and status of Asian carp populations
- Development of new models to assess Asian carp population dynamics providing new decision support tools to better inform the timing and placement of critical Asian carp management field actions
- Increased use of intensive targeted fishing to reduce the size of Asian carp adult population by reducing the number of adult Asian carp at or near a "population front" to slow the advance of Asian carp range expansion
- Development of comprehensive Integrated Pest Management (IPM) strategies focused on effective and coordinated Asian carp prevention and control
- Development of enhanced rapid response planning, including contingency plans, to rapidly respond in the event of the detection of Asian carp in new areas
- Continued efforts by State and Federal law-enforcement to support State and Federal laws and regulations to limit the unintentional or deliberate movement of Asian carp through a variety of pathways and vectors

Additionally, since FY 2015, funding provided to the USFWS through agency base appropriations has been used to support Asian carp control efforts in the UMRB and ORB. Projects are developed cooperatively with State agencies and multijurisdictional resource organizations to address key needs that support goals of basinwide Asian carp management strategies and those of the National Plan. The collaborative projects developed and implemented through this process will augment ongoing activities conducted by State and Federal partners to address the threat of Asian carp in the UMRB, ORB, and other waters.

## 2.0 OBSERVED CHANGES IN THE RANGE OF ASIAN CARP IN THE UPPER MISSISSIPPI AND OHIO RIVER BASINS AND TRIBUTARIES

Range expansion was evaluated for all four species of Asian carp in the UMRB and ORB. Range expansion was defined as the difference (increase) in each species' geographic occurrence as determined by comparing new data collected for the 2016 Report (reporting timeframe of October 2015 to September 2016) to species ranges calculated for and included in the 2015 Report. As in the 2015 Report, the USGS Nonindigenous Aquatic Species (NAS) database was the primary source of information for Asian carp occurrence data. The NAS is a repository for spatially referenced biogeographic accounts of introduced aquatic species across the United States. In addition to scientific information on introduced aquatic species, the database also includes data acquired from many sources, including scientific literature; State, Federal and tribal resource agencies; non-governmental organizations; academic institutions; and private citizens. This database aids efforts to verify presence of species and includes a number of parameters from each collection or sighting such as date, collector, location, and habitat type. It is imperative that field crews (agency, academic, consulting firms, etc.) report occurrence

data into NAS as timely as possible in order to accurately estimate the ranges of expansions, especially into new waters.

For the 2016 Report, the farthest known distribution points (both upstream and downstream) were identified for each mainstream river and major tributary, and range expansion since the 2015 Report was assessed for the UMRB and ORB. Distribution points indicate where at least one individual fish was observed and does not infer that the species is established at that point. Data were mapped and described under two categories: "Pre-Oct 2015" (data summarized in the 2014 and 2015 Reports), and "Oct 2015 – Sept 2016" (new data summarized for the 2016 Report). Observed change in distribution was assessed by comparing the farthest distance upstream an individual fish was observed in the 2016 reporting period with the documented leading edge of the invasion evidenced in pre-2016 data.

Figure 2 demonstrates the extent of range expansion and individual new occurrences observed for each of the four species of Asian carp from October 2015 to September 2016. The red markers indicate recent captures and not necessarily range expansions. Only when the red markers are beyond any green marker (upstream or downstream), would this be considered a range expansion, which is identified by the yellow triangles. The UMRB and ORB are represented by the grey shaded areas on each map.

In the 2016 reporting period, range expansion was documented from a single adult Silver Carp collected at RM 280 of the Ohio River, approximately 64 miles upriver from a prior collection near Wheelersburg, Ohio. There was also a range expansion of Bighead Carp and Grass Carp into the Minnesota River, 103 miles from previous capture locations in the Upper Mississippi River. Range expansion of Black Carp was not detected in 2016.

As of 2016, the number of states with known occurrences of Asian carp are as follows:

- Bighead Carp, 27 states (an increase of one additional state)
- Silver Carp, 22 states (an increase of one additional state)
- Black Carp, 7 states (an increase of two additional states)
- Grass Carp, 45 states (no increase in number of states)

The numbers of Black Carp captures have increased significantly in the last year. From 2011-2015, there was a total of 33 Black Carp adult specimens captured and reported in the NAS database. In 2016, 34 adult fish were captured and reported (nearly all fish were captured by commercial fishers); for a total of 67 total reports since 2011. Although range expansion was not observed for Black Carp in either basin, the increase in the number of captures may indicate that the population has grown.

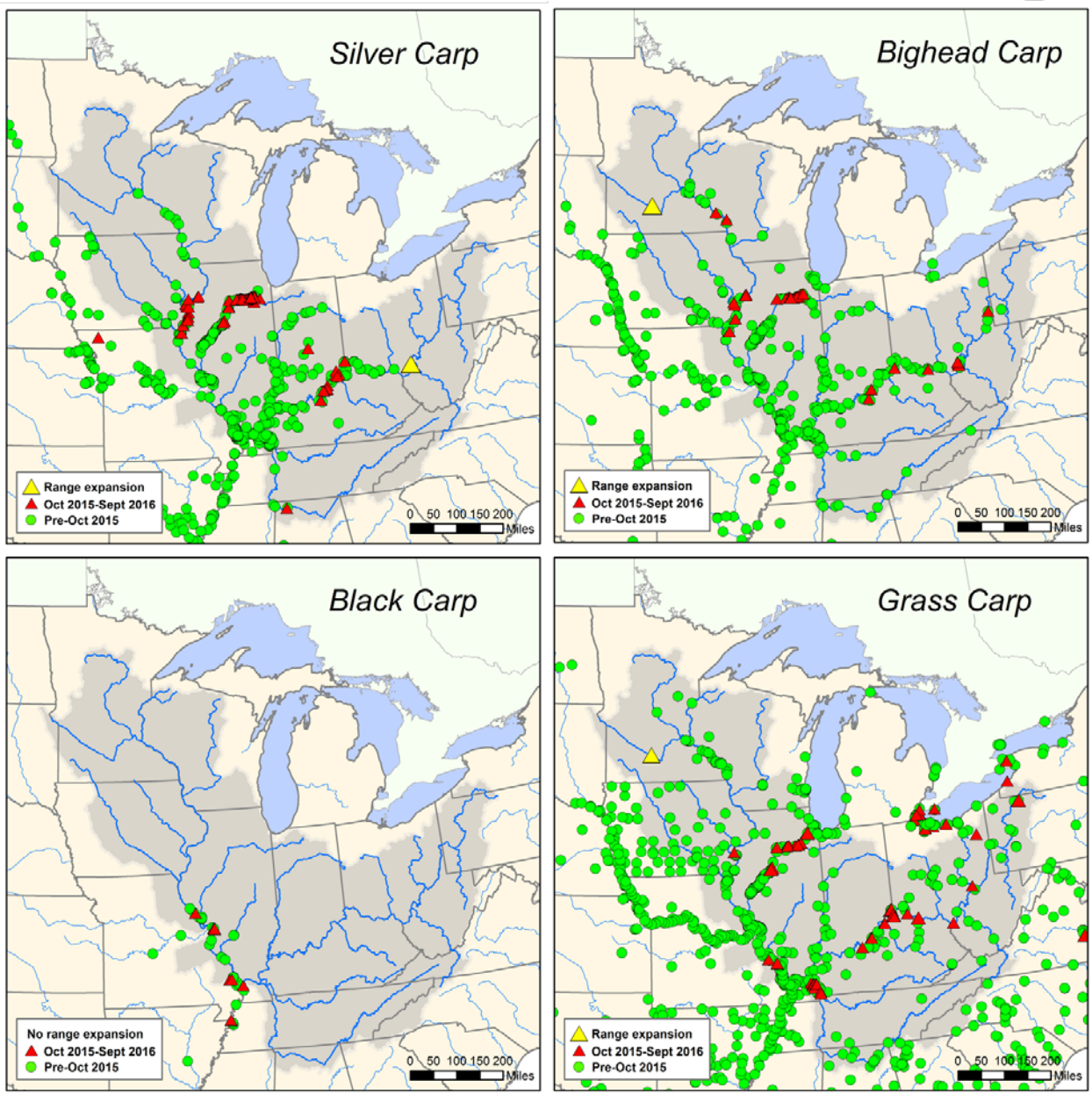


**Figure 2. Range expansion maps of all four species of Asian carp**

*Green circles represent the data points of occurrences before the reporting period (before Oct 2015); red triangles identify the new data points collected in from Oct 2015-Sept 2016; yellow triangles indicate occurrences that expanded the range of that species. Source: USGS NAS Database, Amy Benson.*

**Summary of Juvenile Information**

Individual occurrence data are important to monitor the range expansion of adult Asian carp. While the NAS occurrence data are useful in visualizing species distribution, the data provide only a partial description of the present status of each species. An accurate assessment and understanding of each species distribution and status, including all life stages, is fundamental to determining the appropriate

management and control actions to implement in the correct locations within each basin. Acquiring this critical information requires intensive field and laboratory work and remains a high priority.

In 2016, there was a more focused effort in monitoring for eggs, larval, and juvenile stages of Asian carp in both basins. These efforts were conducted to determine the areas where Asian carp are established (with the presence of spawning, recruitment, and adults), abundant but not established, or present in low abundances. Figure 3 depicts the new areas in 2016 where juveniles of all four species were detected in the Midwest, as reported in the NAS database. Juvenile Silver Carp were reported in both the UMRB and ORB in new locations (pools 18 and 19 in the UMRB and Cannelton, McAlpine, and Markland pools in the ORB), Bighead Carp were found in the ORB (Meldahl Pool), Grass Carp in the UMRB (Pool 17 and in a side channel below Lock and Dam 27 near Chester, Illinois), and Black Carp in the UMRB (Dutchtown Ditch near the Castor River Diversion Canal). These are all locations where adults have been previously detected, but the observation of juveniles indicates potential reproduction at these sites. Please see Figures 4 and 5 for Maps of Navigation Pools of the Upper Mississippi and Ohio Rivers.

**Figure 3. New records of juvenile Asian carp in 2016 (as reported in USGS NAS database)**

## 2.1 UMRB Juvenile Asian Carp Detections and Evidence of Spawning

**Silver Carp Juvenile Detections**

Biologists from the USFWS and Western Illinois University sampled juvenile Asian carp in the UMRB during the 2016 field season. In previous years, reproduction appeared to be limited, with only a handful of individual Silver Carp collected from areas downstream of Nauvoo, Illinois in Pool 19 (RM 375). Spring sampling did not result in the collection of age one Asian carp, consistent with the lack of detection during the 2015 field season. However, later sampling efforts resulted in the collection of nearly 800 young-of-year (YOY) Silver Carp from pools 18 and 19, suggesting that successful spawning occurred in 2016 (YOY refers to fish that were hatched within the calendar year in which they were captured). Recruitment had not been previously documented during sampling at the following locations in pools 18 and 19: Skunk River (RM 396), Carthage Lake (RM 402), Dry Branch Creek (RM 406), and Yellow Spring Creek (RM 410.3) in Pool 19 near Burlington, Iowa; Hawkeye-Dolbee Diversion (RM 422.1) and Boston Bay (RM 433.1) in Pool 18 near New Boston, Illinois. See Figure 4 for a Navigation Map of the UMR. Boston Bay, located approximately 21 miles downstream of Muscatine, Iowa, now represents the furthest upstream evidence of Silver Carp recruitment. Therefore, the range of the established population has moved one pool upstream since the 2015 Report.

**Grass Carp Juvenile Detections**

In Pool 17 of the UMRB, one YOY Grass Carp was collected at Coleman Island (RM 441.7), 12 miles downstream of Muscatine, Iowa. This represents the furthest upstream evidence of recruitment for Grass Carp. The NAS database has 37 records of juvenile Grass Carp located further south, near the St. Louis metro area, also reported by the USFWS in 2016.

**Black Carp Juvenile Detections**

In October of 2015, two juvenile Black Carp were captured near the Castor River Diversion Canal, just south of Cape Girardeau, Missouri. This discovery documented the first successful *in-situ* reproduction of the Black Carp in North American waters. In 2016, 81 juvenile Black Carp were captured from September to November in this same tributary (Figure 6). The majority of individuals were collected about eight miles upstream of the confluence with the Mississippi River. Black Carp were positively identified in the field using head shape morphology and pharyngeal teeth morphology and confirmed through genetic testing by the USFWS Whitney Genetics Laboratory in Onalaska, Wisconsin.

Black Carp relative abundance in the UMRB remains comparatively low, yet monitoring and assessment over the last two years has confirmed that Black Carp are naturally reproducing in the Mississippi River Basin, including the UMRB. Collection of Black Carp in 2016 included several adults, juveniles, and larval fish from multiple sites; however, there is not enough data at the present time to make an accurate characterization of relative abundance.

**Bighead Carp Juvenile Detections**

No juvenile Bighead Carp were detected in the UMRB from October 2015-Septemeber 2016**.**

**Figure 4. Map of Navigation Pools of the Upper Mississippi River**

## 2.2 ORB Juvenile Asian Carp Detections and Evidence of Spawning

In 2016, partner agencies in the ORB (USFWS, Indiana Department of Natural Resources (IDNR), Kentucky Department of Fish and Wildlife Resources (KDFWR) biologists) increased surveillance for evidence of Asian carp spawning in Ohio River waters. Indicators of spawning include the presence of adults with spawning patches (lacerations between the pelvic fins of adult fish), the presence of larval fish, or the presence of juvenile fish. Larval fish identification to species can be difficult; therefore, some evidence of spawning in the Ohio River is limited to information at the genus level. Evidence of spawning was recorded farther upstream in 2016 than in previous years. Collection of larval bigheaded carp (either Silver or Bighead Carp) occurred in the Meldahl Pool (RM 405.7; see Figure 5 for a Navigation Map of the Ohio River). The presence of spawning patches/lesions on individual fish was reported on Silver Carp in the Markland, McAlpine, and Cannelton pools and on Bighead Carp in Meldahl Pool.

Sampling for juvenile Silver and Bighead Carp was conducted in 72 sites within the Ohio River. Recruitment of juvenile carp was limited to lower pools as the IDNR collections resulted in 163 YOY Silver Carp and 7 YOY Bighead Carp in JT Meyers Pool. Of note, no YOY Silver Carp or Bighead Carp were captured in the Tennessee or Cumberland Rivers in 2016, where 2015 sampling efforts yielded hundreds of YOY Silver Carp.

**Black Carp Juvenile Detections**

Although the collections of Black Carp in the UMRB increased dramatically in 2016, no Black Carp have been captured in the ORB.

**Grass Carp Juvenile Detections**

Grass Carp are known to have reproducing populations in many parts of the UMRB and ORB since the 1970s; however, data on the occurrence and abundance of different life stages of this species have been rarely collected until the last two years.

**Silver and Bighead Carp Juvenile Detections**

Figure 6 characterizes Bighead and Silver Carp establishment and relative abundance in the UMRB and ORB, using the most-current data provided by State and Federal partners. The red-shaded area in Figure 6 indicates areas of establishment, where reproduction (spawning) has been verified by collecting taxonomically or genetically confirmed eggs or larvae or YOY Bighead or Silver Carp. The orange-shaded areas in Figure 6 indicate areas of adult Bighead or Silver Carp occurrence, where the population is stable with regular catches of adults and where spawning has not been confirmed (although it may have been observed). The blue-shaded areas in Figure 6 indicate the areas where adults are occasionally captured, either through agency monitoring efforts or commercial fisher catch. Therefore, distribution of fish in the blue-shaded areas should not be considered uniform throughout those reaches.

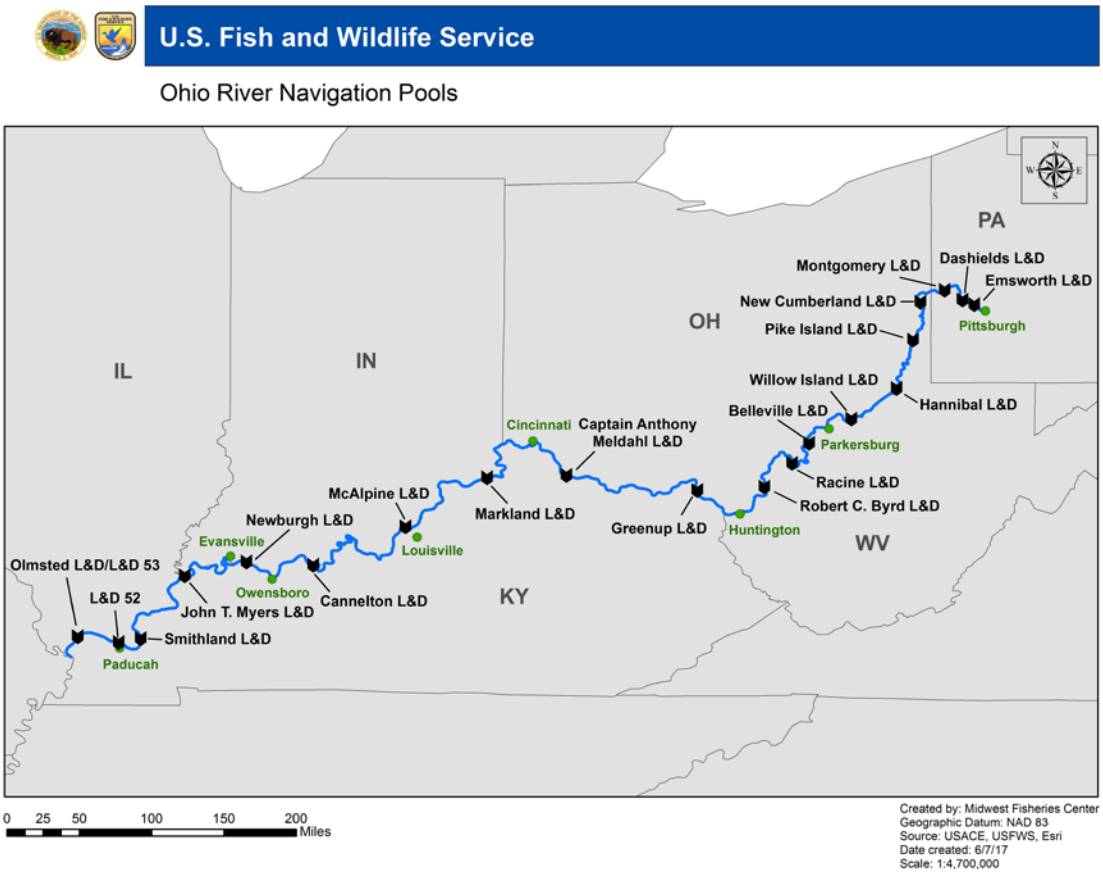


**Figure 5. Map of Navigation Pools of the Ohio River**

Management actions implemented by the basin partnerships are informed by the continually improved understanding of Bighead and Silver Carp populations. Nearly all resources are currently directed at containing established populations and preventing their continued expansion. Different management goals and actions are needed to address Bighead and Silver Carp characterized within the different color zones depicted in Figure 6. Management actions within the established range (red zone in Figure 6) are directed at reducing the abundance of Bighead and Silver Carp, particularly near lock and dam complexes, which act as partial barriers to upriver movement of fish. Reducing the number of fish below locks and dams (i.e., propagule pressure) reduces the numbers of fish migrating into the transitional (orange zone in Figure 6) where reproducing populations have yet to be established, especially where adults congregate below these structures. The fewer fish that migrate into the transitional zone, the lower the risk that Bighead or Silver Carp will reach sufficient abundances to establish reproducing populations in these reaches. Effort is being directed to understanding the extent of fish passage, both Asian carp and native species, at lock and dam complexes between the red and orange zones in Figure 6. These locks and dams are being evaluated for the use of deterrent technologies (e.g., sound/complex noise or Carbon Dioxide barriers) that would increase their effectiveness as barriers and further reduce the number of Bighead and Silver Carp dispersing upriver.

Most effort is being directed to the transitional (orange zone in Figure 6) where Bighead and Silver Carp are abundant, but have not yet established reproducing populations. Several goals have been identified

within these transitional areas to prevent the establishment of populations. The first priority is to conduct intensive monitoring and assessment of all life stages to clearly define and understand where Bighead and Silver Carp are reproducing, delineating where larval fish are present and where they are surviving. Because weather and environmental conditions are highly variable each year, reproductive success is highly variable across years and requires several years of intensive effort to determine where Asian carp have become established. Similar to efforts in the established (red zone in Figure 6), considerable effort is directed at removal of Asian carp from the transitional zones to reduce the abundance of adults and minimize the potential for fish to successfully spawn. Considerable effort is also being directed to understand the timing and extent of Bighead and Silver Carp movements within this reach to inform and improve efficiency of removal and assessment efforts. Additional work is being conducted near the transition between the orange and blue zones in Figure 6 to evaluate the potential for additional deterrent barriers to prevent Bighead and Silver Carp from becoming established in higher abundances in the blue zone where only individual fish have occasionally been collected. The primary goal and management actions within the blue zone in Figure 6 are surveillance monitoring and removal. Collection of a Bighead or Silver Carp within the blue zone may result in collaborative response action, with multiple agencies intensively sampling the area to determine if more Asian carp are present. Outreach and public awareness and education are also critical to ensure accurate reporting by the public is taking place.

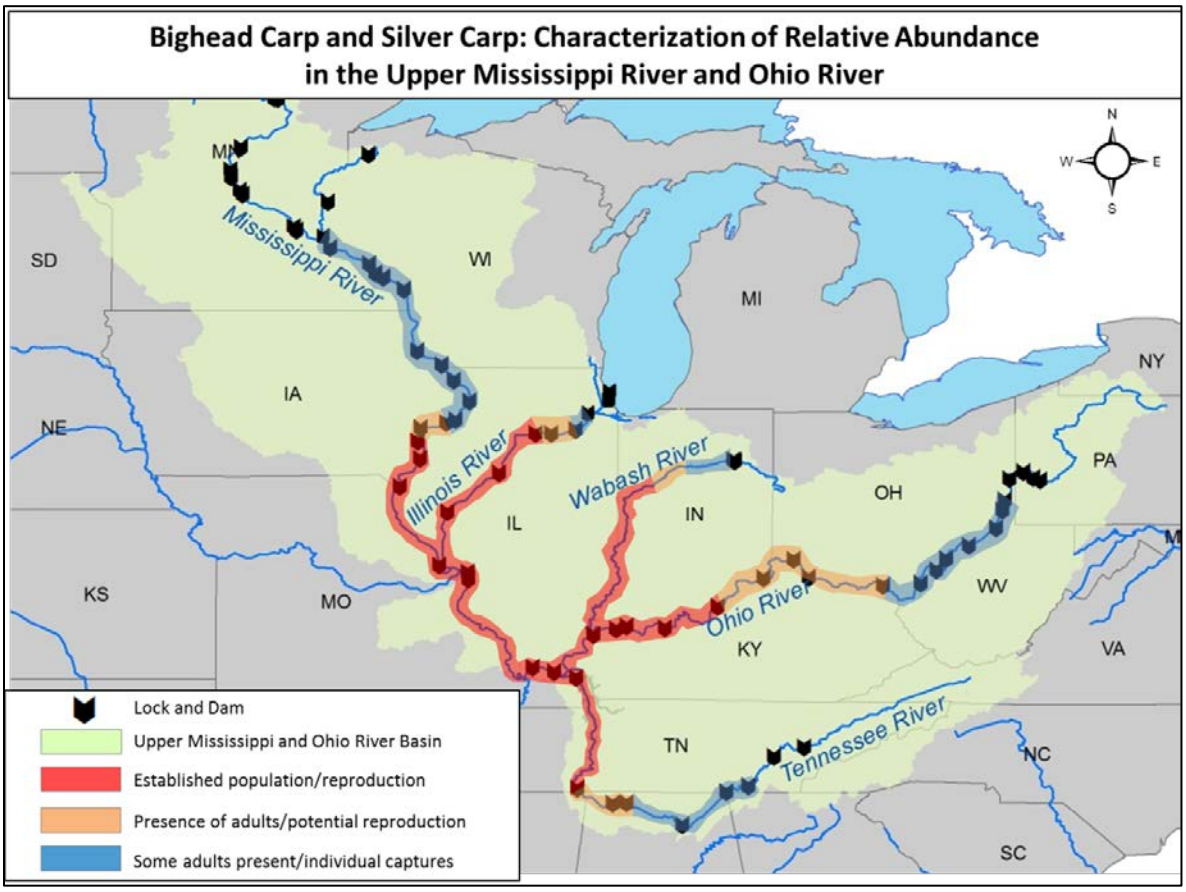


**Figure 6. Characterization of current (2016) relative abundance of Bighead Carp and Silver Carp in the UMRB, ORB, and IWW/CAWS**

### 2.3 Ploidy Analysis

Ploidy analysis is important to determine if a fish is sterile or capable of reproducing, and therefore potentially able to contribute to a natural population. Additionally, ploidy analysis can provide insight as to the origin of the fish (i.e. aquaculture vs. natural reproduction). Ploidy is determined for each individual of Black or Grass Carp to determine if they have naturally reproduced or potentially escaped from aquaculture. Ploidy analyses of Grass and Black Carp using flow cytometry techniques developed by the USGS Wetland and Aquatic Research Center was conducted by the USFWS La Crosse Fish Health Center to determine the risk for invasiveness or establishment of breeding populations in waters where these species were captured. Diploid individuals, whether escaped or breeding in unintended watersheds, are considered capable of reproduction upon reaching sexual maturity, while triploid individuals are likely escaped from intended stockings and are considered sterile (incapable of reproducing). Ploidy results, along with collection data and images are reported to USGS NAS database, where mapped results and the data are available to partners and the public.

### 2.4 FY 2016 Data and Analysis Summary

In 2016, a total of 59 Grass and Black Carp were collected from the UMRB, ORB, and IWW/CAWS and submitted for ploidy analysis (Figure 7). Nearly 90% of samples submitted were collected from the UMRB, and the majority of fish analyzed (83%) were diploid, indicating that reproductive Grass and Black Carp have become established in the UMRB (Figure 9). Reproduction of both species was documented in 2016 near Cape Girardeau, Missouri (Figure 8) by collections of larval fish, diploid verification, and DNA confirmation of species. Several larval Black Carp collected from this site in 2016 provided documentation of natural reproduction of this species in North America.

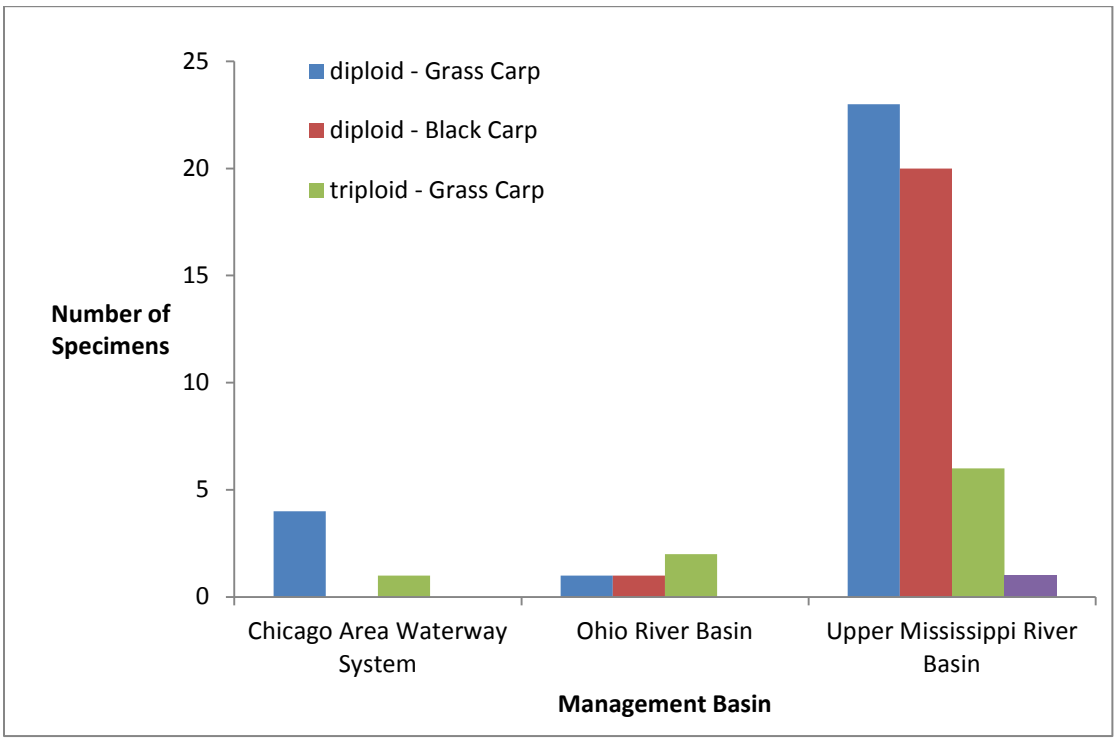


**Figure 7. Number of diploid, triploid, or unknown (could not be determined) ploidy specimens processed by the USFWS LaCrosse Fish Health Center in 2016**

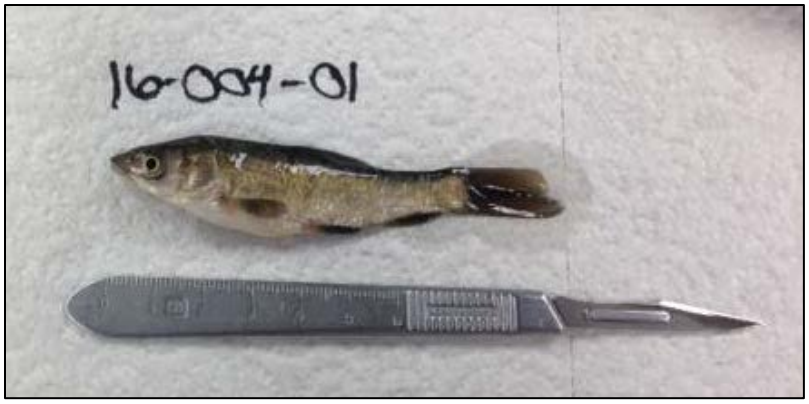


**Figure 8. Black Carp specimen collected from Cape Girardeau, Missouri in 2016 (within the UMRB)**

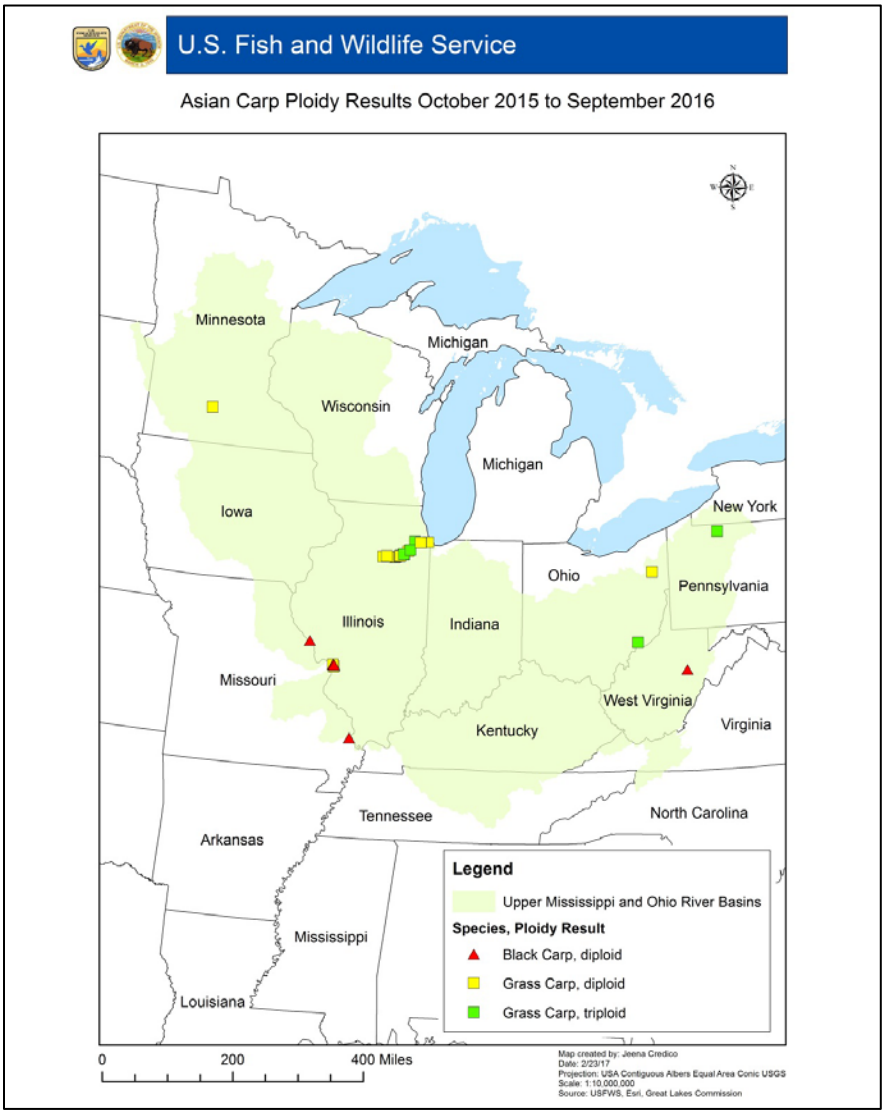


**Figure 9. Map of all ploidy results (N=59) for the reporting period of this report in the UMRB and ORB**
*All Black Carp collected were diploid; Grass Carp specimens were both diploid (N=28) and triploid (N=9).*

# 3.0 FEDERAL AGENCY AND COOPERATIVE STATE/NON-GOVERNMENTAL PARTNER ACTIVITIES TO CONTROL SPREAD OF ASIAN CARP IN THE UPPER MISSISSIPPI AND OHIO RIVER BASINS

## 3.1 Basinwide Planning for Asian Carp Management

Development of long-term strategies and annual research and management workplans in each sub-basin is coordinated through multijurisdictional partnerships comprised of State and Federal agencies. The organizational structures for the ORB and UMRB partnerships are illustrated in Figure 10. The ACRCC partnership is focused on GLB protection, but includes the IWW/CAWS. The ACRCC organization structure is illustrated in Figure 11.

Six states collaboratively manage interjurisdictional fisheries in the mainstem Ohio River through the ORFMT. The OFRMT formed an ORB Asian carp partnership comprised of state and federal agency partners. Universities assisting the partnership and other relevant non-governmental organizations in the basin participate as cooperating entities.

The Upper Mississippi River Conservation Committee (UMRCC) is a five state partnership that promotes cooperation between the conservation agencies on the Upper Mississippi River. The UMRCC states engage federal agencies and other partners through Technical Committees to collaboratively address multiple disciplines including fisheries, mussels, recreation, wildlife, water quality, vegetation, education, and law enforcement. The UMRCC, through the broad membership of the Fisheries Technical Committee, implements the *Asian Carp Control Strategy Framework for the Upper Mississippi River Basin*.

The Mississippi Interstate Cooperative Resource Association (MICRA) (Figure 10) is a partnership of 28 state natural resources agencies organized in 1991 to improve management of interjurisdictional fish and other aquatic resources in the MRB. MICRA formed an Asian Carp Advisory Committee (ACAC) that includes state agency representatives from each of the major sub-basin partnerships that collaborate through MICRA (i.e., Upper Mississippi River, Lower Mississippi River, Ohio River, Missouri River, Tennessee/Cumberland rivers, and Arkansas/Red rivers) and representatives from several key federal agency partners including the USFWS, USGS, USACE, NPS, and Tennessee Valley Authority. The multiple Asian carp sub-basin partnerships in the basin work together through MICRA and the ACAC to develop a basin-wide perspective on Asian carp management and control in the MRB. MICRA works with these Asian carp partnerships to annually identify priority Asian carp management and control needs for the MRB to update to the *Asian Carp Monitoring and Response Plan for the Mississippi River Basin*.

The ACRCC (Figure 11) is a partnership of 27 U.S. and Canadian Federal, State, provincial, and local agencies and organizations working to prevent the introduction and establishment of Bighead, Black, Grass, and Silver Carp populations in the Great Lakes. The ACRCC coordinates the Asian carp management and research efforts of its members through an annual *Asian Carp Action Plan* (Action Plan). The 2016 Action Plan contained a detailed portfolio of approximately 60 activities, including early detection and monitoring, contingency response planning, prevention and control (including addressing permanent and temporary pathways), research and development of new technologies, law enforcement, and partner and stakeholder communication and outreach projects. The work of the

ACRCC focuses heavily on prevention and control opportunities in the IWW/CAWS and other potential secondary pathways of risk to the GLB, as identified in the GLMRIS report. The ACRCC partnership structure includes a Federal Executive Committee ( consisting of the seven U.S. Federal agency partners); a Monitoring and Response Work Group (MRWG) (co-chaired by the Great Lakes Fishery Commission and ILDNR); and a Communications Work Group (co-chaired by USFWS and ILDNR). The MRWG, comprised of agency experts on Asian carp life history, research and management, develops an annual tactical *Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System.*

**Figure 10. Organizational structures of MICRA, ORB, and UMRB sub-basin partnerships**

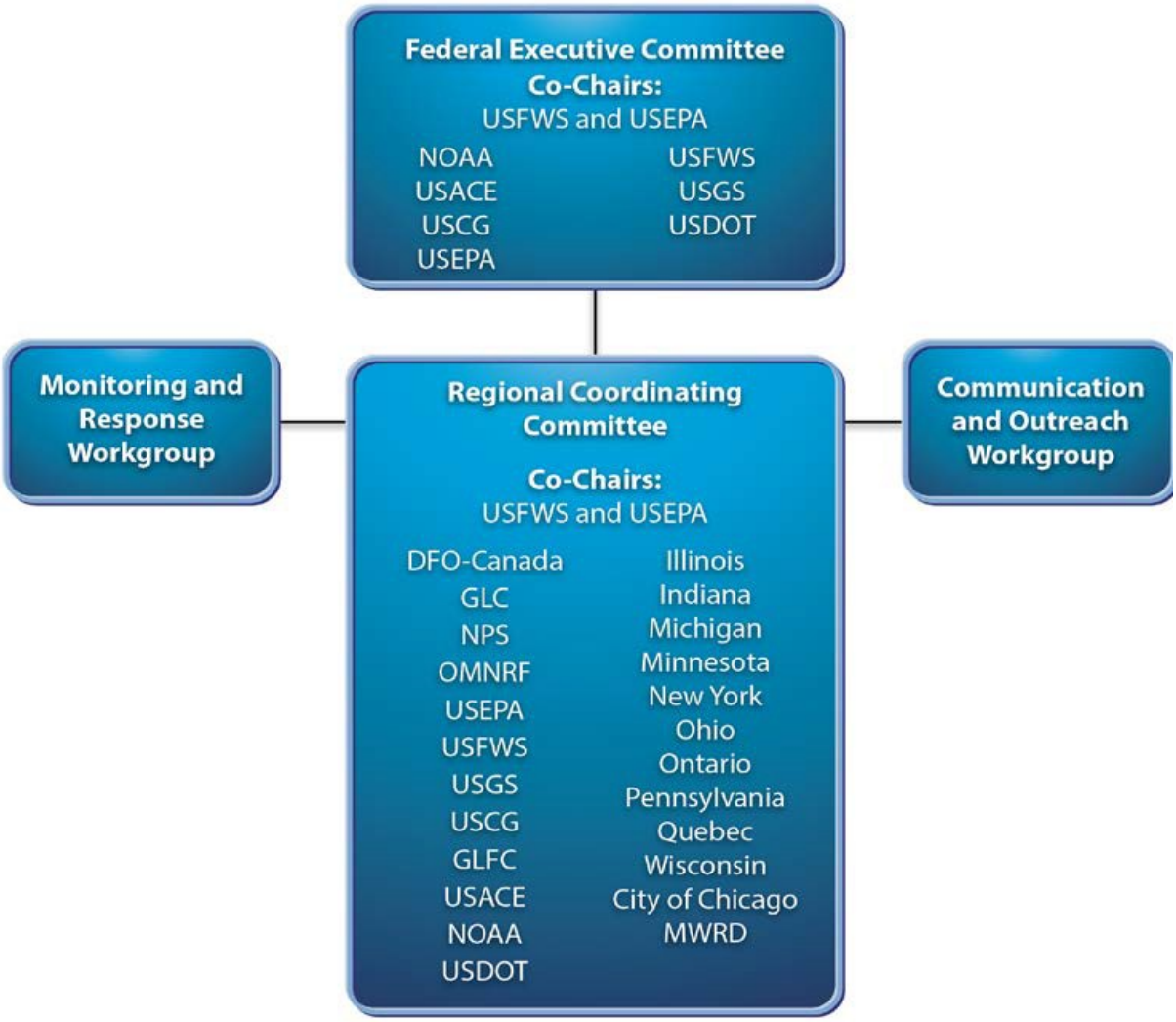


**Figure 11. Organizational structure of the Asian Carp Regional Coordinating Committee GLB partnership (includes actions in the IWW/CAWS for Great Lakes protection)**

**2016 Federal, State and non-Governmental Partnership Accomplishments**

The following sections provide summaries of the many activities and accomplishments achieved in support of the partnership strategies for Asian carp management within each sub-basin (ORB, UMRB, and IWW/CAWS). More comprehensive individual State and Federal agency summary reports on Asian carp management activities conducted in 2016 are available at *www.AsianCarp.us*. This includes the *2016 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin*, a complete compilation of project work plans developed for ORB and UMRB projects that received funding from USFWS in FY2016.

## 3.2 OHIO RIVER BASIN

### 3.2.1 INTERAGENCY COORDINATION

- **NATIONAL PLAN GOAL: Effectively plan, implement, and evaluate management and control efforts for Bighead, Black, Grass, and Silver Carp in the United States.**

In 2016, State and Federal agencies continued close coordination for planning and implementation of management actions to address the threat of Asian carp, primarily Bighead and Silver Carp, in the ORB and tributaries, including the Tennessee River. ORB partners participated in one or more levels of interagency coordination, including the MICRA Asian Carp Advisory Committee, Ohio River Sub-basin Planning Team, and Ohio River Asian Carp Technical Team. Project-specific working groups were created to address routine coordination needs including the Tennessee River telemetry working group and ORB communications working group. Work supported the goals of the National Plan, the *Ohio River Basin Asian Carp Control Strategy Framework* (ORB Framework), the ORB annual workplan, as well as State agency Asian carp management strategies, including the Ohio *Asian Carp Tactical Plan: 2014-2020* (Tactical Plan). The ORB Framework was developed to support other regional plans and outlines actions for prevention, monitoring and response, population control, research, and communication to collectively prevent further expansion and reduce population abundances of Asian carp.

To augment these efforts, the USFWS continued to work in partnership with MICRA and ORB State and Federal agency partners to identify priority project needs that address ORB sub-basin strategy priorities. In 2016, projects were identified and developed for early detection monitoring, monitoring and assessment, control and removal, and containment actions to prevent further distribution and establishment of Asian carp in the ORB.

### 3.2.2 MONITORING, EARLY DETECTION AND RAPID RESPONSE

- **NATIONAL PLAN GOAL: Minimize potential adverse effects of feral Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

**Asian Carp Telemetry Monitoring**
ORB agencies conducted cooperative activities to gather information on Asian carp location and behavior through the use of acoustic telemetry, a technology that relies upon tracking the movement of individually-tagged fish over time. During the reporting period, USFWS, INDNR, Ohio Department of Natural Resources (ODNR), KDFWR, and West Virginia Division of Natural Resources (WVDNR) tagged a total of 218 Asian carp with ultrasonic transmitters. Fourteen receivers were deployed within the lock chambers of Markland, Greenup, Robert C. Byrd, Racine, Belleville, and Willow Island Locks and Dams, with Meldahl Locks and Dam still having receivers deployed from the previous field season. An additional 70 receivers were deployed in tributaries of the Ohio River. From October 2015, to September 2016, nearly three million detections were recorded. Currently, the Ohio River Asian carp telemetry project includes 117 stationary receivers and 410 tagged Asian carp. 256 tagged fish were detected on stationary receivers during the reporting period. A greater emphasis on Asian carp

movements is planned for 2017 focusing on factors that potentially influence upstream movement and range expansion.

The current array of stationary receivers established in the Ohio River continues to provide useful data on the movement of Asian carp. However, the 117 receivers in the array require physical download of data on a monthly basis by field personnel. As a result, there is a time lag in detecting the passage of a tagged fish at any stationary receiver location. Outfitting strategic locations with real-time receivers allows instantaneous detection of Asian carp passage which can be used to fuel response efforts or assess the timing of movements related to spawning events. In collaboration with the USFWS and State partners in 2016, the USGS initiated real-time telemetry sites to detect tagged Asian carp in the Ohio River at Louisville, Kentucky and Ironton, Ohio where tagged Asian carp are present. Data are reported through the Illinois Water Science Center Fish Tracks website (http://il.water.usgs.gov/data/Fish_Tracks_Real_Time/) and are included in the USGS shared database and visualization tool developed for Asian carp telemetry data.

In West Virginia, WVDNR staff collected acoustic fish telemetry data from acoustic receivers deployed in the lock chambers on the Ohio River within West Virginia jurisdiction. WVDNR also conducted Asian carp mobile tracking in the Racine Pool of the Ohio River, specifically searching the area for Bighead Carp that were detected during 2015 surveys.

In addition to the work in the Ohio River, KDFWR deployed eight stationary receivers in Kentucky Lake, the lowermost reservoir and upstream extent of the "established range" on the Tennessee River. Twenty-four Silver Carp were implanted with sonic transmitters to determine their distribution and movement. The Tennessee River Telemetry working group was formed in 2016 and created a work plan that coordinates continuing efforts upstream of Kentucky Lake.

**eDNA Monitoring**

The USFWS conducted eDNA sampling within the ORB for early detection of Silver and Bighead Carp, as an early detection surveillance tool so identify where focused traditional methods should be used. Of the over 1,200 samples collected, none tested positive for Bighead or Silver Carp eDNA. WVDNR collaborated with the USFWS on eDNA surveys in the Willow Island, New Cumberland, Montgomery, and Dashields pools of the Ohio River, as well as the London Pool of the Kanawha and the Little Kanawha rivers (both major tributaries of the Ohio River).

**Traditional Gear Sampling**

Agencies continued sampling for Asian carp in the mainstem Ohio River, tributaries, and reservoirs in 2016. To identify habitat conditions and specific locations that affect the presence or absence of juvenile and adult stages of Asian carp, the USFWS and KDFWR targeted tributaries within Cannelton and McAlpine Pool tributaries. Over the five-week sampling period, 25 adult Silver Carp were captured and removed from 9 tributaries. The KDFWR completed assessments in the Tennessee River and Cumberland drainages for the relative Asian carp population densities and use of novel unconventional gear types for Asian carp capture. The KDFWR also monitored the commercial harvest of Asian carp in Kentucky to assess the impacts of the Asian Carp Harvest Program (ACHP) on sport fish and determine Asian carp demographics in Kentucky Lake.

The Tennessee Division of Wildlife conducted Bighead Carp and Silver Carp monitoring projects in partnership with Tennessee Technological University and other partners in the Tennessee and

Cumberland River systems (Tennessee Technological University's Fisheries Report 16-08). This effort included an Asian carp larval light trap study and Asian carp monitoring below Pickwick Nickajack dams.

Monitoring for Asian carp distribution and abundance in the ORB increased in scope in 2016 with the addition of sampling sites within the Cannelton and RC Byrds Pools of the Ohio River. Sixty hours of electrofishing effort and 38,100 feet of gill nets were used to survey for Asian carp in 5 pools of the Ohio River (Cannelton, McAlpine, Markland, Meldahl, Greenup, and RC Byrd, see Figure 5) including sections of the Asian carp "established range" and "invasion front". Electrofishing efforts produced 57 unique species, including captures of 29 Silver Carp and 9 Grass Carp. Gill netting efforts yielded 13 unique species, including 26 Silver Carp, 2 Grass Carp, and 1 Bighead Carp. As a result of these efforts, the KDFWR determined that Asian carp numbers decreased as sampling efforts moved upriver. No Silver or Bighead Carp were captured above the Markland Pool during standardized monitoring efforts.

ORB partners collaborated with EA Engineering, a private consulting company, to gain access to data from ongoing larval fish sampling in the Ohio River. The farthest upstream capture of Bighead, Silver, or Grass Carp larvae was in Meldahl Pool. Nocturnal collections of Bighead Carp in other sampling projects (telemetry and removal) upstream of the Greenup Pool (RC Byrd and Racine pools) illustrate a need for expanding monitoring efforts upstream and adding a nocturnal component to the sampling design.

Traditional sport fisheries monitoring programs increased our knowledge of the distribution and abundance of Asian carp. For example, the KDFWR conducted fisheries community surveys in backwater sloughs of the Ohio and Mississippi Rivers, which yielded key information on Black Carp and Silver Carp populations. These efforts resulted in the capture of three Black Carp, which were sent to the USGS-Columbia Environmental Research Center (CERC) and USFWS for genetic and ploidy analysis. The KDFWR also conducted creel surveys, angler attitude surveys and fish community surveys in tailwaters below Kentucky Dam (Tennessee River) and Barkley Dam (Cumberland River) to assess potential impacts of Asian carp populations on popular sport fisheries. To date, the KDFWR has interviewed 3,458 anglers and conducted 155 angler attitude surveys. This information is being used to inform Asian carp management planning in Kentucky.

The ODNR Division of Wildlife also conducts traditional sport fish surveys in the Ohio River in conjunction with neighboring Ohio River states. Similarly, WVDNR conducts annual field monitoring surveys for sportfish throughout the West Virginia portion of the Ohio River, as well as the lower reaches of the Kanawha River. These surveys provide opportunities to observe and remove Asian carp when captured.

**Rapid Response**

In September 2016, the Ohio River Sub-basin Asian Carp Planning Team determined that the capture of a single Silver Carp within Raccoon Creek of Robert C. Byrd Pool warranted a rapid removal response. This was the furthest upstream report of a Silver Carp, although Bighead Carp had been occasionally sighted within this pool. The response included the use of acoustic telemetry to locate tagged Asian carp as well as deployment of approximately 1,650 feet of gillnetting and 8 hours of electrofishing by the cooperating response agencies. Crews removed four Bighead Carp, yet no Silver Carp were found. . This response effort shed light on the lack of information on Asian carp distribution within Robert C. Byrd Pool and an immediate need to increase monitoring efforts within that pool.

### 3.2.3 ACTIVE PREVENTION/CONTROL

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIONAL PLAN GOAL: Extirpate, or reduce to levels of insignificant effect, feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

**Asian Carp Capture and Removal**

The KDFWR led the physical removal of Asian carp near the leading edge of Asian carp in the Ohio River, with crews spending 77 days removing Asian carp from the Ohio River with gillnetting (16 days) and electrofishing (61 days). Asian carp were removed from six pools of the Ohio River, but none were captured above Meldahl Pool. Silver Carp made up 98.3% of the Asian carp removed from the Ohio River. In 2016, overall electrofishing removal efforts and catch increased when compared to the same time frame in 2015 (300% increase in effort; 400% increase in catch). Gill netting removal efforts also increased, but capture did not show a relative increase (1000% increase in effort; 350% increase in catch). Increased effort and efficiency resulted in increased removal of Asian carp, but the current level of removal is not likely sufficient to limit upstream expansion. Changes in catch between years could be explained by a combination of improvements in sampling efficiency or increases in Asian carp numbers; accordingly, these results are not used to assess Asian carp population abundance.

The KDFWR also provides support and oversight of the commercial fishing industry, working with the industry to assess impediments to Asian carp harvest. Impediments to commercial fishermen were identified as lack of willing employees, high costs of net building, high transportation costs to move fish to processing facilities, difficulty in maintaining fish quality during the summer months, and low price-per-pound for Asian carp. The most significant impediment to fish processors is a low number of commercial fishers providing consistent and reliable supply of Asian carp. In spite of these impediments, the KDFWR ACHP facilitated the harvest of 2.4 million pounds of Asian carp from Kentucky waters since 2011. The KDFWR has monitored the commercial catch in Kentucky by compiling monthly reports and conducting ride-alongs with commercial anglers. After 5 years of consistent increases in harvest, the commercial harvest and catch per unit effort of Asian carp stabilized between 2015 and 2016.

In addition, the KDFWR partnered with Murray State University to monitor Silver Carp demographics in Kentucky Lake and assess the effect on populations from continued commercial harvest. The study indicated that Silver Carp:

- are larger than in other populations (Wabash, Illinois, Mississippi Rivers)
- have similar condition (length-weight relationship) to other populations
- are fast growing (triple in length between age-0 and age-1)
- have no missing age classes, which suggests routine reproduction or immigration
- exhibit intermediate mortality rates when compared to populations with more commercial harvest (Illinois River) and less commercial harvest (Wabash River)

These results suggest that Kentucky Lake Silver Carp populations remain in the growth phase of invasion and that the current level of commercial harvest is not providing a sufficient level of population control.

**Pathway Closures**
In 2016, the INDNR, ODNR, USACE, and USGS continued efforts to address the highest-priority secondary (intermittent) pathways in Indiana and Ohio, as identified through the GLMRIS Report. These are temporary hydrologic connections that form between the ORB and GLB during episodes of high-water or seasonal flooding, providing a pathway for the potential movement of Asian carp. In 2016, the USGS collected streamflow and water temperature data at sites on either side of the Phase 1 Eagle Marsh interbasin separation berm, a new physical barrier completed in 2016. These data are being used to evaluate inter-basin separation effectiveness of the Phase 1 berm during episodic high flows in the Graham McCulloch Ditch (Wabash River Basin/MRB) and Junk Ditch Basin (Maumee River Basin/Lake Erie) and to enable the USACE to simulate flows and induced flooding related to completion of the final Phase II Berm. The USGS also equipped and operated a webcam at a notch in the Phase I Berm to determine whether unplanned inter-basin connections were achieved during high water level conditions.

Also, opportunities for closure of pathways at Ohio Erie Canal, Little Killbuck Creek, Grand Lake St. Marys, and Mosquito Creek Lake were evaluated by the ODNR and USACE. During the 2016 reporting period, USACE continued work to complete the final design for closing the Ohio Erie Canal connection. At Grand Lake St. Marys, modifications were made at the St. Mary's State Fish Hatchery to allow continued use of lake water without the risk of AIS transfer to the Lake Erie basin. A screening structure will be installed to complete this connection closure in 2017. The Mosquito Creek Lake connection was also assessed and the risk was determined to be low, consequently no further work will be done at this connection.

### 3.2.4 RESEARCH AND DEVELOPMENT

- **NATIONAL PLAN GOAL: Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

**Development of New Deterrent Technologies**
In 2016, Federal and State partner agencies collaborated to organize and conduct the first-ever interagency Sound Deterrent Workshop Coordination and Planning Meeting for researchers and natural resource managers. The information presented and developed at this meeting is being used to inform pilot project implementation to test the use of sound as a potential barrier to Asian carp movement. For example, the KDFWR assisted in initiating a project to test the effectiveness of using sound to deter Asian carp from passing through lock chambers on the Tennessee River system in response to a need identified by researchers and managers at the Sound deterrent workshop. Subsequent to this workshop, the KDFWR also partnered with USGS-CERC to conduct "sound herding" trials on the Asian carp invasion front on the Ohio River as well as feeding station trials in tributaries of the Ohio River (although flash flooding precluded the completion of the sampling event). The partnership created a synopsis of current non-physical barrier types that may be effective for limiting movement of Asian carp by providing brief descriptions of each barrier and summaries of the current understanding of each barrier's potential effectiveness.

**Asian Carp Life History and Reproduction Evaluations**
In 2016, the USGS initiated a study to evaluate Asian carp spawning success in the ORB, which includes collection of water quality and flow data, and the characterization of the river reach from McAlpine Dam

Pool at Louisville, to below the Markland Dam downstream from Cincinnati, Ohio. Data will be compared with computer models to evaluate Asian carp spawning success in the ORB. Data collection started in late October 2016 and is planned from June to July 2017. Also, building on work started in 2014, the USGS collected similar data on the Muskingum River to assess the possibility of Asian carp spawning using the Asian Carp Fluvial Egg Drift Simulator (FluEgg) model. The Muskingum River data were collected in a 50 mile reach from Coshocton (at the confluence of the Walhonding and Tuscarawas rivers) to McConnelsville. The collected field data were supplemented by a hydraulic model of the lower 60 miles for the purposes of floodplain mapping. Results from this study will be published in 2017.

### 3.2.5 OUTREACH WITH INDUSTRY, STAKEHOLDERS AND THE PUBLIC

- **NATIONAL PLAN GOAL: Provide information to the public, commercial entities, and government agencies to improve effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

In 2016, communication and outreach efforts in the ORB included development of a Communications Work Group to develop an interagency communications strategy to support partnership and actions of individual agencies. This strategy will provide guidance on the status of the threat and steps to minimize the risk of introduction and spread, and to gather new occurrence information (e.g., Asian carp catch data from recreational anglers and commercial fishers) by working directly with the public, industry, public officials, and other stakeholders. Additionally, State and Federal agencies conducted the specific activities described below to support outreach and engagement on Asian carp management issues and opportunities.

**AsianCarp.us website**

The USFWS continued to support and administer *www.AsianCarp.us*, the primary interagency website in the United States for outreach related to Asian carp management. The ORB agencies continued to develop opportunities to expand the use of web-based tools for stakeholder engagement. In 2017, the website will be re-designed to include specific content on Asian carp news and developments.

**Public/Stakeholder Engagement**

The USFWS staff provided the public with information on the extent of the Asian carp invasion within the ORB as well as ways to identify Asian carp and prevent further human-assisted spread. This outreach occurred at Cache River Nature Fest and the Southern Illinois Hunting and Fishing Days, reaching a total of over 30,000 people.

In addition, ORB agencies conducted numerous activities focused on education and awareness, as well expanding the scope of participation. ORB agencies informed the public about Asian carp harvest efforts that may create conflicts with recreational anglers and boaters by placing signage at access points, distributing pamphlets to marinas and local businesses, and sending press releases to local media outlets. To support recent regulations in Kentucky that limit the transfer of bait fish between water bodies, the KDFWR fisheries districts purchased and distributed signs at popular boat ramps to notify the public about the harm in bait bucket transfers. To further notify the public about this issue, new sections were created for the annual fishing and boating guide and the KDFWR website. Also, the KDFWR responded to requests to present information about Asian carp to local angling clubs as well as TV and radio outlets. As an example, the KDFWR staff presented information about ORB Asian carp

projects for a webinar organized and hosted by the Indiana Wildlife Federation. The result of the webinar was increased awareness and support from state chapters of the National Wildlife Federation for Ohio River Asian carp efforts.

Activities in other ORB states included:

- In Ohio, advertisements and signage were distributed to promote awareness of AIS issues. ODNR teamed with Wildlife Forever on a "Trash Unused Bait" campaign to encourage anglers to not dump their bait buckets in lakes or rivers
- In Indiana, outreach efforts continue to inform anglers of the dangers of moving bait beyond the area where the bait was collected
- In Tennessee, 2016 outreach efforts included support for a Tennessee High School Fishing Team Program and Asian carp field demonstrations and sampling events for the Tennessee State Legislative Task Force on Asian carp

**Industry Engagement**
The KDFWR continued outreach with the commercial fishing industry to enhance Asian carp reporting and collection. This included meetings with commercial fishers and processors to outline changes to operation of the ACHP, identifying limiting factors to the harvest of Asian carp, development of new gear types for Asian carp capture, and conducting ongoing projects that require cooperation with commercial fishers. In 2016, the KDFWR also met with prospective business people interested in investing in the commercial carp industry.

### 3.2.6 LAW ENFORCEMENT/REGULATORY

- **NATIONAL PLAN GOAL: Prevent accidental and deliberate unauthorized introductions of Bighead, Black, Grass, and Silver Carp in the United States.**

In 2016, ORB agencies continued efforts to ensure compliance with regulations and best-practices related to the transport and use of live bait by commercial harvester, dealers, and anglers. Actions included bait dealers sampling by ODNR Law Enforcement in both the Lake Erie and Ohio River watersheds to monitor for the presence of AIS, including Asian carp. 2016 marked the second year of this sampling effort.

## 3.3 UPPER MISSISSIPPI RIVER BASIN

### 3.3.1 INTERAGENCY COORDINATION

- **NATIONAL PLAN GOAL: Effectively plan, implement, and evaluate management and control efforts for Bighead, Black, Grass, and Silver Carp in the United States.**

Building on efforts from 2015, State and Federal agencies continued strong coordination in the planning and execution of critical management and research actions in the UMRB. This section provides a summary of Federal and State agency accomplishments in the UMRB. Additional details can be found in individual agency activity located in the appendices.

The USFWS worked in partnership with MICRA and State and Federal agency partners in the UMRB to identify priority project needs to address UMRB sub-basin strategy priorities. In 2016, projects were identified and developed for early detection, monitoring and assessment, population control, and containment actions to prevent further distribution and establishment of Asian carp in the UMRB. Those projects are described in further detail in this section.

The UMRB partners regularly coordinate through the UMRCC and UMRCC Fisheries Technical Committee. Activities support implementation of the National Plan and the goals and objectives of the Upper Mississippi River Conservation Committee's (UMRCC) Upper Mississippi River Fisheries Plan (Fisheries Plan). Goal 4 of UMRCC's Fisheries Plan is to "slow or eliminate the spread or introduction of aquatic nuisance species, including pathogens, to the Upper Mississippi River." The UMRCC Fisheries Technical Committee continued development of an UMRB Asian Carp Control Strategy Framework (UMRB Framework) to coordinate Asian carp prevention and control efforts in the Upper Mississippi River. In 2017, a final version will be completed and placed on *www.AsianCarp.us*.

UMRB partner agencies also participated in the 2016 Asian Carp Risk Assessment exercise, hosted by the University of Minnesota; the March 2016 Minnesota Invasive Asian Carp Forum hosted by the MNDNR; the May 17-18, 2016 Acoustic Barrier workshop in LaCrosse, Wisconsin; and the USGS Sound Deterrent Workshop via teleconference.

In Minnesota, activities were conducted in 2016 to support of the *Minnesota Invasive Carp Action Plan* (MICAP). MICAP complements both the National Plan and the Fisheries Plan as this Plan includes specific strategies that address the following: Early Detection and Monitoring of Susceptible Waters; Prevention and Deterrence; Response Preparation; Management and Control; and Outreach and Communication.

### 3.3.2 MONITORING, EARLY DETECTION AND RAPID RESPONSE

- **NATIONAL PLAN GOAL: Minimize potential adverse effects of feral Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

**Asian Carp Telemetry Monitoring**

Telemetry data has provided key long-term and seasonal information on Asian carp populations in the UMR and supported greater capture efficiency by predicting when and where to implement specific removal efforts. In 2016, a total of 300 Asian carp were implanted with acoustic transmitters and are being tracked by the remote array of interagency receivers (Minnesota, USFWS, USGS, USACE, and Missouri) to help understand seasonal movement, dam passage, and the intermixing of populations. The remote array covers the Mississippi River from St. Paul, MN to Cairo, Illinois. Weekly tracking efforts collected 1,300 point locations in pools 16 through 19 and some of the tributaries. These data have provided information on seasonal movements, identified "hotspots", guided removal efforts, and increased capture efficiency. Scientists from the USGS, including the CERC, Upper Midwest Environmental Sciences Center (UMESC), Illinois-Iowa Water Science Center (IIWSC), and Indiana-Kentucky Water Science Center (IKWSC) collaborated on telemetry studies near the invasion front in navigation pools 17 to 20 to assess dam passage and seasonal congregations of Asian carp. This

information is used to inform effective *in situ* control measures including removal. Information from these studies and surveillance has been instrumental in the ongoing control program that has removed over 80,000 pounds of Asian carp at this front.

Additionally, the USGS has developed a shared database and visualization tool for Asian carp telemetry data. Asian carp distribution and movement data from a network of over 100 passive telemetry receivers is now available to partner agencies to inform control efforts. The USGS is developing a real-time telemetry network across all basins to inform rapid response and removal efforts at strategic locations. To date, four real time receivers have been installed and data are being used by managers to direct rapid response and removal. In 2017, USGS will continue to collaborate with the telemetry workgroups for the UMRB on additional Asian carp telemetry studies and the expansion of the receiver networks (passive and real time) and telemetry database.

**eDNA Monitoring**

The USFWS assisted the USACE-ERDC to field-test a newly developed genetic marker for Black Carp eDNA by collecting 450 water samples in March and 422 samples in August of 2016 near Cape Girardeau, Missouri. No collected samples contained positive eDNA detections, however, the samples helped refine future collection methods and determine the sensitivity and specificity of the genetic markers. Sampling for eDNA was also conducted in the St. Croix River and in pools 5A, 8, and 9. All samples were negative for Bighead and Silver Carp eDNA. The USGS also initiated laboratory evaluations of Black Carp and Grass Carp eDNA "shedding rates" to assist development of eDNA monitoring protocols and interpretation of results.

**Traditional Gear Sampling**

In 2016, early detection sampling was completed by UMR agencies using seine and mini-fyke nets. The two-week sampling effort produced ten YOY Black Carp in a ditch south of Dutchtown, Missouri and three juvenile Silver Carp in a ditch in Alexander County, Illinois. These findings prompted additional removal efforts in the surrounding area to further delineate the current range of the Black Carp in surrounding waters.

The USFWS continued to develop, evaluate, and integrate novel sampling techniques for the detection, monitoring and removal of Asian carp in Midwestern U.S. waters. These new gear types are being used for the detection of larval and juvenile Asian carp at the leading edges of the population fronts in the Illinois and Upper Mississippi rivers. Techniques included use of an electrified boat-deployed "paupier" net (a butterfly frame trawl used by commercial fishers for capturing shrimp in surface waters), which demonstrated success as a technique for catching carp of all sizes in deeper, open waters. An electrified "dozer" trawl (a frame trawl pushed in front of a standard electrofishing boat), was used to more effectively sample smaller backwaters, channels, and habitats with depth less than 3 feet. Additional progress was made in developing "purse" seines, for mass removal of juvenile Asian carp in a riverine environment.

The USFWS also used traditional gear sampling to monitor pools 16, 17, 18, 19 for YOY Asian carp from July through September 2016. The furthest upstream detection of larval (presumably Age-0) Silver Carp was in Pool 18 at RM 433, approximately 4 miles downstream from Lock and Dam 17. The greatest density was found in Hawkeye Dolbee Diversion in Pool 18, or RM 422, approximately 15 miles downstream of Lock and Dam 17. Ichthyoplankton samples were also collected from pools 8-13 every 2 weeks from May through September 2016. No larval silver, bighead, or grass carp have been visually

identified in those samples, and the identification of eggs in ongoing. Juvenile monitoring has resulted in the capture of YOY Silver Carp in the upper reach of Pool 18, documenting the furthest upstream location of successful recruitment in the UMR. Previous captures were from 2010 (23 YOY) and 2011 (9 YOY) in Pool 19.

In Minnesota waters, MNDNR conducted Asian carp monitoring using gill nets, electrofishing, trap netting, larval trawling, and targeted commercial fishing. In 2016, MNDNR random sampling effort included 7,600 feet of gill/trammel netting, 1,124 minutes of electrofishing and 8 net-nights of trap netting. The standardized effort included 325 minutes of electrofishing and 156 larval trawls. MNDNR annual reports are completed in April of each year and can be found at: www.dnr.state.mn.us/invasive-carp.

During the summer of 2016, the Iowa DNR (IADNR) conducted electrofishing surveys to monitor for Bighead and Silver Carp distribution and abundance in the Des Moines and Skunk rivers and detect Asian carp in the Maquoketa and Turkey Rivers. IADNR also provided funding to Iowa State University to 1) evaluate adult population characteristics and dynamics of Bighead, Silver, and Grass Carp in pools 14, 15, 16, 17, 18, 19, and 20 of the Mississippi River and the Des Moines River and 2) evaluate Asian carp reproduction in pools 14, 15, 16, 17, 18, 19, and 20 of the Mississippi River and the Des Moines, Skunk, Iowa, Rock, and Wapsipinicon Rivers. Larval sampling took place once every two weeks from May through August 2016 and adult sampling occurred once at each site during September and October 2016. Results from the project will inform an understanding of spatiotemporal patterns of reproduction and adult population characteristics of Asian carp in Iowa waters.

Additional monitoring was conducted to focus on maintaining key baseline datasets for both native and non-native fish species in the UMR ecosystem. UMRB State and Federal agencies conducted research and monitoring within the Long Term Resource Monitoring (LTRM) element of the USACE Upper Mississippi River Restoration (UMRR) Program. The UMRR was the first comprehensive program for ecosystem restoration, scientific research, and monitoring on a large river system in the world. The monitoring and research activities of the LTRM are focused on identifying status and trends in critical natural resources and gaining insight into ecosystem function and the factors influencing the community structure of fishes and aquatic vegetation. Although the UMRR was not designed to specifically address Asian carp or other invasive species, the long-term data (20 plus years) on fish communities, water quality, and aquatic vegetation are unique assets and provide critical pre-invasion baseline conditions within the UMRB. This information allows for rigorous analyses to identify harmful effects of Asian carp (and other non-natives) on native fauna and ecosystem processes. LTRM data and information are available at http://www.umesc.usgs.gov/ltrmp.html.

Key contributions from the LTRM relative to Asian carp include research on the following:

- Non-native fishes in the UMR System
- Status and Trends of Selected Resources of the UMR System
- Multiyear synthesis of the fish component from 1993 to 2002 for the Long Term Resource Monitoring

**Rapid Response**
The USFWS completed rapid response effort in Pool 5A following the capture of a Bighead Carp by a bow fisherman on June 11, 2016. Approximately 1.25 hours of electrofishing and 2,000 yards of gillnet were used in the area adjacent to where the fish was captured. No additional Asian carp were captured. In Minnesota, DNR collaboration with commercial fishers to monitor their catch yielded prompt reporting of individual Grass Carp (December 2015) and Bighead Carp (February 2016) captures from the Minnesota River. These captures were the first reports of Asian carp in the Minnesota River basin. The MNDNR and USFWS conducted follow-up sampling, yet no additional Asian carp were found.

### 3.3.3 ACTIVE PREVENTION/CONTROL

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIOAL PLAN GOAL: Extirpate, or reduce to levels of insignificant effect, feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

**Asian Carp Capture and Removal**
In addition to routine monitoring of the commercial catch, the MNDNR coordinated with commercial fisherman to specifically remove Asian carp from Minnesota waters of the UMRB. In 2016, commercial effort included deployment of approximately 40,600 feet of gillnet. No Asian carp were captured and removed during this activity.

**Pathway Closures**
In Minnesota, stream-connected Illinois Lake, Plum Lake, and Round Lake, were identified as waterbodies that could be targeted for protection from expansion of Asian carp in the Missouri River watershed. Round Lake is an important recreational lake in Southwestern Minnesota and protection was sought for maintenance of this lake. In 2013, an electric barrier was designed and construction was completed in the fall of 2015 for a location downstream of these lakes. Additional electric barriers are being constructed for Madison Lake and Lake Elysian. These lakes were chosen based on recreational value, biological importance, and risk of Asian carp expansion. Work began in 2015, with completion expected by the spring of 2017.

### 3.3.4 RESEARCH AND DEVELOPMENT

- **NATIONAL PLAN GOAL: Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

Research conducted by agencies in support of Asian carp prevention and control in the UMRB included identification and evaluation of opportunities to strategically deploy deterrent technologies in conjunction with the operation of existing locks and dams and other navigation structures. Efforts focused on Lock and Dam 19 in Iowa and Locks and Dams 2, 5 and 8 in Minnesota. These locations were identified as potential Asian carp “choke points” on the mainstem Mississippi River. Additional work on potential deterrent options included laboratory and field evaluations of specific prevention technologies

including complex sound, carbon dioxide, and water velocity manipulation along with participation in multi-basin interagency coordination deterrent tool workshops. Key research included investigations of Asian carp biology, life history, reproductive behavior and success, and habitat use in the sub-basin as well as impacts on select native fish species and fish communities in the UMRB. Additionally, agencies further developed and refined new detection tools for Black Carp, an emerging threat to the UMRB due to expanding numbers and evidence of reproduction downstream in the middle Mississippi River in Missouri.

**Development of New Deterrent Technologies**

The USACE instituted revised dam gate operations at Locks and Dams 5 and 8 to make it more difficult for Asian carp to penetrate weak areas (slower velocities) in the dam flows, as recommended by the Minnesota Aquatic Invasive Species Center, University of Minnesota – Twin Cities. In addition, the USACE partnered with the University of Minnesota Aquatic Invasive Species Research Center to assess the efficacy of the electric barriers at Lock and Dams 2, 5, and 8 to improve their effectiveness. At Lock 19, the USFWS used sonar imagery to examine fish use and provide information necessary for development of an effective deterrent at this site.

The MNDNR provided funding to the Minnesota Aquatic Invasive Species Center, University of Minnesota – Twin Cities for revaluating flow adjustment and acoustic deterrence at Mississippi River Lock and Dams. The Center is looking at fine detail fish movements at Lock and Dam 2 under a variety of flow conditions to understand how often fish challenge the structure, where they attempt to pass, and their success rates. The Center is also evaluating the response of fish to acoustic speakers located in Lock 8. Work began in 2016 and will continue into next year with preliminary results expected in spring 2017. The MNDNR also provided funding to the Water Resources Lab at Minnesota State - Mankato to evaluate the Minnesota River for potential Asian carp deterrence measures. In 2016, work continued on developing inundation maps (flood mapping), floodplain change analysis, bathymetric analysis, and invasive carp habitat suitability models. The evaluation will be completed in 2017.

**Asian Carp Biology, Life History and Reproduction Evaluations**

The USGS, in collaboration with the USFWS, MICRA, and basin states has developed a protocol for handling and conducting research on Black Carp captured in the MRB, including the UMRB and the ORB. All Black Carp captured from the wild are processed through the protocol to determine ploidy, recent reproductive status and activity, age, condition, stomach contents, and location of capture and origin. A similar protocol is in place for Grass Carp captured from portions of the MRB where they are not known to be established. The USGS is currently beginning work on the development of Black Carp selective bait which could be used for population control and protection of endangered mussels.

The INDNR, in cooperation with Missouri Department of Conservation (MoDoC), Big Rivers and Wetlands Field Station, undertook a study to examine the spatial and temporal scale of Bigheaded Carp hatch dates, growth rates, and relative abundance from the Middle Mississippi River (MMR) and associated tributaries. The study demonstrated that favorable conditions for spawning and growth are present in this system and likely serve as a yearly source of recruits to the broader MRB, highlighting the need for increased attention and control efforts in this area.

MoDoC also collaborated with UMRB agency and university partners on several field studies to evaluate Asian carp biology, population characteristics, habitat use, and impacts to native species in MMR pools. Studies included:

- Determining the egg hatch timing and daily growth of Silver Carp and Gizzard Shad (a native species impacted by Asian carp establishment) in the MMR
- Evaluating the effects the invasion of Grass, Silver and Bighead Carp have on native fishes in pools 4, 8, and 13 of the UMRB
- Quantifying the amount of effort necessary to effectively remove invasive Carp from the MMR (simulated removal of 30%, 40%, and 95% of the initial biomass of Grass, Common, and Silver and Bighead Carp, respectively, was shown as the minimum amount of removal required for eradication from the MMR)
- Evaluating Grass Carp status and population dynamics in the MMR
- Examining the prey selectivity of common predators on Silver Carp to assess the diets of native piscivores (predators of fish) collected in Pool 26 and the "Open River" reach of the Mississippi River (results showed that the majority of native piscivores appeared to be avoiding Silver Carp in both reaches and selecting native prey fishes)
- Evaluations of the specific hatching and rearing locations in the MMR of adult Silver Carp during 2015 using otolith trace element and stable isotope analysis (chemical analysis of Asian carp skeletal structures )

### 3.3.5 OUTREACH WITH INDUSTRY, STAKEHOLDERS AND THE PUBLIC

- **NATIONAL PLAN GOAL: Provide information to the public, commercial entities, and government agencies to improve effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

**AsianCarp.us website**

The USFWS continued to support and administer *www.AsianCarp.us*, the primary interagency website in the United States for outreach related to Asian carp management. The UMRB agencies, in coordination with the ACRCC Communication Work Group, identified content to be developed and featured on the *www.AsianCarp.us* website. This information covers the sub-basin partnership's projects and accomplishments on Asian carp management. In 2017, the website will be re-designed and developed to include additional content targeted on Asian carp news and developments. In addition, UMRB Federal and State partners featured news and relevant developments on Asian carp management on their individual agency websites.

**Public/Stakeholder Engagement**

In many UMR states, signs alerting the public to the presence of Asian carp were posted at fishing access sites below dams with known populations of Bighead and Silver Carp. The signs show how to identify the species and warn that it is illegal to possess or transport live Asian carp. In addition, UMR states informed water recreationists about the threats of Asian carp using agency websites, educational brochures, identification card and posters, billboards, and press releases. Many materials were distributed at watercraft inspection stations, fishing clinics, state fairs, parks, nature centers, and businesses supporting aquatic based recreation. The MNDNR regularly communicated with the "Stop-Carp-Coalition", a collaborative comprised of non-governmental organizations concerned about invasive carp and their impacts. The UMRB partners also provided AIS information and a list of AIS-infested waters in fishing and boating regulations booklets and participated in briefings for Federal and State elected officials. The 2016 Minnesota Invasive Carp Forum was held to provide a platform to update

interested stakeholders and the public on invasive carp and related activities, and an opportunity for attendees to ask questions, voice concerns, and provide opinions.

**Industry Engagement**
The USACE conducted outreach efforts with industry and other stakeholders focused on Asian carp prevention in the UMRB. During the reporting period, USACE participated in the following organized stakeholder groups:

- Technical and Policy Workgroup consisting of academia and non-governmental organizations interested in technical and policy issues relating to the design and operation of the electric barriers
- Barrier Navigation Task Force consisting of representatives of the navigation industry interested in research on the efficacy of the electric barriers
- CAWS Advisory Committee comprised of more than two dozen stakeholder organizations that have expressed an interest in preventing AIS transfer into the Great Lakes, especially Asian carp

Additionally, USACE employed a comprehensive public engagement strategy for GLMRIS during the reporting period consisting of focused briefings, stakeholder conference calls, media events, social media, and project websites.

### 3.3.6 LAW ENFORCEMENT/REGULATORY

- **NATIONAL PLAN GOAL: Prevent accidental and deliberate unauthorized introductions of Bighead, Black, Grass, and Silver Carp in the United States.**

Federal and State agencies continue to coordinate closely on enforcement of injurious species regulations, including the Lacey Act and other Federal and State statutes. In 2015, MICRA submitted a report to the USFWS titled: *The use of Grass Carp (Ctenopharyngodon idella) in the United States: Production, triploid certification, shipping, regulation, and stocking recommendations for reducing spread throughout the United States*. The report proposes eight recommendations to establish a consistent national policy strategy for Grass Carp for the purpose of minimizing the risk of unintentional and illegal introductions of diploid and triploid Grass Carp. The fundamental recommendation to achieve a consistent national policy is for all states to prohibit the production, shipment, and stocking of diploid Grass Carp. The MICRA sponsored a symposium on the *Effects of Diploid Grass Carp and State Grass Carp Stocking Policies on Aquatic Ecosystems* to inform state agency discussions and consideration of the recommended consistent national policy strategy. Representatives from the aquaculture industry participating in the symposium expressed minimal concern and overall support for the recommended national policy strategy. Following the symposium, representatives from states that allow use of diploid Grass Carp met to discuss next steps for pursuing recommended regulation changes.

## 3.4 UPPER MISSISSIPPI RIVER BASIN-IWW/CAWS

### 3.4.1 INTERAGENCY COORDINATION

- **NATIONAL PLAN GOAL: Effectively plan, implement, and evaluate management and control efforts for Bighead, Black, Grass, and Silver Carp in the United States.**

Interagency coordination focused on implementing strategic actions in the IWW/CAWS for Great Lakes protection in 2016 was led by the ACRCC (Figure 11) and its technical and scientific sub-committee, the MRWG. The ACRCC continues to coordinate planning and execution of efforts by Federal and State agencies to prevent the introduction, establishment, and spread of Asian carp populations in the GLB. The ACRCC provided oversight and coordination of actions in the IWW/CAWS through its 2016 Asian Carp Action Plan (Action Plan) and the Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System (MRP). The 2016 Action Plan (http://www.asiancarp.us/documents/2016AsianCarpActionPlan.pdf) contains 56 projects focused on monitoring and early detection, control and removal, pathway mitigation, research and development of new tools and technologies, and other strategic actions. The MRWG developed the 2016 MRP (http://www.asiancarp.us/documents/MRP2016.pdf), directly supported by the broader 2016 Action Plan, to serve as the tactical plan to guide the strategic and scientifically-informed implementation of agency actions in the IWW/ CAWS. A more detailed summary of the 2016 MRP accomplishments and results is included in the MRWG's annual summary report (http://asiancarp.us/documents/MRP2016.pdf).

In addition, the USFWS, USACE, and USGS and other agencies participated in other coordinating bodies focused on Asian carp management, including the GLMRIS Executive Steering Committee and other advisory and technical work groups.

### 3.4.2 MONITORING, EARLY DETECTION AND RAPID RESPONSE

- **NATIONAL PLAN GOAL: Minimize potential adverse effects of feral Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

In 2016, the ILDNR, USFWS, USACE, USGS and other cooperating ACRCC agencies conducted a broad scope of monitoring activities for Asian carp of all life stages in the IWW, CAWS and adjoining waters. The efforts included:

- Seasonal Intensive Monitoring in the CAWS, consisting of two high-intensity monitoring events for Asian carp in the waterway above the EDB. Monitoring was conducted in the spring and fall, in areas with historic detections of Asian carp or Asian carp eDNA. Additional eDNA monitoring continued in the IWW/CAWS in strategic locations to provide information on the location of Asian carp

- Larval fish monitoring was conducted in the IWW to sample for Asian carp larvae and eggs. This effort continues to provide crucial information on the location of breeding populations, the conditions that trigger spawning, and current population fronts
- Monitoring for YOY and juvenile Asian carp, conducted as component of other sampling events, with gears targeted for small Asian carp. This project provided crucial information on Asian carp "population fronts", recruitment, and the conditions and habitat required for successful reproduction and establishment of self-sustaining populations
- Additional studies were conducted to evaluate the distribution and movement of small Asian carp in the IWW and to establish where young (larval to age-2) fish occur in the waterway. These studies used directed sampling with gears that target these specific life stages and monthly standardized monitoring at locations downstream of the EDB using electrofishing gear and commercial fishermen. Data from these efforts provides crucial information on the location of the Asian carp population front, population density, and specific habitats favored by Asian carp

**Asian Carp Telemetry Monitoring**

The USACE and its partners continue to implement a telemetry program in the upper IWW/CAWS, in which ultrasonic transmitters are used to track fish movement and behavior. Figure 12 shows the location of the stationary acoustic receivers that make up the acoustic network for this study. Asian carp were tagged in the Dresden Island and Marseilles Pools to determine the leading edge of the Asian carp population. Telemetry is also being used to test the effectiveness of the electronic barriers and other lock structures. For this study, surrogate species (i.e. common carp, buffalo spp.) were tagged at or near the Barrier in the Lockport Pool and monitored to determine the extent to which they challenged or crossed the barriers.

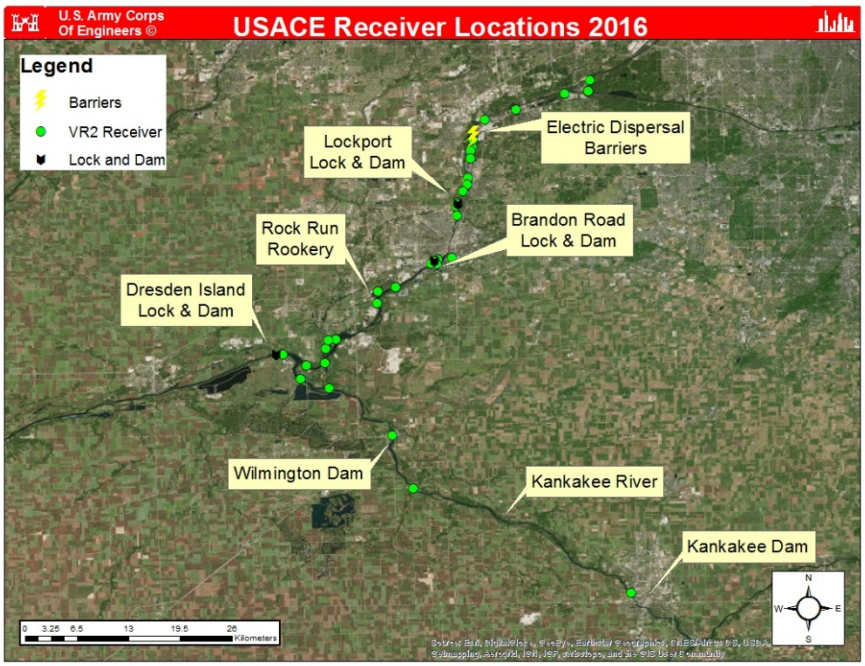


**Figure 12. 2016 USACE telemetry receiver locations**

The USFWS and its partners processed 27 Grass Carp captured within Dresden Island, Brandon Road, and Lockport pools for life history traits. In addition, six Grass Carp were implanted with acoustic telemetry tags in Dresden Island Pool and released. Grass Carp telemetry monitoring will continue in 2017. The USFWS also used telemetry to identify general characteristics of habitat utilized by juvenile Silver Carp (i.e., main channel, side channel, marina, backwater, tributary, and impoundment) and to determine whether temperature or flow is related to fish movement. A total of 75 Silver Carp were tagged in 2016 and released in the IWW near Henry, Illinois to gain additional information in order to target sampling and control efforts. This project will also continue in 2017.

**eDNA Monitoring**

In the 2016 reporting period the USFWS conducted eDNA monitoring in one comprehensive sampling event (240 samples taken) in the CAWS above the EDB. Of these, one sample was positive for both Bighead and Silver carp in the Calumet River. Below the EDB, eDNA sampling was conducted in April (225 samples) and September (225 samples) in the Lower Kankakee and Des Plaines rivers. Of these, one sample was positive for Silver carp in the Brandon Road Pool from the April sampling event. Results from 2016 reflect low baseline eDNA levels in sampled waters and is potentially a result of barges travelling upstream from Asian carp infested areas of the IWW. The likelihood of Asian carp eDNA occurring upstream as a result of maritime traffic is further indicated by the occasional presence of carcasses in Lockport Pool, likely moved upriver on transiting barges or other vessels.

**Traditional Gear Sampling**

As part of the ACRCC's Monitoring and Response Workgroup, the USFWS, USACE, USGS, ILDNR and partners monitored for Asian carp during the reporting period within the CAWS and its tributaries using netting, telemetry, and electrofishing. During the 2016 reporting period, State and Federal agencies coordinated efforts to sample five fixed locations and additional reaches in the CAWS for the presence of Asian carp and local fish populations. In addition to monitoring for Asian carp, these data were used to inform a fishery statistical-based model that will ultimately quantify the potential of Asian carp presence/absence and relative abundance. This effort is part of a larger CAWS monitoring program developed by the MRWG of the ACRCC. In addition, the USACE conducts monthly electrofishing surveys at the EDB, outside of the regular MRWG fixed-site monitoring activities.

In 2016, agency sampling of navigation pools in the upper IWW shifted upstream, focusing on the Brandon Road and Lockport pools. The USFWS performed over 90 hours of traditional electrofishing in Marseilles and Dresden Island pools and conducted seasonal hydroacoustic fish surveys of the Lockport, Brandon Road, and Dresden Island pools in the upper IWW during spring, summer, and fall. Fish densities were observed to increase through summer, increasing in July and peaking in August, whereas densities rapidly declined in the fall when water temperatures became colder. Data from these surveys provided critical information on fish density, age, size, location, and movement within the navigation pools and will be used to inform development of management actions. The USFWS also conducted hydroacoustic surveys adjacent to and within the Brandon Road Lock to determine the fish distribution within the lock chamber. Monitoring was conducted in the upper Illinois River for YOY Asian carp one week per month from May through October, 2016. Novel trawling methods (including Paupier and electrified dozer trawl) were utilized in the Starved Rock, Marseilles, and Dresden Island pools, and other targeted areas. Of the nearly 700 Silver Carp captured during these monitoring efforts, none were smaller than 6 inches in length. Additionally, the USFWS led efforts to monitor for Asian carp in the Upper Des Plaines River and overflow waters; no Silver or Bighead Carp were captured or observed during this effort.

**Development and Deployment of New Asian Carp Sampling Gear**
The USFWS, ILDNR, USACE, USGS and other partner agencies continue to develop, evaluate, and integrate novel sampling techniques and strategies for the detection, monitoring and removal of Asian carp in Midwestern waters. Activities conducted by partner agencies included:

- Evaluation of Gear Efficiency and Asian Carp Detectability - an assessment of the efficiency and detection probability of gears currently used for Asian carp monitoring (e.g., DC electrofishing, gill nets, and trammel nets) and other potential gears (e.g., mini-fyke nets, hoop nets, trap nets, seines, and cast nets) by evaluating capture efficiency of juvenile Asian carp at four sites in the Illinois River. These results will inform decisions on appropriate levels of sampling effort and monitoring regimes, and ultimately improve Asian carp monitoring and control efforts.
- Gear Evaluation for Removal and Monitoring of Asian Carp Species - an evaluation of new techniques for their ability to detect, monitor, and remove all sizes of Asian carp in varying habitats. Effective gears could be used in place of fish poison (e.g. rotenone) for removal actions in the CAWS, for commercial fishing in the lower Illinois River, and incorporation into Asian carp risk assessment and management plans. In 2016, this project focused on evaluating the effectiveness of novel trawling techniques for capturing different size classes of Asian carp.
- Unconventional Gear Development - which focused on developing effective, new trap, or netting methods capable of capturing low densities of Asian carp in the deep-draft canal and river habitats of the CAWS, lower Des Plaines River, upper Illinois River, and possible Great Lakes spawning rivers.

Additionally, the USFWS developed three trawling methods to target Asian carp: an electrified butterfly frame trawl (paupier), a surface trawl, and an electrified push frame trawl (dozer trawl). To determine if these gears are more effective than standard boat electrofishing, the four sampling techniques were simultaneously deployed in Illinois River backwaters, tributaries, and side channels June through October 2016. All techniques successfully sampled Silver Carp; with certain gears demonstrating higher success at sampling a wider range of size classes. These results will be used to help inform new sampling strategies and achieve a higher confidence in sampling efficiency and probability of Asian carp detection.

Progress continued in modifying traditional gears and techniques for mass removal of juvenile Asian carp in river settings. Continued evaluation and refinement is improving sampling and removal protocols used for the management and control of Asian carp. In 2016, the USFWS deployed a modified sampling vessel using new prototype gears to more effectively target Asian carp in specific riverine environments. These techniques have been developed for use in spring and fall seasons, when cooler water temperatures make electrofishing less effective. Agency monitoring of Asian carp using new and novel fishing techniques were employed in the upper pools of the Illinois River (Lockport, Brandon Road and Dresden Island) to capture adult Asian carp where they are not known to be established. One adult Asian carp was captured in Dresden Island Pool at RM 275. Sampling was also conducted in downstream pools, with 107 Asian carp captured in the Peoria Pool and 1,125 Asian carp captured in Marseilles and Starved Rock pools.

**Rapid Response**
Several groups and agencies including the MRWG, ILDNR, GLFC, USACE, USFWS, and USGS assisted development of the Upper Illinois Waterway Contingency Response Plan and participated in a

subsequent tabletop exercise to further develop the preparedness and capacity to rapidly respond to potential new detections of Asian carp in the upper IWW. Also, consistent with direction contained in the Explanatory Statement accompanying the Consolidated Appropriations Act for FY2016, the USACE developed formal emergency response procedures in consultation with the USFWS and ACRCC. In September 2016, the Secretary of the Army endorsed the final procedures that would be used to initiate a response action, authorized under Section 1039(c) of WRRDA 2014 or other applicable authorities, to prevent Asian carp from passing above the Brandon Road Lock and Dam. This process would be initiated in response to a request from the ACRCC, based upon an identified increase in risk of Asian carp transfer.

### 3.4.3 ACTIVE PREVENTION/CONTROL

- **NATIONAL PLAN GOAL: Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

- **NATIONAL PLAN GOAL: Extirpate, or reduce to levels of insignificant effect, feral populations of Bighead, Black, Grass, and Silver Carp in the United States.**

**Addressing Pathways**

The USACE continued ongoing operations of the EDB in the Chicago Sanitary and Ship Canal (CSSC) in Romeoville, IL. The EDB is designed to reduce the risk of transfer of fish between the Mississippi River to the Great Lakes drainage basins via the CSSC. The system currently consists of three barriers (Demonstration, IIA, and IIB, Figure 13) that create a waterborne, pulsed, direct current, electric field in the canal, which expose fish penetrating the electric field to electrical stimuli that act as a deterrent. As fish swim into the field, they are either immobilized or deterred from progressing farther into the field. Although the barriers were placed into service prior to the 2016 reporting period, the USACE continues to operate and maintain them as an integral part of its strategy to prevent movement of Asian carp toward the Great Lakes.

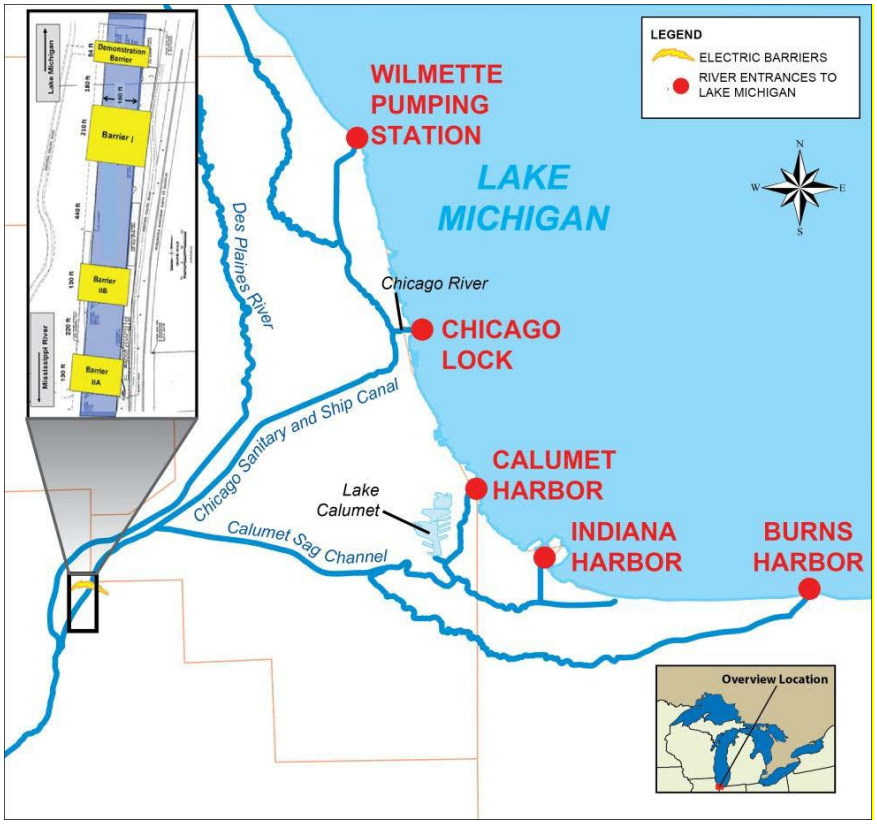


**Figure 13. Electrical dispersal barrier location map**

During the 2016 reporting period, the USACE also continued the GLMRIS –Brandon Road Study to complete the expert elicitation of multiple control measures; compiled research data and other pertinent information from Federal and State agencies to aide in the development of the Environmental Impact Statement and the Tentatively Selected Plan; collaborated on development of recommendations with key agency partners including the USFWS, USEPA, USCG and NOAA; coordinated development of the Draft Fish and Wildlife Coordination Act Report with the USFWS; coordinated with Great Lakes States and Canada on ANS response planning to aid development of the "Future Without Project" conditions assessment; performed economic analysis and assessments; evaluated impacts on Great Lakes resources from ANS establishment (Economic, Environmental/Political Social); coordinated with the navigation industry to obtain information on safety concerns and develop potential alternatives; and engaged other stakeholders to provide study status updates and receive feedback, completed designs, and cost analysis.

The USGS, in collaboration with the USACE, conducted field and laboratory evaluations and trials to support development of new deterrent technologies for potential deployment at the Brandon Road Lock and Dam or other possible control points. These evaluations include studies of carbon dioxide, hot water, and ozone for use as control technologies and include field testing and research related to the efficacy, implementation, and impacts of the use of carbon dioxide as a non-physical chemical barrier to deter the movement of Asian carp. Additionally, the USGS initiated testing of the use of underwater complex sound as potential deterrent to Asian carp, considering factors such as mechanical configuration, operation, and, short- and long-term response of fish to sounds and the potential impacts to native fish and mussel species.

The USACE maintained the Des Plaines River Bypass Barrier, a 13-mile long combination of fence material and jersey barrier that physically blocks known bypasses around the electric barriers that occur during periods of flooding from the Des Plaines River and the Illinois and Michigan (I&M) Canal. This barrier was placed at this location to prevent movement of juvenile and adult Asian carp. The USACE also provided technical support to the Natural Resource Conservation Service on construction-related changes related to the Eagle Marsh interbasin separation berm. This included monitoring flood conditions at Eagle Marsh that may form temporary hydrologic connections between the ORB and GLB.

The USFWS conducted multiple sonar observations of the movement and behavior of wild fish at the USACE's EDB. Direct observations of the behavior of fish in the vicinity of the EDB system were made using two DIDSON multi-beam sonar systems deployed directly over the narrow electrical array of Barrier IIB (area of ultimate field strength), concurrent with barge entrainment trials. Results provided a better understanding of the actual behavior exhibited by fish when confronted with the electrical fields of the barrier system under "real world" settings, including the passage of barge tows.

The USACE, USFWS, ILDNR, and others implemented a Barrier Maintenance Fish Suppression protocol for use during routine or unplanned maintenance operations, as required, to ensure ongoing and effective operation at the EDB. This protocol gives the USACE the ability to safely power down barrier arrays for service without increasing the risk of Asian carp upstream passage. The protocol includes sampling to detect Asian carp downstream of the barriers prior to turning off power, surveillance of the barrier zone with hydroacoustics, side-scan sonar, and DIDSON sonar during maintenance operations, and operations to clear fish between barriers using mechanical or chemical means.

The USFWS, in partnership with the USGS and USACE, conducted barge entrainment studies in the IWW to further evaluate potential barge entrainment, retention, and transport dynamic for wild fish. This study also evaluated the upper size ranges of fish that may be entrained and transported by barge traffic, non-entrainment related pathways for inadvertent fish passage at the EDB concurrent with barge passage (return currents/electrical sagging), and potential mitigation techniques and vessel operational protocols for discouraging barge entrainment and transport of fish. The USACE and partners conducted laboratory investigations of mitigation techniques to minimize potential barge entrainment of fish and other organisms. The purpose of the study was to develop and test methodologies to dislodge and remove fish from the recesses between barges and vessel-induced eddies using submerged water jets and other technologies, reducing the potential for upstream movement.

The ILDNR, USFWS, USACE, and other cooperators conducted the Des Plaines River and Overflow Monitoring project, which included periodic monitoring for Asian carp presence and spawning activity in the upper Des Plaines River. In a second component, efficacy of the Des Plaines Bypass Barrier constructed between the Des Plaines River and CSSC was assessed by monitoring for Asian carp juveniles that may be transported to the CSSC via laterally flowing Des Plaines River floodwaters passing through the barrier fence.

**Asian Carp Capture and Removal**

The ILDNR, USFWS, USACE, partner MRWG agencies, and commercial fishers conducted actions to support the efficacy of the EDB that serve as a defense against the advancement of Asian carp in the CAWS. These actions include:

- Barrier Defense Asian Carp Removal Project – This program was established to reduce the numbers of Asian carp downstream of the EDB through controlled commercial fishing. The intent of the project is to reduce the propagule pressure on the EDB by reducing Asian carp populations in Dresden Island, Marseilles, and Starved Rock pools though targeted and intensive harvest of adult fish. To date, over 5 million pounds of Asian carp have been harvested and removed through this effort, with significant declines noted in the estimated density of Asian carp in navigation pools along the leading edge of established populations in the IWW (notably the Dresden Island Pool); 1.2M pounds harvested in 2016 alone
- Unified Fishing Method – In this project, the ILDNR and ACRCC agency partners and commercial fishers utilized the "unified fishing method", a traditional Chinese technique for the harvest of Asian carp. Using this technique, over 96,000 pounds of Asian carp was removed from a backwater lake on the upper Illinois River near Morris, IL over a period of two weeks. This method will continue to be deployed, where conditions are appropriate, for removal of Asian carp

The ILDNR Urban Fishing Program conducted surveys at eight urban fishing ponds in the Chicago Metropolitan area where positive eDNA detections for Asian carp were detected. Conventional gears (electrofishing and trammel/gill nets) were used to remove stocked Bighead or Silver Carp and prevent transport of fish from these ponds to the CAWS or Lake Michigan.

### 3.4.4 RESEARCH AND DEVELOPMENT

- **NATIONAL PLAN GOAL: Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

**Development of New Deterrent Technologies**
The USACE conducted field and laboratory research to assess the efficacy of the electric barriers and to improve their effectiveness. These projects included assessment of various environmental conditions on barrier effectiveness and fish behavior as well as laboratory tests to confirm barrier optimal operating parameters by examining factors such as variations in canal water temperature and dissolved oxygen levels. The USACE also conducted tests that exposed fish to the electrical field for longer durations of time to determine if the fish become less affected by the field over time. Additional studies included laboratory research related to the efficacy, implementation, and impacts of the use of carbon dioxide as a non-physical chemical barrier to deter the movement of Asian carp.

The USGS continued to develop and refine the microparticle piscicide (fish toxicant) that has demonstrated high toxicity and selectivity toward Asian carp. Additional work was conducted to integrate the use of fish feeding attractants with microparticle delivery to increase the amount of consumption of the microparticles by Asian carp.

**Asian Carp Biology, Life History and Reproduction Evaluations**
The USFWS analyzed feral Grass Carp populations in the CAWS and Upper Illinois River to better understand population status and movement in these waters. Grass Carp collected during sampling efforts were processed for life history traits. Eyeballs or blood samples were sent to the USFWS La Crosse Midwest Fisheries Center in Lacrosse, Wisconsin to analyze ploidy. Otoliths, vertebrae, and

gonads were sent to the USGS CERC to determine age, life history (i.e., where reared), reproductive status, and other factors.

Additional research conducted by the USGS and their partners for Asian carp prevention and control is described in detail in Section 4.0: RESEARCH AND TECHNOLOGIES POTENTIALLY USEFUL FOR CONTROLLING THE SPREAD OF ASIAN CARP.

### 3.4.5 OUTREACH WITH INDUSTRY, STAKEHOLDERS AND THE PUBLIC

- **NATIONAL PLAN GOAL: Provide information to the public, commercial entities, and government agencies to improve effective management and control of Bighead, Black, Grass, and Silver Carp in the United States.**

**AsianCarp.us Website**
The USFWS continued to support and administer the national Asian carp website (*www.AsianCarp.us*) as the primary platform for delivering updates on accomplishments, science, and other products related to Asian carp management. The website houses the current interagency documents on Asian carp management, including all iterations of the WRRDA Report to Congress, ACRCC Action Plans and related strategies, and the National Asian Carp Management Plan. In 2017, the website will be re-designed to include specific content on Asian carp news and developments; additional content is being developed by the multi-agency Communication Workgroup to share ACRCC findings and updates. In collaboration with Canadian ACRCC partners, The Invasive Species Centre developed a complementary web site - *www.asiancarp.ca* - that provides a Canadian perspective on the Asian carp issue.

**Public/Stakeholder Engagement**
The ACRCC member agencies provided periodic briefings to Congress and others on key issues related to Asian carp management in the IWW / CAWS. The USACE employed a comprehensive public engagement strategy for AIS recommendations and actions related to the GLMRIS Report. This strategy consisted of focused briefings, stakeholder conference calls, media events, social media, and project websites.

**Industry Engagement**
The USFWS, USACE, USGS, ILDNR and cooperating agencies participated in the following organized stakeholder groups:

- Technical and Policy Workgroup consisting of academia and non-governmental organizations interested in technical and policy issues relating to the design and operation of the USACE's EDBs
- CAWS Advisory Committee comprised of more than two dozen stakeholder organizations that have expressed an interest in preventing AIS transfer into the Great Lakes, especially Asian carp
- The USACE participated in the Barrier Navigation Task Force consisting of representatives of the navigation industry interested in research on the efficacy of the electric barriers

### 3.4.6 LAW ENFORCEMENT/REGULATORY

- **NATIONAL PLAN GOAL: Prevent accidental and deliberate unauthorized introductions of Bighead, Black, Grass, and Silver Carp in the United States.**

Federal and State agencies continued to coordinate closely on enforcement of the Lacey Act and other Federal and State statutes. Additionally, ILDNR Law Enforcement conducted an Alternative Pathway Surveillance program, increasing education and enforcement activities at bait shops, bait and sport fish production/distribution facilities, fish processors, and fish markets/food establishments known to have a preference for live fish for release or food preparation.

## 4.0 RESEARCH AND TECHNOLOGIES POTENTIALLY USEFUL FOR CONTROLLING THE SPREAD OF ASIAN CARP

Agency and non-governmental partners are conducting critical research to support the development and implementation of potential new technologies for use in Asian carp management strategies in the UMRB and ORB. Federal efforts are led primarily by the USGS, with additional research conducted by the USACE and USFWS. State and Provincial agencies and universities are also conducting key research, adding to the scope of complementary projects currently underway. In 2016, research and development efforts included:

- Early Detection and Monitoring
- Life History/Behavior
- Feeding Ecology
- Prevention
- Control
- Analysis of alternative pathways
- Risk assessment
- Integrated Pest Management Strategies

Research currently being conducted, and highlighted below, has been developed to target potential control opportunities based on known Asian carp life-history vulnerabilities and unique behavioral characteristics. Individual projects being conducted by the USGS for Asian carp management are described in further detail in Appendix 2. Additional research conducted by other Federal and State agencies is described in the ORB, UMRB, and GLB sections of this Report.

As potential new tools are investigated and developed for Asian carp control, research must also consider potential negative impacts to non-target aquatic species, in particular depleted or imperiled State or Federally-listed fish and mussels. As a result, several control tools currently being developed are highly-specific to Asian carp species (primarily Bighead and Silver Carp) to avoid impacts to non-target native aquatic species. Prevention actions that are more general and not selective for Asian carp (e.g. sound carbon dioxide, or bubble barriers to fish movement) are designed to be deployed in a manner to deter fish movement while not being lethal. Research includes the following:

- Underwater Sound Technology to alter behavior of Asian carp: In previous lab and pond tests, scientists found that Bighead and Silver Carp reacted strongly to complex noises such as underwater recordings of boat motors. In 2016, the USGS conducted additional field testing in a backwater area of the Illinois River, where a simulated lock chamber (concrete wall panel) was designed to see how sound waves were affected by structures and to determine potential structural effects. Scientists are also testing different sound broadcasting configurations to achieve the most focused, targeted application.

- Portable hand-held eDNA detection device: The USGS transferred ten portable hand held rapid genetic detection kits to law enforcement officers in Ohio, Michigan and Illinois in 2016. These devices can be used to detect eDNA of Bighead and Silver Carp in water samples and used to look for Asian carp in bait tanks at bait shops. Using the hand-held kit significantly reduces the time between sample collection and results compared to typical laboratory-based analysis which generally require several days to obtain.

- Fluvial Egg Drift Simulator (FluEgg): This model is used to predict likely Asian carp spawning locations and where conditions exist that would allow eggs and larval fish to survive until they can find nursery habitat. FluEgg could also be used to assess risk of establishment of new spawning populations and evaluation of possible control measures. In 2016, scientists incorporated successful recruitment criteria (e.g. available juvenile habitat, etc.) with existing egg transport characterization methods to determine which rivers may pose a greater probability for the establishment of sustainable populations of Asian carp in the GLB.

- Carbon Dioxide as a barrier: Two papers were published in 2016 (links in appendix 2) on the results of the largescale carbon dioxide field trials conducted in 2015 to evaluate the application of this chemical deterrent into an area comparable to the approach channel at Brandon Road Lock and Dam in the Illinois River. Methods to inject carbon dioxide into the water were tested and a pressurized system was identified as most effective and efficient for fixed deployment. Scientists also identified minimum/maximum concentrations for use of carbon dioxide as a barrier.

- Integrated Pest Management (IPM) strategies: IPM strategies have also been developed and continue to be refined for use at selected sites for Asian carp management. These strategies provide a more comprehensive and robust approach to Asian carp management by exploiting multiple opportunities for control (such as feeding ecology, swimming behavior, sound/ carbon dioxide avoidance) by concurrently or sequentially implementing specific tools in a complementary manner. Ultimately, the strategic and effective implementation of both individual control tools and comprehensive IPM strategies within priority locations of the UMRB and ORB are informed by available data on Asian carp population status.

    - Since 2013, the USGS has been conducting research on Asian carp life-history characteristics to identify vulnerabilities in established and emerging Asian carp populations. These studies are designed to identify places and times when Asian carp may be vulnerable to targeted control efforts as part of an IPM system. These efforts broadly fall into three primary categories: (1) identifying Asian carp recruitment constraints; (2) identifying habitat use; and (3) identifying food selection. This information is also used to enhance the FluEgg model described above. Another aspect of this work is coordination and development of real time telemetry efforts and related visualization tools. In 2016, real time telemetry technology was placed in strategic locations to inform Asian carp removal (e.g. contract fishing) and potential rapid response efforts.
    - The USGS has led and organized an interagency collaborative between USFWS, Iowa State University, and the MNDNR to identify recruitment constraints by collecting ichthyoplankton samples from more than 20 locations stretching from the confluence of the Des Moines and Mississippi Rivers to Lacrosse, Wisconsin. This network of sites will allow

identification of the approximate locations where Asian carp reproduction occurs in this emerging population, the environmental conditions that lead to successful spawning activity, and whether spawning may be an opportunity to target Asian carp with control measures. Other work on recruitment constraints has focused on evaluating whether natural predators and habitat availability might constrain larval and juvenile survival. Thus far, this work has confirmed reproduction of Asian carp in the Mississippi River above Keokuk, Iowa, but found that previously established methods for identifying Asian carp eggs and larvae are insufficient to establish identity (thus necessitating the use of genetic methods).

- A key IPM method is the use of microparticles as a delivery mechanism for toxins. To develop a microparticle that would be targeted and eaten by Bighead and Silver Carp, the USGS conducted extensive studies over the past few years and identified the appropriate size particle, the digestive processes for determining how the microparticle would dissolve to release the toxin into the fish, and developed a particle that holds the toxin without leaching during application. Testing has been done in the lab and in study ponds. Potential sites in Missouri have been identified for initial field deployment of microparticles in collaboration with the USFWS, Illinois DNR, and other partners. The required permitting and registration processes for use of the microparticle are in progress, led by the USGS, USFWS and USEPA.

Appendix 1 provides a summary of completed or ongoing research being undertaken in 2016 by the USGS and USFWS, with the assistance of other Federal, State, and research institutions that focus on prevention and control of Asian carp in U.S. waters. This information complements the summary of research projects that were identified in other sections of the 2015 Report.

## 5.0 METRICS AND METHODOLOGIES FOR EVALUATING SUCCESS OF ACTIONS TO CONTROL THE SPREAD OF ASIAN CARP

WRRDA directed the USFWS to identify quantitative measures for use in documenting collective progress in controlling spread of Asian carp. The 2015 Report identified: 1) Short-term Actions to Address the Need for Interagency Coordination, 2) Quantitative Measures of Progress and 3) Qualitative Measures of Progress for collaborative Asian carp management and control in the ORB and UMRB. Progress to date in each of these areas is reported below with current accomplishments through 2016.

### 5.1 Short-term Actions to Address the Need for Interagency Coordination

- Development of interagency UMRB, ORB and other basin-specific Asian carp control strategies that complement the National Plan while addressing the management needs of each basin.
  - The ACRCC MWRG developed the 2016 Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System. This interagency strategy, updated annually by the MRWG, directs the strategic development and implementation of key early detection, response, control and prevention projects in the upper IWW and CAWS in support of the ACRCC's mission of Great Lakes protection from Asian carp. Primary agencies include ILDNR, USFWS, COE, USGS, USEPA, Illinois Natural History Survey, and the Great Lakes Fishery Commission. In 2016, it included the addition of new interagency contingency response plans developed specifically to guide potential coordinated rapid-response actions in the event of new

detections of Asian carp of all life stages (adult, juveniles, larvae, or eggs) in upstream navigation pools and other select locations of the upper IWW and CAWS.

- Integrating the individual basin efforts into a cohesive national strategy is desirable to promote efficacy and efficiency of management actions, support information sharing on best-practices and lessons-learned, and to prevent duplication of effort. Incorporating basin-specific Asian carp control strategies into a national approach will also help identify gaps in science and data in Asian carp management and provide a foundation for collectively developing priority initiatives to benefit multiple basin-wide partnerships.

  - In 2014, the ORFMT released the Ohio River Basin Asian Carp Control Strategy Framework. This Framework outlines actions for prevention, monitoring and response, population control, understanding impacts, and communication to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carp. Implementing the Control Strategy Framework is intended to minimize the social, ecological, and economic impacts of these invasive fishes.
  - The UMRB partners continued to develop and refine the draft Upper Mississippi River Basin Asian Carp Control Strategy Framework. A final version will be completed in 2017.

- Identification of Federal and State resources potentially available for implementing control strategies and actions.

  - The USFWS has worked extensively with the UMRB and ORB states and other Federal agencies to identify resources potentially available for implementing control actions and to leverage those resources where feasible. Limitations in State agency budgets have not allowed some states to significantly supplement Federal funding; however, states that received additional USFWS funding for Asian carp projects in conjunction with their ANSTF approved State ANS management plans provided at least a 25% match for these funds. State staff have also dedicated significant hours to planning and executing Asian carp control projects. In addition, numerous states are evaluating the need for increased funding and are considering increasing fees and other innovative methods to leverage funding.

- Development of ORB/UMRB formal institutional arrangements, using a collaborative model similar to the ACRCC, to facilitate interagency coordination, collaboration, and plan implementation. The ORFMT and UMRCC adopted an agency coordination model utilizing MICRA to provide recommendations for highest priority Asian carp project needs in the ORB and UMRB, with the USFWS making final funding decisions. State representatives from both sub-basins recommended that the USFWS work through MICRA for executive-level Asian carp coordination and multistate project planning and implementation in the Mississippi River Basin. The sub-basin partnerships identified potential inter-agency management structures for coordinated planning and reporting, development of funding strategies, and implementation of actionable plans. Development of an agreement to identify roles and responsibilities of all participating agencies.
  - More formal agreements such as memorandum of understanding or operation principles will be pursued in future years, if deemed necessary.

- Development of an annual project plan with management structure and appropriate funding.
  - MICRA, ORFMT, and UMRCC adopted annual project plans for 2016; whereas ORFMT and UMRB fish managers are currently developing 2017 project plans. With the organizational arrangement through MICRA, development of an annual project plan has been assured. Additionally, the ACRCC developed an annual project plan for the IWW/CAWS focused on implementation of its Great Lakes protection strategy.

- Development of a process to ensure actions are strategically prioritized and properly sequenced.
  - The USFWS has worked extensively with the UMRB and ORB states, MICRA, and other Federal agencies to ensure that individual activities proposed for Asian carp management and control are strategically prioritized and properly sequenced. This action will continue annually.

- Preparation of an annual report measuring success and identifying the strategy for moving forward, including identification of costs for future actions.
  - The USFWS, through this Report, has developed an annual report to measure progress and to identify successes and strategies for moving forward. The USFWS will continue to provide leadership in coordinating this effort on behalf of the Federal agencies (as prescribed in WRRDA) with assistance from other State and Federal agencies, non-governmental organizations, and local entities.

## 5.2 Quantitative Measure of Progress

The following quantitative measures of progress are identified to evaluate Asian carp control progress.

- Changes in movement in the current verified adult Asian carp population front in both the UMRB and ORB and their tributaries.
  - In the 2016 reporting period, the documented range expansion was from a single adult Silver Carp collected at RM 280 of the Ohio River, approximately 64 miles upriver from a prior collection near Wheelersburg, Ohio. There was also a range expansion of Bighead Carp and Grass Carp into the Minnesota River, 103 miles from previous capture locations in the Upper Mississippi River. Although Black Carp did not expand their range, the significant amount of captures in 2016 exceeds cumulative captures from previous years and may be indicative of population growth.

- Changes in numbers or range of current verified spawning areas in the rivers and tributaries.
  - Sampling for Asian carp larval and juvenile stages increased in 2016. Generally, Grass Carp juvenile captures and spawning observations are underreported and this is starting to be addressed. Compared to 2015 data, evidence of Silver Carp spawning was recorded one pool upstream in the UMRB and two pools upstream in the ORB. There was no change in Bighead Carp spawning patterns in the UMRB, but there was evidence of spawning farther upstream than in last year's report for the ORB. Black Carp reproduction was noted for the first time in North America and continues to be sampled in 2016.

- Changes in eDNA positive findings within areas upstream of the known adult population front.
  - 7,639 water samples were collected in 2016 and processed for the presence of Bighead and Silver Carp eDNA as part of the USFWS-led eDNA Surveillance Program. Samples were also collected from Great Lakes tributaries (4,583), the UMR (1,308), CAWS (240), Ohio and

Tennessee Rivers (1,230), and Illinois Waterway (248). The only positive detections for Bighead and Silver Carp eDNA were in the CAWS, where one sample yielded a positive detection for both Bighead and Silver Carp eDNA. Figure 14 depicts the map of all samples collected in 2016.

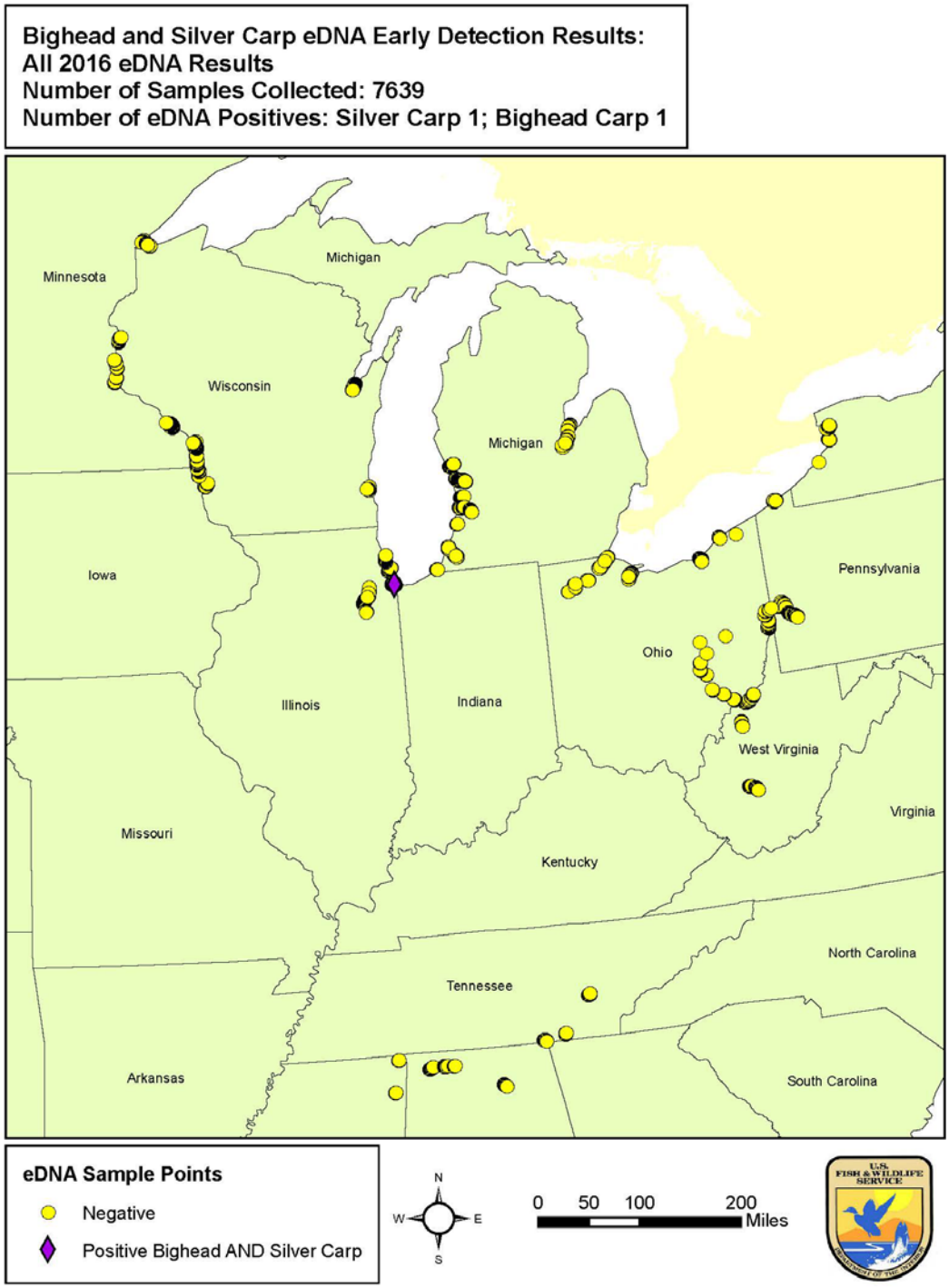


**Figure 14. Overview of all 2016 eDNA sampling sites and results**

- Miles of streams excluded or protected from Asian carp movement.
  - No streams have been excluded or protected from Asian carp movement during the 2016 reporting period. Potential candidate streams for exclusion areas are currently being evaluated by cooperating agencies.

- Number of stream miles assessed for presence of Asian carp.
  - The ORB and UMRB State and Federal agencies do not track the number of stream miles currently assessed for presence of Asian carp. This information will be supplemented in future versions of this report.

- Number of control technologies proven to control or eradicate Asian carp that are ready for in-the-field use.
  - The ACRCC's Monitoring and Response Work Group is working collaboratively with both UMRB and ORB states to evaluate and implement new monitoring technologies.

- The following technologies are being evaluated for potential pilot deployment in the field:
  - Underwater Sound Technology to alter behavior of Asian carp: In laboratory and pond tests, scientists found that Bighead and Silver Carp reacted strongly to complex noises transmitted underwater. In 2015, field trials were conducted in 2015 and additional analysis is ongoing to inform study designs and potential pilot trials that were implemented in 2016. Also in 2016, the USGS, USFWS, USACE, KDFWR, and MNDNR organized a Sound Deterrent Workshop Coordination and Planning meeting for researchers and natural resource managers. The information presented and developed at this meeting informed future testing of sound as a barrier to Asian carp movement. The USGS co-led a multi-basin workshop in 2016 on the state-of-the-science and the steps needed to use complex sound as a deterrent in lock approaches at lock and dams in the UMRB and ORB. Field trials began in 2016 in the ORB and UMRB to use sound to herd Asian carp as part of removal efforts.

  - Portable hand-held eDNA detection device**:** In 2015, USGS validated a commercially-available genetic tool (hand-held sampling kit) to detect the eDNA of Asian carp. The kits were tested by agency conservation officers, successfully allowing them to detect the presence of a single small Silver Carp in a batch of over 10,000 Fathead minnows (a common baitfish in trade in the United States) held in a fish transport tank under simulated industry transport conditions. This tool will support the ability to manage potential accidental transport of Asian carp to new waters through bait transport vectors. In 2016, additional hand-held kits were made available to state law enforcement agencies.

  - FluEgg: In 2015, Grass Carp egg and larval data were incorporated into this scientific model to predict the suitability of rivers for Grass Carp reproduction and recruitment. The FluEgg model will be used to predict likely Asian carp spawning locations as well as conditions that would allow eggs and larval fish to survive until they can find suitable nursery habitat. FluEgg could also be used to assess risk of establishment of new spawning populations and evaluate possible control measures. The FluEgg model was used to analyze the likelihood of spawning success in the Muskingum River in 2016, with results to be published in 2017.

- **Carbon dioxide as a barrier:** Large-scale field trials were completed in 2015 to evaluate the application of carbon dioxide into waters in navigation approach channels or other navigation structures (e.g. locks) as a non-physical barrier chemical to deter the movement of Asian carp. Initial results indicate that Asian carp did not cross a carbon dioxide barrier at peak concentrations. The USGS is evaluating how fish interact with a carbon dioxide gradient to determine optimal exposure conditions (minimum levels required for Asian carp dispersal), and are working with partners to determine better methods to deliver carbon dioxide. Laboratory research by the USACE is currently on-going to determine the efficacy, implementation processes, and impacts of the use of carbon dioxide on USACE infrastructures. Also, as a deterrent, carbon dioxide must be evaluated for its environmental impacts on species of concern to help meet the requirements of the Endangered Species Act (ESA) (Section 7 consultation). Carbon dioxide as a lethal control tool must undergo a rigorous registration process before it may be used within IPM control programs of federal or state natural resource agencies. Currently, the USFWS and USGS are working to (1)provide regulatory affairs support for the use of carbon dioxide as a deterrent to control Asian carp and (2) develop registration-specific data to support the registration of carbon dioxide as a lethal pesticide control. In addition, the USGS, with state and federal partners, is developing comprehensive planning assessments for deploying carbon dioxide at a lock or approach channel to deter Asian carp movement and will be conducting field studies to demonstrate potential management applications, such as:

    - Application of carbon dioxide to block Asian carp access to backwater areas of the Illinois River
    - Application of carbon dioxide to enhance Asian carp removal efforts
    - Application of carbon dioxide as lethal control of Asian carp under-ice in backwaters of large rivers

- Number of agencies with model regulations or ordinances focused on Asian carp prevention in place.
  - No new regulations or ordinances have been developed during this reporting period.

## 5.3 Qualitative Measures of Progress

The following qualitative measures of progress are identified to evaluate Asian carp control progress.

- Monitoring and assessment of Asian carp – This effort includes establishment of a long-term, comprehensive, cooperative monitoring and assessment program within each basin.
  - MNDNR is leading an effort to develop and implement a comprehensive surveillance program to define presence, invasion, and established fronts in UMR. Participating with MNDNR on this effort are ILDNR, Western Illinois University, and IA DNR. In the ORB, the USFWS is partnering with KDFWR, WVDNR, Purdue University, and ODNR, in assessing the distribution, movement, and lock and dam passage of Asian carp through the use of telemetry. The Kentucky DNR (KDNR), Pennsylvania Fish and Boat Commission, ILDNR, INDNR, ODNR, and New York State Department of Environmental Conservation (NYDEC) will be working with WVDNR on this effort. In the upper Illinois River and CAWS, the multiagency Monitoring and Response Work Group of the ACRCC annually develops and implements its Monitoring and Response Plan that includes

monitoring of Asian carp populations (determining status of adult population front and presence of all life stages).

- Preventing the introduction and movement of Asian carp via identified pathways – This effort includes establishment of strategies to manage pathways for accidental or deliberate unauthorized introductions of Asian carp.
  - In the UMRB, the ILDNR along with Western Illinois University will be undertaking contract fishing to reduce propagule pressure in Pool 20; reducing populations in pools 19-17; and characterizing adult Asian carp catches in pools 16-13. Participating with ILDNR-WIU are MoDEC and IADNR. In the ORB, the KDFWR and WVDNR will also be undertaking efforts to control and remove Asian carp. In Illinois, ILDNR conservation police officers employ surveillance to prevent the intentional or unintentional movement of AIS and work collaboratively with Federal and regional State agencies.

- Rapid response planning – Rapid response plans available to prevent range expansions and eradicate new introductions in both basins are necessary.
  - Each State develops response actions or plans as deemed necessary.

- Collaborative research – Currently, the necessary tools are not available to ensure complete control of Asian carp.
  - While Illinois has seen reductions of Asian carp populations in the Upper Illinois Waterway through contract harvesting activities, additional collaborative efforts to conduct research that will yield accurate and scientifically valid information are necessary for effective management and control of Asian carp in the U.S. Continuation of current research efforts and research into new tools and control methods are critical for developing and assisting implementation of control technologies and assessment of methods for population reduction.

  - Federal and State agencies are working collaboratively to develop and evaluate potential control technologies, with the goal of field trial implementation and, where feasible, long-term installation. In addition, many states are working with local universities to address research needs in the UMRB and ORB. For example, Ball State University is evaluating the impact of Asian carp on native fishes in the Wabash River. The USGS is working collaboratively with other agencies to identify additional barriers, technologies, and deterrents for evaluation of the effectiveness in many locations in the UMRB and the ORB.

  - The ACRCC's Monitoring and Response Work Group is working collaboratively with both UMRB and ORB states to evaluate and implement new monitoring technologies. In addition to advances in technical research and development, interagency meetings were convened to address site selection for potential implementation as well as environmental regulations and permitting requirements for field implementation of specific control techniques, including Carbon dioxide. Work is being conducted to address the requirements concurrent to the ongoing research to refine and complete necessary research in advance of deployment.

- Develop strategies to minimize adverse effects – The 2014 Report identified a key component of an overall strategy to control Asian carp as the establishment of collaborative strategies to eradicate or minimize potential adverse effects. Identifying interim solutions can play a key role in minimizing impacts of Asian carp within some areas.

- In the UMRB, the MNDNR will be evaluating Asian carp and native fish passage at Lock and Dam 8 and Lock and Dam 19. Participating with MNDNR are MoDCE and IADNR. In the ORB, KDNR will be evaluating efforts to limit Asian carp dispersal at lock and dams. The WVDNR, USACE, USGS, and USFWS will be participating with KDNR on this effort.

- Information and education – Information and education is essential to long-term success in controlling Asian carp. A critical measure of success is establishing strategies to provide information to the public, commercial entities, and government agencies to improve effective management and control of Asian carp in the ORB and the UMRB.
  - In the ORB, Kentucky has taken the lead on an Asian carp communication, coordination, and outreach efforts. Pennsylvania Fish and Boat Commission, ILDNR, INDNR, ODNR, WVDNR, and NYDEC will be assisting with this effort. In addition, many states have developed informational signs at boat ramps to help anglers identify Asian carp and avoid accidental transport and introduction to new waters. Furthermore, bait shop minnow information campaigns encourage anglers to be vigilant for Asian carp minnows.

- Effective regulations and laws – A long-term strategy for both the UMRB and the ORB includes development of an effective system of compatible laws and regulation, both at the Federal and State levels.
  - Close coordination continued between Federal and State agencies in support of enforcement of the Lacey Act and other laws and authorities regulating Asian carp. Additionally, MICRA had previously completed a review of commercial grass carp production, certification, shipping, stocking and regulation in the U.S. The final report contains eight recommendations from MICRA to improve grass carp regulation, with the goal of preventing the illegal or unintentional release of grass carps into the Great Lakes and other U.S. waters. Through the reporting timeframe, the report was used to inform subsequent discussions on the need for consistent State grass carp regulations, and a broader comprehensive policy strategy to effectively minimize the risks of additional fertile and sterile grass carp introductions in the Great Lakes. No new federal regulations or laws for Asian carp regulation or management were promulgated or enacted during the reporting timeframe.

- Ensuring sufficient resources are available – As identified in the previous Reports to Congress, adequate resources are critical for successful implementation of any strategy. Sufficient financial resources must be available to Federal, State, and local agencies to address the long-term issue of controlling and reducing risk from Asian carp in both basins.
  - The USFWS has received additional agency funding for efforts outside of the Great Lakes, including the UMRB and the ORB. These resources, along with other State and Federal resources are being leveraged to support current activities.

# 6.0 CROSS-CUT SUMMARY OF FEDERAL AND NON-FEDERAL EXPENDITURES IN THE UPPER MISSISSIPPI AND OHIO RIVER BASINS

This cross-cut summary includes an overview of FY 2016 expenditures directly related to Asian carp management activities conducted by Federal and State agencies in the UMRB, ORB, and IWW/CAWS. In the UMRB and ORB, agencies reported a total of $58,954,512 expended on actions to address Asian carp, of which $55,203,807 was used for actions in the IWW/CAWS to protect the Great Lakes from Asian carp. The total expenditures on activities conducted to benefit the ORB and UMRB and tributaries was $3,750,705. An additional $3,340,791 was reported by agencies for work to address GLMRIS Secondary Pathways, temporary hydrologic connections that form between the ORB and GLB during high water and flooding events. However, similar to the IWW/CAWS, these efforts are focused primarily on protecting the Great Lakes from the movement of Asian carp and are not within the geographic delineated boundaries of the UMRB or ORB; accordingly, funds associated with these activities are excluded from the total expenditure figure calculated for the purposes of this Report.

Agencies were queried for an accounting of all Asian carp-related expenditures recorded during their respective FY 2016 for activities related to the following:

- Interagency Coordination (e.g. Strategy Development, Committee Participation)
- Field Monitoring and Early Detection
- Active Prevention/Control (including Physical Removal, Implementation/Operation of Barriers, and Rapid Response)
- Research and Development
- Law Enforcement/Regulatory Actions
- Outreach with Industry, Stakeholders, and the Public

Table 1 provides a summary of expenditures by individual agency and funding source.
Columns in the table are identified as follows:

- Total Agency Great Lakes Restoration Initiative (GLRI) Expenditures: Total reported expenditures of GLRI funds for all activities in support of IWW/CAWS Asian carp management.
- Total Agency Base Expenditures: Total reported expenditures of agency base funds for all activities in support of UMRB, ORB, and IWW/CAWS Asian carp management.
- Total Reported Expenditures: Total reported expenditures of agency base, GLRI, or other funds for all activities in support of UMRB, ORB, and IWW/CAWS Asian carp management.
- Total UMRB/ORB (w/o IWW/CAWS) Expenditures: Total Reported Expenditures (see above), for only UMRB and ORB Asian carp management (excludes all IWW/CAWS activity expenditures).

Note that funds provided by granting agencies (e.g. the U.S. Environmental Protection Agency (USEPA) and USFWS) to financially support activities conducted by a partner agency is only reported once by the recipient, as they expend funds and conduct the actual activity. Agency expenditures under $10,000 were not reported or included for the purposes of this Report, except where it is specifically known that no money was spent

## Table 1. Total FY 2016 Expenditures for Asian Carp Activities.*

| Agency | Total Agency GLRI Expenditures[1] | Total Agency Base Expenditures | Total Reported Expenditures[2] | Total UMRB/ORB (w/o IWW/CAWS) |
|---|---|---|---|---|
| USEPA | -- | -- | -- | -- |
| USACE | $3,775,380 | $30,544,462 | $34,319,842 | -- |
| USDA (Forest Service) | -- | -- | -- | -- |
| USGS | $4,334,264 | $5,215,883 | $9,550,147 | $204,000 |
| NOAA | -- | $192,627 | $192,627 | -- |
| USFWS | $3,277,500 | $2,592,029 | $5,869,529 | $1,616,916 |
| USCG (9th District) | -- | $36,513 | $36,513 | -- |
| NPS | -- | -- | -- | -- |
| Indiana | $4,643 | $3,222 | $7,865 | $3,222 |
| Iowa | -- | $193,152 | $193,152 | $193,152 |
| Kentucky | -- | $100,000 | $409,711 | $409,711 |
| Illinois[3] | $6,949,540 | -- | $7,051,422 | -- |
| Minnesota | -- | $162,826 | $1,055,453 | $1,055,453 |
| Mississippi | -- | -- | -- | -- |
| Missouri | -- | -- | $99,940 | $99,940 |
| New York | -- | -- | -- | -- |
| North Carolina | -- | -- | -- | -- |
| Ohio | -- | $48,024 | $48,024 | $48,024 |
| Pennsylvania | -- | -- | -- | -- |
| Tennessee | -- | $19,200 | $76,800 | $76,800 |
| West Virginia | -- | $20,207 | $43,487 | $43,487 |
| Wisconsin | -- | -- | -- | -- |
| **Total** | **$18,341,327** | **$39,128,145** | **$58,954,512** | **$3,750,705** |

* Agency expenditures under $10,000 were not reported or included for the purposes of this Report, except where it is specifically known that no money was spent.

1 GLRI funds are used exclusively for work to benefit the GLB. Actions for GLB protection that are conducted within the IWW/CAWS are included in this Report based on its hydrologic delineation within the UMRB, and to provide a more complete picture of scope of Asian carp activities carried out within the designated sub-basin. These activities, as well as others focused on Great Lakes protection and conducted through the ACRCC, are further described in the FY2016 Asian Carp Action Plan.

2 Total Report Expenditures includes any other outside funding sources reported by agencies. (e.g. Minnesota expenditures include funding from the Minnesota Environment and Natural Resource Trust Fund and the Minnesota Outdoor Heritage Fund).

3 Total UMRB/ORB (w/o IWW/CAWS) represents all reported expenditures for actions to address Asian carp in the ORB and UMRB, excluding projects conducted in the IWW/CAWS for Great Lakes protection.

# APPENDIX 1

# RESEARCH (USGS FY2016 UPDATES)

### 1.1 Field Deployment of Carbon Dioxide Barrier to Deter Asian Carp

Studies on the effects of carbon dioxide on Bighead Carp and Silver Carp were completed. Based on results of 2015 large scale pond trials, two manuscripts were published; one describing carbon dioxide avoidance responses of Bighead Carp and Silver Carp (https://pubs.er.usgs.gov/publication/70160876); and the other describing swimming responses of Asian carp and native fishes (https://pubs.er.usgs.gov/publication/70171336). Scientists also identified target concentrations for use of carbon dioxide as a barrier and minimum/maximum concentrations have been recommended for moving forward. Methods to inject carbon dioxide into the water were tested and a pressurized system was identified as most effective and efficient for fixed deployment. Testing of effects of injecting carbon dioxide under ice was completed and preliminary results indicate reduced overwinter survival of Bighead and Silver Carp.

### 1.2 Developing Targeted Micro-Particle Control Systems for Asian Carp

The USGS has finalized the formulation of a targeted toxin (antimycin) delivery system in the form of a coated micro-particle with high specificity for Bighead and Silver Carp to control or limit Asian carp while minimizing potential impacts on native species. Pond trials have been completed and preliminary results indicate Bighead and Silver Carp mortality, no mortality of largemouth bass, and that the microparticles are not leaching the toxin when put in the water. Preliminary results also show that using algae as a food attractant enhances Asian carp consumption of microparticles. Potential sites in Missouri, where carp are present, have been identified for initial field deployment of microparticles in collaboration with USFWS, ILDNR, and other partners. Studies were also initiated to develop a delivery system for Grass Carp control. In 2017, scientists will be testing a non-toxic microparticle to identify other organisms that might be at risk of ingesting it.

### 1.3 Registration of Asian Carp Control Technologies (Carbon Dioxide as a Barrier and Microparticles)

Specific registration processes must be followed to obtain approval for the use of carbon dioxide and toxic microparticles as control agents in the environment. The USGS is providing support for these activities to the USFWS through the compilation of data and reports for submission to the USEPA or other regulatory agencies, identification of required data to attain chemical registration, and coordination of experimental use permits and other regulatory support as needed to attain and maintain chemical registrations of tools to control Asian carp. In FY 2016, Section 18 Quarantine Exemption microparticle registration information was drafted and is being finalized to be submitted to the USEPA in 2017 for limited use of microparticles for testing. The USFWS continued development of protocols, Standard Operating Procedures (SOPs), and supporting documentation in advance of registration and field allocation of microparticle controls, and the USGS began development of a protocol to conduct studies to determine what happens to the microparticle in the environment. The USGS provided guidance for studies on effects of carbon dioxide on non-target organisms to ensure compliance with Section 7 Endangered Species Act consultation. The USGS also published findings on the response of native mussels to carbon dioxide and will continue to provide support to the USFWS as

SOPs and safety and training protocols are developed for use of carbon dioxide in the field to control Asian carp.

### 1.4 Use of Complex Sound to Alter Behavior of Asian Carp

Scientists are testing the use of complex sound technology by determining the optimal sound frequencies and sound pressure level to optimize deterrence of Asian carp while preventing injury to native species, and its effectiveness for containing, herding or capturing Asian carp. In 2016, the USGS, University of Minnesota Duluth and Illinois Natural History Survey scientists tested Asian carp habituation to boat motor sounds in large ponds, and designed a simulated lock chamber (concrete wall panel) to see how sound waves were affected by the structure. Initial results indicated decreased passages of fish through the simulated lock when using sound. Scientists also used various configurations of underwater speakers and mapped sound gradients to determine effectiveness. Refining sound broadcasting and mapping will provide a more focused, targeted application. Scientists also conducted complex sound field evaluations in a backwater of the Illinois River using tagged carp to track behavioral responses, and preliminary findings showed sound to be an effective deterrent. The USGS and USFWS held a complex sound workshop in 2016 to bring scientists together to build a science framework. A multi-agency Complex Sound Working Group has been formed to move forward on implementation actions and provide recommendations for management agencies on its use.

### 1.5 Field Evaluation of Chemical Attractants to Control Asian carp and Development of Protocols for Field Verification of Response

Laboratory and field studies, including underwater video, conducted by the USGS and independent researchers have consistently confirmed that an algal food stimulus is highly attractive to Asian carp and increases the abundance of fish in areas within 30 minutes of release where Asian carp have been conditioned to the food. Laboratory and field studies show Asian carp are very responsive to algal mixtures containing powdered algae (*Spirulina* and *Chlorella*). These stimuli are presently being used to condition Asian carp to feeding stations along tributaries and sites along the Illinois and Missouri Rivers Various methods of delivery are being evaluated for the release of the algal stimulus to concentrate Asian carp in areas for removal. Algal attractants were also tested in study ponds in combination with underwater sound technology. Asian carp moved away from the sound, reducing the effectiveness of the attractant. Algal attractants were also tested with microparticles (see 1.2 above) in lab and pond studies which showed Asian carp will ingest toxic microparticles when combined with the algal stimulus, and could potentially be used to enhance microparticle consumption.

### 1.6 Integrated Pest Management (IPM)

IPM is a decision support system that integrates new information and tools with existing information and tools to enhance monitoring, surveillance, control and containment for invasive carp in the upper Illinois River and other rivers while minimizing harm to human health and the environment. This work is developed through collaborative multi-partner efforts that address the field evaluation component of the various control tools and technologies, through technology and information workshops, and development of databases and decision support tools. In 2016, real time telemetry, and a telemetry database and visualization tools were placed in strategic locations to inform Asian carp removal (e.g. contract fishing) and potential rapid response efforts. Three real-time telemetry receivers were deployed in the Upper Illinois River and the real-time receiver data stream was incorporated into the Asian carp telemetry database and visualization tool. Genetic tools were also developed to rapidly

screen samples and supplement on-going surveillance efforts for juvenile and larval Asian carp and will be integrated with existing tactics. Scientists also initiated the development of a decision support tool to inform mitigation measures to minimize the entrainment of Asian carp eggs and larvae by barge traffic.

### 1.7 Assessing Life History Traits of Asian Carp in Established and Emerging Populations to Identify and Characterize Vulnerabilities that can be Exploited for Control

A better understanding of life history traits and population dynamics of Asian carp in areas with established (e.g., Illinois River) and emerging populations is necessary to identify vulnerabilities that could be exploited for control strategies using an IPM approach. In 2016, scientists incorporated successful recruitment criteria (e.g. available juvenile habitat) with existing egg transport characterization methods to determine which rivers may pose a greater probability for the establishment of sustainable populations of Asian carp in the GLB. Flow and velocity data collected during June 2015 spawning conditions on the Illinois River was incorporated into the FluEgg model to simulate egg and larval drift from observed spawning locations and identify potential nursery habitat available for developing Asian carp. Scientists also adapted the USACE's hydraulic models of each pool on the Illinois Waterway into a continuous model from Brandon Road Lock and Dam to the confluence with the Mississippi River to generate input data for FluEgg analysis in FY 2017.

### 1.8 Improving Molecular Techniques for Monitoring, Biomass Estimation, and Correlation with Live Fish

Early detection is a vital part of managing any invasive species, including invasive Asian carp. Genetic methods are being used to detect Bighead and Silver Carp at low abundances and identify their invasion front using molecular signals such as eDNA in water samples. The USGS developed and published an occupancy model using eDNA to detect Bighead and Silver Carp in the Wabash River. Information from repeated observations of Asian carp at each sample site was incorporated into the model to estimate detectability. The USGS and USFWS identified a Next Generation Sequencing method (more advanced genetic technology), to detect Asian carp eggs and larvae from samples collected in nets. Scientists also conducted a field trial of the use of eDNA analysis for monitoring effects of a management action, in conjunction with a test of the unified fishing method, a Chinese method for capturing Asian carp being tested in the U.S. Other genetic studies were initiated to look at the way DNA breaks down and the potential use of ribonucleic acid (RNA) so that genetic markers can be designed to indicate how recent the DNA had been shed from a live fish and alleviate concerns about the source of the DNA.

### 1.9 Development of a Rapid and Quantitative Genetic-based Asian Carp Detection Method

Following successful training efforts, the USGS transferred 10 hand held rapid genetic detection kits to law enforcement officers in Ohio, Michigan and Illinois that detects environmental DNA of Bighead and Silver Carp in water samples and can be used to look for Asian carp in bait tanks at bait shops. Procedures were also developed for use of this detection tool. Using the hand-held kit significantly reduces the time between sample collection and results compared to typical laboratory-based analysis which generally require several days to obtain. Scientists are also working to transfer methods to open water for use in pay-fishing ponds.

### 1.10 Use of Acoustic Video and Side-scan Technology to Determine Behavior of Asian Carp, especially Net Avoidance Behavior

Asian carp are believed to have highly developed net avoidance behavior, which inhibits control methods based on harvest. To assess this, USGS scientists assessed and are quantifying the behavior of Asian carp in relation to different gear types and proposed gear modifications that might enhance harvest efficiency. Nearly all the originally-planned field work was completed in 2016. A presentation on preliminary data was given at the American Fisheries Society meeting.

### 1.11 Hydraulic and Water Quality Evaluation of Asian Carp Habitat in the Upper Illinois River and their Impacts on Asian Carp movement

This project investigates the influence of habitat stimuli, such as river hydraulics and water-quality, on the population range, movement, and spawning and recruitment success of Asian carp. In 2017 water quality data for the Illinois River main channel and backwater sites will be used to determine if there is a relationship between water quality and location of Asian carp in the system. Scientists continued water velocity mapping of selected river reaches and published the data which will be evaluated to determine optimum locations (channel constrictions, pinch points, backwater areas, etc.) for testing and implementation of hydrologic control methods. This work is being conducted in collaboration with ILDNR, USFWS, USACE, and other partners.

### 1.12 Grass Carp Reproduction and Population Dynamics

The USGS research on Grass Carp is diverse, focusing primarily on understanding biology and hydrologic factors related to biology. As knowledge on biology and hydrologic drivers expands, the USGS is building the base of knowledge for managers to formulate potential control and management strategies and tactics under the IPM framework. In 2016, scientists collected egg and larval samples for Grass Carp presence and the FluEgg model was used to estimate spawning and hatching locations of Grass Carp eggs in the Sandusky River. Remote sensing imagery was used to detect and map where submerged aquatic vegetation (SAV – preferred food of Grass Carp) does/does not occur using object-based image analysis and generated maps for western Lake Erie. Hydroacoustic technology was then used to validate remotely-sensed SAV and vegetation was collected to validate hydroacoustics and remotely sensed SAV data.

The USGS continued to receive Grass Carp collected by state and federal collaborators and to collect otoliths and age estimation structures to assess ages of fish, whether they were naturally reproduced, age of maturation, and to assess spawning locations. Real-time VEMCO acoustic receivers were installed in the Sandusky River near projected spawning locations to detect presence of acoustically-tagged Grass Carp. Collaborators include ODNR, Michigan DNR (MIDNR), University of Toledo, Bowling Green State University, University of Illinois, USFWS, Department of Fisheries and Oceans Canada.

### 1.13 Interim barrier - Brandon Road Lock and Dam

Newer barrier technologies to Asian carp movement, such as complex sound or injecting carbon dioxide to drive fish away have been proposed for use at the Brandon Road Lock and Dam on the Illinois River to help prevent the movement of Asian carp from the MRB to the GLB. Implementing new technologies requires a better understanding of hydrologic conditions and water chemistry to assess the impacts these technologies may have on lock structures and to inform barrier deployment strategies. In 2016,

USGS stream gauges installed up and downstream of Brandon Road Lock and Dam provided critical data and information to inform USACE models for decision making. A dye study was completed in a lock chamber to examine mixing in the lock and how it might affect barriers or alternatives that involve chemical treatment or water-quality manipulation and lock flushing alternatives. The USFWS and USGS published data and a journal article on the findings from 2015 studies to assess whether small fish can be drawn along with barges as they move through the lock structures (https://pubs.er.usgs.gov/publication/70176364).

### 1.14 Wabash/Maumee Hydrologic Support to Prevent Interbasin Transfer of Asian Carp

In 2016, the construction of a permanent barrier at Eagle Marsh in Fort Wayne, Indiana between the GLB and MRB eliminated the pathway for Asian carp migration from the Wabash River, where adult Bighead Carp are found, to Lake Erie. As part of the project, the USGS operated streamflow, temperature, and water level gauges as well as a webcam at the site to monitor flow conditions that may lead to flooding and to obtain the stream data that was used to help determine the location for the newly constructed permanent barrier. Post-construction hydrologic and remote observational monitoring is continuing to validate performance of the final design during flood flows. The USGS will continue to provide additional data until a full barrier is in place.

### 1.15 Lock Treatment Options to Prevent Aquatic Invasive Species Movement

Scientists conducted studies to identify methods or tools to prevent two-way movement of AIS through the CAWS from Lake Michigan, as well as from the Illinois River with minimal impact to navigation. This project is evaluating the potential to use chemicals to effect control of aquatic invasive organisms that might be associated with vessels during locking activities. The USGS published a report in 2015 on the results of evaluation of 28 chemicals and hot water and identified hot water, chlorine, and ozone as the most promising treatments requiring further evaluation. In 2016, the USGS initiated lab studies to evaluate efficacy of hot water, chlorine, and ozone (either alone or in combinations); and to conduct the necessary toxicity trials to provide the data to evaluate their use for lethal AIS control in lock operations.

### 1.16 Multi-agency Telemetry Database and Visualization Tool

The USGS is coordinating a telemetry database to inform management and removal efforts. Over 1000 Asian carp have been tagged, and millions of individual detections have been recorded. A network of hundreds of passive receivers was deployed to monitor Asian carp up and downstream as well as channel to backwater movements. This tool will allow for quick transformation of this massive amount of data into usable information to control Asian carp as part of an IPM approach, eventually including real-time receivers.

### 1.17 Black Carp Detection and Risk Assessment

Black Carp captures in the Illinois and Middle Mississippi rivers have increased substantially in recent years, and almost all the captured fish have been diploid (fertile). The USGS has been working for three years with the USFWS and Southern Illinois University to process Black Carp captured by recreational or commercial fishers and by state agencies to generate age, growth, diet, fertility, and source information. Approximately 50 fish have been collected, nearly half of them in 2016. In addition, 47 YOY Black Carp were captured in 2016 by a Missouri Department of Conservation collaborator. Additional study is needed to monitor Black Carp range and geographic extent of natural reproduction, assess the potential

for population growth, and evaluate ecological impacts. The USGS also began design and development of a targeted Black Carp bait to prevent harm to endangered mussels. Black Carp eat mussels and snails by crushing the shells with their strong jaws. The USGS has developed a prototype bait in the form of a hollow glass bead that would be filled with a registered toxicant that would be attached to a bait (still to be determined) that would cause mortality when eaten by Black Carp. Further testing of the glass beads will continue in 2017. A genetic marker has also been developed and validated for Black Carp that could aid in early detection efforts.