



2018 Annual Report to Congress

Annual Summary of Activities and Expenditures to Manage the Threat of Invasive 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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2018 Report to Congress on Invasive Carp in the Upper Mississippi River and Ohio River Basins

EXECUTIVE SUMMARY

The Water Resources Reform and Development Act of 2014 (WRRDA), Public Law 113-121, authorized 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 invasive carp in the Upper Mississippi River Basin (UMRB) and the Ohio River Basin (ORB) and their tributaries.

Additionally, WRRDA requires development of an annual report to the U.S. Congress (Report) summarizing strategies, expenditures, and progress in addressing the threat of invasive carp in the UMRB and ORB and their tributaries. The Report focuses on efforts to manage bighead, silver, black, and grass carp - the four species of carp widely known as “Asian carp” and generally referred to in this report as “invasive carp” - addressed in the ‘Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States’ (National Plan). The National Plan, developed in collaboration with federal, state, nongovernmental, and industry partners and approved by the Aquatic Nuisance Species Task Force (ANSTF) in 2007, continues to serve as the overarching strategy providing guidance for managing invasive carp in our nation’s waters.

In support of WRRDA, and with the National Plan as guidance, interagency partnerships developed step-down management plans to guide strategic invasive carp monitoring, prevention, and control actions in the UMRB and ORB (including the Tennessee and Cumberland rivers), and subsequently in the Lower Mississippi River (including the Arkansas, White, and Red rivers) and Missouri River basins. Further, a partnership management strategy focused on protection of the Great Lakes Basin (GLB) from invasive carp has been developed and implemented since 2010. Finalized plans and reports from these partnerships are available at: <http://www.micrarivers.org/asian-carp-plans-and-reports/> and <https://www.asiancarp.us/PlansReports.html>.

The USFWS coordinated closely with federal and state partners to develop the 2018 Report, which specifically summarizes activities conducted for invasive carp management in the UMRB and ORB and their tributaries from October 1, 2017, to September 30, 2018, in support of their management plan goals and objectives.

The 2018 Report includes the following information:

- Observed changes in the documented range of invasive carp in the UMRB and ORB, including locations of invasive carp within tributaries of the UMRB and ORB.
- A summary of federal agency efforts, including cooperative efforts with non-federal partners, to control the spread of invasive carp in the UMRB and ORB and their tributaries.
- A summary of federally-funded research being conducted to reduce or eliminate the spread of invasive carp.
- An evaluation of accomplishments using qualitative and quantitative measures to document

progress and effectiveness of invasive carp management efforts. A cross-cut accounting of federal and non-federal invasive carp management expenditures in the UMRB and ORB and their tributaries, as reported by individual agencies for their respective 2018 Fiscal Year (FY) reporting periods.

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

1. Ohio River and key tributaries, including the Tennessee River Basin (defined as the ORB)
2. Upper Mississippi River and key tributaries (defined as the UMRB)
3. Illinois Waterway (IWW) and Chicago Area Waterway System (CAWS) (defined as the IWW/CAWS)

Although located within the UMRB delineation, summary information for the IWW/CAWS is reported separately as these actions primarily support invasive carp prevention for 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 invasive carp and is therefore the geographic focus for federal and state management efforts associated with the Asian Carp Regional Coordinating Committee (ACRCC). A general summary of the ACRCC's efforts conducted specifically in the IWW/CAWS for Great Lakes protection is included in this Report, and described in greater detail in the partnership's 2018 Asian Carp Action Plan (<https://asiancarp.us/Documents/2018ActionPlan.pdf>) and the 2018 Monitoring and Response Plan (MRP) (<https://www.asiancarp.us/Documents/MRP2018.pdf>). Activities are summarized annually in the Monitoring and Response Work Group (MRWG) Interim Summary Reports (<http://asiancarp.us/PlansReports.html>).

Reported agency activities for each basin are categorized under the following areas:

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

OBSERVED CHANGES IN THE DOCUMENTED RANGE OF INVASIVE CARP IN THE UMRB, ORB, AND IWW/CAWS

This 2018 Report to Congress (Report) includes detailed results on the occurrence of invasive carp in U.S. waters of the UMRB, ORB, and IWW/CAWS, including summaries of historical and new detections as well as assessments of changes in the observed range of each species. In the 2018 reporting period, range expansion was documented in specific river reaches for bighead carp, silver carp, and black carp. No range expansion was documented for grass carp.

New documented detections of invasive carp were entered into the USGS Nonindigenous Aquatic Species (NAS) database and are available online at <https://nas.er.usgs.gov/taxgroup/fish/default.aspx>. It is important to note that while the collection of an individual invasive carp in a new location may be defined as range expansion in this Report, it does not indicate that the species has become established in that particular point in the watershed. Additional data, such as evidence of spawning activity, the

presence of various life stages of invasive carp (e.g., eggs, larvae, and juveniles), and the relative abundance of adults, are used to holistically assess and better define the geographic boundary or “population front” for self-sustaining populations of each species within a given river basin. This underscores the need for ongoing monitoring to collect data to inform an accurate assessment of population status.

The observed changes in range are summarized as follows:

- Bighead carp: UMRB, Minnesota River – 12 miles upstream; ORB, Ohio River – 6 miles upstream
- Silver carp: UMRB, Cedar River – 61 miles upstream
- Black carp: UMRB, Mississippi River – 19 miles upstream; ORB, Ohio River – 21 miles upstream

Additional range expansion was noted for black carp in the Cumberland River (first detection above Barkley Dam at Lake Barkley), and in the Tennessee River (first detection above Kentucky Dam at Kentucky Lake).

AGENCY PREVENTION AND CONTROL EFFORTS

This Report summarizes the many activities conducted by invasive carp partnerships in the ORB and UMRB under each of the seven goals of the National Plan:

1. Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carp in the U.S.
2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carp in the U.S.
3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carp in the U.S.
4. Minimize potential adverse effects of feral bighead, black, grass, and silver carp in the U.S.
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 U.S.
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 U.S.
7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carp in the U.S.

The ORB, UMRB, and GLB (IWW/CAWS) partnerships described in this Report previously developed and are now implementing comprehensive invasive carp management plans, ensuring strong ongoing interagency coordination, and reflecting the specific needs and opportunities for their respective sub-basins. These plans include:

- Ohio River Basin Asian Carp Control Strategy Framework (ORB Framework), developed by the Ohio River Fisheries Management Team (ORFMT) (http://www.micrarivers.org/wp-content/uploads/2018/08/ORFMT_Asian_Carp_Strategy.pdf)
- Upper Mississippi River Basin Asian Carp Control Strategy Framework (UMRB Framework), developed by the Upper Mississippi River Asian Carp Partnership (<http://www.micrarivers.org/wp-content/uploads/2018/10/UMR-Framework-Final.pdf>)
- Asian Carp Action Plan (Action Plan) (<https://www.asiancarp.us/Documents/2018ActionPlan.pdf>) and the Monitoring and Response Plan for Asian Carp in the Upper Illinois River and the Chicago Area Waterway (Monitoring and Response Plan), developed by the Asian Carp Regional

Coordinating Committee (ACRCC)

The Frameworks for the ORB and UMRB partnerships were further stepped-down to describe individual priority projects targeted for implementation in 2018 within the respective sub-basins in the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin (MRPMB), developed by the Mississippi Interstate Cooperative Resource Association Asian Carp Advisory Committee (<http://www.micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>).

In 2018, projects were identified in the MRPMB to address key ORB and UMRB partnership priorities including scientific monitoring, assessment, and early detection; prevention and containment, including developing and evaluating strategies and technologies for deployment of invasive carp deterrent barriers; and strategic population control and removal to prevent further range expansion and establishment.

The annual MRPMB provides detailed information on the projects supported with FY 2018 USFWS invasive carp funds directed to the UMRB and ORB sub-basins. Projects funded in each basin in FY 2018 include the following (listed by FY 2018 project title).

In the ORB:

- Early Detection and Evaluation of Asian Carp Removal in the Ohio River
- Abundance and Distribution of Early Life Stages of Asian Carp in the Ohio River
- Control and Containment of Asian Carp in the Ohio River
- Quantifying Lock and Dam Passage, Habitat Use, and Survival Rates of Asian Carp in the Ohio River
- Relative Population Densities and Movement of Asian Carp in the Tennessee and Cumberland Rivers, Tributaries of the Ohio River
- Deterrent Strategy Planning for Asian Carp in the Ohio River Basin

In the UMRB:

- Early Detection of Asian Carp on the Invasion Front in the Upper Mississippi River
- Evaluation of Controls, Impacts, and Behaviors of Asian Carp in the Lower Upper Mississippi River
- Evaluation of Fish Passage for Assessment of Asian Carp Deterrents at Multiple Locks in the Upper

Mississippi River:

- Contract Fishing for Asian Carp Detection and Removal in the Upper Mississippi River

A detailed summary of the individual project work plans is provided in the 2018 MRPMB. Accomplishments achieved in 2018 under each of these individual projects, as well as the organizational structures and strategic planning processes for the sub-basin partnerships, are described in Section 3.0 of this Report.

CONDUCTING KEY RESEARCH, TRANSFERRING TECHNOLOGY, AND APPLYING LESSONS-LEARNED

This Report summarizes developments in key research and technology conducted by the ORB and UMRB partnerships related to invasive carp detection and control. The USGS continues to serve as a lead

federal agency on research and development of new and emerging technologies, working closely with federal and state partners. Additionally, the USACE's Engineer Research and Development Center (ERDC) coordinates closely with the USGS and other federal and state agencies and universities to advance the science and technical capacity for managing invasive carp.

Invasive carp research and development projects address partnership needs within the following general categories:

- Early detection and monitoring
- Life history/behavior
- Feeding ecology
- Prevention
- Control
- Analysis of alternative pathways
- Risk assessment

Coordination within and between sub-basin partnerships is fostered to identify highest-priority research and management needs; and to develop consistently used monitoring, data collection, and best-management practices. Individual research activities conducted in 2018 by agencies and non-governmental partners are described by sub-basin in Section 3.0 of this Report.

ESTABLISHING MEASURES OF EFFECTIVENESS FOR INVASIVE CARP PREVENTION

The WRRDA directed the USFWS to develop measures to document progress in controlling the spread of invasive carp in the UMRB and ORB and their tributaries. Appendix 3 of this Report provides a roll-up of relevant agency accomplishments under each related quantitative or qualitative measure during the reporting period for the purposes of tracking specific annual outcomes and general progress toward achieving longer-term management goals in support of the National Plan.

FEDERAL AND NON-FEDERAL EXPENDITURES

This cross-cut summary includes an overview of expenditures directly related to invasive carp activities conducted by federal and state agencies in the UMRB, ORB, and IWW/CAWS in FY 2018. Agencies reported a total of \$55,991,345 for all basins combined, of which \$48,740,155 supported actions focused in the IWW/CAWS to protect the Great Lakes from invasive carp. The total reported expenditures on activities conducted to benefit the ORB and UMRB and tributaries was \$7,251,190 (Table 1 in Section 5.0).

Agencies reported all invasive carp-related expenditures conducted during their respective FY 2018, categorized by both funding source and general type of activity. Percent of total reported expenditures was as follows: Active Prevention and Control, 47.8%; Research and Development, 23.8%; Monitoring, Early Detection, and Rapid Response, 16.9%; Interagency Coordination, 8.6%; Outreach with Stakeholders, 1.2%; and Law Enforcement/Regulatory Actions, <1.0%. An activity category was not assigned to 1.6% of the reported expenditures.

Additional FY 2018 expenditures were reported by agencies conducting actions to prevent invasive carp movement through temporary interbasin hydrologic connections (secondary pathways) identified in the Great Lakes and Mississippi River Interbasin Study (GLMRIS) Other Pathways assessment, released by the USACE in 2014. Since these pathway mitigation efforts are focused on protecting the GLB from the

movement of invasive carp and are not exclusively within the delineated geographic boundaries of the ORB, related costs were excluded from the total expenditures summarized in this Report. However, a brief summary of GLMRIS secondary pathway mitigation activities reported by agencies is included to present a complete overview of the efforts conducted to reduce the risk of potential interbasin range expansion of invasive carp from the ORB to the GLB.

Since FY 2015, additional funding has been provided to the USFWS for invasive carp efforts through its annual agency base appropriations to support an enhanced multiagency invasive carp response in the UMRB and ORB, as directed by WRRDA, Section 1039. The USFWS, in coordination with the Mississippi Interstate Cooperative Resource Association (MICRA), works directly with federal and state agencies to address the highest priority implementation needs for the ORB and UMRB Frameworks that further support the National Plan. Projects supported through these USFWS funds are included in this Report.

1.0 INTRODUCTION

1.1 INTERAGENCY MANAGEMENT OF INVASIVE CARP IN THE UPPER MISSISSIPPI RIVER AND OHIO RIVER BASINS – COLLABORATION UNDER WRRDA 2014

Recognizing the continuing threat from the introduction of invasive carp populations into major river basins of the United States, federal and state agencies have developed collaborative partnerships and management strategies focused on implementing a comprehensive approach to abate further range expansion. The establishment of invasive carp in portions of 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.

WRRDA (Public Law 113-121,) Section 1039(b) supports these efforts by authorizing 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 invasive carp in the UMRB and ORB and their tributaries. This includes provisions for technical assistance, coordination, best practices, and support to state and local governments engaged in activities to decrease the threat of invasive carp. Additionally, WRRDA directed the USFWS to develop, in coordination with the USACE, an annual report to Congress summarizing strategies, expenditures, progress, and emerging research to address the threat of invasive carp in the UMRB and ORB and their tributaries.

Since 2014, the USFWS has coordinated with the USACE, NPS, USGS, and other federal and state agency partners to develop the Annual Report to Congress - Summary of Activities and Expenditures to Manage the Threat of Asian Carp in the Upper Mississippi and Ohio River Basins (Report).

This 2018 Report to Congress (Report) includes the following information:

- Observed changes in the documented range of invasive carp in the UMRB and ORB, including further delineation of the location of invasive carp within tributaries of the UMRB and ORB.
- A summary of federal agency efforts, including cooperative efforts with non-federal partners, to control the spread of invasive carp in the UMRB and ORB and their tributaries.
- A summary of federally funded research being conducted to reduce or eliminate the spread of invasive carp.
- An evaluation of accomplishments using qualitative and quantitative measures to document progress and effectiveness of invasive carp management efforts.
- A cross-cut accounting of federal and non-federal invasive carp management expenditures in the UMRB and ORB and their tributaries, as reported by individual agencies for their respective 2018 Fiscal Year (FY) reporting periods.

Federal and state agencies reported all invasive carp management activities conducted in the UMRB and ORB during the reporting timeframe of October 1, 2017, through September 30, 2018. Agency activities conducted in support of the National Plan have been grouped into the following six general categories:

- Interagency Coordination (e.g., Strategy Development, Partnership Coordination)
- Monitoring, Early Detection and Rapid Response
- Active Prevention/Control (e.g., Physical Removal of Invasive Carp, Implementation/Operation of Barriers, Actions to Address Pathways)
- Research and Development

- Outreach with Industry, Stakeholders, and the Public
- Law Enforcement/Regulatory Actions

The Report also identifies collaborative projects and strategic planning efforts being funded, in whole or in part, through appropriated USFWS funds provided for invasive carp in FY 2018. These funds are being used to support invasive carp projects by our state and multijurisdictional resource partners in the UMRB, ORB, and other priority locations.

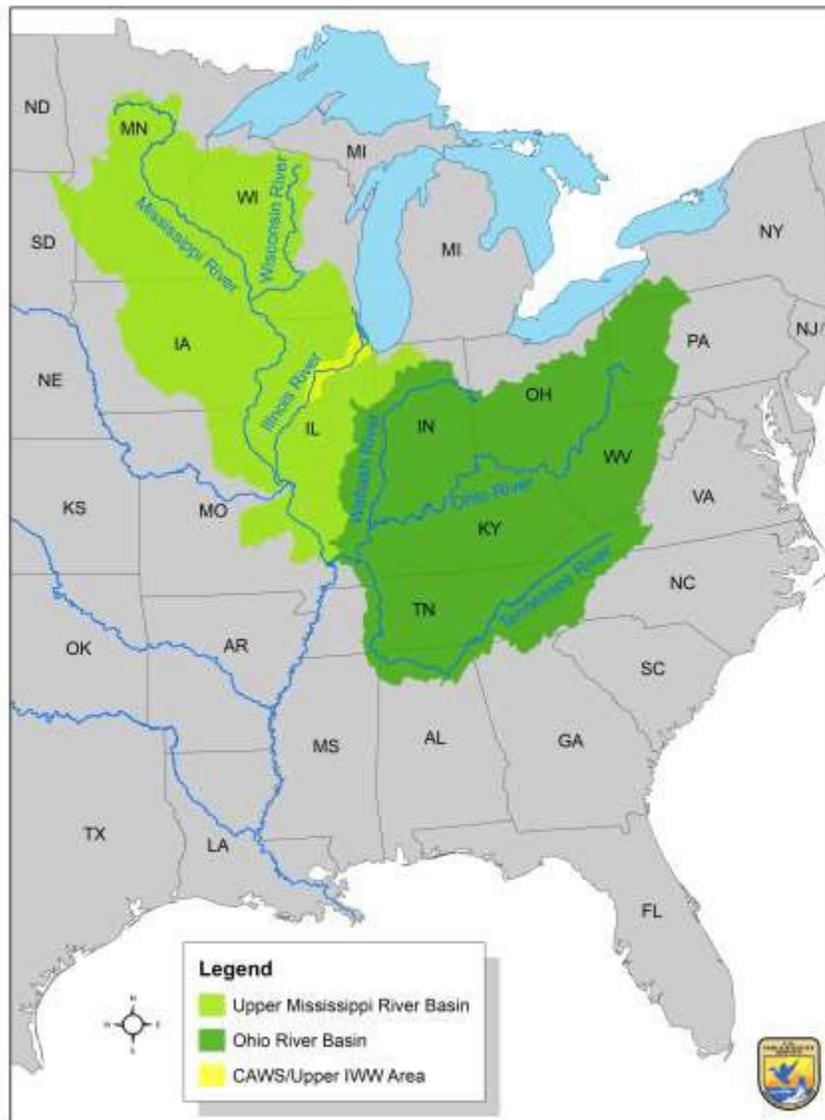
As directed, the Report is transmitted to the Committee on Appropriations and the Committee on Environment and Public Works of the U.S. Senate; and the Committee on Appropriations, the Committee on Natural Resources, and the Committee on Transportation and Infrastructure of the U.S. House of Representatives. In addition, the Report is made available to the public via the Internet at www.invasivecarp.us.

1.2 BASIN PARTNERSHIP OVERVIEWS AND ACCOMPLISHMENTS

This 2018 Report summarizes reported accomplishments and related expenditures conducted to address invasive carp in the ORB and UMRB, two major sub-basins within the larger Mississippi River drainage basin (Figure 1). To clearly describe the agency efforts conducted for the benefit of each specific sub-basin, this 2018 Report is organized into three geographically-focused sections, as follows:

1. Ohio River and tributaries (defined as the ORB), including the Tennessee River Basin
2. Upper Mississippi River and key tributaries (defined as the UMRB)
3. Illinois Waterway and Chicago Area Waterway System (defined as the IWW/CAWS)

This Report focuses on the federal and state agency actions conducted within the mainstream rivers and tributaries of the ORB and UMRB (as directed in WRRDA 2014). Although located within the UMRB delineation, a summary of efforts conducted in the IWW/CAWS are presented in a separate section. While the Illinois River is a tributary of the Upper Mississippi River, actions conducted within the IWW/CAWS (River Mile (RM) 231 to RM 333) are, for the purposes of this Report, categorized as efforts for the protection of the GLB. As the only permanent hydrologic connection between the MRB and the GLB, the IWW/CAWS is considered the primary potential vector for the inter-basin transfer of invasive carp making it the geographic focus for federal and state management efforts associated with the ACRC. Efforts conducted in the IWW/CAWS summarized within this Report are described in greater detail in the ACRC's 2018 Asian Carp Action Plan (<https://www.asiancarp.us/Documents/2018ActionPlan.pdf>) and the 2018 Monitoring and Response Plan (MRP) (<https://www.asiancarp.us/Documents/MRP2018.pdf>).



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 Ohio River Fisheries Management Team (ORFMT), which was formed in 1990 to develop an inter-jurisdictional perspective to manage Ohio River fisheries. The six ORFMT states initiated development of the ORB Framework and requested that the remaining eight states in the ORB (Alabama, Maryland, Georgia, Mississippi, New York, North Carolina, Tennessee, and Virginia) participate in its development and implementation. Invasive 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, and Alabama border the Tennessee River and are active participants in the ORB partnership.

The Upper Mississippi River flows through or along the border of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. These five states collaboratively manage fisheries in the mainstem Upper Mississippi River

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 invasive carp populations in the UMR.

1.3 THE INVASIVE CARP CHALLENGE

The expansion of invasive 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 support thousands of jobs and provide income for communities located on, or adjacent to, rivers and reservoirs. The USFWS 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (National Survey) 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. Although the most recent version of the National Survey, completed in 2016, does not provide a breakout of expenditures within the UMRB or ORB, data demonstrated the consistent value of angling nationally within the United States, with a total of 35.8 million anglers and increases in angling-related expenditures relative to 2011.

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

In response to these threats, 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 effort was led by USFWS, in collaboration with over 70 partners. Approved and released by the ANSTF in 2007, the National Plan identifies seven core goals, with supporting step-down strategies and recommendations. The National Plan continues to serve as a blueprint for federal, state, and non-governmental partnerships on invasive carp management.

Comprehensive invasive carp management strategies have subsequently been developed to protect the natural resources and economies of the Mississippi River and GLB, building on the seven goals of the National Plan:

1. Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carp in the U.S.
2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carp in the U.S.
3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carp in the U.S.
4. Minimize potential adverse effects of feral bighead, black, grass, and silver carp in the U.S.
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 U.S.
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 U.S.
7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carp in the U.S.

1.4 PROGRESS IN FISCAL YEAR 2018

This section provides a brief overview of progress made towards accomplishing the overarching goals of the National Plan during the 2018 reporting period. Subsequent sections provide more detailed summaries of accomplishments for each individual basin. WRRDA directed the USFWS to identify measures to document progress in controlling the spread of invasive carp in the UMRB and ORB and their tributaries; accordingly, Appendix 3 provides a summary of additional agency actions completed through FY2018 under both qualitative and quantitative measures of progress.

1.4.1 INTERAGENCY COORDINATION

- Completed the Upper Mississippi River Basin Asian Carp Control Strategy Framework, a federal and state interagency invasive carp management plan for the UMRB, by the Upper Mississippi River Asian Carp Partnership.
- Completed the Missouri River Basin Asian Carp Control Strategy Framework, a federal and state interagency invasive carp management plan for the Missouri River Basin, by the Missouri River Natural Resource Committee.
- Expanded collaboration between federal and state agencies and non-governmental entities within and across basins to more effectively develop and evaluate coordinated control actions and strategies, including new prototype technologies.

1.4.2 MONITORING, EARLY DETECTION, AND RAPID RESPONSE

- Implemented strategic, science-based monitoring actions described within the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin, the Upper Mississippi River Basin and Ohio River Basin Asian Carp Control Strategy Frameworks, and the 2018 ACRC Asian Carp Action Plan.
- Continued development and refinement of robust data sets for assessing trends in the distribution and status of invasive carp populations within and across MRB sub-basins.
- Conducted additional key fishery assessments, including remote sensing and telemetry tracking of invasive carp to support decision-making on the timing and placement of potential management field actions, such as intensive removal (harvest).
- Expanded development, refinement, and use of contingency (or “rapid response”) plans, including use of the Incident Command System structure and interagency exercises, to ensure responder readiness.

1.4.3 ACTIVE PREVENTION/CONTROL

- Collaboratively developed sub-basin plans to identify potential locations for the strategic deployment of invasive carp deterrent barrier technologies, targeting “pinch points” (e.g., navigation locks) to prevent further range expansion.
- Refined and deployed new detection tools and protocols to enhance the ability of agencies to quickly detect and respond to new occurrences of invasive carp.
- Continued operation and maintenance of a multi-array, electrical dispersal barrier system to prevent the upstream movement of invasive carp in the CSSC.
- Expanded the use of directed contract commercial fishing to strategically reduce invasive carp populations, targeting upstream areas where invasive carp are currently established to prevent further emigration and upstream range expansion.
- Continued state-led coordination with licensed commercial fishers to encourage mass harvest of

invasive carp in waters where currently established to reduce population levels and support restoration and recovery of native fish species.

1.4.4 RESEARCH AND DEVELOPMENT

- Implemented large-scale field trials to evaluate the effectiveness of new potential deterrent technologies, including complex underwater sound and carbon dioxide barriers.
- Continued evaluation and refinement of new tools and strategies to address the emerging threats of black carp and grass carp.

1.4.5 OUTREACH WITH INDUSTRY, STAKEHOLDERS, AND THE PUBLIC

- Continued comprehensive, multi-pronged outreach and education with the public, governments, industry, and other stakeholders on invasive carp, including websites, educational signage at boating access points, news releases, and social media.

1.4.6 LAW ENFORCEMENT/REGULATORY ACTIONS

- Continued cooperative efforts by federal and state law-enforcement to support applicable laws and regulations that limit the unintentional or deliberate movement of invasive carp.

Additionally, since FY 2015, funding provided to the USFWS through agency base appropriations has been used to support invasive carp 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 basin-wide invasive carp management strategies and those of the National Plan. The collaborative projects developed and implemented through this process augment ongoing activities conducted by federal and state partners to address the threat of invasive carp in the UMRB, ORB, and other waters.

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

Range expansion was evaluated for all four species of invasive carp in the UMRB and ORB. For the purposes of this report, range expansion is defined as the difference (increase) in each species' geographic occurrence, documented using data collected during October 2017 to September 2018 (reporting timeframe for this 2018 Report). The new range for each species is compared to the prior range assessments conducted for the 2017 Report to determine upstream or downstream expansion. The USGS NAS database, the national repository housing spatially referenced biogeographic accounts of introduced aquatic species across the United States, continues to serve as the primary catalogue for invasive carp occurrence data. The NAS database aids efforts to verify the presence of species and includes a number of data parameters for each collection or sighting (e.g., date, collector, location, and habitat type).

For this 2018 Report, range expansion since the 2017 Report was assessed by identifying the farthest known distribution points (both upstream and downstream) for each mainstream river and major tributary within 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 2017" (data summarized up through the 2017 Report), and "Oct 2017 – Sept 2018" (new data summarized for the 2018 Report).

Observed changes in geographic distribution was assessed by comparing the farthest distance upstream or downstream an individual fish was observed in the 2018 reporting period versus the documented Pre-Oct 2017 data.

In 2018, there was no increase in the number of states with known occurrences of invasive carp. The breakout by species is as follows:

- Bighead carp, 27 states
- Silver carp, 22 states
- Black carp, 7 states
- Grass carp, 45 states

The extent of range expansion and individual new occurrences observed for each of the four species of invasive carp from October 2017 to September 2018 is illustrated in Figure 2. These range maps represent data archived within the USGS NAS Database for each respective invasive carp species (<https://nas.er.usgs.gov>). The boundary of the UMRB and ORB is delineated on each map by grey shading. Captures of invasive carp along population leading edges, including those that designate new range expansions, primarily result from state or federal agency monitoring, or from commercial or recreational fishing activities. Individual invasive carp species and other key information for these reported captures is verified by a state or federal agency biologist and documented in the database.

Red markers on the maps indicate captures made within the 2018 reporting period, green circles indicate captures prior to October 2017. When a capture made within 2018 was located beyond any green marker (upstream or downstream), this signifies a range expansion and is identified on the maps using yellow triangles.

The observed changes are summarized as follows:

- Bighead carp: UMRB, Minnesota River – 12 miles upstream; ORB, Ohio River – 6 miles upstream
- Silver carp: UMRB, Cedar River – 61 miles upstream
- Black carp: UMRB, Mississippi River – 19 miles upstream; ORB, Ohio River – 21 miles upstream

In addition to exhibiting upstream range expansion of 21 miles within the mainstem Ohio River, black carp were also captured for the first time in: 1) Cumberland River above Barkley Dam at Lake Barkley (approximately 50 miles upriver from the confluence with the Ohio River) and 2) Tennessee River above the Kentucky Dam at Kentucky Lake (32 miles upriver from the confluence with the Ohio River).

A total of 170 black carp were reported in 2018, a 126% increase in captures from the 2017. Illinois DNR and Southern Illinois University continue to support a commercial bounty program, which has resulted in increases of reported captures. Of the 170 black carp reported, two were determined to be reproductively sterile, or triploid, fish originating from aquaculture sources (invasive carp “ploidy” is further described in detail below). Black carp can live and reproduce for many years. Some of the captured adults are estimated to have escaped from aquaculture facilities during large flooding events. Many offspring of escaped broodstock have now reached maturity, and natural reproduction has been suspected for recent years based on the detection of 1- to 5-year-old black carp during commercial fishing or monitoring. In 2016, the first large spawning event was documented when fingerlings (post larval fish in its first year) were captured in the Dutchtown Ditch, a drainage ditch in Missouri.

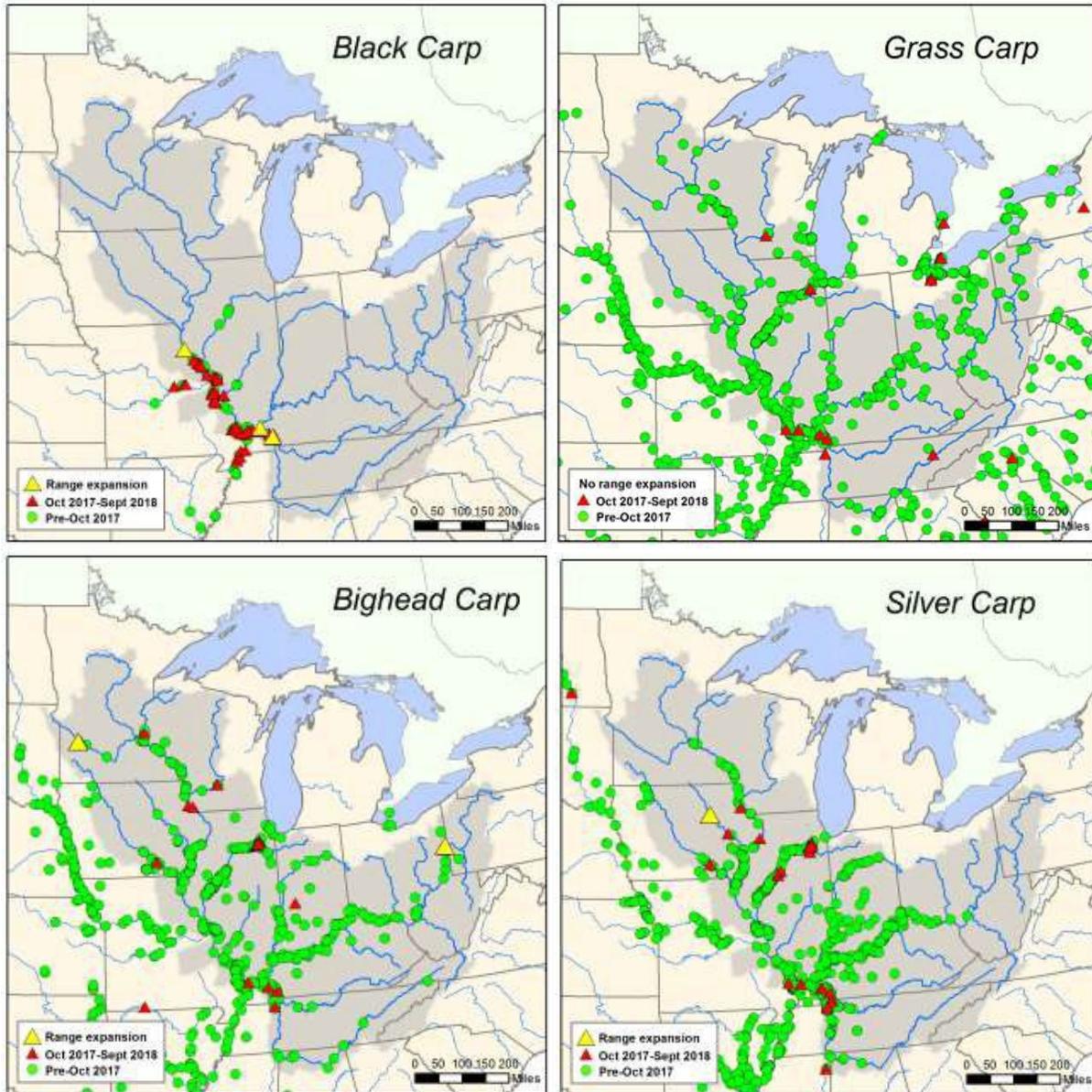


Figure 2. Documented range expansion of invasive carp in the UMRB and ORB in 2018.

Individuals were determined to be reproductively viable (diploid) and capable of reproduction upon maturity based on laboratory analysis. In 2018, 54 of the black carp collected from within the documented range were determined to be diploid (Figure 3). Testing of fish captured in the Mississippi River downstream of the Mel Price Dam near Alton, Illinois was suspended in previous years due to the documented diploid establishment of black carp populations in the downstream portion of the river. Captures continue to be reported, but ploidy analysis is now concentrated on expanding range documentation in the upper Mississippi, Mississippi River tributaries, Ohio and Illinois rivers and their tributaries. Range expansions of diploid black carp were documented in 2018. Diploid fish were collected in new locations as far upstream as Brockport, Illinois in the Ohio River. Additional diploid captures occurred from the Cumberland and Tennessee rivers at Kentucky Lake and Lake Barkley; the Illinois River near Peoria, Illinois; and the upper Mississippi River near Meyer, Illinois (Figure 4).

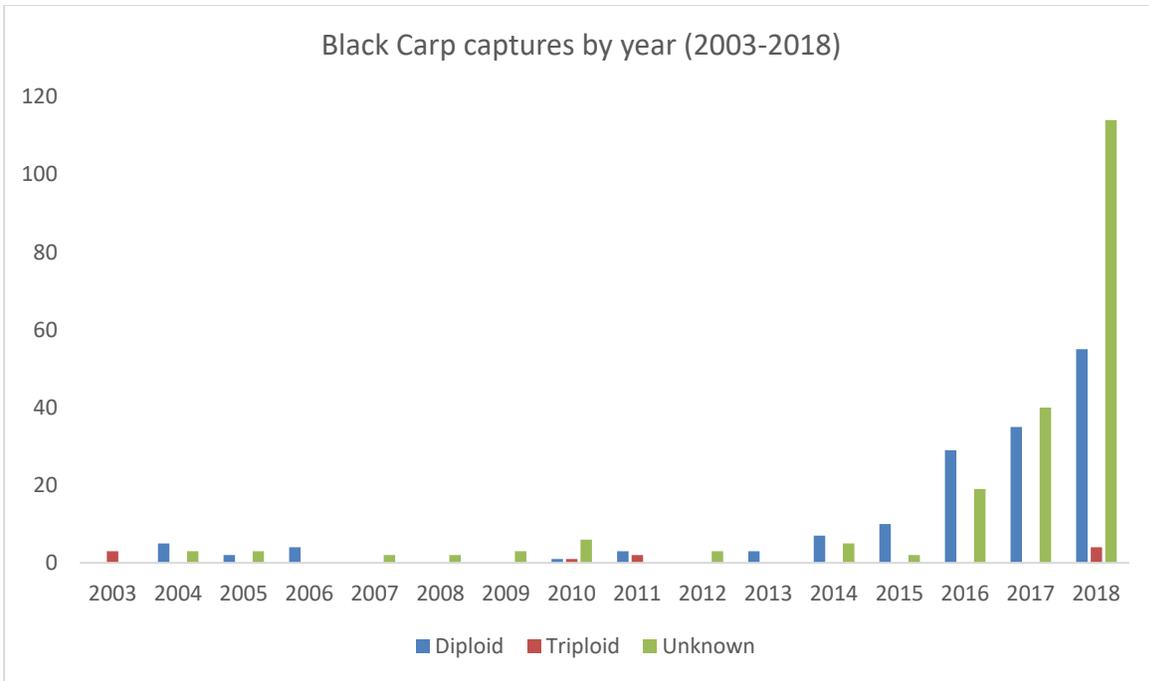
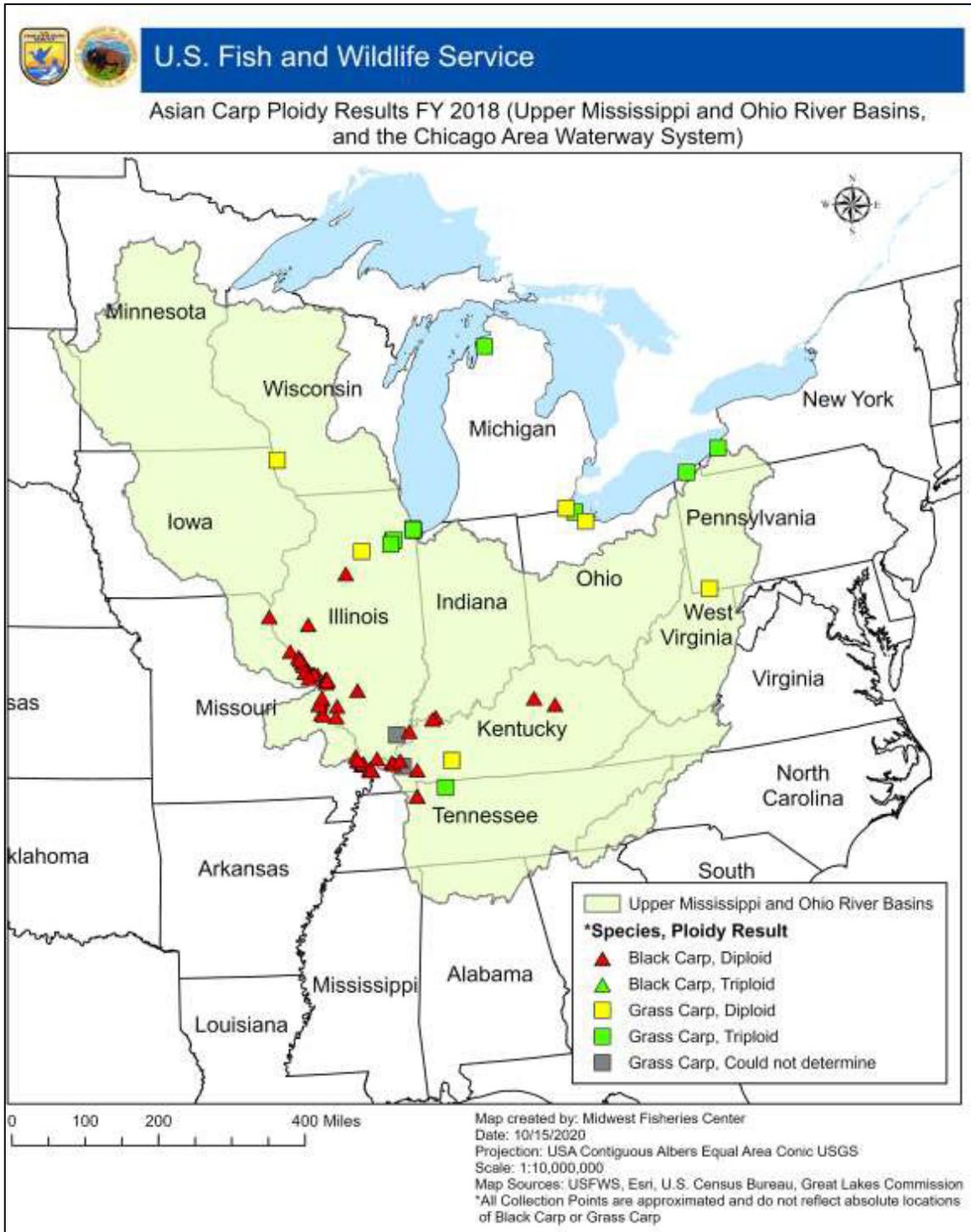


Figure 3. Black carp captures by year (2003-2018), as reported in USGS NAS database.



2.1 DETERMINATION OF INVASIVE CARP REPRODUCTIVE STATUS (PLOIDY)

Additional key data describing invasive carp population status in the UMRB and ORB is collected through the laboratory analysis of fish captured during agency monitoring, commercial fishing, or other activities. Ploidy determination is a genetic analysis of the reproductive capabilities of captured grass and black carp

using flow cytometry. The technology was developed at the USGS (Jenkins et al., 2004) and transferred to the USFWS La Crosse Fish Health Center in 2012 as a management tool to assess risk for establishment of reproductive populations. Analysis of the chromosomal content of cells from captured grass carp or black carp determines if the fish are triploids, escaped from intentional stockings for aquatic weed or snail control, or if the fish are diploids and may establish invasive populations in unintended waters. The program continues to provide support to resource agency partners in grass and black carp management in the Great Lakes and its tributaries, as well as the Mississippi and Ohio River Basins. Results are provided to partners to aid in risk assessment when new populations or range expansions are discovered. Ploidy analysis helps partners focus appropriate actions on areas where diploid fish threaten to establish reproductive populations, rather than in areas where triploid escapees pose little risk to the resource. Ploidy results, along with collection data and images, are reported to the USGS Non-indigenous Aquatic Species (NAS) Database: <https://nas.er.usgs.gov/>.

2.2 POPULATION STATUS ASSESSMENT

Individual occurrence point data are important for visualizing overall species distribution, including range expansions, of adult invasive carp. However, a more comprehensive understanding of the dynamics and overall status of invasive carp populations within a given sub-basin requires the collection and assessment of data for all life stages of invasive carp (eggs, larvae, juveniles, and adults). Holistic, multi-life stage assessments provide a more complete description of the degree of establishment and threat of advance for a given population and can be used to inform the implementation of appropriate management actions at targeted locations within each basin. Acquiring this critical information requires intensive field and laboratory work and remained a high priority of UMRB and ORB agencies in 2018.

Figure 5 uses data from federal and state partners to characterize bighead and silver carp degree of establishment and relative abundance in the mainstem rivers of the UMRB and ORB as of 2018. These data describe the presence of different life stages of invasive carp, the relative abundance of adults in the area, and presence of spawning activity. Three general categories, represented by shaded zones on the map, were used to describe establishment status and relative abundance of invasive carp within river reaches:

- Red shading indicates the Established Zone, areas of established bighead and/or silver carp populations in which reproduction (spawning) has been verified by collecting and taxonomically or genetically confirming eggs, larvae, or juvenile fish.
- Orange shading indicates the Transitional Zone, areas of adult population transition, defined as locations where the population is stable with regular catches of adults, but spawning has not yet been confirmed (although it may have been observed).
- Blue shading indicates the Detected Zone, areas where adult fish are occasionally, but not consistently, captured. The distribution of fish in the blue-shaded areas should not be considered uniform throughout those reaches.

The boundaries between these population categories within river reaches are dynamic and can change over time, underscoring the need for ongoing monitoring to collect data to inform an accurate assessment of population status. It is important to note that a collection of an individual invasive carp in a new location that is defined in this report as a range expansion does not indicate that the species has become established in that particular location.

A detailed summary of invasive carp monitoring and assessment activities conducted by partner agencies within the UMRB and ORB in 2018 is provided in Section 3.0 (Federal Agency and Cooperative State/Non-Governmental Partner Activities to Control the Spread of Asian Carp in the Upper Mississippi River and Ohio River Basins).

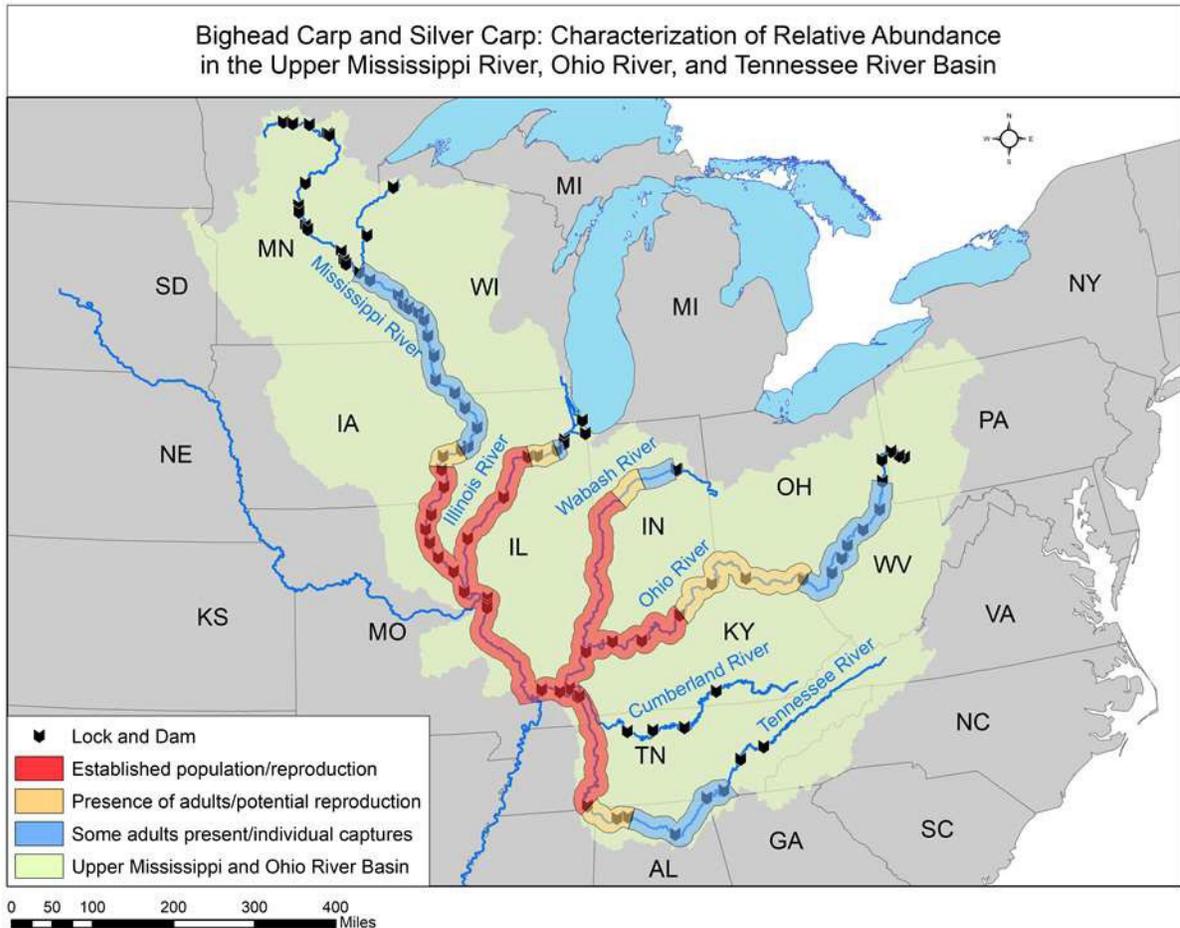


Figure 5. Characterization of relative abundance of bighead carp and silver carp in the UMRB, ORB, and IWW/CAWS as of 2018.

2.3 INFORMING INVASIVE CARP MANAGEMENT ACTIONS

Information on invasive carp population status is used to inform partnership management strategies within each basin. Specific, targeted projects are developed to address bighead and silver carp populations, as characterized at differing levels of invasion and establishment within the three different color zones depicted in Figure 5.

Management actions conducted within the Established Zones (red zones in Figure 5) focus on reducing the abundance of adult bighead and silver carp through physical capture and removal, including from areas near lock and dam complexes that may act as partial barriers to the movement of fish. For example, reducing the number of fish below locks and dams (i.e., propagule pressure) lowers the numbers of fish likely to migrate upstream into the Transitional Zone (orange zone in Figure 5) where reproducing populations have not yet fully established. Additional effort is being directed to quantitatively evaluate the extent of fish passage, including both invasive carp and native species, at lock and dam structures between the established and transitional zones. Further, pilot studies are being conducted to evaluate the

potential effectiveness of deterrent technologies (e.g., acoustic barriers) deployed at lock and dam structures to serve as barriers to fish movement. Additional detailed maps showing navigation pools, and lock and dam structures of the mainstem Upper Mississippi River, Ohio River, Cumberland River and Tennessee River are included in Appendix 2.

Within the Transitional Zone (orange zones in Figure 5), priority actions focus on reducing the risk that invasive carp will reach sufficient abundances to establish reproducing populations. This includes conducting intensive monitoring and assessment of all life stages to clearly define and understand when and where bighead and silver carp are reproducing, and focused capture and removal efforts. Because annual variability in environmental conditions and other factors can strongly influence invasive carp reproductive success across years, understanding the geographic boundary and extent of invasive carp establishment requires ongoing focused monitoring. Similar to efforts in the Established Zone, considerable effort is directed at removing invasive carp from the Transitional Zones to reduce the abundance of adults and minimize the potential for fish to successfully spawn and subsequently increase upstream range. To inform and improve the efficiency of these efforts, studies are being conducted to understand the timing and extent of bighead and silver carp movements.

Between the Transitional and Detected zone (blue zones in Figure 5), additional work is being conducted to evaluate the potential for additional deterrent barriers to prevent bighead and silver carp from becoming established in areas where only individual fish have occasionally been collected. The primary goal and management actions within these reaches are surveillance, monitoring, and removal. Collection of a bighead or silver carp within the Detected Zone may result in collaborative response action, with multiple agencies intensively sampling the area to determine if additional invasive carp are present.

3.0 FEDERAL AGENCY AND COOPERATIVE STATE/NONGOVERNMENTAL PARTNER ACTIVITIES TO CONTROL THE SPREAD OF INVASIVE CARP IN THE UPPER MISSISSIPPI AND OHIO RIVER BASINS

3.1 BASINWIDE PLANNING FOR INVASIVE CARP MANAGEMENT

Development of long-term strategies and annual research and management work plans in the UMRB and ORB are coordinated through collaborative federal and state agency partnerships organized under MICRA (Figure 6). Development of strategies and annual activities focused on protection of the GLB from invasive carp are coordinated under the ACRCC (Figure 7).

The MICRA 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/White rivers); and representatives from several key federal agency partners including the USFWS, USGS, USACE, NPS, and Tennessee Valley Authority. The multiple invasive carp sub-basin partnerships work together through MICRA and the ACAC to develop a unified, basin-wide perspective on invasive carp management across the MRB. MICRA works with its partnerships to identify high-priority invasive carp management needs for the MRB, which are reflected in the annual Asian Carp Monitoring and Response Plan for the Mississippi River Basin.

Six states collaboratively manage interjurisdictional fisheries in the mainstem Ohio River through the ORFMT. In 2014, the ORFMT formed an ORB Asian carp partnership comprised of federal and state agency partners. Universities assisting the partnership and other non-governmental conservation organizations in the basin participate as cooperating entities. Partners in the ORB subsequently developed the ORB Framework. Implemented in 2014, the ORB Framework supplements the National Plan by providing additional strategic guidance and coordination for developing prioritized and complementary actions to support management goals and collaborative efforts to manage invasive carp in the ORB.

The UMRCC is a five-state partnership that promotes cooperation between the conservation agencies on the Upper Mississippi River sub-basin. The UMRCC engages federal and state agencies and other partners through supporting technical committees to collaboratively address fishery and mussel management, recreation, wildlife, water quality, vegetation, education, and law enforcement issues. The UMRCC, through the broad membership of the Fisheries Technical Committee, implements the Asian Carp Control Strategy Framework for the Upper Mississippi River Basin, another step-down plan of the National Plan.



Figure 6. Organizational structures of MICRA, ORB, and UMRB sub-basin partnerships.

The ACRC is a partnership of 28 U.S. and Canadian federal, state, provincial, tribal, and local agencies and organizations working to prevent the introduction and establishment of invasive carp populations in the Great Lakes. The ACRC coordinates the invasive carp management and research efforts of its members through an annual Asian Carp Action Plan. The 2018 Asian Carp Action Plan includes a comprehensive portfolio of 43 projects, including early detection and monitoring, contingency response planning, prevention and control (including addressing permanent and temporary pathways), new technology development, law enforcement, and partner and stakeholder communication and outreach. The work of the ACRC focuses primarily 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 ACRC partnership structure includes a Federal Executive Committee, consisting of the eight U.S. Federal agency partners; the Monitoring and Response Work Group (MRWG), co-chaired by the Great Lakes Fishery Commission (GLFC) and Illinois Department of Natural Resources (ILDNR); and a Communication Work Group, co-chaired by USFWS and ILDNR. The MRWG, comprised of technical and scientific experts on invasive carp life history, prevention, and control from ACRC member agencies, develops an annual

Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System (MRP). The MRP complements the Asian Carp Action Plan, and serves as the comprehensive tactical, on-the-ground annual work plan, with a primary focus on the IWW/CAWS.

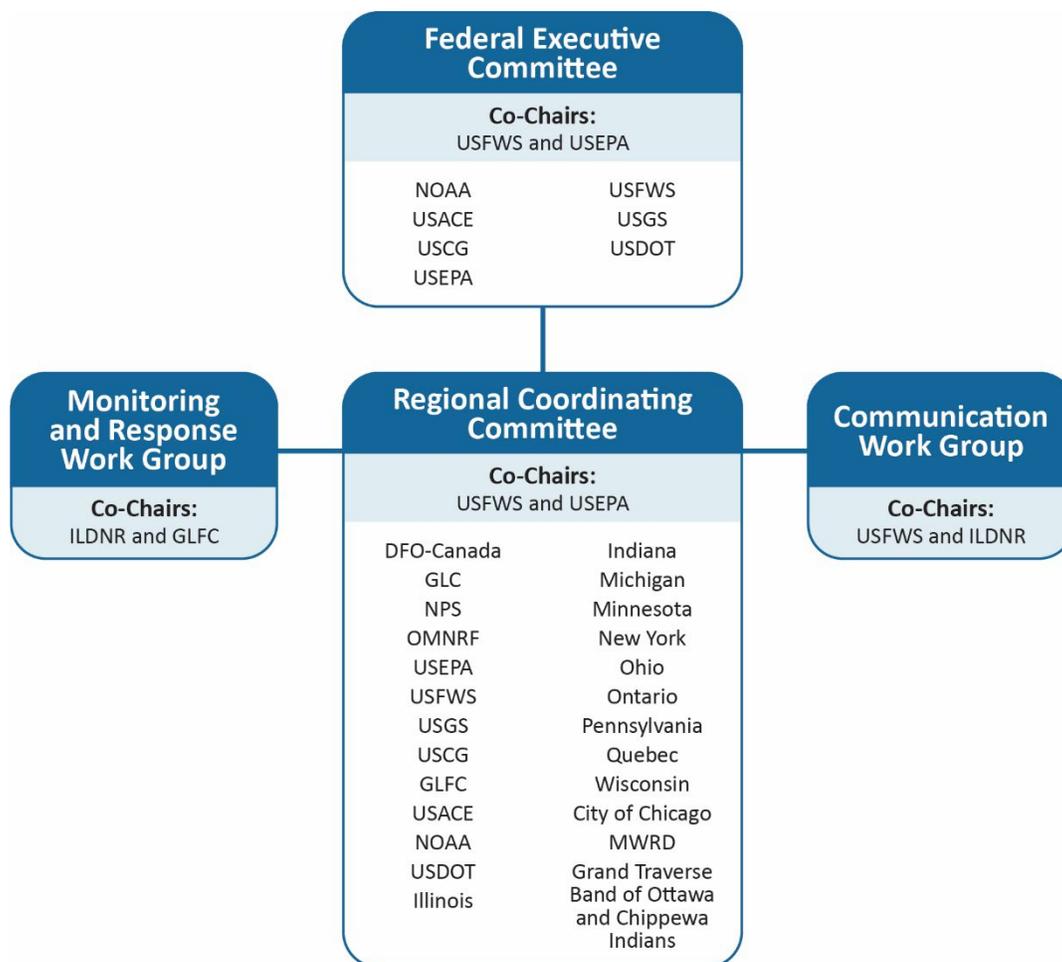


Figure 7. Organizational structure of the ACRCC partnership.

3.2 2018 FEDERAL, STATE, AND NONGOVERNMENTAL PARTNERSHIP ACCOMPLISHMENTS

The following sections provide summaries of the numerous invasive carp management activities and accomplishments achieved within each sub-basin (ORB, UMRB, and IWW/CAWS) in support of partnership strategies. More comprehensive individual federal and state agency summary reports on invasive carp management activities conducted in 2018 are available at: www.micrarivers.org and www.invasivecarp.us. The 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin, a compilation of work plans developed for ORB and UMRB projects that received funding from USFWS in FY2018, is available at: <http://micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>. The 2018 Asian Carp Monitoring and Response Plan Interim Summary Report, a summary of work conducted primarily in the IWW/CAWS, is available at: <https://www.asiancarp.us/Documents/MRP2018.pdf>.

3.3 OHIO 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.**

In FY 2018, federal and state agencies continued coordinated strategic action in the ORB and tributaries (including the Tennessee River) focused on controlling invasive carp populations and preventing further range expansion. ORB interagency coordination included the MICRA Asian Carp Advisory Committee, Ohio River Sub-basin Planning Team, and Ohio River Asian Carp Technical Team. Additionally, the Tennessee River Telemetry Workgroup continued to address priority coordination and technical needs on behalf of the broader partnership. ORB invasive carp management actions supported the goals of the National Plan as well as the priorities of the Ohio River Basin Asian Carp Control Strategy Framework (ORB Framework), the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin (MRPMB), and state agency invasive carp management strategies, including the state of Ohio's Asian Carp Tactical Plan: 2014-2020 (Tactical Plan).

The ORB Framework was previously 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 invasive carp. Additionally, ORB federal and state partner agencies participated in the Mississippi River Basin Panel on Aquatic Nuisance Species (MRBP), the Lower Mississippi River Conservation Committee, and ACRC planning meetings for further collaboration on invasive carp issues in 2018.

The USFWS continued coordination with the MICRA and ORB federal and state agency partners to identify annual ORB sub-basin priorities for funding consideration, based on available resources. Projects were identified and developed for early detection monitoring, monitoring and assessment, control and removal, and containment actions in the 2018 MRPMB (<http://www.micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>).

2018 ORB MRPMB projects (listed by FY 2018 project title) included:

- Early Detection and Evaluation of Asian Carp Removal in the Ohio River
- Abundance and Distribution of Early Life Stages of Asian Carp in the Ohio River
- Control and Containment of Asian Carp in the Ohio River
- Quantifying Lock and Dam Passage, Habitat Use, and Survival Rates of Asian Carp in the Ohio River
- Relative Population Densities and Movement of Asian Carp in the Tennessee and Cumberland Rivers, Tributaries of the Ohio River
- Deterrent Strategy Planning for Asian Carp in the Ohio River Basin

Final summary reports for these projects can be found at: www.micrarivers.org/asian-carp-plans-and-reports/ (see Ohio River Basin Annual Summary Reports).

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.**

Invasive Carp Telemetry Monitoring

In 2018, ORB agencies continued collecting key information on invasive carp largescale movements (e.g., across locks and dams) and fine-scale movements (e.g., habitat use) using acoustic telemetry. This technology tracks the movement of fish by tagging them with transmitters that emit ultrasonic sound pulses unique to each individual. Multi-agency acoustic telemetry efforts supported the Ohio River Asian Carp Telemetry Project (Telemetry Project) and overall monitoring goals within the ORB.

The USFWS, Indiana Department of Natural Resources (INDNR), Ohio Department of Natural Resources (ODNR), Kentucky Department of Fish and Wildlife Resources (KDFWR), and West Virginia Division of Natural Resources (WVDNR) tagged an additional 19 invasive carp with ultrasonic transmitters within the Markland Pool of the Ohio River. Two additional telemetry receivers were deployed in the upper lock approach channel and upper spillway area of McAlpine Locks and Dam at Louisville, Kentucky to help determine invasive carp passage routes. From October 2017 to September 2018, nearly 9.5 million telemetry detection data points were recorded.

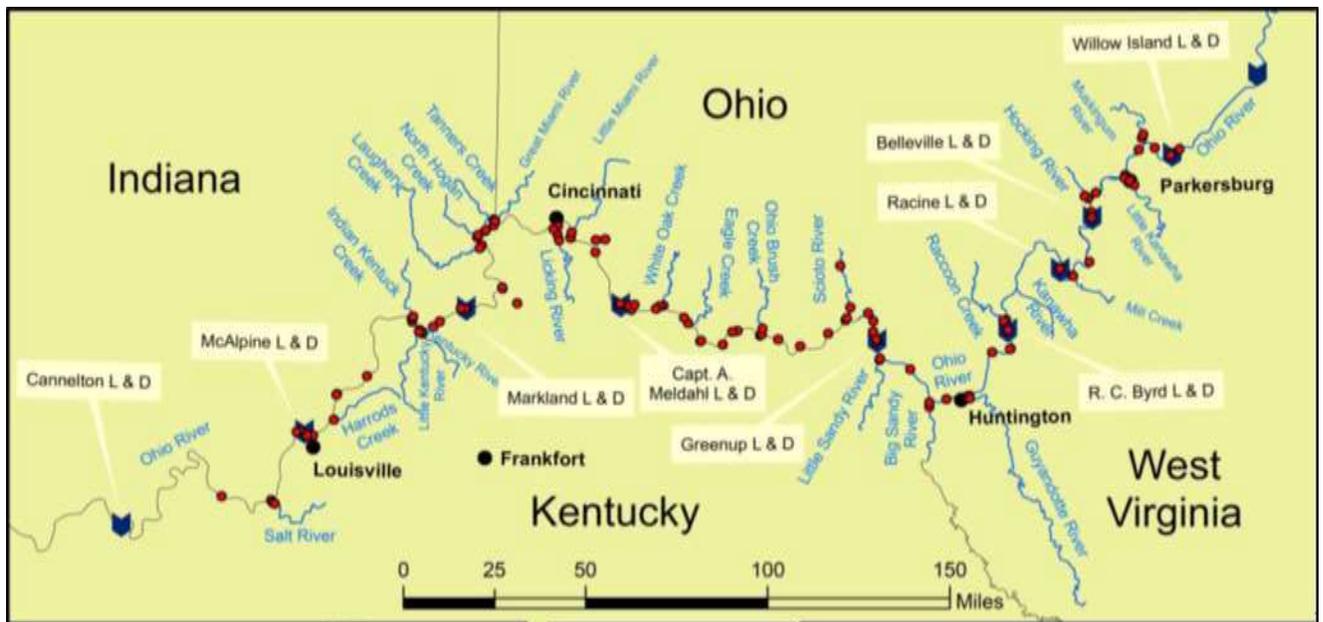


Figure 8. Location of fishery acoustic telemetry receivers in the Ohio River.

As of 2018, the Telemetry Project included 150 stationary receivers (Figure 8, red circles) and 523 tagged invasive carp, of which 19 tags were expected to expire in summer 2018. A total of 244 tagged fish were detected on stationary receivers during 2018. Analysis of the telemetry data revealed that approximately 73% of bighead carp and 78% of silver carp exhibited a net movement of five miles or less both upstream and downstream from their first detection location, with the majority of invasive carp tagged in this study remaining in the Ohio River pool in which they were tagged in 2018 (Figure 9).

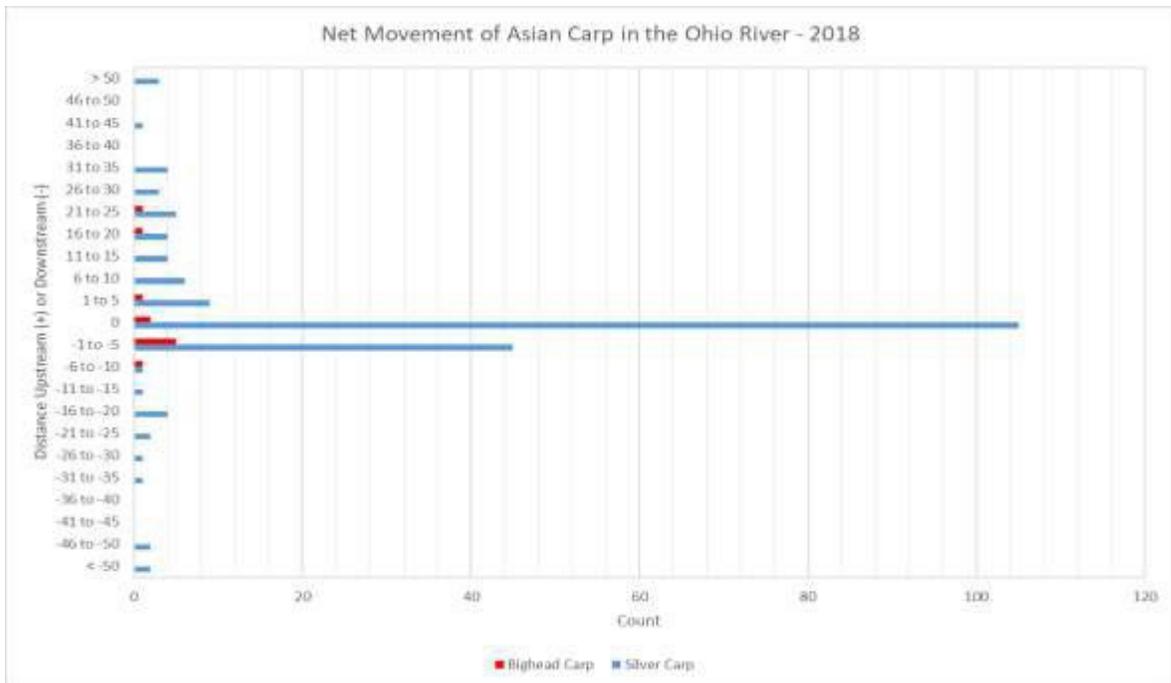


Figure 9. Net upstream (+) and downstream (-) movement in miles of invasive carp in the Ohio River between first and last detection in 2018.

Pool-to-pool transition probabilities were estimated for silver and bighead carp. This analysis included the identification of dams that allow passage more readily, providing managers key information to inform future placement of invasive carp deterrence efforts (e.g., deterrence barriers). Telemetry data was used for the first time in 2018 to estimate annual population survival rates, with silver carp estimates at 65% and bighead carp at 68%. This level of invasive carp survival is expected with relatively low harvest rates of invasive carp to date in the Ohio River. As contract fishing efforts increase in the Ohio River, survival rates are expected to decrease. Continued assessment of invasive carp movements planned for 2019 include a focus on evaluating factors that potentially influence upstream movement, range expansion, and lock and dam passage.

The current array of stationary receivers established in the Ohio River continues to provide useful data on the movement of invasive carp. However, the 150 receivers in the array require routine download of data by field personnel, resulting in a time lag in detecting the passage of a tagged fish at any stationary receiver location. Installing real-time receivers at strategic locations is allowing for the instantaneous detection of invasive carp passage, which can subsequently be used to inform response efforts or more immediately assess the timing of movements related to spawning events. The USGS, in collaboration with partners, previously initiated real-time telemetry sites in 2016 to detect tagged invasive carp in the Ohio River at Louisville, KY, and Ironton, OH. Data are reported through the USGS FishTracks website (http://il.water.usgs.gov/data/Fish_Tracks_Real_Time/) and are included in the USGS shared database and visualization tool developed for invasive carp telemetry data. This effort continued through 2018. Further details on this project can be found in the 2018 annual summary report Distribution, Movement, and Lock and Dam Passage of Asian Carp in the Ohio River through Acoustic Telemetry (<http://www.micrarivers.org/wp-content/uploads/2019/06/2018-OHR-Telemetry-AIR-1.pdf>).

The Tennessee River Telemetry Work Group (TRTWG), formed in 2016, continued to coordinate telemetry efforts throughout the Tennessee River sub-basin to assess movement of invasive carp through

dams and inform removal efforts. The TRTWG created a work plan focused on increasing the number of tagged silver carp and developing a stationary receiver array upstream of Kentucky Lake, including locations in the Tennessee-Tombigbee Waterway (TTW) in Mississippi. Completed in the early 1980s, the TTW is a 234-mile man-made navigation canal with a series of ten lock-and-dam impoundments that connects the Tennessee River at Pickwick Lake to the Black Warrior/Tombigbee River system in Alabama, eventually leading to Mobile Bay. Mississippi Department of Wildlife, Fisheries and Parks (MDWFP), in collaboration with USFWS and Tennessee Tech University, continued monitoring in 2018 to evaluate the potential for the inter-basin transfer of invasive carp from the Tennessee River basin to the Mobile River basin via the TTW. The TRTWG also expanded the stationary receiver array to include all locks and dams on the mainstem of the Tennessee River and some major tributaries. As of 2018, this array consisted of 44 receivers. An array consisting of six stationary receivers was also deployed in the Cumberland River surrounding Barkley Lock and Dam to quantify passage of invasive carp through the lock chamber. Thirteen stationary receivers were previously deployed in Kentucky Lake, the lowermost reservoir and upstream extent of established range of invasive carp on the Tennessee River. During 2018, the total number of silver carp tagged with acoustic transmitters in the Tennessee River and Cumberland River systems was increased to 252, supporting a more robust invasive carp telemetry evaluation in those waters.

eDNA Monitoring

Genetics-based eDNA surveillance serves as an efficient early detection monitoring tool to help identify specific locations where additional targeted sampling or rapid response actions focused on invasive carp capture and removal may be warranted. In the event of a preliminary positive finding of invasive carp genetic material, traditional fishery sampling gears and methods such as gill netting, trap netting, and electrofishing may be deployed. In 2018, the USFWS continued eDNA sampling within the ORB for early detection of silver carp and bighead carp. Efforts included collection and processing of 790 samples in the mainstem Ohio River and its tributaries, including the Tennessee River, Muskingum and Little Kanawha Rivers. None of the samples tested positive for silver carp or bighead carp eDNA.

Gill netting was conducted in November 2017 in the Montgomery Slough, a shallow backwater channel on the Ohio River in Pennsylvania, based on earlier eDNA results that included one positive finding for bighead carp at that location. No invasive carp were captured during this effort. Additional gill netting was performed in a backwater area of the Allegheny River (Ohio River tributary), which also resulted in no invasive carp being collected.

Further details on the agency eDNA monitoring efforts in the ORB and other basins can be found at: <https://www.fws.gov/midwest/fisheries/eDNA.html>.

Traditional Gear Sampling

In 2018, the ORB agencies continued coordinated monitoring and assessment of invasive carp within mainstem rivers, tributaries, and reservoirs. Efforts included assessing the abundance, distribution, and habitat use of adult, juvenile, and larval invasive carp in targeted waters of the ORB, such as detecting the furthest upstream extent of reproducing populations and increased sampling for early life stages (e.g., eggs and larval fish). Multi-agency monitoring efforts supported priorities of the 2018 MRBMRP, including the Early Detection and Evaluation of Asian Carp Removal in the Ohio River (EDEAC) and Abundance and Distribution of Early Life Stages of Asian Carp in the Ohio River projects.

The EDEAC includes baseline work to evaluate potential invasive carp management actions by measuring changes in distribution and relative density through targeted sampling, evaluate potential indirect impacts on native fish communities in response to actions, and evaluate invasive carp presence in upstream areas. KDFW and WVDNR co-led the EDEAC, coordinating with USFWS, PFBC, INDNR, and Ohio River Valley Water Sanitation Commission (ORSANCO). In 2018, targeted sampling for invasive carp was conducted in the six pools in the middle Ohio River upstream of the Cannelton Lock and Dam complex (Cannelton, McAlpine, Markland, Meldahl, Greenup, and R.C. Byrd) using a variety of gears. Electrofishing and gill netting were also utilized during spring and fall (2017 through 2018) at fixed sampling sites to collect key biological data.



Figure 10. The Ohio River from the Cannelton to RC Byrd Pool with corresponding establishment status for silver carp populations as of 2018, based on standard sampling and project data from the Ohio River Basin.

In support of the EDEAC, KDFWR monitored four of the targeted pools during 2018. Data collected from spawning female invasive carp captured in ORB tributaries in 2017 were used to inform and refine targeted removal for population control efforts conducted during spring and summer 2018. During these monitoring efforts, silver carp were detected up to the Markland pool, bighead carp were detected in the Cannelton pool, and grass carp were detected up through the Greenup Pool. Invasive carp catch rates remained significantly higher in downriver pools (Cannelton and McAlpine) when compared to upriver locations (Markland, Meldahl, and Greenup) (Figure 10) with no apparent shift in population ranges since last reported in 2017. These sampling efforts resulted in the removal of approximately 1,000 pounds of invasive carp. Analysis of bighead and silver carp captured in the ORB show similar condition (length-weight relationship) to fish from other basins, indicating comparable growth patterns.

WVDNR conducted monitoring within the Greenup and R.C. Byrd pools in 2018. Boat electrofishing (18.4 hours total effort) and gill netting (64.6 hours total effort) were conducted in fall 2017 and spring 2018 sampling. Three bighead carp were captured in gill nets during monitoring in Raccoon Creek in the R.C. Byrd Pool. Additionally, three grass carp were collected in the Greenup Pool, and an additional three grass carp were collected in the R.C. Byrd Pool. All nine invasive carp captured during this sampling were euthanized, and bony structures removed and preserved for age and growth analysis.

Additional targeted sampling for invasive carp was conducted in Pennsylvania waters in November 2017, including gill netting in the Montgomery Island Pool of the Ohio River, and backwater habitats of the Allegheny River. No invasive carp were captured during these efforts.

In the Tennessee River and Cumberland River drainages, additional field activities were conducted to determine the relative population densities of invasive carp. KDFWR implemented standardized sampling and mark-recapture projects in the Kentucky Lake and Lake Barkley reservoirs of the Tennessee and Cumberland River systems, respectively, to estimate invasive carp abundance. TWRA and partners also assessed the relative abundance of invasive carp in the Kentucky, Pickwick, Barkley, and Cheatham reservoirs, including reservoir dam tailwaters, to inform the potential risk of upstream invasion from the Established Zones, and to determine the leading edge of invasive carp. Additional invasive carp monitoring was conducted within the Tennessee River drainage by MDWFP, in collaboration with USFWS and Tennessee Tech University, using electrofishing and gill netting on the TTW and Pickwick Lake. A total of 10 silver carp captured on Pickwick Lake were tagged and released for evaluation of their potential movement between Pickwick Lake and the TTW (previously described above under Telemetry).

In support of the interagency project Abundance and Distribution of Early Life Stages of Asian Carp, USFWS, KDFWR, WVDNR, IDNR and West Virginia University (WVU) collaborated to conduct targeted sampling for earlier life stages of invasive carp in select waters. This work was informed by results from prior studies confirming the presence of invasive carp yolk-sac larvae, post yolk-sac larvae, and eggs as far upstream as the Meldahl pool on the Ohio River. Data on the presence and abundance of eggs and larvae is critical for informing agencies on the location and status of naturally-reproducing populations in the ORB. Work in 2018 included extensive ichthyoplankton sampling and investigated geographic range and potential factors influencing invasive carp reproduction and recruitment. A total of 120 samples were taken in the Cannelton and McAlpine pools using a conical ichthyoplankton tow deployed at three locations from May through July 2018. Additional sampling was conducted in the Greenup and R.C. Byrd pools. All collected samples were sent to WVU for analysis. Data from this effort were used to document detections of invasive carp larvae in the Ohio River up to the Kentucky River as of 2018. Additional details on the Abundance and Distribution of Early Life Stages of Asian Carp in the Ohio River project are available at: <http://www.micrarivers.org/wp-content/uploads/2019/06/2018-OHR-Early-Life-History-AIR.pdf>.

Detections of black carp continued to increase in 2018, underscoring the importance of additional sampling effort to document the extent of establishment and to inform potential management actions. In 2018, survey efforts in the ORB focused on black carp detection by targeting the species' known preferred habitat types. The USFWS and KDFWR conducted targeted sampling in the lower Ohio River, Tennessee River, and Cumberland River, during which no black carp were captured. However, commercial fishers captured and reported four black carp in Lake Barkley and one in Kentucky Lake. These captures marked the furthest upstream known presence of black carp in the ORB as of the end of the 2018 reporting period.

Rapid Response

Prior to 2018, ORB agencies established a process under which credible reports of invasive carp above the R.C. Byrd Lock and Dam would result in a coordinated rapid response and removal effort. It was subsequently determined that a more scheduled, systematic removal process should be used to target fish during the timeframe when they are sighted in the lock and dam area at specific locations in or above

the R.C. Byrd Pool. This recommendation acknowledged the challenge of effectively capturing invasive carp through a rapid response action following a sighting or capture.

Telemetry tracking of invasive carp was conducted in summer 2018 with the intent of using tracking information to target the removal of bighead carp potentially aggregated and moving with tagged fish. Fish were not located in time to effectively conduct targeted removal at locations informed by telemetry tracking data.

In 2018, the KDFWR successfully conducted a removal response at the R.C. Byrd Lock and Dam after initial reports of invasive carp observations. Crews utilized overnight gill netting to capture two adult bighead carp over three days of sampling. KDFWR biologists extracted otoliths from the collected fish, which were provided to WVDNR for aging. Coordination between partners, including KDFWR, ODNR, WVDNR, and the USACE R.C. Byrd Lock Master were instrumental in planning the response actions, ensuring access to waterways across jurisdictions. The USACE and other credible reporting sources in this area have since formed an agreement to inform ORB partners if additional bighead carp are detected above the R.C. Byrd Locks and Dam. Additionally, the KDFWR utilizes reports from bow fishing tournaments, marina operators, and anglers to determine specific locations in tributaries and embayments where high densities of carp are observed, leading to refinement of removal efforts to include new locations and additional nighttime sampling.

In fall 2017, IDNR confirmed the capture of silver carp in the Turtle Creek Reservoir in Sullivan County, Indiana. This inland reservoir is located close to the Wabash River and is managed by a local power company. Water is drawn for use in cooling the plant, including from the Wabash River (in which invasive carp are present), which likely led to the silver carp introduction.

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.**
- **NATIONAL GOAL: Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carp in the United States.**

Invasive Carp Capture and Removal

ORB agencies continued to deploy traditional fishery capture gears to detect and remove invasive carp in the mainstem rivers, navigation pools, and select tributaries of the ORB in 2018. Agencies collaborated on detection and removal efforts under the Control and Containment of Asian Carp in the Ohio River project (CCACP). Specific objectives included strategically removing invasive carp from the ORB system and reducing propagule pressure (or the likelihood of population growth and subsequent dispersal) in the lower pools to prevent further expansion upriver. Because capture and removal efforts along invasive carp population fronts can become increasingly challenging at lower population densities, agencies used telemetry data, angler reports, and other fishery stock-related information to identify locations where invasive carp were most likely to congregate. Use of this information allowed agencies to identify optimal timing and placement of removal efforts and maximize effectiveness.

In 2018, the KDFWR conducted over 700 hours of capture and removal effort in the Ohio River using traditional fishery gears. The majority of effort focused on the lower (downstream) pools within the CCACP project range (Cannelton and McAlpine pools). Strategic adjustments (e.g., time of year, river

level changes, water temperatures, and site specificity) were used to reduce the number of days needed to conduct removal. Crews harvested over 50,000 pounds of invasive carp, an increase of approximately 150% in harvest compared to 2017 efforts. Agencies also conducted targeted removal efforts in the R.C. Byrd Pool, using boat electrofishing and gill netting. Areas of focus included Raccoon Creek, and the proximity of the R.C. Byrd Lock and Dam. One bighead carp was removed by KDFWR as a result of these efforts.

During fall 2017, ORB agencies deployed hydroacoustics to better locate and target invasive carp for capture and removal. These efforts demonstrated the potential for use of this technology to identify large groups of overwintering fish in locations that can be regularly targeted and fished through the winter months. Most fish harvested were silver carp, comprising 95.1% of the total fish landed during removal efforts. Additional details on the CCACP are available at: <http://www.micrarivers.org/wp-content/uploads/2019/06/2018-OHR-Control-and-Containment-AIR.pdf>.

The Asian Carp Harvest Program (ACHP) was initiated by KDFWR in 2013 to allow commercial fishing targeting invasive carp in previously restricted areas, including Kentucky Lake and Lake Barkley. Commercial fishers are required to submit daily harvest logs and allow KDFWR staff to routinely accompany them to monitor bycatch (ride-along project), providing an additional source of valuable data on invasive carp population status and demographics. To strategically direct and encourage commercial harvest in these locations, the KDFWR previously instituted a \$0.05/pound incentive for harvest of silver and bighead carp in Kentucky Lake and Lake Barkley. In 2018, the KDFWR worked with the industry to utilize intensive harvest as a key control strategy, and to identify existing impediments to increased harvest in select locations. The KDFWR also monitored the commercial harvest of invasive carp in Kentucky to evaluate the impacts of the ACHP on sportfish species and to determine invasive carp demographics in Kentucky Lake.



Figure 11. Bighead carp captured by commercial anglers in Barkley Lake, Kentucky. Photo courtesy of Paul Rister/Kentucky Department of Fish and Wildlife Resources.

From 2013 to the end of the 2018 reporting period, the ACHP supported removal of over 5 million pounds of invasive carp from Kentucky waters, with approximately 1.16 million pounds harvested from October 2017 through September 2018. In 2018, the KDFWR monitored the commercial catch in Kentucky waters by compiling monthly reports from commercial anglers, and by providing KDFWR staff to accompany commercial fishers participating in the ACHP on-board their vessels on 31 occasions. In total,

approximately 1.4 million pounds of silver carp and 61,829 pounds of bighead carp were harvested from Kentucky waters. TWRA provided additional assistance to support commercial fishing infrastructure for invasive carp removal in Kentucky Lake and Lake Barkley, including supplying netting to commercial fishers.

The KDFWR monitored silver carp demographics (including size and age structure) in Lake Barkley to assess the effects of ongoing commercial harvest on fish population characteristics. Additionally, biological and morphometric analyses were conducted on 361 silver carp captured in Lake Barkley through commercial harvest. Results showed that silver carp in Lake Barkley were physically larger than populations in other watersheds (Wabash, Illinois, and Mississippi rivers), have similar condition, grow very fast (triple in length between age 0-1), do not represent all age classes (suggesting variable reproduction), and exhibit mortality rates similar to populations with substantial commercial harvest (Illinois River). Accordingly, the KDFWR determined that the level of commercial harvest of silver carp in Kentucky Lake and Lake Barkley conducted in 2018 was not adequate to provide a sufficient level of control without additional measures.

In support of the ACHP, the KDFWR conducted meetings with commercial fishers and processors to provide updates on operations of the program, conducted assessments to identify limiting factors to the harvest of invasive carp, planned projects to develop new gear types for invasive carp capture, and conducted ongoing projects that require cooperation with commercial fishers such as the ACHP ride-along project and Kentucky Lake invasive carp demographics project.

Actions to Address Pathways

The ODNR and USACE continued efforts to address the highest-priority secondary hydrologic interbasin pathways in Ohio, as identified through the GLMRIS Focus Area 2 Aquatic Pathways Assessment Summary Report. These pathways are temporary hydrologic connections that form between the ORB and GLB during episodes of high-water or seasonal flooding, allowing for the potential dispersal of invasive carp. The GLMRIS Aquatic Pathway Assessment Reports identified several intermittent pathways in Ohio as having a “Medium” probability of transfer of invasive carp and other aquatic invasive species (AIS) from the MRB (via the ORB) to the GLB. In 2018, the USACE and ODNR coordinated to evaluate long-term options for the closure of GLMRIS pathways in Ohio, including those identified at the Ohio-Erie Canal, Little Killbuck Creek, and Grand Lake St. Mary’s.

Planning and coordination activities conducted in 2018 to support the GLMRIS pathway closure projects in Ohio included: 1) receiving all environmental permits and approvals required; 2) facilitating the execution of a cultural resources Memorandum of Agreement between multiple parties (including the Ohio State Historic Preservation Office); 3) finalizing project plans and designs in coordination with multiple landowners and project partners; 4) receiving real estate rights of entry for construction from multiple property owners; 5) preparing bid documents, reviewing contractor bids, and awarding a contract to local firm; and 6) preparing and distributing a project communications plan and related press releases.

For the Ohio-Erie Canal project, the USACE awarded a contract for work to close the GLMRIS interbasin connection. Closure actions identified include construction of a berm along a portion of the canal to prevent interbasin hydraulic connection during flooding events and installation of screening structures and the Long Lake flood and feeder gates.

In support of pathway closure at Little Killbuck Creek, at the request of the USEPA, the USACE-Buffalo

District initiated a peer review of a report completed by an engineering company for the ODNR. This report provided an analysis of structural measures to close the potential AIS surface water connection between the Ohio River watershed and the Lake Erie watershed in Medina County, Ohio; a low-gradient, predominantly agricultural-use area prone to flooding. The USACE team initiated evaluation of the design report, including providing potential alternative designs that would achieve the project purpose for less cost.

For the Grand Lake St. Mary's GLMRIS pathway, the ODNR had previously made modifications at St. Mary's State Fish Hatchery to allow continued use of lake water without the risk of invasive carp transfer to the GLB (Lake Erie basin). A design for the final phase for closing the connection at Grand Lake St. Mary's was initiated, with the final design to be completed in 2021 and the screening structure scheduled for installation in 2022 to complete this connection closure.

Additionally, USGS conducted ongoing monitoring at the Eagle Marsh (Indiana) GLMRIS pathway site. In 2016, the construction of a permanent barrier at Eagle Marsh in Fort Wayne, Indiana, between the GLB and MRB eliminated the pathway for invasive carp migration from the Wabash River to Lake Erie. Bighead carp currently occupy the Wabash River watershed. In 2017 and 2018, following barrier construction, the USGS operated streamflow gauges and a webcam at the site to provide sufficient data to monitor and evaluate water levels in response to rainfall, and to simulate barrier integrity and flooding relative to seasonal high flow conditions. The webcam was used to monitor flood conditions that could result in the potential interbasin transfer of invasive carp during episodic high flows between the Graham McCulloch Ditch (Wabash River Basin/MRB) and Junk Ditch Basin (Maumee River Basin/Lake Erie).

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.**

Development of New Deterrent Technologies

The ORB agencies conducted research to inform and assess the potential implementation and operation of invasive carp barriers, with a focus on limiting their dispersal at locks and dam structures as strategic "pinch points." Actions included scoping and project development for large-scale field pilot studies of potential deterrent systems; assessing the distribution, movement, and lock and dam passage of invasive carp in the Ohio River through acoustic telemetry; and evaluating and recording the movement and lock and dam passage of invasive carp in the Tennessee River. Collaborative interagency planning was further facilitated through the Deterrent Strategy Planning for Asian Carp in the Ohio River Basin project (DSPORB project), a priority of the 2018 MRBMRP. Primary objectives of this planning effort were to characterize the need and identify priority locations for deterrent placement in the ORB, including the Tennessee and Cumberland rivers (Figure 12), and enhance the collection of key baseline data describing the movement of fish among reservoirs and pools to help inform deterrent placement and future deterrent efficacy evaluation.

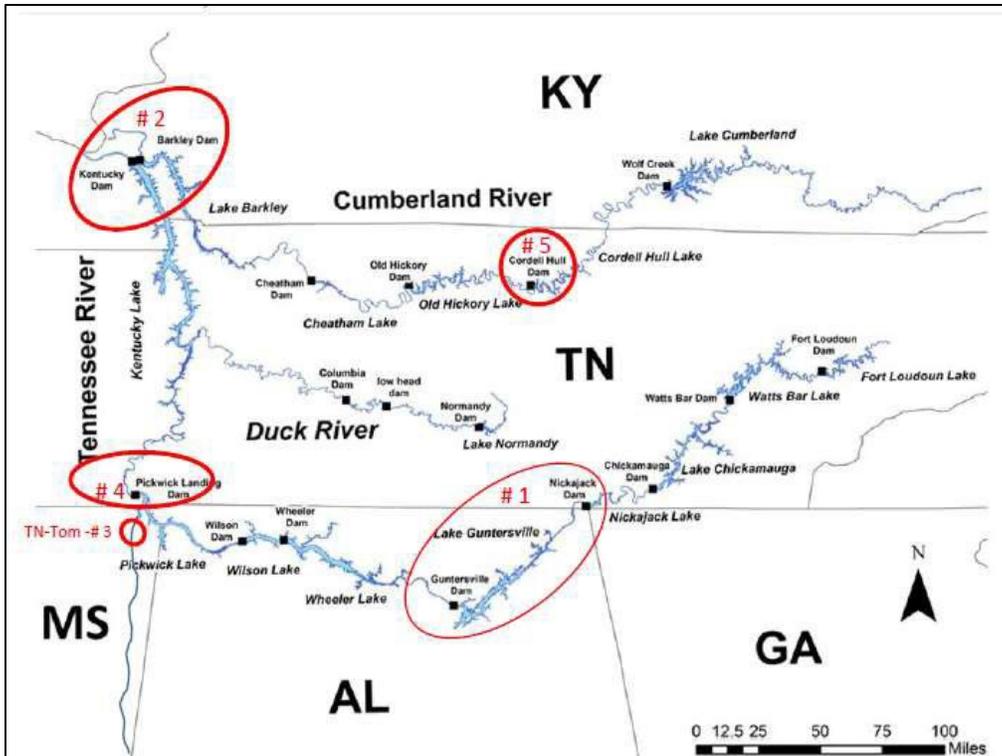


Figure 12. Proposed locations of potential invasive carp barriers identified through planning in 2018 (numbers indicate rank within these high priority sites).

A summary report for DSPORB project is available at: <http://www.micrarivers.org/wp-content/uploads/2019/06/2018-TNCR-Deterrents-AIR.pdf>

Acoustic Deterrent Barriers

The USFWS, USACE, USGS, KDFWR, and other partners comprising an interagency Asian Carp Acoustic Deterrent planning group continued to develop a comprehensive study design for guiding research on deterrent barrier efficacy, focused on implementing a large-scale project at a test location on the Cumberland River in Kentucky. Informed by recommendations from the first interagency Asian Carp Sound Deterrent Workshop Coordination and Planning Meeting held in 2016, potential strategic locations (“pinch points”) were identified in river systems where invasive carp are only able to swim upstream through a lock chamber because the height of the adjoining dam structure makes it impassable. Barkley Lock on the Cumberland River in Kentucky was identified as a potential field trial site for quantitatively evaluating acoustic barrier technology based on meeting suitable criteria for the pilot studies. A Bio-Acoustic Fish Fence (BAFF) deterrent system was selected for test deployment at Barkley Lock. The BAFF system generates a combination of sound and bubbles as a barrier. This project is further referenced in Section 3.4.4 (IWW/CAWS, Research and Development, Development of New Deterrent Technologies - Acoustic Deterrents). Additional information on the BAFF project is available at: <https://www.fws.gov/southeast/pdf/frequently-asked-questions/lake-barkley-bio-acoustic-fish-fence.pdf>.

Development and Testing of New Capture Gears and Techniques

ORB agencies continued development and testing of fishery gears focused on improving the ability to detect and capture invasive carp of all life stages. The IDNR built and tested a surface trawl designed for

sampling juvenile invasive carp. This gear will be deployed to sample locations within river basins where invasive carp reproduction and recruitment is evident through the capture of juvenile fish.

Likewise, the KDFWR designed and built a large, collapsible trap net for use in flooded tributaries and embayments where fish could be herded into the entrapment gear. This large gear-type was deployed once in 2018, although no invasive carp were captured in its initial use. Also, the KDFWR partnered with the USFWS to use a Paupier net on Kentucky Lake and Lake Barkley. In 2018, this gear was deployed to successfully remove 1,642 invasive carp from the two reservoirs during one sampling cycle.

Invasive Carp Life History and Reproduction Evaluations

The USGS conducted evaluations of invasive carp spawning success in the ORB, which included collection of water quality and flow data, and use of the Fluvial Egg Drift Simulator (FluEgg), a biological particle transport model developed specifically for predicting the transport of invasive carp eggs and larvae in rivers. Data was compared with computer models to evaluate invasive carp spawning success. Data collection occurred October 2016 through June 2017, with analysis and modeling conducted in 2018. Application of FluEgg to the Ohio River (Markland-McAlpine reach) began in 2018. Beginning in 2018, the FluEgg model was rebuilt to improve overall accessibility, functionality, maintenance, and potential for expanded use.

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.**

ORB partner agencies continued targeted communication and outreach to the public, industry, and other stakeholder groups. Individual agencies developed and implemented communications strategies to support invasive carp partnership missions by sharing information on the status of the invasive carp invasion, providing guidance on steps to minimize the risk of introduction and spread, and collecting new occurrence information (e.g., Invasive carp catch data from recreational anglers and commercial fishers).

Federal and state agencies conducted the following activities to support outreach and engagement on invasive carp management issues and opportunities:

Invasive Carp Partnership Websites

Key invasive carp documents for the Mississippi River sub-basin partnerships (including Control Strategy Frameworks, Monitoring and Response Plans, Annual Summary Reports, Annual Reports to Congress, and the National Asian Carp Management and Control Plan) are now available on MICRA's website under Resources/Documents/Asian Carp Plans and Reports (<http://micrarivers.org/asian-carp-plans-and-reports/>). Content is updated as new plans and reports become available.

Also, the USFWS continued to support and administer the www.invasivecarp.us website as a primary platform for delivering general updates on accomplishments, science, and other products related to invasive carp management, with a focus on activities of the ACRCC. In 2018, the revised website, incorporating a more user-friendly interface for accessing specific content on invasive carp news and developments, became fully operational.

Public/Stakeholder Engagement

ORB partners conducted a portfolio of activities focused on outreach and education with the public, governments, industry, and other stakeholders in 2018. Agencies developed and placed educational signage at access points, distributed pamphlets to marinas and local businesses, provided press releases to local media outlets, and used social media platforms to inform the public about invasive carp harvest efforts. Postings included messaging to inform local anglers and boaters of commercial fishing activities in specific areas to minimize potential impacts to recreational resource users. Informational materials also included guidance to discourage anglers from moving bait beyond the area where collected, information on how to identify invasive carp species, and what to do if a fish is captured or observed. Further efforts included activities to promote the appeal and edibility of invasive carp products to the public.

ODNR continued an AIS outreach campaign with Wildlife Forever (<https://www.wildlifeforever.org/>) to minimize the movement of bait by anglers using targeted messaging on billboards, print media, and items for distribution at events with the slogan “Trash Unused Bait.” Also, in partnership with Ohio Sea Grant and The Ohio State University, ODNR completed the Ohio Field Guide to Aquatic Invasive Species, which was distributed in 2018 to individuals in the field as an early detection tool.

To educate anglers on regulations in Kentucky that limit the transfer of bait fish between water bodies, KDFWR fisheries distributed signs at popular boat ramps to notify the public about the potential introduction of AIS from bait bucket transfers. To further educate the public about this issue, new sections were created in the annual fishing and boating guide and for the KDFWR website covering the topic. The KDFWR also worked to inform the public of invasive carp harvest efforts to minimize potential impacts to recreational fishers and boaters. To minimize conflicts, signs were placed at access points, pamphlets distributed to marinas and local businesses, press releases distributed to local media outlets, and KDFWR created a Facebook page dedicated to Fisheries in Western Kentucky where invasive carp are most prevalent. To engage anglers in invasive carp control efforts, the KDFWR organized an invasive carp-only bowfishing tournament (“Carp Madness II”). Eighty-one bow-fishing teams participated in the tournament, which resulted in the removal of over 20,000 pounds of invasive carp from the Tennessee and Cumberland River systems.

Additional activities conducted by ORB states included:

- In Indiana, IDNR biologists collected and processed approximately 60 pounds of invasive carp boneless fillets, which were prepared and served to attendees at the Indiana State Fair to promote the appeal and edibility of invasive carp to the public.
- In Tennessee, the TWRA staffed information awareness booths, and installed and maintained signage at boat ramps.
- In West Virginia, invasive carp informational signs developed by Ohio River sub-basin states were maintained at the majority of access sites along the West Virginia portion of the Ohio and Kanawha Rivers.
- In Pennsylvania, the PFBC regularly distributed information about invasive carp on their website, posters, and various outdoor media outlets.

Industry Engagement

The KDFWR continued outreach with the commercial fishing industry to enhance invasive carp reporting and collection. This included meetings with commercial fishers and processors outlining changes to operation of the ACHP, identifying limiting factors to the harvest of invasive carp, and planning projects to

develop new gear types for invasive carp capture. Additional coordination with commercial fishers included planning related to the ACHP ride-along project and the Kentucky Lake invasive carp demographics project. The KDFWR also hosted prospective businesses interested in investment in the commercial carp industry.

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.**

The ORB state resource management agencies continued to enforce regulations providing oversight on AIS, including invasive carp, within their respective jurisdictions. Enforcement focused on compliance with regulations related to the production, possession, sale, and transport of invasive carp along with regulations and best practices related to the transport and use of live bait by commercial harvesters, dealers, and anglers. In 2017, the U.S. Court of Appeals for the District of Columbia Circuit held that section 42(a)(1) of title 18 of the Lacey Act does not "prohibit shipments of injurious species between the continental States." United States Ass'n of Reptile Keepers, Inc. v. Zinke, 852 F.3d 1131, 1142 (D.C. Cir. 2017). Individual states, however, continued to regulate production, possession, sale, and transport of invasive carp. For example, the State of Ohio enacted an administrative rule prohibiting bait collection below dams other than on the Ohio River, and the ODNR Division of Wildlife Law Enforcement (DWLE) regularly monitored bait dealerships for the presence of AIS. Under West Virginia regulations: *"It is unlawful for any person to possess, sell, offer for sale, import, bring or cause to be brought or imported into this state or release into the waters of this state (WV), in a live state, any Asian carps (Bighead, Silver, Black and Largescale Silver carps)"*.

Although regulations are in place on a state-by-state basis, grass carp are not listed as injurious under the Lacey Act. In 2015, MICRA submitted a report to the USFWS proposing eight recommendations to establish a consistent national policy strategy for grass carp to minimize the risk of unintentional and illegal introductions of diploid and triploid grass carp. It included a recommendation that all states should prohibit the production, shipment, and stocking of diploid grass carp. In 2018, the ODNR DWLE completed a two-year assessment of the grass carp supply chain that determined that all tested fish were triploid (Figure 13). The results of the supply chain assessment were published in the Journal of Great Lakes Research (Assessing the risk of diploid Grass Carp *Ctenopharyngodon idella* in the certified triploid supply chain in Ohio (<https://pubs.er.usgs.gov/publication/70198206>)).



Figure 13. Grass carp obtained from a seller for testing. The carp are usually packaged by dealers in this way and then placed into boxes for safe transport and transfer into ponds. Photo courtesy of Ohio Department of Natural Resources.

3.4 UPPER MISSISSIPPI RIVER BASIN

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.**

Federal and state agencies continued collaboration on invasive carp management strategies and projects in the UMRB. As in the ORB, efforts focused on preventing the range expansion and upstream establishment of bighead and silver carp through coordinated monitoring and early detection, mass removal by commercial harvest, development of new deterrent technologies (e.g. barriers) and strategies), and outreach with industry and stakeholders. Additional effort was placed on black and grass carp monitoring and analysis.

The UMRB partners participated in interagency coordination through the MICRA ACAC, UMRCC Fisheries Technical Section and other committees. Priority management actions support implementation of the National Plan, state agency invasive carp management strategies, and Goal 4 of the UMRCC's Upper Mississippi River Fisheries Plan (Fisheries Plan), which is to "slow or eliminate the spread or introduction of aquatic nuisance species, including pathogens, to the Upper Mississippi River." Federal and state agencies within the UMRB participated in other inter-basin coordination efforts, including the Upper Mississippi River Basin Association (UMRBA), MRBP, the Lower Mississippi River Conservation Committee, the Missouri River 100th Meridian Work Group, and ACRC planning meetings.

To further leverage UMRB efforts, the USFWS coordinated with MICRA and ORB federal and state agency partners to identify annual UMRB sub-basin priorities for consideration for project development and funding, with available resources. Projects were identified and developed for early detection, monitoring and assessment, control and removal, and containment actions to prevent further distribution and

establishment of invasive carp in the UMRB (see 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin; <http://www.micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>). Actions conducted in Minnesota also supported the Minnesota Invasive Carp Action Plan (MICAP). MICAP complements both the National Plan and the Fisheries Plan as it includes specific strategies that address early detection and monitoring of susceptible waters; prevention and deterrence; response preparation; management and control; and outreach and communication.

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.**

Invasive Carp Telemetry Monitoring

Telemetry data provide key seasonal movement and location information on invasive carp populations in the UMR, supporting enhanced capture efficiency and providing critical knowledge for planning, implementing, and evaluating deterrent technologies. In 2018, the USGS, USFWS, USACE, Missouri Department of Conservation (MDC), ILDNR, Western Illinois University (WIU), and Minnesota Department of Natural Resources (MNDNR) continued a collaborative telemetry study that tracked acoustically-tagged invasive carp through a telemetry array of over 225 stationary receivers, extending from above Coon Rapids, Minnesota, to Cairo, Illinois, a distance of over 650 river miles. The USFWS installed and maintained 127 remote receivers from Pool 5A to Pool 26, which complemented receivers deployed by the Minnesota DNR and the Missouri Department of Conservation (MDC). Telemetry tracking in targeted locations within the remote receiver array yielded millions of detections (data points indicating the exact location of specific invasive carp at a given time), providing key information on invasive carp movement in this section of the UMR.

In FY 2018, the USGS and USFWS tagged an additional 38 bighead and silver carp with acoustic transmitters, bringing the total number of tagged bighead and silver carp to over 400. Most of these fish are located within the IMZ from Lock and Dam 19 near Keokuk, Iowa, to Lock and Dam 15 near the Quad Cities of Iowa and Illinois. Additional acoustic tagging of invasive carp in 2018 brought the combined total of bighead carp and silver carp with active tags present in Pools 16-20 to 461. During weekly tracking efforts, nearly 2,000 individual point locations of acoustically tagged invasive carp were collected in this reach and associated tributaries. In addition, millions of detections were recorded on the remote receiver array. Preliminary models developed from this data have identified seasonal aggregations and can be used to predict when invasive carp move past key “pinch-point” dams and into tributaries. These data increase the effectiveness of contracted removal efforts and resulted in over 100,000 pounds of invasive carp being removed from the invasion front in the UMR during 2018.

In addition to the telemetry effort in and above the IMZ, the MDOC conducted monthly manual telemetry tracking of tagged fish in Pool 20 and retrieved tracking data from stationary receivers downstream of Pool 20 on a quarterly basis. These data are being used to inform assessments of general invasive carp movement patterns and the potential deployment of deterrent technologies in this section of the UMR.

To support the development and evaluation of deterrents at pinch-point dams on the UMR, scientists from the USGS, USFWS, WIU, and MDC continued collaboration on the deployment of telemetry arrays in the approaches of Lock and Dam 15 (Quad Cities, Iowa) and Lock and Dam 19 (Keokuk, Iowa). In 2018, work included installation of two 2-dimensional (2-D) positioning arrays in the downstream approaches of both locks. These additional arrays provided fine-scale data describing the movement and behavior of acoustically tagged fish within the array zone, revealing when and how these fish use the areas to potentially pass through the lock and dam complexes.

In 2018, the USGS continued to collaborate with partners to develop a multi-basin, real-time telemetry network in the Upper Mississippi, Ohio, and Illinois rivers; and a telemetry database and visualization tool that includes fish tagged and tracked in those rivers. As of 2018, nine real-time receivers were installed (Figure 14). The database facilitates fish tracking, data sharing, and understanding of invasive carp movements across river basins. Data is being used by managers to inform invasive carp removal strategies.



Figure 14. USFWS and USGS staff deploy a real-time telemetry receiver in the Intensive Management Zone of the UMR. Photo courtesy of USFWS.

The USFWS and USGS are also using invasive carp telemetry data from the UMR to populate a multi-state fish movement model. This model provides the rates that invasive carp move between individual navigation pools and will be further used to inform an invasive carp population model to help maximize fishing harvest effectiveness with the goal of reducing numbers of adult fish in targeted areas.

eDNA Monitoring

The USFWS conducted eDNA sampling in Pools 13-15 of the UMR to maintain focused surveillance in locations where invasive carp are suspected to be present but may have a lower likelihood of detectability and capture with traditional fishery monitoring gears. Based on results from previous research and telemetry data showing movements of invasive carp between habitat types in response to water temperature, hydrography, and spawning activity, eDNA field protocols were modified to focus sampling in backwater habitats during spring. Results are being used to inform development of a long-term sampling plan for eDNA, and to prioritize geographic areas for targeted sampling with traditional gears. In 2018, 1,180 samples were collected from the UMRB and processed through this effort. Three samples collected from a backwater area of Pool 14 were positive for invasive carp eDNA (Figure 15). One sample was positive for silver carp and two samples were positive for both silver carp and bighead carp. This represented the first time these pools were sampled for eDNA within the comprehensive study. Previous eDNA surveillance (2014-2016) was focused further upstream in Pools 5-9, with no positive detections of invasive carp eDNA during these earlier sampling efforts.

Further details on the agency eDNA monitoring efforts in the UMRB and other basins can be found at: <https://www.fws.gov/midwest/fisheries/eDNA.html>.

Bighead and Silver Carp eDNA Early Detection Results:
 Upper Mississippi River, Pool 14
 Sampling Period: Week of April 9, 2018
 Number of Samples Collected: 528

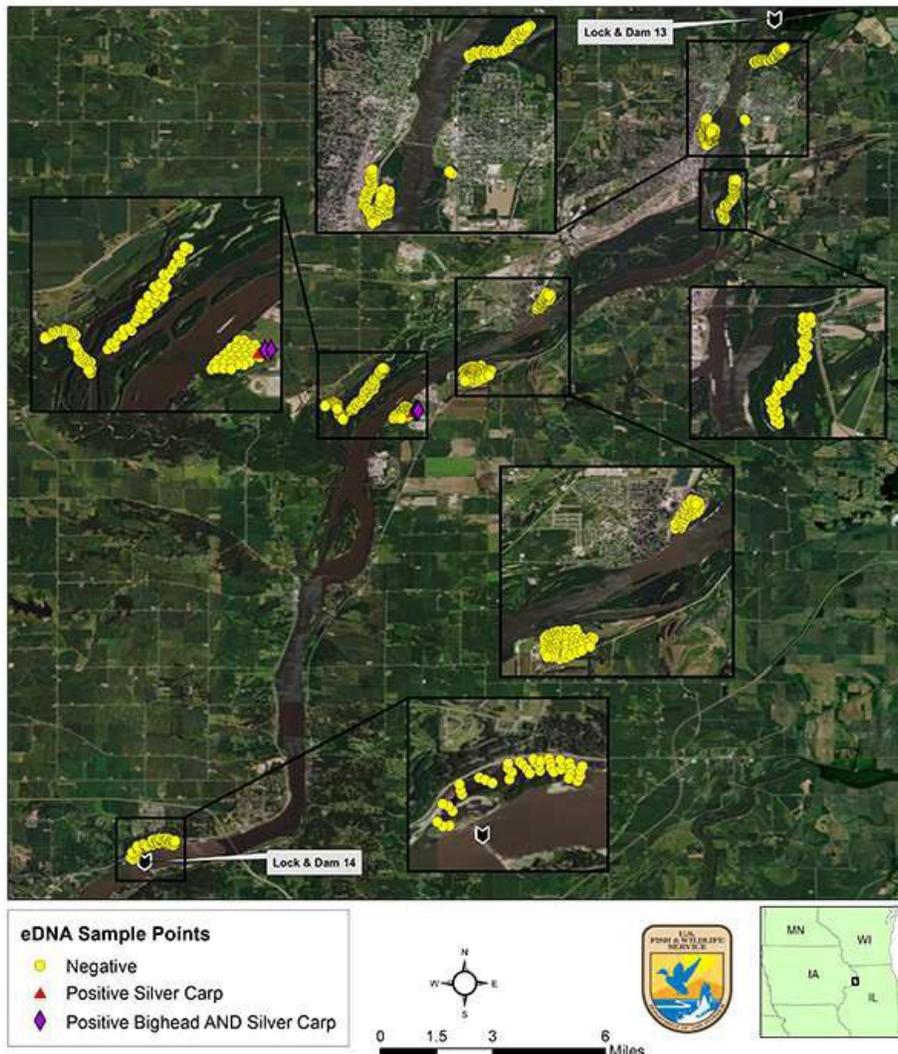


Figure 15. Sample locations and results for invasive carp eDNA monitoring in Pool 14 of the Mississippi River, April 2018.

Traditional Gear Sampling

The UMRB agencies continued to conduct coordinated monitoring for all invasive carp life stages using electrofishing, netting, and other standard fishery gears and capture techniques in targeted pools, river reaches, and tributaries within the basin.

The Iowa Department of Natural Resources (IADNR) conducted electrofishing surveys during the summer of 2018 to monitor for adult bighead, silver, and grass carp distribution and abundance in the Des Moines and Cedar Rivers. The IADNR also collaborated with Iowa State University to continue a study which began in 2014 to evaluate spatiotemporal patterns of reproduction and adult population characteristics of bighead, silver, and grass carp in Pools 14-20 of the Mississippi River; and in the Des Moines, Skunk, Iowa, Cedar, Rock, and Wapsipinicon Rivers. Sampling for larval invasive carp took place once every two

weeks from May through August 2018 and sampling for adult fish was conducted during fall 2018. Invasive carp larvae were previously collected in Pools 18, 19, and 20 of the Mississippi River in 2017. In 2017 and 2018, adult silver carp were captured as far north as Pool 18 near the confluence of the Iowa River. Grass carp were captured as far north as Pool 18 in 2018, although they were previously captured further upriver in Pool 16 in 2017. Relative abundance of silver carp was higher than grass or bighead carp in the UMR during 2018, a trend found in several other Midwest U.S. river sub-basins occupied by invasive carp species. In general, the relative abundance of invasive carp was higher in downstream river locations, and progressively decreased in upstream locations with fewer fish detected and captured. The average size of silver carp captured in IADNR sampling in 2018 was approximately 27.2 inches and 7.6 pounds.

Biologists from the USFWS and WIU also sampled for early life stages of invasive carp in 2018, targeting Pools 18-20 of the UMR. No juvenile or young-of-year (post larval fish in its first year) silver, grass, or bighead carp were collected during this sampling. Juvenile silver carp had been previously captured in Pool 19 and young-of-year silver carp captured in Pools 18 and 19. One juvenile bighead carp was captured in Pool 19 in 2017, representing the furthest upstream capture of a juvenile bighead carp in the UMR as of that date. The USFWS conducted additional sampling in Pools 10, 12, and 13 of the UMR, with no young-of-year bighead or silver carp detected at these locations. Additionally, USFWS conducted 161 ichthyoplankton (fish eggs and larvae) tows from targeted pools in the UMR during 2018. Samples were sorted and examined for presence of invasive carp eggs and larvae by 2019. A total of 5,242 larval and juvenile fish and 3,659 eggs previously collected from the UMR in 2017 were analyzed, with no bighead, silver, grass, or black carp detected.

In 2018, MNDNR continued its UMRB invasive carp sampling program, initiated in 2012. Figure 16 illustrates the location and species of all invasive carp captured in Minnesota waters through 2018.



Figure 16. Locations of all known invasive carp captured in Minnesota waters through 2018. Map courtesy MNDNR.

In 2018, MNDNR provided a dedicated invasive carp sampling crew, led by a full-time fisheries specialist. Invasive carp surveillance methods included the use of gill nets, electrofishing, trap netting, larval fish trawling, monitoring commercial fishing operations, and contracted commercial fishing. Sampling was conducted in the Mississippi River in Pools 1, 2, 3, 5A, 6, and 8, and in targeted locations in the St. Croix River and Minnesota River. Three bighead carp were captured during all combined efforts. MNDNR annual reports can be found at: www.dnr.state.mn.us/invasive-carp. The 2018 annual report can be found at: https://files.dnr.state.mn.us/natural_resources/invasives/aquaticanimals/asiancarp/2018-sampling-report.pdf.

In support of UMR monitoring efforts, the USFWS, MNDNR and WIDNR conducted intensive sampling in Pool 8, targeting locations where bighead carp had been captured in previous years. Block nets were deployed to close the exit/entrance of a backwater area to invasive carp passage and gill nets were set within the backwater for capture. Electrofishing chase boats were then used to herd the fish into the nets. No invasive carp were captured during the Pool 8 sampling effort in 2018.

The USFWS conducted targeted field monitoring and data collection to inform assessments of black carp reproduction in the UMR. Biologists sampled Dutchtown Ditch for young-of-the-year black carp. This location represents one of the first known sites of black carp natural reproduction in the United States. In addition, the USFWS deployed water level data loggers to help determine the relationship between Mississippi River water level gage height and the degree of hydrologic connectivity with Dutchtown Ditch to further evaluate the potential source of young-of-the-year black carp collected in the proximity.

The Wisconsin Department of Natural Resources (WIDNR) provided additional fishery monitoring in the UMRB. Although the agency does not implement directed invasive carp monitoring in the lower Wisconsin River within the UMRB, they do conduct general fisheries surveys between the confluence with the Mississippi River and the first dam at Prairie du Sac, Wisconsin.

In addition to targeted invasive carp surveys, agencies continued coordinated sampling to maintain key baseline datasets for both native and non-native fish species in the UMRB. Federal and state agencies conducted research and monitoring within the Long-Term Resource Monitoring (LTRM) element of the USACE Upper Mississippi River Restoration (UMRR) Program. The monitoring and research activities of the LTRM are focused on identifying status and trends in critical natural resources. Although the UMRR was not designed to specifically address invasive carp, the long-term data (20 plus years) on fish communities, water quality, and aquatic vegetation provide robust pre-invasion baseline conditions within the UMRB. This information is supporting analyses to identify harmful effects of invasive carp and other AIS on native fauna and ecosystem processes. LTRM data and information are available at: <http://www.umesc.usgs.gov/ltrmp.html>.

Rapid Response

In response to the capture of two bighead carp by contract fishers on the St. Croix River near Andersen Bay in May 2018, the MNDNR and USFWS conducted intensive follow-up sampling with gill nets and electrofishing. No invasive carp were captured during the follow-up agency response effort.

Two young-of-year bighead carp were recovered and removed from the IADNR Fairport Hatchery in Pool 16 of the UMR on November 1, 2017 (Figure 17). The two recovered fish were likely inadvertently drawn into the hatchery with water from the Mississippi River earlier during spring 2017. The hatchery draws river water each spring to fill an on-site pond, which is then drained in fall to aid in fish removal. This

represents the first capture of young-of-year bighead carp upstream of Lock and Dam 19 on the UMR. No additional invasive carp were recovered from the hatchery facility.



Figure 17. Photo of a young-of-year bighead carp collected November 1, 2017, while draining the reservoir at Fairport Hatchery in Pool 16. Photo courtesy of Iowa DNR.

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.**
- **NATIOAL PLAN GOAL: Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carp in the United States.**

Invasive Carp Capture and Removal

In 2018, UMRB partners continued focused efforts within the invasive carp Intensive Management Zone (IMZ) identified in the Upper Mississippi River, an area between Lock and Dam 19 in Keokuk, Iowa, to Lock and Dam 14 in Le Claire, Iowa (Figure 18). The designated IMZ brackets the invasion front of invasive carp in the UMR, the upstream location with known invasive carp natural reproduction, and is intended to more strategically focus efforts to halt upstream range expansion.

In concept, the IMZ is defined by effective barriers to invasive carp passage at the upper and lower bounds (e.g. lock and dam complexes), with focused intensive efforts to reduce invasive carp abundance (e.g. commercial harvest) conducted in targeted stretches of the river between the barriers.

Bighead Carp Intensive Management Zone in the Upper Mississippi River

In support of invasive carp removal goals under the UMRB Framework, the deployment of contracted commercial fishers in Pools 16-19 within the IMZ of the UMR continued throughout the year. Data were collected and processed by WIU. From October 2017 through September 2018, targeted commercial harvest in this section of the Mississippi River removed 96,997 pounds of silver carp; 26,898 pounds of bighead carp; and 37,474 pounds of grass carp.

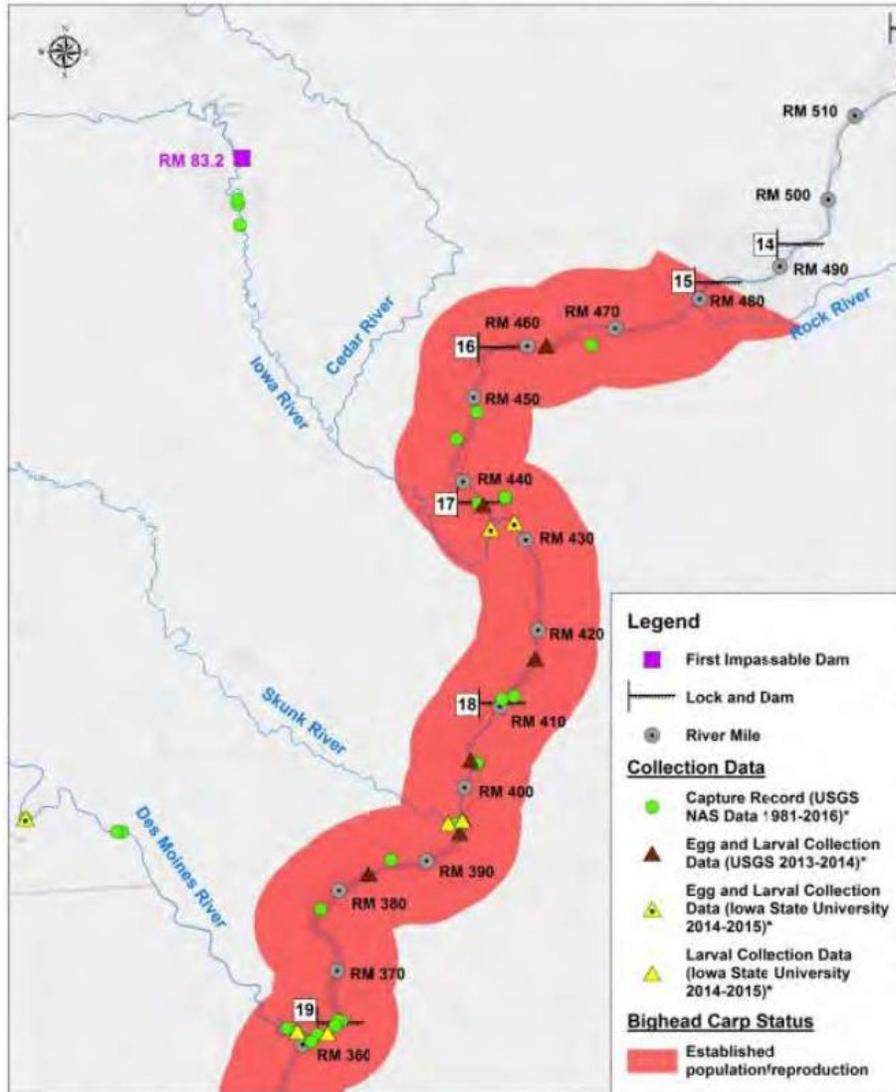


Figure 18. Invasive Carp Intensive Management Zone in the Upper Mississippi River.

In 2018, the total catch-per-unit-effort (CPUE) for bighead and silver carp by contracted commercial fishers was highest in Pool 19 relative to the other pools within the IMZ. CPUE progressively decreased in an upstream direction (Figure 19), underscoring the importance of Pool 19 as a focal point for strategic removal in the UMR given its proximity to downstream established source populations. Targeted removal in 2018 by contracted commercial fishers on the UMR was notably higher than in prior years. In 2018, state-directed commercial fishing efforts were augmented by the deployment of additional fishers to increase overall harvest effort and were informed by agency and academic partner information and technical expertise to more effectively target timing and location to maximize invasive carp capture.

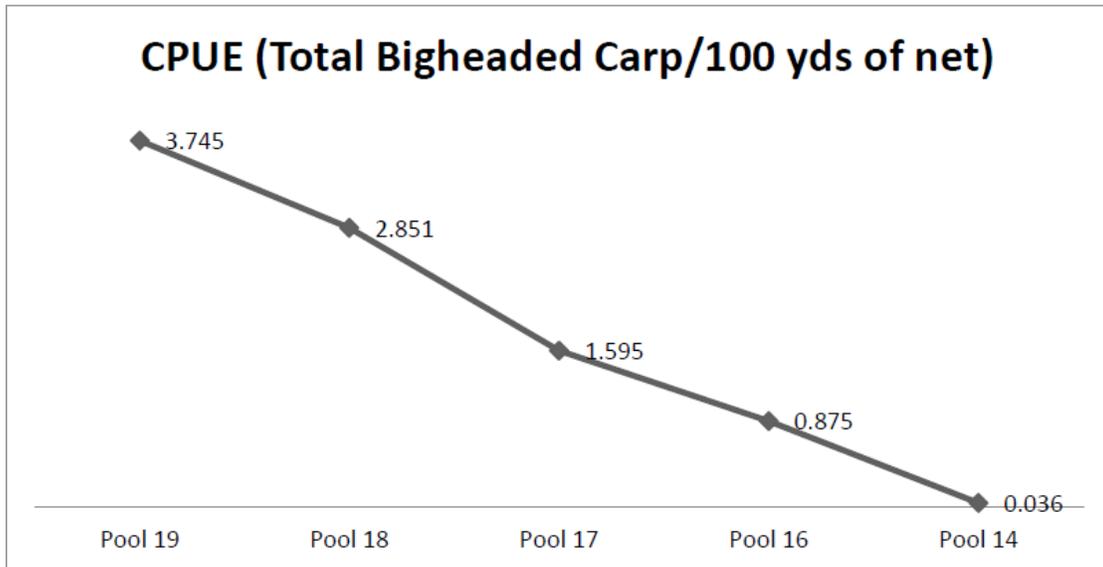


Figure 19. Catch Per Unit Effort of bighead and silver carp by contract commercial fishers with gill nets in Pools 14 - 19 in the UMR in 2018. Values indicate numbers of bighead or silver carp captured per 100 yards of net deployed. Pool 14 is furthest upstream of the five identified pools. Courtesy of Western Illinois University.

Data from the UMRB telemetry network allowed commercial fishers to better target where and when invasive carp were present. The efficiency of removal efforts increased notably from 2017 to 2018 since telemetry data showing movement, presence, and congregations of invasive carp was increasingly used to target capture and removal activities. Additionally, manual tracking data located congregations of invasive carp in real-time. Information was immediately relayed so that contract commercial fishers could be directed to areas where fish were aggregated to maximize capture and removal probability.

The USFWS worked with USGS and WIU to install and maintain two real-time telemetry receivers in two backwater areas of the IMZ of the UMR, including construction of rafts to house the receivers and power source. Receivers were deployed in backwaters frequently used by invasive carp. These receivers were equipped to send text message alerts with notifications of the number of fish being detected. This provided contract fishers with current information on fish presence in real-time, greatly improving catch efficiency and success.

Actions to Address Pathways

Within the Minnesota River watershed in the UMR, MNDNR fishery biologists previously identified priority tributaries for near-term protection in response to the increasing risk of invasive carp introduction. Two sites were chosen to protect lake systems in the Le Sueur River sub-watershed. On Mayhew Creek, an “open-ditch” electrical grid was installed to protect Elysian Lake and Buffalo Lake. At the second site, an unnamed creek, a culvert electrical array was installed to protect Madison Lake and Eagle Lake. These lakes were chosen based on recreational value, biological importance, and risk of invasive carp expansion. Electric barriers placed in the waterbody outlet tributaries were identified as the best management option with pre-construction work beginning in 2015. Both sites were commissioned and operational in December 2018.

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

In FY 2018, agencies and academic partners continued collaboration to develop and evaluate potential invasive carp deterrent and control technologies within the UMRB. Coordination, project planning, and research focused on further development and testing of prototype control tools, such as targeted toxicants, and deterrent technologies, including underwater sound and carbon dioxide. Efforts built off recommendations from earlier structured coordination (e.g., Sound Deterrent Workshop Coordination and Planning Meeting, National Asian Carp Management and Control Strategy Discussion) and focused on opportunities to rigorously evaluate the effectiveness of specific technologies under realistic field conditions. Additional research was conducted to inform the development of deterrent strategies, including telemetry tracking focused on evaluating the movement of invasive carp through lock structures. Previous work included the preliminary identification and evaluation of potential sites for deterrent technology test deployment in conjunction with the controlled operation of existing locks and dams.

In 2018, the USFWS partnered with NPS, USACE, USGS, MNDNR, WIDNR, IADNR, ILDNR, and MDOC to finalize an invasive carp deterrent strategy for the UMR. The interagency team identified potential deterrent technologies; developed fact sheets on each feasible technology; mapped out IMZs for silver carp, bighead carp, and grass carp; identified suitable locations for deterrent sites; and made recommendations for experimentation and next-steps. The strategy summarized deterrent technologies and identified sites for their potential implementation. The strategy also provided guidance on actions that needed to be completed prior to development or implementation of deterrent efforts. The USFWS summarized the strategy and supporting information in the report titled “Asian Carp Deterrent Strategy for the Upper Mississippi River Basin” (http://www.micrarivers.org/wp-content/uploads/2019/08/Potential-Use-of-Deterrents_Final.pdf).

Acoustic Deterrent Barriers

The USGS continued collaboration with USFWS, USACE, IADNR, ILDNR, and academic and industry partners to assess the feasibility of deploying and evaluating a prototype acoustic deterrent system in a large-scale field pilot project at an active navigation lock on the Mississippi River. Mississippi River Lock and Dam 19 (LD19) at Keokuk, Iowa, was identified as a suitable test site as it is a high-head dam that serves as an invasive carp migration pinch-point. Because spillway gates at LD19 are never completely open, the adjoining lock chamber is the only means by which fish can migrate upstream. Study objectives were to: 1) use acoustic telemetry arrays around these lock and dam locations to study the timing (i.e., daily and seasonal) and behavior of invasive carp movements at the site, 2) evaluate the relationship between fish presence in the telemetry array and environmental factors (e.g., flow, temperature, barge passages), and 3) relate upstream fish passage events through the lock to operations of the lock to accommodate river traffic. Analyzed data suggested that specific barge lockage sequences can facilitate upstream passage of native fish, bighead carp, and silver carp. Results on fish behavior and key environmental variables at LD19 collected during this study are being used to design the large-scale field trial to evaluate the potential effectiveness of a sound deterrent system at this location. This project is further referenced in Section 3.4.4 (IWW/CAWS, Research and Development, Development of New

Deterrent Technologies - Acoustic Deterrents). Additional information on this project is available at: <https://www.usgs.gov/news/media-advisory-study-asian-carp-deterrent-begins-january>.



The MNDNR, USFWS, USACE, and the Minnesota Aquatic Invasive Species Research Center, University of Minnesota – Twin Cities (MAISC) continued collaboration to evaluate the potential use of sound deterrents at lock and dam locations in Minnesota waters. The MNDNR and MAISC coordinated the study to evaluate and better understand the movements and behavior of fish in and around lock and dam structures. Activities included tagging and tracking additional fish at Lock and Dams 2 and 8 on the Mississippi River. In addition, the USACE partnered with MAISC to develop flow models and conduct acoustic mapping for Locks and Dams 2, 4, 5, and 8 to assess the efficacy of acoustic barriers. The MAISC is also evaluating the response of fish to acoustic speakers located in Lock 8. The MAISC and USFWS collaborated to assess fish behavior around a speaker (sound deterrent) system deployed at LD 8. The acoustic deterrent was tested by tagging common carp as a surrogate for invasive carp in

this study (Figure 20). Results are being used to inform subsequent evaluations and pilot studies focused on the use of deterrents for invasive carp at lock and dam structures. A final technical report with detailed findings (Integrating Detection, Deterrents, and Operations at Upper Mississippi River Navigation Lock and Dams, Sorenson et al., University of Minnesota-Twin Cities) was submitted to MNDNR.

Additionally, the MNDNR partnered with Minnesota State University – Mankato (MSUM) to evaluate invasive carp deterrent feasibility in the Minnesota River. The study evaluated the hydrologic and geomorphic characteristics of the river including channel migration rates, flood plain inundation, bathymetry, and sediments. The project also examined biological data to identify habitats that are highly suitable for invasive carp. The MSUM provided the final technical report to MNDNR in July 2018. Results of the study will be used to inform and support potential invasive carp management efforts in the MRB.

Further, MNDNR partnered with the University of Minnesota – Duluth (UMD) to continue evaluating the feasibility of using complex noise at Mississippi River Lock and Dam 5 to deter upstream movement of invasive carp. Building off preliminary work from 2017, investigators interviewed a group of experts to evaluate the feasibility of an acoustic system from engineering, biological, and physical landscape perspectives. In 2018, UMD also collected critical soundscape data to inform the final analysis. The final report (Feasibility Study: Using Acoustic Deterrents to Prevent Invasive Bigheaded Carp at Lock and Dam 5, Putland and Mensinger, University of Minnesota-Duluth) was completed and is being used to inform potential deterrent strategies.

Carbon Dioxide Barriers

Carbon dioxide (CO₂) injected into water was further evaluated by the USGS and UMRB partners as a non-physical deterrent method for invasive carp. In 2018, the USGS and partners received approval from the Fox River Navigational System Authority to test the feasibility of CO₂ within a navigational lock on the Fox River near Kaukauna, WI. Design, construction, operation and monitoring of a large-scale CO₂ infusion system within a navigational lock was planned for 2019 to determine the overall costs and feasibility of this new fish deterrent method. The USGS awarded a construction contract for the prototype system at Kaukauna Lock #2. A feasibility study was initially planned for the auxiliary lock at Lock and Dam 14 on the Mississippi River in Iowa. However, the Environmental Services Division of the IADNR was unable to issue a permit for the injection of CO₂ into water in the auxiliary lock chamber.

This project is further referenced in Section 3.4.4 (IWW/CAWS, Research and Development, Development of New Deterrent Technologies – Carbon Dioxide). Additional information on this project is available at: https://www.usgs.gov/centers/umesc/science/invasive-carp-control-carbon-dioxide?qt-science_center_objects=0#qt-science_center_objects.

Development of New Targeted Control Technologies

The USGS and IADNR collaborated on a study to evaluate the potential use of microparticles as a process for targeting chemical piscicides for invasive carp control. The USGS continued work to develop oral delivery formulations that can stabilize and deliver a chemical control agent that targets silver carp, bighead carp, grass carp, and black carp while minimizing potential impacts on native species. The USGS also partnered with IDNR on a field trial to test the application of toxic antimycin microparticles in a flowing system in Iowa. Assessments of target populations were conducted pre- and post-exposure, with analysis of data and results subsequently conducted. Results are being used to continue refinement of the microparticle technology for use as an invasive carp tool. The study was conducted at the IADNR Rathbun Fish Hatchery. This project is further referenced in Section 3.4.4 (IWW/CAWS, Research and Development, Development of New Control Technologies - Microparticles).

Invasive Carp Biology, Life History and Reproduction Evaluations

The UMRB agencies continued laboratory and field evaluations to obtain new information on invasive carp biology, life history, and behavior to inform invasive carp monitoring, prevention, and control efforts.

The USGS, in collaboration with the USFWS, MICRA, and State agency partners, previously developed a protocol now in use for handling and conducting research on black carp captured in the MRB. All black carp captured from the wild are processed following the protocol to determine ploidy (genetic analysis to determine a fish's capability to reproduce), recent reproductive status and activity, age, condition, stomach contents, and location of capture and origin. A similar protocol is now in place for use to analyze grass carp captured from portions of the MRB where they are not known to be established.

The USGS also continued studies to understand and identify recruitment sources of the emerging population of invasive carp in the river systems of the Midwest United States. USGS researchers continued development and refinement of the Fluvial Egg Drift Simulator (FluEgg) simulation model for assessing the risk of invasive carp spawning and the potential survival of eggs and larvae under specific environmental conditions. Beginning in 2018, the FluEgg model was updated to improve overall model accessibility and functionality. Use of FluEgg included an assessment of the likelihood of successful invasive

carp spawning in the St. Croix River downstream of St. Croix Falls, WI, under simulated conditions. An article documenting 2017 laboratory experiments examining the drift and swimming behavior of grass carp eggs and larvae, respectively, and their interaction with bottom material in flowing water was drafted and published in 2018 (Survival and drifting patterns of grass carp eggs and larvae in response to interactions with flow and sediment in a laboratory flume, Prada et. al., USGS) (<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0208326>). The next phase laboratory experiments characterized the settling velocity, drift response, and survival rate of grass carp eggs and larvae under complex bed morphologies and were completed in 2018, with results submitted for publication as a journal article. New laboratory experiments focused on assessing turbulence-induced mortality in grass carp eggs and larvae were planned for 2019.

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.**

Invasive Carp Partnership Websites

Key invasive carp documents for the Mississippi River sub-basin partnerships (including Control Strategy Frameworks, Monitoring and Response Plans, Annual Summary Reports, Annual Reports to Congress, and the National Asian Carp Management and Control Plan) are now available on MICRA's website under Resources/Documents/Asian Carp Plans and Reports (<http://micrarivers.org/asian-carp-plans-and-reports/>). Content is updated as new plans and reports become available. Also, the USFWS continued to support and administer the www.invasivecarp.us website as a primary platform for delivering general updates on accomplishments, science, and other products related to invasive carp management, with a focus on activities of the ACRCC. In 2018, the revised website became fully operational, providing a more user-friendly interface for accessing specific content on invasive carp news and developments.

Public/Stakeholder Engagement

UMRB agencies presented information on interagency invasive carp planning and implementation activities in the sub-basin to multiple stakeholder groups and members of the public during 2018. Presentations highlighted interagency invasive carp partnership strategic planning, overviews of UMR field and research projects, opportunities for the strategic deployment of deterrents to control range expansion in the UMR, assessments of invasive carp population dynamics, and other topics.

In many UMRB States, signs alerting the public to the presence of invasive carp continued to be posted and maintained at fishing access sites with known populations of bighead and silver carp. Signage provides information for readily identifying the species, and warnings regarding the illegal possession and/or transport of live invasive carp. In addition, UMRB state agencies informed water recreationists about the threats of invasive carp using agency websites, educational brochures, identification cards, posters, billboards, and press releases. Outreach materials were distributed at watercraft inspection stations, fishing clinics, state fairs, parks, nature centers, and businesses supporting aquatic-based recreation.

The MNDNR, NPS, and the Minnesota Aquatic Invasive Species Center hosted the annual Minnesota Invasive Carp forum on May 1, 2018. The forum provided a platform to update interested stakeholders and public on activities related to invasive carp prevention and control. Attendees had the opportunity to

ask questions, voice concerns, and provide opinions. Also, MNDNR continued collaboration with the Stop-the-Carp Coalition to support regular communications and outreach on invasive carp-related issues. The Coalition is composed of partner nongovernmental organizations concerned about invasive carp and their impacts.

Industry Engagement

The IADNR coordinated with all licensed commercial fishers operating in Iowa waters to provide information and guidance on the bounty program for Black Carp in 2018. The program continued to provide a source of critical information to management agencies on black carp status, range, and life history within the UMRB.

3.4.6 LAW ENFORCEMENT/REGULATION

- **NATIONAL PLAN GOAL: Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carp in the United States.**

The UMRB state resource management agencies continued to enforce regulations providing oversight on AIS, including invasive carp, within their respective jurisdictions. Enforcement included compliance with regulations related to the production, possession, sale, and transport of invasive carp along with regulations and best practices related to the transport and use of live bait by commercial harvesters, dealers, and anglers. In 2017, the U.S. Court of Appeals for the District of Columbia Circuit held that section 42(a)(1) of title 18 of the Lacey Act does not "prohibit shipments of injurious species between the continental States." United States Ass'n of Reptile Keepers, Inc. v. Zinke, 852 F.3d 1131, 1142 (D.C. Cir. 2017). Individual states, however, continued to regulate the production, possession, sale, and transport of invasive carp.

A regulation allowing the MNDNR Commissioner to issue a permit to MNDNR divisions for tagging bighead, black, grass, or silver carp for specific research or control purposes was passed by the Minnesota State Legislature in 2017 and remains in place until December 31, 2021. Under the permit, invasive carp may be released into the water body from which they are captured. With the legislation in effect, the MNDNR began telemetry tagging and tracking of several invasive carp to collect information on habitat use and movement in state waters.

3.5 UPPER MISSISSIPPI RIVER BASIN-IWW/CAWS

3.5.1 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.**

Since 2010, the ACRCC has served as the primary partnership coordinating the planning and execution of federal and state agency efforts to prevent the spread of invasive carp populations from the MRB into the GLB. Invasive carp management actions conducted in the IWW/CAWS are identified and funded through the partnership's annual Asian Carp Action Plan (Action Plan) and implemented through the complementary Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System (MRP). The MRP is the annual operational work plan developed by the ACRCC's Monitoring and Response Work Group (MRWG) that describes the location, timing, and other logistics for many of the projects contained within the Action Plan and conducted within the IWW/CAWS. In total, the 2018 Action Plan contained over 60 projects focused on monitoring and early detection; control and removal;

pathway mitigation, research, and development of new tools and technologies; stakeholder communications; and other strategic actions focused on Great Lakes protection (<http://asiancarp.us/Documents/2018ActionPlan.pdf>). The 2018 MRP served as the field operational plan for Action Plan projects geographically focused in the IWW/CAWS. A more detailed summary of 2018 MRP-related accomplishments and results is included in the 2018 Interim Summary Report (<https://www.asiancarp.us/Documents/MRP2018.pdf>).

The ACRC partner agencies regularly participated in internal planning and coordination discussions addressing invasive carp management within the GLB and IWW/CAWS, including in-person or virtual meetings of the full partnership, the ACRC's Federal Executive Committee, and the ACRC Work Groups. Effort was primarily focused on development and implementation of the 2018 Action Plan, initial scoping for the FY 2019 Action Plan, and development and implementation of the 2018 MRP. Additional coordination included discussion of key updates on invasive carp population and risk status, emerging prevention or control technologies, and other priority topics; and contingency response (emergency or rapid response) planning to ensure general preparedness in the event a multi-agency response is warranted (if triggered by an invasive carp detection upstream of the Electric Dispersal Barrier).

ACRC agencies also collaborated with the ORB and UMRB partnerships to leverage opportunities for invasive carp management across basins, and with other coordinating bodies focused on invasive carp and AIS management, in general. This additional coordination included, but was not limited to, the GLMRIS Executive Steering Committee, the ANSTF, the Great Lakes Regional Panel on Aquatic Nuisance Species, and the Great Lakes Water Quality Agreement Aquatic Invasive Species Annex (Annex 6). Additional interagency coordination occurred during the execution of activities described in the subsequent sections of this report.

3.5.2 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.**

The ILDNR, USFWS, USACE, USGS, and other ACRC partners planned and conducted both ongoing and new monitoring activities for all life stages of invasive carp in the IWW, CAWS, and adjoining waters. Sampling strategies utilized traditional gears (netting and electrofishing), eDNA, and remote sensing techniques including telemetry tracking of tagged fish and hydroacoustics.

Invasive Carp Telemetry Monitoring

In FY 2018, the USACE continued to implement a telemetry program in the upper IWW/CAWS using an acoustic receiver array to track the movement and behavior of individual fish tagged with coded ultrasonic transmitters (Figure 21). Telemetry is used to assess effectiveness of the electric dispersal barriers (EDB) by monitoring movement of tagged fish (non-invasive carp) in the immediate vicinity to determine if the fish challenge or penetrate the EDB arrays. Additionally, telemetry is used to assess general invasive carp movement patterns in the IWW, including potential migration through lock structures in the system. Surrogate (non-invasive carp) species (i.e. common carp, buffalo spp.) were tagged at or near the EDB in the Lockport Pool, while invasive carp were tagged in the Dresden Island and Marseilles Pools. The acoustic network is composed of stationary acoustic receivers supplemented by a mobile hydrophone unit.

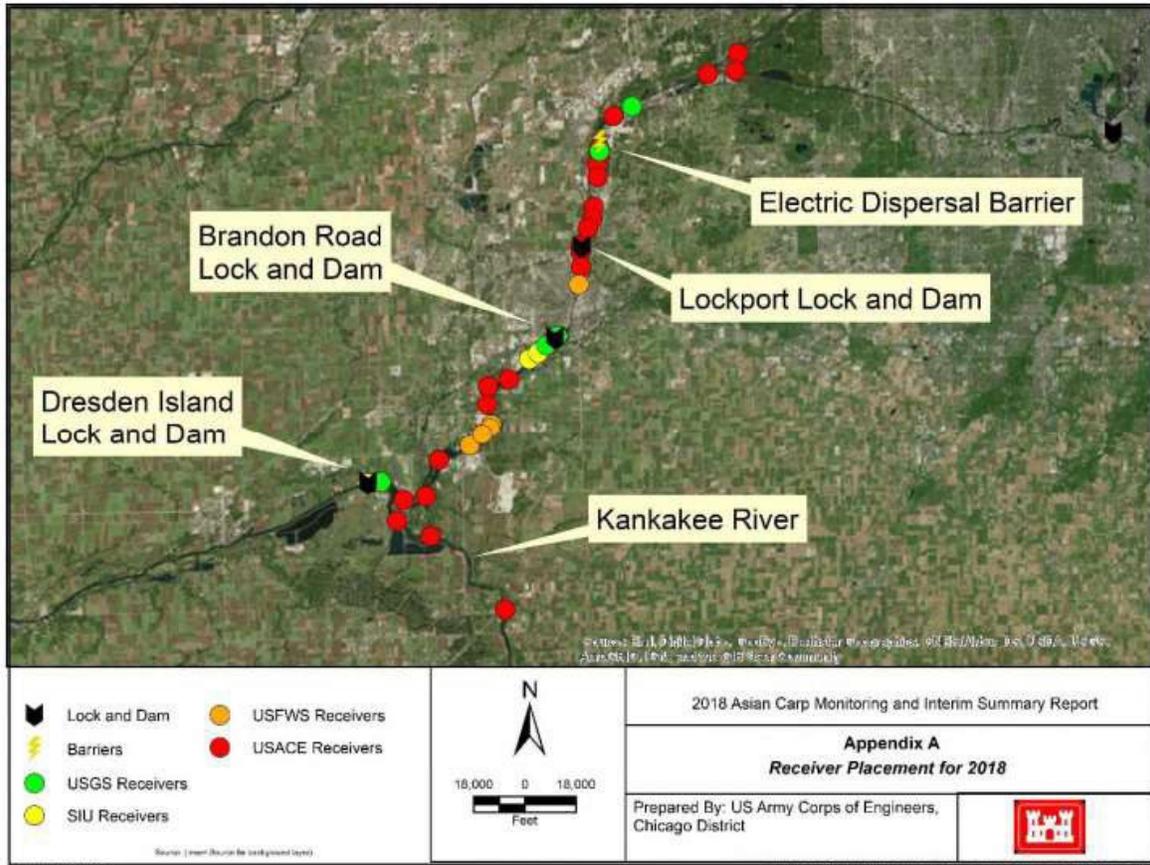


Figure 21. Telemetry receiver array in the upper Illinois Waterway in 2018 (figure from 2018 Monitoring and Response Plan).

At the end of the 2017 season there were approximately 97 tagged fish fitted with transmitters that remained active, with only two of these transmitters expected to expire within calendar year 2018. Additional tagging of fish was required to sustain the recommended levels of the telemetry target sampling size due to the expiration of transmitter battery life and mortalities in some previously tagged fish. Because increases in the numbers of transmitters deployed also increase the burden to stationary receivers for detection, the USACE decided to limit the number of new transmitters to be implanted within certain high detection zones of the study area. A total of 11 transmitters were implanted into surrogate species in 2018 to maintain adequate transmitter saturation within the Lower Lockport Pool and downstream of the EDB. An additional 25 silver carp and 8 bighead carp were implanted with transmitters within the Dresden Island Pool. This increased the number of transmitters to 142 that were active for at least a portion of calendar year 2018. Prioritized response activities and other logistical challenges prevented additional transmitter implementation in 2018. Results to date have shown that no live fish have crossed the EDB in the upstream (northward) direction.

In 2018, the USGS deployed and maintained seven real-time receivers in the Upper IWW. An automated alert system for key personnel was established in 2017 for detections of tagged bighead and silver carp in strategic locations to alert management agencies and inform potential contingency actions. The alert system was continued in 2018. The USGS provided data from all real-time receivers in the interagency telemetry network online. In 2018, new real-time telemetry receivers were deployed in the Upper IWW, including below the EDB near Romeoville, IL.

To facilitate greater accessibility and use of telemetry data, an updated version of the telemetry database and visualization tool (FishTracks) was released in 2018 to collaborating management and research agencies. Enhancements included new features that allow users to import and share data, and a profiler tool for viewing real-time fish movements and related environmental conditions (e.g., water temperature and discharge) at the time of movement. The profiler tool allows users to tie environmental conditions to fish habitat preferences and to analyze fish behavior. An additional update supports enhanced data management and archiving by including metadata utilities. All data and application software continue to be actively maintained.

The USFWS conducted the second year of a telemetry study focusing on evaluating the movements of tagged juvenile silver carp from their initial capture and release site in the Peoria Pool of the IWW. The study provided information on the general habitat categories used by tagged fish (i.e., main channel, side channel, marina, backwater, tributary, and impoundment) and the relationship of water temperature and flow to tagged fish movement. A total of 73 fish were tagged and released (31 with radio and acoustic transmitters) within the Peoria Pool. This pool represents the furthest upstream location within the IWW where all life stages of bighead and silver carp are known to be established and has been targeted for increased use of intensive commercial harvest as a control strategy.

The USFWS also tagged an additional 130 adult invasive carp ≥ 11.8 inches Total Length (TL) in the Peoria Pool for assessing movement and behavior. Fish TL is the length measured from the tip of the snout to the farthest tip of the tail (with the tail compressed). Tagged fish ranged in size from 15.4 - 25.0 inches TL with an average size of 19.1 inches TL. All fish were tagged over an eight-day period and were captured using electrofishing and an electrified dozer trawl. In addition, fin clips were taken of every tagged fish to assist in determining hybridization rates within the Peoria Pool.

eDNA Monitoring

In May 2018, the USFWS collected and processed a total of 310 samples from the CAWS, which includes the Chicago Sanitary Ship Canal, the Mainstem, South and North Branches of the Chicago River, the Calumet and Little Calumet River, and Lake Calumet (Figure 22). No sites tested positive for bighead or silver carp. Samples were processed at the USFWS Whitney Genetics Lab-Midwest Fisheries Center. All sample collection, handling, and processing was conducted following the protocols established and outlined in the FWS Quality Assurance Project Plan for eDNA Monitoring of Bighead and Silver Carps (QAPP) (<https://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf>).

Further details on the agency eDNA monitoring efforts in the CAWS and other basins can be found at: <https://www.fws.gov/midwest/fisheries/eDNA.html>.



Figure 22. Sample locations and detection results for invasive carp eDNA samples collected in the Chicago Area Waterway System in May 2018.

In 2018, the USGS developed and validated the use of a portable eDNA detection kit for silver, bighead, and grass carp for use in the field in open water applications. Additionally, the USGS conducted studies to identify the appropriate number of samples needed to minimize the risk of false negatives within invasive carp eDNA sampling; and continued development of a protocol for the use of molecular tools to prioritize ichthyoplankton samples. Additional studies focused on informing the application of eDNA monitoring for black carp and grass carp detection based on knowledge and data from prior investigations focused on those species.

Traditional Gear Sampling

The ILDNR, USFWS, USACE, USGS, SIU, and contract commercial fishers conducted comprehensive multi-gear sampling in targeted locations in the CAWS upstream of the EDB through the Seasonal Intensive Monitoring (SIM) program. SIM sampling is conducted two times per year (every spring and fall effort) in support of early detection and monitoring objectives described in the annual MRP. In 2018, SIM

monitoring was conducted in June and September, with each sampling cycle running for two back-to-back weeks (weeks of June 4, June 11, September 10, and September 17). Total effort in 2018 included 103.5 hours of electrofishing (414 transects) with an estimated 990 person-hours, 76.6 miles of trammel/gill netting (710 sets) with an estimated 1,485 person hours, 1.4 miles of commercial seine with an estimated 135 person hours, and seven Fyke nets fished for 43 net nights with an estimated 135 person hours. No bighead or silver carp were captured or observed in the CAWS upstream of the EDB during 2018 SIM monitoring. Additional sampling in the CAWS was conducted by ILDNR, USFWS, and USACE at five fixed locations. Additional reaches using boat electrofishing focused on surveillance for invasive carp and characterizing the overall local fish community at these sites. Survey data were used to inform a statistical-based fishery model to quantify the probability of invasive carp presence or absence and relative abundance. Also, the USACE conducted monthly electrofishing surveys within the CAWS to monitor for the presence of fish within or in proximity to the EDB array.

In the upper IWW downstream of the EDB, the ILDNR, Illinois Natural History Survey (INHS), USFWS, and USACE continued monitoring efforts within the Lockport, Brandon Road, Dresden Island, and Marseilles pools. This standardized sampling provided key data on population growth and range expansion, and the threat of possible further upstream advance of invasive carp toward the EDB and Lake Michigan. Monitoring data provided key information on the location of the invasive carp adult population front, determined to be unchanged at approximately 47 miles from Lake Michigan. Additional information collected included the distribution and movement of larval to age-2 invasive carp, estimated site-specific population densities, and specific habitats favored by invasive carp in the IWW. Monitoring for juvenile and larval (age-0) invasive carp and eggs was conducted using gears designed for the collection of earlier (smaller) life stages. Effort targeting adult or juvenile invasive carp included the use of electrofishing, commercial netting, and hoop/mini fyke netting. The overall objectives of the monitoring were:

- Monitor for the presence of invasive carp in the four pools below the EDB (Lockport, Brandon Road, Dresden Island, and Marseilles pools).
- Determine relative abundance of invasive carp in locations where likely to congregate.
- Supplement invasive carp distribution data obtained through other sampling activities in the upper IWW.
- Obtain information on the non-target fish community to verify sampling success, guide modifications to sampling locations, and assist with detection probability modeling and gear evaluation studies.

Larval fish monitoring in the IWW was conducted in the Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange Pools and adjacent backwater lakes; and also in the Kankakee, Fox, Mackinaw, Spoon, and Sangamon Rivers. The objectives of the sampling were to:

- Identify locations and timing of invasive carp reproduction in the IWW.
- Monitor for invasive carp reproduction in the CAWS.
- Determine relationships between environmental variables (e.g., temperature, discharge, habitat type) and invasive carp reproduction and recruitment.

In 2018, 782 ichthyoplankton samples were collected from 12 sites across the length of the IWW, capturing over 86,000 larval fish, including over 51,000 larval invasive carp and over 72,000 invasive carp eggs. Data indicated a high likelihood of a large invasive carp spawning event during the week of June 24, 2018, during which extremely high densities of eggs were observed at all sites from the Starved Rock Pool

to the upper LaGrange Pool. High densities of invasive carp larvae were also present in the Peoria and upper LaGrange Pools at this time. Small numbers of invasive carp larvae continued to be collected in the lower LaGrange Pool through early July, followed by very large numbers of juvenile silver carp captured during gear evaluation sampling in late July. No invasive carp eggs or larvae were collected at any site after July in 2018. No invasive carp eggs were collected upstream of the Starved Rock Pool, and no invasive carp larvae were collected upstream of the Peoria Pool during 2018.

The USFWS conducted monitoring in the Peoria, Starved Rock, Marseilles, Dresden Island, Brandon Road, and Lockport pools using gear types targeting smaller life stages of bighead and silver carp. Effort included 192 electrofishing sites (42.1 hours of fishing time), 64 dozer trawl runs, and 52 mini-fyke net sets. In 2018, no small invasive carp (< 6 inches TL) were captured by the USFWS upstream of the Peoria Pool. Additionally, the USFWS deployed specialized gears (Paupier nets and “dozer” trawls) to target backwater sites in the Peoria Pool where concentrations of juvenile silver carp were collected in 2015 and suspected of serving as nursery habitat. During this effort, a total of 1,354 silver carp were captured.

Additional monitoring included a standardized fishery assessment in the Alton, LaGrange, Peoria, Starved Rock, and Marseilles pools of the IWW to collect population and demographic data on silver carp. Approximately 2,800 silver carp of various year classes (ranging in sizes from 1.6-34.3 inches TL) were captured. Size classes varied across pools and seasons and, in general, the relative abundances of invasive carp increased progressively from upstream (lower) to downstream (higher) navigation pools. In 2018, the USFWS conducted additional monitoring using standard sampling gears targeting invasive carp in the Upper Des Plaines River and overflow locations. Station crews were deployed for two weeks and no silver or bighead carp were captured or observed in the area.

Hydroacoustic Sampling

In 2018, the USFWS, in coordination with the USACE and ILDNR, continued hydroacoustic fishery surveys in the CAWS directly downstream of the EDB. Surveys were conducted approximately every two weeks to measure and evaluate fish density in the EDB sample reach. Results from these surveys demonstrated that fish density (non-invasive carp) directly downstream of the EDB was relatively low late winter through spring, increased measurably in early summer, and peaked in late August. This change was potentially the result of the influx of young-of-year (age-0) non-invasive carp species into the study location, and their subsequent detection during the acoustic surveys. By mid-October, fish densities declined from higher summer levels but were still greater than those observed during spring surveys. Data were used to inform the agencies’ understanding of seasonal characteristics and movements of fisheries adjacent to the EDB.

The USFWS and Southern Illinois University (SIU) regularly conducted seasonal hydroacoustic fishery surveys in the lower and upper IWW (Alton through Lockport pools) in 2018. The survey data provided key information on the relative abundance and densities, spatial distribution, and sizes of fish that occupy the sampled pools. In addition, USFWS conducted hydroacoustic surveys to collect underwater habitat data in the lower IWW at Alton, Illinois, a location where black carp have regularly been captured by commercial fishers. This information is being used to inform the agencies’ understanding of black carp habitat preference and occupancy within the IWW.

3.5.3 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.**

Invasive Carp Capture and Removal

In 2018, the ILDNR, USFWS, USACE, partner MRWG agencies, and commercial fishers continued strategic actions to reduce adult invasive carp numbers in the upper IWW. The primary goal of this ongoing, annual effort is to reduce the likelihood of the progressive advancement of adult invasive carp further upstream in the CAWS, thereby defending and supporting the efficacy of the EDB by reducing the risk of fish challenging the barrier array.

Actions included the Barrier Defense Asian Carp Removal Project, a program established to reduce the numbers of invasive carp downstream of the EDB by reducing invasive carp populations in Dresden Island, Marseilles, and Starved Rock pools through targeted and intensive harvest of adult fish.

Through 2018, over 7.7 million pounds of invasive carp were harvested and removed as a result of this effort, with measured declines noted in the estimated density of invasive carp in navigation pools along the leading edge of established populations in the upper IWW.

Additionally, the USFWS utilized specialized capture gears, including an electrified Paupier netting boat to target habitats typically not sampled by contract commercial fishers with traditional gill nets. USFWS sampling with the Paupier technique targeted concentrations of invasive carp in side channels and tributaries of the Starved Rock Pool. A total of 14 days of sampling effort was conducted during June and September 2018. Sampling was conducted in the main pool immediately above the Starved Rock Dam, in side channel habitats, in the Fox River (a tributary of the IWW), and in other identified silver carp “hot spots” (fish aggregation areas) previously identified in the Starved Rock Pool using hydroacoustic data and boat-mounted sonar. Invasive carp comprised approximately 80% of all fish captured during this effort (primarily silver carp). Approximately 215,000 pounds of invasive carp were captured and removed from the Upper IWW during the season through this effort.

The USFWS, USGS, ILDNR, Southern Illinois University, Illinois Natural History Survey, and Western Illinois University continued development and refinement of a data driven, multi-parameter invasive carp population model (Spatially Explicit Asian carp Population model [SEAcARP]). The SEAcARP model is being used to evaluate and inform the implementation of potential invasive carp management scenarios, including optimal locations and times for harvest of adult fish, and potential locations for implementing deterrents to prevent the continued influx of invasive carp from established downstream populations. In FY 2018, collaborating agencies identified different combinations of the harvest-based mortality rates and upstream movement deterrent effectiveness needed to achieve a given objective (e.g., eliminate invasive carp in Dresden Island Pool over a 25-year period). Also, underlying demographic parameters such as invasive carp growth, natural mortality, weight and length were updated, informed by data collected from numerous agency and university partners. The USFWS also initiated development of a multi-basin population model to account for effects associated with invasive carp movement among the Illinois, Mississippi, Missouri, and Ohio Rivers.

In support of the SEAcARP modeling effort, high resolution bathymetry data was collected in Starved Rock, Marseilles, Dresden Island, and Brandon Road pools. Development of an online visualization tool to inform invasive carp removal efforts (i.e. GIS visualization and decision support tool) was initiated using the La Grange reach of the Illinois River as the test area. Development and expansion of the visualization tool

will continue, incorporating additional key data layers and adding analysis tool capabilities to identify areas with similar environmental conditions.

To improve the effectiveness of invasive carp capture strategies, agencies evaluated potential improvements to methodologies in the IWW. Trials were conducted to determine efficacy of sound and electrofishing to increase fish catch in nets, including the effectiveness of underwater sound generated by boat motors to drive silver and bighead carp to target locations for removal. The USGS, ILDNR, and Joliet Junior College conducted a field study investigating the effectiveness of a pineapple-flavored bait brick as an attractant to invasive carp for possible use to enhance the effectiveness of targeted fishing. A trial using both baited and non-baited nets was conducted in the Starved Rock Pool and Fox River. Laboratory studies will build on field results and continue to screen for other potential attractants and testing for physiological responses by recording electrical activity of scent receptors in the fish and looking at behavioral response to those stimuli.

Actions to Address Pathways

The USACE continued its execution of the GLMRIS - Brandon Road Study, including identification and release of the Tentatively Selected Plan (TSP) for the project (Figure 23). The GLMRIS - Brandon Road Study initially evaluated options and technologies near the Brandon Road Lock and Dam site in Will County, Illinois, to prevent the upstream transfer of AIS from the MRB into the GLB, while minimizing impacts to existing waterway uses and users.

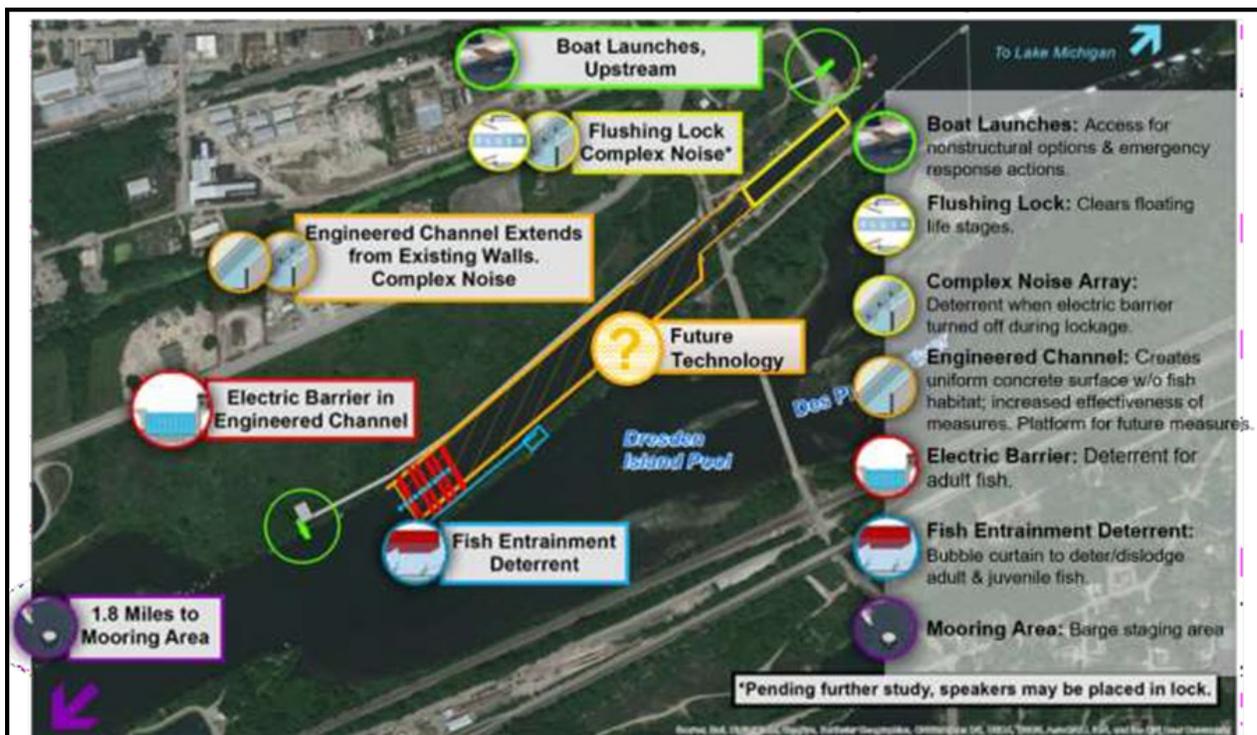


Figure 23. Diagram of the USACE GLMRIS Brandon Road Tentatively Selected Plan.

The TSP contained measures that could potentially be employed at the Brandon Road Lock and Dam and was documented in a draft report released for public review and comment. The USACE released the TSP draft report for public review; conducted four public meetings to allow for public comment on the TSP; and completed the Agency Technical Review (ATR), Independent External Peer Review (IEPR), Policy Review,

and National Environmental Protection Act (NEPA) review. Additionally, the USACE analyzed public comments received during the public review period, developed a recommended path forward to complete the feasibility study based on comments received, and determined needs for completion of the study and to present a path forward at the Agency Decision Milestone. The USACE further developed and employed a comprehensive public engagement strategy to ensure stakeholder awareness and communication of specific project developments and timelines on GLMRIS. For more information visit <http://glmris.anl.gov/brandon-rd/>.

In 2018, the USACE supported the implementation of multiple existing fish deterrent measures in the CAWS, each designed to prevent the potential upstream movement of invasive carp toward the Great Lakes through a distinct hydrologic pathway. The USACE continued maintenance, operations, and enhancements to the EDB in the CSSC in Romeoville, Illinois, the primary permanent deterrent technology barrier against the upstream movement of invasive carp in the CAWS (Figure 24). The EDB is designed to reduce the risk of transfer of fish between the Mississippi River to the GLB via the CSSC. The system currently consists of three barriers (Demonstration, IIA, and IIB) 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. The USACE continues to operate and maintain the EDB as an integral part of its strategy to prevent movement of invasive carp toward the Great Lakes. Construction of an additional permanent barrier continued in 2018.



Figure 24. Map of the USACE Electrical Dispersal Barrier and upstream tributaries.

In 2018, the USACE conducted field and laboratory research to assess the efficacy of the EDBs and to improve its effectiveness, including developing research equipment; methods, modeling, and simulation approaches; and scaled models. The USACE also conducted research to evaluate an Alternating Current (AC) powered electric barrier to design an AC electric dispersal barrier (AC EDB) and determine its efficacy. The USACE developed scaled models and conducted “Simulations of Intrusion” with small sizes of live bighead carp to determine spatial and temporal characteristics for the waterborne electric field that would need to be produced by the AC EDB to achieve the desired effect on invasive carp.

Additionally, the USACE, USFWS, USGS, ILDNR, and other ACRCC partners implemented a Barrier Maintenance Fish Suppression protocol for use during routine or unplanned maintenance operations, as needed, to ensure ongoing effective operation of the EDB. This protocol gives the USACE the ability to safely power down EDB arrays for service without increasing the risk of invasive carp upstream passage.

The protocol includes sampling to detect potential invasive carp downstream of the EDB prior to turning off power; conducting surveillance of the barrier zone with hydroacoustics, side-scan sonar, and dual

frequency identification sonar (DIDSON) during maintenance operations; and employing operations to clear fish between barriers using mechanical or chemical means, if needed.

In support of USACE-required maintenance on the EDB, the USGS developed a temporary underwater acoustic deterrent system for deployment to reduce the risk of invasive carp upstream passage while portions of the EDB were taken offline to ensure in-water worker safety. The temporary system was deployed and monitored below the EDB during maintenance timeframes in winter and early spring.

The USACE continued to maintain the Des Plaines River Bypass Barrier, a 13 mile long combination fence and jersey barrier that physically blocks the movement of invasive carp through potential hydrologic bypasses around the EDB that occur during periods of flooding from the Des Plaines River and the Illinois and Michigan (I&M) Canal. The barriers placed in these locations are intended to stop upstream movement of juvenile and adult invasive carp towards the Great Lakes. The ILDNR, USFWS, USACE, and other cooperating agencies conducted the Des Plaines River and Overflow Monitoring project, which included periodic monitoring for invasive 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 is assessed by the USFWS during its monitor efforts to detect invasive carp juveniles that may be transported to the CSSC via laterally flowing Des Plaines River floodwaters passing through the barrier fence. No invasive carp were captured or observed during this monitoring effort.

The USACE also continued to operate bar screens on sluice gates at Thomas J. O'Brien Lock and Dam on the Calumet River in Chicago. The screens were previously installed by USACE to impede the potential entry of invasive carp into Lake Michigan, in the event fish were present at that location.

Barge Entrainment

In 2018, the USFWS completed planning and study design for a large-scale, on-water field trial to further evaluate the potential inadvertent entrainment and transport of small invasive carp by commercial barges transiting the IWW. The field trial was designed to address additional questions and information needs resulting from prior laboratory and field evaluations of barge entrainment conducted by the USFWS and its partners and was informed by discussions with the commercial navigation industry. The study was scheduled to be conducted in the La Grange Pool in the vicinity of Peoria Lock and Dam on the lower IWW in October 2018. The selected study location is in the downstream portion of the IWW in which populations of silver and bighead carp are already well-established, with all size classes present. The study design incorporated a commercial barge tow interacting with small invasive carp while operating under normal navigating conditions during multiple transects in the IWW. A goal of the evaluation was to more realistically simulate and objectively evaluate the likelihood and dynamics of transiting commercial barge tows interacting with small invasive carp under real-world scenarios (barges transiting active navigation channels of the IWW where small size classes of invasive carp are known to be present). Results of this work will be available following completion of the study, data analysis, and development of the final report.



Figure 25. A commercial barge traveling through the Chicago Sanitary and Ship Canal. Photo courtesy USFWS.

In 2018, the USGS undertook additional investigations to further evaluate barge entrainment and fish interaction dynamics, building on previous studies conducted during 2015, 2016, and 2017. Earlier studies showed that the efficacy of the EDB in preventing the passage of small, wild fish was temporarily impacted while tows moved across the barrier system. In 2018, preliminary results from studies of options for potential mitigation of “return flow” (temporary changes to local hydrology in the canal from moving barge tows) were summarized in a presentation to stakeholders. This study tested the potential for preventing upstream passage of small fish across the EDB by preventing upstream return currents. The return flow mitigation study showed that preventing upstream return currents may reduce, but does not prevent, tow-mediated upstream fish passages because tows also cause a temporary reduction in the streamwise voltage gradient at the EDBs. Hydraulic data from the return flow mitigation study was published as a USGS data release, and a manuscript was submitted to the *Journal of Great Lakes Research*. Actions in 2018 also included preliminary processing of tow shiptrack data and FluEgg simulations for the Illinois River to be used in an assessment of the risk of entrainment of early life stage invasive carp by transiting barges.

3.5.4 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

Federal, state, and nongovernmental partners continued efforts in 2018 to develop and evaluate potential new invasive carp deterrent technologies to augment broader basin-wide prevention and control strategies. The ACRCC’s 2018 Asian Carp Action Plan identified the development and testing of emerging deterrent technologies as a priority for bolstering defense of the Great Lakes from invasive carp. Building on prior work, agency projects conducted in 2018 addressed high-priority needs to advance and evaluate deterrents as potential new management tools. Activities conducted in 2018 were

supported through strong collaboration between federal and state agency partners across the IWW/CAWS, UMRB, and ORB.

Acoustic Deterrent Barriers

The USFWS, USGS, USACE, and other federal, state, and nongovernmental partners continued collaborative development and evaluation of underwater acoustic technology as a potential fish deterrent tool. The potential effectiveness of underwater sound as a selective barrier to invasive carp had been previously demonstrated in laboratory and pond settings. Prior studies demonstrated that both bighead and silver carp react negatively to sound, while many native fish species are less impacted. The 2018 Action Plan included projects focused on large-scale field evaluations of the efficacy of acoustic deterrent systems conducted in locations within river systems with active navigation locks where populations of bighead and/or silver carp were previously established.

To quantitatively evaluate the effectiveness of acoustic deterrent systems against the passage of invasive carp, ideal test sites were identified within river sub-basins that included active navigation lock and dam complexes that also had a known history of upstream passage of invasive carp and limited fish migration to the lock chamber (e.g. adjacent to high-head dams that precluded upstream fish passage). Project study teams determined that these characteristics would facilitate a more robust and repeatable assessment of proposed acoustic deterrent technology effectiveness under a variety of measurable operational scenarios. Based on these physical and biological characteristics, individual project locations for conducting field trials were identified in the ORB (Barkley Dam on the Cumberland River) and in the UMRB (Lock and Dam 19 on the Mississippi River). An existing deterrent system technology consisting of a combination of underwater sound, bubbles, and lights (“Bio Acoustic Fish Fence” from Fish Guidance Systems, LLC) was selected for testing at Barkley Dam. A prototype sound-only acoustic deterrent system being developed by the USGS was proposed for testing at Lock and Dam 19.

To identify suitable sites available for testing the technologies, project planning involved strong collaboration across the IWW/CAWS, UMRB, and ORB watersheds. It is important to note that technological advancements, scientific findings, and operational strategies resulting from these projects will be used to inform the development of acoustic deterrent systems for defense of the Great Lakes, including development of the USACE-Brandon Road project; as well as to inform invasive carp management strategies in the UMRB, ORB, and other sub-basins. These projects are further referenced in Section 3.2.4 (ORB, Research and Development, Development of New Deterrent Technologies, Acoustics); and Section 3.3.4 (UMRB, Research and Development, Development of New Deterrent Technologies, Acoustics).

Additionally, the USGS initiated efforts to test the use of underwater acoustic deterrents by determining the optimal sound characteristics (e.g., sound pressure levels, frequencies, and particle velocities) that deter invasive carp, while preventing injury to native species, and its effectiveness for containing, herding, or capturing invasive carp. In 2018, the USGS completed studies with the University of Minnesota-Duluth, to test the hearing ability of silver, bighead, black, and grass carp and identify the potential for temporary shifts in hearing to occur if fish were exposed to high decibel sound for extended periods of time.

Carbon Dioxide Barriers

The USGS and partner agencies continued the evaluation of CO₂ injected into water as a potential non-physical deterrent barrier to invasive carp migration. In 2018, the USGS and partners initiated testing of

the feasibility of effectively deploying CO₂ as a barrier within a navigational lock. In 2018, the USGS and partners received approval from the Fox River Navigational System Authority to test the feasibility of CO₂ within a navigational lock on the Fox River near Kaukauna, Wisconsin. Identifying an appropriate pilot study site was facilitated by strong collaboration between federal and state agencies working across sub-basin boundaries. The design, construction, operation, and monitoring of a large-scale CO₂ infusion system within a navigational lock were planned as next steps in 2019 to determine the overall costs and feasibility of operationalizing the proposed new fish deterrent technology for managing invasive carp and other AIS. This project is further described in Section 3.3.4 (UMRB – Research and Development, Development of New Deterrent Technologies – Carbon Dioxide).

Development of New Targeted Control Technologies

The USGS continued development of a microparticle piscicide (fish toxicant) that has demonstrated high toxicity and selectivity toward invasive carp. USGS is developing oral delivery formulations that can stabilize and deliver a control agent that targets silver, bighead, grass, and black carp while minimizing potential impacts on native species. In late 2017 and September 2018, the USGS conducted two field assessments of microparticles. Studies included evaluations of the impacts of an application of toxic antimycin microparticles on fish in an impoundment to the Wabash River in Indiana, and the application of toxic antimycin microparticles in a flowing system in Iowa. Data and results were used to inform microparticle development and refinement. Also, a new bait formulation was developed to selectively target the delivery of antimycin to grass carp. The USGS also purchased the strain used to produce antimycin and is working toward re-establishing registration as a fish toxicant. Additional studies were conducted with Joliet Junior College on potential development of a bait formulation that, when used with specific attractants, will elicit an involuntary feeding response in invasive carp. Specific registration processes must be followed to obtain approval for the use of toxic microparticles as control agents in the environment. The USGS is collaborating with USFWS on the compilation of data and reports for submission to the USEPA or other regulatory agencies to support approval of microparticle for use. The USFWS continued to work with the USGS to develop standard operating procedures and coordinate submission of studies to address EPA and ESA Section 7 consultation data requirements of antimycin-incorporated microparticles. This project is further referenced in Section 3.3.4 (UMRB – Research and Development; Development of New Control Technologies – Microparticles).

Additionally, the USGS tested an additional potential method for selectively delivering a piscicide for invasive carp control. Evaluations included testing the potential black carp bait size and delivery method. A dose of the toxin antimycin-A encapsulated in a glass vial was attached to the exterior of an Asian clam that was consumed by a black carp. The test resulted in no mortality. Subsequent efforts focused on increased doses and assessing the ingested toxicity of antimycin-A. Preliminary results of this work titled “Development of an oral piscicide delivery method for invasive Black Carp” were presented at the American Fisheries Society National Meeting in 2018.

Development and Testing of New Capture Gears and Techniques

The USFWS, ILDNR, USACE, and USGS continued to develop, evaluate, and integrate new sampling techniques and gears for invasive carp detection and removal in a variety of habitats. Efforts included evaluating and optimizing capture methods and novel sampling gears to better target invasive carp in tributaries, large reservoirs, and backwater lakes. The USGS continued to assess and improve the Unified Method, a fishing strategy used for intensive and focused harvest of invasive carp from a pre-determined portion of a large body of water (e.g., reservoir or embayment). Using this approach, sound

and electricity are used to herd invasive carp towards an area where they are concentrated and removed with large seines or trap nets. Also, the USFWS evaluated methods to more effectively capture adult silver carp from Midwest river environments using standard-sized fishing boats. These activities included evaluating fish behavior in response to potential sampling scenarios (e.g., large traps and herding methods) and developing new gears or modifying existing gears to increase effectiveness for invasive carp detection and capture. New sampling gears developed included a large, high-speed seine and a flexible curtain system for use on boats in combination with high-intensity light to herd fish for collection. The USFWS also conducted a pilot study to determine invasive carp abundance using hydroacoustics and an electrified dozer trawl in two pools of the Illinois River. Based on results of field evaluations, effective techniques (e.g., fish herding, capture, and mass removal) could potentially be employed by agencies and commercial fishers in the future to augment existing management efforts in appropriate locations, within broader basin-wide invasive carp control strategies.

Invasive Carp Biology, Life History, and Reproduction Evaluations

In 2018, the FluEgg model was rebuilt to improve overall accessibility and functionality. A web-deployable FluEgg forecast model for the Illinois River was completed and a new method for predicting spawning locations from captured eggs and larvae using FluEgg was developed and applied to the Illinois River. Additionally, the USGS conducted laboratory experiments in 2018 to characterize the settling velocity, drift response, and survival rate of grass carp eggs and larvae under complex lake/riverbed morphologies. An article was published in 2017 describing laboratory experiments examining the drift and swimming behavior of grass carp eggs and larvae and their interaction with bottom material in flowing water. Results from these evaluations and model simulations are used to inform agency and partner understanding of grass carp spawning dynamics under a variety of environmental scenarios in river and lake systems.

The USGS and partners conducted research on wild-caught black carp to obtain key information on diet, reproductive status, and ploidy age, growth, and genetics of populations in Midwest US river systems. Black carp specimens captured primarily through cooperating commercial fishers were assessed at the USGS. In 2018, the USGS hosted experts in fish age estimation for a face-to-face workshop to discuss structure processing, age assignments, and preferred structures that minimize bias in estimating fish ages. Proposed standard guidelines were developed for use by investigators to ensure consistent analyses and data compatibility for black carp. Also, the USGS completed processing and aging of structures and gonad samples from wild black carp captured 2011-2017, with results provided to collaborators to inform the preparation of manuscripts for publication. The USGS also provided additional key findings on black carp biology and life history thorough numerous scientific workshops, symposia, and publications.

In 2018, the USGS continued to investigate the potential influence of river hydraulics and water quality on the population range, movement, and spawning and recruitment success of invasive carp. The USGS analyzed water quality samples collected at seven sites along the IWW on four occasions in 2015 for chemicals, identifying some specific compounds (e.g., pharmaceuticals, volatile organic compounds) that may be contributing to the stalled invasive carp population front near river mile 278 of the IWW. The data from this study were published as a USGS data release (Duncker et al. 2017). In a related, collaborative study with the University of Illinois, analyses of fish tissue from silver carp captured by commercial netting near and downstream of the population front showed invasive carp at the population front exhibited increased activity of genes associated with detoxification and other differences.

Additional fish tissue samples were collected in 2018 from bighead and silver carp caught by commercial

harvesters near the population front in the IWW for analysis, with publication of the results expected in 2020. The USGS continued mapping the velocity of selected river reaches to inform invasive carp spawning documentation studies and continued the operation and maintenance of two USGS streamflow gauging stations on the IWW (main channel and backwater) to document river conditions and water quality associated with invasive carp movement and inform commercial fishing and mass harvest operations.

3.5.5 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.**

Invasive Carp Partnership Websites

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

Public/Stakeholder Engagement

The ACRCC member agencies provided periodic briefings to Congress, officials from Great Lakes States, and others on key issues related to invasive 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

In addition to public engagement by the USACE on the GLMRIS Report, the USFWS, USACE, USGS, ILDNR, and other cooperating agencies participated in the following organized stakeholder groups:

- The Technical and Policy Workgroup, composed of academia and non-governmental organizations interested in technical and policy issues relating to the design and operation of the USACE EDB.
- The CAWS Aquatic Nuisance Species Advisory Committee, composed of more than two dozen stakeholder organizations that have expressed an interest in preventing AIS transfer into the Great Lakes, especially invasive carp.
- The Barrier Navigation Task Force, composed of representatives from the navigation industry interested in research on the efficacy of the EDBS.

The USACE also conducted outreach with members of the navigation industry in advance of and during significant electric barrier maintenance activities that impacted navigation traffic in the Chicago Sanitary

and Ship Canal. The USFWS produced and distributed outreach materials to provide information on the Illinois DNR black carp bounty program and encouraged reporting of invasive carp captures or observations by the public and other agencies.

3.5.6 LAW ENFORCEMENT/REGULATORY

- **NATIONAL PLAN GOAL: Prevent accidental and deliberate unauthorized introductions of bighead, black, grass, and silver carp in the United States.**

In 2017, the U.S. Court of Appeals for the District of Columbia Circuit held that section 42(a)(1) of title 18 of the Lacey Act does not "prohibit shipments of injurious species between the continental States." United States Ass'n of Reptile Keepers, Inc. v. Zinke, 852 F.3d 1131, 1142 (D.C. Cir. 2017). Individual states, however, continued to regulate the production, possession, sale, and transport of invasive carp within their respective jurisdictions. In addition, enforcement focused on compliance with regulations and best-practices related to the transport and use of live bait by commercial harvesters, dealers, and anglers. In 2018, the ILDNR Office of Law Enforcement conducted an alternative pathway surveillance program intended to increase education and enforcement activities at bait shops, bait and sport fish production and distribution facilities, fish processors, and fish markets and 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 INVASIVE CARP

Agency and nongovernmental partners conduct critical research to support the development and implementation of potential new technologies and tools for use within invasive carp management strategies. In 2018, federal agency efforts were led primarily by the USGS, USACE, and USFWS, with state agencies and universities conducting additional key research. Research and technology development activities addressed priority needs under the following general categories:

- Early detection and monitoring
- Prevention
- Control
- Pathway analysis
- Risk assessment
- Life history and behavior
- Feeding ecology

Potential new invasive carp control technologies are designed to exploit known species-specific life-history vulnerabilities and unique behavioral characteristics to achieve optimal population management impact. As potential new tools are investigated and developed, supporting research must also consider potential negative impacts to non-target aquatic species, especially depleted or imperiled state or federally-listed fish and mussels. As a result, several control tools currently being developed are highly specific to invasive carp species to avoid impacts to non-target native aquatic species. Prevention actions that are more general and not selective for invasive carp, including sound, CO₂, or bubble barriers, are designed to be deployed in a manner to deter fish movement while not being lethal. Additionally, information on invasive carp life history, including habitat use and migration patterns, is integral for informing and directing the strategic timing and placement of potential control technologies; and understanding the risk posed by potential movement through various pathways.

Key research and technology projects conducted in 2018 by federal and state agencies and partners within the individual basins are further described in Section 3 under “Research and Development” for each respective sub-basin within this Report (ORB-Sec. 3.2.4; UMRB-Sec. 3.3.4; and IWW/CAWS-Sec. 3.4.4).

Additionally, weblinks have been included to provide additional background on specific research and technology development projects reported within Section 3.

5.0 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 2018 expenditures directly related to invasive carp activities conducted by federal and state agencies in the UMRB, ORB, and IWW/CAWS. Agencies reported a total of \$55,928,765 for all basins combined, of which \$48,740,155 supported actions in the IWW/CAWS to protect the Great Lakes from invasive carp. The total reported expenditures on activities conducted to benefit the ORB and UMRB and tributaries was \$7,188,610 (Table 1 in Section 5.0).

Agencies were queried for an accounting of all invasive carp-related expenditures incurred during their respective FY 2018, categorized by both funding source and general type of activity conducted. Activities were categorized as follows:

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

The percent of total reported expenditures is as follows: Active Prevention and Control, 47.8%; Research and Development, 23.8%; Monitoring, Early Detection, and Rapid Response, 16.9%; Interagency Coordination, 8.6%; Outreach with Stakeholders, 1.2%; and Law Enforcement/Regulatory Actions, less than 1.0%. An activity category was not assigned to 1.6% of the reported expenditures.

Additional FY 2018 expenditures were reported by agencies conducting actions to address the Great Lakes and Mississippi River Interbasin Study (GLMRIS) Secondary Pathways. Since these pathway mitigation efforts are focused on protecting the GLB from the movement of invasive carp and are not exclusively within the delineated geographic boundaries of the ORB, related costs were excluded from the total expenditures summarized in this Report. However, this Report includes a brief summary of GLMRIS Secondary Pathway mitigation activities reported by agencies to present a more complete overview of the scope of efforts conducted to reduce the risk of potential interbasin range expansion of invasive carp from the ORB to the GLB. Table 1 provides a summary of all expenditures reported by individual agencies. Columns in the table are identified as follows:

- Total Agency Great Lakes Restoration Initiative (GLRI) Expenditures - Total reported expenditures of GLRI funds for activities that support invasive carp management in the IWW/CAWS
- Total Agency Base Expenditures - Total reported expenditures of agency base funds for activities that support invasive carp management in the UMRB, ORB, and IWW/CAWS
- Total Other Expenditures - Includes additional expenditures not supported by GLRI or agency base funds
- Total Reported Expenditures - Total reported expenditures of agency base, GLRI, or other funds for activities that support invasive carp management in the UMRB, ORB, and IWW/CAWS
- Total UMRB/ORB (without IWW/CAWS) Expenditures - Total Reported Expenditures (see above) for only UMRB and ORB invasive carp management (excludes all IWW/CAWS activity expenditures)

Note that funds provided by granting agencies (e.g. the 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 by an agency for invasive carp management.

Total FY 2018 Expenditures Reported for Invasive Carp Activities

Agency	Total Agency GLRI Expenditures ¹	Total Agency Base Expenditures	Total Other Expenditures	Total Reported Expenditures ^{2,4}	Total UMRB/ORB (w/o IWW/CAWS) Expenditures ³
USACE	4,053,514	25,785,497	0	29,839,011	0
USGS	4,178,749	5,430,690	266,350	9,875,789	1,461,600
NOAA	190,206	0	0	190,206	0
USFWS	4,619,500	3,428,666	0	8,048,166	2,573,800
NPS	4,343	3,542	0	7,885	5,420
Indiana	131,681	6,667	28,921	167,268	20,000
Iowa	0	59,500	0	59,500	59,500
Kentucky	0	465,000	385,000	850,000	850,000
Illinois	4,963,599	0	431,555	5,395,154	396,555
Minnesota	0	208,524	690,714	899,238	899,238
Mississippi	0	9,682	0	9,682	9,682
Ohio	130,501	16,131	115,892	262,524	0
Pennsylvania	0	63,426	0	63,426	0
Tennessee	0	260,915	0	260,915	260,915
West Virginia	0	46,935	15,645	62,579	62,579
Total	18,272,093	35,785,175	1,934,077	55,991,345	7,251,190

Table 1. Expenditures reported by federal and state agencies for efforts to address invasive carp in the UMRB, ORB, and IWW/CAWS in 2018.

¹ 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 invasive carp activities carried out within the designated sub-basin. These activities, as well as others focused on Great Lakes protection and conducted through the ACRC, are further described in the FY2018 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 Minnesota Outdoor Heritage Fund).

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

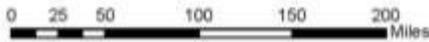
⁴ USFWS invasive carp expenditures include those for the UMRB, ORB and IWW/CAWS but exclude GLB. Also, USFWS appropriated funding provided to States as grants are individually reported by each State.

APPENDICES

- Appendix 1: Maps of Navigation Pools and Lock and Dam Structures in the UMRB and ORB
- Appendix 2: Summary of 2018 Accomplishments Described by Qualitative/Quantitative Metric
- Appendix 3: List of Acronyms Used in this Report

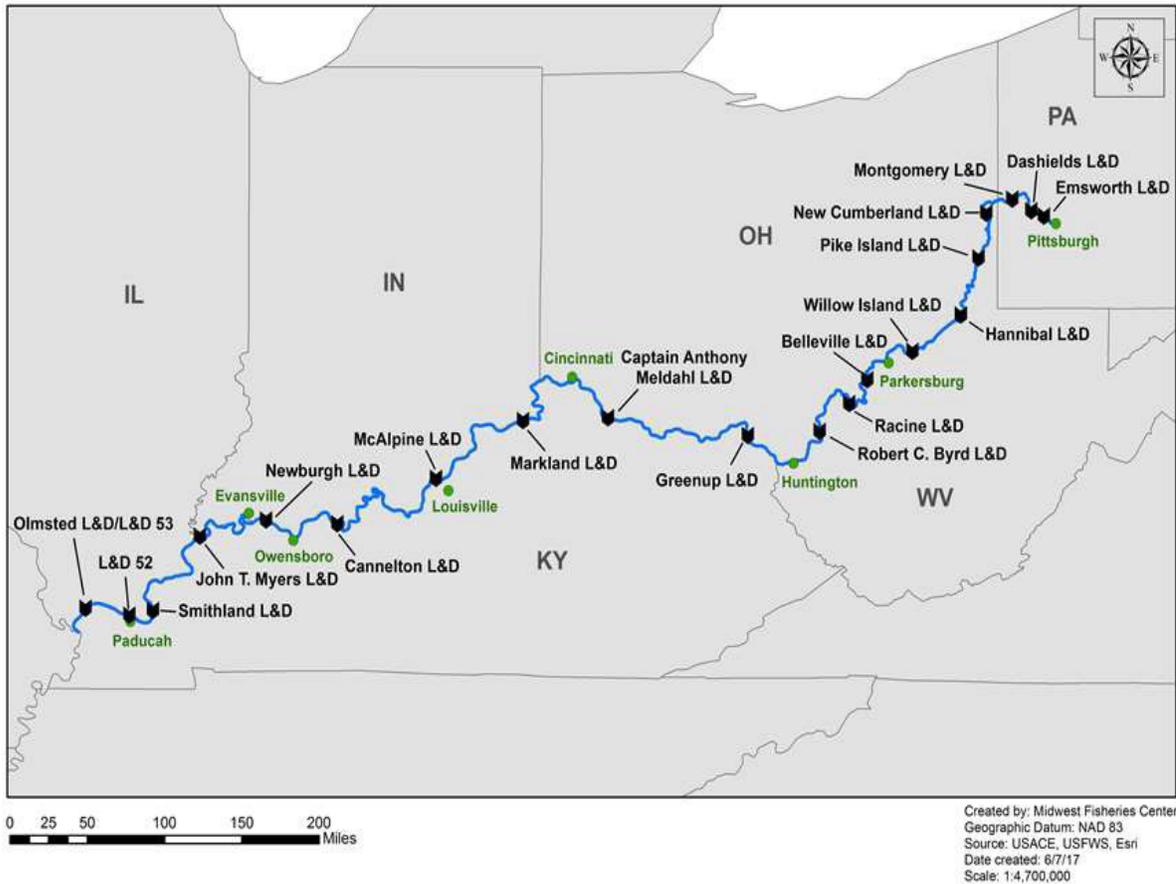
**APPENDIX 1: MAPS OF NAVIGATION POOLS AND LOCK AND DAM
STRUCTURES IN THE UMRB AND ORB**

Upper Mississippi Navigation Pools

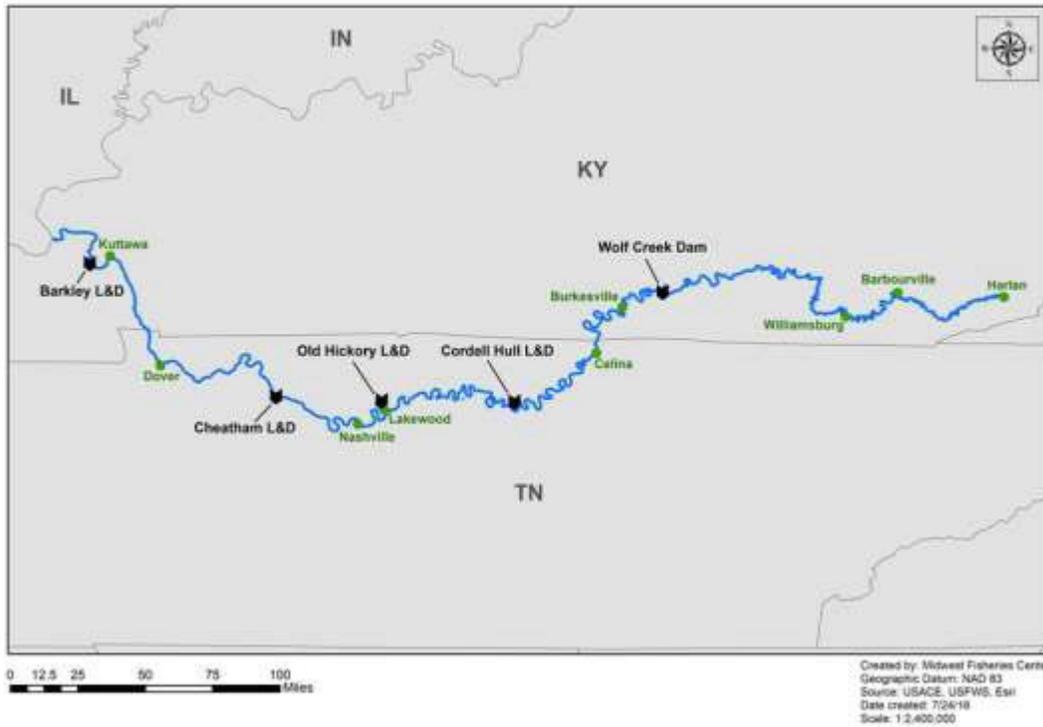


Created by: Midwest Fisheries Center
 Geographic Datum: NAD 83
 Source: USACE, USFWS, Esri
 Date created: 8/23/17
 Scale: 1:4,577,000

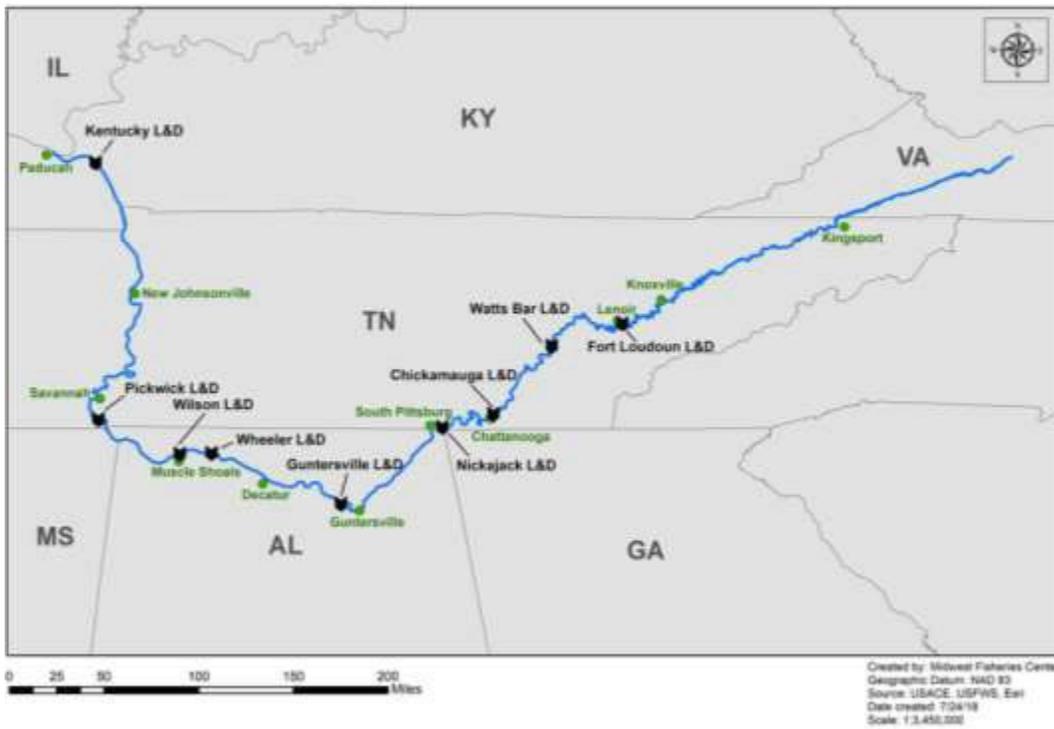
Ohio River Navigation Pools



Cumberland River Navigation Pools



Tennessee River Navigation Pools



APPENDIX 2: SUMMARY OF 2018 ACCOMPLISHMENTS DESCRIBED BY QUALITATIVE/QUANTITATIVE METRIC

The WRRDA directs the USFWS to identify measures to document progress in controlling the spread of invasive carp in the UMRB and ORB and their tributaries. The initial 2014 Report identified: (1) proposed measures and outcomes for ensuring progress toward the goals of controlling spread of invasive 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 use of these measures is intended to promote ongoing evaluation, reporting, and accountability in support of the National Plan, and invasive carp strategies in the ORB, UMRB, and IWW/CAWS. The identified measures of progress include specific actions to support comprehensive and sustained interagency coordination; and both qualitative and quantitative measures of progress identified to describe progress in strategically implementing comprehensive invasive carp detection, prevention, and control actions.

A summary of accomplishments achieved in 2018 and described in this Report by each measure is provided below. Summaries of progress will continue to be provided in subsequent annual reports.

Actions to Address the Need for Interagency Coordination

The following measures of progress are identified to evaluate progress in strengthening coordination between federal and state agencies to cohesively manage invasive carp:

- 1. Development of interagency UMRB, ORB, IWW/CAWS, and other basin-specific invasive carp control strategies that complement the National Plan while addressing the management needs of each basin. 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 prevent duplication of effort. Incorporating basin-specific invasive carp control strategies into a national approach will also help identify gaps in science and data in invasive carp management and provide a foundation for collectively developing priority initiatives to benefit multiple basin-wide partnerships.***

Accomplishments in the ORB

- The ORFMT continued to implement the Ohio River Basin Asian Carp Control Strategy Framework (ORB Framework) (http://www.micrarivers.org/wp-content/uploads/2018/08/ORFMT_Asian_Carp_Strategy.pdf), originally released in October 2014. The ORB Framework provides recommendations for priority prevention, monitoring, response, control, and communication actions to prevent further expansion, reduce populations, and better understand the impacts of invasive carp. Implementing this comprehensive strategy supports the goals of the National Plan, and is intended to minimize the social, ecological, and economic impacts of these invasive fishes within the ORB.
- In 2018, the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin (<http://micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>) was developed and implemented to deliver priority projects in support of the goals and recommendations of both the ORB and UMRB Frameworks.

Accomplishments in the UMRB

- The UMRB partners finalized and implemented the Upper Mississippi River Basin Asian Carp Control Strategy Framework (UMRB Framework). A final version was completed in August 2018 (<http://micrarivers.org/wp-content/uploads/2018/10/UMR-Framework-Final.pdf>). Similar to the ORB Framework, the strategy outlines key management goals and related actions to control invasive carp populations and prevent further expansion.
- See reference to the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin in the previous section.
- The MNDNR, through the University of Minnesota, completed the *Minnesota Bigheaded Carps Risk Assessment*, describing the varying potential adverse effects and risks posed by bighead and silver carps across watersheds. The Minnesota River-Mankato watershed was estimated to have the highest probability of establishment (70%), followed by the Lower St. Croix River (45%) and Nemadji River watersheds (38%).
- Federal and state agency partners finalized an invasive carp deterrent assessment and strategy for the UMRB, identifying potential suitable deterrent technologies and locations for deployment, and providing recommendations for experimentation and next steps. The assessment, led by the USFWS, is summarized in the report entitled Asian Carp Deterrent Strategy for the Upper Mississippi River Basin (http://www.micrarivers.org/wp-content/uploads/2019/08/Potential-Use-of-Deterrents_Final.pdf).

Accomplishments in the IWW/CAWS

- The ACRCC developed its 2018 Asian Carp Action Plan, which included 31 agency-led projects for prevention, early detection, response, and long-term control of invasive carp, including pathway mitigation actions and the development of new deterrent technologies. The Action Plan supported implementation of the ACRCC's tactical 2018 Monitoring and Response Plan (MRP), and the goals and recommendations of the National Plan. In 2018, priority control technology development projects were conducted in cooperation with federal and state partners in other sub-basins, including the ORB and UMRB. Results and lessons learned will be shared across the multiple river sub-basins conducting invasive carp management actions.
- The ACRCC MRWG developed its comprehensive 2018 MRP, primarily focused on invasive carp prevention and control in the IWW/CAWS. This annual interagency strategy directs the implementation of 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 invasive carp. Additional projects support assessments of invasive carp population dynamics and behavior, and the efficacy of control and capture methods. The MRP sets pool-by-pool targets for population removal and includes short-term and long-term goals for control, including downstream commercial removal of invasive carp at 20 to 50 times the current annual level. The MRWG includes work groups of technical subject matter on key management and research themes, including Contingency Planning, Removal, Hydroacoustic Assessments, Telemetry, Modeling, and Behavioral Deterrent Technologies. Primary agencies include the ILDNR, USFWS, USACE, USGS, USEPA, ILNHS, and the GLFC. The 2018 MRP is available at: <https://www.asiancarp.us/Documents/MRP2018.pdf>.
- The MRWG developed its annual Interim Summary Report (ISR) summarizing completed MRP projects for the designated year, with the emphasis on actions in the IWW/CAWS. The ISR provided results and recommendations for next steps for each project. The ISR is available at: <https://www.asiancarp.us/Documents/InterimSummary2017.pdf>.

2. Identification of federal and state resources potentially available for implementing control strategies and actions.

Accomplishments

- The USFWS continued to coordinate with UMRB and ORB states and other federal agency partners to identify potential resources to implement highest-priority detection and control actions and leverage those resources where feasible. States that received additional funding from the USFWS for invasive carp projects in conjunction with their ANSTF-approved state ANS management plans provided at least a 25% match for these funds. Numerous states also evaluated the need for increased state resources, exploring options including increasing fees and other innovative methods to leverage funding.

3. Development of ORB/UMRB formal institutional arrangements, using a collaborative model similar to the ACRCC, to facilitate interagency coordination, collaboration, and plan implementation.

Accomplishments

- The USFWS continued to work through the MICRA for annual and longer-term invasive carp coordination and multistate project planning and implementation in the ORB and UMRB. The sub-basin partnerships previously identified interagency organizational structures and processes for coordinated planning and reporting, development of funding strategies, implementation of actionable plans, and identification of roles and responsibilities for all participating agencies. Utilizing the MICRA, the ORFMT and UMRCC adopted an interagency coordination model to identify and provide recommendations for the highest priority invasive carp project needs in the ORB and UMRB, with the USFWS making final funding decisions.
- Continuing in 2018, priority projects were proposed for funding approval by the MICRA Asian Carp Advisory Committee and the USFWS. This coordination model ensured that annual projects were vetted through the USFWS and the MICRA Asian Carp Advisory Committee, and that funded projects support the management priorities of the respective sub-basin strategies and the National Plan. This process directly supported implementation of the Ohio River Basin Asian Carp Control Strategy Framework (http://www.micrarivers.org/wp-content/uploads/2018/08/ORFMT_Asian_Carp_Strategy.pdf), and the Upper Mississippi River Basin Asian Carp Control Strategy Framework (<http://www.micrarivers.org/wp-content/uploads/2018/10/UMR-Framework-Final.pdf>), completed in August 2018.

4. Development of an annual project plan with management structure and appropriate funding.

Accomplishments

- In 2018, the MICRA and USFWS coordinated with the ORB and UMRB sub-basin partnership planning teams to develop the annual comprehensive work plans incorporating priority USFWS-funded projects for FY 2018. The 2018 Asian Carp Monitoring and Response Plan for the Mississippi River Basin (MRPMB) outlined collaborative efforts to manage and control invasive carp populations in the ORB and UMRB. The MRPMB is adaptive and updated annually, informed by current data and priorities, in support of the ORB and UMRB sub-basin Frameworks and the National Plan. The 2018 MRPMB is available on the MICRA partnership website

<http://www.micrarivers.org/wp-content/uploads/2018/10/2018-Monitoring-and-Response-Plan-for-Asian-carp-in-the-Mississippi-River-Basin.pdf>).

- Deliverables outlined in the MRPMRB are provided in annual technical reports for each project conducted within the ORB and UMRB, and include detailed findings as well as future recommendations for respective projects (<http://www.micrarivers.org/asian-carp-plans-and-reports/>).

5. *Development of a process to ensure actions are strategically prioritized and properly sequenced.*

Accomplishments

- The USFWS has worked extensively with the UMRB and ORB States, MICRA, and other federal agencies to ensure that individual activities proposed for invasive carp management are strategically prioritized, properly sequenced, and support the goals and recommendations of the
- National Plan and sub-basin Frameworks. This process continues annually, informed by and building upon the ongoing interagency coordination mechanisms currently in place for invasive carp strategic planning within the respective sub-basins. Further, interagency partnership work groups develop, implement, and evaluate annual comprehensive work plans, and inform needed changes based on results and recommendations.

6. *Preparation of an annual report summarizing accomplishments and strategies for management of Invasive Carp, as prescribed in WRRDA 2014, Section 1039.*

Accomplishments

- The USFWS develops the annual report to Congress, summarizing accomplishments and expenditure for invasive carp prevention and control efforts in the UMRB and ORB. The report includes measures of progress to identify successes and cumulative progress in the reporting year. The 2018 Report represents the fifth iteration since the original 2014 Report. The USFWS will continue to provide leadership in coordinating this effort on behalf of the federal agencies, with assistance from other federal and state agencies conducting activities to address invasive carp in the UMRB and ORB. As required, the Report includes a summary of agency accomplishments and related expenditures for invasive carp activities, status of the distribution of invasive carp (including any observed changes in range), and an overview of key research to support prevention and control measures.

Quantitative Measures of Progress

The following quantitative measures of progress are identified to evaluate progress in controlling invasive carp.

1. *Physical removal of invasive carp through the use of focused contracted commercial harvest in the UMRB, ORB, and the Upper Illinois River.*

Accomplishments

- In 2018, agencies in the UMRB, ORB, and IWW/CAWS continued to actively support the physical removal of invasive carp within river basins, focusing on reducing fish densities along the

upstream “leading edge” and within established downstream source populations. Given their designated management authority over the fisheries in their respective jurisdictional waters, state agencies continued to provide oversight to both the contract efforts and the commercial fishing industry. State-led efforts are being informed by surveys and statistically-based fishery modelling efforts, conducted in collaboration with the USFWS and USGS. Additional assessments included modelling the cumulative effects of the potential placement of fish migration barriers in conjunction with commercial harvest and quantitatively evaluating the effects of intensive harvest on invasive carp population dynamics in support of invasive carp management goals.

- The KDFWR continued to support the Asian Carp Harvest Program (ACHP), focused on intensive removal of adult invasive carp from Kentucky Lake and other waterways. From 2013 to the end of the 2018 reporting period, the ACHP supported removal of over 5 million pounds of invasive carp from Kentucky waters, with approximately 1.16 million pounds harvested from October 2017 through September 2018.
- In 2018, the KDFWR and Murray State University monitored silver carp population characteristics in Kentucky Lake to assess and document the effects of continued intensive commercial harvest as a means of strategic population suppression.
- Additionally, the KDFWR conducted work to inform the potential use of invasive carp harvested in Kentucky by fish processors. The KDFWR collaborated with the commercial fishing industry to assess the feasibility of consistently supplying harvested fish to processors for product use. The assessment identified the challenge of providing a consistent supply of fish due to the decreasing number of commercial fishers; high costs of supplies and materials, including transportation costs to move fish to processing facilities; difficulty in maintaining fish quality during the summer months; and the low average price per pound paid to fishers for harvested invasive carp.
- The ILDNR continued contract fishing to reduce the numbers of invasive carp in the Upper Illinois Waterway and lower Des Plaines Rivers, downstream of the EDB. Through 2018, over 7,760,000 pounds of invasive carp were harvested and removed through this effort, with measured declines noted in the estimated density of invasive carp in navigation pools along the leading edge of established populations in the upper IWW.
- In support of invasive carp removal goals under the UMRB Framework, the deployment of contracted commercial fishers in Pools 16-19 within the IMZ of the UMR resulted in the removal of 96,997 pounds of silver carp; 26,898 pounds of bighead carp; and 37,474 pounds of grass carp.

2. *Verify changes in movement in the current adult invasive carp population front in the UMRB and ORB and their tributaries.*

Accomplishments

- Continuing in 2018, agencies conducted coordinated targeted fishery monitoring to assess the geographic extent of invasive carp populations within the UMRB and ORB, with a focus on verifying current population fronts. Continuing in 2018, documented captures of bighead, silver, black, and grass carp were reported to the USGS Nonindigenous Aquatic Species database (<https://nas.er.usgs.gov/>), and analyses conducted to evaluate extent of range expansion from 2017 to 2018 for each species.
- Species-specific invasive carp range expansion documented for 2018 in the UMRB and ORB are described in Section 2 of this Report (Observed Changes in the Range of Invasive Carp in the Upper Mississippi River and Ohio River Basins and Tributaries).

3. Document changes in eDNA positive findings within areas upstream of the known adult invasive carp population fronts.

Accomplishments

- In 2018, the USFWS continued eDNA sampling in the UMRB, ORB, and IWW/CAWS for the early detection of silver carp and bighead carp. Samples were processed at the USFWS Whitney Genetics Lab-Midwest Fisheries Center. All sample collection, handling, and processing was conducted following the protocols established and outlined in the FWS Quality Assurance Project Plan for eDNA Monitoring of Bighead and Silver Carps (QAPP) (<https://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf>).
- In the ORB, efforts included collection and processing of 790 samples in the mainstem Ohio River and its tributaries, including the Tennessee River, Muskingum, and Little Kanawha Rivers. None of the samples tested positive for silver carp or bighead carp (no new eDNA detections above the established population front in 2018).
- In the UMRB, USFWS conducted eDNA sampling in Pools 13-15 of the UMR to maintain focused surveillance in locations where invasive carp are suspected to be present but may have a lower likelihood of detectability and capture with traditional fishery monitoring gears. Based on results from previous research, eDNA field protocols were modified to focus sampling in backwater habitats during spring. In 2018, 1,180 samples were collected from the UMRB and processed through this effort. Three samples collected from a backwater area of Pool 14 were positive for invasive carp eDNA. One sample was positive for silver carp and two samples positive for both silver carp and bighead carp. This represented the first time these pools were sampled for eDNA within this comprehensive study. Previous eDNA surveillance (2014-2016) was focused further upstream in Pools 5-9, with no positive detections of invasive carp eDNA during these earlier sampling efforts.
- In the IWW/CAWS, the USFWS collected 310 samples from the CAWS, with no positive detections for bighead carp or silver carp (no new eDNA detections above the established population front in 2018).
- Results from all eDNA sampling and analyses conducted through the USFWS eDNA program are available at: <https://www.fws.gov/midwest/fisheries/eDNA.html>.

4. Increase number of river miles (RM) excluded or protected from invasive carp movement.

Accomplishments

- The CAWS (RM 296-RM 333) is currently protected from invasive carp dispersal via the USACE EDB. This represents the most upstream portion of the CAWS between Romeoville, Illinois to Lake Michigan.
- The navigation lock on the Mississippi River at Upper St. Anthony Falls in Minneapolis, Minnesota, was previously permanently closed in June 2015. The lock closure by the USACE was supported by the MNDNR to serve as a barrier against the upstream spread of invasive carp in the Mississippi River watershed.
- UMRB and ORB partnerships developed deterrent strategies to inform future actions focused on strategic deployment of barrier technologies, focusing on lock and dam structures as potential invasive carp pinch points.

5. Increase the number of control technologies proven to control or eradicate invasive carp that are

ready for in-the-field use.

Accomplishments

- Partnerships within the UMRB, ORB, and IWW/CAWS continued efforts to advance the development and testing of new prototype control technologies or identify appropriate opportunities to utilize existing technologies. The technologies summarized below are being evaluated for potential pilot deployment in the field or are already being implemented as control tools.
- Underwater Sound Technology to Control the Movement of Invasive Carp: In 2018, agencies and partners advanced project planning for acoustic technology pilot deployment at strategic locations, or pinch points, in the river system, specifically where invasive carp can only freely move upstream through an active lock chamber.
- Bio Acoustic Fish Fence: ORB partners collaborated on a planning and design for a large-scale project at the Barkley Lock and Dam on the Cumberland River in Kentucky. The Bio Acoustic Fish Fence will be evaluated through a three-year field study for potential future deployment at key locations to prevent the range expansion of invasive carp in U.S. river systems and reduce the risk of their entry into the Great Lakes.
- Prototype Acoustic Deterrent Systems: UMRB partners collaborated on planning and design for a large-scale project to assess the feasibility of deploying and evaluating a prototype acoustic deterrent system at Lock and Dam 19 (LD 19) on the Mississippi River at Keokuk, Iowa. Initial baseline work was conducted, and results are being used to design a large-scale field trial to evaluate the effectiveness of a prototype sound deterrent system for use against invasive carp at this location.
- Temporary Underwater Acoustic System: In 2018, the USGS developed and deployed a temporary underwater acoustic deterrent system in the Chicago Sanitary and Ship Canal (IWW/CAWS) at Romeoville, Illinois to reduce the risk of invasive carp upstream passage while portions of the EDB were temporarily taken offline to ensure worker safety during required maintenance. The temporary system was successfully deployed and monitored below (downstream of) the EDB during maintenance timeframes in winter and early spring.
- Carbon Dioxide (CO₂) as an Invasive Carp Control Technology: The USGS, USFWS and USACE advanced development of CO₂ as a technology to both control and deter invasive carp. In 2018, the USGS initiated efforts to test the feasibility of CO₂ as a barrier to fish movement within a navigational lock. Planning was initiated to evaluate the deployment of CO₂ at a lock or approach channel to deter invasive carp passage. Additionally, field studies to demonstrate potential management applications for CO₂ included evaluations of the following options:
 - Blocking invasive carp access to backwater areas of the Illinois River
 - Enhancing invasive carp removal efforts
 - Lethally controlling invasive carp under ice in backwaters of large rivers
- The USACE initiated laboratory research to evaluate the efficacy, implementation processes, and impacts of the use of CO₂ on USACE infrastructures (e.g., lock complexes). The USFWS and USGS conducted work on needed regulatory affairs support, including acquiring data to support the registration of CO₂ for use as a non-lethal deterrent to control invasive carp, and as a lethal pesticide within specific, targeted, under-ice applications.
- Microparticles as a Targeted Invasive Carp Control Technology: The USGS advanced development of a microparticle piscicide (fish toxicant) for invasive carp control. The USGS continued work to develop oral delivery formulations that can deliver a control agent that targets silver, bighead, grass, and black carp while minimizing potential impacts on native

species. Data and results were used to inform further steps in microparticle development and refinement. Additionally, a new bait formulation was developed to selectively target the delivery of antimycin to grass carp, and the USGS purchased the strain used to produce antimycin and is working toward re-establishing registration as a fish toxicant. The USGS collaborated with the USFWS to compile data and reports for submission to regulatory agencies, including the USEPA, to support approval of microparticle use. The USFWS continued to work with the USGS to develop standard operating procedures to guide safe and effective use in the field, and to complete and submit needed studies to address USEPA and ESA Section 7 consultation data requirements for this proposed control tool.

6. *Increase the number of agencies with model regulations or ordinances that focus on invasive carp prevention.*

- There was no increase in the number of agencies with model regulations or ordinances focused on invasive carp during the reporting timeframe.

Qualitative Measures of Progress

The following qualitative measures of progress are identified to evaluate progress in controlling invasive carp.

1. *Monitoring and assessment of invasive carp - Establishment of a long-term, comprehensive, cooperative monitoring and assessment program within each basin.*

Accomplishments

- Agency and academic partners in the UMRB and ORB have developed and are implementing comprehensive strategies for monitoring invasive carp populations, including evaluating the degree of reproduction and establishment (presence of various life stages), determination of the invasion leading edge, and detection of potential range expansion. Individual projects addressed these needs and supported the priorities of the 2018 Monitoring and Response Plan for Asian Carp in the Mississippi River Basin. Monitoring efforts will continue in outyears, informed and refined based on results from assessments completed in 2018.
- In the ORB, priority monitoring and assessment actions in 2018 were conducted through the following projects: Abundance and Distribution of Early Life Stages of Asian Carp in the Ohio River; Early Detection and Evaluation of Asian Carp Removal in the Ohio River; Distribution, Movement, and Lock and Dam Passage of Asian Carp in the Ohio River Through Acoustic Telemetry; and Relative Population Densities and Movement of Asian Carp in the Tennessee and Cumberland Rivers, Tributaries of the Ohio River.
- In the UMRB, priority monitoring and assessment actions in 2018 were conducted through the following projects: Early Detection of Invasive Carp on the Invasion Front in the Upper Mississippi River; and Evaluation of Controls, Impacts, and Behaviors of Asian Carp in the Lower Upper Mississippi River (included larval fish, recruitment, and telemetry surveys).
- In the IWW and CAWS, the multiagency MRWG of the ACRC annually develops and implements intensive and focused monitoring of invasive carp populations coordinated through the Monitoring and Response Plan and supported under the Asian Carp Action Plan. Agency and cooperator monitoring and surveillance include traditional fishery gears, contract fishers, eDNA, and remote sensing (telemetry, hydroacoustics, and other techniques). These monitoring

efforts inform the status of the adult population front and presence of all life stages in the Upper IWW and CAWS.

2. *Preventing the introduction and movement of invasive carp via identified pathways – Establishment of strategies to manage pathways for accidental or deliberate unauthorized introductions of invasive carp.*

Accomplishments

- The interagency partnerships in UMRB, ORB, and IWW/CAWS have established actions to address the accidental or deliberate unauthorized introductions of invasive carp, in support of a primary goal of the National Plan and the step-down sub-basin management strategies. Partnership efforts include stakeholder outreach and education on best-practices and prohibited species; identified pathway monitoring, including the use eDNA detection; agency regulatory oversight of bait and aquaculture industries, with enforcement based on applicable federal and state laws and authorities; and coordinated response plans in the event of a detection in a new waterbody or location. Key strategies to manage invasive carp introductions include early detection monitoring and rapid response, and the development and testing of pathway-specific deterrent barrier technologies and implementation plans. Federal and state agencies enforce regulations on the collection, sale, and use of bait for recreational fishing to prevent the inadvertent capture and movement of small invasive carp between waterbodies; and the transport of invasive carp between state waters and between individual state jurisdictions.
- In 2018, ILDNR employed surveillance to prevent the intentional or unintentional movement of AIS, including invasive carp, and worked collaboratively with federal and regional state agencies. Through the Alternative Pathway Surveillance in Illinois project in the 2018 MRP, the ILDNR strengthened the enforcement component of the State's invasive species program by increasing education and enforcement activities at bait shops, bait and sport fish production and distribution facilities, fish processors, and fish markets and food establishments known to have a preference for live fish for release or food preparation. Inspection and surveillance efforts focused on the Chicago Metropolitan Area.
- Additional efforts in the ACRCC's Asian Carp Action Plan focus on addressing pathways for Great Lakes protection, including mitigation of the threat of invasive carp movement through the CAWS, closure of secondary (intermittent) interbasin hydrologic connections between the GLB and ORB, and evaluation and mitigation of the inadvertent movement of small fish by commercial navigation operations (e.g., barge entrainment).
- The USACE continues to operate and maintain the EDB to prevent the migration of invasive carp toward the Great Lakes.
- The USACE continues to maintain the Des Plaines River Bypass Barrier, a 13-mile long combination of fence material and jersey barrier that physically blocks known bypasses around the EDB that occur during periods of flooding from the Des Plaines River and the I&M Canal. The barrier prevents the possible migration of juvenile and adult invasive carp.
- The USACE evaluated the closure of multiple GLMRIS Secondary Pathways in Ohio, including the Ohio-Erie Canal (OEC), Little Killbuck Creek (LKC), and Grand Lake St. Mary's. The USACE will complete the final design for closing the OEC connection. The ODNR completed the design for closing the LKC connection. Modifications have been made at St. Mary's State Fish Hatchery to allow continued use of lake water without the risk of invasive carp transfer to the Lake Erie basin.
- The USFWS completed planning and study design for a field trial to further evaluate the

potential entrainment and transport of small invasive carp by commercial barges. Results will inform potential entrainment mitigation strategies and technologies.

- The USGS conducted additional work to evaluate barge entrainment dynamics and temporary impacts on the effectiveness of the EDB while commercial barge tows are moving across the barrier system.
- The USACE continued its execution of the GLMRIS - Brandon Road Study, including release of the Tentatively Selected Plan (TSP) for the Brandon Road Lock and Dam (BRLD) on the IWW. The TSP contained measures that could potentially be employed in the BRLD project at Joliet, IL, to prevent the upstream movement of invasive carp beyond the site toward Lake Michigan. The USACE completed agency and NEPA reviews, and further developed and employed a comprehensive public engagement strategy to ensure stakeholder awareness and communication of project milestones (<http://glmr.is.anl.gov/brandon-rd/>).
- Activities implemented through the 2018 MRPMRB and the ACRCC's 2018 MRP for the IWW/CAWS are described in additional detail in this Report in Sections 3.1 (ORB actions), 3.2 (UMRB actions), and 3.3 (UMRB-IWW/CAWS).

3. *Rapid response planning –Development of rapid response plans available to prevent range expansions and eradicate new introductions in both basins.*

Accomplishments

- In the ORB, interagency efforts are coordinated to address early detection and rapid response needs through the Early Detection and Evaluation of Asian Carp Removal in the Ohio River project (EDEAC). The EDEAC includes key baseline work to evaluate potential invasive carp management actions (e.g., prevention and control projects) by measuring changes in distribution and relative density through targeted sampling and to evaluate invasive carp presence in upstream areas where rarely detected to inform potential future containment efforts.
- In 2018, the KDFWR conducted a successful removal response at the R.C. Byrd Lock and Dam after initial reports of invasive carp sightings, capturing two large adult bighead carp. Coordination between partners, including the KDFWR, ODNR, WVDNR, and the USACE R.C. Byrd Lock Master directly supports response planning and implementation, including ensuring access to waterways across jurisdictions.
- In the IWW/CAWS, interagency early detection and rapid response actions are coordinated through the Upper Illinois Waterway Contingency Response Plan, now embedded within the annual MRP. Cooperating federal and state agencies conduct annual scenario-based tabletop contingency response planning and preparedness exercises. MRWG agencies have implemented the plan to address detections of invasive carp above the EDB in the CAWS as recently as June 2017.
- Individual state agencies develop response plans for AIS within their respective jurisdictions, including invasive carp, as deemed necessary.
- Rapid response coordination and implementation actions conducted in 2018 are further described in additional detail in Section 3.1 of this Report (see “Monitoring, Early Detection, and Rapid Response” section for each sub-basin: ORB-3.2.2, UMRB-3.3.2, and UMRB-IWW/CAWS- 3.4.2).

4. *Collaborative research –Develop and validate tools to ensure control of invasive carp.*

Accomplishments

- Within the ORB, UMRB, and IWW/CAWS, federal and state agency partners collaborated on the development and field-testing of select invasive carp control technologies, and on methodologies to inform and evaluate focused population control actions.
- Prototype tools being developed and evaluated in 2018 include CO₂ barriers, acoustic deterrent barriers, a Bio Acoustic Fish Fence (sound, bubbles, and lights) deterrent barrier, and species-specific invasive carp toxicants (microparticle delivery of ingested antimycin fish toxicant).
- Within the sub-basin partnerships, partner agencies collaborated to develop and evaluate new invasive carp monitoring and control fishery detection and capture gears and strategies. In the ORB and IWW/CAWS, federal and state agencies developed and evaluated new sampling strategies and detection gears to ensure monitoring for all life stages of invasive carp, including eggs and larvae.
- The USFWS and USGS conducted research to improve the effectiveness of eDNA as an early-detection tool for invasive carp, including genetic marker refinement and validation.
- The USFWS and partners had previously developed and implemented the Quality Assurance Project Plan for eDNA Monitoring of Bighead and Silver Carps (QAPP) as guidance for ensuring that all eDNA sample collection, handling, and processing is conducted following established protocols (<https://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf>).
- The USGS developed and validated the use of a portable eDNA detection kit for silver, bighead, and grass carp for use in the field in open water applications. Additionally, the USGS conducted studies to identify the appropriate number of samples needed to minimize the risk of false negatives within invasive carp eDNA sampling and continued development of a protocol for the use of molecular tools to prioritize ichthyoplankton samples.
- The USFWS, USGS, ILDNR, Southern Illinois University, Illinois Natural History Survey, and Western Illinois University continued development of an invasive carp population model to evaluate and inform potential strategic control strategies, including geographically-focused harvest and the installation of fish deterrents at optimal locations (e.g., fish movement choke points).
- The NOAA conducted ecological modelling to evaluate potential impacts of invasive carp (bighead, silver, black, and grass) on Great Lakes food webs and fisheries. The NOAA applied the model to simulate bighead and silver carp effects on nearshore communities of Lake Huron. In 2018, the NOAA developed a food web model of the Illinois River and simulated effects of invasive carp on the Illinois River's fish communities and lower trophic levels.

5. *Develop strategies to minimize adverse effects – Establishment of collaborative strategies to eradicate or minimize potential adverse effects.*

Accomplishments

- In 2018, UMRB, ORB, and IWW/CAWS federal and state agency partners routinely collaborated to develop comprehensive prevention and control priorities, strategies, and on-the-water work plans. This work was informed by the most current data on invasive carp distribution and population dynamics with emphasis on strategic opportunities to prevent further range expansion and, where feasible, reduce local population levels toward short-term management goals.
- Interagency meetings were convened to identify opportunities for abating and subsequently reducing the range of invasive carp in Midwest U.S. river basins by combining control actions

(e.g., harvest) with deterrent technologies, including selection of potential project sites, environmental regulation considerations, and permitting requirements for field implementation of specific control techniques.

- In 2018, the USFWS, NPS, USACE, USGS, USFWS, Minnesota DNR, Wisconsin DNR, Iowa DNR, Illinois DNR, and Missouri Department of Conservation finalized the “Asian Carp Deterrent Strategy for the Upper Mississippi River Basin” (http://www.micrarivers.org/wp-content/uploads/2019/08/Potential-Use-of-Deterrents_Final.pdf). The strategy identified potential deterrent technologies; identified “Intensive Management Zones” for silver, bighead, and grass carp and suitable locations for deterrent deployment in the UMRB; and made recommendations for experimentation and next-steps.
- Invasive carp population control projects implemented in the UMRB and ORB in 2018 supported efforts to reduce impacts from invasive carp populations, with the near-term goal of minimizing propagule pressure and likelihood of range expansion, and the long-term goal of progressive eradication. Projects in the UMRB included Contract Fishing for Asian Carp Detection and Removal, and Evaluation of Controls, Impacts, and Behaviors of Asian Carp in the Lower Upper Mississippi River. Projects in the ORB included Control and Containment of Asian Carp in the Ohio River, and Early Detection and Evaluation of Asian Carp Removal in the Ohio River.
- The ACRC’s 2018 MRP incorporated the use of monitoring, surveillance, and decision support tools to increase defense of the EDB and enhance the impact of targeted invasive carp removal through agency and contract harvest capture efforts in the IWW. The annual collaborative actions further minimize the risk of invasive carp upstream range expansion in the IWW and threat of introduction into the Great Lakes.

6. ***Information and education – Establishment of strategies to provide information to the public, commercial entities, and government agencies to improve effective management and control of invasive carp in the ORB and the UMRB.***

Accomplishments

- The MICRA established an invasive carp issues and resources web portal under the broader MICRA organizational website (<http://micrarivers.org/asian-carp-plans-and-reports/>). The website houses all MRB invasive carp documents including partnership Frameworks, Monitoring and Response Plans, Annual Work Plans, Annual Summary Reports, and Annual Reports to Congress.
- The USFWS continued to manage the invasivencarp.us website, supporting invasive carp communication efforts focused on the IWW/CAWS. Content included emerging topics such as grass and black carp issues, and federal and state actions conducted through the ACRC.
- Through MICRA and the ACRC, federal and state agencies provided informational briefings for Members of Congress and their staffs on annual invasive carp partnership work plans, accomplishments, and key biological findings.
- Federal and state biologists regularly communicated current information regarding invasive carp to the public and actions that the agencies are taking to research and control these species.
- In the ORB, Kentucky has taken the lead on invasive carp communication, coordination, and outreach efforts, working in coordination with the PFBC, ILDNR, INDNR, ODNR, WVDNR, and NYDEC. In addition, states have developed informational signage for installation at boat ramps

to help anglers identify invasive carp and avoid accidental transport and introduction to new waters. Further, information campaigns focused on bait retailers encourage anglers to be vigilant against the inadvertent purchase and use of invasive carp minnows during recreational fishing.

- In the ORB, UMRB, and IWW/CAWS, partner agencies conducted outreach with commercial fishers and recreational resource users to enhance awareness of the four invasive carp species and support proper identification and reporting of invasive carp captures.

7. *Effective regulations and laws – Development of an effective system of compatible Federal and State laws and regulations for the UMRB and the ORB.*

Accomplishments

- In 2018, close coordination continued between federal and state agencies in the UMRB and ORB to support enforcement of regulations providing oversight on AIS, including invasive carp, within their respective jurisdictions. Enforcement focused on compliance with regulations related to the production, possession, sale, and transport of invasive carp along with regulations and best-practices related to the transport and use of live bait by commercial harvester, dealers, and anglers.
- In 2017, the U.S. Court of Appeals for the District of Columbia Circuit held that section 42(a)(1) of title 18 of the Lacey Act does not "prohibit shipments of injurious species between the continental States." United States Ass'n of Reptile Keepers, Inc. v. Zinke, 852 F.3d 1131, 1142 (D.C. Cir. 2017). Individual states, however, continued to regulate the production, possession, sale, and transport of invasive carp within their respective jurisdictions.
- In 2015, the MICRA submitted a report to the USFWS proposing eight recommendations to establish a consistent national policy strategy for grass carp for minimizing the risk of unintentional and illegal introductions of diploid and triploid grass carp. The MICRA had previously completed a review of commercial grass carp production, certification, shipping, stocking, and regulation in the U.S. The fundamental recommendation provided in the report to achieve a consistent national policy is for all states to prohibit the production, shipment, and stocking of diploid grass carp. Regulations are in place on a state-by-state basis for grass carp in most States throughout the Continental United States.
- In 2018, the ODNR DWLE completed a two-year assessment of the grass carp supply chain that determined that all tested fish were triploid (sterile). The results of the supply chain assessment were published in the Journal of Great Lakes Research (Assessing the risk of diploid grass carp *Ctenopharyngodon idella* in the certified triploid supply chain in Ohio (<https://pubs.er.usgs.gov/publication/70198206>)).
- In the ORB, state agencies have promulgated rules to prevent the inadvertent capture and movement of invasive carp during bait collection from the tailwater areas below dams (locations where bighead and silver carp are known to congregate).
- The Indiana DNR developed an administrative rule to eliminate baitfish collections for 500 yards below any dam, except for the Ohio River.
- The ODNR maintains two administrative rules to prevent AIS transfer through bait collection and use.
- The KDFWR purchased and distributed signs at boat ramps notifying the public of the potential threat of AIS introduction through bait bucket transfers. New informational content was also

created for the State of Kentucky's annual fishing and boating guide and the KDFWR website regarding best-practices to prevent the inadvertent transfer of AIS through bait use.

8. *Ensuring sufficient resources are available –Identify sufficient resources for Federal, State, and local agencies to address the long-term issue of controlling and reducing risk from invasive carp in the UMRB and ORB.*

Accomplishments

- In 2018, federal and state agencies continued to receive funding to support invasive carp detection, prevention, and control activities primarily through annual budgeting and agency appropriations processes, in support of implementation of the National Plan and step-down sub-basin partnership strategies.
- The USFWS, USGS, USACE, USEPA, and state agency partners provided informational briefings for Members of Congress and their staffs and the White House Office of Management and Budget. The briefings covered annual invasive carp partnership strategies and work plans, recent accomplishments, and key biological findings.
- In FY 2018, the USFWS received additional agency funding for invasive carp management efforts outside of the Great Lakes, including the UMRB and the ORB. These resources, along with other federal and state resources, were leveraged to support high-priority activities, in support of the goals and recommendations of the National Plan and sub-basin Frameworks and Action Plans.

APPENDIX 3: LIST OF ACRONYMS USED IN THIS REPORT

- Monitoring and Response Plan (MRP)
- Asian Carp Advisory Committee (ACAC)
- Asian Carp Harvest Program (ACHP)
- Asian Carp Regional Coordinating Committee (ACRCC)
- Aquatic Nuisance Species Task Force (ANSTF)
- Great Lakes and Mississippi River Interbasin Study (GLMRIS)
- Great Lakes Fishery Commission (GLFC)
- Illinois Department of Natural Resources (ILDNR)
- Illinois Natural History Survey (ILNHS)
- Indiana Department of Natural Resources (INDNR)
- Intensive Management Zone (IMZ)
- Kentucky Department of Fish and Wildlife Resources - KDFWR
- Kentucky Department of Natural Resources (KYDNR)
- Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (National Plan)
- Minnesota Department of Natural Resources (MNDNR)
- Minnesota Invasive Carp Action Plan (MICAP)
- Missouri Department of Conservation (MDC)
- Monitoring and Response of Asian Carp in the Ohio River Project (MRORB)
- Monitoring and Response Work Group (MRWG)
- New York State Department of Environmental Conservation (NYDEC)
- Ohio Asian Carp Tactical Plan: 2014-2020 (Tactical Plan)
- Ohio Department of Natural Resources (ODNR),
- Ohio River Basin Asian Carp Control Strategy Framework (ORB Framework)
- Ohio River Fisheries Management Team (ORFMT)
- Ohio River Valley Water Sanitation Commission (ORSANCO)
- Pennsylvania Fish and Boat Commission (PFBC)
- Tennessee River Telemetry Work Group (TWG)
- Tennessee Wildlife Resources Agency (TWRA)
- Upper Mississippi River Basin Asian Carp Control Strategy Framework (UMRB Framework)
- Upper Mississippi River Basin Association (UMRBA)
- Upper Mississippi River Conservation Committee (UMRCC)
- USGS Columbia Environmental Research Center (CERC)
- USGS Upper Midwest Environmental Sciences Center (UMESC)
- West Virginia Division of Natural Resources (WVDNR)
- Western Illinois University (WIU)
- Wisconsin Department of Natural Resources (WIDNR)