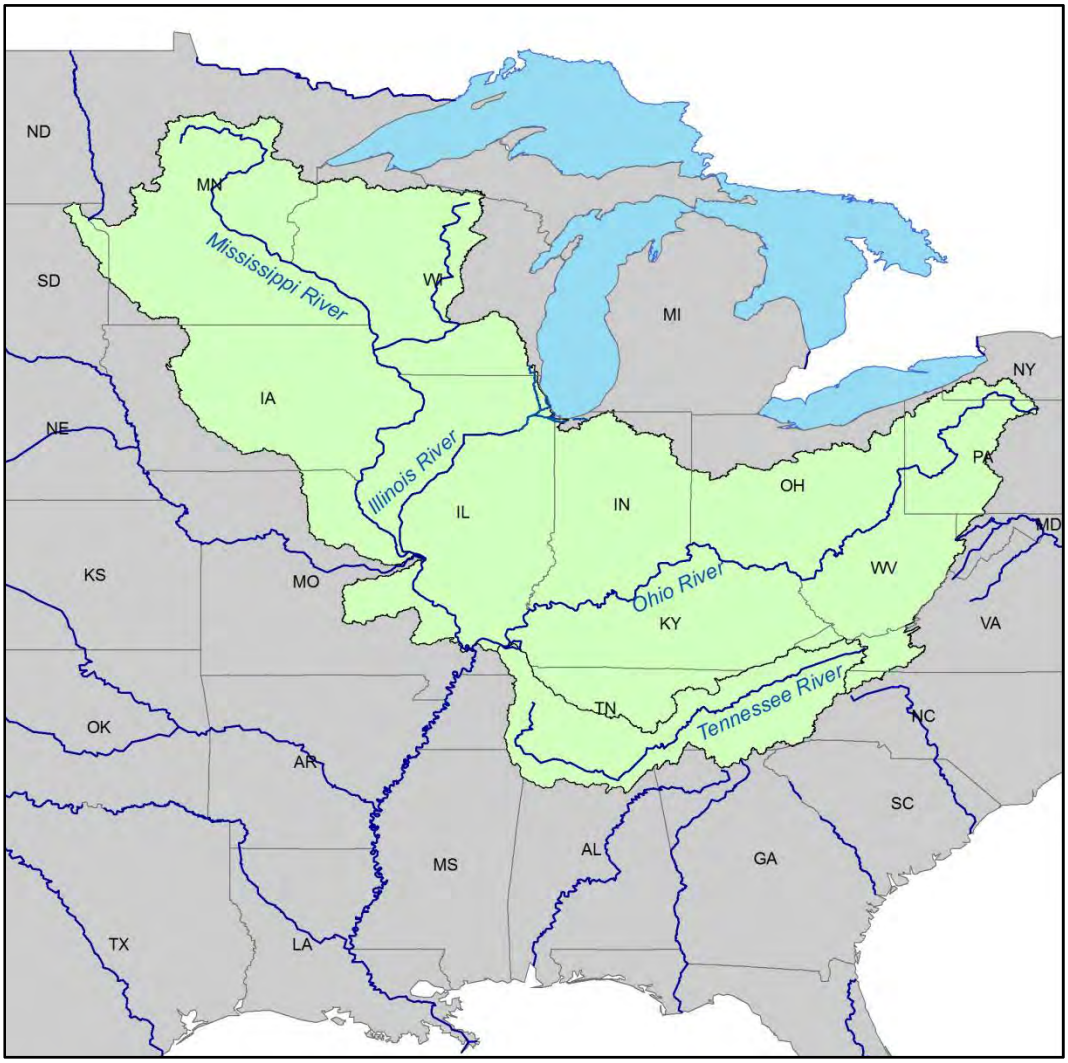
Monitoring and Response Plan for Asian carp in the Mississippi River Basin



Prepared by the

Mississippi Interstate Cooperative Resource Association

Asian Carp Advisory Committee

November 2016

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Introduction

The 2016 Monitoring and Response Plan provides a summary of the collaborative partnership efforts planned in Fiscal Year 2016 to implement Asian Carp Control Strategy Frameworks developed for the Ohio River Basin (ORB) and Upper Mississippi River Basin (UMRB), two sub-basins within the larger Mississippi River Basin (Figure 1). These sub-basin control strategy frameworks are step-down plans of the national *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (National Plan). The National Plan was approved for implementation by the Aquatic Nuisance Species Task Force in 2007; however, until recently, minimal resources have been available to prevent the continued range expansion and population growth of Asian carp in the Mississippi River Basin. States have been working with their partners at the sub-basin level to assess the status of Asian carp populations and implement management and control actions to the extent possible with limited resources.

Figure 1. Map outlining the Mississippi River Basin which drains all or a portion of 31 states and 2 Candadian Provinces. The Ohio River and Upper Mississippi River sub-basins are shaded dark green.

The Asian Carp Regional Coordinating Committee (ACRCC), a partnership of state, provincial, and United States and Canadian federal agencies and other stakeholders, has coordinated the development and implementation of an annual Asian Carp Control Strategy Framework (now referred to as the Action Plan) to prevent the introduction and establishment of Bighead and Silver carp populations in the Great Lakes since 2010. The ACRCC Action Plan coordinates the implementation of strategically targeted actions to prevent and control the movement of Bighead and Silver carps from the Mississippi River Basin into the Great Lakes. Many of these projects are implemented in the uppermost reach of the Illinois River (43 miles; 69.2 km) and the

Chicago Area Waterways System (CAWS). Asian carp prevention and control efforts in this small area within the Mississippi River Basin are addressed in the ACRCC Asian Carp Action Plan.

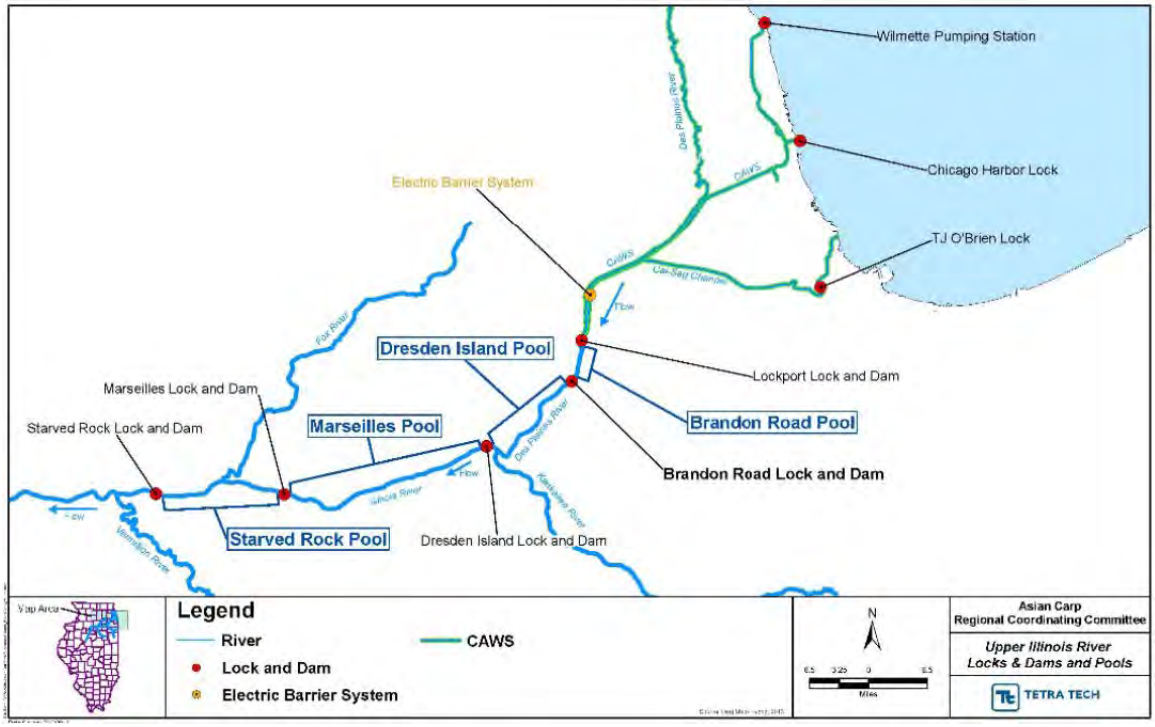


Figure 2. Map of the Upper Illinois River and Chicago Area Waterway System (CAWS) addressed in the ACRCC Asian Carp Action Plan (Source: 2017 Asian Carp Action Plan, www.asiancarp.us)

Bighead, Silver, and Grass carps have been established in the Mississippi River Basin, including the lower reaches of the ORB and UMRB for more than two decades (Figures 3 and 4). In recent years, Black Carp have been captured with increasing frequency in the Lower Mississippi River and in the Upper Mississippi River below Lock and Dam 19 and in the lower Illinois River. With the collection of young-of-the-year Black Carp in the Mississippi River Basin in 2016, it is evident that Black Carp are likely self-sustaining in the open reach of the Mississippi River. Although Black Carp have been collected from the UMRB, Lower Mississippi River, and Missouri River, there have been no confirmed collections of Black Carp in the ORB to date (Figure 3).

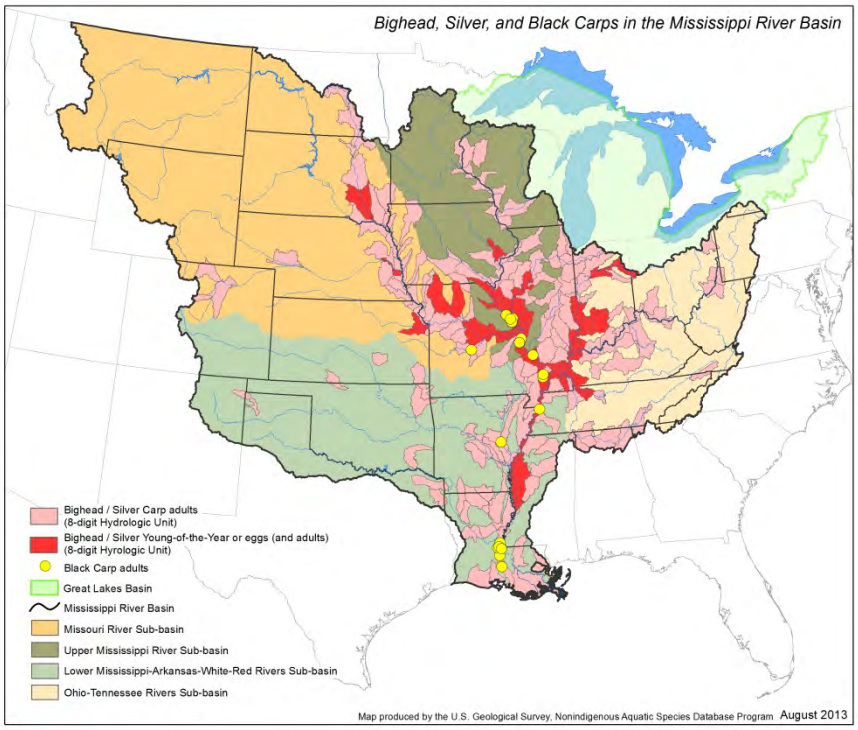


Figure 3. Distribution of Bighead Carp, Silver Carp, and Black Carp in the Mississippi River Basin as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of August 2013.

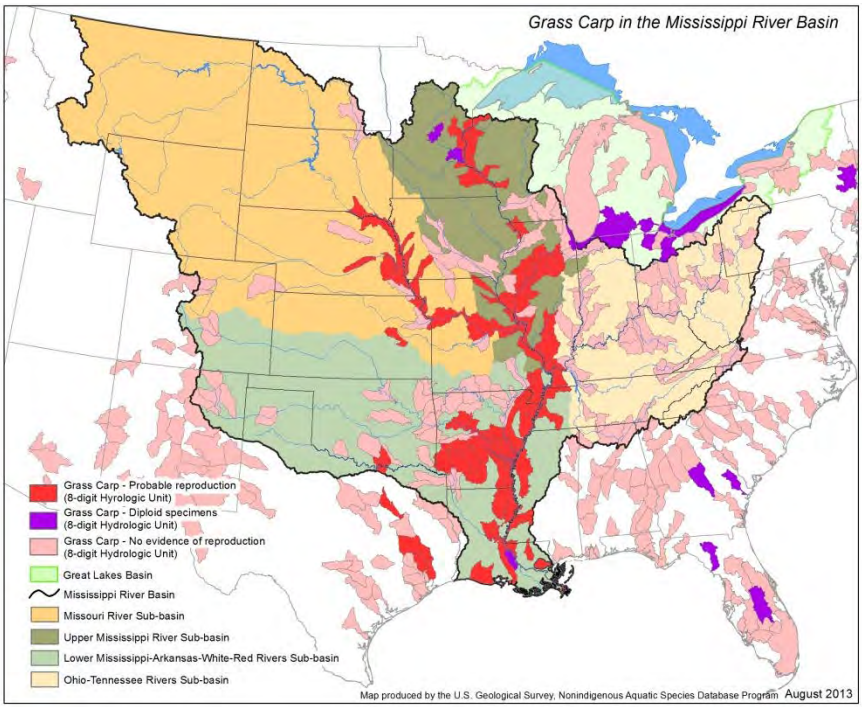


Figure 4. Distribution of Grass Carp in the Mississippi River Basin as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of August 2013.

On June 10, 2014, the United States Congress, in Section 1039 (b) of the Water Resources Reform and Development Act of 2014 (WRRDA), charged the USFWS, to work in coordination with the Secretary of the Army, the Director of the National Park Service (NPS), and the Director of the U.S. Geological Survey (USGS) to lead a multiagency effort to slow, and eventually eliminate, the spread of Asian carp in the ORB and UMRB. Congress then appropriated $2.37 million in the USFWS's FY2015 budget for Asian carp prevention and control in the ORB and UMRB, providing the first substantial funding to address Asian carp populations in the Mississippi River Basin beyond the upper Illinois River and the CAWS. USFWS received a slight increase to $2.62 million in FY2016 for Asian carp work in the ORB and UMRB.

The USFWS met with state and federal agency partners in the ORB and UMRB in February and March 2015, respectively, to foster inter-agency coordination and to discuss planning, funding, and operations for Asian carp prevention and control. The USFWS informed the sub-basin partnerships that the agency would provide a total of $800,000 of its FY2015 base funding for Asian carp to support implementation of the highest priority actions identified in the Asian carp control strategy frameworks for both the ORB and UMRB. State representatives from both sub-basins recommended that the USFWS work through the Mississippi Interstate Cooperative Resource Association (MICRA) for executive level Asian carp coordination and multi-state project planning and implementation in the Mississippi River Basin. The sub-basin partnerships agreed on an inter-agency management structure for coordinated planning and reporting, development of funding strategies, and implementation of actionable plans. The same structure for interagency coordination and collaboration was continued in 2016 after USFWS informed the sub-basin partnerships that the agency would provide a total of $1,000,000 of its FY2016 base funding to support implementation of the ORB and UMRB Asian Carp Frameworks.

MICRA is a partnership of 28 state agencies with fisheries management jurisdiction in the Mississippi River Basin. Federal agencies with relevant authorities in the Mississippi River and tributaries also participate in the MICRA partnership. MICRA functions as an umbrella organization that provides coordination and communication among the multi-state partnerships that address interjurisdictional fishery management issues within six Mississippi River sub-basins: Upper Mississippi, Lower Mississippi, Ohio, Tennessee-Cumberland, Missouri, and Arkansas-Red. The existing multi-state sub-basin groups provide a forum for Asian carp coordination, project development, and implementation at the sub-basin level and MICRA provides a mechanism for basin-wide inter-agency coordination and collaboration.

MICRA formed an Asian Carp Advisory Committee (ACAC) to provide for state and federal agency executive level coordination on Asian carp prevention and control in the Mississippi River Basin. The ACAC consists of the MICRA Executive Board (i.e., one state agency representative from each of the six sub-basin groups, two federal entity members, MICRA Chairman, MICRA Chairman-elect, and MICRA Coordinator) and a single agency

representative from key federal partners not on the MICRA Executive Board (Figure 5). The ACAC provides a mechanism for coordination, communication, and collaboration across the regional sub-basin efforts to provide for the most effective implementation of a Mississippi River basin-wide strategy for prevention and control. The Executive Boards of the regional sub-basin groups in the ORB and UMRB are comprised only by state agencies. The ACAC provides an opportunity for federal agency partners to participate in the decision making process at the executive level.

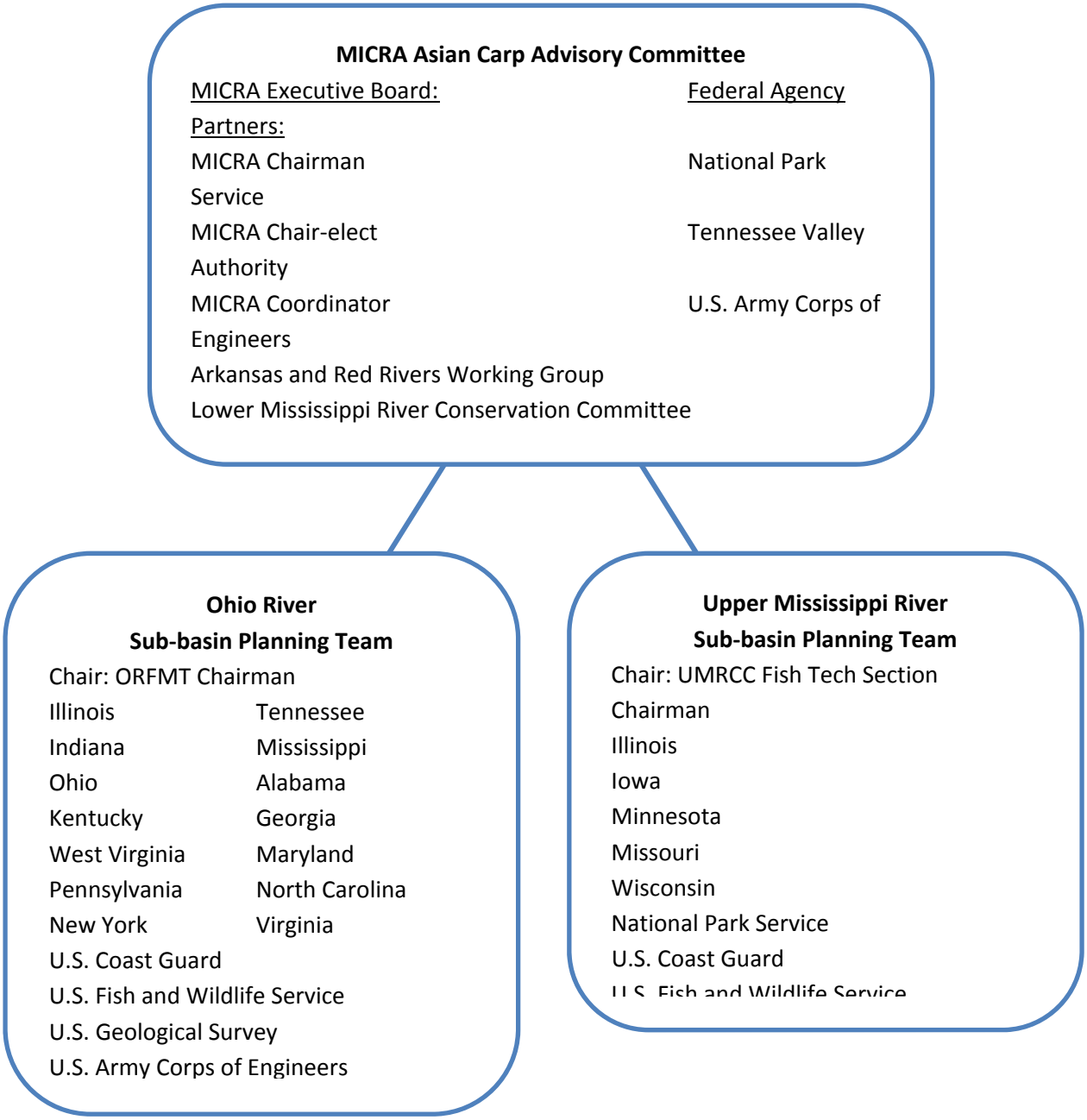


Figure 5. Structure for Inter-agency Coordination and Implementation of Asian Carp Control Strategy Frameworks in the Ohio River and Upper Mississippi River Basins.

MICRA has an active role working with the partnerships and planning teams throughout the Mississippi River Basin to develop and implement sub-basin level Asian Carp Control Strategy Frameworks. In the ORB and UMRB, where the USFWS has committed federal funding for implementation of highest priority control strategy framework projects, MICRA actively works with the sub-basin planning teams to identify annual priorities, develop project proposals and work plans, and to prepare an annual 'Asian Carp Monitoring and Response Plan for the Mississippi River Basin' (MRP). The MRP describes USFWS funded collaborative partnership efforts to manage and control Asian carp populations in the ORB and UMRB each year. Agencies collaborating on the USFWS funded partnership projects provide annual (calendar year) reports each year to track and evaluate progress, report results, propose recommendations for adaptive management, and inform planning for management and control actions in future years. Final technical project reports are provided by funded agencies at the conclusion of the 2-year performance period for each USFWS grant awarded. The annual MRPs, progress reports, and final project reports are made available to the public on www.asiancarp.us.

The Ohio River (OHR) flows through or along the border of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia; these six states collaboratively manage fisheries in the mainstem OHR through the Ohio River Fisheries Management Team (ORFMT). The ORFMT recognized the magnitude of the Asian carp threat and the need for coordinated efforts to prevent the continued spread, explore strategies to reduce the abundance of established populations, and better understand the impacts of established populations. The ORFMT engaged the remaining OHR basin states and key federal partners in the development of an Ohio River Asian Carp Control Strategy Framework (Ohio River Framework) to collaboratively prevent further range expansion, reduce populations, better understand and minimize impacts of Asian carps, and improve communication and coordination in the basin. Following completion of the Ohio River Framework in October 2014 the OHR basin partners formed an OHR Planning Team to implement the Ohio River Framework. The OHR Planning Team met in November 2015 to determine highest priority projects from the Ohio River Framework for implementation in 2016, identify lead and cooperating agencies for each project, and develop project proposals for USFWS funding consideration. OHR Planning Team project proposals were provided to the MICRA ACAC through the ORFMT, compiled with project proposals from the Upper Mississippi River basin, and submitted as part of a Mississippi River Basin proposal package to the USFWS for funding consideration. The OHR Planning Team developed funded project proposals into full project work plans for implementation and inclusion in the 2016 Asian Carp Monitoring and Response Plan for the Mississippi River Basin. Project implementation and coordination between agencies occurred at the field level and was not a function of the OHR Planning Team.

The Upper Mississippi River Conservation Committee (UMRCC) is a partnership of the five mainstem Upper Mississippi River (UMR) states. The UMRCC Fisheries Technical Committee, which includes federal agency partners, completed a revised *Upper Mississippi River Fisheries*

Plan in 2010. Goal 4 in the 2010 Fisheries Plan is to 'slow or eliminate the spread or introduction of aquatic nuisance species, including pathogens to the UMR.' The UMRCC Fisheries Technical Committee members undertook the collaborative development of an Upper Mississippi River Asian Carp Control Strategy Framework (UMR Framework) to coordinate Asian carp prevention and control efforts in the Upper Mississippi River. The UMR Framework is designed as a regional stepdown plan from the National Plan and is based on the existing UMRCC's 2010 Fisheries Plan Goal 4. The Fisheries Technical Committee formed an Ad-hoc Asian Carp Planning Team to coordinate the collaborative development and implementation of the UMR Framework, determine highest priority projects from the UMR Framework for implementation in 2016, identify lead and cooperating agencies for each project, and develop project proposals for USFWS funding consideration. UMR Planning Team project proposals were provided to the MICRA ACAC through the UMRCC Executive Committee, compiled with project proposals from the Ohio River basin, and submitted as part of a Mississippi River Basin proposal package to the USFWS for funding consideration. The UMR Planning Team developed funded project proposals into full project work plans for implementation and inclusion in the 2016 Asian Carp Monitoring and Response Plan for the Mississippi River Basin. Project implementation and coordination between agencies occurred at the field level and was not a function of the UMR Planning Team.

Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring and Response Field Activities

Implementation of the project plans described in the Monitoring and Response Plan pose a risk of transporting and introducing aquatic nuisance species (ANS), including fish, plants, invertebrates, and pathogens. These best management practices (BMPs) are designed to be effective, easy to implement, and realistic; their use should reduce or potentially eliminate the threat of ANS spread by Monitoring and Response Plan activities. Further, BMPs combined with diligent record keeping can benefit the organizations participating in Monitoring and Response Plan activities by demonstrating that they are taking effective actions to prevent the spread of AIS.

For the purposes of these BMPs, all gear utilized in the process of field work that comes in contact with the water, including but not limited to those in the list below will be referred to as "sampling gear."

boats	eDNA collection gear	cast/beach/purse seines	hoop nets
trailers	personal gear	trammel nets	pound nets
electrofishing gear	ichthyoplankton nets	fyke nets	gill nets
hydroacoustic gear	cast nets	trawl nets	fish collection tubs

Field activities that have location-specific gear may need to do less to ensure that they are not transporting ANS or their genetic material. Examples might include boats, electrofishing gear, nets, or personal gear that are only used to sample one location. If potentially contaminated gear does not travel, the possibility of that equipment transporting ANS is reduced or eliminated. Maintaining duplicate gear for use in contaminated vs. non-contaminated locations or sampling all non-contaminated locations before moving on to contaminated locations may also reduce or eliminate the possibility of ANS spread.

Before traveling to a sampling location:

- ❒ ***Check*** gear and determine if it was previously cleaned. Accurate record-keeping can eliminate the need for inspecting or re-cleaning prior to equipment use. If you do not know if the sampling gear was cleaned after its last use, inspect and remove any plant fragments, animals, mud, and debris, and drain any standing water. If necessary, follow the appropriate "Clean" step(s) listed below.

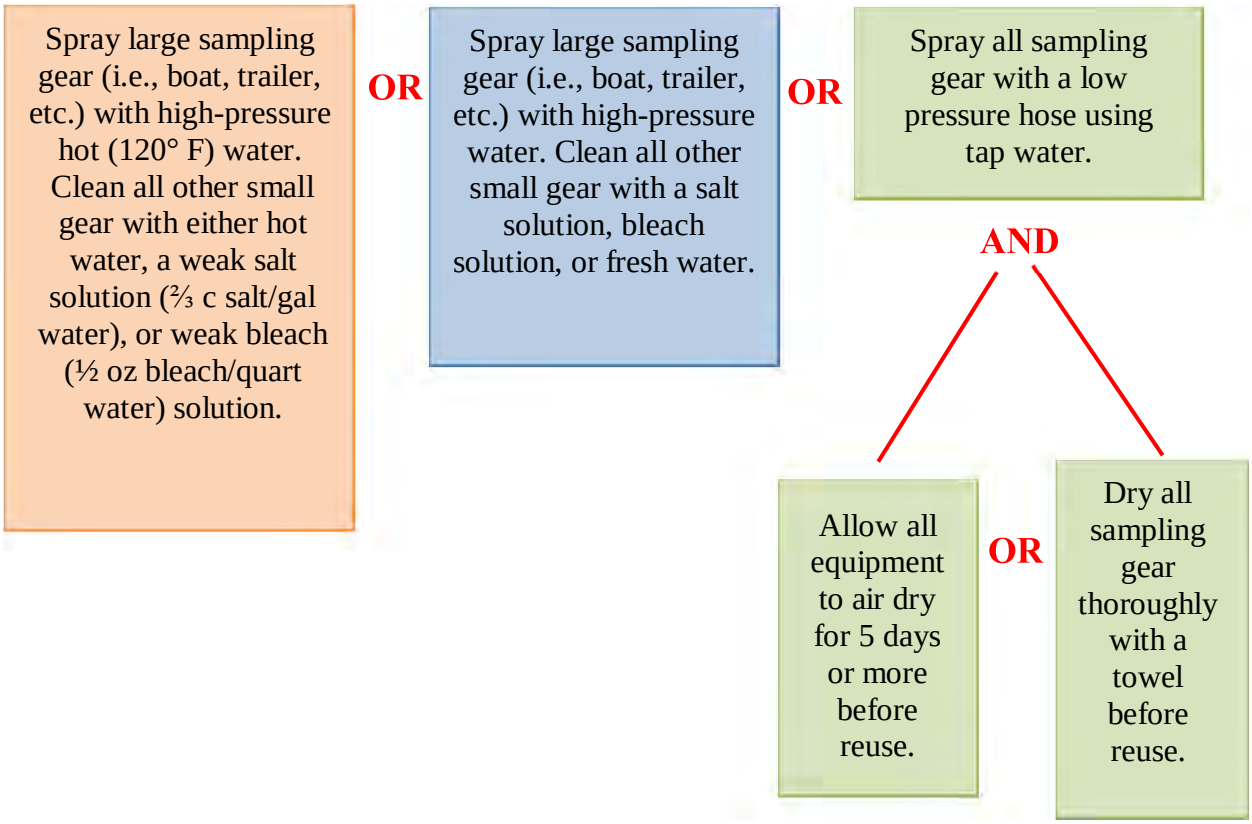
After each sampling event, *before leaving waterbody*:

The following steps should occur before gear is transported away from the waterbody to prevent transport of aquatic plants and animals by boats, trailers, and vehicles.

- ❒ ***Remove*** plants, animals, and mud from all sampling gear.
- ❒ ***Drain*** all water from boat and sampling gear.

After each sampling event, *before using gear at another location*:
The following cleaning/decontamination steps may occur either at the water access point (preferred, if possible) or may be completed at the gear storage location.

- ❒ ***Clean*** all sampling gear. Select an option below based on the available equipment (i.e., high-pressure hot washer, pressure washer, and low-pressure hose). In general, pressure wash removes organisms while high temperatures will kill organisms. A three-minute pressure wash is effective at removing zebra mussel larvae and other microscopic organisms. Keep nozzle at a 90 degree angle to the boat and at least 12 inches away from the boat to prevent removing decals.



Keep Records:
Develop a Standard Operating Procedure (SOP) or checklist for cleaning equipment to make ANS prevention steps easy to follow and documentable. Complete the checklist for each sampling event with date, location, the recorder's name and what was done. These records over time demonstrate a solid commitment to AIS prevention, will help build a standard cleaning protocol, and will eliminating wasted time spent re-checking or re-cleaning equipment.

(Adapted by Illinois-Indiana Sea Grant from BMPs created by the Great Lakes Sea Grant Network.)

Project Plans

Twelve project plans have been prepared for 2016 to address the highest priority prevention and control needs for Asian carp in the Mississippi River Basin. The project plans summarize the activities funded (in full or in part) by USFWS FY2016 base funding for Asian carp. Following the USFWS coordination meetings with state and federal agency partners in the Ohio River and Upper Mississippi River sub-basins in November and December 2015, the partnerships in both sub-basins held meetings (face-to-face and teleconference) to collaboratively identify Asian Carp Control Strategy Framework priority needs, determine cooperating agencies and funding needs for each project, and to develop project proposals and work plans. Consequently, most cooperating agencies did not initiate grant agreements with the USFWS until late in the fiscal year. Much of the work described in the project plans will be on-going or initiated during the coming year. Project plans and schedules are included as a guideline for implementation; however actual plans and implementation schedules may vary as actions are undertaken.

Ohio River Basin

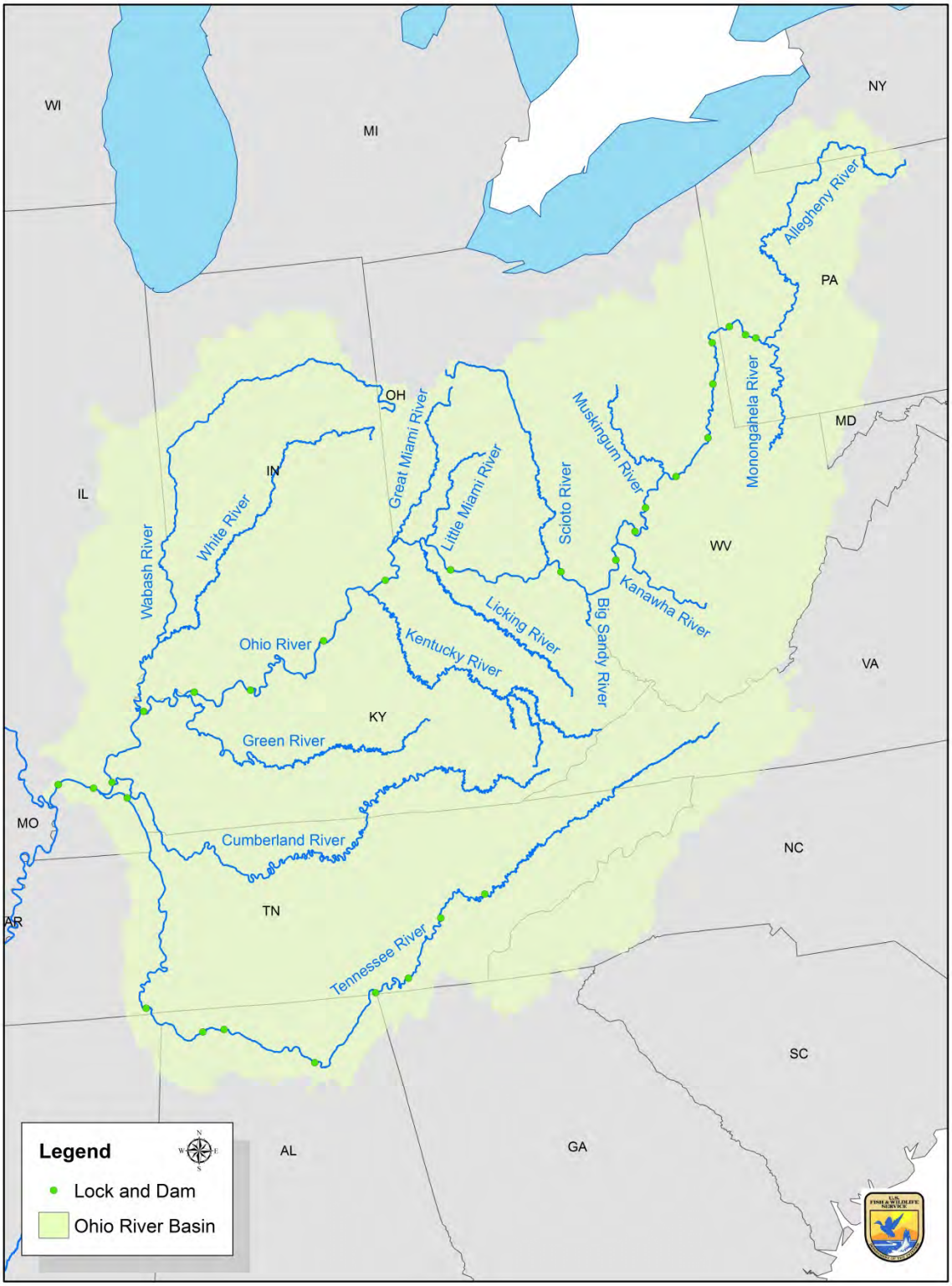


Figure 6. Map of the Ohio River Basin.

Monitoring and Response of Asian carp in the Ohio River

Participating Agencies: West Virginia Division of Natural Resources (WVDNR), Indiana Department of Natural Resources (INDNR), Kentucky Department of Fish and Wildlife Resources (KDFWR), Ohio Department of Natural Resources (ODNR), Pennsylvania Fish and Boat Commission (PFBC), Unites States Fish and Wildlife Service (USFWS), Ohio River Valley Water Sanitation Commission (ORSANCO)

Location: Ohio River pools from Cannelton lock and dam complex to the Racine lock and dam complex.

Introduction and Need: Invasive species are increasingly responsible for undesirable economic and environmental impacts across the nation (Lovell and Stone 2005, Pimentel et al. 2004; Jelks et al. 2008). Although considerable effort and funding has been expended to understand and mange Asian carp in the Great Lakes and Mississippi River basin, limited funding has been afforded for research activities on Asian Carp quickly expanding their range in the Ohio River sub-basin.

While volumes of research are available about the bigheaded carps in their native waters, there is relatively little information about Asian carp behavior and habitat use in their introduced range. Asian carp have been successful invaders in the waters of the United States because of their tolerance and adaptability to a wide range of environmental conditions. The Ohio River basin provides a broad variety of potential habitats available to invading Asian carp. As a result, there is a necessity for the evaluation of a host of different sampling methodologies between systems. It is necessary to gain information on Asian carp behavior and habitat use in the Ohio River Basin to aid in the prevention, removal, and response efforts for Asian carp.

The tasks outlined in this template will not only provide valuable information on Asian carp distribution and habitat use in the Ohio River Basin, but also provide a coordinated approach to the development of effective and efficient sampling protocols for Asian carp in the Ohio River Basin. Assembling information on the distribution and habitat use of Asian carp provides an assessment tool that will inform Asian carp sampling efforts of state and federal agencies in the Ohio River Basin. In addition, this information may aid in determining impacts of carp on native fish assemblages in the Ohio River drainage and could provide information for removal efforts and potential barrier placements.

Objectives:

- Conduct targeted sampling for surveillance, early detection, distribution, and relative population density of Asian carp at multiple life stages.
- Monitor Asian carp population dynamics in the Ohio River.

- Evaluate validity of consistent positive eDNA results in Ohio River pools (Montgomery) upstream of the invasion front.
- Compile and incorporate all available current and historical fish sampling data from other state and federal agencies in select Ohio River pools to increase range and effort of Asian carp detection. This data will also be used as background community assemblage data for comparison with current and future data collected within the scope of this project.
- Re-evaluate, and adjust if needed, the monitoring protocol developed in 2015 that defines objectives, and specifies preferred gears, locations, and required effort for targeted surveillance monitoring of Asian carps.
- Conduct community-based fish surveys in the R.C. Byrd and Greenup Pools to gain fish community assemblage and condition data.

Status: This project is a continuation of the "Monitoring and Response of Asian carp in the Ohio River" project plan of 2015. Since 2013, various projects have resulted in the capture, tagging, removal, and harvest of Asian carp in Ohio River project pools between Cannelton and R.C. Byrd lock and dam. In 2015, community-based fish surveys were added to gain community assemblage and condition data for Ohio River fishes in pools potentially affected by the upper range of Asian carp expansion.

Methods: Participating agencies will conduct targeted sampling for Asian Carp at several pools upstream of the Cannelton Lock and Dam complex using a variety of gears. Both focused pDC electrofishing and gill netting techniques will be utilized during the spring and fall sampling seasons. Targeted pools include the Cannelton, McAlpine, Markland, Meldahl, Greenup, R.C. Byrd and Montgomery of the Ohio River. A minimum of 8 survey days will be employed at each pool.

Table 1. Proposed Sampling Schedule.

Sampling Week	Pool	Agency	Sampling Week	Pool	Agency
11–April	McAlpine/Greenup	KDFWR/WVDNR	10 – Oct.	Greenup	KDFWR/WVDNR
18–April	R.C. Byrd	WVDNR	17 – Oct.	R.C. Byrd	WVDNR
18– pril	Markland	KDFWR	17 – Oct.	Meldahl	KDFWR
25–April	Meldahl	KDFWR	24 – Oct.	Markland	KDFWR
02 – May	Cannelton	KDFWR/INDNR	31 – Oct.	Cannelton	KDFWR/INDNR

The McAlpine, Markland, Meldahl and Greenup Pools of the Ohio River have been evaluated for five macrohabitat types: mainstem, island back channel, tributary, embayment, and

tailwater. Sampling locations were developed based on macrohabitat availability. The R.C. Byrd and Montgomery Pools will be evaluated in 2016. Electrofishing and gill net samples within each pool will include a variety of macrohabitat types where available (Appendix A). Electrofishing samples will consist of 15-minute transects at each location. Gill net sets will be utilized to target fish species not easily captured with electrofishing equipment (i.e. Paddlefish, Flathead catfish, Blue catfish, Bighead carp, etc.). Net set locations will also encompass all macrohabitat types, but will be focused more in the embayment and tributary macrohabitats. Each net set will be actively tended and effort will be expended to run fish into the nets with boat noise. All fish encountered will be collected, identified to species, geo-located and enumerated. Lengths and weights will be taken during the fall to allow for evaluation of fish condition. Asian carp will either be implanted with an acoustic transmitter (below Greenup Dam) or exterminated (above Greenup Dam).

In response to several positive eDNA results for both Silver and Bighead carps in 2014-2015 in the Montgomery Pool and Montgomery Slough, effort (electrofishing and gill netting) will be afforded in these locations to validate whether these results were from actual fish.

Currently, ORFMT states conduct surveys on catfish, percids, black bass, and true bass at several tailwaters, tributaries and embayments of the Ohio River. Data collection during these surveys has been augmented to include condition information on sportfish species as well as to include collection, identification, data gathering and reporting of any Asian Carp. All Asian carp collected will be identified, sexed (when applicable) and lengths and weights will be noted. Otoliths and pectoral fin rays will be removed as needed from Asian carp for microchemistry and age and growth analysis.

Abundance and Distribution of Juvenile Asian carp in the Ohio River

Participating Agencies: Kentucky Department of Fish and Wildlife Resources (KDFWR), Indiana Department of Natural Resources (INDNR), United States Fish and Wildlife Service (USFWS), Ohio River Valley Water Sanitation Commission (ORSANCO)

Location: Ohio River tributaries from JT Meyers lock and dam to McAlpine lock and dam.

Introduction and Need: Since their introduction in the United States, Asian carp have increased their distribution throughout the Mississippi River basin through their ability to densely colonize river ecosystems and tolerance of a wide range of environmental conditions (Kolar et. al 2005). In order to limit the negative impacts of Asian carp populations and their further spread, efforts have increased to understand the distribution and abundance of Asian carp in the waters they currently inhabit.

As a result of the Water Resources Reform and Development Act of 2014 (WRDDA), Public Law 113-121, funding became available to address concerns with Asian carp in river basins outside the Great Lakes basin. The USFWS summarizes efforts funded under WRDDA in a report to Congress each year (USFWS 2014). A critical portion of that report focuses on the distribution of Asian carp in each river basin, and characterizes the distribution into three categories (Established population, Presence of Adults, and Some Adults present) based on the relative abundance of Asian carp. The "established population" range has been defined as the portion of the river where spawning has been verified.

While Asian carp abundance and distribution is better understood in parts of its range (Illinois River), this critical information is lacking in many places, including the Ohio River. To date, information on the distribution of Asian carp in the Ohio River is limited to targeted sampling on the leading edge of invasion above McAlpine Locks and Dam at RM606 (see Monitoring and Response of Asian carp in the Ohio River) and sampling efforts in the Lower Ohio River below JT Meyers Locks and Dam (RM 846) conducted by the Illinois Department of Natural Resources (IDNR). Currently, confirmed Asian carp spawning events in the Wabash River verify the "established population" range to be as far upstream on the Ohio River as JT Meyers Locks and Dam. However, there is a significant portion of the Ohio River (240 miles) where targeted sampling has not occurred to determine the extent of Asian carp spawning. For the purposes of this study, verification of Asian carp spawning is defined as the presence of juvenile Asian carp (<200mm).

There are many methods that can be used to verify the presence of Asian carp spawning (Schrank et. al 2001; Deters et. al 2013). The collection of eggs and larval Asian carp are an

obvious choice, but the time frame for field efforts is limited and sampling requires specialized gear that is not as commonly used by fish managers. Furthermore, additional effort and expertise is required to identify and verify egg and larval samples after collection. Targeting juvenile Asian carp via electrofishing surveys allows researchers a broader temporal window in which to conduct surveys, a more efficient measure of juvenile Asian carp presence/absence, and additional information on Asian carp nursery areas, while using methods and gears that are readily available.

Objectives:

- Define the "established population" range of Asian carp in the Ohio River via targeted sampling for juvenile Asian carp.
- Identify characteristics of potential Asian carp nursery areas when juvenile Asian carp are encountered.
- Identify other sources of fish sampling data in the Ohio River that may inform previous objectives (ORSANCO).

Status: This is a new project for 2016 that builds off of information gathered during other projects in 2015.

Methods: Participating agencies will conduct targeted sampling for juvenile Asian carp above JT Meyers Locks and Dam. Because typical nursery habitat in the form of shallow backwater areas is uncommon in the Ohio River, flooded creek mouths and tributaries may serve as a substitute. Tributaries large enough for entrance with a shocking boat will be identified and targeted (Appendix A) with pulsed DC electrofishing during July and August (Table 2), the time of year when juvenile Asian carp have been captured in the lower Ohio River in previous years.

Table 2. Intended sampling schedule by pool.

Sampling Week	Pool	Agency
25 – July	Cannelton	KDFWR/INDNR
01 –Aug	Newburgh	INDNR/KDFWR
08 – Aug	JT Myers	INDNR/KDFWR

*Weather Permitting

Electrofishing samples will target 15-minute transects, but may vary based on the size of each tributary. Juvenile Asian carp will be targeted, and those encountered will be collected, identified to species, geo-located and enumerated. When Asian carp are encountered, a subsample of lengths and weights will be recorded. A suite of habitat measurements will be

collected at each site to describe both the morphology of the tributary as well water quality parameters.

Leading Edge Asian Carp Suppression in the Ohio River

Participating Agencies: KDFWR, WVDNR, USFWS

Location: Ohio River pools above RM 531.5 with a focus between the Markland and R.C. Byrd locks and dam complexes.

Introduction and Need: Since their introduction in the Mississippi River basin, Asian carp (Silver Carp, Black Carp, and Grass Carp) have steadily increased their range. Asian carp rapidly and densely colonize river reaches affecting the native food web in large river ecosystems (Freedman et al. 2012, Irons et al. 2007). As a result, significant funding has been allocated in the basin to limit the impacts of Asian carp where they exist as well as halt their spread into uninhabited waters.

There are currently few tools available to limit the negative impacts of Asian carp and their spread into new waters. Integrated pest management approaches include barrier technologies that prevent movement of the Asian carps into critical areas as well as the targeted removal of Asian carp below barriers to decrease propagule pressure (Tsehaye et al. 2013). Planning and implementation of barriers to Asian carp movement are widely believed to be an important aspect of the control of Asian carp in the Mississippi River basin. However, planning barrier projects requires an understanding of the distribution and abundance of invading carps which requires years of data collection. Urgent efforts to gather this data in the Ohio River basin began in earnest in 2015 and will continue in the foreseeable future. In the meantime, the best tool for limiting impacts and dispersal of Asian carps is the physical removal of fish.

The leading edge of Asian carp invasion on the Ohio River is located above Markland Locks and Dam (RM 531.5). Asian carp abundance above this point is relatively low, and the majority of fish captures occur in the lower portions of tributaries. Multi-agency sampling and removal projects have successfully targeted Asian carp in select tributaries of this reach in recent years. Removal of Asian carp along this stretch of river reduces the number of Asian carp moving upstream, reduces the likelihood of successful reproduction, and buys managers time to plan and implement potential barriers to Asian carp movement.

Objectives:

- Remove Asian carp from the leading edge of invasion of the Ohio River, above RM 531.
- Compare methodologies and gear types to increase efficiency of Asian carp removal.
- Provide data for monitoring and response efforts and utilize active telemetry to inform removal efforts.

Status: This project is a portion of what was the Control and Removal project in 2015. For 2016, it was split into two separate projects that reflect somewhat different objectives and focus areas.

Methods: Agency crews will tag and remove Asian carp from the Ohio River system (Table 3), focusing on tributaries and other known or suspected areas of high Asian carp density. Sampling effort will rely on pulsed DC electrofishing and gill nets, but other gear types may be used to increase catchability depending on sampling circumstances. Sampling sites were identified throughout the 2015 season; additional sites will be added as we learn more about the habitat preferences of Asian carp. Manual telemetry will remain a tool in finding Asian carp for the purpose of removal.

Table 3. Intended sampling schedule by pool.

Sampling Week	Pool	Agency
23 – May	Markland	KDFWR
30 – May	Meldahl	KDFWR
06 – June	Markland	KDFWR
26 – Sep	Meldahl	KDFWR
03 – Oct	Greenup	KDFWR

*Weather Permitting

All untagged Asian carp will either be tagged with a sonic transmitter or exterminated. Exterminated fish will be used to provide pectoral fin rays for aging. All fish collected will be identified, counted, and geo-located in addition to determining standard length and weight measurements.

Agency crews will remove Asian carp from the Ohio River system focusing on tributaries and other known or suspected areas of increased Asian carp density. Sampling effort will rely on pulsed DC electrofishing and gill nets, but other gear types may be used to increase catchability depending on sampling circumstances. Sampling sites were identified throughout the 2015 season; additional sites will be added as we learn about the habitat preferences of Asian carp. Manual telemetry will remain a tool in finding Asian carp for the purpose of removal.

Control and Removal of Asian carp in the Ohio River

Participating Agencies: KDFWR, USGS, USACE

Location: Ohio River below Markland Locks and Dam.

Introduction and Need: Since their introduction in the Mississippi River basin, Asian carp (Silver carp, Bighead carp, and Grass carp) have steadily increased their range. Asian carp rapidly and densely colonize river reaches affecting the native food web in large river ecosystems (Freedman et al. 2012, Irons et al. 2007). As a result, significant funding has been allocated in the basin to limit the impacts of Asian carp where they exist, as well as halt their spread into uninhabited waters.

There are currently few tools available to limit the negative impacts of Asian carp and their spread into new waters. Integrated pest management approaches include barrier technologies that prevent movement of the Asian carps into critical areas as well as the targeted removal of Asian carp below barriers to decrease propagule pressure (Tsehaye et al. 2013). Planning and implementation of barriers to Asian carp movement are widely believed to be an important aspect of the control of Asian carp in the Mississippi River basin. However, implementation of barrier projects can be very expensive and require an understanding of the distribution and abundance of invading carps, which can take years to collect. Urgent efforts to gather this data in the Ohio River basin began in earnest in 2015 and will continue in the foreseeable future. Currently, the best tool for limiting impacts and dispersal of Asian carps is the physical removal of fish.

Removal of Asian carp has shown promise in the Illinois River where collapse of the Asian carp fishery may be possible if efforts for removal are high and target all size ranges of fish (Tsehaye et al. 2013). Removal efforts in areas of low density showed variable success in 2015. Methods are proposed for 2016 that will focus efforts in areas of high Asian carp density and incorporate a larger suite of existing information as well as experimentation that will lead to improvements in removal efficiency.

Objectives:

- Remove Asian carp from portions of the Ohio River where they are established below Markland Locks and Dam.
- Pursue novel gear types, attractants, and use of sound to congregate Asian carp for capture.
- Identify private entities that have a use for removed fish and support the creation of Asian carp markets as possible.
- Encourage removal of all size classes of Asian carp in the commercial fishery.

Status: This project is a portion of what was the Control and Removal project in 2015. For 2016, it was split into two separate projects that reflect somewhat different objectives and focus areas.

Methods: Agency crews or contracted commercial fisherman will remove Asian carp from the Ohio River system focusing on known or suspected areas of high Asian carp density (Table 4; Figure 7). Sampling effort will rely on pulsed DC electrofishing and gill nets, but other gear types may be used to increase catchability depending on sampling circumstances. The expertise of other researchers and commercial fishers will be employed to investigate ways to improve capture efficiency at multiple life stages. Sampling effort will focus in the Ohio River downstream of Markland Dam where Asian carp densities are much higher.

Table 4. Intended sampling schedule by pool.

Sampling Week	Pool	Agency
13 – June	McAlpine	KDFWR
27 – June	McAlpine	KDFWR
04 – July	Cannelton	KDFWR
11 – July	Cannelton	KDFWR
15 – Aug	McAlpine	KDFWR
29 – Aug	McAlpine	KDFWR
05 – Sep	Cannelton	KDFWR
12 – Sep	Cannelton	KDFWR

*Weather Permitting

**Pools below Cannelton may be substituted in schedule depending on fishing success

Gill net removal will typically involve short, active net sets similar to those used in the 2015 season. However, these methods met limited success in 2015. As a result, a priority of this project will be to identify sampling conditions and locations where gill net removal is effective. Nets will be a large (4”-5” bar) mesh size to specifically target adult carp unless specifically targeting locations with young of the year fish. Active telemetry will be used to locate tagged fish and inform removal efforts.

All untagged Asian carp will be tagged below Greenup Dam with a sonic transmitter. Asian carp captured above Greenup Dam will be exterminated. Exterminated fish will be used to provide pectoral fin rays for aging (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). All fish collected will be identified, counted, and geo-located.

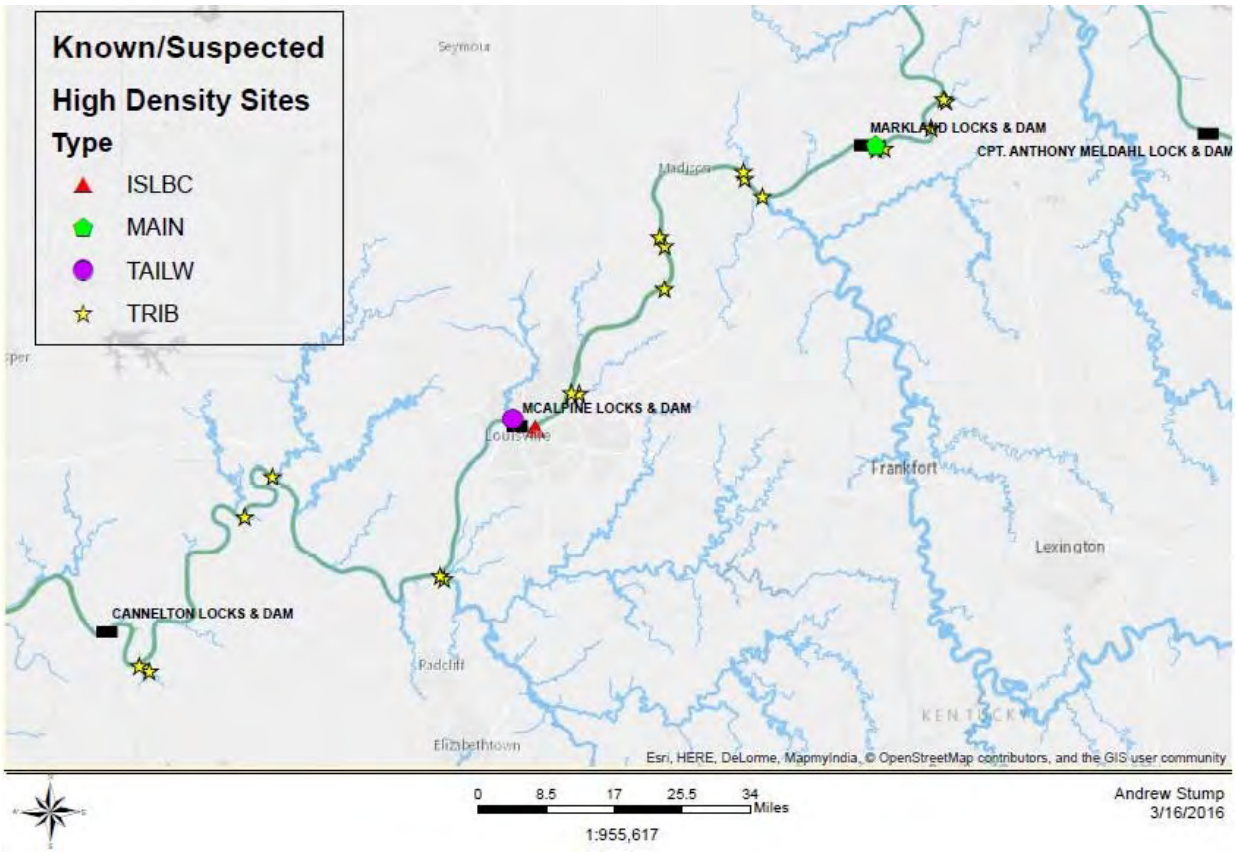


Figure 7. Sites of known or suspected high densities of Asian carp in Cannelton, McAlpine, and Markland pools. Only those sites below Markland Locks and Dam will be sampled during removal.

Distribution, movement, and lock and dam passage of Asian carp in the Ohio River through acoustic telemetry

Participating Agencies: USFWS, KDFWR, WVDNR, ODNR, INDNR

Location: The Ohio River from the McAlpine Lock and Dam near Louisville, KY, upstream to the Hannibal Lock and Dam near the town of New Martinsville, WV.

Introduction and Need: The bigheaded carps, herein referred to as Asian carp, include the Silver Carp (*Hypophthalmichthys molitrix)* and Bighead Carp (*H. nobilis)* as well as hybrids between these species. Populations of these two introduced aquatic nuisance species (ANS) are spreading throughout the Mississippi River Basin (Conover et al. 2007; Chapman and Hoff 2011; O'Connell et al. 2011). Kolar et al. (2007) rated the probability of Silver and Bighead Carp spreading to previously uncolonized areas as "high" and assigned this rating a "very certain" degree of certainty. Asian carp are highly invasive fishes that have been expanding their range in the U.S. since the early 1980's when they first began to appear in public waters (Freeze and Henderson 1982; Burr et al 1996). Populations of Asian carp have grown exponentially because of their rapid growth rates, short generation times, and dispersal capabilities (DeGrandchamp 2003; Peters et al. 2006; DeGrandchamp et al. 2008). Asian carp have been shown to exhibit very high reproductive potentials with high fecundity and the potential for a protracted spawning period (Garvey et al. 2006). Garvey et al. (2006) stated that high reproductive capacity of both species, in particular Silver Carp ensure that attempts to exclude or remove individuals will require a massive undertaking that targets juveniles as well as adults. These fishes have invaded the Ohio River system and are spreading up the river and many tributaries. Populations of Asian carp have become well established in the lower and middle reaches of the Ohio River and successful reproduction is suspected but not confirmed as far upstream as the Falls of the Ohio at Louisville, Kentucky. The upper reaches of the Ohio River as well as many upper basin tributary streams may not currently be inhabited by Asian carp. The need exists to prevent the establishment of these species into the upper portions of the Ohio basin. Any information that we can learn about Asian carp distribution, abundance, and/or biology that could help managers to limit or stop their spread would be important to a wide variety of ecosystems.

The Great Lakes and Mississippi River Interbasin Study (GLMRIS) identified six different possible routes for ANS to access the Great Lakes Basin through tributaries of the Ohio River. Because of these potential connections between Ohio River tributaries and Lake Erie, natural resource managers are concerned about the potential for the invasion of Asian carps into the Great Lakes Basin through the upper Ohio River watershed. If Asian carp gain entry into the Great Lakes they could pose a significant threat to established fisheries by competing with economically and recreationally important fishes for limited plankton resources (Sparks et al. 2011). They would also pose a very real danger to recreational boaters. Although predictions of the effects of Asian carp on the Great Lakes ecosystem vary widely, negative impacts on the fishery and recreational use of these resources are expected.

The overall goal of these efforts is to understand the distribution and movement patterns of Asian carp in the middle and upper Ohio River. Understanding these aspects of Asian carp biology in the Ohio River will assist efforts to minimize their further spread in the basin and reduce the size of existing populations.

Objectives:

1. Understand Asian carp use of tributaries with potential connections to the Great Lakes.
2. Delineate the upstream-most distribution of Asian carp and potential for further upstream movement. This will help with identification of barrier sites or other points where fish can be slowed or stopped.
3. Utilize mobile tracking data and Judas fish techniques to guide contract fishers and agency sampling efforts.
4. Identify habitat preferences of Asian carp within the middle and upper Ohio River including tributary use.

Status: The Ohio River Asian Carp Telemetry project is a continuation of work begun in 2013.

Methods: Ultrasonic telemetry will be used to track the movements of Asian carp and evaluate their ability to navigate the lock and dam systems upstream of current known populations.

Ultrasonic Transmitter Tagging: Adult Bighead Carp and Silver Carp will be surgically implanted with ultrasonic transmitters (Vemco, Model V16-6H; 69 kHz) which provide individual identification. The V16-6H coded transmitters being used are nominally programmed to transmit a signal every 40 seconds yielding a battery life of 1,825 days (5 years). Fish to be tagged will be collected by Agency personnel from the McAlpine, Markland, Meldahl, or Greenup pools. They will be implanted with transmitters according to surgical procedures described by Summerfelt and Smith (1990). Following surgery, fish will be measured for total length (mm) and weight (g), visually or manually sexed (if possible). Fish will be allowed to revive before being released, any tagged fish which does not appear robust (i.e. swimming upright and vigorously) will be destroyed and the tag retrieved for use in another fish. Tagged fish will be fitted with an individually numbered external jaw tag which is applied to the dentary bone (lower jaw) (National Tag Co. #1242 F9). Commencing in spring 2016 Bighead Carp and Silver Carp will be tagged and released into the Cannelton, McAlpine, Markland, Meldahl, or Greenup pools. Location of this tagging, and subsequent releases will depend on locations of captures during agency netting and electrofishing efforts. Trammel nets, gill nets, and/or hoop nets will be used to capture Asian carp for implantation of ultrasonic transmitters. Boat electrofishing will be used to supplement netting efforts. The Meldahl, Markland, McAlpine, Greenup, and possibly R.C. Byrd pools will be sampled. Night time electrofishing will be employed upstream of known populations to attempt to document the maximum upstream extent of catchable Asian carp. Trammel nets, gill nets, and/or hoop nets will be fished in areas that may be attractive to Asian carp such as side channels, island tips, backwaters, and drowned creek mouths.

Ultrasonic receiver array: An array of VR2W receivers was installed in the river beginning in summer 2013. Fifty-eight receivers were placed above and below lock and dams, in the lower portions of major tributary streams, in lock chambers and downstream lock approaches, and at regular intervals between lock and dams. In 2015 five VR2AR acoustic release receivers were deployed in the mainstem approximately one mile upstream of the Markland, Meldahl, Greenup, Byrd, and Belleville locks and Dams. In spring 2016 these five will be downloaded and redeployed and five additional VR2AR receivers will be deployed strategically in areas upstream

of Belleville Lock and Dam. Figure 8 illustrates the locations of VR2W receivers that have been deployed. Most of the mainstem receivers were removed from the river in November 2015 to protect them from ice flows and high waters. Receivers will be re-deployed into the mainstem river as early as practicable during Spring 2016. VR2W receivers will be place in the lock chambers and lock approach at the Hannibal Locks and Dam. Additional tributaries will have one or more receiver deployed far enough upstream of the confluence with the Ohio River that it cannot detect fish from the mainstem Ohio. Mainstem receivers will be deployed at lock and dam complexes downstream of McAlpine pool in 2016. Any receivers that are lost will be replaced as quickly as possible. Receiver data will be downloaded monthly. Data gleaned from stationary receivers will provide information on gross movements of tagged fish including any movements upstream or downstream through lock and dam complexes and movements into or out of tributaries.

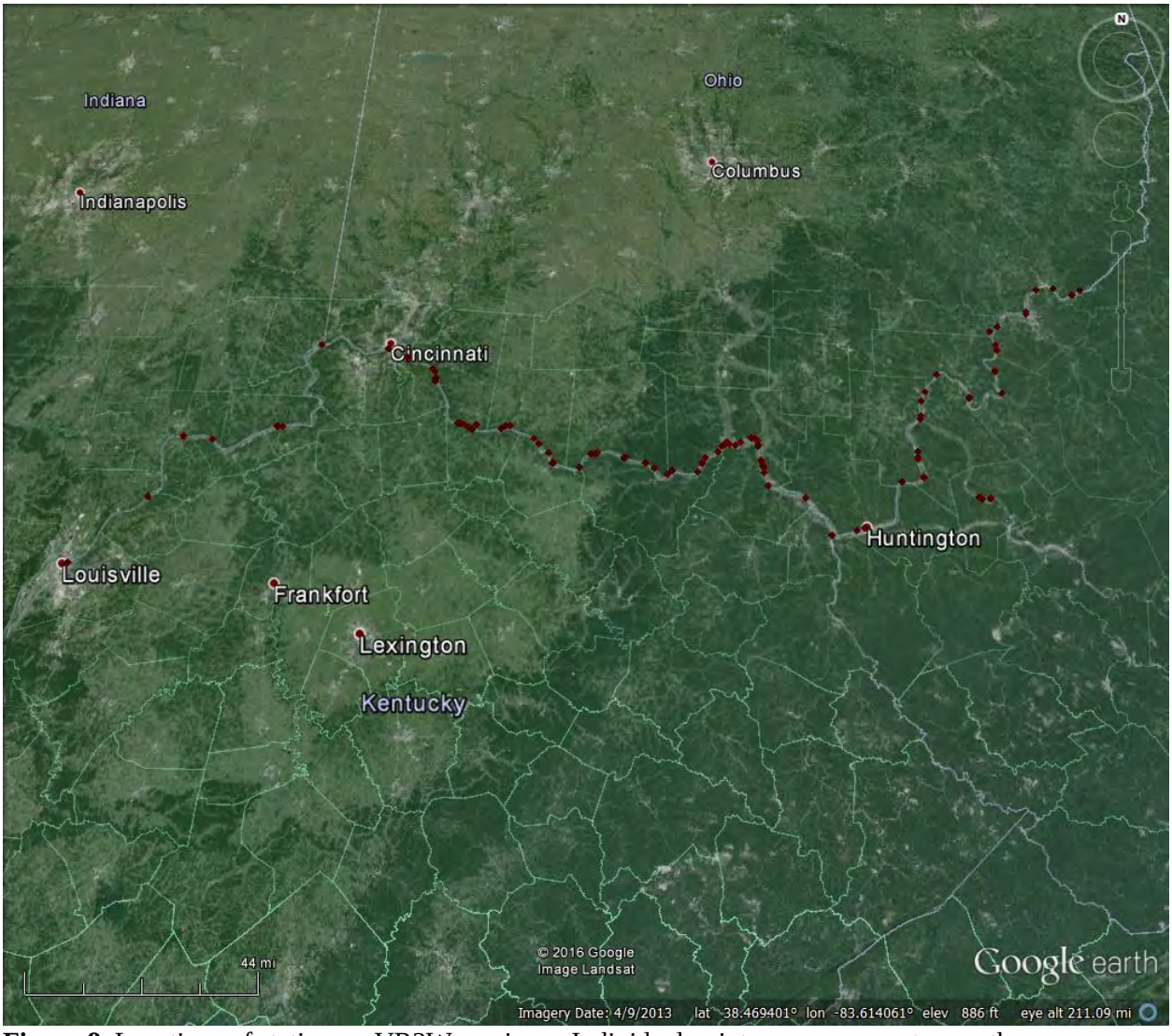


Figure 8. Locations of stationary VR2W receivers. Individual points may represent more than one receiver at this scale.

Mobile Tracking: Active tracking will be used in concert with other collecting methods to locate tagged fish and increase the likelihood of capturing new fish to tag. Fish will be located with a

portable hydrophone and receiver (Vemco Model VH110-10M and Vemco Model VR100, respectively) and GPS coordinates will be recorded at each site of location.

Roles for telemetry work: Personnel from USFWS, Kentucky Department of Fish and Wildlife Resources (Kentucky), Ohio Department of Natural Resources (Ohio) and the West Virginia Division of Natural Resources (West Virginia), (collectively referred to as the states) will be responsible for placement of stationary receivers and routine downloading of data. Mobile tracking of tagged fish will be done by the states and USFWS. USFWS will purchase an additional 200 V-16 6H transmitters for implantation this year. Ohio will provide 10 additional VR-2Ws, and USFWS will purchase 40 additional receivers for deployment during 2015. USFWS will purchase replacement batteries and desiccant packs for all receivers in use. Telemetry data will be shared with all partners via an FTP site that Ohio DNR established during 2014.

Table 5. 2016 Sampling Schedule:

Week	Agency	Pool	Activity
6 July	USFWS, KDFWR, WVDNR	Multiple pools	Install receivers
27 July	USFWS	McAlpine	Tag Fish
17 August	USFWS	Meldahl	Tag Fish
24 August	USFWS	McAlpine	Tag Fish
14 September	USFWS, KDFWR, WVDNR	McAlpine	Tag Fish
28 September	USFWS	Meldahl	Tag Fish
5 October	USFWS, KDFWR, WVDNR	McAlpine	Tag Fish
19 October	USFWS	Meldahl	Tag Fish
2 November	USFWS	Markland	Tag Fish
16 November	USFWS	Multiple pools	Remove receivers

Table 6. 2016 Download Schedule:

Pool	June	July	August	September	October	November
Willow Isl.	OH D4	USFWS	OH D4	USFWS	OH D4	USFWS
Belleville	OH D4	USFWS	OH D4	USFWS	OH D4	USFWS
Racine	OH D4	USFWS	OH D4	USFWS	OH D4	USFWS
RC Byrd	OH D4	USFWS	OH D4	USFWS	OH D4	USFWS
Greenup	OH D5	USFWS	OH D5	USFWS	OH D5	USFWS
Meldahl	OH D5	KDFWR	OH D5	KDFWR	OH D5	KDFWR
Markland	OH D5	KDFWR	OH D5	KDFWR	OH D5	KDFWR
McAlpine	KDFWR	KDFWR	KDFWR	KDFWR	KDFWR	KDFWR

Movement and Lock and Dam Passage of Asian carp in the Tennessee River

Participating Agencies: Tennessee Wildlife Resources Agency; USGS Tennessee Cooperative Fishery Research Unit; Kentucky Department of Fish and Wildlife Resources; Mississippi Department of Wildlife, Fisheries, and Parks; Alabama Department of Conservation and Natural Resources; Murray State University; Georgia Department of Natural Resources; US Fish and Wildlife Service Region 4; Tennessee Valley Authority, US Army Corps of Engineers

Location: Tennessee River impoundments in Kentucky, Tennessee, Mississippi, and Alabama waters

Introduction and Need: Silver Carp *Hypophthalmichthys molitrix* are spreading in the Ohio River Basin and many of its tributaries. Increasing occurrences in one of the major tributaries, the Tennessee River, has created concerns for the five states that manage fisheries within the Tennessee River's watershed. Populations of Asian carp have become well established in the lower reaches of the Tennessee River, especially below Pickwick Dam. The commercial harvest of Asian carp in Kentucky Lake, the farthest downstream reservoir on the system, has increased dramatically since 2010 and young- of-year Asian carp were captured for the first time in Kentucky Lake in 2015.

Multiple agencies have begun an effort to understand the movement of Asian carp in the Tennessee River basin via acoustic telemetry. These efforts intend to inform removal efforts in downstream areas and inform invasion into the upper portions of the Tennessee River basin including the Tennessee Tombigbee waterway. There is significant potential for limiting dispersal of Asian carp at Lock and Dams on the system because the design of these structures limits upstream movement to the lock chambers. Previous and ongoing studies have created an acoustic receiver array that covers much of the system. This project would fill in the gaps and complete the array of receivers on the Tennessee River system.

This project joins multiple, independent projects on the system working towards a common goal. Movement data from these projects will lead to better understanding of Asian carp dispersal and invasion dynamics, evaluation of movement through lock and dam systems, and identification of seasonal congregations in the Tennessee River.

Objectives:

(1) Quantify spatial and temporal movements of Silver Carp in Kentucky Lake; Identify habitat preferences and factors influencing movements; Evaluate invasion from Ohio River via lock chamber at Kentucky Lake
(2) Expand telemetry receiver array to include all impoundments on the Tennessee River to enhance movement studies
(3) Measure movement between Kentucky Lake and Pickwick Lake; quantify movement cues to inform lock management and potential future barrier

construction

(4) Measure movement from Pickwick Lake to connecting waters of the Tombigbee waterway

Methods: Ultrasonic telemetry will be used to track movements of Asian Carp in the Tennessee River and its impoundments. Currently, approximately 30 Silver Carp have been implanted with Vemco ultrasonic transmitters in Kentucky Lake. In 2016 and 2017, an additional 70 Silver Carp will be implanted with Vemco ultrasonic transmitters in Kentucky Lake. In the headwaters of Kentucky Lake, immediately below Pickwick Dam, 20 Silver Carp will be implanted with ultrasonic transmitters to evaluate passage through the lock. Flows and water temperature will be obtained to evaluate patterns in environmental conditions and inter-lake movement. Lastly, approximately 20 Silver Carp in the Yellow Creek Arm of Pickwick Lake will be implanted with transmitters to track their movements through the Bay Springs Lock and Dam, which connects to the Tombigbee Waterway and the Mobile River basin. We will use Vemco V-16 transmitters because they have been used successfully for Silver Carp in other waters. The transmitters will have a life expectancy exceeding 2 years; thus, data retrievals from receivers should be considered a multi-year process. Surgeries will follow standard methods and only fish that revive quickly and in good condition will be released. If all transmitters are not at-large after 2016, tagging will continue in 2017.

Data to describe Asian carp movements will be obtained primarily from stationary Vemco receivers. Currently, there are approximately four receivers in lower Kentucky Lake, three in the Yellow Creek arm of Pickwick Lake, and twenty in the Tennessee River upstream of Chattanooga. In 2016, an additional 20 receivers will be deployed, primarily at dam locks, thus providing complete coverage within the Tennessee River and detectability of inter-lake movements. In Kentucky Lake, crews from Murray State University, Kentucky DFWR, and Tennessee Tech University will also employ active tracking to further provide fine-scale movement and habitat preference data. Lastly, receivers will be deployed near the mouths of the Duck River and Beech River where young-of-year AC were captured in 2015. Detections from receivers at these major tributaries could indicate spawning movements and the timing of those movements, and thus, be critical to understanding barrier placement to impede within-lake natural recruitment.

Personnel from Murray State University, Tennessee Tech University, Mississippi DWFP, and Kentucky DFWR, and USFWS will coordinate receiver locations and routine downloading of data. Telemetry data will be shared, potentially using the visualization database developed by the USGS for Mississippi River Watershed acoustic telemetry projects.

Deliverables: Relocation data will be shared among cooperating agencies/universities. Semi-annual updates will be distributed; however, any urgent findings will be shared as soon as possible. Project updates will be provided in the fall for the USFWS report to congress and project technical reports will follow.

Table 7. Tennessee River Asian Carp Ultrasonic Telemetry Activity Schedule

Agency	Year	Activity	Month(s)	Waterbody
USFWS	2016	Receiver mapping	May - June	All
KDFWR	2016	Receiver deployment	May, July	Kentucky
TTU	2016	Receiver deployment*	Sep-Oct	Kentucky, Pickwick, Wilson, Wheeler
MDWFP	2016	Receiver deployment	May	Pickwick
KDFWR	2016	Capture/ tagging *	July	Kentucky
MDWFP	2016	Capture/tagging*	May - ??	Pickwick
TTU	2016	Capture/tagging*	Sep-Oct	Kentucky, Pickwick
KDFWR	2016	Active Tracking	May - ??	Kentucky
TTU	2016	Active Tracking	Sep - ??	Kentucky
All	2016	Coordinated data retrieval	TBD	All

*Transmitter and receiver deployment dates are dependent on funding receipt and procurement of materials from Vemco. Tags not deployed in 2016 will be implanted in 2017

Evaluate reproductive success, established leading edges, and abundance of age-0 Asian carp in Kentucky and Barkley reservoirs

Participating Agencies: Tennessee Wildlife Resources Agency, Kentucky Department of Fish and Wildlife Resources, Tennessee Valley Authority

Location: Kentucky Lake and Lake Barkley, the lowermost reservoirs on the Tennessee and Cumberland Rivers, respectively.

Project/Activity Explanation: Partners will develop and implement larval sampling protocol to determine the presence of larval Asian carp in Kentucky and Barkley reservoirs. Adult Bighead, Grass, and Silver carps have been documented in Kentucky and Barkley reservoirs. Adult Bighead and Grass carps have been recognized for the last ten to fifteen years but Silver Carp have only been collected within the Tennessee portion of the reservoirs for the last three years. Sampling efforts with gill nets and electrofishing gear has only collected adult and the Silver Carp population appeared to be a migrant population. However, during fall sampling 2015, several smaller individuals (150 – 235mm) were collected during electrofishing and with cast nets by commercial fishers. Resource managers do not have a clear understanding of whether these fish migrated through the locks at Kentucky Dam or actually reproduced and recruited within the confines of Kentucky and Barkley reservoirs.

Larval sampling with appropriate gear will provide definitive evidence of reproduction within Kentucky or Barkley reservoirs. The project will also define the current invasion status of Asian carp, the established leading edge of Asian carp (areas with verified spawning and recruitment), and how these "edges" may change over time. This type of information is very important in determining where to target commercial fishing activities, where to develop containment measures, and to define areas of suitable spawning habitat with the reservoirs. Any information that can be collected to determine spawning requirements, spawning triggers, and distribution would be important in protecting the aquatic resource.

Objectives:

1) Determine presence and/or extent of Asian carp reproduction within Kentucky and Barkley reservoirs.
2) Determine level of recruitment to age 1 through standardized and non-standardized electrofishing surveys.

Status: This is a new project for USFWS funding in 2016. However, similar work was conducted in 2015 using other funding mechanisms.

Methods: Larval sampling will be conducted using a bow mounted icthyoplankton net (0.75 m x 3 m) consisting of 500 um mesh. The larval tow nets will be placed on booms that extend parallel to the front of the boat and the nets will be pushed near the surface into the current so that the velocity of the water entering the net is between 1.0 to 1.5 m/s. At sampling locations where no water current exists (e.g. backwaters), sampling will occur towards a random direction that will allow for a complete sample to be taken in a relatively linear path. A mechanical flow meter will be placed in the mouth of the net to determine the volume of water sampled. Each location will be sampled with two, five-minute pushes. Sample contents will be placed in containers labeled with sample location, name of water body, and date, and will be preserved in 10% buffered formalin for 24-48 hours, rinsed with water, and preserved in 90% ethanol.

Quadrafoil type larval light traps will be deployed at randomly generated sites in backwaters to target recently hatched invasive carp. Traps will be deployed at a minimum of one hour after sunset (10 traps at a time), allowed to fish for approximately 60 minutes, contents removed and redeployed and rerun within one hour after sunrise. Water quality, site description, depth, coordinates and soak time will be recorded for all traps for each individual sampling event. Traps will be set far enough away from other traps to avoid the effects of light contamination from nearby traps. All contents will be preserved in formalin and all larval fish will be enumerated and identified to the lowest necessary taxonomic rank. Asian carp will be identified to species, counted, and individual total length obtained.

The Tennessee Valley Authority (TVA) will also assist TWRA in determining Asian carp reproductive success in Kentucky and Barkley reservoirs, TVA will support this effort by providing two biologists, larval push boat, nets, formalin, jars and other non-labor expenses one day per week from April through July to sample for larval Asian carp. Sampling will consist of utilizing larval fish nets and/or light traps every-other-week per reservoir. Samples collected will be processed by sorting Asian carp from non-Asian carp and preserved in formalin.

TWRA will conduct electrofishing surveys each spring and fall on Kentucky and Barkley reservoirs. These are our traditional game fish survey sites. During the spring survey, at each standardized site we will use pulsed-DC current (5-8 Amps, 535 Volts, 120 pulses per second) using one netter for 900 seconds. Fall sites are non-standardized samples targeting bass, but carp will be netted if observed. During all these samples Asian carp will be identified, counted, measured (TL mm) and weighed (grams). We will remove otoliths from carp for age determination.

Relative Population Densities of Asian Carp in the Tennessee River and Cumberland River Drainages

Participating Agencies: Tennessee Wildlife Resources Agency; USGS Tennessee Cooperative Fishery Research Unit; Tennessee Technological University; Kentucky Department of Fish and Wildlife Resources; Mississippi Department of Wildlife, Fisheries, and Parks; Alabama Department of Conservation and Natural Resources

Location: There are four downriver reservoirs of the Tennessee River and Cumberland River: Kentucky Lake, Pickwick Lake, Barkley Lake, and Cheatham Lake. These impoundments are the closest waterbodies to the Asian Carp source population in the Ohio River and the leading edge of Asian Carp invasion in the Tennessee and Cumberland rivers.

Introduction and Need: Bighead carp have been observed in the Tennessee waters of the Cumberland River and Tennessee River for at least 10 years. Silver carp were first observed in Tennessee waters in ~2008, but they were not observed in the headwaters of the lowermost reservoirs in each river system until ~ 2012. In the summer and fall of 2015, Tennessee Tech University (TTU) researchers and others collected young-of-year Silver Carp in both river systems, including a Kentucky Lake site nearly 250 km upstream of the Tennessee River's confluence with the Ohio River. All empirical and anecdotal evidence points to a rapid expansion of Asian Carp (AC) upstream in both river systems and into their tributaries and successful reproduction by Silver Carp in the headwaters of Kentucky Lake. Unlike other locales in the Ohio River basin, a paucity of information exists on AC in the Tennessee and Cumberland river systems. Accompanying this relative lack of information on AC in Tennessee is a deficit in our understanding of where to direct commercial fishing activity and other measures to slow the spread of AC and reduce their potential impact on native fish and mussel assemblages.

Objectives:

(1) Assess spatial variation in relative abundance of AC in the main basins of two Tennessee River impoundments (Kentucky and Pickwick lakes) and two Cumberland River impoundments (Barkley and Cheatham lakes), which are the perceived leading edge of AC invasion;

(2) Develop indices of AC abundance in the headwaters (i.e., dam tailwaters) of those four impoundments, which are proximal sources for further upstream invasion;

(3) Evaluate tailwater sampling efficiency and relate tailwater AC indices to AC catches in the main basins; and

(4) Sample additional tailwaters within the Tennessee and Cumberland river systems where the status of AC is unknown to further delineate the leading edge of AC in the waters of Tennessee, Mississippi, and Alabama.

Status: This project builds upon previous efforts of delineating the ongoing "leading edge" project in the Ohio River by expanding to connecting watersheds (i.e., Tennessee and Cumberland rivers) that have been invaded by AC.

Methods: TTU will design and execute a field experiment to understand how catch data across a longitudinal gradient, from a dam tailrace in the headwaters downstream to the lacustrine zone, represents lakewide density in each reservoir. The four target systems that span Kentucky, Tennessee, Mississippi, and Alabama waters will be stratified by flow and habitat characteristics and AC will be collected across this gradient using gillnets. The larger waterbodies (Kentucky and Barkley lakes) will be divided into riverine, transition, and lacustrine zones; whereas, the smaller waterbodies (Cheatham and Pickwick lakes) will have upper and lower reservoir zones. Gillnets will be similar to commercial fishing gear and nets used by TTU in previous studies and target AC in waters 2-3 m deep. Each net will consist of 30-m panels ranging from 74-mm to 152-mm (3" to 6") bar measure mesh, and thus, target multiple age classes vulnerable to capture. Lengths of gangs will depend upon habitat availability. Active gill net fishing will be used where set times are short (e.g., 20 minutes) and a boat will be used to increase fish movement and drive them into the net. Collected fish will be measured, weighed, sexed, and select biological samples will be archived.

Below dams, AC in tailwaters will be targeted using combined electrofishing and active gillnet sampling. Gillnet catches will be used to inform relative densities and electrofishing will be used to confirm presence or absence of AC. AC exhibit a common behavior of jumping in the presence of electric current, and thus, using electrofishing while gillnets are fishing can help determining their presence. Furthermore, jumping AC that are observed during electrofishing will be tabulated to help further inform gill net catch density data. Occupancy models will be developed to estimate detection probabilities using repeated visit to these sites. Outcomes of occupancy modeling will be applied to other waters where AC are not known to exist, but may be present. We will use gillnets and electrofishing to sample in unknown AC invasion waters and apply detection probability information to understand how reliable "zero" observations are to understanding the lack of AC presence.

A graduate Master's student will be recruited to begin in fall, 2016 to lead field work and execute data analyses to compares relative densities of AC across the four focal systems and develop occupancy models using presence/absence data.

Deliverables: Results of seasonal sampling will be summarized quarterly. An interim report will be prepared in August 2017 presenting the findings of year one. Final data analysis and modeling will occur in 2017-2018 and will be supported with a second year of funding provided

by TWRA. A final report will be prepared in summer 2018 and be followed by a Master's student thesis and publications for submission to peer reviewed journals.

Table 8: 2016-2018 Asian Carp sampling schedule in four Tennessee River and Cumberland River impoundments.

Location	Season	Year	Gear	Effort Days
Lake embayments	Fall	2016	Gillnet	12
Lake embayments	Winter	2016	Gillnet	12
Tailwaters	Spring	2017	Gillnet/electrofishing	6
Tailwaters	Summer	2017	Gillnet/electrofishing	6
Lake embayments	Summer	2017	Gillnet	12
Lake embayments	Fall	2017	Gillnet	12
Tailwaters	Spring	2018	Gillnet/electrofishing	86
Tailwaters	Summer	2018	Gillnet/electrofishing	86

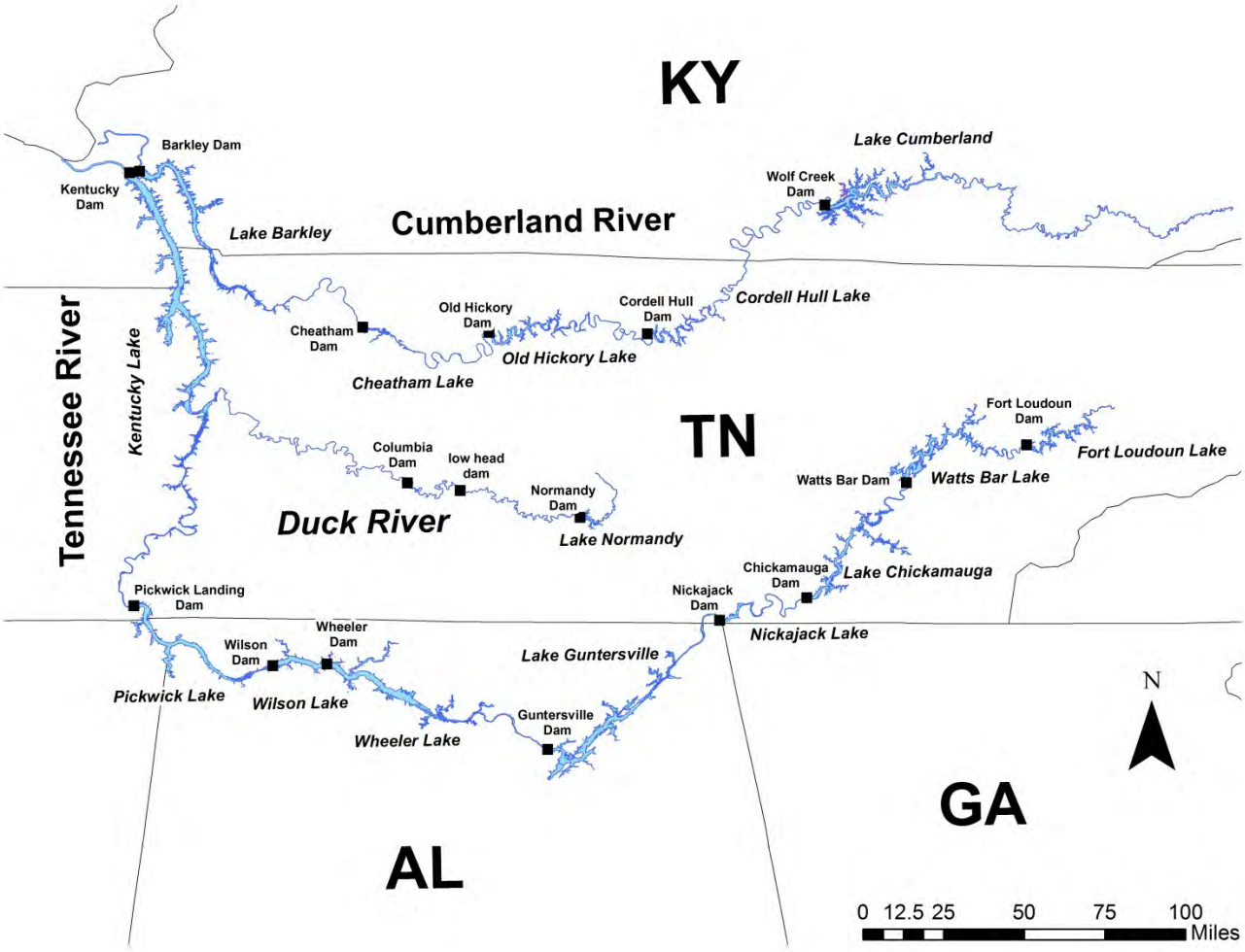


Figure 9. Asian Carp have recently been collected in Kentucky, Barkley, Cheatham, and Old Hickory Lake, and in the Duck River, but sampling effort has been limited and their population and invasion status throughout the Tennessee and Cumberland river systems remain uncertain.

Environmental DNA (eDNA) for early detection of Asian carp in the Ohio River Basin

Participating Agencies: USFWS, Ohio, West Virginia, Pennsylvania, Mississippi, Tennessee, Alabama

Location: Upper Ohio River and tributaries in Ohio, West Virginia, and Pennsylvania including the Muskingum River, Kanawha River, Little Kanawha River, Beaver River, Little Beaver River, and New Cumberland and Montgomery Island Pools.

Tennessee and Tombigbee River systems in Alabama, Mississippi, and Tennessee including the tailwaters of Bay Springs Lake, Wilson, Wheeler, Guntersville, Nickajack, Chickamauga, and Watts Bar Reservoirs.

Introduction and Need: Asian carp are spreading up the Ohio River and many of its tributaries. Populations of Asian carp have become well established in the lower and middle reaches of the Ohio River and are abundant as far upstream as the Falls of the Ohio at Louisville, Kentucky. The upper reaches of the Ohio River as well as many upper basin tributary streams may not be inhabited by Asian carp at present. The need exists to prevent the establishment of these species into the upper portions of the Ohio and Tennessee River basins. Any information that we can learn about Asian carp distribution, abundance, and/or biology that could help managers to limit or stop their spread would be important for the protection of aquatic ecosystems.

Environmental DNA is an emerging science which can provide evidence of a species presence even if that species occurs at very low densities in a given area. Environmental DNA can serve as a highly sensitive early detection tool in areas threatened with invasion by Asian carps.

Environmental DNA
Sampling for environmental DNA (eDNA) will be used as an early detection tool in the upper Ohio River system and the Tennessee River system and tributaries.

Objectives:

1. Identify high priority locations in the Ohio River Basin (including upper Ohio River and upper Tennessee River) for eDNA early detection monitoring.
2. Develop and implement eDNA early detection monitoring program for highest priority locations.
3. Identify areas to use eDNA as a potential indicator of spawning times, locations, and over-wintering habitat.

Status:
This project is ongoing since 2013.

Methods:

- FWS will sample the upper Ohio River and tributaries in Ohio, West Virginia, and Pennsylvania including the Muskingum River, Kanawha River, Little Kanawha River, Beaver River, Little Beaver River, and New Cumberland and Montgomery Island Pools (number of samples to be determined).
- FWS (R3 & R5) will sample the Tennessee and Tombigbee River systems in Alabama, Mississippi, and Tennessee including the tailwaters of Bay Springs Lake, Wilson, Wheeler, Guntersville, Nickajack, Chickamauga, and Watts Bar Reservoirs.
- The USFWS Whitney Genetics Laboratory will process and test all samples for the presence of Asian carp eDNA.

Mainstem Ohio River States

- Ohio: will provide field assistance to FWS for the collection of water samples for eDNA processing.
- West Virginia: will provide field assistance to FWS for the collection of water samples for eDNA processing.
- Pennsylvania: will provide field assistance to FWS for the collection of water samples for eDNA processing.

Tennessee River States

- Alabama: will provide field assistance to FWS for the collection of water samples for eDNA processing.
- Mississippi: will provide help to FWS for the collection of water samples for eDNA processing.
- Tennessee: will provide help to FWS for the collection of water samples for eDNA processing.

Upper Mississippi River Basin

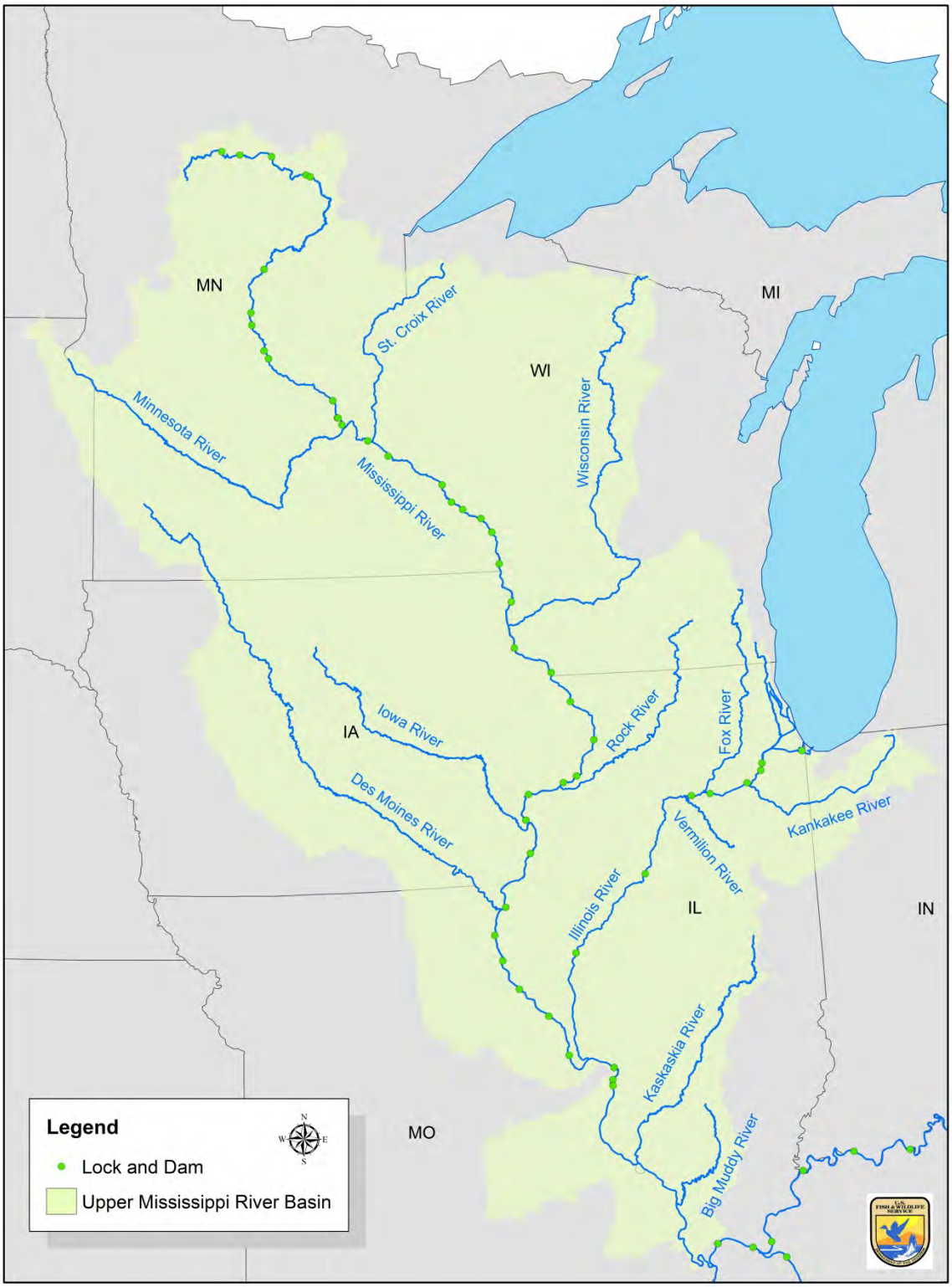


Figure 10. Map of the Upper Mississippi River Basin.

Upper Mississippi River Invasive Carp Monitoring

Participating Agencies: Minnesota Department of Natural Resources (lead), Iowa Department of Natural Resources/Iowa State University, Illinois Department of Natural Resources/Western Illinois University, Missouri Department of Conservation, and USFWS

Location: Mississippi River Pool 19 through Pool 1; St. Croix River in Minnesota and Wisconsin; Wisconsin River in Wisconsin; Des Moines, Skunk, Iowa, Wapsipinicon, Maquoketa, Turkey, and Upper Iowa rivers in Iowa; Rock and Illinois rivers in Illinois; Fabius, Cuivre, Missouri rivers and Castor River Diversion Channel in Missouri,

Introduction and Need: Partners will continue development and implementation of a comprehensive and complementary early detection, monitoring, and population assessment program for Bighead, Silver, Grass, and Black carps in the Upper Mississippi River (UMR) basin. Black carp have not been collected above Lock and Dam 22. Adult Bighead, Grass, and Silver carps are present in varying abundance in Pools 19 through Pool 13, but resource managers do not have a clear understanding of population status within each pool. The comprehensive surveillance program is intended to provide empirical data to define the current invasion status throughout the UMR above Lock and Dam 19 by defining the current presence front (i.e., occasional collection of an individual fish), invasion front (i.e., high numbers of adults collected), and the established front (i.e., areas with verified spawning and recruitment to Age-1) of the four species of invasive carp and evaluate how these fronts change through time. This is fundamental information that will inform all aspects of prevention and control such as where to target early detection monitoring, where to consider containment measures such as deterrent barriers, where to target management actions to disrupt spawning and recruitment, and where to target control activities. Additionally, this effort will help evaluate the effects of proposed management actions (e.g., adult harvest, barrier at Lock and Dam 19). Sampling will use a diverse array of traditional and novel gears to sample all potential life stages in targeted areas.

Objectives:

1) Delineate geographic boundaries of the various stages of invasion and monitor invasive carp population changes at the presence front.
2) Determine the extent of Bighead Carp, Silver Carp, and Grass Carp reproduction above Lock and Dam 19.

Status: Minnesota DNR has been conducting monitoring at the presence front since 2012. Iowa State University initiated a project looking at invasive carp reproduction in Mississippi River Pools 18 through 20 and select Iowa tributaries in 2014 and 2015. Iowa DNR monitors invasive carp through its base management activities. USFWS La Crosse FWCO began monitoring invasive carp in the UMR in 2013. While agencies have been conducting various monitoring projects and programs, 2015 is the first year agencies began to formally collaborate on a basin wide monitoring program.

Minnesota DNR maintains an array of 50 stationary acoustic receivers (Vemco Model VR2W) in the Mississippi River from the Coon Rapids Pool to Pool 3; the St. Croix River to Taylors Falls,

MN; and the Minnesota River to Shakopee, MN (Figure 11). USFWS has increased the number of stationary receivers maintained from 56 in 2015 to 85 for 2016. USFWS maintains the array from Pool 5A (RM 737) to Pool 19 (RM 365) (Figure 12). Stationary receivers have been deployed on navigation buoys above and below dams in all pools from 5A through 19 and in lock chambers at locks 14-18 to monitor movement within and among pools and determine if fish utilize the lock chamber for inter-pool movement. In 2015, stationary receivers were also deployed in select backwaters of the Mississippi River and attached to bridge piers in four major tributaries (Skunk, Iowa, Rock, and Wapsipinicon Rivers). The Missouri Department of Conservation (MDC) maintains an array of 28 stationary acoustic receivers (Vemco Model VR2W) above, below, and inside the lock chamber at Lock and Dam 19 and at locations downstream to Cairo, IL (Figure 13).

A total of 155 Bighead, Silver and hybrid Asian carps from Pools 16-20 were implanted with acoustic transmitters by the USFWS from 2013-2015. At the start of the 2016 field season, 105 of the transmitters will still be active. In 2015, MDC had 10 Black Carp and 15 Silver Carp from Pool 20 near LD19 with ultrasonic tags. MN DNR has not implanted sonic tags into any invasive carp.

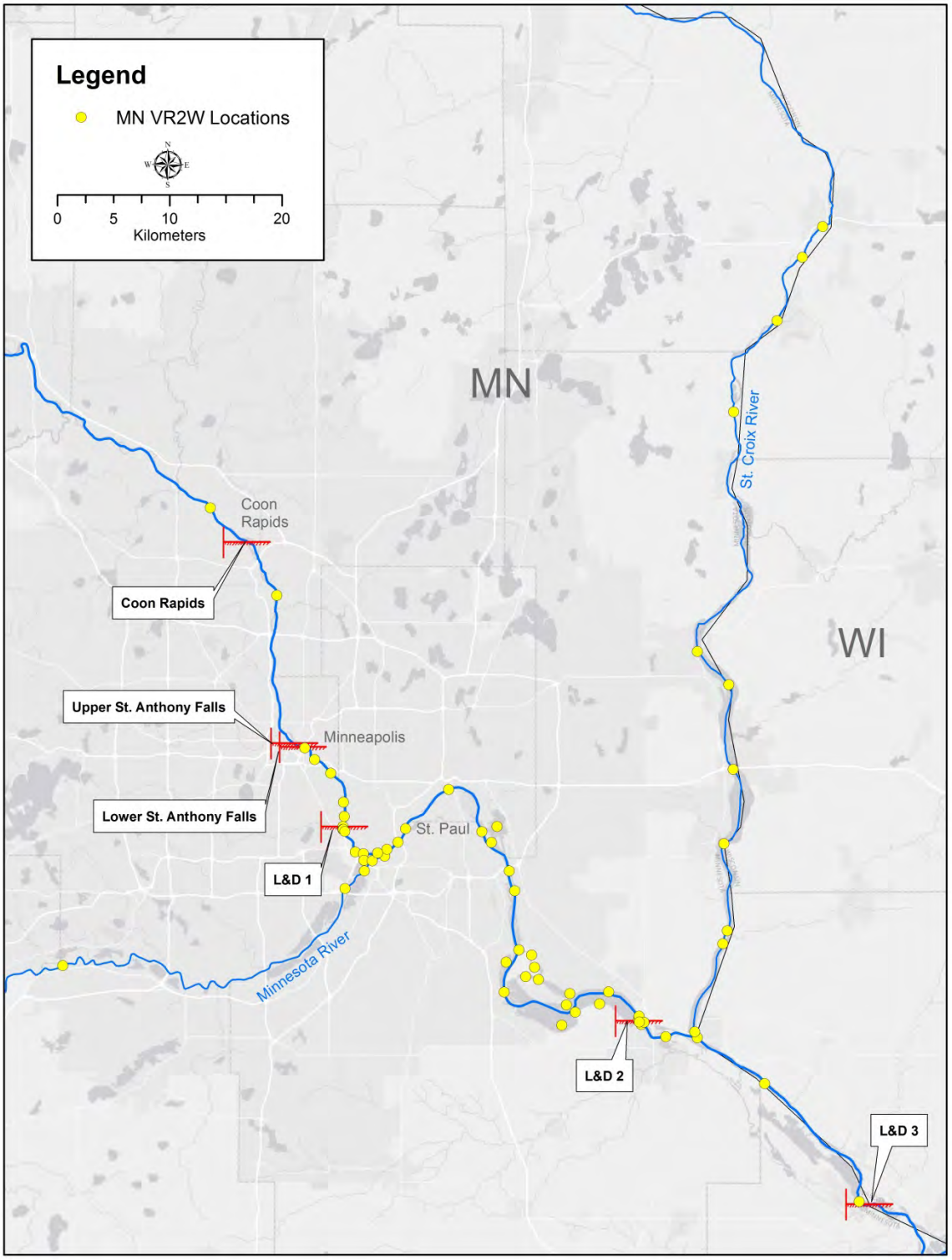


Figure 11. Locations of remote receivers maintained by Minnesota DNR in the Upper Mississippi River basin in 2016.

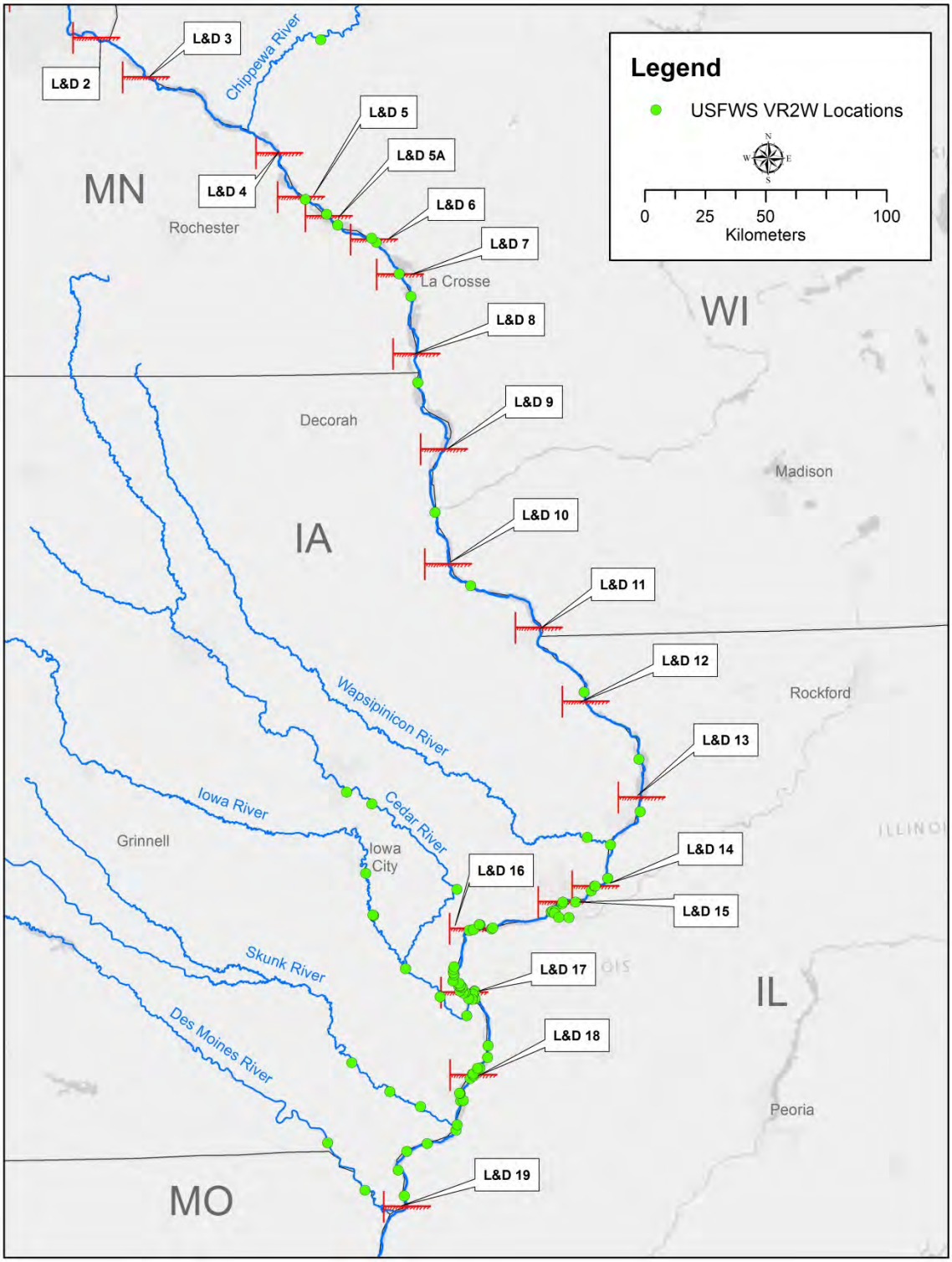


Figure 12. Locations of remote receivers maintained by USFWS in the Upper Mississippi River basin in 2016.

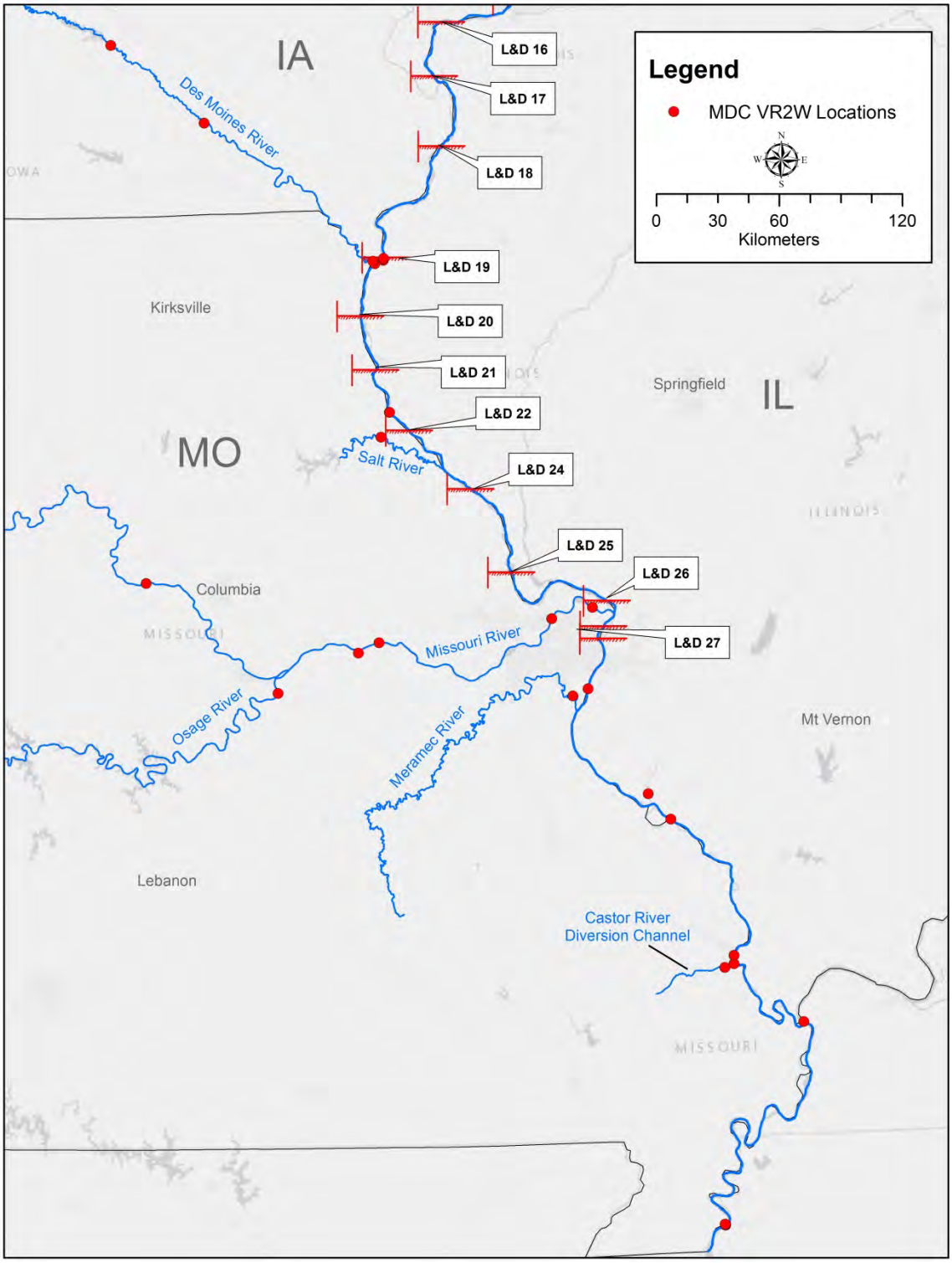


Figure 13. Locations of remote receivers maintained by Missouri DOC in the Upper Mississippi River basin in 2016.

Methods:

Larval Trawling

Method 1

A bow mounted icthyoplankton net (0.75 m x 3 m) consisting of 500 um mesh will be pushed near the surface into the current so that the velocity of the water entering the net is between 1.0 to 1.5 m/s. At sampling locations where no water current exists (e.g. backwaters), sampling will occur towards a random direction that will allow for a complete sample to be taken in a relatively linear path. A mechanical flow meter will be placed in the mouth of the net to determine the volume of water sampled. Each location will be sampled with two, five-minute pushes. Sample contents will be placed in containers labeled with sample location, name of water body, and date, and will be preserved in 10% buffered formalin for 24-48 hours, rinsed with water, and preserved in 90% ethanol. All fishes will be identified to lowest feasible taxonomic category and enumerated.

Method 2

Ichthyoplankton (0.5 m diameter net with 500 µm mesh) tows will be conducted at the surface at a constant boat speed relative to the shoreline up to four minutes depending on debris load. A General Oceanics Model (2030R) flowmeter is mounted in the mouth of the net to estimate volume (m^3) of water filtered during each tow. Three tows are conducted at each site parallel to river flow: the first tow is in the main thalweg for drifting eggs and larvae (<24 hours post fertilization), the second tow occurs near channel borders where water velocity is moving downstream slower than the thalweg, and the third is in an adjacent backwater area for mobile larvae (>24 hours post fertilization). After each tow, ichthyoplankton net contents are rinsed toward the cod end, placed in sample jars, and preserved in 95% ethanol. The ethanol will be replaced in each sample container after the first 24 hours of storage to further preserve samples for later genetic analyses (Kelso *et al.* 2012).

In the laboratory, eggs and larvae will be separated from detritus, counted, and preserved for morphometric and, if necessary, genetic, identification. All larval fishes will be identified to the lowest taxonomic level possible using Auer (1982) as a primary taxonomic key. Asian Carp eggs and larvae are difficult to distinguish among species and will only be identified to genus using meristic and morphometric characteristic (Chapman 2006, Chapman and George 2011). Determining the species of specific Asian Carp larvae or eggs collected during monitoring activities will likely require mitochondrial DNA analysis. All fishes will be differentiated first as larval or juveniles based on fin development. Fish recognized as having a full complement of fins will be categorized as juvenile fish.

Missouri DOC larval tows: ichthyoplanton tows will be conducted bi-weekly from May until early October, 2016 at select tributaries from RM 2 to 364. Two ichthyoplanton nets (0.76m, 500 µm mesh) will be deployed on each side of the boat facing upstream, with each tow lasting 3 minutes. All contents will be rinsed into a 500 µm sieve and preserved in 95% ethanol. At each site, the UMR will be sampled below, adjacent to, and above the tributary, in that order. The tributaries will be sampled in the center of the channel, with the first sample taken at the most downstream site that was deemed not influenced by the UMR and will progress upstream for samples two and three in that tributary. For each ichthyoplanton tow, velocity (m/s) will be measured using a Marsh-McBirney flow meter and depth (m) and water temperature (^{0}C) will

also be recorded using a boat-mounted Garmin. To calculate volume of water sampled, a General Oceanics flow meter (model 2030R) will be attached to the ichthyoplankton net frame and used to calculate relative abundance (number/m3). Many samples will likely be sub sampled due to large amounts of detritus or high density of eggs, embryos, or larval fish using a Folsom plankton splitter. After sub-sampling, all samples will then be stored in 95% ethanol for latter identification, measurement and otolith extraction. Morphometric characteristics developed by Chapman and George (2011) will be used to identify eggs, embryos, and larval Invasive carps.

Hoop Netting

Two different hoop nets will be used. The large 1.2 m diameter "buffalo" nets consist of 9 tapered steel hoops and three throats, with a tapered mesh size of 7.6 cm sq. mesh at the mouth, 5.1 cm sq. mesh in the middle, and 3.8 cm. sq. mesh at the cod end. The 0.9 m diameter hoop nets consist of seven tapered steel hoops and two throats, with either 2.5 cm or 5.1 cm sq. mesh throughout. Preference will be placed towards using the "buffalo" nets over the smaller nets. Specific sampling sites cannot be preemptively set, because exact set locations will vary along with varying water levels and flows. Hoop nets will be set on Monday, checked and re-set on Wednesday, and checked and pulled on Friday.

Minnesota DNR Mini-Fyke and Trap Netting

Mini-fyke nets consist of a double frame (0.7 m x 1.0 m), four hoops (0.6 m), a single throat, and a 7.6 m lead, with a square mesh size of 3.2 mm throughout. The standard trap nets consist of a double frame (0.9 m x1.8 m), five hoops (0.8 m), two throats, and a 12.2 m lead, with a square mesh size of 19.1 mm throughout. If possible mini-fyke and trap netting will be conducted in occurrence with hoop netting. Mini-fyke and trap nets will be set on Monday, checked and re-set on Tuesday and Wednesday, and checked and pulled on Thursday. If possible all fish will be identified and enumerated in the field. If positive identification is not possible, voucher specimens will be kept, labeled and preserved in 90% ethanol for later identification.

USFWS Mini-Fyke and Trap Netting

Most mini-fyke sets will incorporate Long Term Resource Monitoring Program specifications, which consist of 15 ft long X 2 ft high lead, 2 rectangular frames (2 ft X 4 ft), 2 hoops (2 ft diameter), 0.125 in square mesh, single throat with 2 in inside diameter ring sewn in place, and a total cab and frame length of 9 ft (Ratcliff et al 2014). Different variations (longer lead, more hoops, no throat ring, etc) may also be used. Mini-fyke sets will include traditional shoreline sets as well a tandem sets. Tandem sets will be set in open water with lead ends tied together. Sets will be left for approximately 24 hours. Mini-fyke sets will be deployed from June through September to target YOY Asian carp.

Minnesota DNR Electrofishing

All electrofishing by Minnesota DNR will use pulsed-DC current (6-8 Amps, 360 Volts, 60 pulses per second) and include two netters. Standardized electrofishing sites have fixed distances of 500 m in length or 15 min. All electrofishing transects are conducted in a downstream direction. All invasive carp will be collected, identified, measured and weights and aging structures will be taken from fish included in the age and growth analysis. If positive identification is not possible, voucher specimens will be kept, labeled and preserved in 90% ethanol for later identification. At sampling sites, agencies have the option to identify and collect

data on all or targeted native species. Agencies may choose to focus only on invasive carp to reduce unnecessary processing time and allow for greater sampling effort.

USFWS Electrofishing

USFWS will use electrofishing for both adult and juvenile monitoring. All electrofishing will be standardized using pulsed-DC current corrected for temperature and specific conductivity to produce a potential transfer of 3000 W from water to fish at 60 pulses per second (Burkhardt and Gutreuter 1995). All electrofishing runs will be 15 minutes in length and proceed in a downstream direction where applicable. All electrofishing will include two netters. Power may be turned off/on to prevent driving fish. All fish will be netted. Electrofishing will also serve as an adult monitoring tool and will commence in April and continue through October.

Gill and Trammel Netting

Stationary large mesh gill nets of depths from 2.4 to7.3 m with square mesh sizes of 8.9 to15.2 cm will be used to target adult invasive carps. Stationary trammel nets with outside wall square mesh sizes of 30.5 to 35.6 cm and inner square mesh sizes of 5.1 to10.2 cm will also be used to target adult invasive carps. Stationary experimental gill nets 76.2 m in length and 1.8 m deep consisting of 515.2 m compliments of net with square mesh sizes 19.1,25.4, 31.8, 38.1, 50.8 mm will be used to target juvenile invasive carps. Nets may be set either short term or overnight, with short-term sets favored when water temperatures are greater than 15.6º C. Species, number, and condition (i.e., healthy, moribund, dead) of non-target species captured in nets will be recorded and reported.

Paupier Trawl

The paupier butterfly trawl consists of a 3.7 m wide by 1.5 m deep rigid frame on either side of the boat with the nets consisting of 35 mm mesh in the body reducing to 4 mm mesh in the cod. The system can be electrified if desired. Length and duration of trawl will be dependent on the site characteristics and available habitat.

Dozer Trawl

The dozer trawl is a trawl that is pushed in front of the boat. It has a 2 m wide by 1 m tall rigid frame attached to a net with 35 mm mesh at the opening reducing to 4 mm at the cod end. The net extends under the boat and is 2.5 m long. The system can be electrified if desired. Length and duration of trawl will be dependent on the site characteristics and available habitat.

Seine

A small mesh seine will be deployed in areas where it is applicable (i.e. free of snags and current). The specifications of the seine are currently in development. One end of the seine will be staked to shore. A boat will feed the seine out in a “U” pattern back to shore. The seine will be drawn in via hand or winch.

Commercial Fishing

Commercial fishermen will be contracted to target invasive carp with both gill nets and seines at strategic locations. Agency personnel will accompany contracted commercial fisherman to direct sampling locations and monitor efforts. Netting will occur in likely invasive carp habitats, determined at the discretion of the agency field crews. Fish collected that are also needed for age

and growth analysis or tagging may be utilized. Number of fish caught by species will be recorded during gill netting operations and total weight harvested will be requested from the commercial fisherman for both gill netting and seining operations. Sampling site locations, sampling dates, gear description, effort, habitat type (main channel border, backwater, wing dike, etc.), water depth, and crew details will be recorded for each net set.

Light Traps

Quadrafoil type larval light traps (Aquatic Research Instruments) will be deployed at randomly generated sites in Pool 17 backwaters to target recently hatched invasive carp. Traps will be deployed at a minimum of an hour after sunset (4 traps at a time), allowed to fish for approximately 60 minutes, contents removed and redeployed 2 additional times during the night (total of 12 traps per night) . Water quality, site description, depth, coordinates and soak time will be recorded for all traps for each individual sampling event. Traps will be set far enough away from other traps to avoid the effects of light contamination from nearby traps. All contents will be preserved in formalin and all larva and fish will be enumerated and identified to the lowest possible taxonomic rank. If target species are identified, a subsample of 30 target species will be measured and staged.

Telemetry

USFWS will use gill and trammel nets (7.6, 8.9, 10.2, 10.8, and 12.7 cm bar mesh) to collect and tag 170 Bighead and Silver carps from pools 16 through 19 with coded acoustic transmitters (Vemco, Model V16-6H; 69kHz, 16mm diameter, 95mm length, 34g). V16 coded transmitters have a 2543 day battery life and a random delay from 30 to 90 seconds. Each transmitter will be tested before implantation for recognition with a portable receiver and hydrophone (Vemco Model VR-100 and Vemco Model VH-165). Fish will be held in a holding tank or net with oxygenated water, anesthetized with carbon dioxide gas, and implanted with transmitters according to surgical procedures described by Summerfelt and Smith (1990). Individual fish will also be tagged with uniquely numbered orange Monel jaw bands printed with contact information placed on the upper jaw. Following surgery, fish will be placed in a recovery tank saturated with dissolved oxygen before release near the capture site.

Movement of tagged fish within and among pools will be monitored throughout the UMR with an expansive array of more than 100 stationary receivers (Figure 14). USFWS and MN DNR receivers above Lock and Dam 15 will be downloaded two times per year during the spring and fall seasons. In the Pools where tagged invasive carp are present or could be present (Pools 15-19, and upstream as necessary), data from stationary receivers will be downloaded monthly during the field season to provide information on gross movements of tagged fish.

River conditions permitting, USFWS will conduct mobile telemetry monthly to determine habitat use and movement on a finer scale than what is detected with the remote receivers. Standardized point transects spaced every 0.33 miles will be used during 2016 to provide efficient and consistent coverage. An approximate total of 2,195 river miles will be covered by manual tracking in 2016 using the point transect design. Monthly tracking will provide nearly 1,000 manual tracking locations which nearly doubles the number of locations recorded from 2014-2015 (n = 515) Depth (m) and temperature (°C) will be recorded at sites where tagged fish are located.

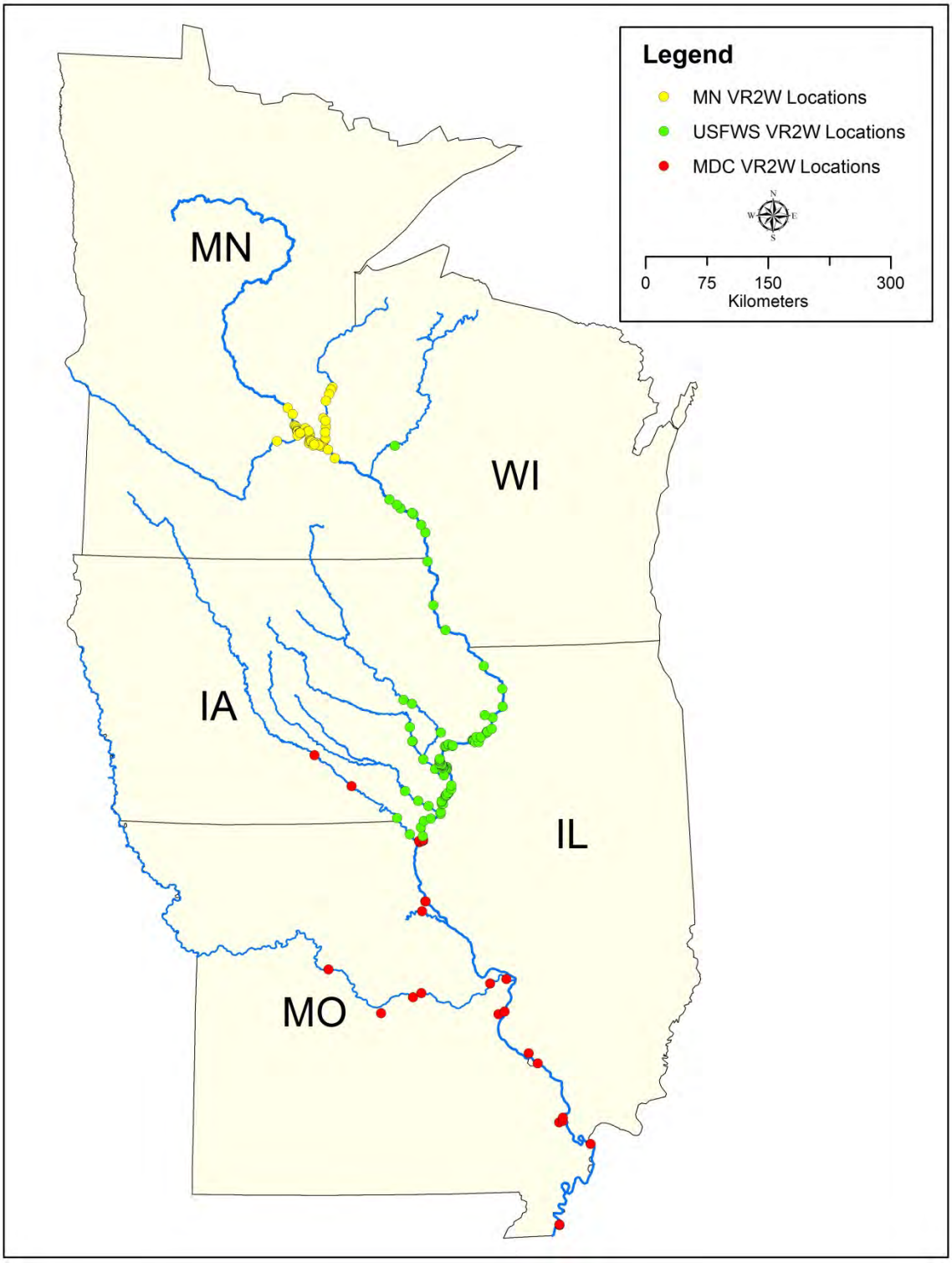


Figure 14. VR2W stationary receiver locations on the Upper Mississippi River for the 2016 field season.

Sampling Sites:

Minnesota - St. Croix and Upper Mississippi River Pools 2 through 8

Minnesota DNR's sampling design includes both fixed and targeted sites in Pools 2, 3, 4, and 8. Fixed sites were established in 2012 and have not changed. Targeted sampling varies by year, based on current conditions, and focused on areas most likely to sample targeted invasive carp. Fixed sampling includes 16 electrofishing sites and 37 larval trawling sites on the Mississippi and St. Croix rivers (Figure 15). Estimated targeted sampling includes 32 electrofishing transects, 20 gill/trammel nets, 18 hoop nets, 5 commercial seines, and 8 commercial gill net sets on the Mississippi and St. Croix rivers.

When feasible and with appropriate state approval, USFWS La Crosse FWCO will conduct large mesh gillnetting and electrofishing in Pools 2 through 8 in response to recent Asian carp capture reports.

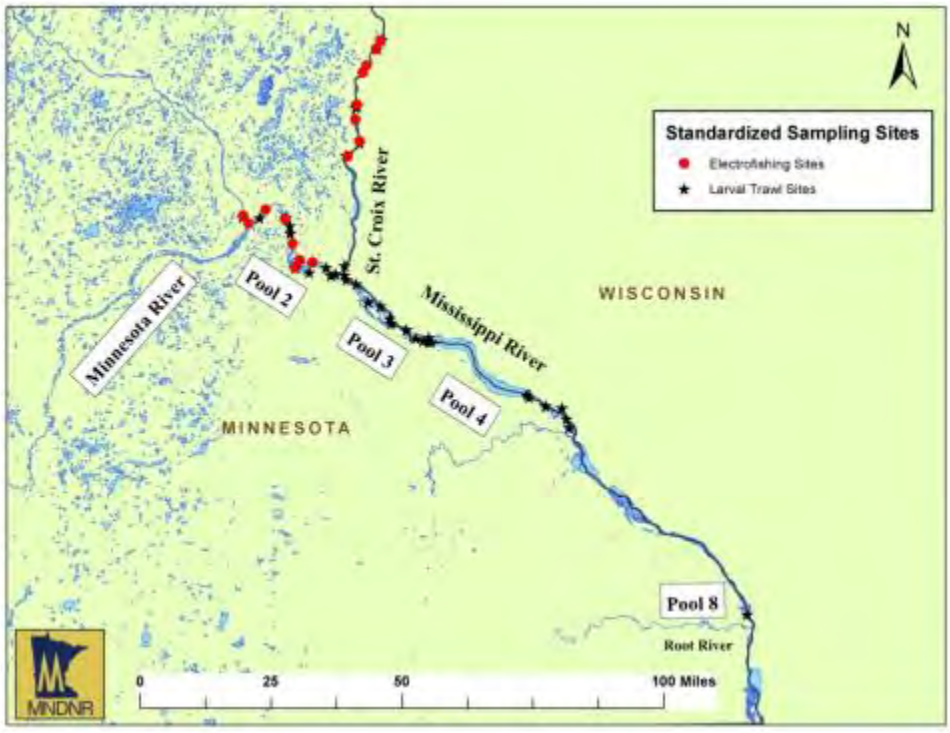


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Figure 15. Minnesota DNR 16 standardized electrofishing sites and 37 larval trawling sites on the Mississippi (including Pool 2, 3, 4, and 8) and St. Croix rivers.

Illinois, Iowa and Wisconsin– Upper Mississippi river Pools 8 through 13 and Maquoketa, Turkey, Iowa and Wisconsin rivers

USFWS Lacrosse FWCO will monitor for Asian Carp eggs and larvae using Method 2 for larval trawling (ichthyoplankton tows) at 28 fixed-locations approximately every 2 weeks from May until August 2016 (9 sampling events). At each tributary location, one fixed sampling location will be established inside the tributary ~1km upstream of the confluence with the Mississippi River and another location will be established along the main channel border of the Mississippi River ~1km downstream of the tributary's confluence. Additional fixed locations will be

established above the Upper Iowa River and Wisconsin River confluences because of their relative distance from mainstem sampling locations.

When feasible and with appropriate state approval, USFWS La Crosse FWCO will conduct large mesh gillnetting and/or electrofishing in Pools 9 through 13 in response to recent Asian carp captures. Any invasive carp captured in Pool 10 through 16 will be implanted with acoustic transmitters with appropriate state approvals. Bighead, Silver, and Black carps captured above Lock and Dam 9 will be removed and sacrificed, and otoliths collected for age and microchemistry analysis. Eye tissue will be collected for ploidy analysis from Grass and Black carps.

Iowa and Illinois- Upper Mississippi River Pools 14 through 20 and Des Moines, Skunk, Iowa, Rock, and Wapsipinicon river mouths

Iowa State University will sample adult invasive carp once in fall (September or October) at 7 sites in pools 14-20 in the Upper Mississippi River and one site in the Des Moines River (Figure 16) using daytime boat electrofishing. Electrofishing (DC; amps 4-13, voltage 100-500) will target channel border and backwater areas less than 4 m deep. Electrofishing will be conducted for at least three transects in side channel and/or backwater habitats for 15 minutes each per transect.

Figure 16. Iowa State University eight primary electrofishing and larval sampling sites (red points) on pools 14-20 on the Upper Mississippi River and the Des Moines River. Larval trawling at river confluences occurs above, in, and below the confluence mouth.

USFWS netting for adults

USFWS will conduct adult sampling with large mesh gill and trammel nets in one pool at a minimum of one week per month. Areas targeted will be sites with appropriate invasive carp habitat (deep areas in plankton rich backwaters), where previous captures have been reported and/or in response to recent capture events (Figures 17-21). Up to 170 invasive carp captured in pools 16, 17, 18, and 19 will be implanted with acoustic transmitters. Any invasive carp captured in Pool 10 through 16 will be implanted with acoustic transmitters with appropriate state approvals. Bighead, Silver, and Black carps captured above Lock and Dam 9 will be removed and sacrificed, and otoliths collected for age and microchemistry analysis. Eye tissue will be collected for ploidy analysis from Grass and Black carps.

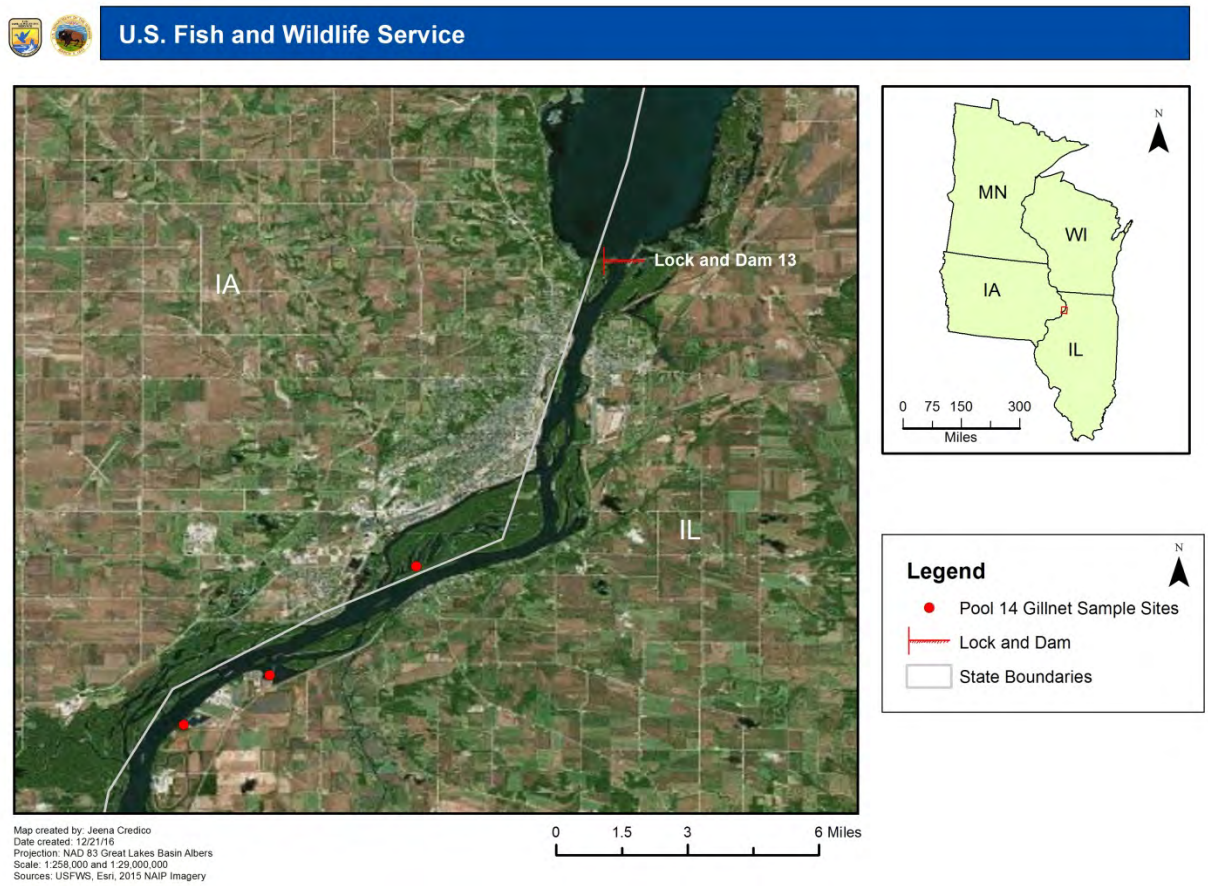

Figure 17. USFWS large mesh gillnet sample sites in Pool 14 of the Upper Mississippi River, 2016.

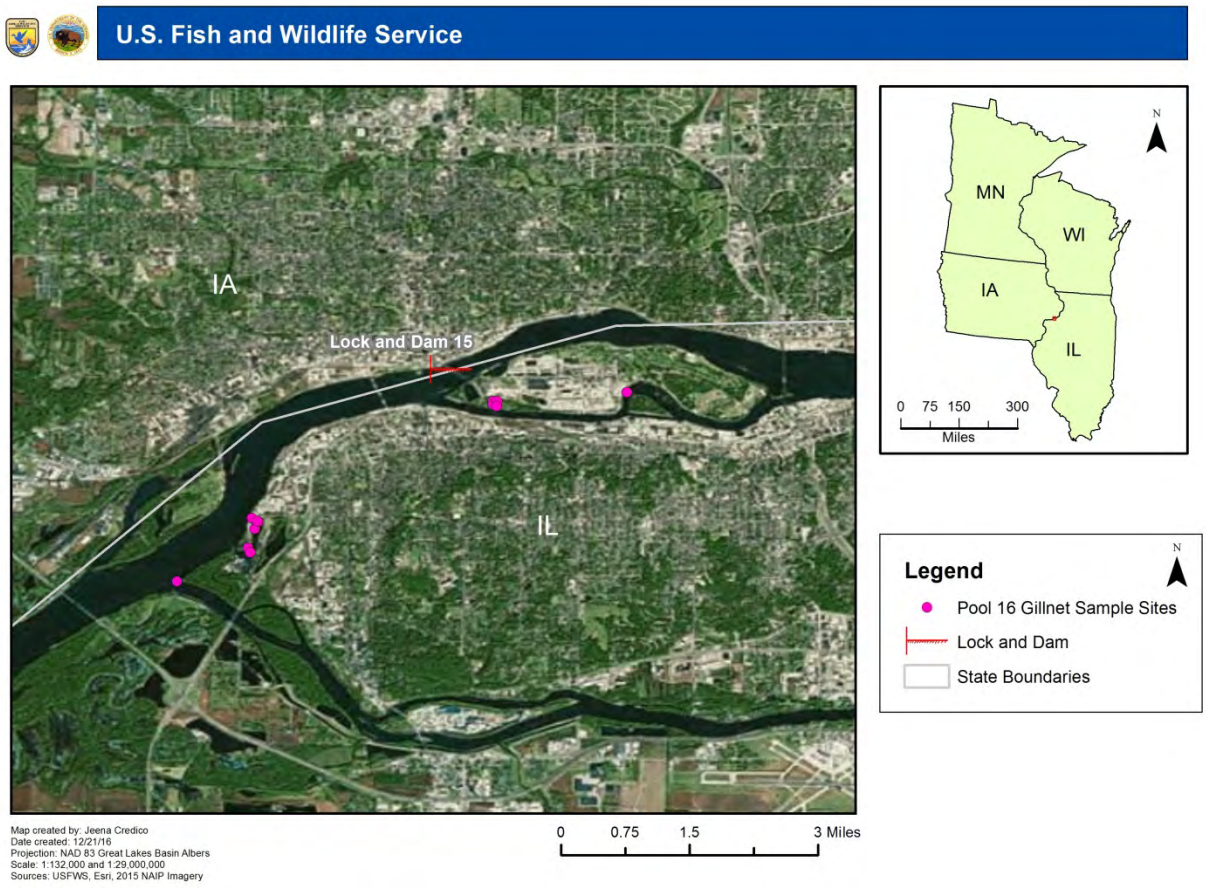

Figure 18. USFWS large mesh gillnet sample sites in Pool 16 of the Upper Mississippi River, 2016.

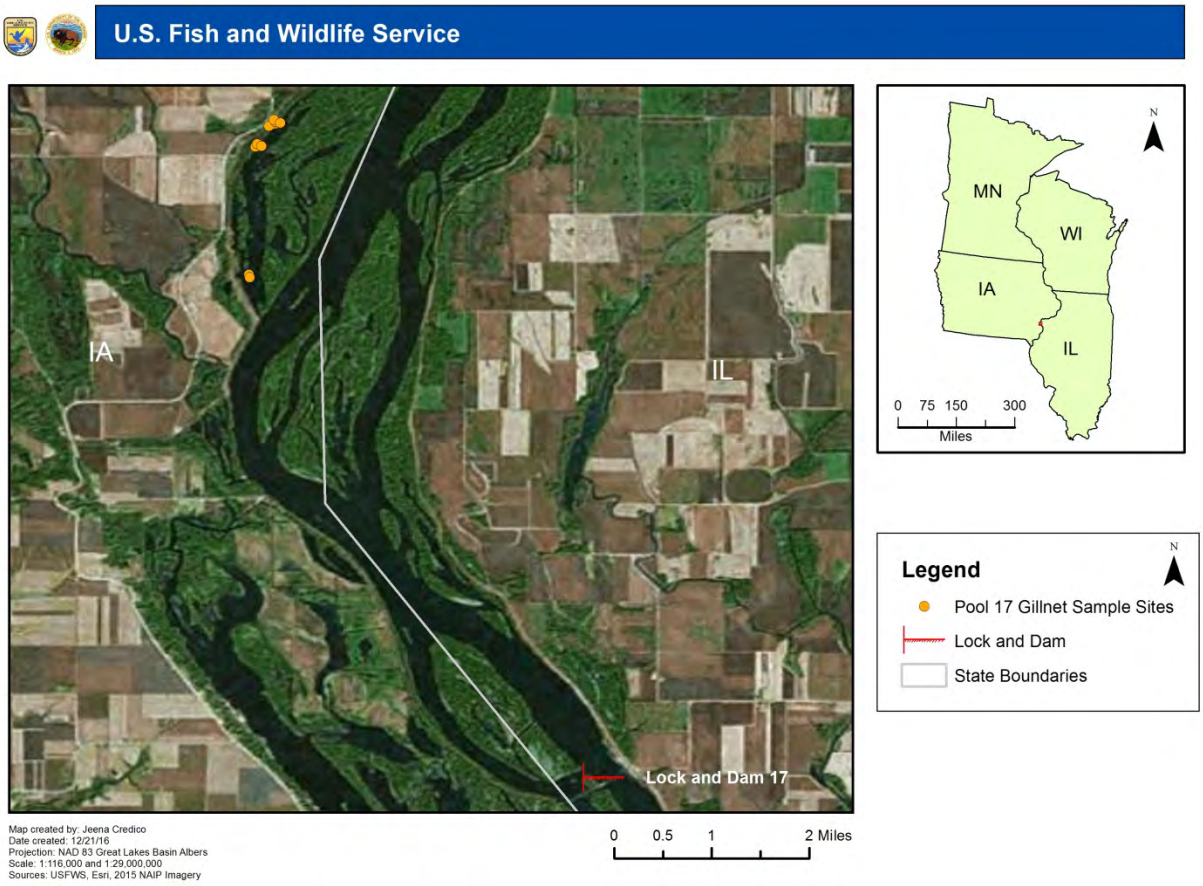

Figure 19. USFWS large mesh gillnet sample sites in Pool 17 of the Upper Mississippi River, 2016.

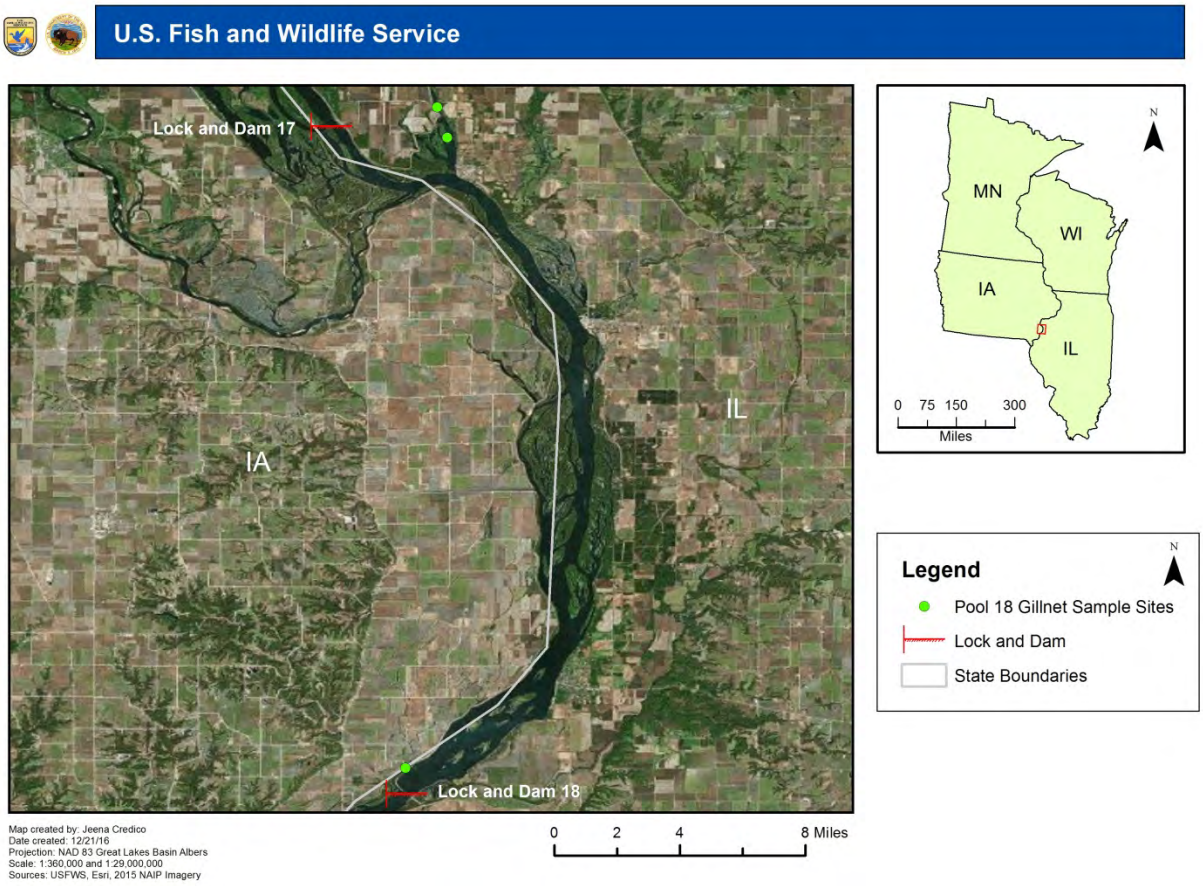

Figure 20. USFWS large mesh gillnet sample sites in Pool 18 of the Upper Mississippi River, 2016.

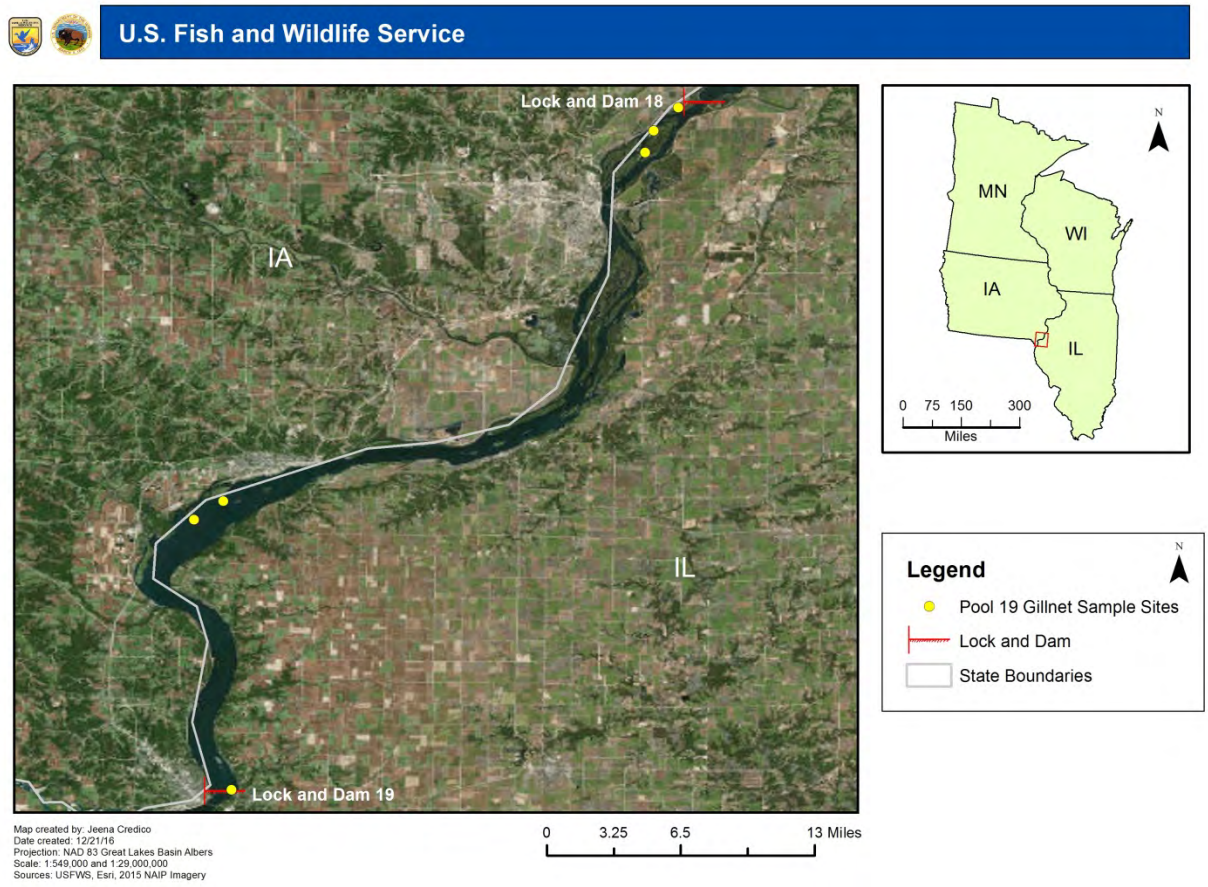

Figure 21. USFWS large mesh gillnet sample sites in Pool 19 of the Upper Mississippi River, 2016.

USFWS sampling for juvenile and YOY

Pools 16-19 will be sampled with a variety of gears to increase capture probability throughout the field season. Mini-fyke nets will target YOY. Dozer and Paupier trawls, seines, and electrofishing will be used to increase probability of capturing YOY later in the field season and age-1 fish. Habitats that will be targeted include large flats on the channel border, tributary mouths, and backwaters.

Western Illinois University's sampling design includes deploying quadrafoil type larval light traps (Aquatic Research Instruments) in open and vegetated (if present), shallow backwater areas in pool 17, 18, and 19 (Figure 22). Larval light trapping will be conducted every week from May 1 until conditions are no longer conducive to Invasive carp spawning. A total of 36 traps will be deployed each week and placed at randomly generated sites within targeted backwater areas per pool. Traps will be deployed at a minimum of an hour after sunset (12 traps per night, per pool), allowed to fish for approximately 60-240 minutes. Water quality, site description, depth, coordinates and soak time will be recorded for all traps for each individual sampling event. Traps will be set far enough away from other traps to avoid the effects of light contamination from nearby traps. All contents will be preserved in formalin for 24 hours and stored in 95% ethanol (allowing for genetic confirmation)

and all larva and fish will be enumerated and identified to the lowest possible taxonomic rank. If target species are identified, a subsample of 30 target species will be measured and staged.

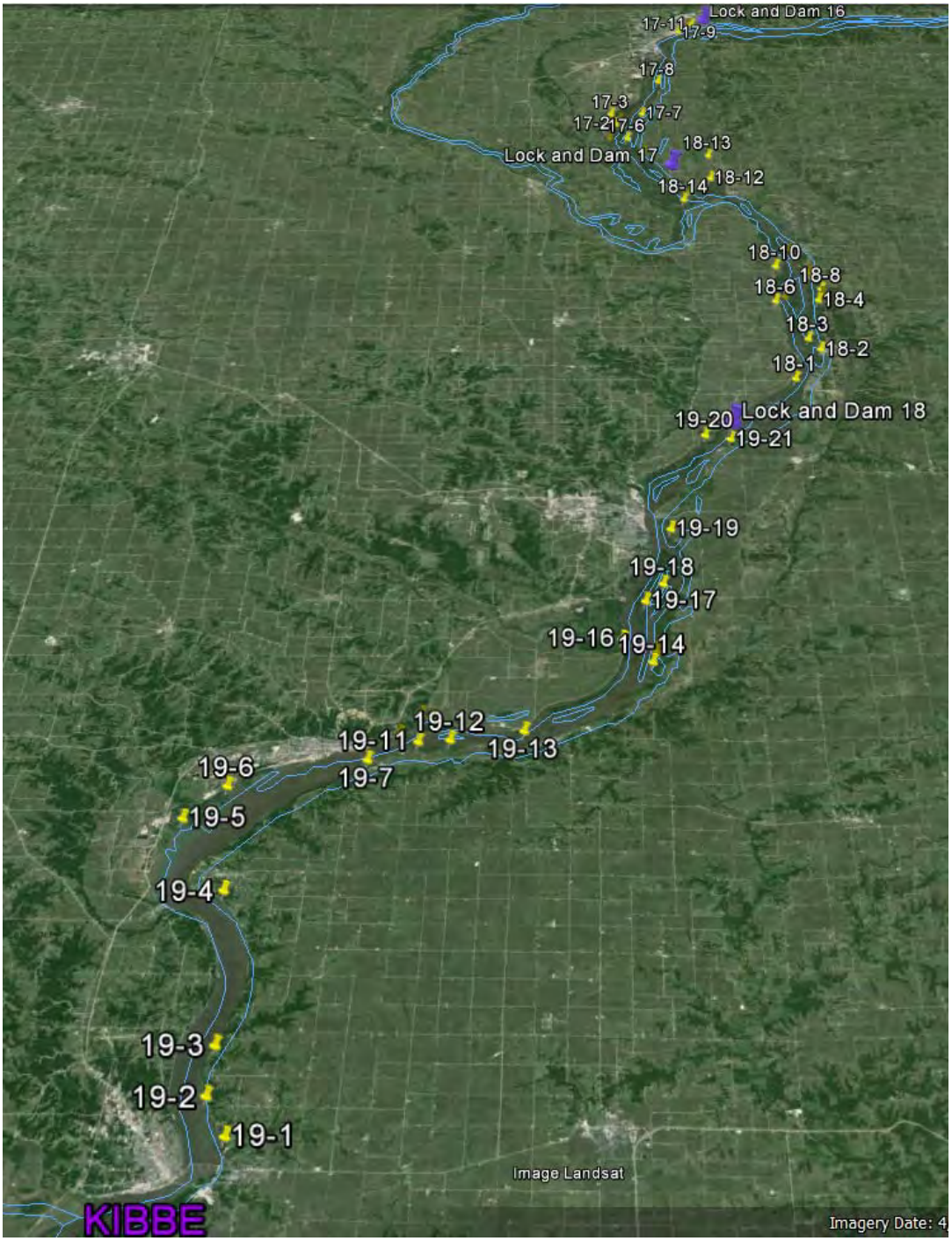

Figure 22. Western Illinois University larval light trap deployment sites in Mississippi River Pools 17, 18, and 19.

Iowa State University will sample for Asian carp eggs and larvae using Method 2 for Larval trawling (Ichthyoplankton tows). Samples will be collected at 8 locations (Figure 16) approximately every 14 days, depending upon river conditions, from the end of April until September.

The Missouri Department of Conservation will conduct egg and larval sampling at the confluence of the Des Moines River in Pool 20.

Iowa, Illinois, and Missouri tributaries waters

The Missouri Department of Conservation will conduct egg and larval sampling at the confluence of the Des Moines River, Fabius River, Cuivre River/Illinois River, Missouri River, Castor River Diversion Channel, and the Ohio River (Figure 23).

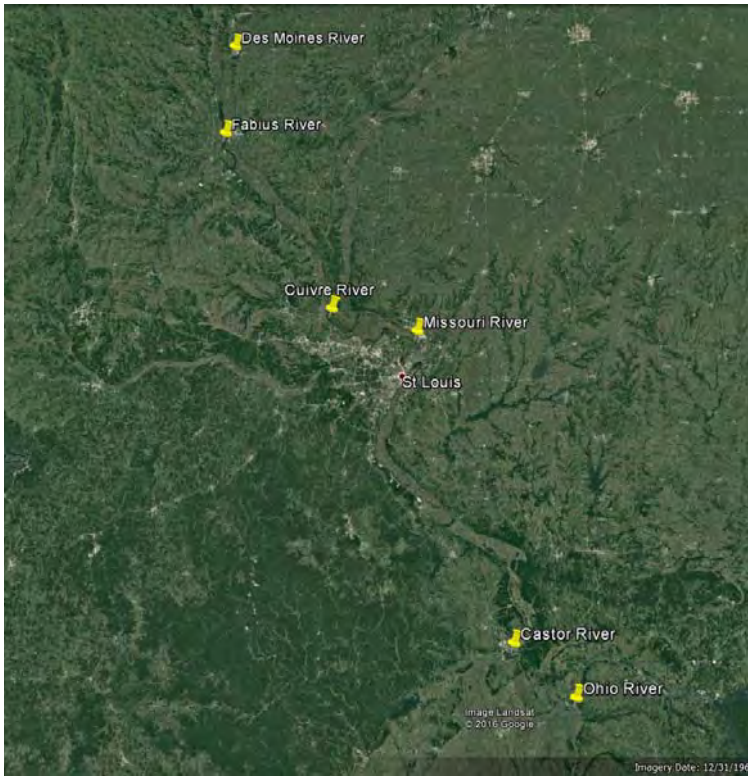

Figure 23. Missouri Department of Conservation six primary ichthoplankton sampling locations from Upper Mississippi River Mile 2 to river mile 364.

2016 Sampling Schedule:

Table 9. A list of primary gears, sampling time periods, estimated annual sampling events and days spent sampling, and estimated annual effort for each gear used by Minnesota Department of Natural Resources to target invasive carps in Mississippi River Pools 1-8 and the St. Croix River up to Taylors Falls, MN for 2016.

Gear	Time Period	Sampling		Effort
		Events	Days	
Gill/Trammel Netting	March - November	20	10	15,000 feet of net
Electrofishing	May - September	48	12	800 minutes
Hoop Netting	May - October	18	3	18 net nights
Mini-Fyke/Trap Netting	June - September	40	8	40 net nights
Larval Trawling	May - September	150	30	300 pushes
Commercial Seining	Year round	5	5	5 seine hauls
Commercial Gill Netting	Year round	8	8	30,000 feet of net

Table 10. A list of primary gears, sampling time periods, estimated annual sampling events and days spent sampling, and estimated annual effort for each gear used by Iowa State University to target invasive carps in Mississippi River Pools 18-20, and the Des Moines, Skunk, Iowa, Rock, Wapsipinicon rivers for 2016.

Gear	Time Period	Sampling		Effort
		Events	Days	
Electrofishing	April - October	8	10	~1,000 minutes
Larval Trawling	April – September	14	42	~900

Table 11. A list of the primary gears, sampling time periods, estimated annual sampling events and days spent sampling, and estimated annual effort for each gear used by Western Illinois University to target invasive carps in Mississippi River Pools Mississippi River Pools 17, 18, and 19 for 2016.

Gear	Time Period	Sampling	Effort

		Events	Days	
Light Traps	July - September	12	18	216 sets

Table 12. A list of the primary gears, sampling time periods, estimated annual sampling events and days spent sampling, and estimated annual effort for each gear used by Missouri Department of Conservation to target invasive carps at the confluence of the Des Moines River, Fabius River, Cuivre River/Illinois River, Missouri River, Castor River Diversion Channel, and the Ohio River for 2016.

Gear	Time Period	Sampling		Effort
		Events	Days	
Larval Trawling	May - October	12	24	432 Ichthyoplankton (bongo) net deployments

Table 13. A list of primary gears, sampling time periods, estimated annual sampling events and days spent sampling, and estimated annual effort for each gear used by USFWS to target invasive carps in Mississippi River Pools 8-19 for 2016.

Gear	Time Period	Sampling		Effort
		Events	Days	
Gill/Trammel Netting (Pools 8, 9, 11, 13, 14, 17, 18)	April - September	6	18	~ 100 sets, 30,000 ft of net
Electrofishing (Pool 19)	June-July	3	6	19 EF runs
Mini-Fyke Netting (Pools 16 and 19)	May-September	5	15	250 net nights
Larval Trawling	July-September	10	10	240 trawls
Paupier Trawl	April-October	7	21	
Dozer Trawl	April-October	7	21	
Receiver Download	April – November	8	16	1 crew, 2 people per crew, 16

(Pools 16-19)				days=32 staff days
Receiver Download (Pools 5A-15)	Spring and Fall	2	6	1 crew, 2 people per crew, 6 days per year =12 staff days
Manual Tracking	April-November	8	36	2 crews, 2 people per crew, 4 days per week, 8 weeks per year=128 staff days

Deliverables:
Data will be summarized in annual reports and project plans updated for annual revisions. Data will be used by the UMR workgroup to prioritize and guide deterrence and management actions.

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

Participating Agencies: Illinois DNR (lead) Western Illinois University (WIU), Iowa DNR, U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), Missouri Department of Conservation (MDC), Minnesota DNR, Wisconsin DNR

Location: Upper Mississippi River above lock and dam 19.

Introduction and Need: A contracted harvest program similar to what is being used in the Illinois River has the potential to control Asian carp populations in pools of the Upper Mississippi River. Whereas densities of Asian carp do not appear to be as high in the Upper Mississippi River as in the Illinois River, moderate populations with limited reproduction occur in Pools 18 and 19, with some recent commercial catches being reported as far upstream as the Rock River and Pool 14. Because recruitment appears limited in the pools above Lock and Dam 19, this removal strategy is more likely to succeed. Reducing Asian carp densities in these pools and other Mississippi River tributaries (e.g., Skunk, Iowa rivers) may prevent further upstream spread of populations in the Upper Mississippi River, and if continued could lower overall local populations and potentially further limit reproduction and recruitment. This contracted effort will also be valuable in monitoring Asian carp population dynamics within the Upper Mississippi River, as catch rates by these fishers often exceed our agency netting efforts. Contracted fishers will provide additional data for mark-recapture studies, and may find/detect fish in novel areas.

Objectives:

1. Control the invasion of Asian carp in the UMR by removing significant numbers of fish in pools 19 and above by employing the aid of commercial fishers.
2. Improve understanding of population dynamics and densities above L&D 19 with high numbers of captures obtained by utilizing commercial fishing expertise.
3. Evaluate efficacy of a harvest program in this area of the UMR.

Status: Contracted fishing was implemented in the fall of 2015, resulting in over 700 tagged Grass Carp, Black Carp and Silver Carp above Lock and Dam 19 and the removal of over 2000 lbs of Black Carp, Silver Carp, and Grass Carp during the initial week of removal. Commercial fishing is allowed by the Iowa and Illinois DNRs in that portion of the river. 1800 Black Carp, Silver Carp, and Grass Carp have been jaw-tagged in pool 20 in early winter 2015, with an additional deployment of 8200 tags scheduled for mid-February.

Methods: Two commercial fishing crews will be employed for 21 weeks each. This effort will require appropriate agency observers to fish with contracted fishers to monitor and report catches as well as provide information on the unintentional impacts of fishing on native fish populations, so each crew will include a biologist to oversee operations and record data. Current telemetry efforts and planned manual tracking by USGS-UMESC and FWS-LaCrosse will be used to help inform harvest in pools above Lock and Dam 19. Netting efforts will alternate between pools, with approximately 15 weeks of effort split between pools 17-19 (7 weeks in pool 19, 4 weeks each in pools 17 and pool 18). The greatest concentration of fishes is believed to occur in pool 19. Additional WIU watercraft will be used to assist netting efforts, especially shallow water

vessels capable of driving fishes from shallow American lotus beds and shallow backwaters. Two weeks of netting efforts will be devoted to pools 14-16. These pools contain Asian carp, but not in high enough densities to effectively target large numbers of Asian carp. Netting efforts for removal are expected to begin June 1, 2016 and end April 30, 2017 and will consist of M-F, 8-5, every other week.

Jaw-tags will be used to determine the effectiveness of commercial harvest. Bighead Carp, Silver Carp, and Grass Carp (500-700 fishes) will be tagged annually for at least five years (pending future funding) to obtain robust population size, exploitation, and survival estimates. Fishes will be tagged only from pools 17-19 (highest densities of fish) obtained from commercial crews during the first 4 weeks of sampling (May 1, 2016 – May 31, 2016: 2 weeks in pool 19, 1 week in pool 18, and 1 week in pool 17).

When possible, efforts will be made to standardize gear deployment at each site to determine gear effectiveness (type, mesh size, depth, etc.) for capturing Asian carp and different sizes of Asian carp.

Sample Sites: Contracted crews will primarily be deployed in Illinois-Iowa portions of the UMRS upstream of Lock and Dam 19 (pools 17-19) but may be directed further to characterize Asian carp occurrences in other upstream reaches (14-16) as practicable. As needed by agency and to answer UMRS Asian carp plan objectives, contracted fishers may be directed in other waters, such as below Lock and Dam 19, to provide information on fish that may move to or through a lock, to assess hydroacoustic data, or as needed.

Deliverables: An annual analysis of data and interim summary report will be completed in FY17.

Value Added Products: The results of this effort will allow the Upper Mississippi River Asian Carp Working Group to review and evaluate contracted fishing effectiveness and implementation. A product of this would be development of guidelines outlining conditions when contracted harvest would be beneficial. These guidelines would identify density requirements, amount of harvest needed to influence populations, and how to minimize impacts to native aquatic communities.

Developing a collaborative strategy for the advancement of deterrent barrier research, design and implementation to minimize the spread of invasive carp in the Upper Mississippi River

Lead Agencies: U.S. Fish and Wildlife Service, U.S. Geological Survey, and U.S. Army Corps of Engineers

Participating Agencies: Minnesota Department of Natural Resources, Iowa Department of Natural Resources/Iowa State University, Illinois Department of Natural Resources/Western Illinois University, Missouri Department of Conservation, and Wisconsin Department of Natural Resources

Location: Upper Mississippi River Basin

Introduction and Need: Prevention is accepted as the best method to limit the impacts of invasive species given the difficulty and costs of eradication and control. Over the long term, prevention is the most cost effective strategy for limiting impacts of Bighead Carp (*Hypophthalmichthys nobilis)*, Black Carp (*Mylopharyngodon piceus*), Grass Carp (*Ctenopharyngodon Idella*), and Silver Carp (*Hypophthalmichthys molitrix*); collectively referred to as invasive carp. Invasive carp are established in the upper, middle, and lower Mississippi River and expanding upstream threatening a variety of aquatic ecosystems. The upper Mississippi River contains a network of locks and dams that may provide an opportunity for deterring upstream movement of invasive carp. Though telemetry studies suggest that invasive carp can move through upper Mississippi River locks and spillway gates during closed and open river conditions (Tripp et al. 2013), ongoing computer modeling at the University of Minnesota, concurrent tests of Silver Carp swimming performance and other fish passage research suggests that lock and dam structures in the Upper Mississippi River may reduce the upstream movement of Bighead and Silver carps under certain conditions. Some dams may be better at stopping fish than others based on operating parameters of the gates, especially how often, when, and for how long are gates open during high water conditions (Wilcox et al. 2004).

For example, Lock and Dam 19 near Keokuk, IA, is a partial but significant barrier to fish passage in the Upper Mississippi River. It is a high head dam that always maintains a water surface differential that creates a waterfall over the dam that fish cannot swim through. Upstream fish passage is restricted to the lock chamber. Grass Carp, and to a lesser degree Silver and Bighead carps, are established upstream of Lock and Dam 19. However, Silver and Bighead carps are much more abundant downstream from Pool 20 to the Gulf of Mexico where populations are characterized by high adult abundance, reproduction, and recruitment. There are also non-native fish species of concern that have not been captured in the upper portions of the Mississippi including Black Carp which was captured as far north as Pool 24, near Louisiana, Missouri. Severing the connection by implementing deterrent technologies at strategic dams on the Mississippi River could be effective at slowing the upstream movement of fish species, allowing time for control methods such as overfishing to be more effective at reducing abundance.

As the abundance of invasive carp species increases in the Upper Mississippi River, it is important to evaluate the feasibility of using deterrent barrier technologies and operational modifications at lock and dams to minimize the upstream passage of invasive carp, while maximizing native fish passage. Multiple agencies and organizations are evaluating complex noise as a deterrent barrier for Invasive carps and initial research suggest it is a promising technology but further research in-situ is needed. The ongoing modeling suggests that operational modifications at navigation locks and dams may also prove useful as a tool to increase effectiveness of these dams at restricting invasive carp passage.

This ongoing monitoring and research suggests that the time is right for managers to evaluate promising deterrent and operational modifications at locks and dams, and recommend next steps for in-situ research. Managers also need to evaluate these technologies, UMR dams in regards to fish deterrence and passage, and invasive carp distributions to develop a deterrent research and management strategy.

Objectives:

1) Organize a complex sound workshop to develop an understanding of ongoing research efforts in the Mississippi River and Great Lakes basins, and determine a collaborative process to address research needs, and implement and evaluate complex sound in the UMR.
2) Conduct an evaluation of barrier technologies, UMR locks and dams in regards to fish deterrence, and Invasive carp distribution to develop a deterrent barrier strategy for the UMR.
3) Evaluate sites at UMR locks and dams where Invasive carp are abundant to implement a complex sound research project to compliment the on-going projects at Lock and Dam 8 and in the Illinois River. Site(s) evaluated should also be strategically important as determined by Objective 2.

Status: The Minnesota Aquatic Invasive Species Research Center, with the Sorensen laboratory as project lead, installed acoustic speakers on the doors to the lock chamber at Lock and Dam 8 in June 2014. The speakers are still in operation. Completion of hydrologic modeling of water velocities though the tainter and roller gates in Dam 8 under various operational conditions was completed in August 2015. These results along with suggest modifications to gate operations was presented to the US Army Corps of Engineers in Fall 2015. The Sorensen laboratory, with funding from the state of Minnesota and USFWS, has an evaluation of this work in progress. Field work began in spring of 2016.

USGS/University of Minnesota-Duluth

This group has completed lab and pond studies demonstrating a consistent avoidance response of bigheaded carp (Bighead and Silver carps) to complex sound (i.e., motorboat recording). In general native species did not demonstrate avoidance behaviors under the same experimental conditions. Field trials with complex sound at Morris, IL did not demonstrate reduced passage (i.e., deterrence) through an opening in a barrier as compared to trails with no sound. However, investigators have preliminarily concluded that the complex sound recordings during these field experiments might have been too loud and that bigheaded carp had no place to seek refuge from the sound as demonstrated by their continual agitated behavior when sound was played. Pond

studies are underway now (summer 2016) to determine if bigheaded carp acclimate to complex sound recordings, and to determine optimal sound levels and gradients (gradual vs sharp) in mock-up lock chambers. In cooperation with the USFWS and Illinois DNR, another field experiment is planned for August-September 2016 at the Copperas Creek lock chamber in the La Grange Pool of the Illinois River using wild-caught Bighead and Silver carps, and information about optimal levels and gradients gained from the ongoing pond trails.

Methods:

Objective 1

A two day workshop will be organized by a committee comprised of representatives from the USFWS, USACE, USGS, Upper Mississippi River Basin, and Ohio River Basin. Day one of the workshop will bring everybody up to date on the current state of acoustic technology through presentations by research groups. The second day will be more management focused and explore implementation opportunities, needs, and requirements.

Objectives 2 and 3

Participant agencies will have three face-to-face meetings to:

1. Develop a mutually agreed upon process to develop a comprehensive deterrent-barrier strategy, including priority locations and tools, as part of integrated pest management for Asian carp in the UMR
2. Assess developed (e.g., physical barrier and electricity) and nearly developed (e.g., complex sound and CO2) deterrents that could be used as part of this strategy in an adaptive manner (i.e., learn-as-you-go).
3. Prioritize deterrents and location(s) for implementing deterrents.
4. Create a timeline and assign lead agencies to plan, implement and evaluate priority deterrents at priority locations.

2016 Timetable:

Table 14. A list of meeting events to discuss invasive carp deterrent measures in 2016.

Event	Description	Time Period
Acoustic Workshop	Evaluate and devise strategy to keep moving forward on acoustic deterrent technology	May
Deterrent Meeting #1	Develop vision, process, and timeline for developing an UMR deterrent strategy	September
Deterrent Meeting #2	Explore available tools	October
Deterrent Meeting #3	Determine locations and implementation steps and timelines	November

Deliverables:

Outcomes of the workshops and meetings will be summarized and described in an applicable format (i.e. report, plan, summary, etc.).

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Appendix A: (Suggested Fixed Sites)

Site Description	State	Latitude	Longitude	Type
Carter's Landing Bar	IN	37.873795	-86.599399	MAIN
Clover Creek - Upper	KY	37.828831	-86.607332	TRIB
Clover Creek - Mouth	KY	37.838488	-86.630906	TRIB
Millstone Creek	IN	37.906862	-86.644604	TRIB
Deer Creek - Mouth	IN	37.915162	-86.672369	TRIB
Deer Creek - Upper	IN	37.926867	-86.680242	TRIB
Carter's Landing Bar	IN	37.868666	-86.600230	MAIN
Deer Creek	IN	37.924947	-86.679334	TRIB
Oxbow Bend	IN	38.142211	-86.322410	MAIN
Wolf Creek	KY	38.106460	-86.391885	TRIB
Little Blue River	IN	38.116723	-86.416682	TRIB
Wattson Creek	KY	38.065857	-86.428311	TRIB
Flint Island	KY	38.040801	-86.464383	MAIN
Oil Creek	IN	38.040227	-86.521413	TRIB
Oxbow Bend	IN	38.142211	-86.322410	MAIN
Little Blue River	IN	38.130356	-86.411863	TRIB
Rock Run Bar	IN	37.993989	-86.073460	MAIN
Buck Creek	IN	38.015981	-86.188411	TRIB
Haunted Hollow Bar	IN	38.034149	-86.224954	MAIN
Indian Creek	IN	38.116370	-86.273637	TRIB
Blue River Bar	KY	38.172170	-86.327897	MAIN
Blue River	IN	38.182094	-86.328898	TRIB
Rock Run Bar	IN	37.993989	-86.073460	MAIN
Blue River Bar	KY	38.172170	-86.327897	MAIN
McAlpine Lock & Dam	IN	38.286458	-85.778506	TAILW
Sand Island	KY	38.282349	-85.789257	ISLBC
Hughes Bar	IN	38.202696	-85.880967	MAIN
Salt River - Upper	KY	37.996136	-85.934697	TRIB
Salt River - Mouth	KY	38.001805	-85.944625	TRIB
Otter Creek	KY	37.964123	-86.030204	TRIB
Hughes Bar	IN	38.202696	-85.880967	MAIN
Salt River - Mouth	KY	38.001805	-85.944625	TRIB
Fourteen Mile Creek	IN	38.423366	-85.620916	TRIB
Harrods Creek	KY	38.331826	-85.625985	TRIB
Harrods Creek	KY	38.331901	-85.643039	TRIB
Six Mile Island	IN	38.305006	-85.671970	ISLBC
Beargrass Creek	KY	38.268459	-85.724005	TRIB
Toehead Island	KY	38.267319	-85.726383	ISLBC
Harrods Creek	KY	38.331826	-85.625985	TRIB

Toehead Island	KY	38.267319	-85.726383	ISLBC
Corn Creek	KY	38.597543	-85.427703	TRIB
Patton's Creek	KY	38.519709	-85.429092	TRIB
Big Saluda Creek	IN	38.613638	-85.439859	TRIB
Little Camp Creek	IN	38.510879	-85.467107	TRIB
Eighteen Mile Creek	KY	38.475257	-85.482244	TRIB
Eighteen Mile Island	KY	38.464960	-85.490452	ISLBC
Patton's Creek	KY	38.519709	-85.429092	TRIB
Eighteen Mile Island	KY	38.464960	-85.490452	ISLBC
Craig's Bar	IN	38.704414	-85.130590	MAIN
Kentucky River - Upper	KY	38.655159	-85.154475	TRIB
Kentucky River - Mouth	KY	38.683607	-85.188530	TRIB
Little Kentucky	KY	38.686111	-85.202542	TRIB
Locust Creek	KY	38.718363	-85.243065	TRIB
Indian-Kentucky Creek	KY	38.731803	-85.245883	TRIB
Craig's Bar	IN	38.704414	-85.130590	MAIN
Kentucky River - Upper	KY	38.655159	-85.154475	TRIB
Markland L&D	KY	38.775288	-84.972563	TAILW
Markland L&D	IN	38.779035	-84.990203	TAILW
Log-Lick Creek	IN	38.778931	-84.990275	MAIN
Plum Creek	IN	38.757549	-85.032315	MAIN
Vevay Bar	KY	38.734833	-85.073558	MAIN
Indian Creek	IN	38.726792	-85.101626	TRIB
Markland L&D	IN	38.779224	-84.974693	TAILW
Vevay Bar	KY	38.734833	-85.073558	MAIN
Big Sugar Creek	KY	38.782936	-84.810639	TRIB
PaintLick Creek	KY	38.807891	-84.811236	TRIB
Craig's Creek - Northeast Shoreline	KY	38.771353	-84.919696	TRIB
Trutle Creek	IN	38.783224	-84.920559	TRIB
Craig's Creek - Mouth	KY	38.770198	-84.937875	TRIB
Belterra Embayment	IN	38.776895	-84.940079	MAIN
Craig's Creek - Northeast Shoreline	KY	38.771353	-84.919696	TRIB
Belterra Embayment	IN	38.776895	-84.940079	MAIN
Big Bone - Above Ramp	KY	38.855147	-84.775499	TRIB
Big Bone - Below Ramp	KY	38.859282	-84.780825	TRIB
Gunpowder Creek	KY	38.906518	-84.803133	TRIB
Laugherty Island	IN	38.993222	-84.840535	ISLBC
Grant's Creek	IN	38.896985	-84.872744	TRIB
Arnold's Creek	IN	38.920444	-84.880840	TRIB
Big Bone - Below Ramp	KY	38.859282	-84.780825	TRIB

Laugherty Island	IN	38.993222	-84.840535	ISLBC
Little Miami River	OH	39.078891	-84.432514	TRIB
Licking River	KY	39.032921	-84.489982	TRIB
Licking River	KY	39.092194	-84.503694	TRIB
Medoc Bar	KY	39.105663	-84.808268	MAIN
Great Miami River	OH	39.114590	-84.828848	TRIB
Tanner's Creek	IN	39.074883	-84.869885	TRIB
Hogan Creek	IN	39.057396	-84.897663	TRIB
Medoc Bar	KY	39.105663	-84.808268	MAIN
Great Miami River	OH	39.114590	-84.828848	TRIB
Meldahl L&D, KY	OH	38.798806	-84.179418	TAILW
Meldahl L&D, KY	KY	38.794118	-84.180765	TAILW
Main Channel Down From Bear Creek	OH	38.801016	-84.194446	MAIN
Big Indian Creek, Point Pleasant	OH	38.893293	-84.234130	TRIB
Twelvemile Creek	OH	38.968302	-84.293792	TRIB
Main Channel Pendery Park	KY	39.028945	-84.340515	MAIN
Big Indian Creek, Point Pleasant	OH	38.893293	-84.234130	TRIB
Main Channel Pendery Park	KY	39.028945	-84.340515	MAIN
Straight Creek	OH	38.775458	-83.914357	TRIB
White Oak Creek	OH	38.793432	-83.953562	TRIB
RM 126.5 Main OH Side	OH	38.787338	-83.980437	MAIN
Bracken Creek	KY	38.776856	-83.991206	TRIB
Locust Creek	KY	38.776423	-84.113401	TRIB
Snag Creek	KY	38.790485	-84.162348	TRIB
White Oak Creek	OH	38.797535	-83.956070	TRIB
Bracken Creek	KY	38.777518	-83.990027	TRIB
Cabin Creek	KY	38.620408	-83.667067	TRIB
Fish Gut Creek	OH	38.655384	-83.765524	TRIB
Big Three Mile Creek	OH	38.695415	-83.781036	TRIB
Eagle Creek	OH	38.721763	-83.820737	TRIB
Lawrence Creek	KY	38.702573	-83.829028	TRIB
Charleston Bar	KY	38.715148	-83.840864	MAIN
Cabin Creek	KY	38.620408	-83.667067	TRIB
Charleston Bar	KY	38.715148	-83.840864	MAIN
Ohio Brush Creek - Upper	OH	38.706896	-83.447380	TRIB
Ohio Brush Creek - Mouth	OH	38.673593	-83.453306	TRIB
Brush Creek Island	KY	38.670676	-83.458898	ISLBC
Manchester Islands	KY	38.689513	-83.577094	ISLBC
Isaacs Creek	OH	38.679373	-83.626566	TRIB
Crooked Creek	KY	38.634947	-83.640499	TRIB

Ohio Brush Creek - Mouth	OH	38.673593	-83.453306	TRIB
Manchester Islands	KY	38.689513	-83.577094	ISLBC
Greenup L&D	OH	38.652510	-82.857294	TAILW
Greenup L&D	KY	38.651989	-82.862200	TAILW
Pine Creek	OH	38.727763	-82.869296	TRIB
Little Scioto River	OH	38.755083	-82.885365	TRIB
Tygarts Creek	KY	38.731242	-82.955451	TRIB
Scioto River	OH	38.745201	-83.007855	TRIB
Scioto River	OH	38.730538	-83.012939	TRIB
Little Scioto River	OH	38.755083	-82.885365	MAIN
Scioto River	OH	38.730538	-83.012939	TRIB
Strom's Creek	OH	38.544975	-82.698482	TRIB
RM 332 KY Main (Down river of Chinn's Creek)	KY	38.556703	-82.757204	MAIN
Little Sandy - Mouth	KY	38.579207	-82.840703	TRIB
Little Sandy Oxbow	KY	38.577590	-82.847632	TRIB
Ginat Creek	OH	38.616174	-82.852763	TRIB
Chandler's Run	OH	38.642191	-82.854315	TRIB
RM 332 KY Main (Down river of Chinn's Creek)	KY	38.556703	-82.757204	MAIN
Little Sandy - Upper	KY	38.568278	-82.847239	TRIB
Symmes Creek	OH	38.428065	-82.449796	TRIB
Twelvepole Creek	WV	38.401124	-82.530476	TRIB
Big Sandy Chadwick Creek	KY	38.383007	-82.595599	TRIB
Big Sandy River - Mouth	WV	38.415171	-82.596695	TRIB
Ice Creek	OH	38.500053	-82.657779	TRIB

Appendix B: Intended Sampling sites, ranked and organized by pool.

Pool	Rank	Embayment/Tributarty	Reach	Ramp	Notes
Myers	1	Hovey Lake - IN	Lower	Hovey Lake FW area	**Largest backwater - AC present**
	2	Lost Creek - KY	Lower	Uniontown or Hovey	small creek
	2	Backwater at Uniontown KY	Lower	Uniontown or Hovey	both sides of Mill St access ramp
	1	Highland Creek - KY	Lower	Ramp South of Hovey Lake or Uniontown	Medium creek
	2	Cypress Slough - IN	Lower	Mt Vernon	small backwater near shipping yard
	2	Bayou Creek - IN	Mid	Mt Vernon(or Henderson) - Private ramps at mouth	narrow channel
	2	Field drain ditches - IN	Mid	Henderson or private Bayou Creek ramp	two small ditches
	1	Canoe Creek - KY	Mid	Henderson KY	next to Henderson Island
	1	Pigeon Creek - IN	Mid	Evansville	In Evansville, similar to Bayou.
	2	LST Marina	Upper	Evansville	small marina backwater
	1	Green River - KY	Upper	Angel Mounds	Largest tributary in pool. Wide, deep
Newburgh	2	Cypress Creek - IN	Lower	Use Little Pigeon	**very shallow from mouth to Honey Creek**
	1	Little Pigeon Creek - IN	Lower	Yes-in trib off Hwy 66	**submerged timber along banks.**
	2	Van Buren Creek - KY	Mid	Owensboro KY or Rockport IN	Small creek
	2	Borrow Pits - KY	Mid	Owensboro KY or Rockport IN	Private
	2	Honey Creek - IN	Mid	Grandview	Small Creek
	1	Blackford Creek - KY	Mid	Grandview	Small stream
	1	Sandy Creek - IN	Mid	Grandview	small stream, easy access
	2	Little Sandy Creek - IN	Mid	Grandview	Small stream, turns to marsh like area
	2	Crooked Creek - IN	Upper	Troy	Small stream
	1	Anderson River - IN	Upper	Troy	Medium stream
Cannelton	1	Deer Creek - IN	Lower	Private Ramp? or KY Ramp in Cloverport	Embayment
	1	Millstone Creek - IN	Lower	KY ramp in Cloverport or private @ Deer Creek	Embayment area, close to Deer Creek
	1	Clover Creek - KY	Lower	KY ramp in Cloverport	Large embayment
	1	Bull Creek - KY	Lower	KY ramp in Cloverport	Medium embayment
	1	Town Creek - KY	Lower	KY ramp in Cloverport	Medium embayment
	2	Buck, Fanny, Bear Creek - IN	Lower	use Goehagan ramp	small embayments, unsure if accessible
	1	Sinking Creek - KY	Lower	Rome IN-Goehagan Creek is straight across	Medium embayment
	1	Poison Creek - IN	Lower	Yes-in embayment	**Big embayment - AC present**
	2	Yellowbank Creek - KY	Lower	Poison or Oil Creek Ramp	small embayment
	2	Oil Creek - IN	Lower	Yes-at mouth on Ohio River	**limited embayment, flooded creek,lot of submerged timber - AC present**
	1	Spring Creek - KY	Lo/mid	In creek at Concordia	Small Creek
	1	Little Blue River - IN	Mid	Alton IN-1 in trib and 1 in Ohio	Medium more stream like
	1	Wolf Creek - KY	Mid	At mouth on Ohio River	Small creek
	1	Blue River - IN	Mid	Leavenworth IN - at confluence	**Medium more stream like**
	1	Indian Creek - IN	Mid	Use Blue River	Medium more stream like
	2	Buck Creek - IN	Mid/Up	Brandenburg KY	Small stream
	1	Otter Creek - KY	Upper	West Point KY	Small stream
	1	Salt River - KY	Upper	West Point KY	Large tributary