Final Project Report:

Implementation of the Ohio River Asian Carp Control Strategy Framework

(Federal Financial Assistance Award F15AP00893)

Submitted to the U.S. Fish and Wildlife Service

by

Mississippi Interstate Cooperative Resource Association

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Table of Contents

Introduction

The Mississippi River and its tributaries comprise one of the largest and most ecologically and economically valuable ecosystems in the world. The Mississippi River Basin is the fourth largest watershed in the world, and the largest watershed in the nation, draining all or part of 31 states and 2 Canadian provinces (Figure 1). The watershed measures approximately 1.2 million square miles, covers 41% of the continental United States, and includes numerous large, interjursidictional tributary systems including the Arkansas, Illinois, Missouri, Ohio, Tennessee, Cumberland, Red, and White rivers. Recreational boating and fishing in the Mississippi River and tributaries support many local economies throughout the Mississippi River Basin. In 2015, the U.S. Fish and Wildlife Service (USFWS) estimated the economic output from recreational fishing in the Mississippi River Basin at more than $19 billion (USFWS, unpublished data).

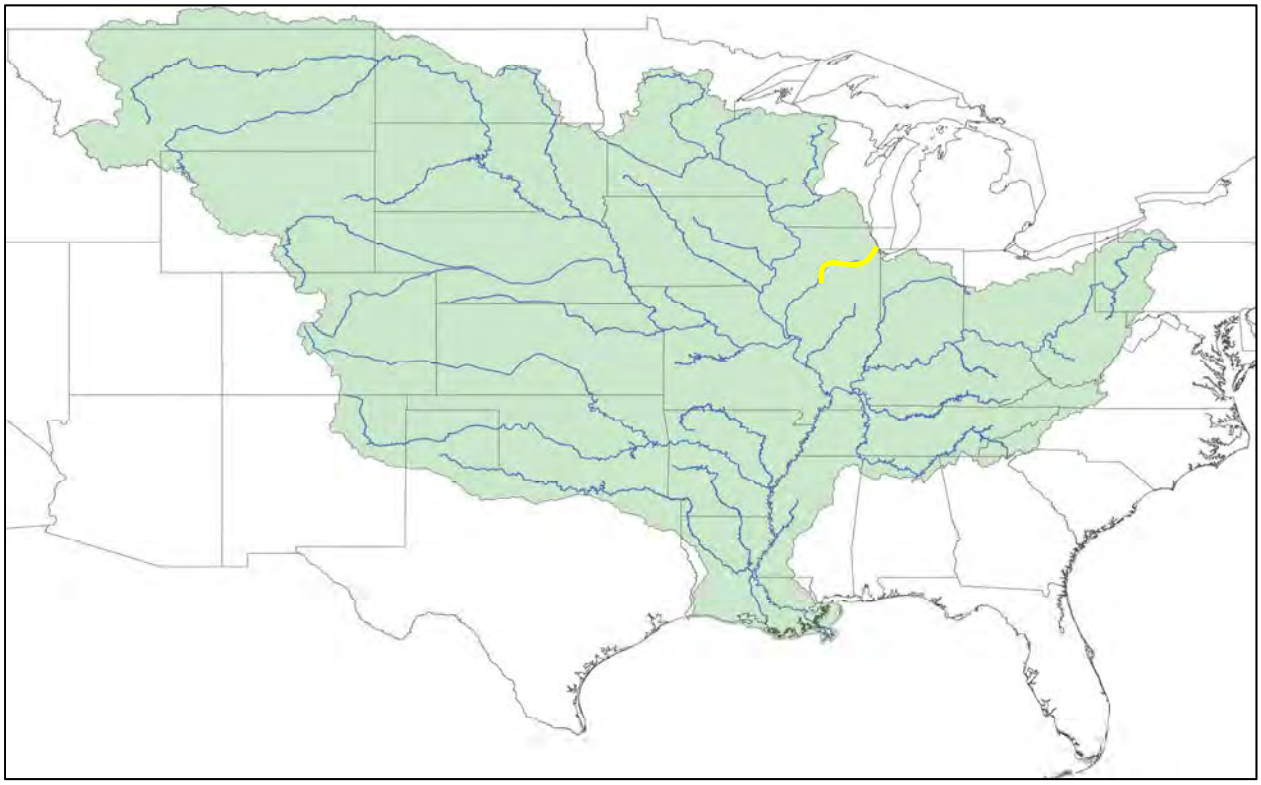

Figure 1. Mississippi River and major interjursidictional tributary rivers, including the Arkansas, Illinois, Missouri, Ohio, Tennessee, Cumberland, Red, and White rivers. The upper 175 miles of the Illinois River and Chicago Area Waterway System are shaded yellow.

Aquatic Invasive Species (AIS) are having negative impacts and reversing recent progress made towards ecological rehabilitation and restoration in the Mississippi River Basin. Over the past two decades four species of Asian carp (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) have become a basin wide issue of concern for natural resource management agencies and the public. Bighead, Silver, and Grass carps have established self-sustaining populations and are spreading throughout the Mississippi River Basin (Figures 2 and 3). In recent years, Black Carp have been captured with increasing frequency in the

Lower Mississippi, Upper Mississippi (below Lock and Dam 19), Illinois, lower Ohio and lower Cumberland rivers. 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 mainstem river and some major tributaries within the Mississippi River Basin.

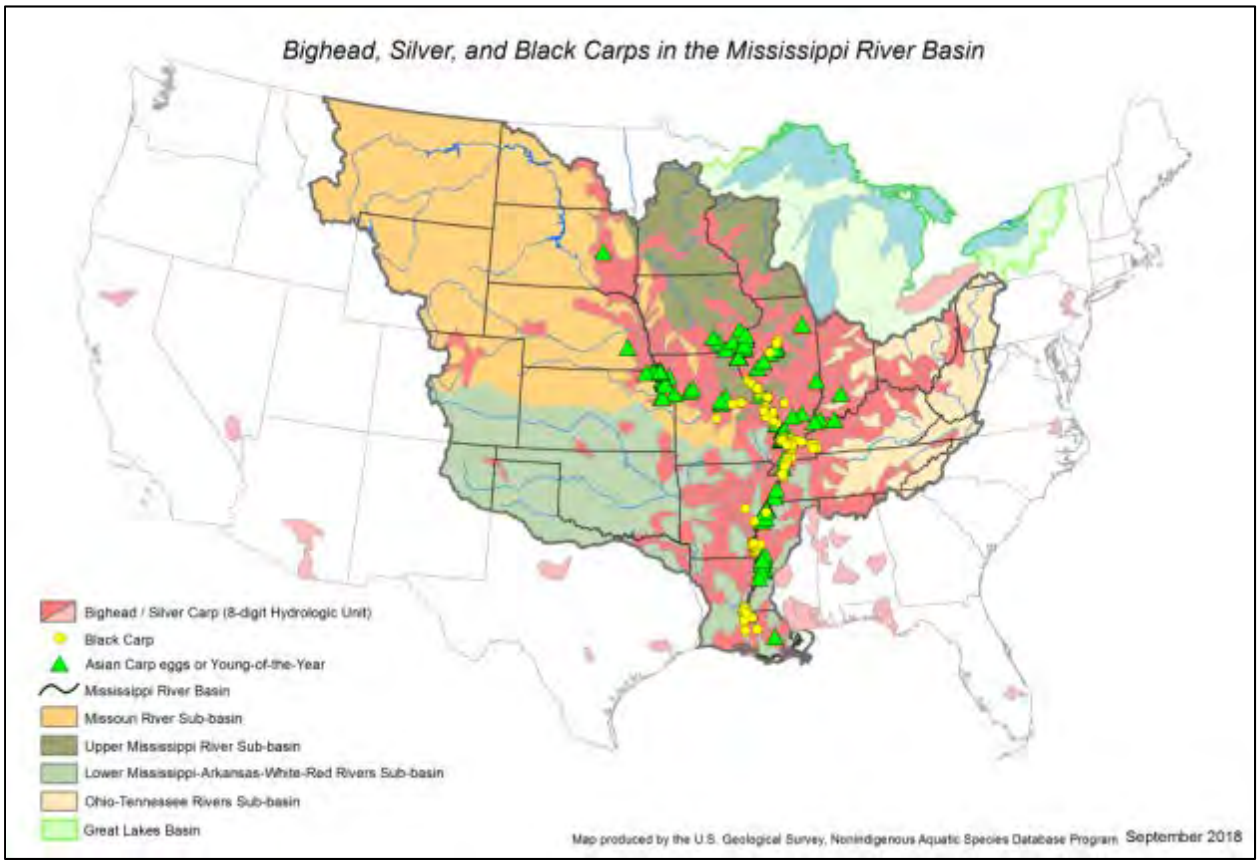

Figure 2. Distribution of Bighead Carp, Silver Carp, and Black Carps in the Mississippi River Basin as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of September 2018. Collections of Bighead Carp and Silver Carp by 8-digit Hydrologic Unit in the Mississippi River Basin are shaded dark pink; collections of Bighead Carp and Silver Carp by 8-digit Hydrologic Unit outside the basin are shaded light pink. Black Carp collections are indicated by yellow circles. Bighead Carp, Silver Carp, and Black Carp eggs or young-of-the-year are denoted with green triangles.

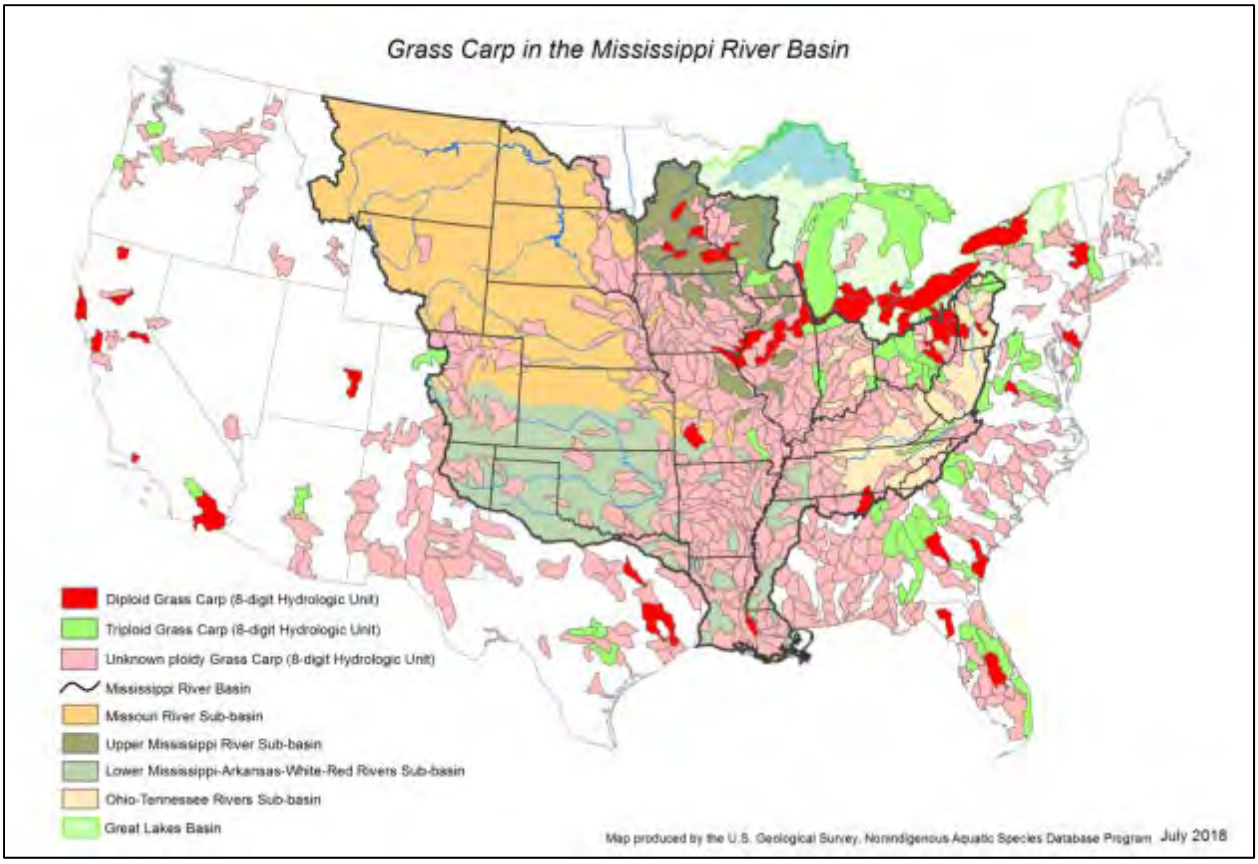

Figure 3. Distribution of Grass Carp in the Mississippi River Basin as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of July 2018.

The Aquatic Nuisance Species (ANS) Task Force approved the national *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (National Asian Carp Plan; Conover et. al 2007) for implementation in 2007. State fisheries management agencies and their federal partners formed multiple inter-agency partnerships to develop and implement regional Asian Carp Control Strategy Frameworks (Frameworks) to step-down implementation of the National Asian Carp Plan to the local level. The Mississippi Interstate Cooperative Resource Association (MICRA), a partnership of 28 state agencies with fisheries management jurisdiction in the Mississippi River Basin, works with regional inter-agency partnerships in the Upper Mississippi River sub-basin (UMRB), Ohio River sub-basin (ORB), Missouri River sub-basin (MORB), and the Lower Mississippi River sub-basin (LMRB) to provide for coordinated Asian carp management and control in the Mississippi River Basin (Figure 4).

Figure 4. Asian carp coordination and implementation of projects in the Mississippi River Basin is broken down into sub-basins including the Ohio River Sub-Basin (green; includes the Tennessee and Cumberland rivers), Upper Mississippi River Sub-Basin (yellow), Missouri River Sub-Basin (blue) and the Lower Mississippi River Sub-Basin (purple; includes the Arkansas, Red, and White rivers).

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 Framework (now called an Asian Carp Action Plan) to prevent the introduction and establishment of Bighead and Silver carp populations in the Great Lakes since 2010 (www.asiancarp.us). The ACRCC Framework (ACRCC 2015) coordinates the implementation of projects 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 175 miles (282.6km) of the Illinois River and the Chicago Area Waterways System (CAWS; Figure 1). In FY2015, the USFWS received agency base funding ($3.13 million) and the U.S. Environmental Protection Agency (USEPA) received Great Lakes Restoration Initiative funding ($4,024 million) totaling more than $7 million to support implementation of the ACRCC's 2015 Framework, including prevention and control efforts in this small area within the Mississippi River Basin.

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 appropriated $2.365 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. The USFWS provided a total of $800,000 in FY2015 funding to support implementation of the Ohio River and Upper Mississippi River Frameworks.

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 ORB and UMRB partners considered a potential inter-agency management structure for coordinated planning and reporting, development of funding strategies, and implementation of actionable plans. State representatives from both sub-basins recommended that the USFWS work through the MICRA partnership for executive level Asian carp coordination and multi-state project planning and implementation in the Mississippi River Basin. MICRA functions as an umbrella organization that provides coordination and communication among the multi-state partnerships that address interjurisdictional fishery management issues within regional sub-basin management units throughout the Mississippi River Basin. Federal agencies with relevant authorities in the Mississippi River and tributaries also participate in the MICRA partnership. MICRA formed an Asian Carp Advisory Committee specifically for executive level inter-agency coordination of Asian carp management and control in the Mississippi River Basin.

MICRA has taken an active role working with the sub-basin partnerships and planning teams throughout the Mississippi River Basin to develop and implement sub-basin Frameworks. Together, Frameworks for the LMRB, MORB, ORB, and UMRB provide for coordinated Asian carp management and control actions for the entire Mississippi River Basin (excluding the upper Illinois River and CAWS addressed in the ACRCC Framework). Each sub-basin partnership is actively working to manage and control Asian carp populations within only one portion of a much larger, interconnected basin, and therefore each sub-basin's success is ultimately dependent upon successful management and control throughout the remainder of the Mississippi River Basin. Similarly, waterway connections between the Mississippi River and Great Lakes basins provide direct pathways for Asian carp movements between these two basins. Successfully preventing Asian carp from spreading and establishing in the Great Lakes is ultimately dependent on successful management and control in the Mississippi River Basin as a whole, not just the upper Illinois River and CAWS. This is further supported by the analyses completed by the U.S. Army Corps of Engineers (USACE) for the *Great Lakes and Mississippi River Interbasin Study* (USACE 2014) that assessed the risk of aquatic nuisance species transfer between the two basins. MICRA provides a forum for basin wide coordination among the sub-basin partnerships and between the Mississippi River Basin and the Great Lakes Basin (i.e., ACRCC).

Following the USFWS coordination meetings with state and federal agency partners in the ORB and UMRB in February and March 2015, MICRA facilitated numerous sub-basin partnership meetings in the ORB and UMRB (face-to-face and teleconference) to identify highest priority Framework needs in each of these sub-basins and to develop collaborative project proposals for USFWS Asian carp funding. MICRA worked with the sub-basin partnerships to develop collaborative project work plans for implementation of ten projects in the ORB and UMRB supported with USFWS FY2015 Asian carp funding. The project work plans were compiled into an annual *Asian Carp Monitoring and Response Plan for the Mississippi River Basin* (MRP) and made available to the public at: http://www.micrarivers.org/asian-carp-plans-and-reports/.

Project Implementation

The USFWS executed grant agreements with most state agencies receiving USFWS FY2015 funding for implementation of the ORB and UMRB framework projects. However, MICRA also received USFWS funding to facilitate implementation of several ORB projects included in the 2015 MRP. All USFWS funding received by MICRA was issued in the form of sub-awards for the completion of projects developed by Ball State University, Purdue University, and the West Virginia Division of Natural Resources as part of the ORB sub-basin collaborative partnership effort. The following projects were included in the MICRA scope of work:

Part A: Ball State University

1. Effects of Asian Carp on Native Fishes – Wabash River Long-Term Fisheries

Part B: Purdue University

1. Ohio River Asian Carp Telemetry - Lower Wabash River

Part C: West Virginia Division of Natural Resources

1. Monitoring and Response of Asian Carp in the Ohio River
2. Control and Removal of Asian Carp in the Ohio River
3. Limiting Dispersal of Asian Carp at Lock and Dam Facilities
4. Ohio River Asian Carp Telemetry
5. Ohio River Asian Carp Coordination and Outreach

MICRA worked quickly with the ORB and UMRB partnerships to develop project proposals for implementation during the 2015 field season. However, by the time USFWS received FY2015 appropriations and executed financial assistance agreements, MICRA did not receive USFWS funding until August 27, 2015, which was too late for MICRA to execute sub-awards with the partner agencies in time for work to be implemented during the 2015 field season. This delay impacted the ability of both Purdue University and WV DNR to complete their funded scopes of works as proposed, and resulted in a number of modifications by USFWS for the MICRA project, including the approval of an additional sub-award with the Kentucky Department of Fish and Wildlife Resources (KDFWR) in 2017.

Results

Results of the individual projects are summarized in the attached project reports provided by the partner agencies that received sub-awards to complete the projects. This federal financial assistance award included a provision for reporting non-target species take from gill netting. These data, when applicable, are included in the individual project completion reports provided by each sub-award recipient. A brief description of the outcome of each sub-award is provided below.

Ball State University

The sub-award with Ball State University was fully executed on January 11, 2016. Ball State University completed all proposed work and project objectives in 2016. The final project report is included in Appendix 1.

Purdue University

The sub-award with Purdue University was fully executed on September 28, 2015. Proposed fieldwork for this project was originally planned for August – November 2015. The delayed start to this project resulted in the start of fieldwork being postponed until 2016 field season. High river stages in spring 2016 prevented Purdue University from completing the two manual tracking surveys from Merom, Indiana, to the confluence with the Ohio River (Objective 3) prior to the end of the sub-award period of performance in July 2016.

The sub-award project period was extended through November 2017 to provide Purdue University with additional opportunity to complete the two manual tracking surveys and associated data collection. Purdue University attempted to conduct a float trip in October 2017 despite relatively low water conditions. The vessel used for the float trip was damaged after impacting several submerged rocks and only 1/3 of the survey could be completed. Following this development, MICRA requested and received a modification to extend the performance period for this Federal Financial Assistance Award (F15AP00893) to allow additional time for safe river conditions to complete the remaining manual tracking surveys. The sub-award period of performance was subsequently extended a second time through July 2018. Purdue University successfully completed a manual tracking survey in May 2018, but was unable to conduct additional surveys in June or July 2018. Despite multiple attempts, Purdue University was only able to complete 1 and 1/3 of the 2 proposed manual tracking surveys.

Due to the challenges unsafe river conditions created for completing manual tracking surveys, Purdue University increased the number of stationary receivers deployed in the lower Wabash River from 4 to 6 to provide improved spatial coverage (Objective 1). The high river levels that prevented manual tracking surveys in spring 2016 also delayed deployment of stationary receivers until June and July 2016, and prevented monthly data downloads (Objective 2) prior to their retrieval at the end of the field season in November 2016.

All other project objectives were completed as proposed. The final project report is included in Appendix 2.

West Virginia Division of Natural Resources

West Virginia Division of Natural Resources (WV DNR) developed a scope of work for the five projects included in Part C of the MICRA proposal funded by USFWS. Following receipt of the financial assistance award from USFWS, WV DNR experienced personnel changes that affected the agency's ability to fulfill all of the proposed work for the five projects. A revised scope of work was developed for the sub-award with WV DNR and is included in Appendix 3. The revised scope of work for WV DNR does not include Project #3: Limiting Dispersal of Asian Carp at Lock and Dam Facilities. WV DNR conducted work on the

four projects in the revised scope of work between August 2015 and July 2016. The final project report for the work completed by WV DNR is included in Appendix 4.

MICRA requested and received a modification to extend the Federal Financial Assistance Award period of performance from July 2017 through January 2018 to provide additional time for the completion of the work that WV DNR was unable to complete.

Kentucky Department of Fish and Wildlife Resources

MICRA executed a sub-award with the Kentucky Department of Fish and Wildlife Resources (KDFWR) in April 2017 for a new scope of work (Appendix 5) that addressed the portions of the five project proposals that WV DNR was unable to complete. KDFWR completed this scope of work during the 2017 field season in conjunction with other Asian carp fieldwork. KDFWR final project report for this sub-award includes information from KDFWR's overall Asian carp control efforts during 2017 to provide the larger context that this work fits within as part of the overall management and control strategy for the ORB. The final project report is included in Appendix 6.

Together, the work completed by WV DNR in 2016 and KDFWR in 2017 fulfills the objectives of the five projects in Part C of the MICRA scope of work funded by USFWS.

Discussion

Following ANS Task Force approval of the National Asian Carp Plan for implementation in 2007, MICRA began encouraging fisheries management agencies in the Mississippi River Basin to develop step-down plans for implementing the National Asian Carp Plan at the regional and local levels. Several states began to identify Asian carp management and control needs within their respective ANS Management Plans, Wildlife Action Plans, and species management plans; however, collaborative multi-agency planning and project implementation at the sub-basin level did not begin in earnest for several years as only minimal state agency resources were available for Asian carp control.

In 2014, MICRA was requested to assist the Ohio River Fisheries Management Team (ORFMT) with the development of the *'Ohio River Basin Asian Carp Control Strategy Framework'* as a collaborative multi-agency strategy for implementing the National Plan in the ORB. Similarly, the Upper Mississippi River Conservation Committee (UMRCC) Fisheries Technical Committee began developing the *'Upper Mississippi River Basin Asian Carp Control Strategy Framework'* in early 2015. (Frameworks for the Mississippi River Sub-basins are available at: http://www.micrarivers.org/asian-carp-plans-and-reports/.)

Congress provided the first substantial funding for Asian carp control in the Mississippi River Basin in FY2015. USFWS provided $800,000 of the agency's FY2015 funding to support ORB and UMBRB Framework implementation. State agency partners leveraged these critical funds to substantially increase collaborative Asian carp control actions within these portions of the Mississippi River Basin. MICRA facilitated multiple planning meetings with state and federal agency partners in both sub-basins to identify priorities and funding needs, develop project proposals and work plans, and discuss long-

term control needs. The FY2015 funding and collaborative planning resulted in the development and implementation of the first *Monitoring and Response Plan for Asian Carp in the Mississippi River Basin*. Project progress and completion reports, including those developed under this FY2015 Federal financial assistance agreement, are shared with the ORB and UMRB partnerships, and the ACRCC, as part of an adaptive management cycle to inform the annual sub-basin partnership planning efforts. All project completion reports are made available to the public on the MICRA website (http://micrarivers.org/asian-carp-plans-and-reports/).

Federal funding has enabled substantial progress implementing ORB and UMRB Frameworks, but additional funding to support implementation of sub-basin frameworks in the MORB and LMRB is critically needed to provide for effective management and control of Asian carp throughout the Mississippi River Basin. Limiting large-scale management and control actions to specific locations within the Mississippi River Basin, while populations within other portions of the Basin are left largely unchecked, does not address the problem at the scale required and will not produce the desired long-term results. Implementing a holistic and unified strategy that addresses Asian carp populations on a basin-wide or national scale is of paramount importance to long-term success throughout the Mississippi River Basin and the Great Lakes.

Literature Cited

Conover, G., R. Simmonds, and M. Whalen, editors. 2007. Management and control plan for bighead, black, grass, and silver carps in the United States. Asian Carp Working Group, Aquatic Nuisance Species Task Force, Washington, D.C. 223 pp.

U.S. Army Corps of Engineers. 2014. The GLMRIS Report: Great Lakes and Mississippi River Interbasin Study. Washington, D.C. 232 pp.

Water Resources Reform and Development Act of 2014, Public Law 113-121.

Appendix 1.

Project Completion Report Prepared by Ball State University

Long-term Impacts of Asian Carp on Native Fishes in the Wabash River

FINAL PROJECT REPORT

For

Mississippi Interstate Cooperative Resource Association

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October 2016

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

APPENDICES **Page**

FORWARD

This report is a final report of field activities and findings for the project entitled: Long-term impacts of Asian Carp on native fishes in the Wabash River. The funding agency is MICRA.

EXECUTIVE SUMMARY

We collected fishes by boat electrofisher at 11 sites on the Wabash River. Sites were selected based on historical sites where Gammon (1998) and Pyron et al. (2006) collected, to allow examination of long-term trends. 1) correlations of Silver Carp (Bighead Carp abundance is relatively low) with abundances of native species; 2) relative weight (W_r) and condition factor of Silver Carp and native fishes; 3) multivariate procedures to examine long-term variation in fish assemblages; and 4) trend analyses of long-term abundances of native fishes.

INTRODUCTION AND OBJECTIVES

The Wabash River downstream of the Huntington reservoir flows unimpounded for 661 km (Karns et. al. 2006). The river today bears little resemblance to the Wabash River described by early naturalists that explored and catalogued diversity in the area (Gammon 1998). The Wabash River drainage has multiple current and historical anthropogenic impacts. Agricultural activities associated with row crops, power plant cooling water inputs, and wastewater from manufacturing facilities and urban sewage significantly altered the natural assemblage and distribution of native fishes (Simon 2006). In addition to sedimentation, warming, and pollution by land use and industry, overharvesting severely reduced freshwater mussel diversity (Fisher 2006).

The most recent threats to the Wabash River ecosystem are introductions of aquatic invasive species. The river contains two invasive bivalves (*Corbicula fluminea* and *Dreissinia polymorpha*) and five invasive fishes *Cyprinidae*: Common Carp (*Cyprinus carpio*), Grass Carp (*Ctenopharyngodon idella*), Goldfish (*Carassius auratus*), Bighead Carp (*Hypophthalmichthys nobilis)*, and Silver Carp (*Hypophthalmichthyes molitrix*). The invasive Asian carps of greatest current concern are Silver Carp and Bighead Carp. These large cyprinids were brought to the US from China in the 1970s as a biological control to remove phytoplankton from the rearing ponds of large aquaculture operations (Irons et al. 2007). By the early 1980s Asian carp escaped into the Mississippi River basin and dispersed throughout the central U.S. (Pflieger 1997).

Asian carp filter plankton from the water column with specialized gill rakers. This results in competition with native filter feeding fishes such as Gizzard Shad (*Dorosoma cepedianum*), Bigmouth Buffalo (*Ictiobus cyprinellus*), and Paddlefish (*Polydon spathula*) (Irons et al. 2007). Irons et al. (2007) documented a significant reduction in body condition of Gizzard Shad and Bigmouth Buffalo after the establishment of Asian carp in the Illinois River, as well as an overall decline in the abundance of Bigmouth Buffalo. In addition, Asian carp may indirectly affect other native fish species through the shunting of algal biomass from the water column to the benthos. The plankton consumed by Asian carp are not thoroughly digested and are egested as compacted fecal pellets. These fecal pellets are a food source for age-0 catfishes (Yallaly et al. 2015). Impacts of Asian carp on native fish competitors are of concern, but competition for resources may not be their only effect on stream ecosystem.

We collected fishes by boat electrofisher at 11 sites on the Wabash River in 2015 (Fig. 1) and six sites in 2016. Sites were selected based on historic sites where Gammon (1998) and Pyron et al. (2006) collected, to allow examination of long-term trends. We examined 1) correlations of Silver Carp (Bighead Carp abundance is relatively low) with abundances of native species; 2) relative weight (W_r) and condition factor of Silver Carp and native fishes; 3) multivariate procedures to examine long-term variation in fish assemblages; 4) trend analyses of long-term abundances of native fishes; and 5) a comparison of electrofishing Silver Carp using minimum threshold settings vs. our historic settings.

OBJECTIVES:

Objective 1: Fish samples at 11 sites
We collected fishes in August 2015 by boat electrofisher for 500 m distances, at 11 sites on the Wabash River (Fig. 1). Sites were selected based on historical sites where Gammon (1998) and Pyron et al. (2006) collected, to allow examination of long-term trends.

Objective 2: Quantify Asian carp abundances
We quantified Asian carp abundances by our standard DC electrofishing technique to allow comparison to historic data. Abundance and body size data were added to the long-term database to allow analyses.

Objective 3: Analyses
We analyzed fish data for 1) correlations of Silver Carp abundance with abundances of native species; 2) relative weight of Silver Carp and native fishes; 3) multivariate procedures were used to examine long-term variation in fish assemblages; 4) trend analyses of long-term abundances of native fishes; and 5) a comparison of electrofishing Silver Carp using minimum threshold settings vs. our historic settings.

METHODS

Fishes were collected from 500 meter transects along outer bends of the middle Wabash River by boat electrofishing (Infinity Box, Midwest Lake Electrofishing Systems, Polo, MO). Modifications to target Silver Carp were 240 Volts, 30 Hz, and duty cycle of 15 % (https://www.fws.gov/fieldnotes/regmap.cfm?arskey=30806) were used for 2015 collections. Our historical and 2016 electrofishing settings were pulsed DC at 400 Volts, 60 Hz, and duty cycle of 40 %. Collections were made during low flow periods using our historical decision attribute (discharge < 5000 cfs at Montezuma USGS gaging station). We identified all fish to species and recorded total length and weight of each individual.

We analyzed fish data for 1) correlations of Silver Carp abundance with abundances of native species; 2) relative weight of Silver Carp and native fishes were examined; 3) multivariate procedures were used to examine long-term variation in fish assemblages; 4) trend analyses of long-term abundances of native fishes were examined; and 5) a comparison of electrofishing Silver Carp using minimum threshold settings vs. our historic settings. Our multivariate procedures were Correspondence Analysis (CA) and Nonmetric Multidimensional Scaling (NMS). However NMS was not able to successfully find a stable solution with stress below 40 (stress should be < 20, McCune et al. 2002). CA ordination is geared to ecological data and results in a first axis that describes species turnover among sites (McCune et al. 2002).

Relative weights for common carp, freshwater drum, gizzard shad, shorthead redhorse, and spotted bass were calculated using intercept, slope, and minimum total length (Blackwell et al. 2000). Relative weight for blue sucker was calculated using data from Neely et al. (2008).

RESULTS

Objective 1: Fish samples at 11 sites
A total of 467 individuals were collected, in 31 species (Appendix A). Mean species richness per site was 15, and ranged from 12 to 20.

Objective 2: Quantify Asian carp abundances
We collected 22 Silver Carp in 2015, with a site mean of 2 and a range from 0-6 (Appendix A). We did not observe Bighead Carp in 2015. The first occurrence of Silver Carp in our long term data was in 2006. Between 2006 and 2015, abundance of Silver Carp increased with the highest abundance in 2014 (Figs. 2 and 3).

Objective 3: Analyses
We calculated correlation coefficients for Silver Carp log+1 transformed abundance with native species log+1 transformed abundances. Channel Catfish, Common Carp, Gizzard Shad resulted in significant negative correlations, and Freshwater Drum with a significant positive correlation (Table 1).

In the absence of published data for Silver Carp condition (average of intercept, slope, and minimum length used to calculate the relative weight (W_r) of a fish species), we estimated the relative condition of Silver Carp in the Middle Wabash River using length-weight ratios. This ratio is modelled by the equation, Log weight = - 5.30 + 3.15(Log length) (Fig. 17). Our model is similar to Silver Carp collected from the Lower Missouri River by Wanner and Klumb (2009) (Table 2).

Abundances and relative weights (W_r) of native species were examined for significant correlations with abundance of Silver Carp. Abundances and W_r varied significantly with time in all species (Figs. 4 – 15) but there was only one significant effect of Silver Carp abundance on Blue Sucker. Blue Sucker abundance declined during years when Silver Carp had high abundance (Figure 16, $P = 0.005$, $F_{(13, 255)} = 2.36$). No other significant effects of Silver Carp abundance on abundance or W_r of other fishes were found.

A multivariate procedure was used to examine long-term variation in fish assemblages. Correspondence Analysis resulted in two axes that were significantly different from random ($P < 0.001$) that explained 11.6 and 10 % of variation (Fig. 18). The first CA axis was significantly correlated with river location ($r = 0.62$, $P < 0.001$, Fig. 19) and the second CA axis with collection year ($r = 0.39$, $P < 0.001$, Fig. 20). Species that were collected in the highest abundances in downstream reaches were Goldeye, Paddlefish, Flathead Catfish and Bowfin (Fig. 19). Species that were collected in the highest abundances in upstream reaches were River Redhorse, Black Buffalo, Longear Sunfish, and Black Redhorse. Species that were collected in higher abundances earlier in the time period were Mooneye, White Crappie, River Carpsucker, and White Sucker (Fig. 20). Species that were collected in higher abundances more recently were Bighead Catfish, Shovelnose Sturgeon, Grass Carp, and Black Buffalo. The first CA axis was

also significantly correlated with year, but the relationship was not as strong ($r = 0.39$, $P < 0.001$).

In Sep and Oct 2016 we repeated boat electrofishing collections at six of the sites to compare electrofishing settings for targeting Silver Carp. One individual Silver Carp was collected in 2016, at the Lafayette site. Ten individual Silver Carp were collected in 2015 at these six sites (Appendix 1). A Kruskal-Wallis nonparametric comparison of 2015 and 2016 collections resulted in marginallly significant differences ($H = 3.5$, $P = 0.06$), with more Silver Carp collected using targeted settings. This comparison has low power due to low sample sizes. We are aware that Silver Carp abundances in 2016 remained high. The same month (Sep 2016) we collected >20 Silver Carp in the lagoon that is connected to the Wabash River in Lafayette, using electrofishing settings to target Silver Carp.

DISCUSSION

Asian Carp invaded the Mississippi River watershed in the early 1980s (Simon 2006) and the Wabash River watershed around 1995 (Broadway et al. 2015). These species did not appear in our long-term data set until 2006 when they were in high abundance. We identified a trend of increasing abundance of Silver Carp that began in 2006, with the highest abundance in 2014. Silver Carp abundance in 2015 was similar to previous years. Irons et al. (2007) similarly showed that Asian carp abundance in the Illinois River was low until 2000 when the population grew rapidly.

Temporal abundances of six selected native species resulted in high annual variation. Gizzard Shad abundance in the Wabash River decreased dramatically when Silver Carp abundance increased, but with frequent peaks in abundance. Gizzard Shad is a species that competes with Silver Carp for food resources (Sampson et al. 2009). However, Freshwater Drum is a benthic invertivore that increased in abundance beginning in the mid-1990s (Broadway et al. 2015). Broadway et al. (2015) found evidence for a community shift in dominant functional feeding groups of fishes. Abundances of filter feeding fishes declined simultaneous to benthic invertivores increase in abundance. Shorthead Redhorse abundance was extremely variable, but did not have obvious temporal trends. Blue Sucker abundance increased, starting in the early 1990s, but with higher annual variation than for Freshwater Drum abundance.

The condition of Silver Carp in the Middle Wabash River was similar to the condition of Silver Carp 400 km distant in the Lower Missouri River. This is reasonable because both rivers are in watersheds dominated by rowcrop agriculture and similar latitude. Without more data on mean Silver Carp condition throughout its North American range this is the only available comparison.

Variation in Blue Sucker abundance was partially explained by variation in Silver Carp abundance in our regression model. Although competitive interactions between the species are unknown, larvae and/or juveniles likely use similar plankton resources. In addition, adult Silver Carp are potential predators of larval Blue Suckers. Silver Carp schooling and jumping behaviors may be disruptive to native fishes that use the same habitats.

Relative weights of six native Wabash River species had high variation during these 40 years, but appeared to be independent of Silver Carp abundance. Blue Sucker, Freshwater Drum, and Spotted Bass relative weights were higher than the mean for most of the 40 years. Common Carp, Gizzard Shad, and Shorthead Redhorse relative weights were consistently low. Relative weights for all of these native species decreased during the mid-1990s and mid-2000s. A mechanistic explanation requires detailed information that is currently unavailable, for nutrient variation, primary producers, food web linkages, and potential disturbances.

River distance patterns were distinctive in a multivariate analysis of Wabash River fish assemblages. These patterns are likely a result of upstream-downstream habitat variation produced from discharge and geomorphology interactions (Frissell et al. 1986, Thorp et al. 2006). Upstream reaches of the Wabash River are higher gradient, have increased riffle-pool development, and larger sediments. Temporal patterns were present in the multivariate analysis of Wabash River fish assemblages also. The strongest patterns were decreased abundances of Gizzard Shad, Common Carp, and Mooneye and increased abundances of most benthic invertivore fishes (Shovelnose Sturgeon, Freshwater Drum, Redhorse suckers) more recently. Broadway et al. (2015) interpreted the overall variation in the Wabash River fish assemblages as likely responding to multiple stressors including Asian carp. A potential mechanism for modifications to the Wabash River food web is Silver Carp consumption of plankton that are not thoroughly digested, resulting in fecal pellets that may subsidize benthic invertebrates and benthic invertivore fishes. Our comparison of electrofishing settings to target Silver Carp resulted in increased collections of Silver Carp, compared to our historic settings.

Recommendations for Asian carp management in the Ohio River basin:

1) Eliminate the potential for connectivity to Great Lakes watersheds.
2) Continue to monitor Asian carp abundances and body condition in Ohio River drainages, native fishes abundances and body conditions to allow knowledge of invader effects.
3) Study North American river colonization patterns by Asian carps, to test for explanations for differing body condition, diets, and changes in abundance of native fishes.

LITERATURE CITED

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Table 1. Correlation coefficients for log_{10}+1 transformed Silver Carp mean annual abundance with native fish and Common Carp log+1 transformed mean annual abundances.

Species	**Correlation coefficient r**	**P**
Bighead Carp	0.11	0.47
Blue Catfish	0.05	0.74
Blue Sucker	0.16	0.28
Channel Catfish	- 0.29	0.05
Common Carp	- 0.60	0.001
Flathead Catfish	- 0.48	0.04
Freshwater Drum	0.30	0.10
Gizzard Shad	- 0.24	0.001
River Carpsucker	- 0.03	0.86
Shorthead Redhorse	- 0.21	0.15
Spotted Bass	- 0.13	0.39

Table 2. r Silver Carp Weight-Length Relationships for the Wabash River and the Lower Missouri River.

River	Model	N	r^2
Lower Missouri River	$Log_{10}weight = - 5.35 + 3.13(Log_{10}length)$	68	0.93
Wabash River	$Log_{10}weight = - 5.30 + 3.15(Log_{10}length)$	66	0.96

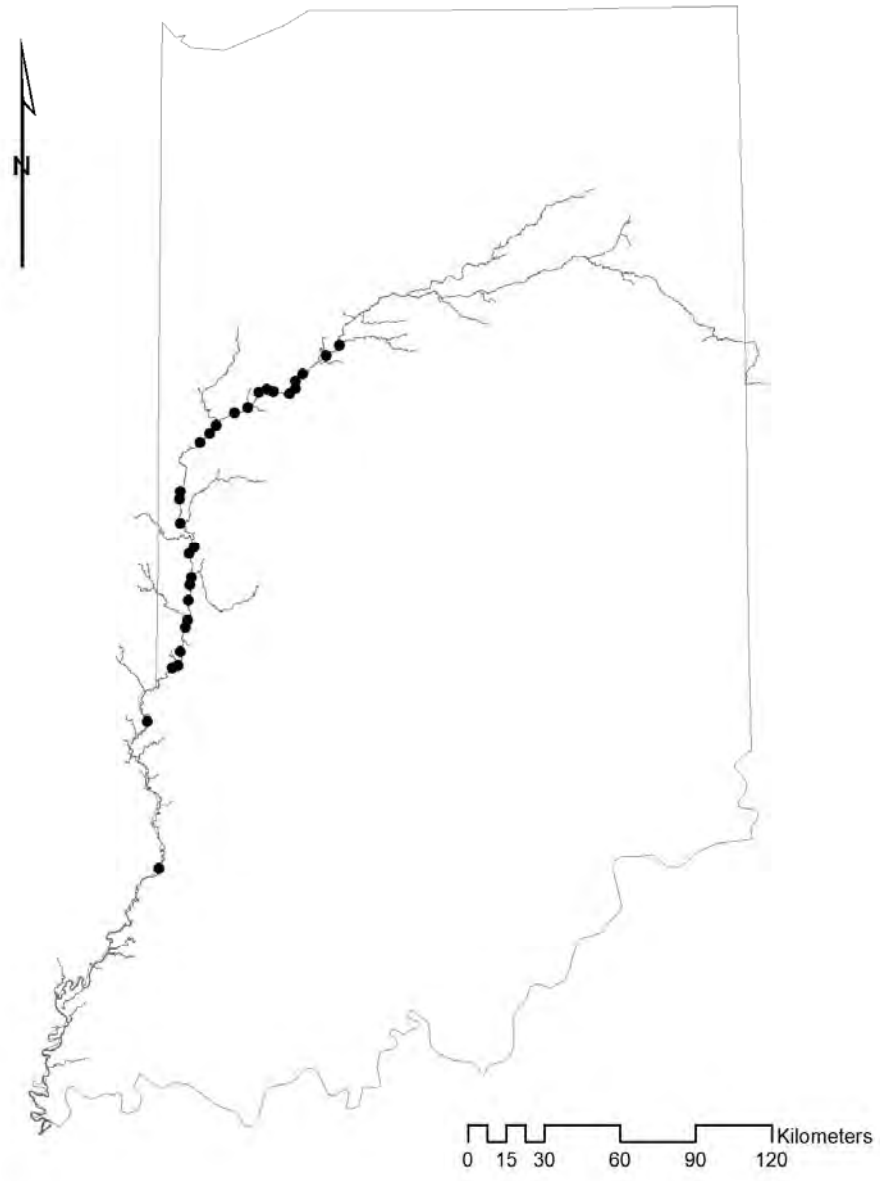

Figure 1. Site map of the Wabash River, Indiana.

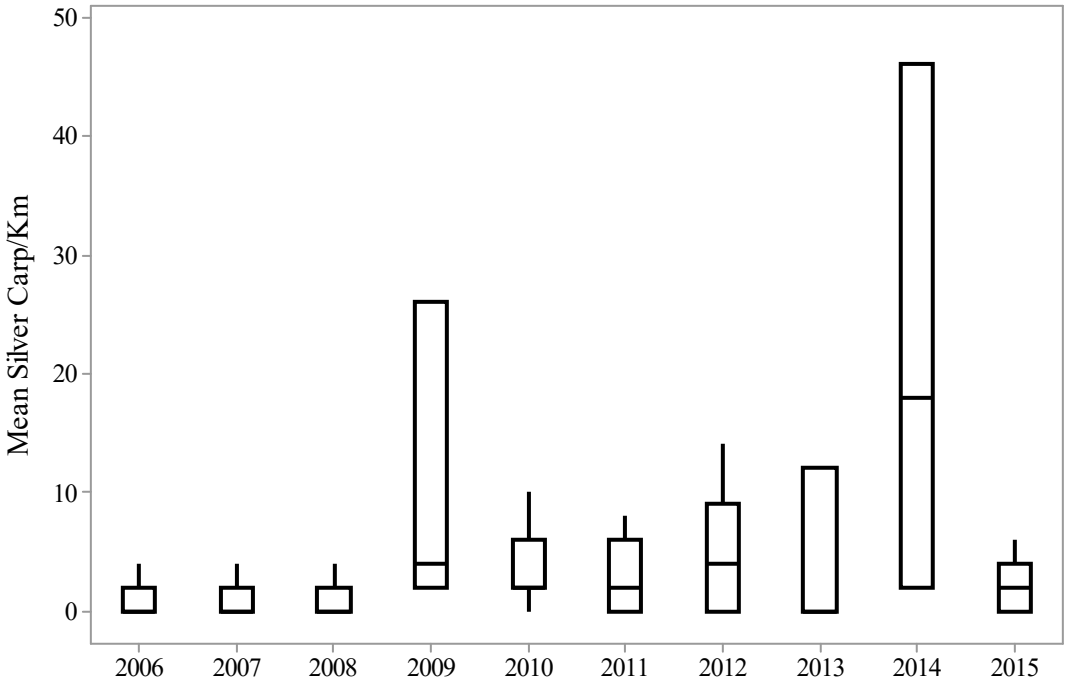

Figure 2. Catch per km of Silver Carp in the Wabash River at all sites from 2006-15.

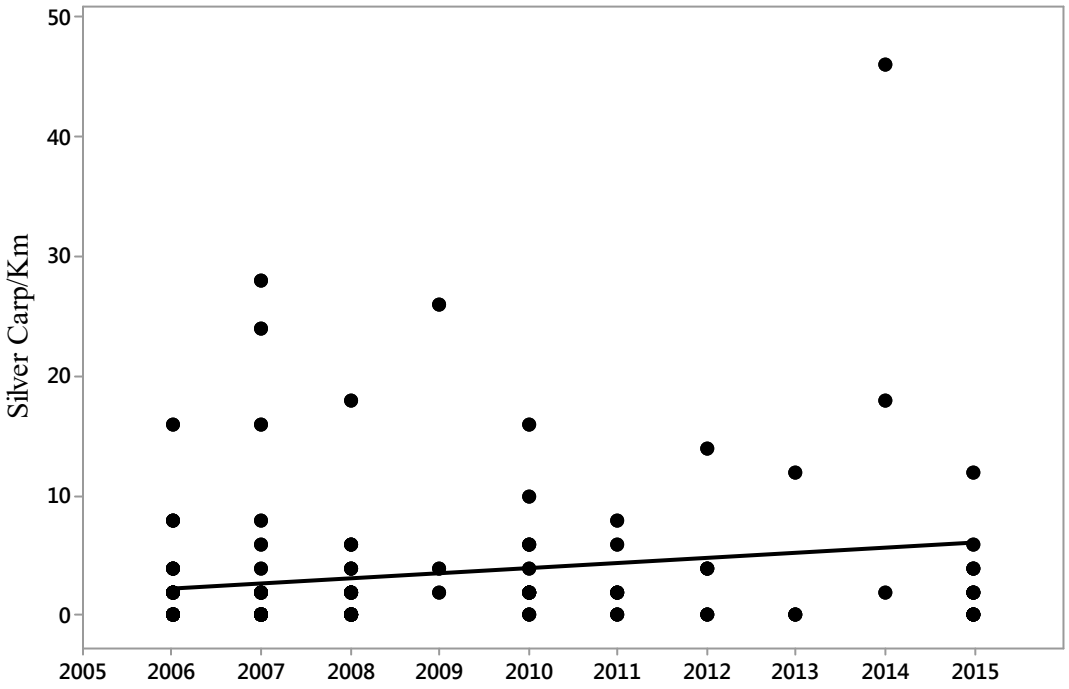

Figure 3. Regression of Silver Carp catch per km with year of collection (R^2 = 18.8).

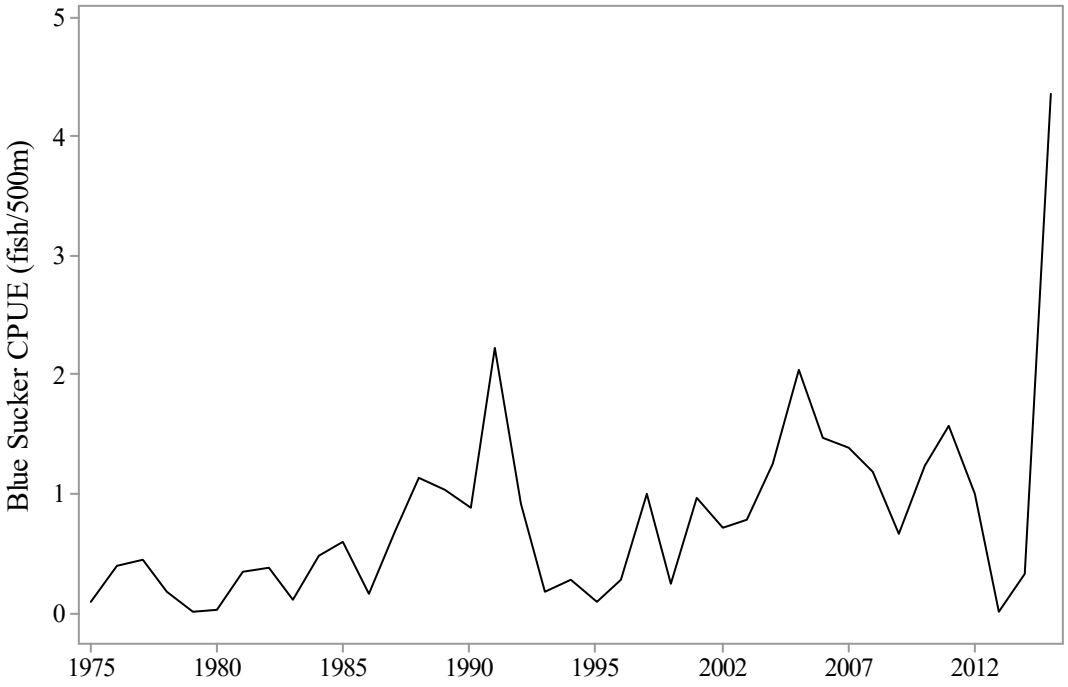

Figure 4. Mean Blue Sucker CPUE (fish/500m) between 1975 and 2015.

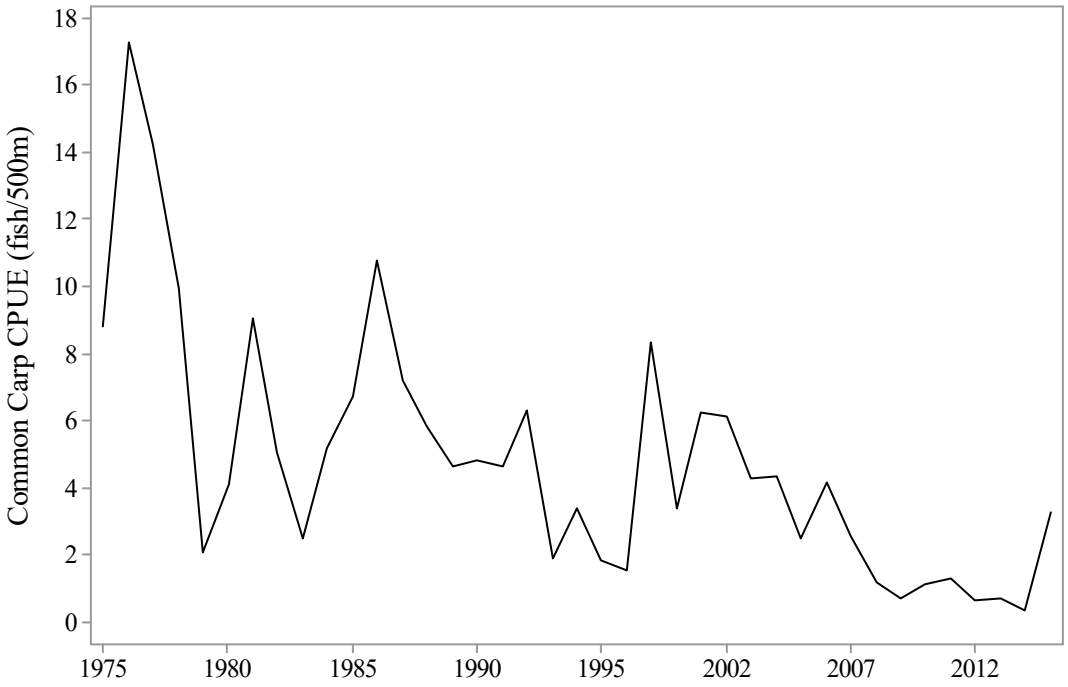

Figure 5. Mean Common Carp CPUE (fish/500m) between 1975 and 2015.

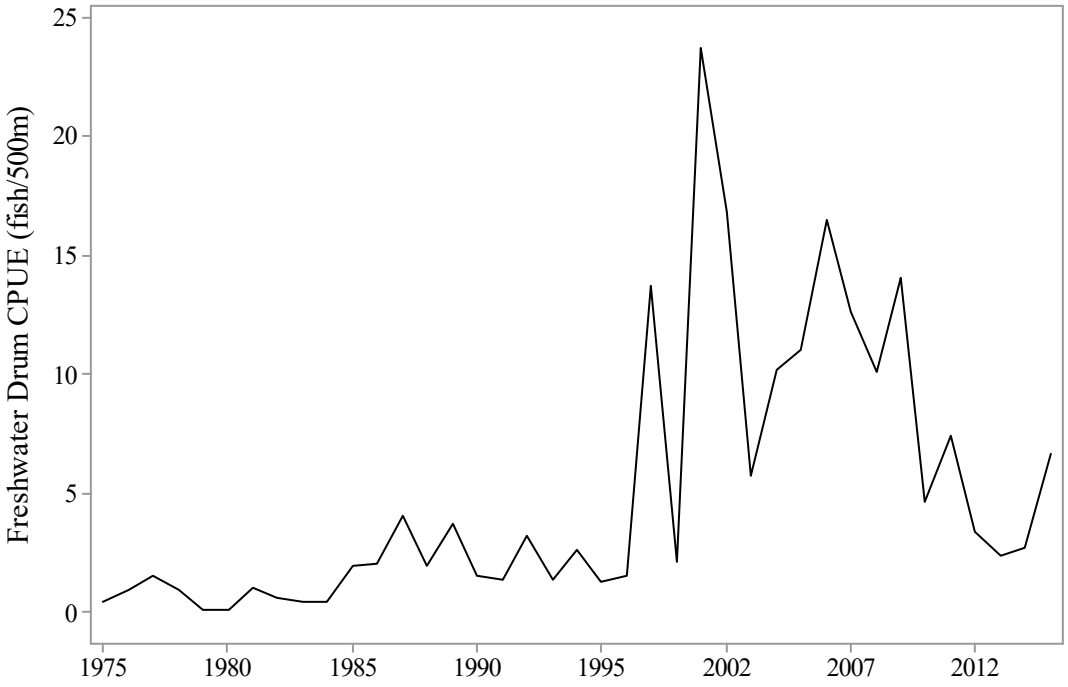

Figure 6. Mean Freshwater Drum CPUE (fish/500m) between 1975 and 2015.

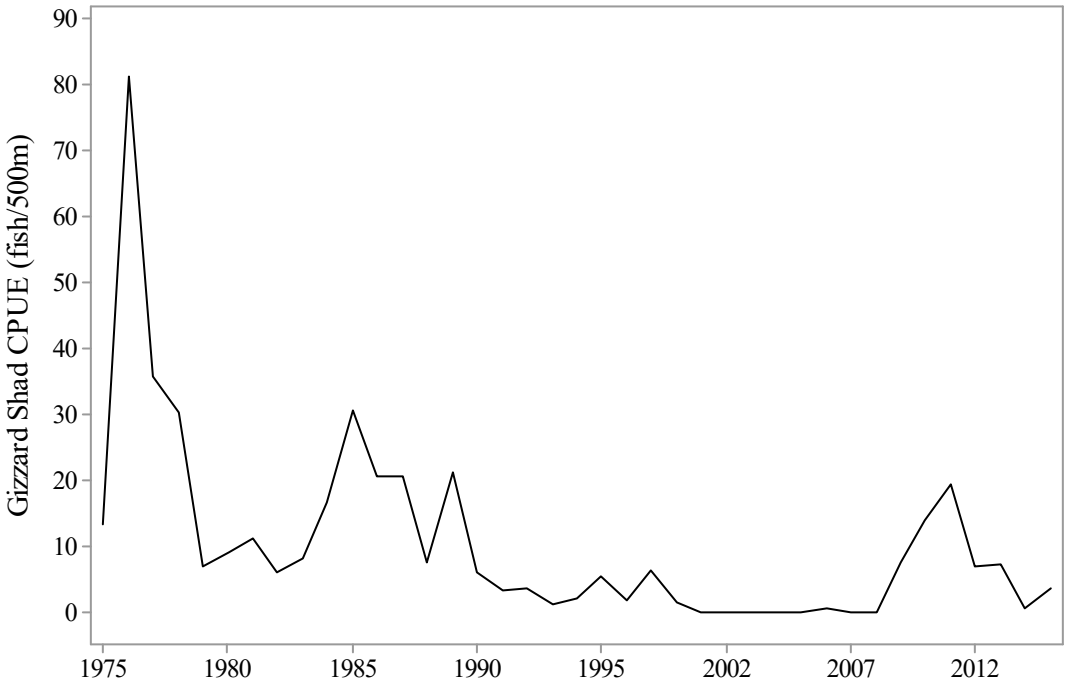

Figure 7. Mean Gizzard Shad CPUE (fish/500m) between 1975 and 2015.

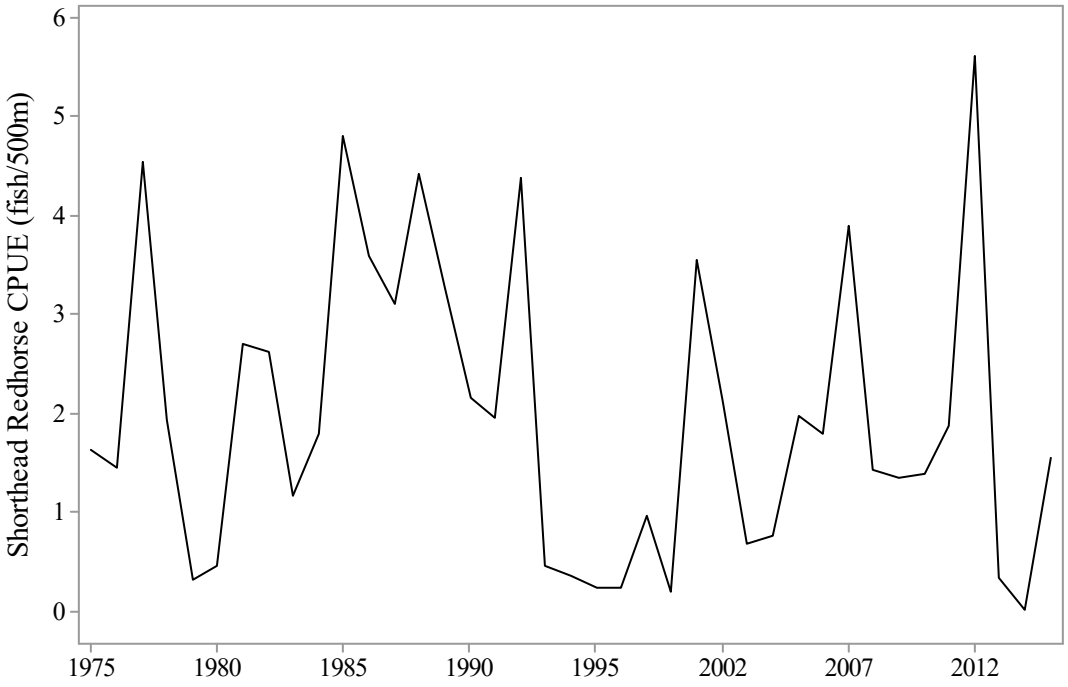

Figure 8. Mean Shorthead Redhorse CPUE (fish/500m) between 1975 and 2015.

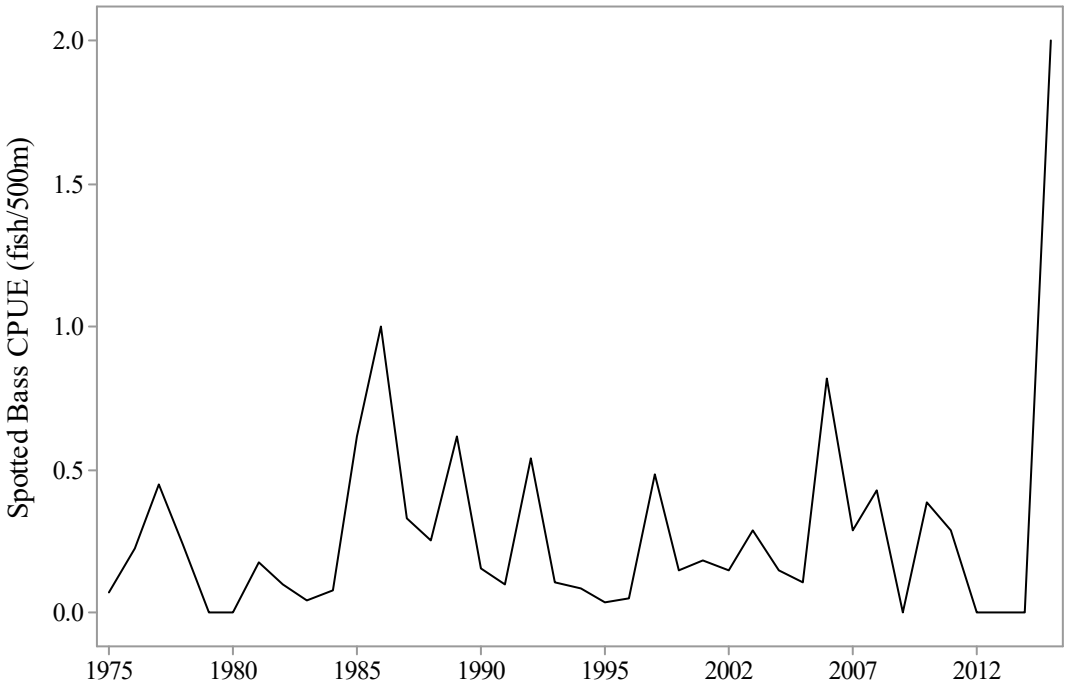

Figure 9. Mean Spotted Bass CPUE (fish/500m) between 1975 and 2015.

Figure 10. Mean Blue Sucker relative weight between 1975 and 2015.

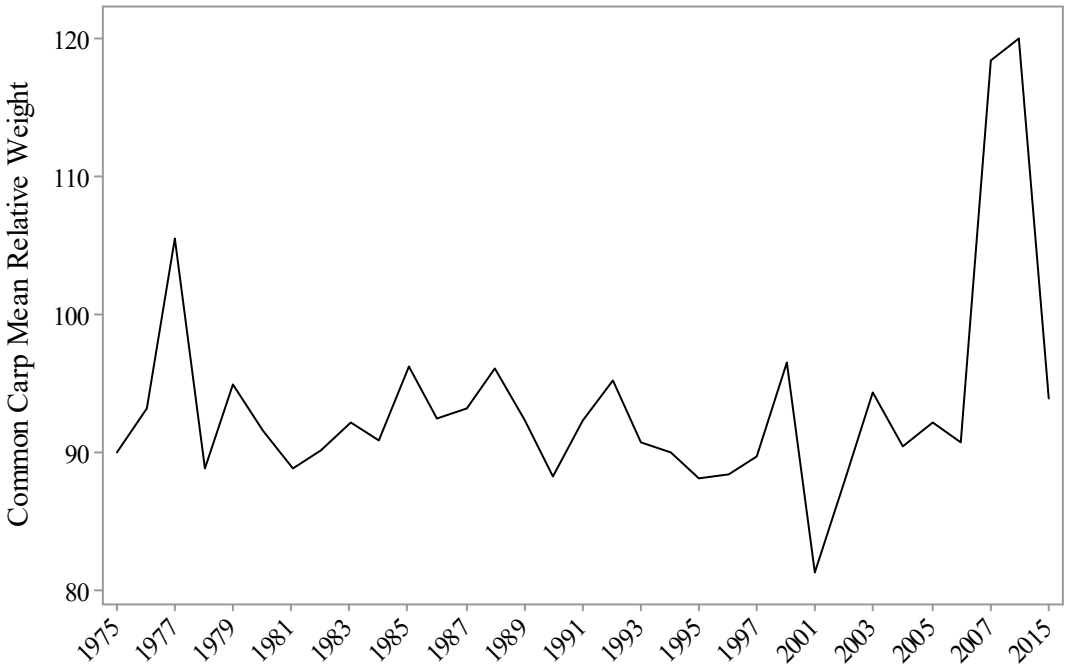

Figure 11. Mean Common Carp relative weight between 1975 and 2015.

Figure 12. Mean Freshwater Drum relative weight between 1975 and 2015.

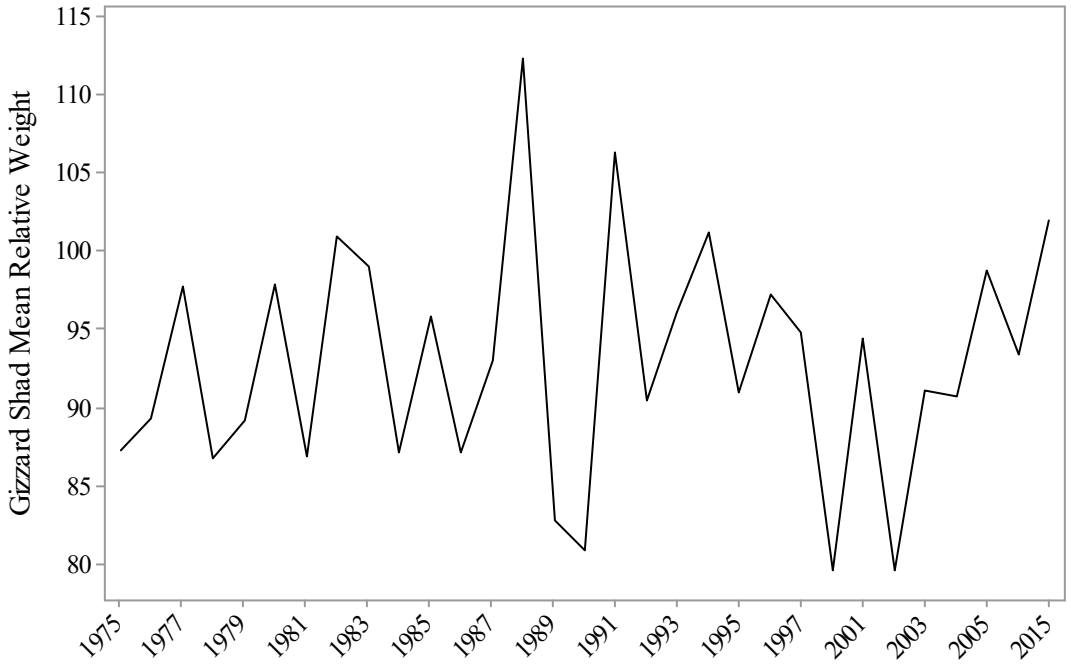

Figure 13. Mean Gizzard Shad relative weight between 1975 and 2015.

Figure 14. Mean Shorthead Redhorse relative weight between 1975 and 2015.

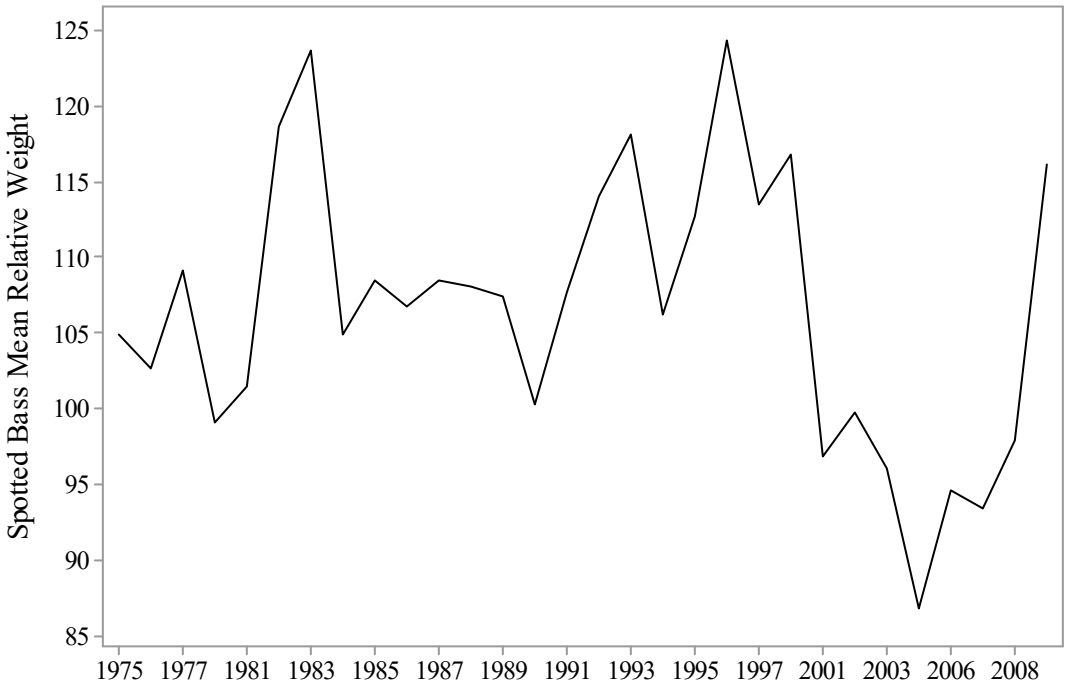

Figure 15. Mean Spotted Bass relative weight between 1975 and 2015.

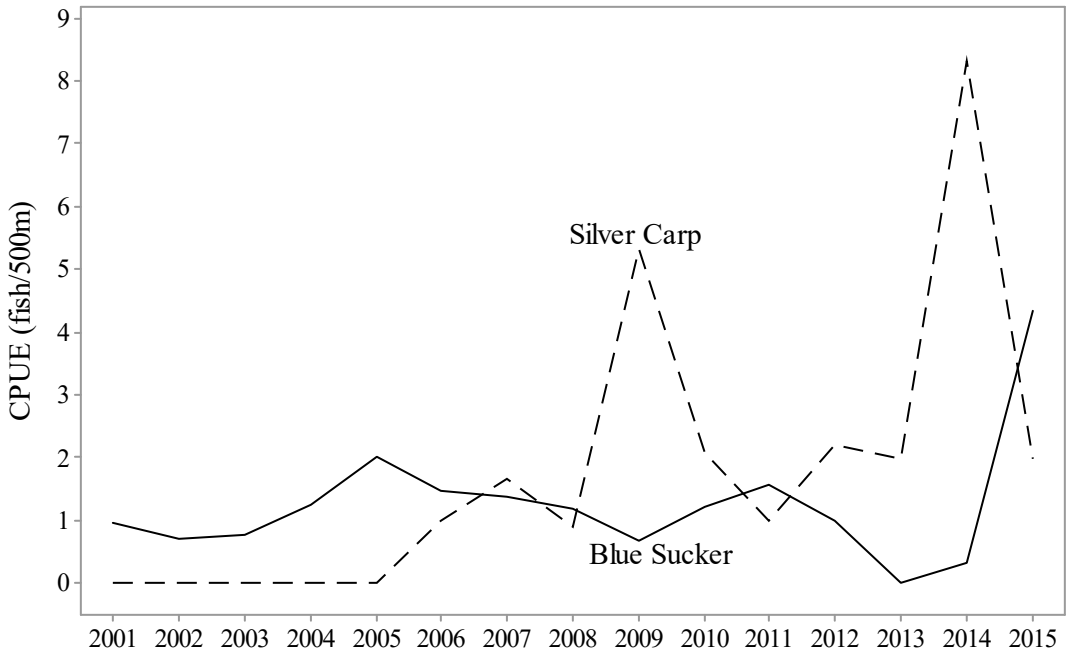

Figure 16. The mean CPUE of Blue Sucker decreased in years when Silver Carp CPUE increased (P = 0.005, F = 2.36).

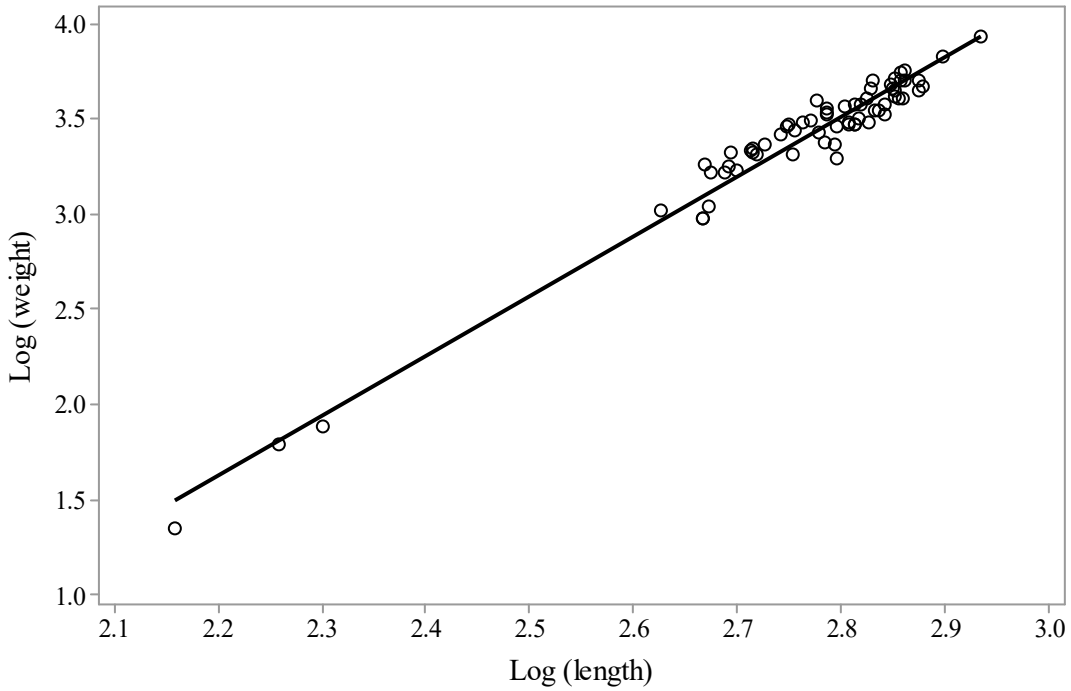

Figure 17. Condition factor of Silver Carp in the Middle Wabash River can be modeled as $Log_{10}weight = - 5.30 + 3.15(Log_{10}length)$, $P < 0.001$.

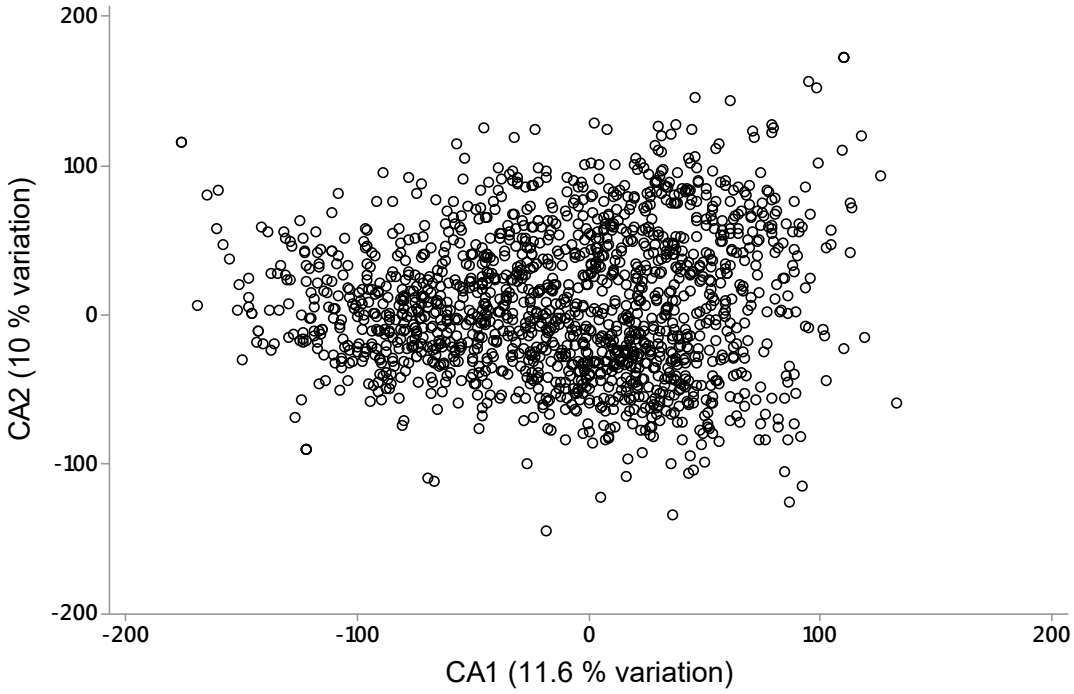

Figure 18. First two axes from a Correspondence Analysis ordination of all fish collections from 1968-2015.

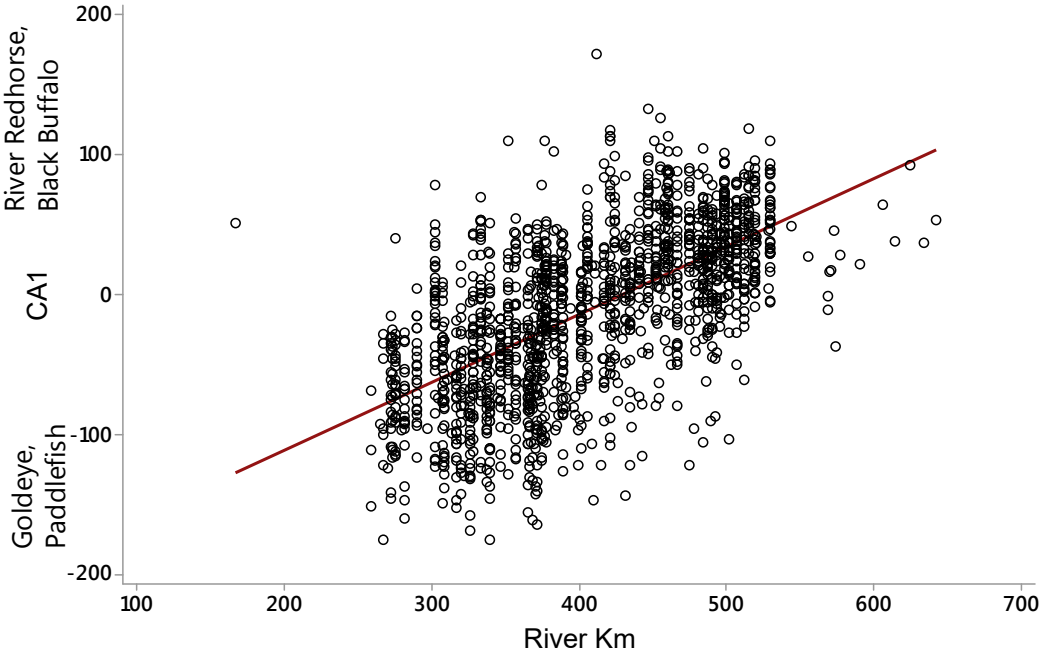

Figure 19. The first CA axis and river location. Highest loading species are listed on the axis.

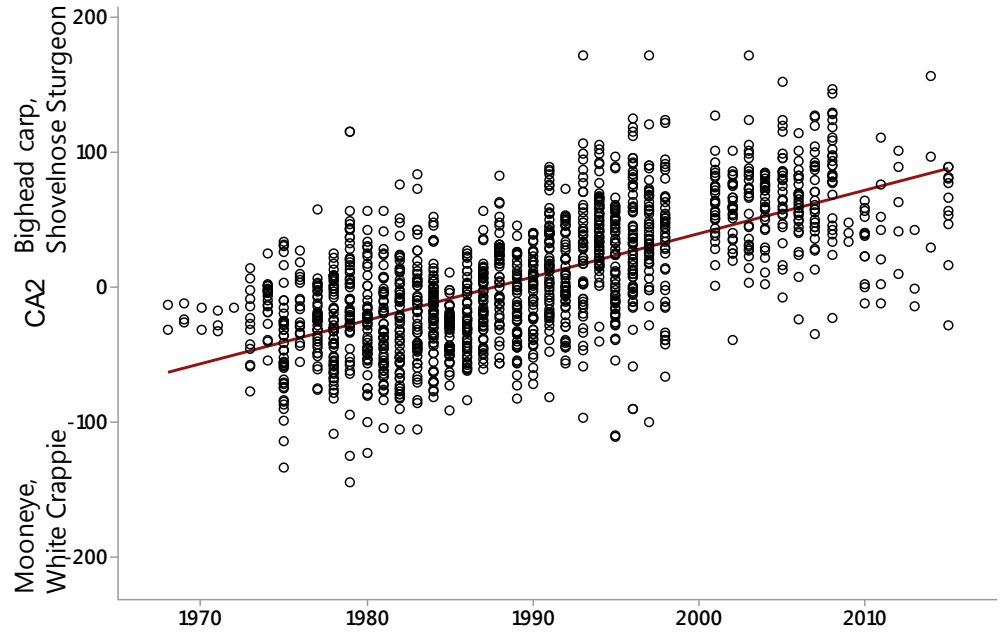

Figure 20. Correlation of the second CA axis with collection year. Highest loading species are listed on the axis.

Appendix A. Abundances of Wabash River fishes collected in 2015.

Year	KM	Bighead Carp	Bigmouth Buffalo	Black Buffalo	Black Crappie	Blue Sucker	Bluegill	Bowfin	Channel Catfish	Common Carp
2015	167	0	0	0	0	5	2	0	3	1
2015	302	0	0	1	0	6	0	0	0	2
2015	328	0	2	2	0	4	0	0	2	3
2015	333	1	1	2	1	8	0	0	1	2
2015	338	0	0	3	0	1	4	0	0	1
2015	367	0	0	1	0	1	3	0	1	4
2015	372	0	0	1	0	4	0	0	0	1
2015	375	0	1	1	0	6	0	1	0	11
2015	459	0	0	4	0	13	0	0	0	6
2015	507	0	1	1	0	0	0	0	1	1
2015	529	0	0	0	0	0	0	0	0	4

Year	KM	Emerald Shiner	Flathead Catfish	Freshwater Drum	Gizzard Shad	Golden Redhorse	Grass Carp	Green Sunfish	Longear Sunfish	Longnose Gar
2015	167	0	0	12	2	0	0	0	0	0
2015	302	0	0	6	0	0	0	0	0	0
2015	328	0	0	5	7	0	0	0	0	0
2015	333	0	1	5	4	0	0	0	1	0
2015	338	0	1	6	7	0	0	1	3	0
2015	367	0	0	1	4	0	0	0	2	0
2015	372	0	0	0	1	0	1	0	1	2
2015	375	0	1	6	0	0	0	0	0	0
2015	459	0	0	6	1	1	1	0	0	0
2015	507	2	1	11	3	5	0	0	1	0
2015	529	3	0	15	10	2	2	0	1	0

Appendix A. cont.

Year	KM	Mooneye	Northern Hogsucker	Quillback Carpsucker	River Carpsucker	Sauger	Shorthead Redhorse	Shortnose Gar
2015	167	1	0	1	1	0	0	0
2015	302	1	0	0	5	0	0	0
2015	328	0	0	0	1	0	0	0
2015	333	0	1	0	1	0	1	1
2015	338	0	0	0	4	0	1	1
2015	367	0	0	0	0	0	0	0
2015	372	0	0	1	3	0	1	3
2015	375	0	0	1	3	0	2	6
2015	459	0	0	0	2	1	3	2
2015	507	0	0	0	41	2	6	4
2015	529	0	5	0	5	1	3	1

Year	KM	Shovelnose Sturgeon	Silver Carp	Silver Redhorse	Skipjack Herring	Smallmouth Bass	Smallmouth Buffalo	Spotted Bass	White Bass
2015	167	0	0	0	0	0	5	4	0
2015	302	2	0	0	0	4	0	1	0
2015	328	1	3	0	0	0	1	1	1
2015	333	3	6	1	0	0	0	1	0
2015	338	0	2	0	1	3	1	2	1
2015	367	0	2	0	0	1	0	12	0
2015	372	0	1	0	0	1	0	1	0
2015	375	1	1	0	0	0	2	0	0
2015	459	0	5	6	0	0	1	0	0
2015	507	0	2	1	1	0	0	0	0
2015	529	0	0	1	2	1	0	0	1

Appendix 2.

Project Completion Report Prepared by Purdue University

Ohio River Asian Carp Telemetry: Lower Wabash River Telemetry

Participating Institutions/Agencies: Purdue University, Indiana Department of Natural Resources, US Fish and Wildlife Service

Location: Wabash River from confluence with the Ohio River upstream to Merom, IN

Project Monitoring and Evaluation

Objective 4 of the Ohio River Asian Carp Telemetry Project Plan specifically identifies Asian Carp (*Hypophthalmichthys* spp.) telemetry activities to be conducted in the lower Wabash River from its confluence with the Ohio River upstream to Merom, Indiana. There are currently 300 acoustically tagged Silver (*Hypophthalmichthys molitrix*), Bighead (*Hypophthalmichthys nobilis*), and hybrid (*H. molitrix* X *H. nobilis*) Carps (hereafter, collectively referred to as Asian Carp) at large in the Wabash River, although all individuals were tagged at upstream locations, and the extent of their use of habitats downstream from Terre Haute, Indiana, are largely unknown. Similarly, large numbers of Asian Carp have been (and continue to be) acoustically tagged in the Ohio River and middle Mississippi River, although there has historically been no infrastructure in place in the lower Wabash River to detect potential interpopulation movements of these fishes among the Ohio, Mississippi, and Wabash Rivers. Asian Carp movements within moderately sized drainages have been studied and reported (e.g., DeGrandchamp et al. 2008; Coulter et al. 2016; Prechtel et al. 2018), although their capacity for interbasin movements to maintain gene flow and facilitate range expansion is unknown.

Project Activity

The Goforth Lab at Purdue University was provided with grant monies to achieve nine project objectives under its cooperative agreement with the Mississippi Interstate Cooperative Resource Association (MICRA, agreement # MICRA-15-03). These objectives were established with a project start date of August 1, 2015, and although the contracted project period was from August 1, 2015 through July 31, 2016, monies were not available for expenditure at Purdue University until September 30, 2015. This delay in project funding availability made it impossible to achieve several objectives as originally stated in the agreement. The principal investigator, Dr. Reuben Goforth (hereafter, PI Goforth), communicated with MICRA's coordinator, Mr. Greg Conover, regarding this and it was informally agreed that the Goforth Lab would move forward as able in the following spring to provide telemetry information on the lower Wabash River. Although this was not formalized with an amended agreement, PI Goforth took actions in good faith to deliver the best possible telemetry coverage for the lower Wabash River given the limited project timeframe. However, river conditions hampered project activities at many times both within and beyond the original project period. Despite these difficulties and with generous project extensions, all but one element of the project objectives were completed. This report reflects these activities and the resulting data derived from these activities.

Project Objective 1 - Deploy four Vemco VR2W stationary receivers in the lower Wabash River from Merom, IN, to the confluence with the Ohio River in August 2015; retrieve stationary receivers in mid-November 2015.

Because funds were not available for use until September 30, 2015, VR2Ws could not be purchased and deployed for fall 2015. This also precluded the float trips planned for September

and October 2015 (see Objective 3). In an effort to provide improved spatial coverage of the lower Wabash River in the absence of manual receiver float trips, PI Goforth purchased two additional VR2Ws to enable deployment of six total stationary receivers in the lower Wabash River (vs. the original four receivers). PI Goforth reasoned that this additional infrastructure would be a justifiable compromise given that the originally planned float trips could not be performed as originally planned due to delayed funding followed by unsafe river conditions during planned float trips. The Goforth Lab constructed six deployment platforms and anchoring systems for these VR2Ws. These deployments were planned for May 2016 to provide the longest deployment time possible given the July 31, 2016 project end date. Several attempts to deploy receivers were unsuccessful due to high water conditions in May 2016. The next window for safe deployment was in late June into July 2016, and the deployments were made during this time. Given the brevity of deployment time relative to the original end date of the project (31-Jul-2016), PI Goforth decided to move forward and to use discretionary lab funds after the project period to retrieve the VR2Ws in November 2016 to provide the best telemetry information possible given the constraints. The additional time and resources required to make multiple deployment trips and to add the additional VR2Ws were equivalent to the time and resources that would have been necessary to conduct two additional stationary receiver downloads (see Project Objective 2 below).

Project Objective 1 specifies that stationary receivers would be deployed from Merom, Indiana (Wabash River Mile [WRM] 165.2, most upstream deployment) to the confluence with the Ohio River (WRM 0, most downstream deployment). PI Goforth expected deployment to the confluence to be readily achievable using the platforms and anchors he developed for this project (Plates 1-4). However, on-site reports from lab personnel indicated that deployment at the confluence was not recommended using these methods. The decision was therefore made to deploy the most downstream receiver in a location that was appropriate for the stand and anchor systems constructed for the project. This was justified also by recognition that meaningful movements between rivers would be best detected upstream from the confluence rather than at the confluence itself (i.e., detection at the confluence does not necessarily connote movement between rivers). Receivers were therefore deployed at the following locations (in order from most upstream to most downstream): WRM 165.2 near Merom, IN; WRM 131.2 near Vincennes, IN; WRM 103.7 near Mt. Carmel, IL; WRM 69 near Crawleyville, IN; WRM 56 near New Harmony, IN; and WRM 19.3 near Mt. Vernon, IN (Figures 1-2). These deployments were spaced such that even relatively modest movements by tagged fish would be detected by the array (e.g., Prechtel et al. 2017 reported total ranges for telemetered Silver Carp tracked over 2-3 years that were larger than the average 29-mile distance between stationary receivers in this study).

Project Objective 2 – Download data from deployed VR2W stationary receivers in September, October, and November 2015.

The delayed availability of project funding made multiple downloads of data from stationary receivers impossible. Deployment in May 2016 would have provided sufficient time for at least one download prior to retrieving the VR2Ws at the project's end, but unsafe, high water levels prevented deployment at that time. High water levels also required additional personnel time and resources that would have been used for these downloads because multiple attempts had to be made to successfully deploy the VR2Ws, including the two additional receivers as indicated for Project Objective 1. Sufficient discretionary lab funds were available after the original project

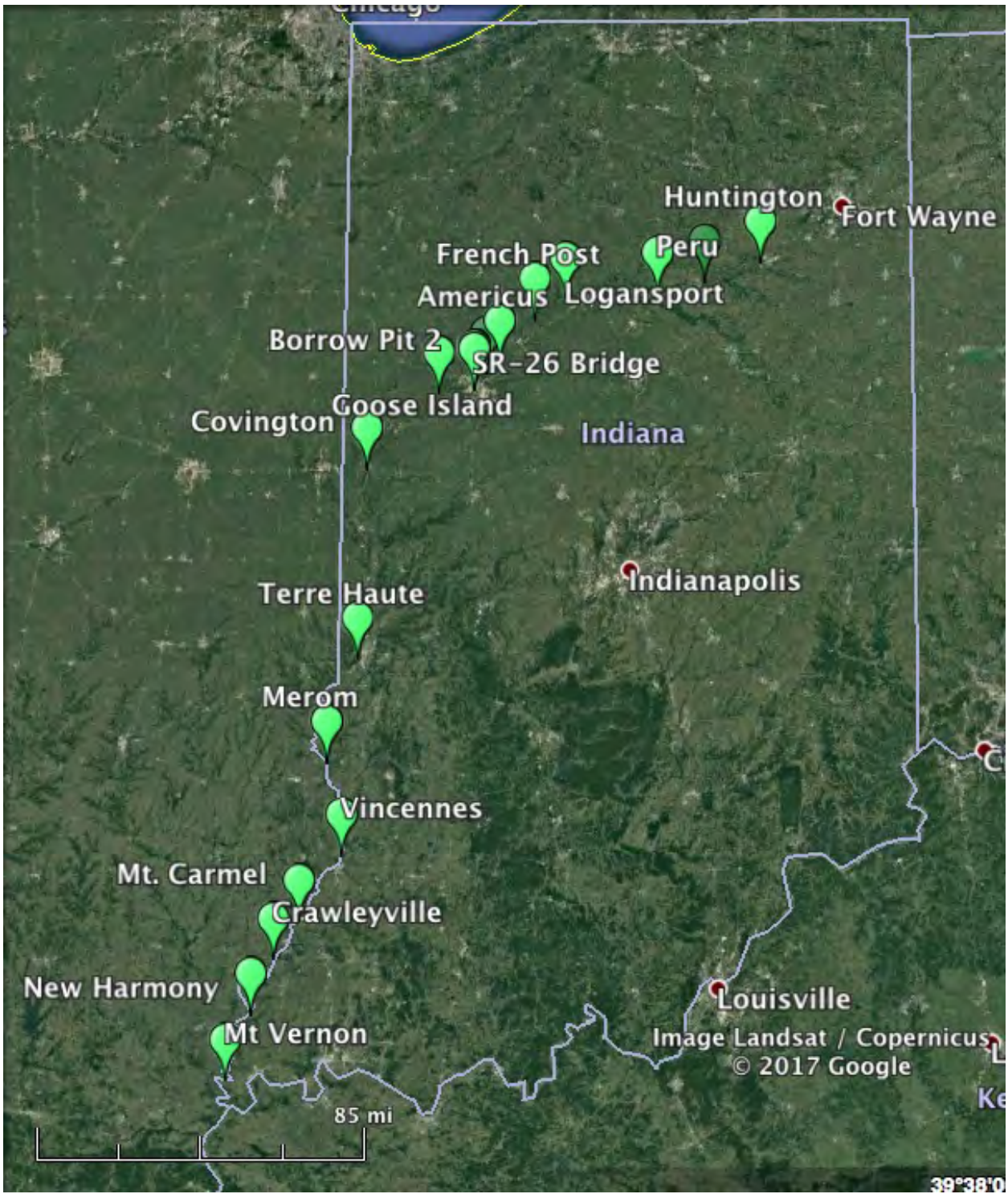

Figure 1. Locations of all Vemco VR2W stationary receivers deployed in the Wabash River mainstem from 2011 – 2016. Note: not all VR2Ws upstream of Wabash River Mile (WRM) 165.2 were deployed in 2016, and all VR2Ws downstream of WRM 213 were only deployed from July-November 2016.

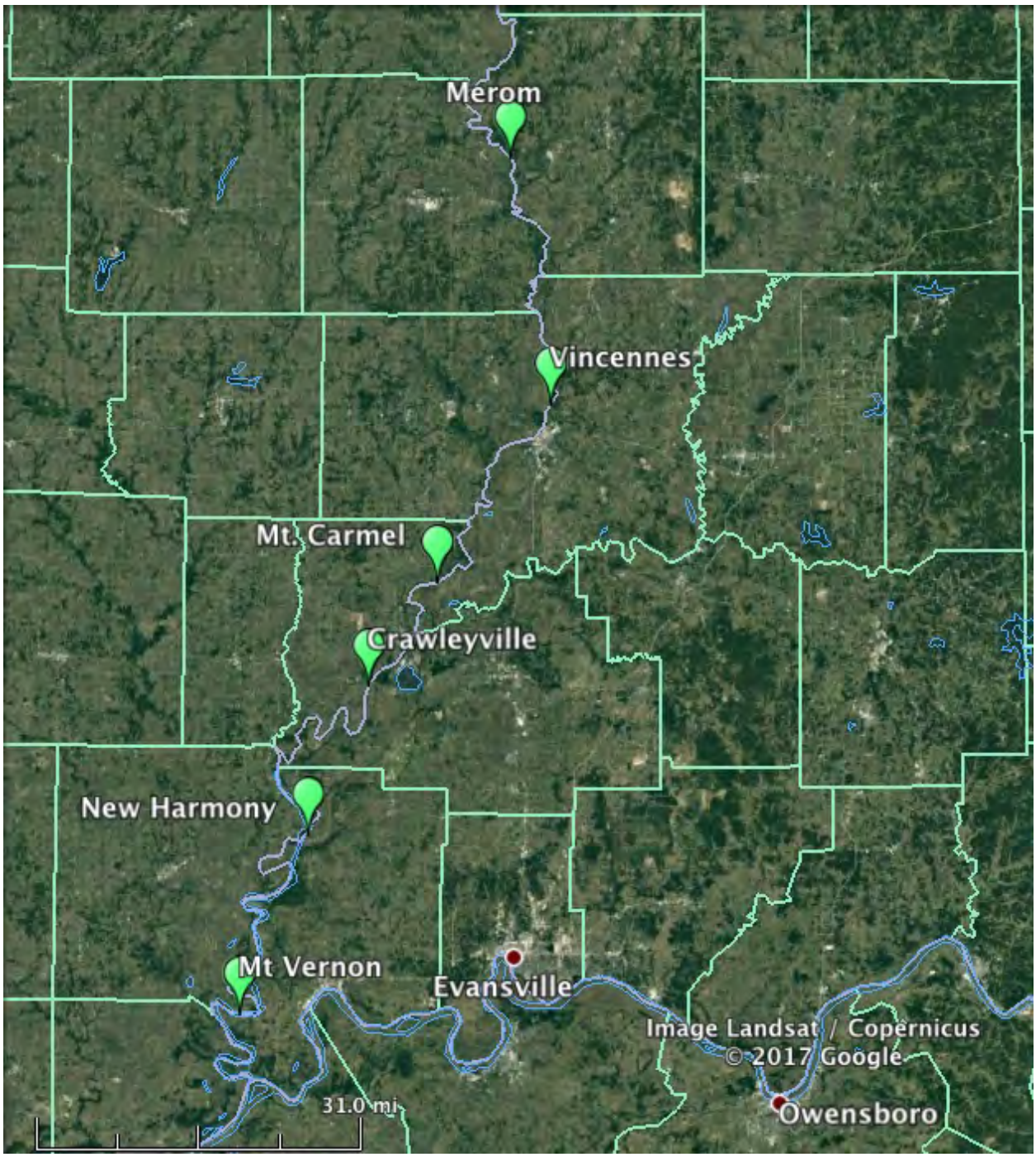

Figure 2. Locations of Vemco VR2W stationary receivers deployed in the lower Wabash River mainstem in 2016. Wabash River Mile (WRM) designations are provided for each deployment location.

end date (31-Jul-16) for a single retrieval attempt for each of the VR2Ws, and that was pushed to November 2016 to maximize deployment time for the VR2Ws.

Objective 3 - Conduct manual tracking surveys using a Vemco VR100 receiver in September and October 2015 to detect any tagged fishes at large between stationary receivers. Ideally, the river will be manually surveyed from Merom, IN, to the confluence with the Ohio River by conducting float trips once during each of these two months.

As previously discussed, the timeline for actionable funds in 2015 and unsafe, high water levels in May 2016 precluded the Goforth Lab's ability to achieve this goal. To enable the Goforth Lab to achieve this objective beyond the original project period, MICRA provided project extensions through July 2018, with the expectation that two complete float trips could be completed from September 2017 to July 2018. The first of these two float trips commenced 23-Oct-2018, starting at Wabash River Mile 165.2, the most upstream extent of the study area. Despite relatively low water conditions, this float trip continued to approximately Wabash River Mile 110.0 on 24-Oct-2018, at which time the steering cable for the outboard motor on the vessel used for the float trip broke after many impacts with submerged rocks. After limping back to the boat ramp, field personnel determined the damage to be completely irreparable in the field, and the float trip had to be cancelled. Were it not for this damage, a full float trip would have been completed during October 2017. No tagged fish were detected during this partial float trip.

The second float trip commenced on 08-May-18 at the most upstream location of the study area, and the field crew completed this full float trip on 10-May-18. No tagged fish were detected during this full float trip.

The Goforth Lab planned to complete a second full float trip by initiating a trip from the point at which the float vessel was damaged in October 2017 (approximately Wabash River Mile 110.0). This trip was planned for mid-June 2018, although near flood stage river conditions made the river unsafe for a float trip for the latter half of June 2018. Personnel were not available to make another attempt to complete this float trip prior to the 31-July-18 project end date. Thus, the Goforth Lab did not fully meet the objective to conduct two full float trips. It is again notable that the first float trip conducted in October 2017 would have resulted in complete coverage of the study area were it not for the heavy damage sustained under the relatively low water conditions.

Project Objective 4 - Measure water depth and estimate riverbed composition in the vicinity of fishes detected by manual tracking.

As discussed for *Project Objective 3*, manual tracking did not yield any detections, and so no water depths or riverbed compositions were assessed relative to manual telemetry detections.

Project Objective 5. - Determine the identity and source of any transmitter detections not matching those deployed in Asian carp by Purdue University.

Four of the six VR2Ws were retrieved from November 10-12, 2016 (WRM 19.3, WRM 69, WRM 131.2, and WRM 165.2). VR2Ws at WRM 56 and WRM 103.7 could not be located using grapples or SCUBA in November 2016. The Goforth Lab was equipped to try to recover the remaining two VR2Ws during the October 2017 float trip; however, the float vessel was damaged before these additional retrieval attempts could be made. River water conditions during the May 2018 float trip were judged to be unsafe for use of SCUBA to retrieve the remaining

two VR2Ws at that time. No non-Purdue transmitters were detected by the four retrieved VR2Ws.

Project Objective 6 - Integrate stationary and manual tracking detections of tagged fishes into the Wabash River Asian carp telemetry database maintained at Purdue University.

Four of the six VR2Ws were retrieved November 10-12, 2016; the two that were not retrieved (WRM 56 and WRM 103.7) could not be found using grapples or SCUBA. Although Goforth Lab personnel were equipped (i.e., SCUBA gear, including drysuits) to try to recover these two receivers during the October 2017 float trip, the float vessel was damaged beyond field repair before any retrieval attempts could be made. The remaining receivers covered the full study area (i.e., WRM 19.3 to WRM 165.2, ≈145.9 total river miles). The receivers at WRM 19.3 and WRM 69 yielded 1,361 and 776 pings, respectively, although there were no tagged fish detections recorded by these receivers.

The receiver at WRM 131.2 recorded 6,638 pings, including eight detections for a single Silver Carp of unknown sex that was tagged as an adult (total length [TL] = 737 mm at the time of tagging) using a Vemco V16-4H 69 Hz individually coded acoustic transmitter (#A69-9001-31621) in the upper-middle Wabash River in summer 2011. Three of these detections occurred on 06-Aug-16 and the remaining five detections occurred on 16-Aug-16 (Table 1). Although the overall number of detections for this fish was low, the frequency of detections on both days (i.e., 1-10 min apart) suggested that these were actual detections of the tagged fish as opposed to Type B false detections (Simpfendorfer et al. 2015). This is the widest ranging Silver Carp in the Wabash River known to date, with detections spanning just over 241 total river miles. Interestingly, this fish was largely sedentary from 27-Mar-12 through 31-Aug-13, remaining largely within a borrow pit backwater at WRM 312.5 for most of that period. However, it was detected at downstream receivers in September 2013, including the most downstream receiver of our original receiver array at WRM 213 and was not observed again until the August 2016 detections.

The receiver at WRM 165.2 recorded 28,417 pings, including 53 total detections of two Silver Carp of unknown sex that were tagged in the upper-middle Wabash River in spring 2013. Fifty-two of these detections were for one of the two tagged Silver Carp (Vemco tag # A69-9001-29204) and occurred over a 6.5 hr period on 06-Sep-16. These detections were recorded at intervals ranging from 1 min to 35 min, with most occurring at intervals <10 min. The pattern of detections suggested that the fish was moving in and out of detection range during the 6.5 hr period. This adult Silver Carp (TL = 723 mm at the time of tagging) was tagged in spring 2013 and exhibited detections that were restricted to the upper-middle Wabash River (WRM 293 to WRM 325.5) from 12-Apr-13 through 08-Apr-16 (Table 2). Notably, this fish was detected in the upper-middle Wabash River at WRM 323 on 16-Sep-16. This reflects a movement of this fish nearly 160 river miles upstream in 10 days, the largest movement rate for any fish in the Purdue University Wabash River Asian Carp Telemetry Database to date.

Table 1. All detections for an adult Silver Carp (*Hypophthalmichthys molitrix*) tagged with a Vemco V16-4H 69 Hz individually coded acoustic transmitter (transmitter #31621) in the upper-middle Wabash River in summer 2011. Detections of this fish in the lower Wabash River near Vincennes, IN, are indicated in gray.

Fish ID	Date(s)	Location Name	River Mile
	7/15/11 - 7/16/11	Borrow Pit 1	293
	8/25/11	Peru, IN	359
	8/25/11	French Post Park	325.5
	8/26/11	Americus, IN	303
	8/26/11	I-65 Bridge	297.5
	8/27/11	I-65 Bridge	297.5
	8/27/11	French Post Park	325.5
	3/27/12 - 4/2/12	Borrow Pit 1	293
	12/11/12 - 12/25/12	Borrow Pit 1	293
	12/28/12 - 1/25/13	Borrow Pit 1	293
	1/27/13 - 2/7/13	Borrow Pit 1	293
	2/9/13 - 2/14/13	Borrow Pit 1	293
	2/16/13 - 2/25/13	Borrow Pit 1	293
	2/28/13 - 3/24/13	Borrow Pit 1	293
	3/26/13 - 4/11/13	Borrow Pit 1	293
31621	4/16/13 - 4/20/13	Borrow Pit 1	293
	4/24/13 - 5/1/13	Borrow Pit 1	293
	5/4/13	Borrow Pit 1	293
	5/6/13 - 5/7/13	Borrow Pit 1	293
	5/9/13 - 6/1/13	Borrow Pit 1	293
	6/2/13 - 6/3/13	Americus, IN	303
	6/3/13 - 6/11/13	Borrow Pit 1	293
	6/13/13 - 6/30/13	Borrow Pit 1	293
	6/16/13 - 6/17/13	Borrow Pit 2	292.5
	7/10/13 - 8/1/13	Borrow Pit 1	293
	8/3/13 - 8/12/13	Borrow Pit 1	293
	8/15/13 - 8/31/13	Borrow Pit 1	293
	9/2/13	Goose Island	281.5
	9/22/13	Terre Haute	189
	8/6/16	Vincennes	118
	8/16/16	Vincennes	118

Table 2. All detections for an adult Silver Carp (*Hypophthalmichthys molitrix*) tagged with a Vemco V16-4H 69 Hz individually coded acoustic transmitter (transmitter #A69-9001-29204) in the upper-middle Wabash River in summer 2013. Detections of this fish in the lower Wabash River near Merom, IN (River Mile 143), are indicated in gray.

Fish ID	Date(s)	Location Name	River Mile
	4/12/13 - 5/5/13	Borrow Pit 1	293
	5/7/13 - 5/13/13	Tippecanoe River	N/A
	5/14/13	Americus, IN	303
	10/10/13 - 10/12/13	I-65 Bridge	297.5
	12/29/13 - 1/24/14	Borrow Pit 1	293
	4/3/14	I-65 Bridge	297.5
	4/17/14	Americus, IN	303
	4/30/14 - 5/1/14	Americus, IN	303
29204	5/3/14	Americus, IN	303
	5/29/14	French Post Park	325.5
	6/9/14 - 6/10/14	French Post Park	325.5
	10/20/14	I-65 Bridge	297.5
	3/20/15	I-65 Bridge	297.5
	4/8/16	Borrow Pit 2	292.5
	4/8/16	Borrow Pit 1	293
	9/6/16	Merom, IN	143
	9/16/16	Americus, IN	303

The second tagged Silver Carp recorded on the VR2W deployed at WRM 165.2 (tag # A69-9001-29208, TL = 740 at the time of tagging) was only detected once. Vemco recommends that such single detections be disregarded as Type B false detections. It is included and interpreted here for the sake of completeness, although this detection should be considered with caution. This tagged fish has been detected extensively since it was tagged in spring 2013, with most detections occurring in Borrow Pit 1 at WRM 312.5 (Table 3). Consistent with the single detection at WRM 165.2, this fish was detected downstream of the borrow pit at WRM 297.6 in late summer/early fall 2015 and was then detected again in Borrow Pit 1 after the two downstream detections. This bears some resemblance to the fish's sudden detection at WRM 165.2 12 days after it was last detected in Borrow Pit 1, although this would have reflected a much larger movement than detected in 2015. Additional telemetry may reveal regular patterns of downstream-upstream movement by this individual, but it cannot be conclusively determined by the single detection in this study.

Project Objective 7 - Calculate improved total range, movement rate, and frequency of movement estimates for Asian Carp tagged in the Wabash River.

Detections of tagged fish in the lower Wabash River yielded the greatest total ranges for Silver Carp in the Wabash River to date. Fish 31621 was recorded as far upstream as WRM 359 and was detected as part of this study at WRM 118 for total range of 241.0 river miles. Prior to this, the greatest total range recorded for Silver Carp in the Wabash River was 222.8 river miles. Inclusion of these total ranges as part of the database yielded a mean (±1 standard deviation) total range for Wabash River Silver Carp as 51.6±55.5 river miles. This high standard deviation reflects the substantial variation in total ranges exhibited by tagged fish in the study. Many fish exhibited total ranges <16 river miles, and the occurrence of 19 fish moving >67 river miles reflect this high variation. While the movement rate of fish 29204 (10 river mi/day) was among the largest recorded for tagged Silver Carp in the Wabash River, it was smaller than the previously recorded movement rate by fish 31621 in 2011 (33.5 river mi/day). Most detections of tagged Silver Carp in the Wabash River are of fish in Borrow Pit 1 where they often remain for extended periods of time. Thus, despite occasional rapid movements by a few individuals in the database, movement rates of Silver Carp in the Wabash River are <1 river mile/day. The extremely small number of detections of tagged Silver Carp in the lower Wabash River precluded any analysis of movement frequency by these fish either as individuals or within the context of the larger Wabash River Silver Carp database.

Project Objective 8 - Map detections and associated habitat characteristics in the vicinity of the detections.

The detections and site characteristics can be mapped to the VR2W deployment locations included in Figures 1-2. Water depth at the time the receivers were retrieved and substrate types associated with the sites were as follows: WRM 19.3 (3.0 m, shifting sand), WRM 56 (2.1 m, shifting sand), WRM 69 (5.5 m, shifting sand), WRM 103.7 (3.4 m, shifting sand), WRM 131.2 (2.1 m, shifting sand), and WRM 165.2 (2.1 m, shifting sand).

Project Objective 9 - Provide MICRA with interim and final performance and financial reports in accordance with reporting requirements outlined in Section VII below.

This document serves as the final performance report and a final financial report has been submitted to MICRA separately. An interim report was not submitted due to the substantial

Table 3. All detections for an adult Silver Carp (*Hypophthalmichthys molitrix*) tagged with a Vemco V16-4H 69 Hz individually coded acoustic transmitter (transmitter #A69-9001-29208) in the upper-middle Wabash River in spring 2013. Detections of this fish in the lower Wabash River as part of this study are indicated in gray.

Fish ID	Date(s)	Location Name	River Mile
29208	5/28/13 - 5/29/13	I-65 Bridge	317
	4/11/13	Borrow Pit 1	312.5
	4/14/13 - 4/19/13	Borrow Pit 1	312.5
	4/21/13 - 4/27/13	Borrow Pit 1	312.5
	4/29/13 - 5/3/13	Borrow Pit 1	312.5
	5/7/13 - 5/9/13	Borrow Pit 1	312.5
	5/11/13 - 5/28/13	Borrow Pit 1	312.5
	6/2/13	Americus, IN	323
	6/4/13	Borrow Pit 1	312.5
	6/6/13 - 6/7/13	Borrow Pit 1	312.5
	6/9/13 - 6/11/13	Borrow Pit 1	312.5
	6/13/13 - 6/19/13	Borrow Pit 1	312.5
	6/21/13 - 6/29/13	Borrow Pit 1	312.5
	7/1/13 - 7/4/13	Borrow Pit 1	312.5
	7/6/13 - 7/7/13	Borrow Pit 1	312.5
	7/12/13 - 7/15/13	Borrow Pit 1	312.5
	7/17/13 - 7/30/13	Borrow Pit 1	312.5
	8/1/13 - 8/2/13	Borrow Pit 1	312.5
	8/7/13	Borrow Pit 1	312.5
	8/9/13 - 8/12/13	Borrow Pit 1	312.5
	8/17/13 - 8/23/13	Borrow Pit 1	312.5
	8/25/13 - 9/4/13	Borrow Pit 1	312.5
	9/10/13 - 9/16/13	Borrow Pit 1	312.5
	9/18/13	Borrow Pit 1	312.5
	9/21/13 - 9/29/13	Borrow Pit 1	312.5
	10/1/13 - 10/7/13	Borrow Pit 1	312.5
	10/9/13	Borrow Pit 1	312.5
	10/11/13 - 10/27/13	Borrow Pit 1	312.5
	11/5/13 - 11/13/13	Borrow Pit 1	312.5
	11/17/13 - 11/30/13	Borrow Pit 1	312.5
	12/2/13 - 12/9/13	Borrow Pit 1	312.5
	12/11/13 - 12/15/13	Borrow Pit 1	312.5
	12/17/13 - 1/14/14	Borrow Pit 1	312.5
	1/16/14 - 3/2/14	Borrow Pit 1	312.5

Table 3. *cont.*

Fish ID	Date(s)	Location Name	River Mile
29208	3/4/14 - 4/22/14	Borrow Pit 1	312.5
	4/29/14	Borrow Pit 1	312.5
	5/2/14 - 5/3/14	Borrow Pit 1	312.5
	5/12/14 - 5/15/14	Borrow Pit 1	312.5
	5/17/15 - 5/28/14	Borrow Pit 1	312.5
	6/2/14 - 6/17/14	Borrow Pit 1	312.5
	6/19/14 - 7/2/14	Borrow Pit 1	312.5
	7/8/14	Borrow Pit 1	312.5
	8/23/14 - 9/13/14	Borrow Pit 1	312.5
	9/15/14	Borrow Pit 1	312.5
	9/17/14 - 10/12/14	Borrow Pit 1	312.5
	3/23/15	Goose Island	297.6
	3/26/15 - 3/28/15	Borrow Pit 1	312.5
	3/31/15	Borrow Pit 1	312.5
	4/2/15	Borrow Pit 1	312.5
	4/9/15 - 4/11/15	Borrow Pit 1	312.5
	4/13/15 - 4/24/15	Borrow Pit 1	312.5
	4/26/15 - 4/30/15	Borrow Pit 1	312.5
	5/4/15	Borrow Pit 1	312.5
	5/11/15 - 5/13/15	Borrow Pit 1	312.5
	5/15/15	Borrow Pit 1	312.5
	5/17/15	Borrow Pit 1	312.5
	5/20/15	Borrow Pit 1	312.5
	5/23/15 - 5/26/15	Borrow Pit 1	312.5
	5/28/15 - 6/3/15	Borrow Pit 1	312.5
	6/7/15	Borrow Pit 1	312.5
	6/11/15 - 6/17/15	Borrow Pit 1	312.5
	6/18/15	Borrow Pit 2	312.2
	6/21/15 - 6/27/15	Borrow Pit 1	312.5
	6/30/15	Borrow Pit 1	312.5
	7/2/15 - 7/9/15	Borrow Pit 1	312.5
	7/11/15 - 8/14/15	Borrow Pit 1	312.5
	7/16/25	Borrow Pit 2	312.2
	8/16/15	Borrow Pit 1	312.5
	8/18/15 - 8/20/15	Borrow Pit 1	312.5
	8/30/15	Borrow Pit 1	312.5
	8/31/15	Goose Island	297.6
	9/3/15	Goose Island	297.6
	9/4/15 - 9/12/15	Borrow Pit 1	312.5
	9/15/15 - 9/21/15	Borrow Pit 1	312.5

Table 3. *cont.*

Fish ID	Date(s)	Location Name	River Mile
29208	3/4/14 - 4/22/14	Borrow Pit 1	312.5
	4/29/14	Borrow Pit 1	312.5
	5/2/14 - 5/3/14	Borrow Pit 1	312.5
	5/12/14 - 5/15/14	Borrow Pit 1	312.5
	5/17/15 - 5/28/14	Borrow Pit 1	312.5
	6/2/14 - 6/17/14	Borrow Pit 1	312.5
	6/19/14 - 7/2/14	Borrow Pit 1	312.5
	7/8/14	Borrow Pit 1	312.5
	8/23/14 - 9/13/14	Borrow Pit 1	312.5
	9/15/14	Borrow Pit 1	312.5
	9/17/14 - 10/12/14	Borrow Pit 1	312.5
	3/23/15	Goose Island	297.6
	3/26/15 - 3/28/15	Borrow Pit 1	312.5
	3/31/15	Borrow Pit 1	312.5
	4/2/15	Borrow Pit 1	312.5
	4/9/15 - 4/11/15	Borrow Pit 1	312.5
	4/13/15 - 4/24/15	Borrow Pit 1	312.5
	4/26/15 - 4/30/15	Borrow Pit 1	312.5
	5/4/15	Borrow Pit 1	312.5
	5/11/15 - 5/13/15	Borrow Pit 1	312.5
	5/15/15	Borrow Pit 1	312.5
	5/17/15	Borrow Pit 1	312.5
	5/20/15	Borrow Pit 1	312.5
	5/23/15 - 5/26/15	Borrow Pit 1	312.5
	5/28/15 - 6/3/15	Borrow Pit 1	312.5
	6/7/15	Borrow Pit 1	312.5
	6/11/15 - 6/17/15	Borrow Pit 1	312.5
	6/18/15	Borrow Pit 2	312.2
	6/21/15 - 6/27/15	Borrow Pit 1	312.5
	6/30/15	Borrow Pit 1	312.5
	7/2/15 - 7/9/15	Borrow Pit 1	312.5
	7/11/15 - 8/14/15	Borrow Pit 1	312.5
	7/16/25	Borrow Pit 2	312.2
	8/16/15	Borrow Pit 1	312.5
	8/18/15 - 8/20/15	Borrow Pit 1	312.5
	8/30/15	Borrow Pit 1	312.5
	8/31/15	Goose Island	297.6
	9/3/15	Goose Island	297.6
	9/4/15 - 9/12/15	Borrow Pit 1	312.5
	9/15/15 - 9/21/15	Borrow Pit 1	312.5

delay in initiating project activities. This was an oversight that will not occur again if additional funding is made available to the Goforth Lab via MICRA and/or USFWS.

Special Conditions and Provisions

No gillnetting was conducted as part of this project, and there are thus no non-species take to report.

Project Conclusions

Although the period during which the VR2W receivers were active was limited, there were no detections of tagged fishes to suggest interbasin movements of Asian Carp. This was further supported by the lack of detections during the partial and full float trips in October 2017 and May 2018, respectively. Of course, the float trips represented very limited periods during which tagged fish could be detected. However, the combined lack of detections by both stationary and active tracking suggested that interbasin movements are likely rare. Additional, longer-term telemetry efforts are needed to more definitively assess the frequency of interbasin movements by Asian carp.

Detections of three Silver Carp originally tagged in the upper-middle Wabash River indicated that movements occurred beyond the range included as part of an earlier telemetry study focused on that portion of the river. These three fish represent 1% of the 300 fish tagged from 2011-2013. While there has certainly been some tag loss prior to the current study (e.g., mortality and spent tag batteries), this remains a very small number of tagged fish detected in the Lower Wabash relative to the total number of tagged fish at large. This suggests that the large movements exhibited by these individuals are not likely representative of most Silver Carp. Still, these detections demonstrate the substantial movement abilities of at least some Silver Carp.

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Plate 1. Platforms constructed from 3/8” rebar for deploying Vemco VR2W stationary receivers in the lower Wabash River, Indiana.

Plate 2. Rebar platform and reinforced concrete anchor system for deploying Vemco VR2W stationary receivers in the lower Wabash River, Indiana.

Plate 3. Placing the upstream anchor as part of the platform-anchor system for deploying Vemco VR2W stationary receivers in the lower Wabash River, Indiana.

Plate 4. Placing the downstream platform as part of the platform-anchor system for deploying Vemco VR2W stationary receivers in the lower Wabash River, Indiana.

Appendix 3.

Revised Scope of Work for Sub-Award with West Virginia Division of Natural Resources

Project Summary

Title: Implementation of the Ohio River Asian Carp Control Strategy Framework

The U.S. Fish and Wildlife Service (USFWS) leads two different efforts to manage and control Asian carp populations in the United States (U.S.). These are Asian Carp Regional Coordination Committee's *Asian Carp Control Strategy Framework* for the Great Lakes and Chicago Area Waterway System, and the national *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States*. Through the Water Resources Reform and Development Act (WRRDA) of 2014, Congress directed the USFWS to lead multi-agency efforts to manage and control Asian carp populations in the Upper Mississippi River and Ohio River basins.

The Ohio River Basin Asian Carp Control Strategy Framework outlines actions to be implemented in the Ohio River and tributaries for prevention, monitoring and response, population control, understanding impacts, and communication to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carp. Implementing the Ohio River Basin Asian Carp Control Strategy Framework is intended to minimize the social, ecological, and economic impacts of these invasive fishes. The coordinated strategies outlined in Ohio River Basin Asian Carp Control Strategy Framework directly meet the goals, as specified by the United States Congress in Section 1039 (b) of WRRDA 2014, of controlling the spread of Asian carp in the Upper Mississippi and Ohio River basins and tributaries by carrying out activities designed to slow and eventually eliminate the threat posed by these species.

The Mississippi Interstate Cooperative Resource Association (MICRA) is a partnership of the 28 state fish and game agencies with management jurisdiction of the fishery resources in the Mississippi River Basin. MICRA provides a structure for inter-agency and inter-basin coordination and has organized an Asian Carp Advisory Committee to ensure communication between the relevant state and federal agencies and the different regional efforts in the Great Lakes, Upper Mississippi River, and Ohio River basins.

MICRA assisted the Ohio River Basin partners in the development of the Ohio River Basin Asian Carp Control Strategy Framework and is now assisting with the development and implementation of a 2015 Asian Carp Monitoring and Response Plan for coordinated implementation of the highest priority projects. This proposal includes project work plans for implementation of priority projects in the 2015 Asian Carp Monitoring and Response Plan for the Ohio River Basin. MICRA will provide the funding received for these projects (pass through) to the West Virginia Department of Natural Resources, Purdue University, and Ball State University to implement the seven projects described below. The proposed projects compliment additional 2015 Asian Carp Monitoring and Response Plan projects to be completed by partner agencies including USFWS, Kentucky Department of Fish and Wildlife Resources, Ohio Department of Natural Resources, and the Pennsylvania Fish and Boat Commission.

The four Ohio River Basin Asian Carp Control Strategy Framework projects to be funded by this proposal are:

- Monitoring and Response of Asian Carp in the Ohio River

- Control and Removal of Asian Carp in the Ohio River
- Ohio River Asian Carp Telemetry
- Ohio River Asian Carp Coordination and Outreach

Results of these projects will be directly reported to MICRA in progress and final technical reports. Reports will be shared with the USFWS, Upper Mississippi River and Great Lakes Basin regional Asian carp teams through MICRA. Reports will also be broadly disseminated via www.asiancarp.us. The results will be used by the Ohio River Basin partnership to inform design and implementation of future management actions identified in the Ohio River Basin Asian Carp Control Strategy Framework to slow and eliminate the threat posed by Asian carps in the Ohio River basins and tributaries.

Project Narratives (4)

Project (1) Title: Monitoring and Response of Asian Carp in the Ohio River

Location: Greenup and R.C. Byrd Pools

Project/Activity Explanation:
Although considerable effort has been expended to understand and mange Asian carp in the Mississippi River basin, focused activities have been to a lesser degree in the Ohio River sub-basin. The tasks outlined in this template will not only allow for the continuation of current information gathering tasks by both state and federal agencies within the Ohio River sub-basin, but will initiate a planning process that will guide expanded efforts in upcoming years. The major outcome of these activities will be to not only conduct on-river activities in a coordinated approach, but more importantly develop planning protocols for future activities that will enhance this collaborative approach though more efficient and effective methodologies.

Objectives:

- Conduct targeted sampling for surveillance, early detection, and distribution of Asian carp within the Greenup and R.C. Byrd Pools.
- Monitor Asian carp population dynamics in the Ohio River upstream of the Greenup lock and dam complex
- Determine whether Asian carp DNA is present in strategic locations in the Ohio River Basin to inform status of Asian carp population expansion.
- States augment protocols for existing annual fisheries surveys as needed to include collection, identification, data gathering and reporting of Asian carps.

Methods:
WVDNR will monitor Asian carp presence and distribution through electrofishing surveys. The Greenup and R.C. Byrd pools will be segmented into four macrohabitat types: island back channel, embayment, tailwater, and tributary. Monitoring will be conducted in Spring and Fall of 2015, and Spring 2016. Effort will be partitioned into upstream, middle and downstream thirds of each pool. The number of samples completed per day will be dependent on sampling conditions, fish densities, habitat types, and distance between sites. Sampling effort may be amended after the initial round of monitoring is completed.

Electrofishing based-techniques will use pulsed-DC current and include 1-2 dippers (two dippers preferred). Depending on distance traveled between sampling sites, the target number of sampling sites will be 6-9 per day.Each sampling transect will be identified with GPS coordinates, and each run will begin at the coordinate and continue downstream for 15 minutes. Transects of smaller tributaries will begin at the mouth and continue upstream until sample is completed or until navigation is blocked, at which the transect will be completed in the mainchannel downstream of the mouth. All fish will be dipped and placed in a live well. Schools of small shad will be sub-sampled by dipping a portion of each school encountered. Small shad-like fish will be examined closely to identify potential Asian carp. All fish will be identified and counted. During fall samples, all fish species will be measured and weighed to allow for evaluation of population characteristics.

All Asian carp collected will be inspected for the presence of tags (sonic and jaw tags), identified, geo-located, and subsamples of individual total lengths, total weights, and gonad weights will be recorded. Otoliths and pectoral fin rays will be removed from Asian carp for microchemistry and age and growth analysis as needed.

Environmental DNA (eDNA) analysis will be conducted in areas of the Ohio River basin upstream of the invasion front in an effort to detect any presence of lone Asian Carp. This information can provide a tool for early detection surveillance and to identify distribution patterns of DNA when the fish are low in abundance. The WVDNR will assist partner agencies with the collection of water samples in the upper pools of the Ohio, Allegheny, and Kanawha rivers.

The WVDNR routinely samples the Ohio River as part of related projects. Where possible, these sampling protocols will be modified to include collection of Asian carp (all size classes). When Asian carp are encountered, they will be enumerated. These data will be compiled in final reports as well as the dedicated Asian carp monitoring.

Table 1. WVDNR 2015 fish surveys scheduled on the Ohio River and associated tributaries.

Location	Targeted Species	Time of Year	Gear	Effort Days
Ohio River (select WV Reach tailwaters)	Catfish	May and June	Electrofishing	8
Ohio River (select WV Reach Pools)	Black Bass	Fall	Electrofishing	10
Ohio River (select WV Reach tailwaters)	Percids	Spring and Fall	Electrofishing	8
Kanawha River	Percids	Spring and Fall	Electrofishing	3

Deliverables:

- Data will be compiled and provided to lead agencies for annual reports and updated project plans which will include sampling efficiency, relative abundance and spatial distribution of Asian carp and other fish species in the Ohio River above Cannelton Lock and Dam.
- State agency annual reports on sport fish population characteristics,
- Community assemblage/density data for select Ohio River pools.
- Summary information will be provided for inclusion in the Ohio River Asian carp communication program.

Project (2) Title: Control and Removal of Asian Carp in the Ohio River

Location: Greenup and R.C. Byrd Pools

Project/Activity Explanation:
Eradication of invasive species after establishment is difficult. Asian carp removal efforts may be effective at slowing the upstream expansion of Asian carp. Diverse and consistent removal efforts in the portion of the Ohio River where Asian carp are established will limit distribution of Asian carp, decrease pressure on defined barriers, and reduce numbers of Asian carp in sensitive areas such as to protect species of conservation need or important sport fisheries. Removal efforts will also complement monitoring efforts to further understand the status, distribution, and biology of Asian carp in the Ohio River. This data will provide an assessment tool which will guide monitoring, barrier defense, and removal efforts in future years. Removal efforts of fish encountered above the "leading edge" are increasingly difficult at low population densities. WVDNR will employ radio telemetry and eDNA research to guide removal efforts in the pools above the leading edge.

Objectives:
- Remove Asian carp from WV jurisdiction pools upon receipt of credible evidence of fish presence (i.e. telemetry detection, consistent positive eDNA results, angler reports).
- Provide information and data to monitoring and response efforts.

Methods:
WVDNR will mobilize a research team to conduct both electrofishing and gill netting upon receipt of credible evidence of the presence of Asian carp (consisting of telemetry detections and/or active tracking of individual fish, consistent positive eDNA results in certain areas, and/or credible/validated angler reports), WVDNR will deploy surveys in the assumed location of the Asian carp in an attempt to locate the fish. Specific sampling sites and number of sites will be dependent upon staff availability, sampling conditions,

Large mesh (3.0" – 5.0") gill nets will be used and each set will consist of 30 minutes of soak time with fish being driven to the nets by electrofishing boats and/or boat noise. Nets may be set overnight in some areas. Boat electrofishing may be employed in conjunction with gill nets where applicable. Staff will enumerate and record the catch of Asian carp and identify by-catch to species. Fish previously inserted with a telemetry transmitter and by-catch will be returned live to the water (tagged fish caught above R.C. Byrd dam will be returned to a location downstream of the dam). All other Asian carp will be exterminated. Lengths and weights will be taken when applicable. Supplemental samples including gonad weights, aging structures, and genetic samples will be collected as needed.

Deliverables:
- Summary information included in the Ohio River Asian carp communication program and be shared with participating agencies.
- Data will be compiled for annual reports and updated project plans.

Project (3) Title: Ohio River Asian Carp Telemetry

Location: The Ohio River from below the McAlpine Lock and Dam near Louisville, KY, upstream to Broadback Island near the Town of Willow Island, WV. WVDNR will be responsible for the telemetry project from the Kentucky-West Virginia Stateline upstream to the Willow Island pool.

Project/Activity Explanation:
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. The probability of Silver and Bighead Carp spreading to previously uncolonized areas is considered high.

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) and their populations have grown exponentially. Asian carp have been shown to exhibit very high reproductive potentials with high fecundity and the potential for a protracted spawning period. Populations of Asian carp have become well established in the lower and middle reaches of the Ohio River and successful reproduction is suspected 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.

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. 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.

Objectives:
- Understand Asian carp use of tributaries.
- Delineate the upstream-most distribution of Asian carp and potential for further upstream movement.
- Utilize mobile tracking data and Judas fish techniques to guide contract fishers and agency sampling efforts.

Methods: WVDNR will aid USFWS in all aspects of this project including, but not limited to: collecting and implanting new fish with tags, deploying and pulling stationary receivers, downloading and sharing data from stationary receivers, active mobile tracking, purchasing of new equipment and supplies, and reporting new or significant detections to participating agencies.

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.

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 may be used to supplement netting efforts. 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. Fish to be tagged will be collected by WVDNR staff from the Greenup pool. 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).

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, and at regular intervals between lock and dams. Receivers will be re-deployed into the mainstem river during spring and summer months. In 2015, additional receivers were placed in the approach to each lock chamber on the upstream side of the lock and in each lock chamber (mounted behind recessed ladders). 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.

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.

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.

Deliverables:

- Status reports covering any urgent and significant findings will be shared among partner agencies as soon as possible following the finding.
- An annual report summarizing all work will be produced by USFWS.

Project (4) Title: Ohio River Asian Carp Coordination and Outreach

Location: Ohio River sub-basin

Project/Activity Explanation:
Every program requires a successful communications effort. There are many examples of successfully executed projects that were not effectively communicated to the appropriate audiences. The collaborative Mississippi River basin Asian carp field efforts conducted by multi-agency work groups have been coordinated effectively. Communication of project results between these groups will be achieved through inter-agency efforts outlined in associated templates. The focus of this template is to enhance effective communication between and amongst state and federal agencies, and the public, as well as elected officials.

The ORFMT member states and other ORB partners have conveyed the issues concerned with Asian carp on a limited basis. Future communications strategies will operate on two fronts. First, interagency communication must be effective to aid in field related activities. This will be accomplished through efforts associated with directed project templates. The second effort will be to develop collaborative outreach messages and approaches. These efforts will focus on the success of field work that is ongoing, future goals and strategies of Asian carp monitoring, prevention, and control. This will be achieved through a communication plan developed by a working group of both biologists and communication specialists and overseen by the ORFMT member states, the USFWS, and ORB partners.

Objectives:

- Gather information and direction from ORFMT and ORB partners for development of an Ohio River basin Asian carp communications plan;
- Develop a Ohio River basin Asian carp communications plan for ORFMT and ORB partner review that clearly defines:
  i. Communication objectives ,
  ii. Target audiences,
  iii. Key messages for specific target audience,
  iv. Best communications tools and activities for each target audience,
  v. Human and financial resources to implement tools and activities,
  vi. Expectations and timetables for implementation, and
  vii. Evaluation processes.
- Create a working group for communications among partner agencies
- Identify a field level working group for communications and planning among partner agencies.
- Develop web content as requested by ORFMT or identified in the Ohio River basin Asian carp communication plan for posting on www.Asiancarp.us

Methods:
WVDNR will provide assistance to KDFWR in all aspects of this project.
Initially, a communication workgroup will be created among partner agencies. This working group may be extended to include representatives from ORFMT member states and ORB partners. This work group will consist of both natural resources and communication

professionals. ORFMT and ORB partners will identify information needs and elements for a communication plan.. An Ohio River basin Asian carp communications plan will be drafted.. Ohio River communications work group will also develop web content for posting on www.Asiancarp.us

Deliverables:

- Formation of a communication workgroup of both natural resources and communication professionals.
- Draft of Asian Carp Communication Plan outline which will include information needs and elements of a comprehensive communication plan.

WVDNR Organizational Structure

Project Leader:	Chris O'Bara/Katherine Zipfel
Technical Leader:	Katherine Zipfel
Field Crew:	District Biologists, Assistant Biologists, seasonal laborers
ORFMT Representative:	Bret Preston
Ohio River Asian Carp Working Group:	Chris O'Bara & Katherine Zipfel

Budget Justification

The following budget narrative breaks down the proposed budget in more detail. All funding to MICRA will be passed through to sub-contractors. Proposed budget is based on estimates for completion of the sub-recipients individual projects.

Personnel: $15,267

Project Leader	26 weeks @ 4 hours / week	$24.04 / hour	$2500
Project Leader	52 weeks @ 10 hours/week	17.50/ hour	$9100
Technical Leader	26 weeks@ 9 hours/week	$15.67 / hour	$3667

Fringe: $2,866

Project Leader	18.76%	$2500	$469
Project Leader	18.78%	$9100	$1709
Technical Leader	18.76%	$3667	$688

Travel: $3,720

Targeted sampling related to the proposed Monitoring and Response and Control and Removal projects will require extensive travel from the West Virginia Department of Natural Resources Field Office in Parkersburg, West Virginia, to numerous sites along the upper Ohio River in the Greenup, R.C. Byrd, Racine pools. One week of electrofishing sampling (three days/week) will be completed during each monitoring sampling period in the Greenup and R.C. Byrd pools in spring and fall, for an estimated 12 field trips. Most field work will require round trip travel each day. Total estimated mileage for the proposed sampling is approximately 3,585 miles.Total mileage at the GSA rate (0.54 cents/mile) is estimated at $1936.

Two proposed trips related to the eDNA portion of the Monitoring and Response Project will require overnight travel to the upper Ohio River pools. Estimated travel costs for a 4 day/3 night trip for one person is estimated at $433/trip. Mileage is estimated at 450 miles per trip, for a total of 900 miles. Two additional sampling events will require round trip travel each day. Mileage for these trips is estimated at 400 miles per trip, for a total of 800 miles. Total estimated costs for four field sampling trips for eDNA collection are estimated at $1784.

Equipment: No federal owned equipment will be used or purchased to complete this project.

Supplies: $1,996

An estimated 200 gallons of unleaded gasoline will be purchased for operation of outboard motors and generators during this project. Total estimated fuel cost is $500 ($2.50/ gallon).

Supplies for building hangers to deploy telemetry receivers will be purchased and assembled. This includes steel rods, steel pipe, and hardware. Total cost is $1159. Storage containers for gill nets previously purchased will be obtained. Total cost is $337.

Contractual: $0

Construction: $0

Total Direct Cost: $23,849

Indirect Cost: $1,192

$23,849 x 5% = $1,192

Total Project Costs: $25,041

Appendix 4.

Project Completion Report Prepared by West Virginia Division of Natural Resources

West Virginia Division of Natural Resources –
Final Report

FINANCIAL AGREEMENT # MICRA-15-001

Reporting Period: August 1, 2015 through July 31, 2016

Pertaining to:

The financial agreement between the Mississippi Interstate Cooperative Resource Association and the West Virginia Division of Natural Resources for the Implementation of the Ohio River Basin Asian Carp Strategy Framework.

Project Summary

The West Virginia Division of Natural Resources (WVDNR) has been active in conducting and participating in activities associated with implementation of the Ohio River Basin Asian Carp Control Strategy Framework (Framework). This Framework was developed with the guidance of the Mississippi Interstate Cooperative Resource Association (MICRA) and is considered a step-down plan of the National Asian Carp Control Framework and is intended to compliment the additional regional Asian Carp Control and Response Plans and projects there-in. The Framework outlines actions to be implemented in the Ohio River and associated tributaries for prevention, monitoring and response, population control, understanding impacts, and communication to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carp in the basin. Implementing the Framework is intended to minimize the social, ecological, and economic impacts of these invasive fishes. The coordinated strategies outlined in the Framework directly meet the goals, as specified by the United States Congress in Section 1039 (b) of WRRDA 2014, of controlling the spread of Asian carp in the Upper Mississippi and Ohio River basins and tributaries by carrying out activities designed to slow and eventually eliminate the threat posed by these species.

WVDNR staff has coordinated with other Ohio River Basin state and federal agencies (Table 1) on planning for Ohio River Basin Asian Carp control activities. During the reporting period, WVDNR was a co-lead and/or a participating agency in the implementation of five projects within the Framework. These projects compliment additional Framework projects completed by partner agencies. The five Framework projects that will be included in this progress report are:

1. Monitoring and Response of Asian Carp in the Ohio River
2. Control and Removal of Asian Carp in the Ohio River
3. Distribution, Movement, and Lock and Dam Passage of Asian carp in the Ohio River Through Acoustic Telemetry
4. Ohio River Asian Carp Coordination and Outreach.

These activities included on-river tasks to document the current extent of Asian carp in the Ohio River and associated large tributaries, as well as monitor fish community population status. WVDNR worked particularly close with both Kentucky Department of Fish and Wildlife Resources (KDFWR) and the U.S. Fish and Wildlife Service (USFWS) on completing these projects.

1. Monitoring and Response of Asian Carp in the Ohio River

Lead Agency: KDFWR, WVDNR, USFWS

Participating agencies: USFWS, Indiana Department of Natural Resources (INDNR), Ohio Department of Natural Resources (ODNR), Pennsylvania Fish and Boat Commission (PAFBC), Tennessee Wildlife Resources Agency (TWRA)

Introduction and Need:

Assembling information on the distribution and habitat use of Asian carp provides an assessment tool that informs Asian carp prevention, removal, and response efforts. In addition, this information aids in determining impacts of carp on native fish assemblages in the Ohio River drainage. While some research is available about Asian carps in their native waters, there is relatively little information about their introduced range in the Ohio River. The tasks outlined in this project will not only provide valuable information on Asian carp distribution and habitat use in the ORB, but also provide a coordinated approach to the development of sampling protocols for monitoring select pools in the Ohio River. Assembling information on the distribution and habitat use of Asian carp provides an assessment tool that will direct actions from state and federal agencies in the ORB. In addition, this information may aid in determining impacts of invasive carp on native fish assemblages in the Ohio River drainage and could provide information for removal efforts and potential barrier placements.

Environmental DNA (eDNA) is a surveillance tool used to monitor for the genetic presence of an aquatic species. Currently, eDNA is used to monitor for the genetic presence of Bighead carp and Silver carp. Bighead and Silver Carp are traditionally difficult to catch using traditional sampling gears, especially in low population numbers. By sampling waters that could potentially be invaded by these species, the detection of their DNA can indicate the potential presence of the fish itself.

In the Ohio River Basin, eDNA surveillance is being used as an early detection tool to help define the upstream extent of Bighead and Silver Carp population invasion when the fish are low in abundance. This tool can also be useful to help identify high-priority areas for targeted fish sampling and removal efforts.

National Plan Goal Supported:

Goal 3.2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.5. Provide information to the public, commercial entities, and government agencies to improve effective management and control of bighead, black,

grass, and silver carps in the United States.

Goal 3.6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of bighead, black, grass, and silver carps in the United States.

Goal 3.7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass and silver carps in the United States.

National Plan Strategy Supported:

Strategy 3.2.3. Minimize the range expansion and ecological effects of feral populations of Asian carps in conjunction with management actions to enhance aquatic environments for the sustainability of native biological communities.

Strategy 3.2.4. Forecast, detect, and rapidly respond to new feral Asian carp introductions and range expansions.

Strategy 3.2.6. Develop an information exchange network for agencies, organizations, and partners to communicate and share "real time" data to facilitate early detection and rapid response programs.

Strategy 3.3.1. Determine life history characteristics and build population dynamics models of Asian carps in the Mississippi River Basin.

Strategy 3.6.2. Assemble information about the distribution, biology, life history, and population dynamics of bighead, black, grass, and silver carps.

Strategy 3.6.5. Determine the demonstrated and probable ecological and economic effects of Asian carps in the United States and determine the degree to which these effects are negative.

Sub-basin Management Plan Goal Supported:

2. Monitoring and Response

4. Understanding Impacts

Sub-basin Management Plan Strategy Supported:

2.2 State agencies of the Ohio River basin continue, or initiate, annual fisheries monitoring programs for the Ohio River and its tributaries to serve as an additional means of surveillance.

2.3 Implement a program of surveillance surveys targeting Asian carp to monitor their upstream range expansion as well as monitor changes of their distribution and abundance.

2.4 Survey areas upstream of McAlpine Lock and Dam complex to enhance surveillance and early detection capabilities.

2.6 Use eDNA testing to guide early detection efforts.

2.8 Support research to improve capabilities to detect early stages of invasion and spawning populations of Asian carp.

4.1 Conduct collaborative inter-agency research to measure the distribution, movement, and habitat use of Asian carp in the middle Ohio River.

Objectives:

1. Conduct targeted sampling for the purpose of surveillance, early detection and distribution, and relative population characteristics of Asian carp in the Ohio River.
2. Conduct community surveys in order to monitor fish populations in the Ohio River.
3. Determine whether Asian carp DNA is present in strategic locations in the Ohio River Basin to inform status of Asian carp.
4. Compile and incorporate additional data from other state and federal entities on Asian carp and fish communities in the Ohio River.
5. 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.
6. States augment protocols for existing annual fisheries surveys as needed to include collection, identification, data gathering and reporting of Asian carps.

Methods:

Targeted Asian Carp Sampling and Community Surveys

WVDNR performed targeted monitoring samples for Asian carp presence and distribution and community assemblages in the Greenup and R.C. Byrd Pools in Fall 2015 and Spring 2016. The Greenup and R.C. Byrd pools were segmented into four macrohabitat types: island back channel, embayment, tailwater, and tributary. Sampling sites were generated randomly using the four habitat types and marked with GPS coordinates. Sampling effort was focused on sampling all habitat types.

Pulsed DC boat-mounted electrofishing surveys (2 dippers) were completed during the day. Surveys consisted of 15-minute timed transects beginning at the marked coordinates and continued downstream in the mainstem river and large tributaries. Surveys of small tributaries and embayments began at the marked coordinates and continued upstream to the completion of the timed transect, or until navigation was blocked, upon which the remainder of the timed transect was completed in the main channel just downstream of the mouth. The number of samples completed per day varied and was dependent on sampling conditions, fish densities, habitat types, and distance between sites.

All fish collected were identified to species and enumerated to collect community assemblage information. Fish collected in the fall were also measured for total length (mm) and weighed

to the nearest gram (g) to evaluate fish condition. Schools of small fish (minnows and shad) were sub-sampled by dipping a portion of each school encountered. Small shad-like fish will be examined closely to identify potential Asian carp. Any Asian carp collected were to be inspected for the presence of tags (sonic and jaw tags), identified, geo-located, and subsamples of individual total lengths, total weights, and gonad weights were to be recorded. Otoliths and pectoral fin rays were to be removed from Asian carp for microchemistry and age and growth analysis as needed. Data analysis included total abundance (CPUE as no. per hour) and condition (Wr; where applicable) estimators.

Determine whether Asian carp DNA is present in strategic locations in the Ohio River Basin to inform status of Asian carp

Samples were taken from the top 4 cm of surface waters in areas of surface film accumulation such as in eddies, foamy areas, downstream of structures, and in backwaters. Wind direction and currents were taken into consideration when selecting sampling locations. Depth, wind direction, water temperature, and geographic coordinates in decimal degrees were measured and recorded at every sample location. Samples were processed according to USFWS protocols for eDNA collection. USFWS was responsible for analyzing samples and reporting and sharing data. Results were uploaded to the USFWS-Midwest Region website (https://www.fws.gov/midwest/fisheries/eDNA.html).

eDNA has not been predesignated to be used as a trigger for rapid response actions. eDNA results will be communicated to the states in which they are collected as soon as they are available, and then posted on the USFWS eDNA webpage per USFWS communication protocol. States can request follow up eDNA sampling, and take actions based on their results as their discretion, potentially enlisting the assistance of the USFWS. A summary of all eDNA results will be made available by USFWS at the end of each year.

Compiling additional Ohio River sampling data

Where possible data collected by other agencies/companies conducting fish surveys on the Ohio River were collected and compiled.

Adjusting the Monitoring Protocol

The Monitoring Protocol established in 2015 was followed and any needed changes and adjustments were noted for future sampling efforts.

Annual Sportfish Surveys

The WVDNR routinely samples the Ohio River as part of related sportfish monitoring projects. Where possible, these sampling protocols were modified to include collection of Asian carp (all size classes). If Asian carp were encountered, they were to be enumerated.

Results:

Targeted Asian Carp Sampling and Community Surveys

Approximately 13 hours of electrofishing effort was expended during the reporting period. Surveys yielded data from 43 species of fish (Table 2). No Bighead or Silver carp were collected. One grass carp was collected in Symmes Creek, OH in the Greenup Pool. Spring surveys yielded a greater diversity of species and numbers (excluding data from Emerald Shiners and Gizzard Shad). Catch rates were highest for Emerald Shiners, Gizzard Shad, Smallmouth Buffalo, Longnose Gar, and Freshwater Drum. Average relative weights for applicable species ranged from 85 to 112 (Table 4). Detailed results for the entire Ohio River Basin can be found in the Monitoring and Response project report of the FY 2016 Framework.

Determine whether Asian carp DNA is present in strategic locations in the Ohio River Basin to inform status of Asian carp

WVDNR staff spent eleven man days assisting USFWS crews conducting eDNA surveys in the Willow Island, New Cumberland, Montgomery, and Dashields pools of the Ohio River (October 2015, May 2016), as well as the London Pool of the Kanawha River and the Little Kanawha River (both major tributaries of the Ohio River; June 2016). There were several sample sites that tested positive for Bighead and Silver Carp DNA in the 2015 samples, but no sample sites in 2016 tested positive. Full details about the Asian Carp eDNA project and detailed results can be found at: https://www.fws.gov/midwest/fisheries/eDNA.html.

Compiling additional Ohio River sampling data

Data from the Ohio River Sanitation Commission's (ORSANCO) annual biotic assessments were collected and will be used for comparison of fish assemblage in Ohio River pools through years.

Adjusting the Monitoring Protocol

It was noted that the random mainchannel and tailwater habitat fixed sites were not efficient for catching Asian Carp. Future targeted Asian Carp surveys will focus on tributary and island backchannel habitat sites. All sites were deemed appropriate for fish community surveys.

Annual Sportfish Surveys

WVDNR Staff conducted sportfish surveys on the Ohio River for catfish, black bass, and percids (Table 5). No Asian Carp were seen or collected during these surveys.

2. Control and Removal of Asian Carp in the Ohio River

Lead Agency: KDFWR

Participating agencies: WVDNR, INDNR, USFWS

Introduction and Need:

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 containment 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. Efforts to gather this data in the Ohio River basin began in 2015 and will continue into the foreseeable future.

The leading edge of the Asian carp invasion on the Ohio River is located above Markland Locks and Dam (RM 531). Asian carp abundance above this point is relatively low, and the majority of fish captures occur in the lower portions of tributaries. Past multi-agency sampling and removal projects have successfully targeted Asian carp in select tributaries along this stretch of river. Removal of Asian carp within these pools may act as a buffer that reduces the number of Asian carp migrating upriver; in addition, it lowers the likelihood of successful reproduction and may buy managers time to plan and implement barriers inhibiting farther Asian carp expansion. Removal efforts will also complement monitoring efforts to further understand the status, distribution, and biology of Asian carp in the Ohio River. This data will provide an assessment tool which will guide monitoring, barrier defense, and removal efforts in future years.

National Plan Goal Supported:

Goal 3.2. Contain and control the expansion of feral populations of Bighead, Black, Grass, and Silver carps in the United States.

Goal 3.3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass and silver carps in the United States.

National Plan Strategy Supported:

Strategy 3.2.3. Minimize the range expansion and ecological effects of feral populations of Asian carps in conjunction with management actions to enhance aquatic environments for the sustainability of native biological communities.

Strategy 3.3.1. Determine life history characteristics and build population dynamics models of Asian carps in the Mississippi River Basin.
Strategy 3.3.2. Increase the commercial harvest of Asian carps.
Strategy 3.3.4. Physical removal by natural resources management agencies
Strategy 3.6.2. Assemble information about the distribution, biology, life history, and population dynamics of bighead, black, grass, and silver carps.
Strategy 3.6.4. Develop an integrated management strategy to extirpate or reduce abundances of feral Asian carps.

Sub-basin Management Plan Goal Supported:

3. Population Control

Sub-basin Management Plan Strategy Supported:

3.1 Encourage increased commercial harvest and implement contract fishing of Asian carp.

Objectives:

1. Surgically implant transmitters in Asian carp between Markland and Greenup Locks and Dams.
2. Remove Asian carp from the Ohio River, above Markland dam.
3. Attempt to contain carp below the exclusion point for tolerable upriver expansion.

Methods:

Surgically implanting transmitters

No activities were planned by WVDNR for this objective.

Remove Asian Carp above Markland Dam

WVDNR mobilized a research team to conduct both electrofishing and gill netting upstream of the R.C. Byrd Dam upon receipt of credible evidence of the presence of Asian carp (consisting of telemetry detections and/or active tracking of individual fish, consistent positive eDNA results in certain areas, and/or credible/validated angler reports) in the assumed locations of the Asian carp in an attempt to locate fish. Specific sampling sites and number of sites were dependent upon staff availability and sampling conditions.

Large mesh (4.0" – 5.0") gill nets were used and each set consisted of a minimum of 30 minutes of soak time while actively driving fish towards the nets by electrofishing boats, creating motor noise, boat wake, and banging on the boat. Boat electrofishing was employed in conjunction with gill nets where applicable. Staff were to enumerate and record the catch of Asian carp and identify by-catch to species. Fish previously inserted with a telemetry transmitter and by-catch were to be returned live to the water (tagged fish caught above R.C.

Byrd dam to be returned to a location downstream of the dam). All other Asian carp were to be exterminated. Lengths and weights were taken when applicable. Supplemental samples including gonad weights, aging structures, and genetic samples were collected as needed.

Contain carp below exclusion point

No activities were planned by WVDNR for this objective.

Results:

Surgically implanting transmitters

No activities were conducted by WVDNR for this objective.

Remove Asian Carp above Markland Dam

In October 2015, WVDNR staff were assisting USFWS staff with downloading data from acoustic telemetry receivers in the mainstem Ohio River. We received detections of a tagged Bighead Carp (#28345, tagged in 2013 in Meldahl Pool) on three receivers in the Racine Pool. Both agencies, with the help of KDFWR manually tracked the fish to Mill Creek (WV). The following day USFWS and KYFWR deployed gill nets in Mill Creek in the attempt to capture and remove the tagged Bighead Carp and any other Asian Carp it may be associated with. WVDNR assisted USFWS with deploying and checking the nets. Attempts to capture this fish were unsuccessful. Attempts to employ boat noise to move the fish were also unsuccessful leading us to believe the fish could have died in that location. A subsequent trip was made by WVDNR staff to confirm this with mobile tracking, but the fish had indeed moved from that location and, therefore, was not dead. The effort did demonstrate the effectiveness of the current field-level communication and coordination between agencies. Gill net by-catch was reported by USFWS and KYFWR.

Contain carp below exclusion point

No activities were conducted by WVDNR for this objective.

3. Distribution, Movement, and Lock and Dam Passage of Asian carp in the Ohio River Through Acoustic Telemetry

Lead Agency: USFWS

Participating agencies: WVDNR, KDFWR, INDNR, Ohio Department of Natural Resources (ODNR), USFWS, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE)

Introduction and Need:

The need exists to prevent the establishment of Asian carp into the upper portions of the Ohio River Basin. Any information that we can learn about Asian carp distribution, abundance, and/or biology that could help managers limit or stop their spread would be important for the protection of aquatic ecosystems. Results to date using ultrasonic acoustic telemetry indicate that large-scale movements of Asian carp (i.e., pool to pool movement) appears to be occurring by a few individuals within the population, with Bighead Carp being more mobile than Silver Carp. This information is important to devise best management strategies such as whether population reduction may be more beneficial than containment fishing at the periphery of population. That said, current estimates of movement probabilities are hampered by low sample sizes.

The overall goal of this project 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. 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. These movement data will help to better understand Asian carp dispersal and invasion dynamics, evaluate their ability to navigate the lock and dam systems, and identify areas of seasonal congregations in the Ohio River and its tributaries.

WVDNR is a participating agency in the Ohio River Asian Carp Telemetry Project within the Framework. WVDNR coordinated with USFWS and other Ohio River basin states in planning for and conducting this project.

National Plan Goal Supported:

Goal 3.2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.3. Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.6. Conduct research to provide accurate and scientifically valid information necessary for the effective management and control of bighead, black, grass, and silver carps in the United States.

National Plan Strategy Supported:

Strategy 3.2.3. Minimize the range expansion and ecological effects of feral populations of Asian carps in conjunction with management actions to enhance aquatic environments for the sustainability of native biological communities.

Strategy 3.2.4. Forecast, detect, and rapidly respond to new feral Asian carp introductions and range expansions.

Strategy 3.2.6. Develop an information exchange network for agencies, organizations, and partners to communicate and share "real time" data to facilitate early detection and rapid response programs.

Strategy 3.3.2. Increase the commercial harvest of Asian carps.

Strategy 3.3.4. Physical removal by natural resources management agencies.

Strategy 3.6.2. Assemble information about the distribution, biology, life history, and population dynamics of bighead, black, grass, and silver carps.

Sub-basin Management Plan Goal Supported:

4. Understanding Impacts

Sub-basin Management Plan Strategy Supported:

4.1 Conduct collaborative inter-agency research to measure the distribution, movement, and habitat use of Asian carp in the middle Ohio River.

Objectives:

1. Understand Asian carp use of tributaries.
2. Delineate the upstream-most distribution of Asian carp and potential for further upstream movement.
3. Utilize mobile tracking data and Judas fish techniques to guide contract fishers and agency sampling efforts.

Methods:

Understand Asian carp use of tributaries.

Delineate the upstream-most distribution of Asian carp and potential for further upstream movement.

WVDNR aided USFWS in all aspects of these objectives outlined below including, but not limited to: collecting and implanting new fish with tags, deploying and pulling stationary receivers, suggesting locations for new receivers, downloading and sharing data from stationary receivers, active mobile tracking, purchasing of new equipment and supplies, and reporting new or significant detections to participating agencies.

Ultrasonic telemetry was used to track the movements of Asian carp and evaluate their ability to navigate the lock and dam systems upstream of current known populations. Location of tagging, and subsequent releases depended on locations of captures during agency netting and electrofishing efforts. Trammel nets, gill nets, and/or hoop nets were used to capture Asian carp for implantation of ultrasonic transmitters. Boat electrofishing was also used to supplement netting efforts. Adult Bighead Carp and Silver Carp were surgically implanted with ultrasonic transmitters (Vemco, Model V16-6H; 69 kHz; estimated battery life 1825 days) which provide individual identification. Following surgery, fish are measured for total length (mm) and weight (g), visually or manually sexed (if possible). Fish were allowed to revive before being released, any tagged fish which did not appear robust (i.e. swimming upright and vigorously) were destroyed and the tag retrieved for use in another fish. Tagged fish were also fitted with an individually numbered external jaw tag applied to the dentary bone (lower jaw) (National Tag Co. #1242 F9).

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, and at regular intervals between lock and dams. The array stretches from just below the McAlpine Lock and dam near Louisville, KY to just upstream of Willow Island Lock and Dam near St. Mary's, WV. Receivers were removed during the winter months to avoid damage from ice and re-deployed into the mainstem river in the spring. In 2015, additional receivers were placed in the approach to each lock chamber on the upstream side of the lock and in each lock chamber (mounted behind recessed ladders). Any receivers that were lost were replaced as quickly as possible. Receiver data was 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.

Personnel from USFWS, KDFWR, WVDNR, and ODNR shared responsibility for placement of stationary receivers and routine downloading of data. Mobile tracking of tagged fish was completed by all participating agencies. Telemetry data was uploaded to an FTP site that Ohio DNR established during 2014 and shared with all partners. Significant findings were shared with all partners immediately. USFWS is responsible for compiling and analyzing all data.

Utilize mobile tracking data and Judas fish techniques to guide contract fishers and agency sampling efforts.

Active tracking was also used in concert with other collecting methods to locate tagged fish and increase the likelihood of capturing new fish to tag or removing fish. Fish were located with a portable hydrophone and receiver (Vemco Model VH110-10M and Vemco Model VR100, respectively) and GPS coordinates were recorded at each site of location.

Results:

Understand Asian carp use of tributaries.

Delineate the upstream-most distribution of Asian carp and potential for further upstream movement.

WVDNR staff spent fifteen man days conducting telemetry work within the WV boundaries of the Ohio River during the reporting period. This work included: deploying and downloading stationary receivers in the mainstem of the Ohio, deploying stationary receivers in the lock chambers of Locks and Dams within the boundaries of current array (Willow Island, Belleville, Racine, R.C. Byrd), and active tracking for tagged carp in the Racine and R.C. Byrd Pools.

Utilize mobile tracking data and Judas fish techniques to guide contract fishers and agency sampling efforts.

In October 2015, partner agencies used recent stationary receiver detection of a tagged Bighead Carp discovered in the Racine pool to mobilize a removal effort for that area (see Control and Removal). Details about the status of this project can be found in the Ohio River Asian Carp Telemetry Project report of the FY2016 Framework.

4. Ohio River Asian Carp Coordination and Outreach

Lead Agency: KDFWR

Participating agencies: All Ohio River Basin partner agencies

Introduction and Need:

With the growing need for a collaborative approach to Asian carp management in the Ohio River Basin, the need for effective, coordinated communication has become increasingly important. Future communications strategies will operate on two fronts. First, interagency communication must be effective to aid in field related activities. This will be accomplished through efforts associated with directed project templates. The second effort will be to develop collaborative outreach messages and approaches. These efforts will focus on the success of field work that is ongoing, future goals and strategies of Asian carp monitoring, prevention, and control. This will be achieved through a communication plan developed by a working group of both biologists and communication specialists and overseen by the ORFMT member states, the USFWS, and ORB partners.

WVDNR is a participating agency in the Ohio River Asian Carp Coordination and Outreach project with the Framework, of which KDFWR is the lead agency.

National Plan Goal Supported:

Goal 3.2. Contain and control the expansion of feral populations of bighead, black, grass, and silver carps in the United States.

Goal 3.7. Effectively plan, implement, and evaluate management and control efforts for bighead, black, grass, and silver carps in the United States.

National Plan Strategy Supported:

Strategy 3.2.6. Develop an information exchange network for agencies, organizations, and partners to communicate and share "real time" data to facilitate early detection and rapid response programs.

Strategy 3.7.1. Develop an implementation program that effectively coordinates, oversees, and drives implementation efforts.

Sub-basin Management Plan Goal Supported:

5. Communication

Sub-basin Management Plan Strategy Supported:

5.1 Maintain effective communication among the ORFMT, Ohio River basin partners, and regional coordinating groups.

5.2 Provide information to the public on prevention and control of Asian Carp in the Ohio River basin using the media and other communication tools to educate and engage the general public, user groups, and elected officials.

Objectives:

1. Gather information and direction from ORFMT and ORB partners for development of an Ohio River basin Asian carp communications plan.
2. Develop an Ohio River basin Asian carp communications plan for ORFMT and ORB partner review.
3. Create a working group for communications among partner agencies
4. Identify a field level working group for communications and planning among partner agencies.
5. Develop web content as requested by ORFMT or identified in the Ohio River basin Asian carp communication plan for posting on www.Asiancarp.us.

Results:

Gather information and direction from ORFMT and ORB partners for development of an Ohio River basin Asian carp communications plan

WVDNR staff attended two coordination meetings with Ohio River sub-basin states and interested federal agencies to plan and allocate funds for implementation of the Ohio River Basin Asian Carp Control Strategy Framework for FY 2016. WVDNR was invited and attended an ACRCC meeting in Cleveland, OH to learn about ongoing Asian Carp control activities in Great Lakes states.

Develop an Ohio River basin Asian carp communications plan for ORFMT and ORB partner review

Efforts for this project led to the creation of a communications working group of members of all Ohio River Basin states. A communications plan for the basin is still in progress.

Identify a field level working group for communications and planning among partner agencies

A field-level working group for all Basin states has also been identified for communication and coordination of field activities for the basin. WVDNR staff attended a fieldwork coordination meeting with Ohio River sub-basin states and interested federal agencies to discuss and coordinate activities at the ground level associated implementing the Ohio River Basin Asian Carp Control Strategy Framework for FY 2016.

Develop web content as requested by ORFMT or identified in the Ohio River basin Asian carp communication plan for posting on www.Asiancarp.us

Partner information has been provided for each state and is accessible on the asiancarp.us website.

Table 1: List of partner agencies coordinating activities for the Ohio River Basin Asian Carp Control Strategy Framework

Partner Agencies of Ohio River Basin Asian Carp Control Strategy Framework
STATE
Alabama Wildlife and Freshwater Fisheries
Illinois Department of Natural Resources
Indiana Department of Natural Resources
Kentucky Department of Fish and Wildlife Resources
Mississippi Wildlife Fisheries and Parks
New York Department of Environmental Conservation
Ohio Department of Natural Resources
Pennsylvania Fish and Boat Commission
Tennessee Wildlife Resources Association
West Virginia Division of Natural Resources
FEDERAL
United States Fish and Wildlife Service (Columbia FWCO, Carterville FWCO, LMR FWCO)
United States Geological Survey (Columbia Environmental Research Center, IN-KY Water Science Center, Upper Midwest Environmental Science Center)
United States Army Corps of Engineers
UNIVERSITY
Murray State University
Purdue University
Southern Illinois University at Carbondale
Tennessee Technological University
OTHER
Indiana Wildlife Federation
Ohio River Valley Water Sanitation Commission
Tennessee Valley Authority

Table 2: Effort and species collection list for Monitoring and Response boat electrofishing surveys conducted by WVDNR 2015-2016.

	Count			
	Greenup		R.C. Byrd	
	Fall 2015	Spring 2016	Spring 2016	
Effort	4.53hrs	3.73hrs	4.69hrs	
Species	**N**	**N**	**N**	**Total**
Black Crappie	9	2		11
Black Redhorse	1		1	2
Bluegill	23	8	28	59
Bowfin	4	2		6
Channel Catfish	31	10	11	52
Common Carp	15	13	10	38
Emerald Shiner	1450	630	1035	3115
Fathead Minnow			1	1
Flathead Catfish	2	20	8	30
Freshwater Drum	134	50	72	256
Gizzard Shad	140	433	801	1374
Golden Redhorse	21	10	15	46
Grass Carp		1		1
Green Sunfish		1	9	10
Highfin Carpsucker	1	2	2	5
Hybrid Striped Bass	8	27	44	79
Hybrid Sunfish			1	1
Lamprey		1		1
Largemouth Bass	9	1	13	23
Logperch			4	4
Longear Sunfish	1	8	18	27
Longnose Gar	19	383	105	507
Mimic Shiner	2			2
Mooneye	6	1	13	20
Northern Hogsucker			1	1
Orangespotted Sunfish	1			1
Quillback	11	7	5	23
Redear Sunfish		1		1
River Carpsucker	32	44	41	117
River Redhorse	9	6	5	20
Sauger	58	27	68	153
Saugeye	1			1
Shorthead Redhorse	23	6	1	30
Silver Chub	3			3
Silver Redhorse	17	9	27	53
Skipjack Herring	1		1	2
Smallmouth Bass	7	9	49	65
Smallmouth Buffalo	414	84	181	679
Spotfin Shiner			7	7
Spotted Bass	5	38	13	56
Spotted Sucker	2	2	29	33
Walleye	3	1		4
White Bass	5	2	3	10
White Crappie	4	2	3	9
Total	**2472**	**1841**	**2624**	**6937**

Table 3: Catch Per Unit Effort (CPUE; number per hour; with 95% CL) for species collected during Monitoring and Response boat electrofishing surveys conducted by WVDNR 2015-2016.

	CPUE (no./hr)			
	Greenup		R.C. Byrd	
	Fall 2015	Spring 2016	Spring 2016	
Effort	4.53hrs	3.73hrs	4.69hrs	
Species				**Ave**
Black Crappie	2.1 (2.8)	0.5 (0.7)	--------	1.33 (1.8)
Black Redhorse	0.2 (0.4)	--------	0.4 (0.5)	0.3(0.4)
Bluegill	5.3 (6.7)	2.2 (1.8)	5.9 (7.6)	4.5 (5.4)
Bowfin	1.0 (1.6)	0.5 (1.0)	--------	0.7 (1.3)
Channel Catfish	7.9 (4.2)	2.8 (2.3)	2.3 (1.8)	4.3 (2.8)
Common Carp	3.0 (2.3)	3.5 (2.9)	2.1 (2.0)	2.9 (2.4)
Emerald Shiner	293.8 (176.9)	166.1 (87.5)	217.5 (88.4)	677.4 (117.6)
Fathead Minnow	--------	--------	0.2 (0.4)	0.2 (0.4)
Flathead Catfish	0.5 (0.6)	5.2 (6.7)	1.7 (1.3)	2.5 (2.9)
Freshwater Drum	29.9 (9.8)	14.2 (15.6)	16.5 (6.2)	20.2 (10.5)
Gizzard Shad	30.6 (15.2)	112.3 (59.4)	170.0 (130.5)	104.3 (68.4)
Golden Redhorse	4.6 (2.4)	3.3 (1.8)	3.2 (3.6)	3.7 (2.6)
Grass Carp	--------	0.3 (0.5)	--------	0.3 (0.5)
Green Sunfish	--------	0.3 (0.5)	1.9 (3.2)	1.1 (1.8)
Highfin Carpsucker	0.6 (1.1)	0.6 (0.8)	0.4 (0.6)	0.5 (0.8)
Hybrid Striped Bass	1.6 (1.0)	7.6 (7.5)	9.4 (6.6)	6.2 (5.0)
Hybrid Sunfish	--------	--------	0.2 (0.4)	0.2 (0.4)
Lamprey	--------	0.3 (0.6)	--------	0.3 (0.6)
Largemouth Bass	2.3 (1.4)	0.3 (0.5)	2.7 (3.6)	1.8 (1.8)
Logperch	--------	--------	0.8 (1.1)	0.8 (1.1)
Longear Sunfish	0.2 (0.4)	2.3 (2.0)	3.8 (3.6)	2.1 (2.0)
Longnose Gar	3.8 (3.7)	99.9 (156.3)	22.7 (15.5)	42.1 (58.5)
Mimic Shiner	0.4 (0.8)	--------	--------	0.4 (0.8)
Mooneye	1.2 (1.9)	0.3 (0.5)	2.7 (1.9)	1.4 (1.4)
Northern Hogsucker	--------	--------	0.2 (0.4)	0.2 (0.4)
Orangespotted Sunfish	0.3 (0.5)	--------	--------	0.3 (0.5)
Quillback	3.1 (2.5)	2.0 (2.2)	1.0 (1.0)	2.0 (1.9)
Redear Sunfish	--------	0.3 (0.6)	--------	0.3 (0.6)
River Carpsucker	8.2 (5.6)	12.4 (6.2)	8.5 (3.7)	9.7 (5.2)
River Redhorse	2.2(1.8)	1.7 (1.5)	1.1 (1.4)	1.7 (1.6)
Sauger	12.6 (5.8)	6.8 (5.5)	14.3 (12.1)	11.2 (7.8)
Saugeye	0.2 (0.4)	--------	--------	0.2 (0.4)
Shorthead Redhorse	8.6 (11.4)	1.7 (1.3)	0.2 (0.4)	3.5 (4.4)
Silver Chub	0.6 (0.8)	--------	--------	0.6 (0.8)
Silver Redhorse	4.6 (3.7)	2.5 (2.1)	5.7 (2.3)	4.3 (2.7)
Skipjack Herring	0.2 (0.4)	--------	0.2 (0.4)	0.2 (0.4)
Smallmouth Bass	1.4 (1.6)	2.5 (2.1)	10.4 (7.4)	4.8 (2.0)
Smallmouth Buffalo	91.0 (45.9)	22.8 (10.3)	37.8 (15.5)	50.5 (23.9)
Spotfin Shiner	--------	--------	1.5 (1.4)	1.5 (1.4)
Spotted Bass	1.1 (1.0)	10.5 (8.3)	2.7 (1.5)	4.8 (3.6)
Spotted Sucker	0.4 (0.8)	0.5 (1.0)	6.1 (11.3)	2.3 (4.4)
Walleye	1.0 (1.2)	0.3 (0.5)	--------	0.6 (0.8)
White Bass	1.0 (0.9)	2.1 (1.8)	0.9 (1.3)	1.3 (1.3)
White Crappie	1.0 (1.3)	0.5 (0.7)	0.6 (0.7)	0.7 (0.9)
Total	**526.4 (197.3)**	**489.0 (193.7)**	**555.8 (187.5)**	**523.7 (192.8)**

Table 4: Average Relative Weights (Wr) for species collected during Monitoring and Response boat electrofishing surveys conducted by WVDNR in Fall 2015 in the Greenup Pool. (calculated using Nuemann et. al. 2012). Outliers were removed from analysis. Lengths and weights were not collected during the first day of sampling.

Greenup Pool Fall 2015		
Species	**N**	**Wr**
Channel Catfish	31	85
Freshwater Drum	134	97
Gizzard shad	140	96
Hybrid striped bass	8	90
River carpsucker	32	95
Sauger	58	93
Saugeye	1	112
Shorthead redhorse	23	102
Smallmouth bass	7	94
Walleye	3	90
White bass	5	108
White crappie	4	87

Table 5. Completed sportfish surveys by WVDNR staff on the Ohio River and associated tributaries during the reporting period.

Targeted Species	Location (Pools)	Time of Year	Gear	Effort Days
Catfish	Ohio River-R.C. Byrd Pool	May, June 2016	Electrofishing	8
Black Bass	Ohio River-Greenup, Racine, Belleville, Willow Island, Pike Island	Oct 2015	Electrofishing	20
Percids	Ohio River – Racine, Willow Island	Dec 2015	Electrofishing	10
Walleye	Ohio River-Greenup, Belleville, Willow Island, Pike Island Kanawha River – Winfield, Marmet, London	March 2016	Electrofishing	3

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Appendix 5.

Scope of Work for Sub-Award Executed with Kentucky Department of Fish and Wildlife Resources

Kentucky Department of Fish and Wildlife Resources Project Summary, Project Narrative, and Budget Narrative

Project Summary

Title: Implementation of the Ohio River Asian Carp Control Strategy Framework

The U.S. Fish and Wildlife Service (USFWS) leads two different efforts to manage and control Asian carp populations in the United States (U.S.). These are Asian Carp Regional Coordination Committee's *Asian Carp Control Strategy Framework* for the Great Lakes and Chicago Area Waterway System, and the national *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States.* Through the Water Resources Reform and Development Act (WRRDA) of 2014, Congress directed the USFWS to lead multi-agency efforts to manage and control Asian carp populations in the Upper Mississippi River and Ohio River basins.

The Ohio River Basin Asian Carp Control Strategy Framework outlines actions to be implemented in the Ohio River and tributaries for prevention, monitoring and response, population control, understanding impacts, and communication to collectively prevent further expansion, reduce populations, and better understand the impacts of Asian carp. Implementing the Ohio River Basin Asian Carp Control Strategy Framework is intended to minimize the social, ecological, and economic impacts of these invasive fishes. The coordinated strategies outlined in Ohio River Basin Asian Carp Control Strategy Framework directly meet the goals, as specified by the United States Congress in Section 1039 (b) of WRRDA 2014, of controlling the spread of Asian carp in the Upper Mississippi and Ohio River basins and tributaries by carrying out activities designed to slow and eventually eliminate the threat posed by these species.

The Mississippi Interstate Cooperative Resource Association (MICRA) is a partnership of the 28 state fish and game agencies with management jurisdiction of the fishery resources in the Mississippi River Basin. MICRA provides a structure for inter-agency and inter-basin coordination and has organized an Asian Carp Advisory Committee to ensure communication between the relevant state and federal agencies and the different regional efforts in the Great Lakes, Upper Mississippi River, and Ohio River basins.

MICRA assisted the Ohio River Basin partners in the development of the Ohio River Basin Asian Carp Control Strategy Framework and is now assisting with the development and implementation of a 2015 Asian Carp Monitoring and Response Plan for coordinated implementation of the highest priority projects. MICRA received a grant from USFWS for implementation of seven Ohio River Basin Asian Carp Control Strategy Framework projects in 2015 by sub-contractors working with MICRA. As a sub-recipient of the USFWS grant with MICRA, the Kentucky Department of Fish and Wildlife Resources will evaluate the distribution and movements, methods for removal, and methods for limiting dispersal of bigheaded carps (i.e. silver carp and bighead carp). They will also assist in the development of a communications plan for the basin. The proposed project compliments additional 2015 Asian Carp Monitoring and Response Plan projects to be completed by partner agencies including USFWS, Ohio Department of Natural Resources, Pennsylvania Fish and Boat Commission, and West Virginia Department of Natural Resources.

Results of these projects will be directly reported to MICRA in progress and final reports. Reports will be shared with the USFWS, Upper Mississippi River and Great Lakes Basin

regional Asian carp teams through MICRA. Reports will also be broadly disseminated via www.asiancarp.us. The results will be used by the Ohio River Basin partnership to inform design and implementation of future management actions identified in the Ohio River Basin Asian Carp Control Strategy Framework to slow and eliminate the threat posed by Asian carps in the Ohio River basins and tributaries.

Project Narrative

Project (1) Title: Monitoring and Response of Asian Carp in the Ohio River

Location: Greenup Pool, Ohio River Mile 341.0 – 279.2

Project/Activity Explanation:
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. 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 control efforts in the Ohio River Basin.

Objectives:
- Conduct community sampling for surveillance, early detection, and distribution of Asian carp within the Greenup Pool.
- Monitor Asian carp population dynamics including fish condition, age and growth, and mortality when appropriate sample sizes are met.

Methods:
KDFWR has been conducting gillnetting for the monitoring project since fall 2015 and will continue in spring 2017. The Greenup pool will be segmented into five macrohabitat types: mainstem, island back channel, embayment, tailwater, and tributary. Gill net sites within each pool will include a variety of macrohabitat types where available. 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 be exterminated.

Deliverables:

- Data will be compiled for annual reports and updated project plans.

Project (2) Title: Control and Removal of Asian Carp in the Ohio River

Location: Greenup Pool, Ohio River Mile 341.0 – 279.2

Project/Activity Explanation:
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, 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.

Greenup pool is the a farthest upstream edge of the Asian carp invasion front. Asian carp abundance above this point is relatively low, and the majority of fish captures occur in the lower portions of tributaries. Because tributaries are uncommon in the Greenup pool, the habitat where removal may be successful is limited. 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 Greenup Pool.
- Compare methodologies and gear types to increase efficiency of Asian carp removal.
- Provide data for monitoring and response efforts.

Methods:
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 and 2016 seasons, additional sites will be added as we learn more about the habitat preferences of Asian carp.

All Asian carp 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 in addition to determining standard length and weight measurements.

Table 2. Locations where densities of Asian carp are potentially highest. These locations will be surveyed initially during the removal effort.

Pool	Tributary	Ohio River River Mile	State
Greenup	Little Guyandotte River	287	West Virginia
	Guyandotte River	305	West Virginia
	Symmes Creek	308	Ohio
	Twelvepole Creek	313	West Virginia
	Big Sandy River	317	West Virginia
	Strom's Creek	328	Ohio
	Little Sandy River	336	Kentucky

Deliverables:

- Data will be compiled for annual reports and updated project plans.

Project (3) Title: Limiting Dispersal of Asian Carp at Lock and Dam Facilities

Location: Lock and Dam facilities near the "leading edge" of carp dispersal

Project/Activity Explanation:
The national ANSTF Asian carp management plan goals and strategies outline the importance of limiting continued dispersal of Asian carp throughout the river basins they inhabit. Asian carp can navigate many of the dams in large rivers, however, in select locations, this movement may be limited to passage through the lock chamber. This project specifically addresses limiting Asian carp movement by focusing efforts on lock and dam facilities that create pinch points, or areas where upstream movement is decreased. Information derived in this task will directly link to future barrier efforts such sound, CO2, electricity, or water guns, or by alteration of operational methods at existing facilities (e.g. altering lock operation and flow regimes; Best Management Practices, BMP's).

Objectives:

- Gather information on Asian carp dam passage and historical conditions on the Ohio River that may impact passage.
- Identify lock and dam complex practices that may minimize Asian carp passage, or that create conditions that favor Asian carp removal.

Methods:
The USACE is responsible for operation and maintenance of lock and dam structures in the Ohio River Basin, which includes multiple USACE districts. KDFWR staff will contact lock masters on the Ohio River and discuss lock design and operations that may affect Asian carp passage.

KDFWR staff will acquire historic river stage data from Ohio River lock and dam complexes. Data will be compiled to determine the periodicity of "open river" conditions with consideration for the times of year where Asian carp movement is highest. These pieces of information will be integrated into future consideration of locations for barriers to Asian carp dispersal.

Deliverables:

- Report on potential locations for testing barrier technologies based on open river conditions at dams and information gathered from lock masters about potential techniques for limiting dispersal of Asian carp.

Project (4) Title: Ohio River Asian Carp Telemetry

Location: The Ohio River from below the McAlpine Lock and Dam near Louisville, KY, upstream to Broadback Island near the Town of Willow Island, WV.

Project/Activity Explanation:
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. The probability of Silver and Bighead Carp spreading to previously uncolonized areas is considered high.

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) and their populations have grown exponentially. Asian carp have been shown to exhibit very high reproductive potentials with high fecundity and the potential for a protracted spawning period. Populations of Asian carp have become well established in the lower and middle reaches of the Ohio River and successful reproduction is suspected 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.

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:

- Understand Asian carp use of tributaries.
- Delineate the upstream-most distribution of Asian carp and potential for further upstream movement.

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.

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 may be used to supplement netting efforts. Adult Bighead Carp and Silver Carp captured in Markland and Meldahl pools 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. 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).

An array of VR2W receivers was installed in the river beginning in summer 2013. One hundred four receivers were placed above and below locks and dams, in the lower portions of major

tributary streams, and at regular intervals between locks and dams. However, particular interest has risen over the specific timing of tributary use along the invasion front. As a result, KDFWR will work with WVDNR to identify tributaries for receiver deployment in additional tributaries. KDFWR will also assist in downloading data from receivers as needed. KDFWR will compile data sets at the end of the year (November) and "clean" up the data for analysis. 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.

Deliverables:
Status reports covering any urgent and significant findings will be shared among partner agencies as soon as possible following the finding. Annual reports summarizing all work will be produced by approximately March 1st of each year.

Project (5) Title: Ohio River Asian Carp Coordination and Outreach

Location: Ohio River sub-basin

Project/Activity Explanation:
Every program requires a successful communications effort. There are many examples of successfully executed projects that were not effectively communicated to the appropriate audiences. The collaborative Mississippi River basin Asian carp field efforts conducted by multi-agency work groups have been coordinated effectively. Communication of project results between these groups will be achieved through inter-agency efforts outlined in associated templates. The focus of this template is to enhance effective communication between and amongst state and federal agencies, and the public, as well as elected officials.

The ORFMT member states and other ORB partners have conveyed the issues concerned with Asian carp on a limited basis. Future communications strategies will be to developed into a plan that includes collaborative outreach messages and approaches. These efforts will focus on the success of field work that is ongoing, future goals and strategies of Asian carp monitoring, prevention, and control. This will be achieved through a communication plan developed by a working group of both biologists and communication specialists including representativesfrom ORFMT states, the USFWS, and other ORB partners.

Objectives:
- Assist in development of an Ohio River basin Asian carp communications plan
- Develop web content as requested by ORFMT or identified in the Ohio River basin Asian carp communication plan for posting on www.Asiancarp.us

Methods:
Initially, a communication workgroup will be created that includes representatives from ORFMT member states and ORB partners. KDFWR will help establish the working group and develop plans for outreach related to Asian carp efforts in the ORB. An Ohio River basin Asian carp communications plan will be developed with assistance of agency communications specialists. Ohio River communications work group will also develop web content for posting on www.Asiancarp.us

Deliverables:
- Formation of a communication workgroup of both natural resources and communication professionals.
- Draft Asian Carp Communication Plan outline which will include information needs and elements of a comprehensive communication plan.

Budget Justification

Personnel: $30,391

Biologist	200hours	$26.02 / hour	$5,204
Biologist	250	$21.87 / hour	$5,467.5
Field Technician	250hours / week	$18.03 / hour	$4,507.5
Field Technician	250hours / week	$12.96 / hour	$3,240

Fringe: $

Biologist	$16.91	$3382
Biologist	$14.22	$3555
Field Technician	$11.72	$2930
Field Technician	$8.42	$2105

Travel: $8,840

Targeted sampling related to the proposed Monitoring and Response and Control and Removal projects will require extensive travel from the Kentucky Department of Fish and Wildlife office out of Frankfort, kytes along the upper Ohio River Two field crews will generally be used to complete each sampling effort. Most field work will require round trip travel each day. Average mileage per round trip is estimated at 200 miles. Total estimated mileage for the proposed sampling is approximately 5000 miles / per field crew. Total mileage at the approved rate (0.46 cents/mile) is estimated at $4,600.

Two weeks of proposed sampling events in the middle Ohio River will require overnight travel for two field crews.Per diem rate for is $83 for lodging and $35 for meals and incidental expenses per person per night. Estimated travel costs for five people sharing three hotel rooms is at $$424 per day is $4,240.

Equipment: $30,000

Kentucky Department of Fish and Wildlife will purchase one net boat and use an existing elecrofishing boatfor the proposed projects.

No federal owned equipment will be used to complete this project.

Supplies: $2,000

An estimated 750 gallons of unleaded gasoline will be purchased for operation of outboard motors and generators during this project. Total estimated fuel cost is $2,000 ($2.66 / gallon).

Contractual: $0

Construction: $0

Total Direct Cost: $ 71231

Indirect Cost: $3,728

Total Project Costs: $$74,959

$71,212 (direct) + $3,728 (indirect < 5% of total grant)

Appendix 6.

Project Completion Report prepared by Kentucky Department of Fish and Wildlife Resources

TOURISM, ARTS AND HERITAGE CABINET
KENTUCKY DEPARTMENT OF FISH & WILDLIFE RESOURCES

Matthew G. Bevin
Governor

Don Parkinson
Secretary

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Regina Stivers
Deputy Secretary

Frank Jemley, III
Acting Commissioner

December 17, 2018

Mr. Greg Conover
Mississippi Interstate Cooperative Resource Association
9053 Route 148
Marion, IL 62959

Subject*: Final Project Report (Financial Agreement # MICRA-15-004)*

Dear Mr. Conover,

Attached please find the final project report completed by the Kentucky Department of Fish and Wildlife Resources (KDFWR) as a requirement of their financial agreement with the Mississippi Interstate Cooperative Resources Association (MICRA). The report contains the activities fulfilled by the KDFWR as part of the agreement. As requested, the report contains actual accomplishments as they relate to the original goals and objectives in the agreement.

During 2016-2017, KDFWR received additional funding outside of this agreement for Asian Carp work on the "establishment" and "invasion" front (identified in Project 1, Figure 1 report) of Asian Carp on the Ohio River from United States Fish and Wildlife Service Region 4. Despite MICRA agreement 15-004 not yet being formalized in 2016, KDFWR increased sampling outside of that required by the Region 4 grant in the upper "presence" front pools of Greenup and R.C. Byrd to complete sampling that other project partners were unable to conduct. At the request of MICRA as part of this agreement, KDFWR continued those efforts into 2017, sampling the Ohio River further upriver in West Virginia and Ohio.

All projects were completed as outlined in the project narrative and deliverables have been provided in the attached report. For simplicity, the last two pages of the report provide a summary of all non-target fishes captured and their disposition. Please note that KDFWR was the lead on several multi-state Asian Carp projects in this agreement and results provided in the narrative include analysis conducted by KDFWR staff with limited field sampling conducted by other agencies in the partnership. Additional project summaries were provided to MICRA representatives for the 2017 Congressional report, technical reports in 2016 and 2017 (available on Asiancarpu.us/PlansReports.html), and partnering agencies.

If you have any questions or need any additional information please feel free to contact me. You may contact me at (502) 892-4461 or by email at paul.wilkes@ky.gov.

Sincerely,

Paul A. Wilkes
Program Coordinator – Fisheries Division

Project 1: Monitoring and Response to Asian Carp in the Ohio River

Geographic Location: For this agreement, the Greenup Pool of the Ohio River was the targeted area. However, this report also contains monitoring and response results from the Ohio River basin, extending from the Cannelton pool (RM 720.7) to the Racine pool (RM 237.5) along with the Montgomery Island (RM 31.7) and New Cumberland (RM 54.4) pools of the Ohio River in addition to the Allegheny and Monongahela rivers.

Objectives:

1. Conduct community sampling for surveillance, early detection, and distribution of Asian carp within the Greenup Pool.
2. Monitor Asian carp population dynamics including fish condition, age and growth, and mortality when appropriate sample sizes are met.

Methods:

Clarification of Terminology Referenced in This Document

With the current rate of Asian carp expansion and the massive effort to study and adaptively manage carp impacts across several Mississippi River sub-basins, it is important to clarify terminology used in technical documentation and annual reports. Currently, there may not be consistent terminology used across the basins when talking about basin-specific distribution and abundance of Asian carp. With this in mind, below are a list of terms used in this report.

Bigheaded Carps – a term used to reference all species of the bigheaded carps (*Hypophthalmichthys molitrix* and *Hypophthalmichthys nobilis*) and their hybrids, found in the Ohio River basin.
Establishment Front – the farthest upriver range expansion of Asian carp populations that demonstrates the presence of natural recruitment.
Invasion Front – the farthest upriver extent where reproduction has been observed (eggs, embryos, or larvae), but recruitment to young-of-year fish has not been observed.
Macrohabitat – One of five habitat types used to categorize fixed sites within a pool (e.g. Tributary, Tailwater, Embayment, Island Back-Channel, Main Stem River).
Presence Front – The farthest upstream extent where Asian carp populations occur, but reproduction is not likely.
Targeted Sampling – sampling that uses gear and/or techniques intended to specifically target one species (i.e. Silver Carp and Bighead Carp) and exclude others (i.e. native species).

Spring Targeted Sampling (Cannelton – R.C. Byrd)

Asian carp targeted sampling was introduced in 2017 to take the place of spring community monitoring, conducted in 2016. This adjustment was made in an effort to better reflect the annual change in relative carp abundance and provide a baseline assessment to direct future removal efforts. The sampling period was from 10 April – 23 May, along six pools (Cannelton – R.C. Byrd pools) in the middle Ohio River. This geographic range is significant because it currently represents the upper end of the establishment front through the lower end of the presence front for Silver Carp in the ORB (Figure 1). All sites were selected from a stratified random design using GIS map study from sampling efforts in 2015. Pools were segmented into four sections (upper, upper-middle, lower-middle, and lower) with six fixed electrofishing sites and two fixed gill netting sites per section (~24 electrofishing runs and 8 gill net sets per pool). The intent of this standardized design, with fixed sampling locations, was to sample five major macrohabitat types in each pool in order to compare trends within pools through time. Macrohabitat types included main-stem locations, island back-channels, embayments, dam tailwaters, and tributaries in each pool.

Electrofishing transects were standardized at 900 seconds with one dipper. An output power between ~4000 - 5000 (Watts) at 40% duty-cycle and 80 pulses per second (pulsed DC) was targeted using a

MLES Infinity Box or a Smith-Root system at ~7amps and 60 pulses per second. Transects were conducted in a downstream direction in order to minimize fish escapement due to flow. Asian carp were specifically targeted using increased driving speeds and allowed pursuit of individual carp upon sightings. During more aggressive boat maneuvering, all other fish species were ignored. All small, shad-like species were collected and examined thoroughly before release to avoid misidentication of juvenile Asian carps. Other non-target species were not collected.

Gill nets used in targeted sampling were typically 45 – 90 m (150 - 300 ft) in length, 3 m (10 ft) in depth, and constructed of large mesh (either 10cm or 12.5cm bar mesh) and foam core float line to keep them suspended at top water. Sites sampled consisted of at least two net sets, fished for two hours while creating noise and water disturbance every 30 minutes within 90 – 100 meters of the set. Regular disturbance was intended to target and persuade the movements of bigheaded carps into the gear. All bycatch was released immediately.

Upon capture, all bigheaded carps were examined for the presence of external and/or internal tags (jaw tags and sonic implants attached in 2013-2016 through the Ohio River Asian Carp Telemetry Project), identified, geo-located, weighed, and measured. In most cases, bigheaded carps were euthanized and the left, pectoral fin ray and/or otoliths were collected for aging following established protocols (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). Grass Carp (*Ctenopharyngodon idella*) presence was also recorded and fish were euthanized upon capture. Any *Hypophthalmichthys spp*. that were not euthanized were tagged with a distinct jaw tag and a 95mm VEMCO 69 kHz – V16 acoustic-coded transmitter. Tagged fish were released at point of capture to contribute to the Ohio River Asian Carp Telemetry project.

Fall Standardized Community Monitoring (Cannelton – R.C. Byrd)
From 02 October – 28 November, fish community surveys were repeated along the same six pools in the middle Ohio River (Cannelton, McAlpine, Markland, Meldahl, Greenup, and R.C. Byrd) using sampling sites selected in 2015 (see above) (Figure 1). Pool divisions (upper, upper-middle, lower-middle, and lower reaches) remained the same with six fixed electrofishing sites and two fixed gill netting sites per section (~24 electrofishing sites and 8 gill netting sites per pool). These sites are also intended to remain constant throughout consecutive years of monitoring in order to compare trends within and among pools through time.

Electrofishing transects were standardized at 900 seconds with one dipper. An output power ranging between 3000 – 4000 (Watts) was targeted at 25% duty-cycle and 60 pulses per second (pulsed DC) using a MLES Infinity Box (Gutreuter et. al. 1995) or a Smith-Root system at ~7amps and 60 pulses per second. Transects were conducted in a downstream direction in order to minimize fish escapement due to flow. All fish encountered during a 15-minute transect were collected and placed into a live well until the end of a run. All small, shad-like species were examined thoroughly to avoid misidentifying young Asian carps. In areas where large schools of Clupeid or Cyprinid species were encountered, as many fish as possible were collected while maintaining a consistent, straight-line speed.

Gill nets used in community monitoring were typically 45 – 90 meters in length, 3 m (10 ft) in depth, and constructed of large mesh (either 10cm or 12.5cm bar mesh) and foam core float line to keep them suspended at top water. Sites sampled consisted of at least two net sets, fished for two hours while creating noise and water disturbance every 30 minutes within 90 – 100 meters of the set. Regular disturbance was intended to target and persuade the movements of bigheaded carps into the gear.

Fish were identified to the lowest taxonomic level possible, enumerated, weighed, and measured. After all data had been recorded, fish were released in the same location as their capture (excluding Asian

carps). Invasive carps were euthanized or tagged after data collection using the same procedure as described above from the targeted sampling in the spring.

Monitoring Asian Carps Ahead of the Invasion Front (New Cumberland, Montgomery Island pools)
Targeted sampling for Asian Carp was conducted in December 2017 in the Montgomery Slough portion of the Ohio River (Montgomery Island Pool, RM 949.78 to 950.11) in proximity to the location of positive eDNA detections for Bighead Carp (2017 and historically), as well as in a backwater area of the Allegheny River in Pool 7 near Tarrtown, PA (RM 48.33). Gill nets used in sampling were 90 meters in length, ~4 meters (12 ft) in depth, and constructed of 8 cm, 10 cm, or 13 cm bar mesh. Gill nets were fished for approximately 24 hours.

Incidental sampling for Asian Carp was conducted using baited tandem hoop nets, beach seining, and boat electrofishing. Baited tandem hoop nets (1 meter diameter, 4 cm bar mesh, 3 nets in tandem) were set in the New Cumberland, Montgomery Island, Dashields, and Emsworth pools of the Ohio River in August and September 2017 and were fished for three consecutive nights. All species were identified and enumerated before being released except for Channel and Flathead Catfish, which were retained for aging using otoliths.

Beach seining was conducted in August at six fixed locations in the Montgomery Island Pool of the Ohio River using a 30 meter seine with 1 cm mesh. One seine haul was conducted at each of the six locations. Species readily identifiable in the field were enumerated and released; all other species were retained for identification and enumeration in the laboratory.

Daytime boat electrofishing was conducted in July and August on four fixed sites in the Montgomery Island Pool of the Ohio River, four fixed sites on the Charleroi Pool of the Monongahela River, and six fixed sites on Pool 4 of the Allegheny River. Electrofishing was conducted using an ETS MBS electrofishing system operated at 25% duty cycle and 60 pulses per second (pulsed DC) at variable voltages and amperages depending on river conditions. Transects were fixed length (100 – 300 m) and were sampled from 6 to 13 minutes. Black bass were measured and enumerated, and presence/absence of other species was recorded.

Nighttime boat electrofishing was conducted in September in the New Cumberland Pool of the Ohio River and Pool 4 of the Allegheny River. Electrofishing was conducted using an ETS MBS electrofishing system operated at 25% duty cycle and 60 pulses per second (pulsed DC) at variable voltages and amperages depending on river conditions. Three 15 minute transects were sampled in the New Cumberland Pool in the tailwater portion of the Montgomery Dam on each bank. All black bass and true bass were collected, and presence/absence of other species was recorded. On the Allegheny River, four fixed sites were sampled. Black bass and Sander species were collected, and presence/absence of other species was recorded.

Assessing Asian Carp Population Demographics
The lengths and weights of Silver carp, H. molitrix, captured from August through December in 2016 and 2017 were compiled and $\log_{10}$ transformed for regression analysis and annual comparisons. A single regression line was derived to describe the relationship between Silver Carp total length and weight and compared to regressions from additional basins (Figure 2, Table 2). In addition, ANCOVA analysis was applied to a multiple linear regression model ($y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \varepsilon$), with weight (g) being determined by total length (mm) and year used as a categorical predictor variable for fish captured after spawning activity. Predicted weights at each length along the regression were used to determine if there was a statistically significant difference in growth of fish from the previous year. This analysis may serve as one benchmark to determine the effects of harvest as removal efforts increase in the future.

A single linear regression was derived using data compiled from 2016 and 2017 for Bighead carp, H. nobilis, and used to describe the relationship between total length (mm) and weight (g) (Figure 3, Table 3). However, due to low capture rates between the two years, ANCOVA analysis was not applied to determine if conditional growth had changed between the two sampling seasons.

Throughout all ORB projects, a subsample of individual carp lengths (mm), weights (g), otoliths, and pectoral spines were taken to aid in assessing population characteristics of carp along the invasion front. Pectoral spines were collected and sectioned on a low speed saw for aging (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). Cross sections are currently being processed and will be photographed while submerged in water against a dark background and aged with reflected light under a dissecting microscope (Figure 4). In addition, all otoliths collected will be adhered to a glass slide using thermoplastic cement, ground to the nucleus, and imaged using reflected light under a microscope (Figure 5). Each fish will be aged by two independent readers. Spines and otoliths will be crosschecked to age each fish. Where ages between each reader differ too widely (> 2 years), otoliths will be excluded from analyses. Ages which differ to a lesser degree (≤ 2 years) will be recounted and an agreed upon age by each reader will be assigned to that fish. Age data will be used to calculate the mean length (range, 95% confidence interval) at each age for carp captured in the ORB. It is expected that this information will be included with the next annual report (October, 2018).

Hydroacoustic Analysis

USFWS conducted mobile hydroacoustic surveys to estimate relative abundance, size distribution, spatial distribution, and density of Asian carp in each pool of the Ohio River from Cannelton to R.C. Byrd. A total of 20 sampling locations were surveyed in October and November of 2017 using methods similar to that described in MacNamara et al. (2016). Briefly, surveys were conducted using two 200 kHz split-beam transducers (BioSonics, Inc.) pointed toward the shoreline and oriented just below the surface of the water. Each transducer had an effective acoustic beam (i.e., -3 dB angle) of 6.4° and was offset in angle to minimize interference from the surface and maximize water column coverage (i.e., 3.2° and 9.6° below the surface of the water). Angles were adjusted and maintained throughout surveys using a dual-axis rotator. Occasionally transducer angles were adjusted farther down to reduce surface interference from inclement weather. Data were collected at 5 pings/s with a pulse width of 0.4 ms. Temperature was recorded at the time of each survey to compensate for its influence on absorption and the speed of sound in water. An on-axis calibration was conducted after each survey following Foote et al. (1987).
Each hydroacoustics survey was conducted parallel to the shoreline on both banks of the Ohio River for 4 miles and up to 2 miles into tributaries. Survey locations were chosen to encompass clusters of sites that were sampled by KDFWR with electrofishing and gill nets (see monitoring section for additional details on fish community sampling). Data from fish community sampling were used to separate species-specific information as detailed below.

Data are in the process of being analyzed using Echoview 8.0 following MacNamara et al. (2016). After background noise removal, the split-beam single target detection (method 2) algorithm was used to detect fish echoes. Multiple targets from a single fish were grouped into a fish track using EchoView's fish tracking algorithm to reduce the potential of overcounting fish targets. Size of fish targets (total length; cm) were estimated from a relationship between maximum side-aspect acoustic target strength (dB) and fish size (Love 1971). This function is wavelength- and temperature-dependent and was therefore scaled appropriately for 200 kHz transducers and temperature recorded during the survey. To estimate density of fish (e.g., number/m^3), the volume of water ensonified was estimated using the wedge volume approach. Individual fish detections cannot reliably be assigned to a particular species using single-frequency hydroacoustics data. Rather, the proportion of fish at each length class determined from community data is applied to the size distribution and frequency of fish echoes. Fish community data from each pool will be apportioned among 3 fish categories (i.e., Silver carp, Bighead carp, and other fish species) for each length class. Finally, pool specific length-weight regressions will be used to estimate length-specific

biomass for each species of interest. Density (numeric and mass) will be estimated following MacNamara et al. (2016).

Compilation and Incorporation of Other ORB Data Sources
Regional and national georeferenced databases are ideal for compiling both historical and current Asian carp range data from ORB states and participating basin groups. The Nonindigenous Aquatic Species (NAS) database, currently maintained by United States Geological Survey, was accessed in February 2018 and used to inform the range of Asian carp species captured and reported throughout the ORB. The NAS database provides a single point of reference where confirmed sightings from all partners can be submitted and will be considered when discussing the range and expansion of Asian carps in the ORB and its tributaries. In addition, data from Ohio River Valley Water Sanitation Commission (ORSANCO) were downloaded and compiled to determine the additional occurrences of Asian carps from community sampling data taken between 1957 – 2017. Data were sorted and mapped in order to supplement project records and additional upstream detections of bigheaded carps in the Ohio River (Figures 6 - 8). Some tributaries of the Ohio River are also included in this search, but are only referenced using their associated pools. Internal reports from other agency and partner projects are also included to expand carp sightings and our knowledge of invasion status within basin states. KDFWR's ichthyology branch has provided additional counties where Asian carp have been documented in internal state streams, connected to the larger Ohio River system.

Results:
Spring Targeted Sampling (Cannelton – R.C. Byrd)
Spring community electrofishing in 2016 produced no Bighead Carp captures and an overall CPUE of 0.70 fish/hour (n = 22, SE = 0.32) for Silver Carp and 0.16 fish/hour (n = 5, SE = 0.10) for Grass Carp (Table 4). All Silver Carp were captured within the Cannelton, McAlpine, and Markland pools. In 2017, targeted electrofishing produced one Bighead Carp in the Cannelton pool for an overall CPUE of 0.05 fish/hour (n = 1, SE = 0.05) and 74 Silver Carp for an overall CPUE of 3.71 fish/hour (n = 74, SE = 1.31). No Grass Carp were observed or captured during targeted electrofishing efforts in 2017. The detection range where Silver Carp were captured remained Cannelton through Markland, as in 2016. However, captures of Silver Carp in 2017 were a 236% increase over captures in 2016 using targeted methods.

Spring gill netting in 2016 (Cannelton through Greenup) produced an overall CPUE of 0.02 fish/set (n = 1, SE = 0.02) for Bighead Carp, 0.35 fish/set (n = 22, SE = 0.16) for Silver Carp, and 0.03 fish/set (n = 2, SE = 0.02) for Grass Carp (Table 5). Sixty-two sets made up 18,590ft of net, yielding a total catch of 165 fish and 13 unique taxa. No Asian carps were caught with gill nets above Meldahl Locks and Dam. Smallmouth buffalo and Silver Carp made up over 50% of the total catch by number. In contrast, spring gill netting in 2017 produced an overall CPUE of 0.10 fish/set (n = 10, SE = 0.06) for Bighead Carp, 0.70 fish/set (n = 31, SE = 0.34) for Silver Carp, and 0.19 fish/set (n = 17, SE = 0.10) for Grass Carp (Table 5). Eighty-five sets made up 19,100ft (5,800m) of net, yielding a total catch of 197 fish and 11 unique taxa. No Silver Carp were captured above Meldahl Locks and Dam, but one Bighead Carp and one Grass Carp were captured in the R.C. Byrd pool. Once again, smallmouth buffalo and Silver Carp made up over 50% of the total catch by number; however, Bighead Carp made up ~5% of the total catch in contrast to the <1% seen in 2016. In total, 23 non-target fish were captured in Greenup and R.C. Byrd pool, all were released alive (Table 5). Therefore, no demographic data was able to be obtained for the Greenup pool and no by-catch data is reported.

Fall Standardized Community Monitoring (Cannelton – R.C. Byrd)
Fall electrofish sampling in 2017 produced no Bighead Carp or Grass Carp captures and an overall CPUE of 0.18 fish/hour (n = 5, SE = 0.07) for Silver Carp. This was a decrease in catch for both Silver carp and Grass carp from efforts in 2016 with no bighead carp captured during the fall of either year (Table 6). A total of 130 transects were completed to yield a catch of 6,536 fish comprising 52 unique taxa. All Silver

Carp were captured in the Cannelton and McAlpine pools, as seen previously in 2016. Gizzard shad were also the most commonly encountered species in 2017 sampling, but only comprised 37% of the total catch by number throughout the sampling period (Table 8). Reductions in the proportional catch of gizzard shad occurred in the Cannelton and R.C. Byrd pools with moderate increases in catches in the McAlpine, Markland, and Meldahl pools between 2016 and 2017.

Fall gill netting in 2017 produced an overall CPUE of 0.10 fish/set (n = 9, SE = 0.53) for Bighead Carp, 0.28 fish/set (n = 26, SE = 1.40) for Silver Carp, and 0.01 fish/set (n = 1, SE = 0.01) for Grass Carp (Table 7). Limited non-target species were captured including two smallmouth buffalo, a channel catfish, a flathead catfish, and a paddlefish. All non-target species were released alive. In contrast to 2016, two Silver Carp were captured with nets above Meldahl Locks and Dam during 2017 sampling. Ninety four sets made up 18,220ft (5,550m), yielding a total catch of 111 fish and 13 unique taxa. Smallmouth buffalo and Silver Carp alone made up over 50% of the total catch with Bighead Carp and common carp making up an additional 16% (Table 9).

In 2016, clupeids made up the vast majority of species documented across the lower three pools (Cannelton – Markland) sampled in the middle Ohio River. This was typically followed by those species found within the cyprinid, centrarchid, and catostomid families (Figures 9 – 11). Altogether, this reflected more than 85% of the total family diversity in each of the lower three pools during fall sampling. In 2017, this within-pool representation appeared consistent with the previous year's sampling and family representation over both seasons appears to be similar. In 2016, the Meldahl pool had less cyprinid representation than in lower pools and ictalurids, moronids, and sciaenids were more frequent in addition to clupeids, centrarchids and catostomids (Figure 12). This distribution shifted in 2017 with a much lower proportional catch of clupeids and a 43% percentage-point increase in cyprinid representation (mostly comprised of large groups of emerald shiners at sampling locations), making the minnows the most common group of fishes in Meldahl during fall 2017, followed closely by the herrings (primarily comprised of gizzard shad). Both Greenup and R.C. Byrd had dominant family representations distributed across Clupeidae, Cyprinidae, Centrarchidae, Sciaenidae, and Catostomidae both in 2016 and 2017 (Figures 13 – 14). However, in 2017, clupeid numbers decreased drastically within both pools and catostomids, sciaenids, and centrarchid numbers increased.

Trophic guilds were assigned to each fish using the classifications from Simon and Emery (1995) and Emery et al. (2002) as reported in Thomas et al. (2004) or The Fishes of Tennessee (2001) text (Etnier and Starnes 2001, Thomas et al. 2004). The proportional representation of trophic guilds within each pool varies greatly between 2016 and 2017 depending on catch. Guilds identified in the Cannelton, McAlpine, and Markland pools look similar across years with herbivores making up the majority of the population. In 2016, Meldahl, Greenup, and R.C. Byrd communities were comprised mostly of herbivores, but in 2017 the dominant guilds shifted, likely in response to the large change in major taxa groups represented in those pools. Particularly, Meldahl samples displayed a majority of planktivores while Greenup and R.C. Byrd shifted to primarily invertivores, detritivores, and piscivores.

Assessing Asian Carp Population Demographics

In total, the number of Bighead Carp captures across all projects in 2017 was 46 fish. However, this was a >100% increase in total bighead captures when compared to 2016's twenty-one Bighead carp removed from the ORB. Of those two years, males were more common and immature fish were only captured during 2017 sampling. The four immature fish were caught in the Cannelton pool and ranged in total length from 520 – 596mm. The mean total length of bighead across both years was similar, with 2016 average TL = ~1011mm (n = 21, SE = 60.9) and 2017 average TL = ~1020mm (n = 46, SE = 31.0). Using records from both seasons, a weight-length regression using $\log_{10}$ transformed data produced the curve $\log_{10}[\text{Weight}_g] = -5.05 + 3.03 * \log_{10}[\text{Length}_{mm}]$ (Adj $R^2 = 0.971$, Figure 3). Regressions were achieved utilizing the general linear model function (lm()) in base R (R Core Team 2016).

In 2017, 1,661 Silver Carp were removed from the Ohio River during projects being conducted by all partners within the basin. This was an increase in total number of Silver Carp captured in reference to 2016 efforts. The mean total length of Silver Carp captured in 2016 was around 820mm (n = 1578, SE = 1.77) while the mean total length of Silver Carp in 2017 was 796mm (n = 1661, SE = 4.15). Smaller length-classes of Silver Carp were seen with more frequency in 2017 when compared to 2016 due to several occasions where juvenile fish < 400mm were captured in the Cannelton pool. Across both seasons, the relative frequency of larger length-classes in each pool increased with a progression upriver (Figure 15).

The presence of spawning patches on female fish was also tracked throughout 2016 and 2017, which we took as evidence of recent spawning activity. A spawning patch was noted if it was actively hemorrhaging or the flesh was raw, with scales missing along the ventral surface of the body, and there was little to no visible signs of healing. Females captured in all pools exhibited fresh spawning patches from May – August. Within the Cannelton and McAlpine pools, this time period was associated with increases in CPUE for all gears, but most notably electrofishing (Figure 16). This pattern was also seen in 2016 and was likewise associated with increases in Silver Carp catch rates.

Using records from both seasons, a weight-length regression using LOG_{10}-transformed data for Silver Carp was produced for each year (Figure 17) using fish records collected after August to remove the influence of spawning activity on weight. All calculations were conducted in base R (R Core Team 2016). A factorial ANCOVA was used to determine that there was no significant difference between years for LOG_{10}-transformed weights (g) at length (mm) of Silver Carp captured after annual spawning activity, $F(1, 260) = 3.168$, $p = 0.076$ (Figure 17). All records from the fish captured outside of the spawning activity across both years were combined to produce the curve $\log_{10}[Weight_g] = -5.13 + 3.05 * \log_{10}[Length_{mm}]$ (Adj $R^2 = 0.976$, Figure 2) in base R (R Core Team 2016).

In total, 131 pectoral spines were taken from Silver Carp captured in the ORB in 2017 have been sectioned and are in the process of being photographed. Otoliths were also taken from a sub-sample of both species of bigheaded carp and are in the process of being ground to the nucleus and imaged before being read. A subsample from each length-class of all aging structures collected will be used to determine the average length at age for Silver Carp within the ORB.

Hydroacoustic Analysis

Hydroacoustic analyses by USFWS are ongoing; results are anticipated by June 2018.

Monitoring Asian Carps Ahead of the Invasion Front

Targeted gill net sampling for Asian Carp in the Montgomery Slough of the Ohio River and the backwater portion of Pool 7 of the Allegheny River yielded no Asian Carp species. Common Carp and River Carpsucker comprised 56% and 24% of the total catch on the Ohio River and Smallmouth Buffalo and Muskellunge comprised 52% and 43% of the total catch on the Allegheny River.

Twenty-three baited tandem hoop nets were fished for 69 net nights and captured no Asian Carp species. Sixteen species were captured, and Channel Catfish and Smallmouth Buffalo comprised 39% and 31% of the total catch.

Beach seining on the Montgomery Island Pool collected no Asian Carp species. Total numbers of individuals and species have yet to be determined as laboratory identification is ongoing.

Daytime boat electrofishing on the Ohio River Montgomery Island Pool, Monongahela River Charleroi Pool, and Allegheny River Pool 4 was conducted for 2.1 hrs of effort and no Asian Carp were captured. Similarly, night boat electrofishing on the Ohio River in the New Cumberland Pool at the Montgomery Dam tailwater for 1.5 hrs of effort and in Pool 4 of the Allegheny River for 1.91 hrs of effort captured no Asian Carp.

Compilation and Incorporation of Other ORB Data Sources
Data taken from ORSANCO records since 1957 show a similar pattern in presence/absence of Asian carps as seen during standard monitoring sampling and removal efforts conducted between 2015-2017. The farthest up-river accounts of Asian carps by ORSANCO were in the Markland Pool in 2012 and McAlpine Pool in 2014 (Figures 6 – 8). The USGS NAS database expands the range of carp sightings depending on the species. The farthest upriver detection of Silver Carp was a capture in Raccoon Creek, a tributary of the R.C. Byrd Pool, in 2016 while a Bighead Carp was captured as far up as a tributary of the Pike Island Pool 2016 (Figures 6 – 7). Data records for Grass Carp are sporadic throughout the basin and likely are indicative of establishment throughout the ORB (Figure 8). During routine sampling, the KDFWR ichthyology branch reported Silver Carp sightings at six locations between August and October in McCracken and Ballard counties (Figure 18). Two of six sites (Massac Creek and Clanton Creek wetland) contained juvenile Silver Carp. Seven voucher specimens were obtained from Clanton Creek in October that were YOY species ranging in size from 69 – 85mm. Both of these inland drainages contact the Ohio River below Lock 52 and carp located at each site were within close proximity to the river.

Discussion:

The 2017 Monitoring and Response project built on the design and efforts of monitoring in 2015 – 2016. The original four pools (McAlpine through Greenup) sampled in 2015 were expanded to include one additional down-river pool (Cannelton) and one additional up-river pool (R.C. Byrd) in 2016. Community sampling during 2016 provided the first spring community data obtained during this project, but was modified to target Asian Carp in 2017 to better understand relative carp numbers by pool. In addition to community sampling effort targeted carp sampling is conducted in the spring. This targeted removal not only addresses the goal of tracking relative abundance through time, but also has the added benefit of allowing crews to focus on catching only invasive carp species and therefore increases the number of total fish removed from the system during this period. This benefit was demonstrated in 2017 with the total number of Silver Carp captures during targeted sampling exceeding a 200% increase in catch when compared to the previous year. Increases in capture numbers between 2016 and 2017, specifically with gill nets is a likely indication of a better understanding of how to target these species and when to utilize these gears rather than an increase in relative abundances. However, with the geographic range of detection being similar to that seen during community monitoring in 2016, it is likely that, at present, a higher amount of effort per pool would be necessary to reach any level of detection for carp in lower abundance pools (Meldahl, Greenup, R.C. Byrd).

The Greenup Pool likely remains the invasion front for silver carp on the Ohio River (Figure 1). Asian Carp have been sporadically captured in Greenup pool in previous year's sampling efforts and 2017 was no different, with none sampled during the spring monitoring project. As such, population dynamics were not able to be assessed. This report includes the monitoring and response to Asian Carp in pools above and below the Greenup pool to provide perspective on the community composition and Asian Carp relative abundance throughout the full study area (Cannelton through R.C. Byrd). The Greenup Pool lacks the abundance of shallow backwater and tributary habitat where Asian Carp are frequently captured in McAlpine, Markland, and Meldahl pools. Although carp may be inhabiting more difficult to sample main river habitat, telemetry data from Greenup pool seems to indicate that the few tagged bighead carp that migrate into the pool have low residency time and linger below the R.C. Byrd Dam (Project 4). No tagged silver carp have migrated into the pool. Furthermore, relative catch rates of Asian Carp steadily

decline the further upriver sampling occurred, supporting the conclusion the Greenup Pool remains the invasion front of silver carp and that none of the species have significantly increased their ranges from 2016 (Figure 19).

In addition to monitoring, community sampling was conducted in the Greenup pool in the fall. Although Clupeid numbers decreased drastically in Greenup from the 2016 sample, the dominant families remained Clupeidae, Cyprinidae, Centrarchidae, Sciaenidae, and Catastomidae. Community sampling data was provided from additional pools to highlight the pool to pool variation in community make up. The large variation in Clupeid numbers highlights the necessity of continued community monitoring in order to have adequate baseline data to determine the effect of Asian Carp on native species should they establish in the pool.

Relative catch rates (CPUE) of Silver Carp over both years continue to support increases in relative abundances of Silver Carp from upriver to downriver pools (Figures 19 – 20). This trend among Silver Carp abundance is also apparent during removal efforts and additional observations during projects further up the Ohio River. No gear types currently used seem to be effective at targeting Bighead Carp; however, reports from fishermen on catches that match or exceed state and federal sampling records in the R.C. Byrd may indicate that the pool has higher numbers of Bighead Carp than previously thought (WVDNR personal communication, 2016). In light of this evidence and relatively little information about Bighead Carp in each pool, it is difficult to determine if they follow a similar geographic pattern of decreasing relative abundance in pools where targeted monitoring was conducted.

Fall community monitoring in 2017 produced catches of four unique taxa when compared to sampling conducted in 2016, but did not contain the presence of seven other taxa, which were sampled the previous year. Across both years, gizzard shad were the most commonly encountered species in electrofishing efforts while smallmouth buffalo were the most commonly encountered species during gill netting. Asian carp were captured from the Cannelton pool through Markland pool, as in 2016, but the number of bigheaded carps captured in the Cannelton pool greatly exceeded the previous year's catch. The majority of carp encountered during monitoring were captured in tributaries. It is unclear if this can be attributed to habitat preference or increased sampling effectiveness in shallower habitats. In 2017, community monitoring began around the same time as 2016 in the lower pools (Cannelton – Markland) with similar temperatures to the previous year; however, sampling the upper pools (Meldahl and R.C. Byrd specifically) extended to almost the end of November with water temperatures getting cooler (~ 14°F difference) when compared to previous years' average temperatures. With upriver pools in 2017 having been sampled later in the season, most of the community assemblage and trophic level shifts seen in those pools may be partly explained by the extension in sampling activities and cooler water temperatures. This reinforces the need to spread effort across resource agencies and partner groups and focus on maintaining a discrete sampling period for community monitoring efforts in the future.

Regressions for growth of both Silver Carp and Bighead Carp were comparable to other basins, suggesting that growth and condition of fish in the Ohio River is similar to that found elsewhere (Tables 1 – 2). Increased frequency of larger length-classes of Silver Carp in upriver pools, in addition to more narrow ranges of total lengths overall, suggests that fish captured upriver are more indicative of migrants rather than successfully reproducing populations. This is further reinforced by reported data from additional sources such as the NAS database records, which have few recent records of Silver Carp extending past the R.C. Byrd pool. However, increases in the frequency of smaller length classes of silvers in Cannelton indicate that fish within that pool may have had a successful spawn and juveniles are now recruiting to gears being used. Tributaries where these younger individuals were observed in 2017 are potentially important to spawning success (primarily Clover Creek/Tug Fork and Oil Creek, among others).

With CPUE highly correlated with spawning activities in 2017, it is important to note that carp are likely more susceptible to the gears and techniques currently being used by project collaborators during the months of May – August (Figure 16). Catch rates have tended to decrease as water temperatures drop toward the fall season. However, recent pursuits between USFWS and KDFWR utilizing hydroacoustics and removal effort in the Cannelton pool during the cooler months suggest that large groups of riverine fish can likely be targeted using side-scan and split-beam technologies and may aid in pinpointing areas where removal efforts can focus during cooler months.

Recommendations:
It is recommend that both targeted sampling and community monitoring continue in 2018 using the consistent and repeatable design now established for this project. Although the monitoring range is geographically extensive, more care to ensure a discrete (~ 3 week) sampling period within a water temperature range of 60° – 70° F (average being ~65°F) will benefit efforts to identify community trends in future monitoring assessments. Control and containment efforts would likely benefit from using spawning periods as an advantage for removal. The majority of effort placed into carp removal should likely be conducted in the Cannelton and McAlpine pools between April and September to maximize efficiency. Other gears and techniques should be used in an attempt to increase catch of carp outside of this period and hydroacoustic technologies would likely aid in pinpointing focal areas for removal efforts.

Deliverables: Data from this project was compiled for Ohio River Basin Asian Carp Control Strategy Framework technical reports in Feb 2017 and 2018. KDFWR staff took lead on writing the Basin "Monitoring and Response of Asian Carp in the Ohio River" technical report, funding templates, and project planning for 2018 efforts. KDFWR staff presented the data to the basin working group Oct. 2017, participated in numerous conference calls, and led in basin project planning in July 2018. Additionally, KDFWR hosted an Asian Carp symposium at the Southeaster Association of Fish and Wildlife Agencies Conference in Louisville, Ky in October of 2017 where data from this project was presented.

Project Highlights:

- A new net boat was purchased that that is used exclusively for Ohio River Basin Asian Carp sampling
- The 2017 Monitoring and Response to Asian Carp in the Ohio River project built on the design and efforts of monitoring in 2015 – 2016.
- Work conducted in 2017 was an increase in effort and geographic range when compared to previous efforts conducted since the "Leading Edge" projects were established in 2015.
- A total of 2.0 electrofishing hours during spring monitoring efforts in the Greenup Pool, no Asian Carp were captured
- A total of 3,050 ft of gill net was deployed during spring monitoring efforts in the Greenup Pool, no Asian Carp were captured
- A total of 5.0 hrs electrofishing in fall community sampling in the Greenup Pool yielded 983 fish representing 29 different, no Asian Carp were captured
- A total of 5850 ft of gill net was deployed for fall community sampling in the Greenup Pool yielded 5 fish representing 4 species, no Asian Carp were captured
- Continual incorporation of data sources and additional monitoring ahead of the current invasion front should continue in order to inform managers of significant expansions of Asian carp up-river.
- Capture numbers again appear to reflect that Cannelton and McAlpine have much higher densities of invasive bigheaded carp than the pools above them and relative abundance numbers indicate that the current geographic approximate line for Silver Carp establishment still exists near McAlpine pool.
- Silver Carp, if present, are still in very low numbers in Green Pool

- With less information from sampling efforts on bighead and Grass Carp, little can be said to the extent of their establishment within the ORB.
- It is recommended that monitoring continue in 2018 with more focus on informing control and containment efforts in the Cannelton and McAlpine pools.

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Figures:

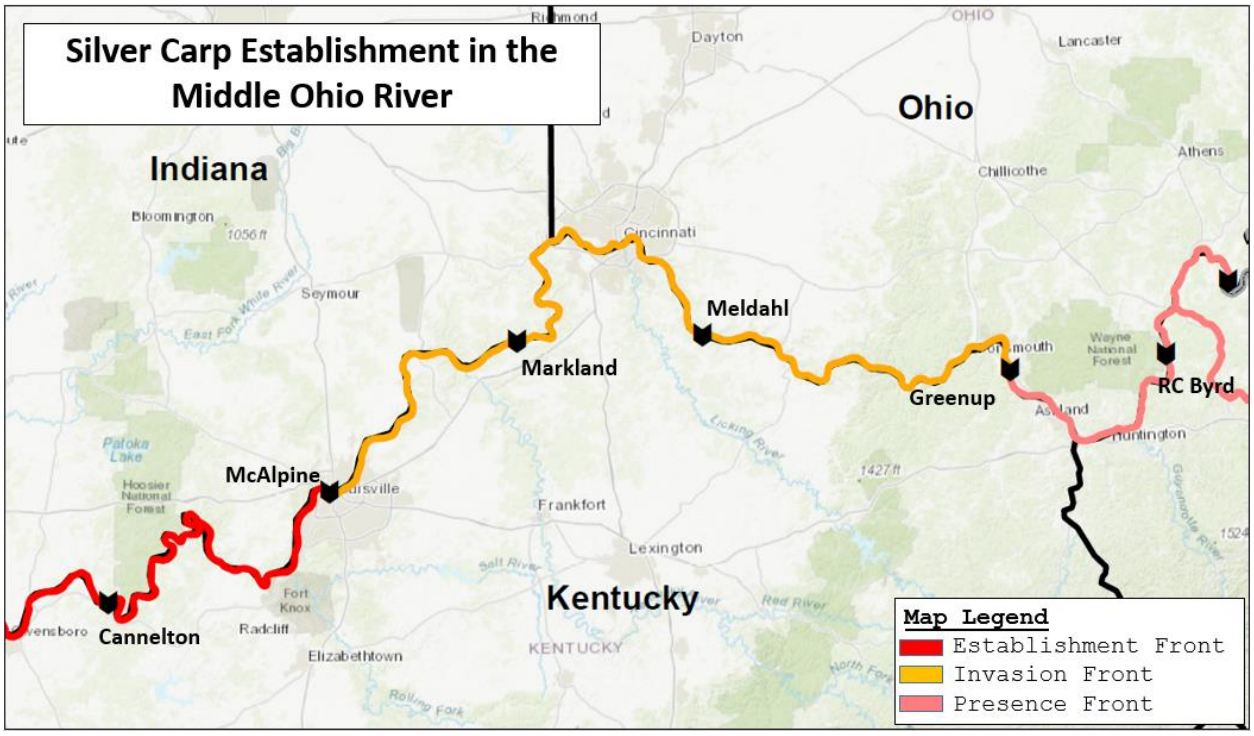

Figure 1. A map depicting the differing levels of Asian carp establishment in the middle Ohio River where targeted sampling and regular suppression is currently being conducted.

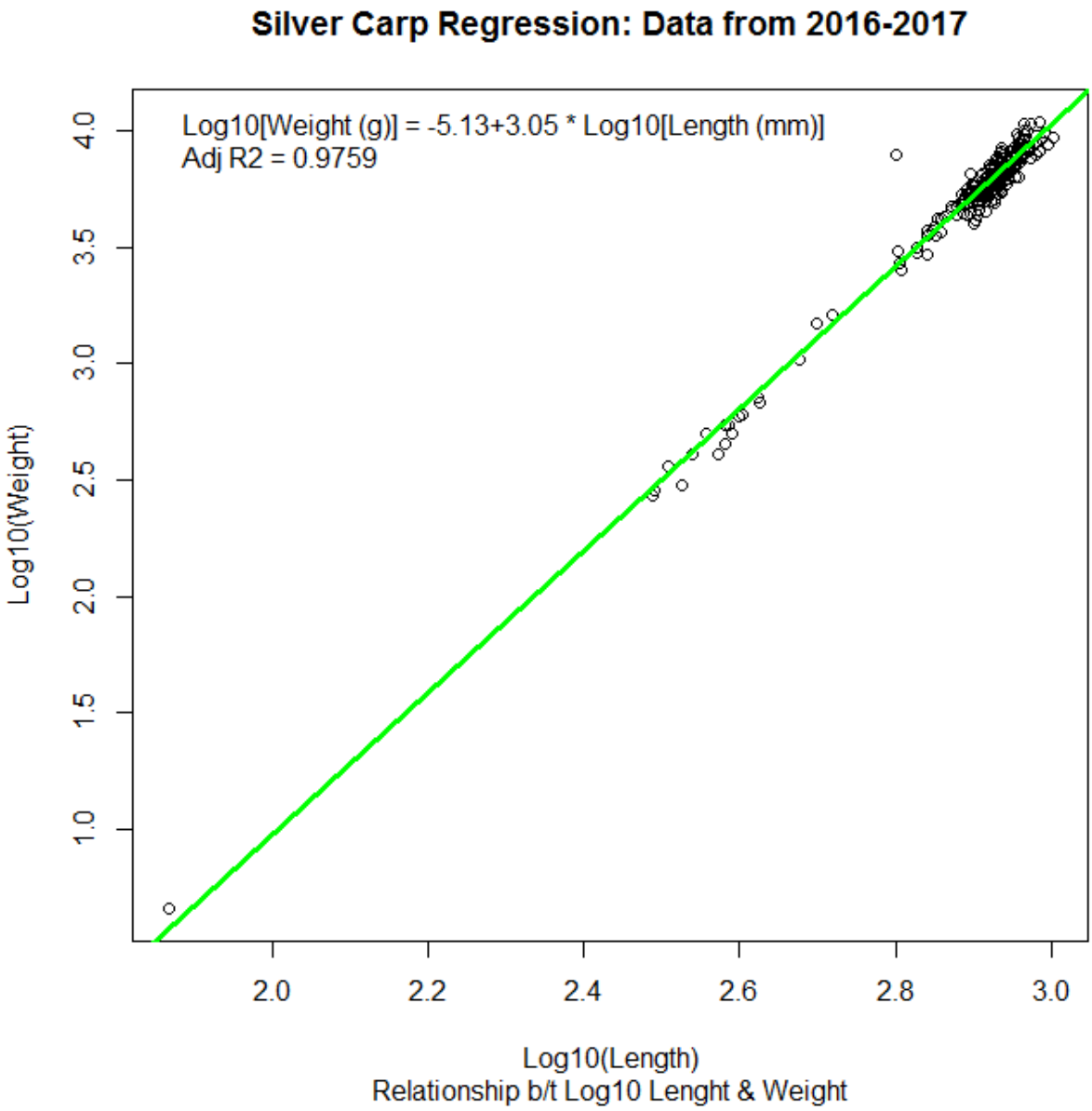

Figure 2. A scatterplot of log_{10}-transformed lengths (mm) and weights (g) from *H. molitrix* captured from August through December in 2016 and 2017 with a regression line describing the relationship between lengths and weights in the ORB (n = 336).

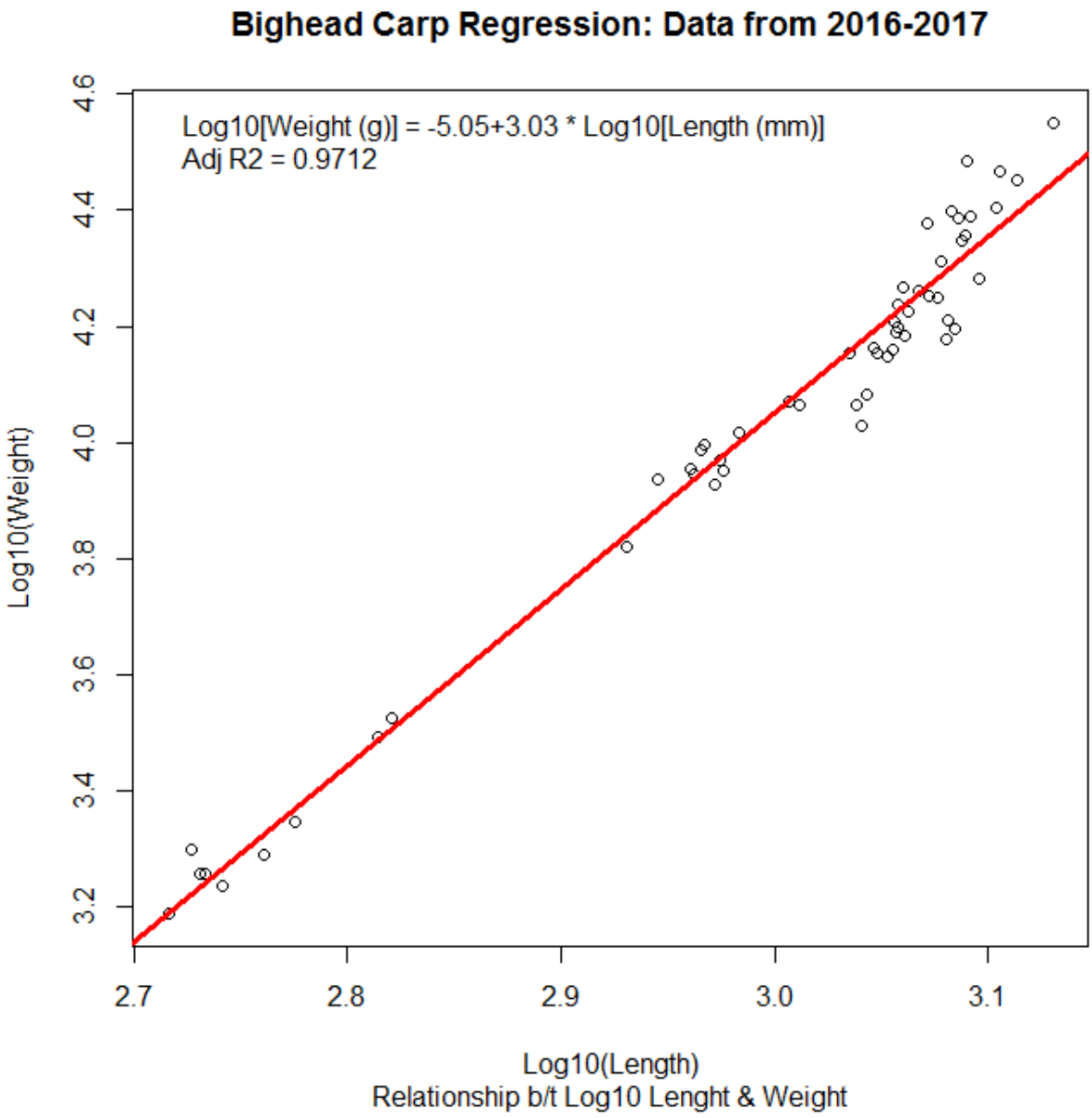

Figure 3. A scatterplot of $\log_{10}$-transformed lengths (mm) and weights (g) from all *H. nobilis* captured from August through December in 2016 and 2017 with a regression line describing the relationship between lengths and weights in the ORB (n = 55).

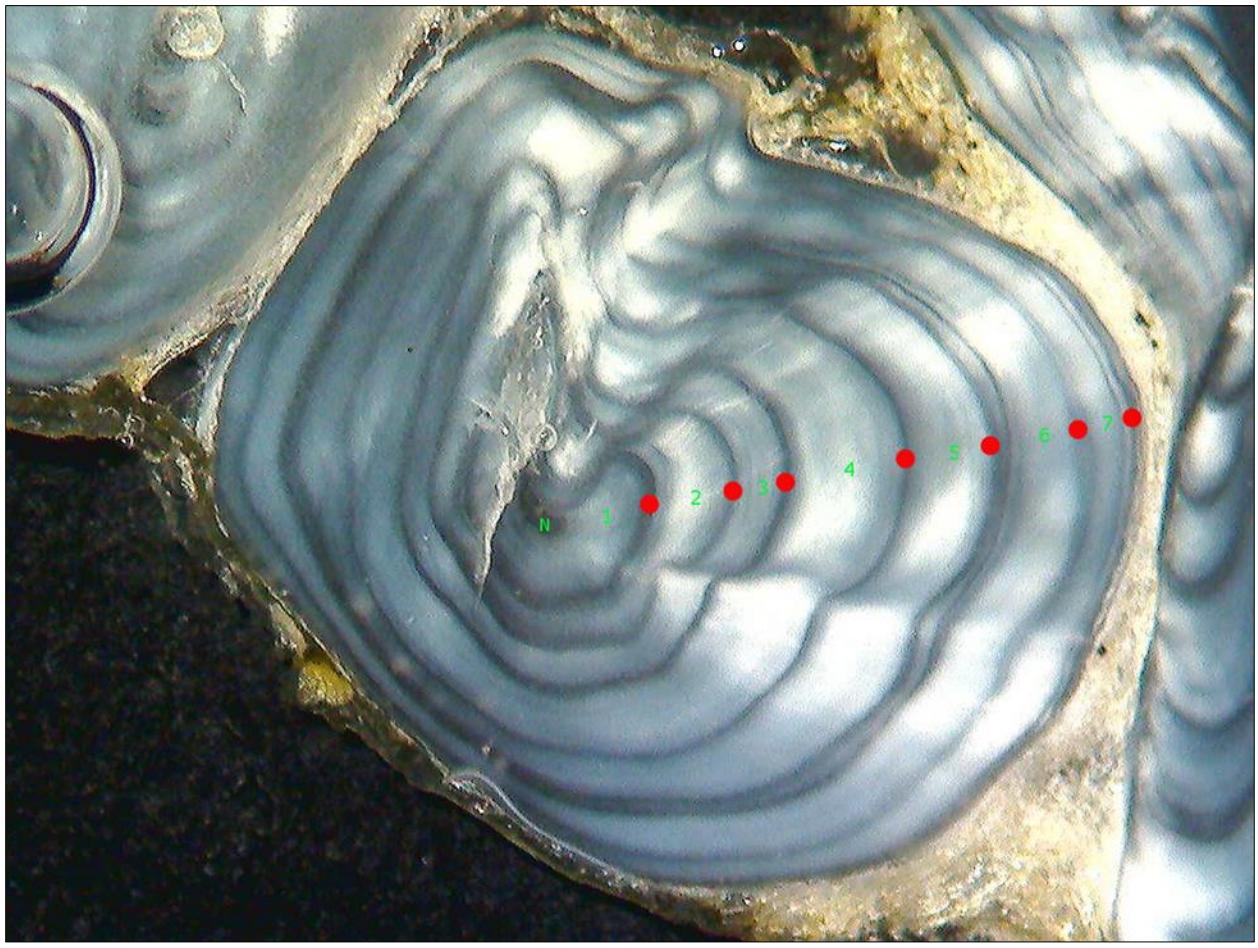

Figure 4. An image of a spine cross-section collected from a 7-year-old silver carp in the Cannelton pool, captured in May 2016.

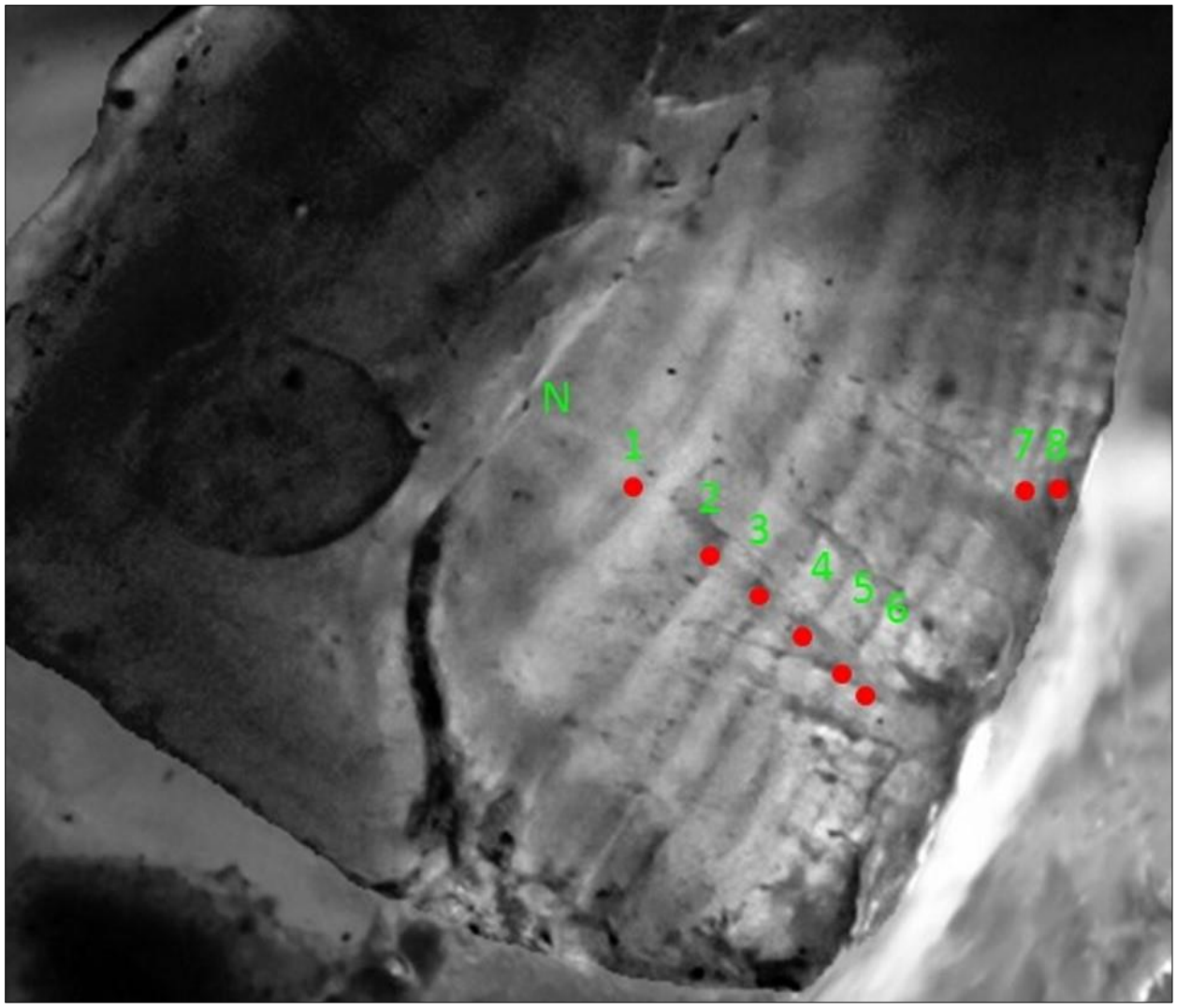

Figure 5. An image of a silver carp otolith collected from an 8-year-old fish, captured in the McAlpine pool in July 2013.

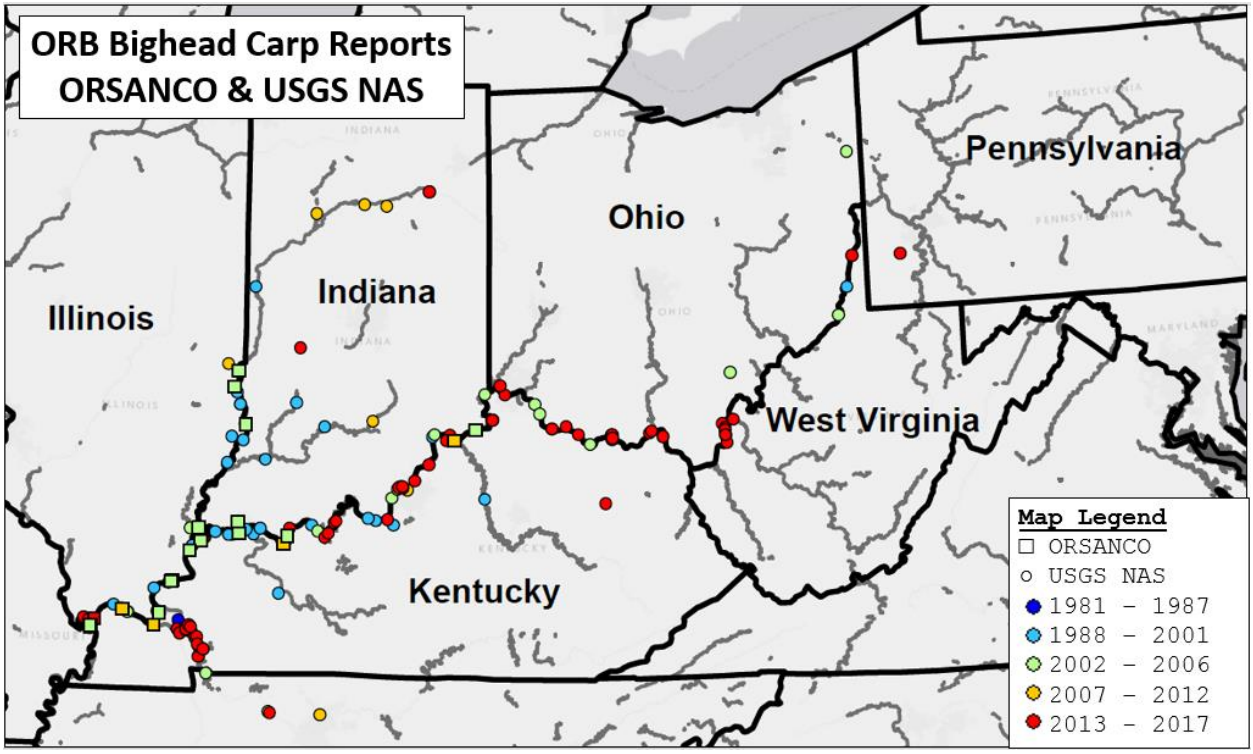

Figure 6. A range map of bighead carp reported within the ORB, organized by date using data queried from ORSANCO and the USGS NAS databases.

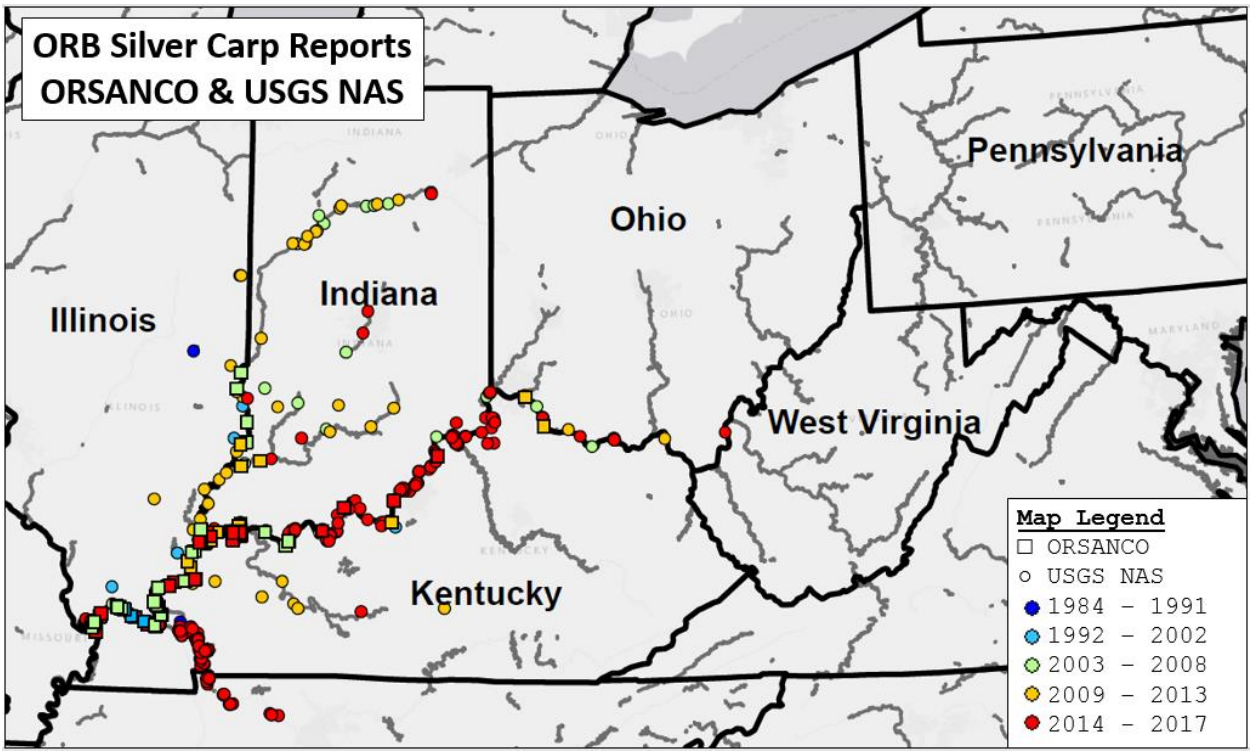

Figure 7. A range map of silver carp reported within the ORB, organized by date using data queried from ORSANCO and the USGS NAS databases.

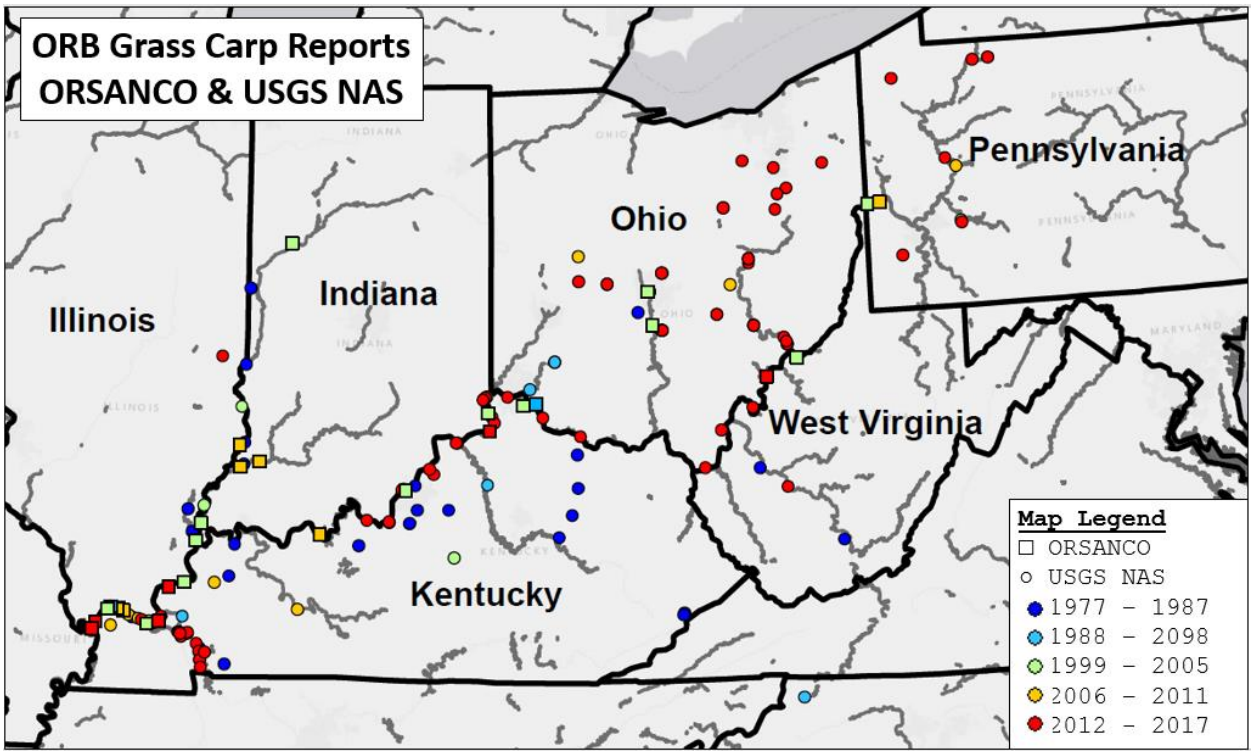

Figure 8. A range map of grass carp reported within the ORB, organized by date using data queried from ORSANCO and the USGS NAS databases.

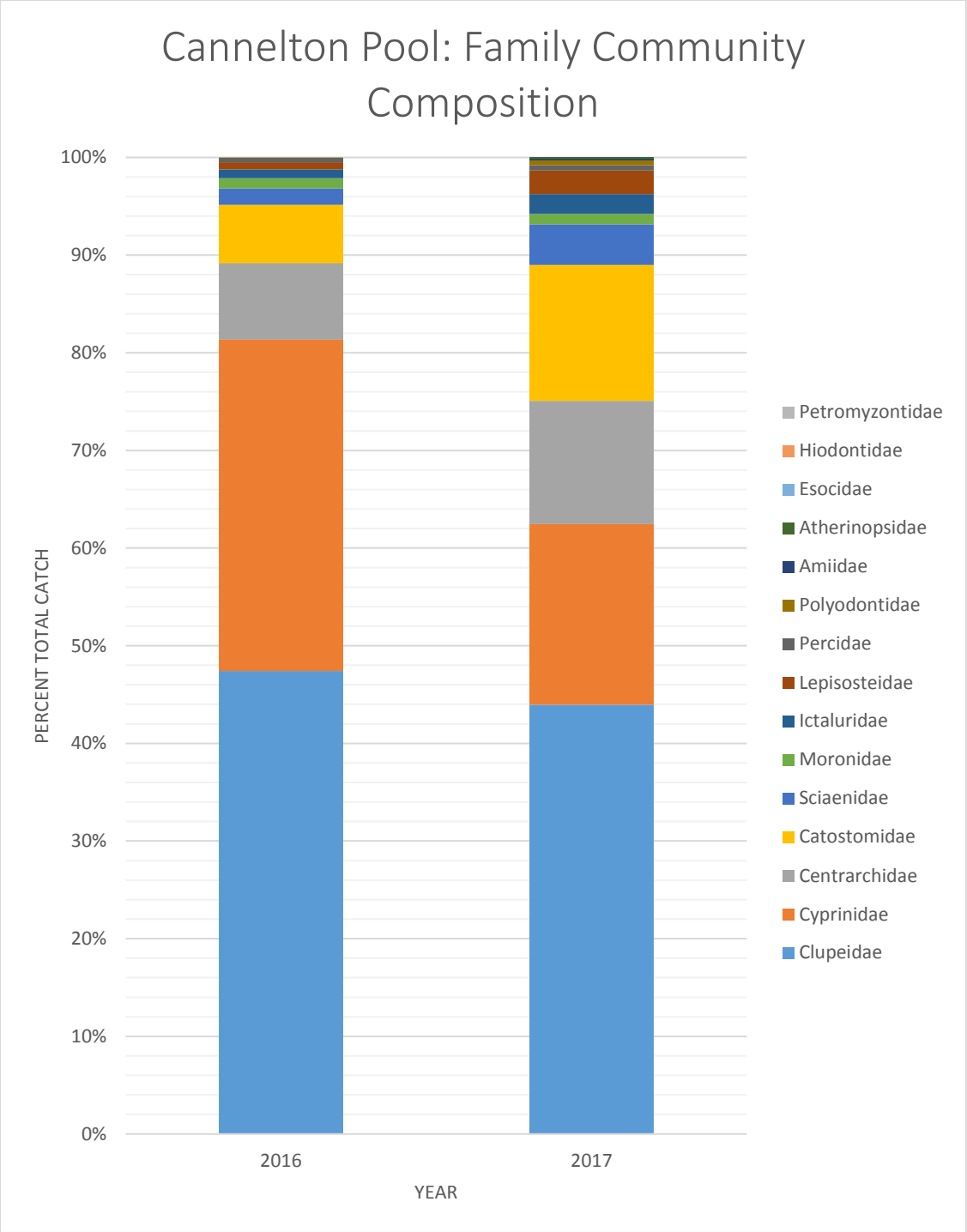

Figure 9. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the Cannelton pool.

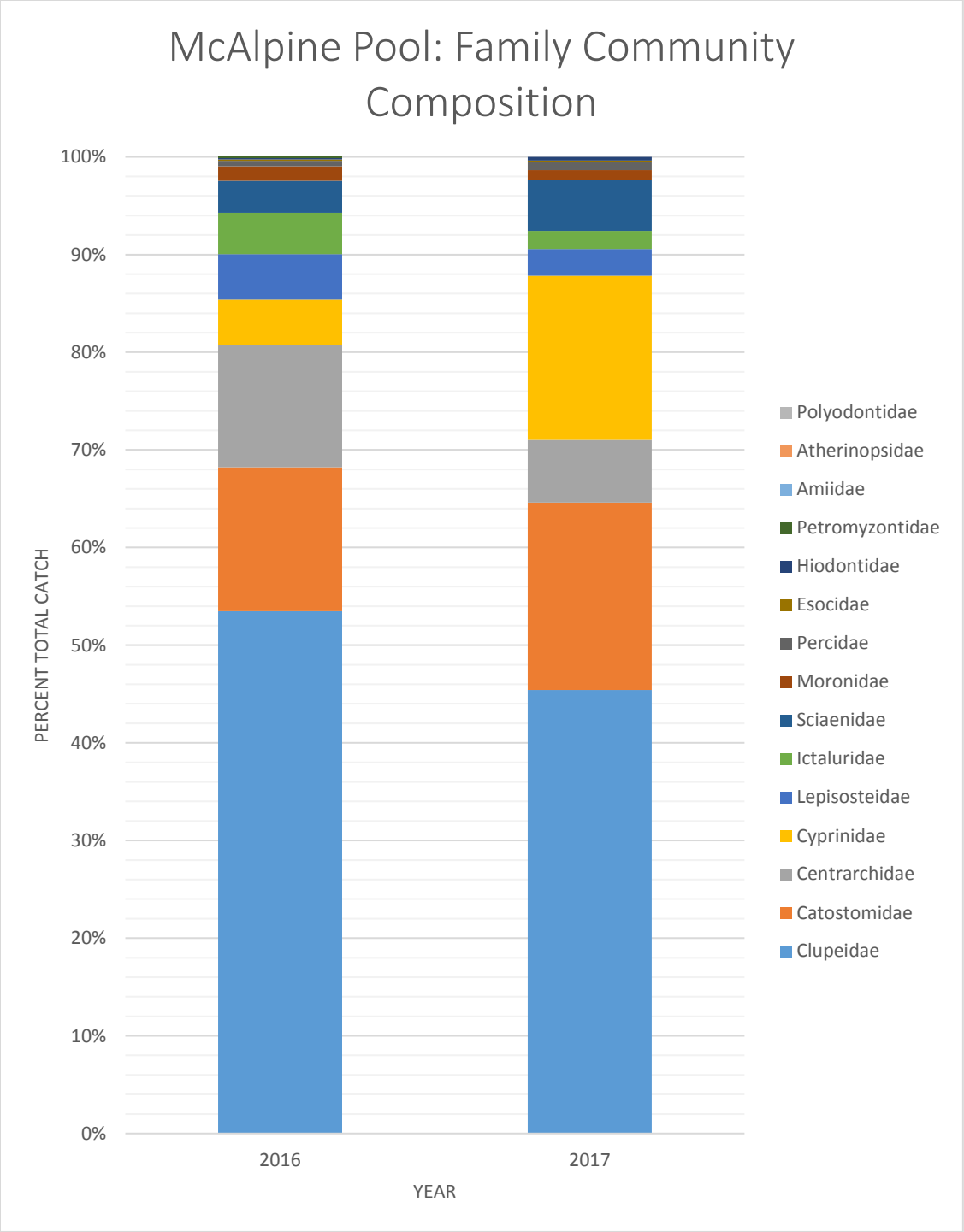

Figure 10. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the McAlpine pool.

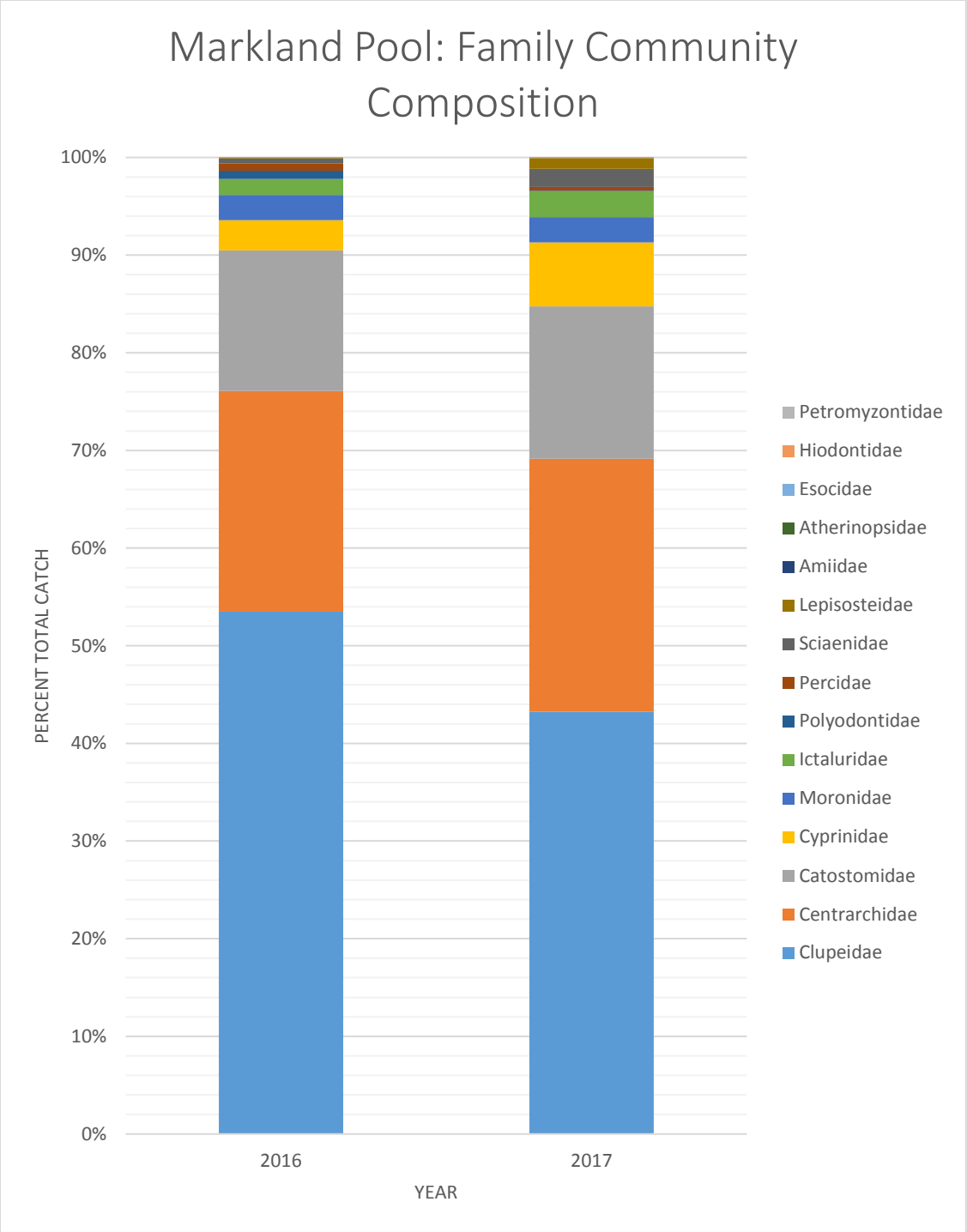

Figure 11. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the Markland pool.

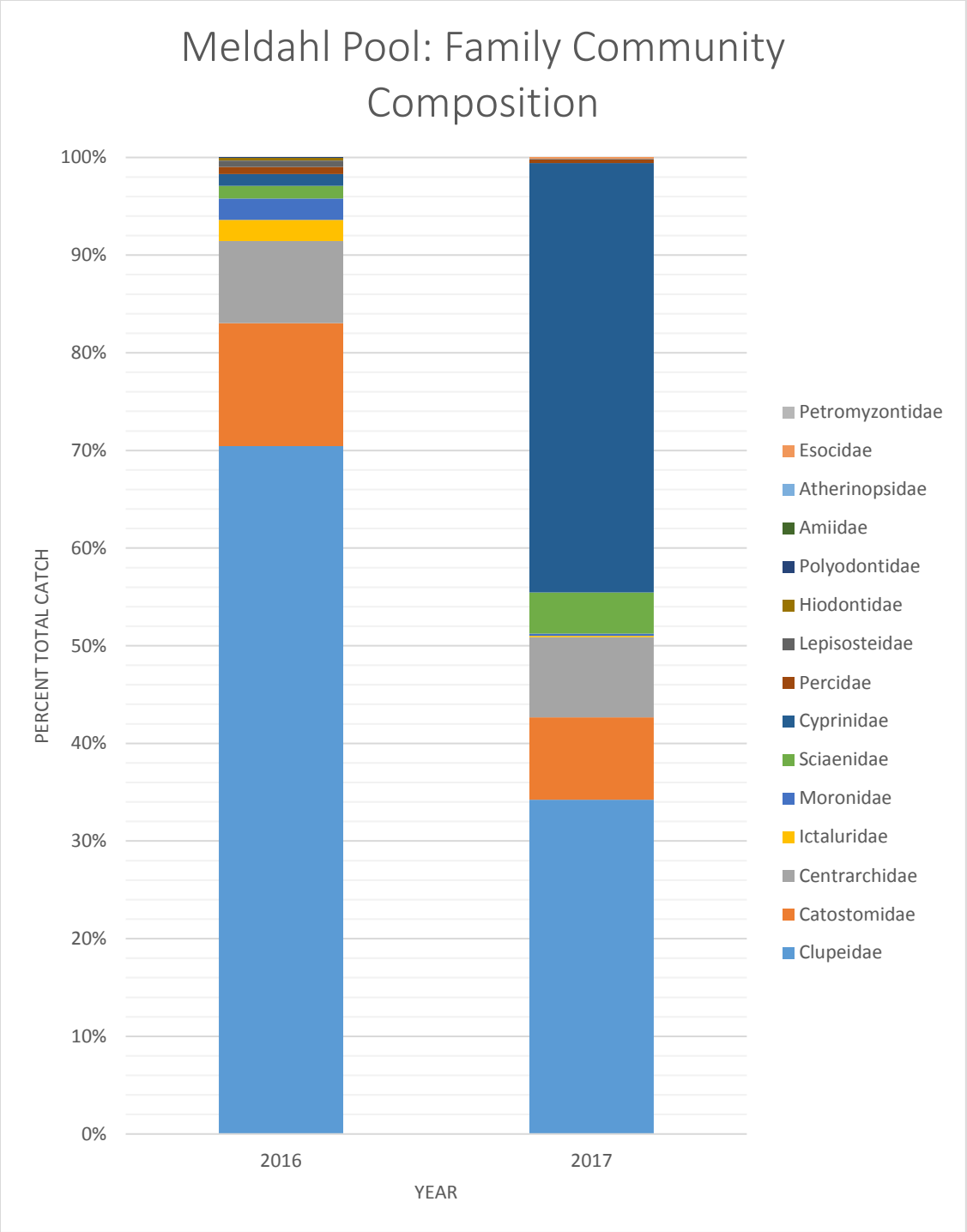

Figure 12. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the Meldahl pool.

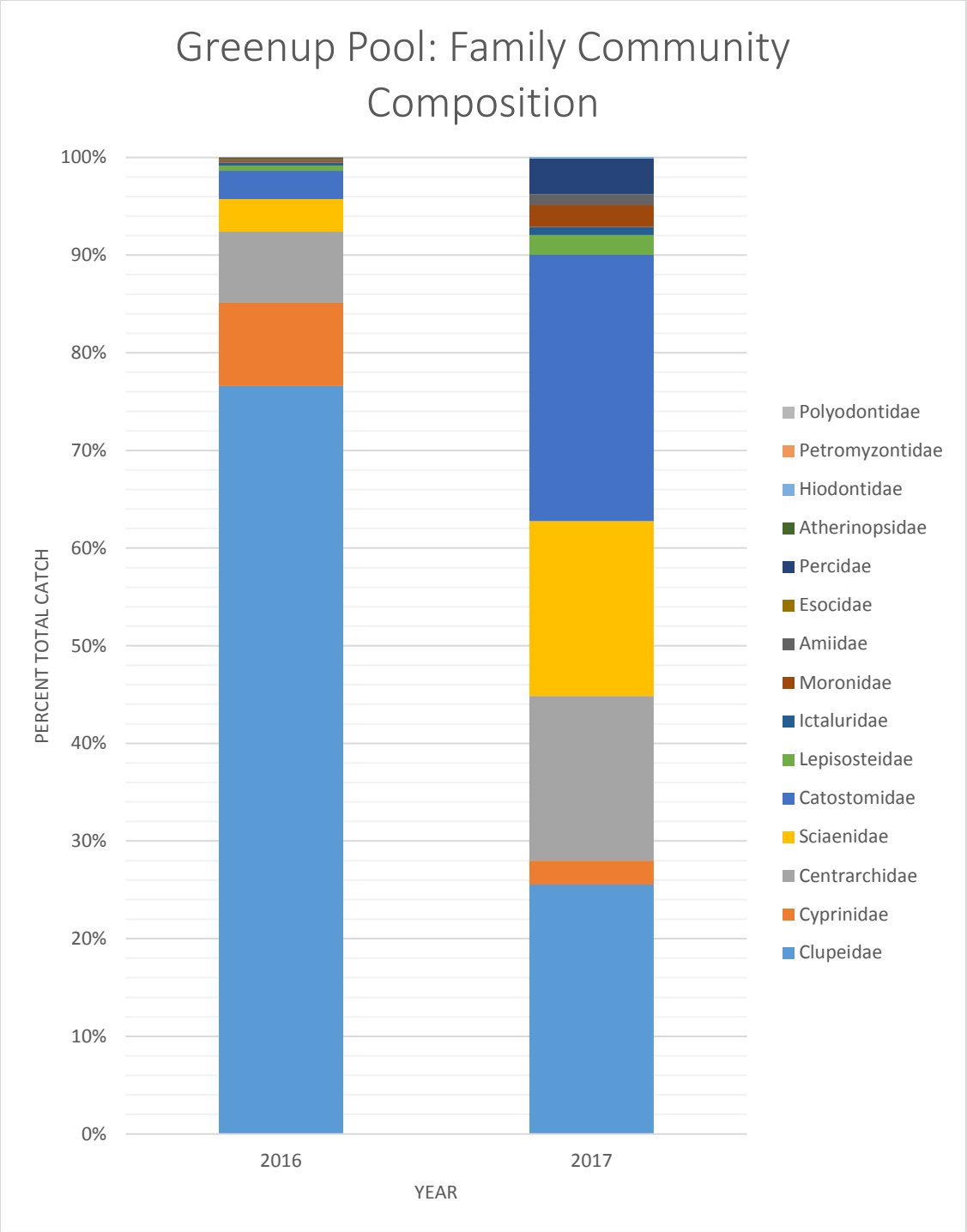

Figure 13. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the Greenup pool.

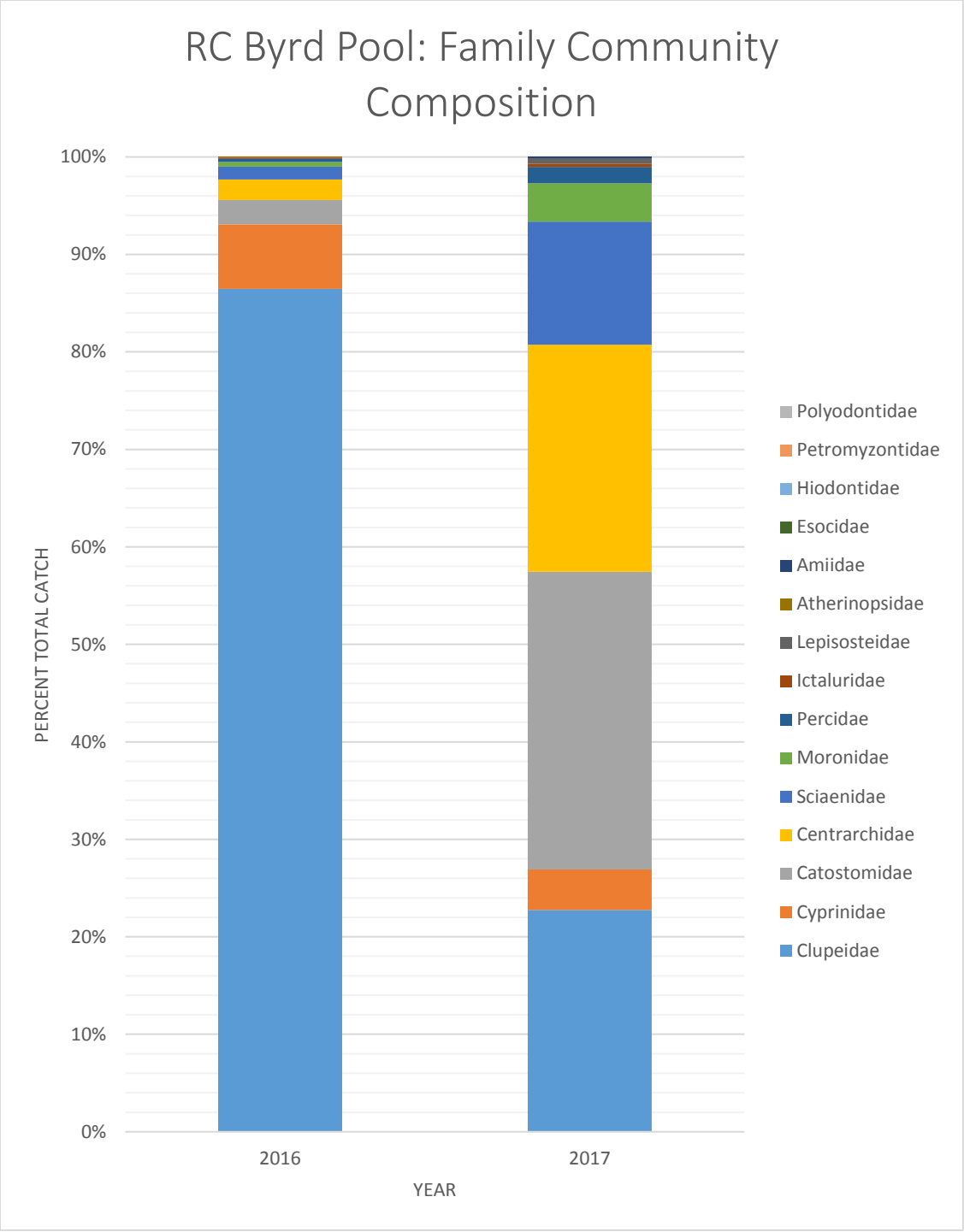

Figure 14. Percent total catch by number of each family identified from fall community sampling in 2016 and 2017 in the RC Byrd pool.

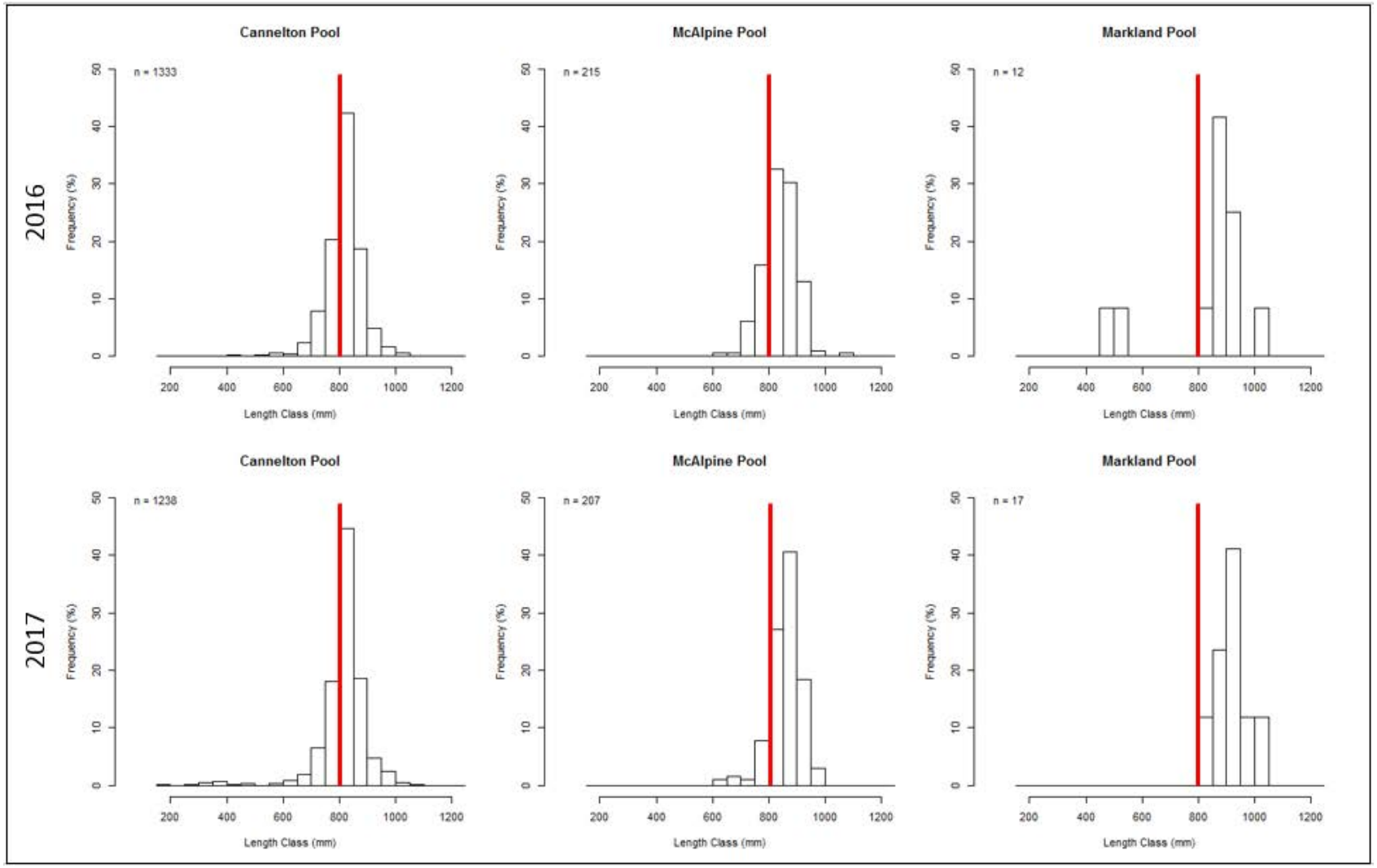

Figure 15. Length frequencies of silver carp captured during sampling efforts in 2016 and 2017. A line at 800mm highlights the change in length-classes from fish captured farther upriver with Cannelton being the farthest pool downstream and Markland the farthest pool upstream.

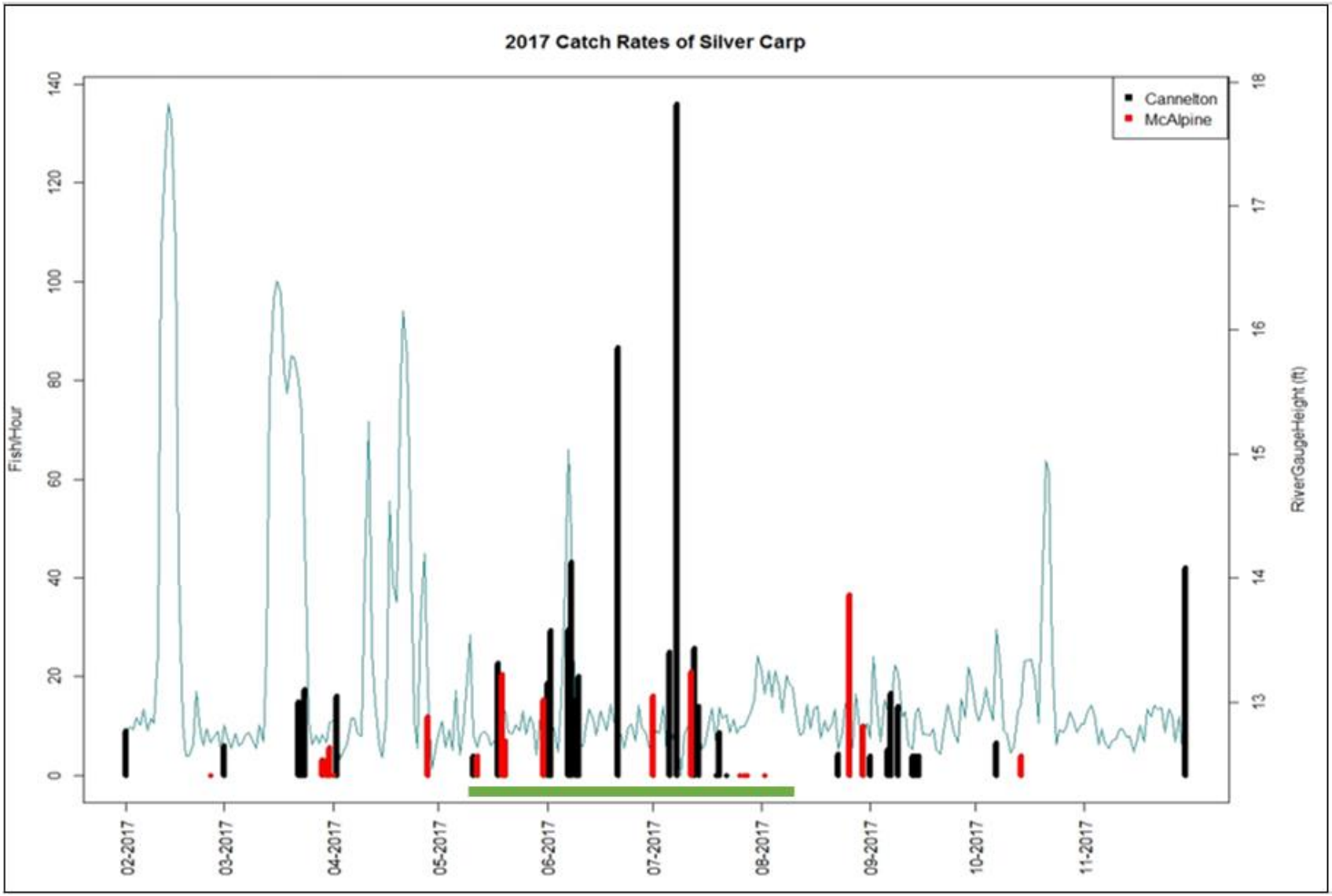

Figure 16. A histogram showing catch rates by month of silver carp captured in Cannelton and McAlpine in 2017 along with the gauge height in feet. The green line between the months of May and August indicate the period where spawning patches appear on females.

Year	Intercept	Slope
2016	-4.938	2.991
2017	-5.250	3.092

	Df	Sum Sq	F value	Pr(>F)
(Intercept)	1	9.539	3386.703	< 2e-16
Log10[Length]	1	28.556	10138.649	< 2e-16
Year	1	0.009	3.168	0.076
Log10[Length]:Year	1	0.008	2.758	0.098
Residuals	260	0.732		

Figure 17. (Top) A table with individual intercepts and slopes for regressions of silver carp log-transformed lengths (mm) and weights(g) in 2016 and 2017. (Bottom) An ANOVA table showing the results of the ANCOVA analysis for the linear regression model ($y = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x1x\ 2 + Ɛ$), with weight (g) being determined by total length (mm) and year used as a categorical predictor variable for silver carp captured after spawning activity in each sampling year.

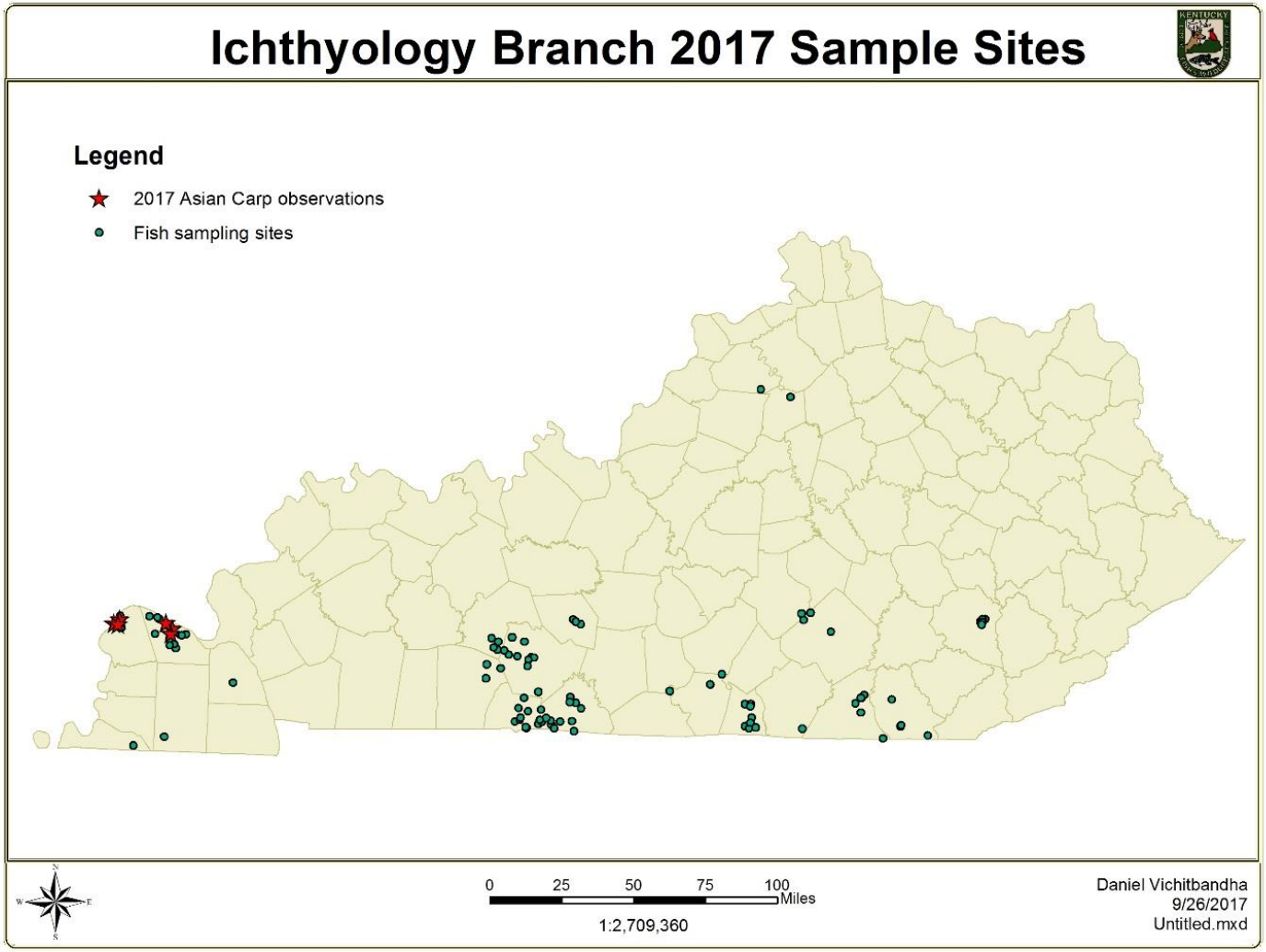

Figure 18. A map of Kentucky showing the sites where the KDFWR ichthyology branch conducted 2017 project sampling with incidental Asian carp observations indicated using red stars.

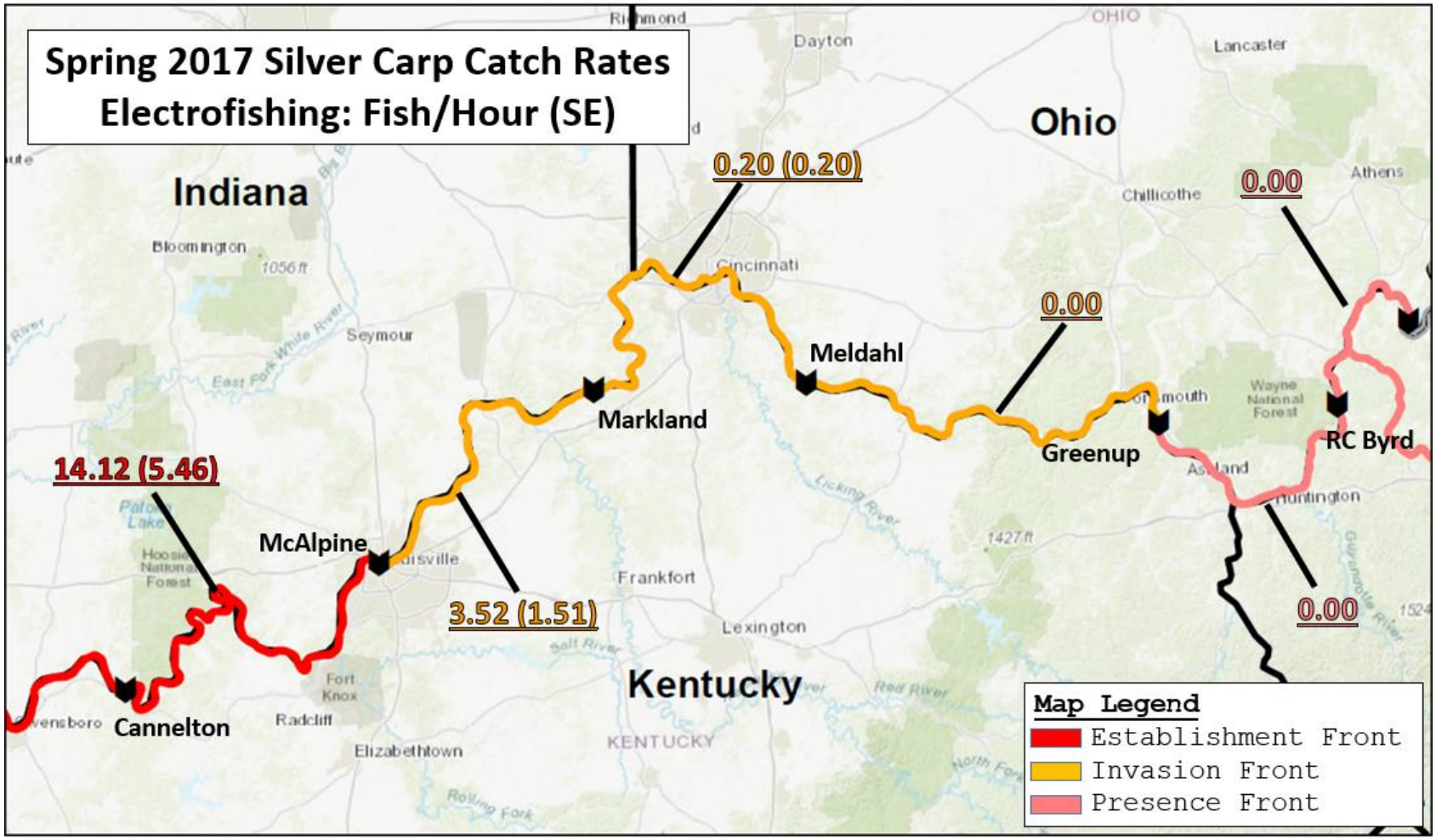

Figure 19. Mean silver carp catch rates by navigation pool using boat electrofishing during targeted sampling in 2017. Standard errors are in parenthesis.

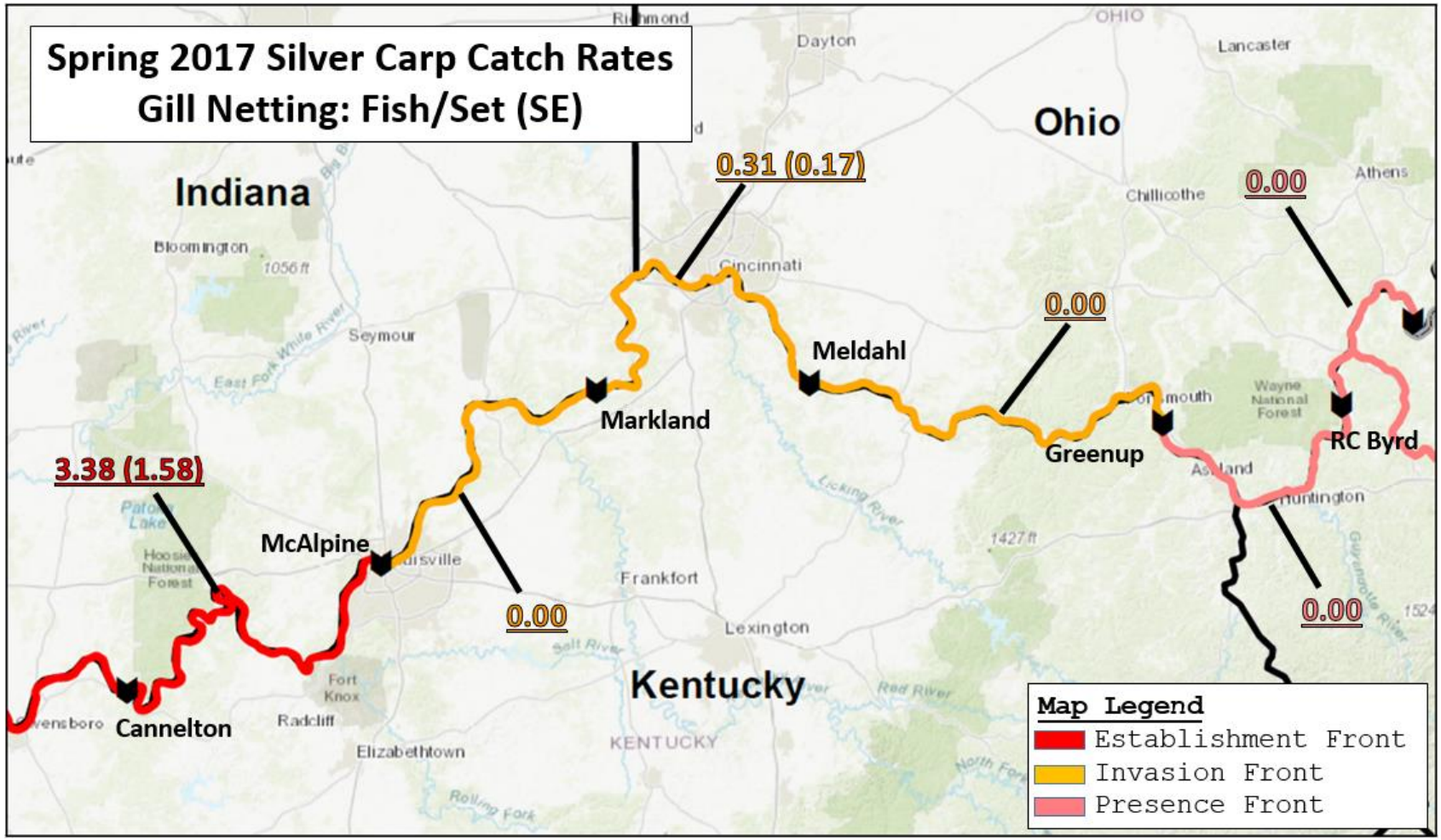

Figure 20. Mean silver carp catch rates by navigation pool using gill netting during targeted sampling efforts in Spring 2017. Standard errors are in parenthesis.

Tables:

Table 1. A summation of sampling efforts by agencies participating in monitoring efforts for 2017.

Partner Group	Electrofishing (hrs)	Gill Netting (ft)	Hoop Netting (Net-nights)	Beach Seine (Events)
INDNR	8.25	4,650	0	0
KDFWR	28.40	17,900	0	0
PFBC	5.50		69	6
USFWS	6.25	2,770	0	0
WVDNR	9.40	12,000	0	0
Total	57.80	37,320	69	6

Table 2. Estimated weights at two lengths for Silver carp from published data collected throughout the Silver carp ranges in the Mississippi River basin. Amended from Hayer et al. 2014.

System: Specific Locale	L-W Regression Equation (metric)	Predicted weight for 450mm (g)	Predicted weight for 800mm (g)	Reference
Ohio River	$\log_{10}$ weight = -5.13 + 3.05($\log_{10}$ length)	917	5302	This Report 2018
Illinois River	$\log_{10}$ weight = -5.29 + 3.12($\log_{10}$ length)	972	5856	Irons et al. 2011
Middle Mississippi River	$\log_{10}$ weight = -5.29 + 3.11($\log_{10}$ length)	915	5477	Williamson and Garvey 2005
Missouri River: Gavins Point	$\log_{10}$ weight = -6.92 + 3.70($\log_{10}$ length)	788	6628	Wanner and Klumb 2009
Missouri River: Interior Highlands	$\log_{10}$ weight = -5.35 + 3.13($\log_{10}$ length)	900	5453	Wanner and Klumb 2009
Missouri River tributary: Big Sioux River	$\log_{10}$ weight = -5.53 + 3.21($\log_{10}$ length)	970	6150	Hayer et al. 2014
Missouri River tributary: James River	$\log_{10}$ weight = -5.26 + 3.11($\log_{10}$ length)	981	5869	Hayer et al. 2014
Missouri River tributary: Vermillion River	$\log_{10}$ weight = -4.82 + 2.90($\log_{10}$ length)	748	3971	Hayer et al. 2014

Table 3. Estimated weights at two lengths for Bighead carp from published data collected throughout the bighead carp range in the Mississippi River basin.

System: Specific Locale	L-W Regression Equation (metric)	Predicted weight for 450mm (g)	Predicted weight for 800mm (g)	Reference
Ohio River	$\log_{10}$ weight = -5.05 + 3.03 ($\log_{10}$ length)	976	5577	This Report 2018
Illinois River: La Grange	$\log_{10}$ weight = -4.84 + 2.95 ($\log_{10}$ length)	970	5298	Irons et al. 2010
Missouri River (Males)	$\log_{10}$ weight = -5.42 + 3.15 ($\log_{10}$ length)	866	5306	Schrank and Guy 2002
Missouri River (Females)	$\log_{10}$ weight = -5.40 + 3.13 ($\log_{10}$ length)	803	4860	Schrank and Guy 2002
Missouri River: Gavins Point	$\log_{10}$ weight = -4.86 + 2.96($\log_{10}$ length)	985	5409	Wanner and Klumb 2009
Missouri River: Interior Highlands	$\log_{10}$ weight = -4.30 + 2.75($\log_{10}$ length)	991	4825	Wanner and Klumb 2009

Table 4. Electrofishing effort and the resulting total catch by the number of fish, number of species, and catch per unit effort (fish per hour) of three species of Asian carp captured in six pools of the Ohio River from spring targeted sampling in 2016 and 2017. Standard errors are in parentheses.

	Spring Boat Electrofishing													
	Ohio River 2016							**Ohio River 2017**						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sampling Dates	13 April - 08 June							10 April - 23 May						
Effort (Hours)	5.00	5.00	6.25	5.75	4.55	4.65	31.20	4.25	3.90	5.00	5.00	2.00	0.00	20.15
Sample Transects	20	20	25	23	18	19	125	17	16	20	20	8	0	81
All Fish (N)	1366	1310	2117	2313	2223	2626	11955	61	13	1	0	0	0	75
Species (N)	38	31	36	36	38	34	51	2	1	1	0	0	0	2
Bighead Carp (N)	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Silver Carp (N)	16	5	1	0	0	0	22	60	13	1	0	0	0	74
Grass Carp (N)	0	4	0	0	1	0	5	0	0	0	0	0	0	0
Bighead Carp CPUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24 (0.24)	0.00	0.00	0.00	0.00	0.00	0.05 (0.05)
Silver Carp CPUE	3.20 (1.85)	0.10 (0.49)	0.16 (0.16)	0.00	0.00	0.00	0.70 (0.32)	14.12 (5.46)	3.52 (1.51)	0.20 (0.20)	0.00	0.00	0.00	3.71 (1.31)
Grass Carp CPUE	0.00	0.80 (0.55)	0.00	0.00	0.22 (0.22)	0.00	0.16 (0.10)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5. Gill netting effort and summaries of the resulting total catch by the number of fish, number of species, and catch per unit effort (fish per set) of three species of Asian carp captured in six pools of the Ohio River from spring targeted sampling in 2016 and 2017. Standard errors are in parentheses.

	Spring Gill Netting													
	Ohio River 2016							**Ohio River 2017**						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sampling Dates	12 April - 06 June							04 April - 23 May						
Effort (ft)	4800	4800	3000	4790	1200	0	18590	2400	1800	3900	3300	3050	4650	19100
Net Sets	16	16	10	16	4	0	62	8	6	13	11	16	31	85
All Fish (N)	74	8	48	34	1	0	165	46	1	70	57	2	21	197
Species (N)	10	4	9	6	1	0	13	6	1	10	8	2	9	11
Bighead Carp (N)	1	0	0	0	0	0	1	6	0	2	1	0	1	10
Silver Carp (N)	19	0	3	0	0	0	22	27	0	4	0	0	0	31
Grass Carp (N)	1	0	1	0	0	0	2	0	1	13	1	1	1	17
Bighead Carp CPUE	0.06 (0.06)	0.00	0.00	0.00	0.00	0.00	0.02 (0.02)	0.75 (0.62)	0.00	0.15 (0.15)	0.00	0.00	0.03 (0.03)	0.10 (0.06)
Silver Carp CPUE	1.18 (0.59)	0.00	0.30 (0.15)	0.00	0.00	0.00	0.35 (0.16)	3.38 (1.58)	0.00	0.31 (0.17)	0.00	0.00	0.00	0.70 (0.34)
Grass Carp CPUE	0.06 (0.06)	0.00	0.10 (0.10)	0.00	0.00	0.00	0.03 (0.02)	0.00	0.17 (0.17)	1.00 (0.62)	0.09 (0.09)	0.06 (0.06)	0.03 (0.03)	0.19 (0.10)

Table 6. Electrofishing effort and the resulting total catch by the number of fish, number of species, and catch per unit effort (fish per hour) of three species of Asian carp captured in six pools of the Ohio River from fall community sampling in 2016 and 2017. Standard errors are in parentheses.

	Fall Electrofishing													
	Ohio River 2016							**Ohio River 2017**						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sampling Dates	04 October - 17 November							02 October - 28 November						
Effort (Hours)	5.50	6.00	3.50	5.10	1.50	2.58	24.18	6.00	6.25	6.75	3.75	5.00	4.40	32.15
Sample Transects	22	24	14	21	6	11	98	24	25	27	15	20	19	130
All Fish (N)	2865	713	1075	1222	958	3355	10188	686	1024	1614	1341	983	888	6536
Species (N)	40	34	31	36	30	38	62	37	36	38	30	29	34	56
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silver Carp (N)	6	6	0	0	0	0	12	5	1	0	0	0	0	6
Grass Carp (N)	0	0	3	0	0	0	3	0	0	0	0	0	0	0
Bighead Carp CPUE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver Carp CPUE	1.09 (0.65)	0.99 (0.50)	0.00	0.00	0.00	0.00	0.49 (0.19)	0.83 (0.34)	0.16 (0.16)	0.00	0.00	0.00	0.00	0.18 (0.07)
Grass Carp CPUE	0.00	0.00	0.86 (0.46)	0.00	0.00	0.00	0.12 (0.07)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 7. Gill netting effort and summaries of the resulting total catch by the number of fish, number of species, and catch per unit effort (fish per set) of three species of Asian carp captured in six pools of the Ohio River from fall community sampling in 2016 and 2017. Standard errors are in parentheses.

	Fall Gill Netting													
	Ohio River 2016							**Ohio River 2017**						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sampling Dates	04 October - 19 November							02 October - 28 November						
Effort (ft)	3000	4800	4200	4800	3000	3600	23400	4650	2770	3450	1500	5850	0	18220
Net Sets	10	16	14	16	10	12	78	31	10	23	10	20	0	94
All Fish (N)	7	20	17	16	3	0	63	60	4	7	35	5	0	111
Species (N)	2	7	5	7	2	0	12	11	3	4	4	4	0	12
Bighead Carp (N)	0	1	0	0	0	0	1	9	0	0	0	0	0	9
Silver Carp (N)	5	5	0	0	0	0	10	24	0	2	0	0	0	26
Grass Carp (N)	0	1	2	0	0	0	3	1	0	0	0	0	0	1
Bighead Carp CPUE	0.00	0.06 (0.06)	0.00	0.00	0.00	0.00	0.01 (0.01)	0.29 (0.16)	0.00	0.00	0.00	0.00	0.00	0.10 (0.53)
Silver Carp CPUE	0.50 (0.31)	0.31 (0.25)	0.00	0.00	0.00	0.00	0.13 (0.07)	0.77 (0.43)	0.00	0.09 (0.06)	0.00	0.00	0.00	0.28 (1.40)
Grass Carp CPUE	0.00	0.06 (0.06)	0.14 (0.10)	0.06 (0.06)	0.00	0.00	0.05 (0.03)	0.03 (0.03)	0.00	0.00	0.00	0.00	0.00	0.01 (0.01)

Table 8. The number of fish captured by species and percent of total catch in six pools of the Ohio River with boat electrofishing surveys at fixed monitoring sites in 2016 and 2017. (Ohio River Pools: Cann = Cannelton; McAlp = McAlpine; Mark = Markland; Meld = Meldahl; Green = Greenup)

	Ohio River Pools in 2016								Ohio River Pools in 2017							
Species Captured	Cann	McAlp	Mark	Meld	Green	RC Byrd	Total	Percent	Cann	McAlp	Mark	Meld	Green	RC Byrd	Total	Percent
Bigmouth Buffalo	1	1		2			4	0.039%	3	2	4	1			10	0.153%
Black Buffalo							0	0.000%		1	2				3	0.046%
Black Crappie	4	3	1	2		1	11	0.108%			1	2	5	3	11	0.168%
Black Redhorse						1	1	0.010%					1		1	0.015%
Blue Catfish				1			1	0.010%	3						3	0.046%
Bluegill Sunfish	57	20	103	23	21	29	253	2.483%	34	14	239	45	65	119	516	7.895%
Bluntnose Minnow							0	0.000%		3	1			2	6	0.092%
Bowfin					1		1	0.010%	1				11	1	13	0.199%
Brook Silverside						1	1	0.010%	1						1	0.015%
Bullhead Minnow	8						8	0.079%							0	0.000%
Central Stoneroller							0	0.000%					1		1	0.015%
Channel Catfish	24	30	16	21	1	4	96	0.942%	8	17	40	2	8	3	78	1.193%
Common Carp	9	17	25	8	2	3	64	0.628%	4	1	34	3	23	10	75	1.147%
Emerald Shiner	940	2	2	3	77	215	1239	12.161%	90	146	59	595		19	909	13.908%
Fathead Minnow						2	2	0.020%							0	0.000%
Flathead Catfish	2	1	1	4	2		10	0.098%	2	1	2				5	0.076%
Freshwater Drum	48	24	6	15	32	45	170	1.669%	30	54	30	56	176	112	458	7.007%
Gizzard Shad	1320	374	573	850	736	2898	6751	66.264%	322	442	685	470	251	200	2370	36.261%
Golden Redhorse	44	21	12	17	10	8	112	1.099%	18	62	42	4	24	15	165	2.524%
Goldeye				2			2	0.020%							0	0.000%
Goldfish			1				1	0.010%			3				3	0.046%
Grass Carp			3				3	0.029%							0	0.000%
Green Sunfish		1	5	1	1	3	11	0.108%			2	1	5	14	22	0.337%
Highfin Carpsucker			2			1	3	0.029%		6	2	1	1		10	0.153%
Lampery Family		1					1	0.010%							0	0.000%
Largemouth Bass	40	23	50	26	2	9	150	1.472%	22	10	70	30	38	21	191	2.922%
Logperch					1	2	3	0.029%	1	3	1		1		6	0.092%
Longear Sunfish	16	6	9	3	5	2	41	0.402%	9	5	25	2	2	2	45	0.688%
Longnose Gar	10	32	1	8	5	2	58	0.569%	14	27	18	1	20	5	85	1.300%
Minnow Family	2						2	0.020%		6				4	10	0.153%

Table 8 (cont). The number of fish captured by species and percent of total catch in six pools of the Ohio River with boat electrofishing surveys at fixed monitoring sites in 2016 and 2017. (Ohio River Pools: Cann = Cannelton; McAlp = McAlpine; Mark = Markland; Meld = Meldahl; Green = Greenup)

Mooneye		1		1			2	0.020%		4	1		1		6	0.092%
Moxostoma Genus	6		1	2			9	0.088%							0	0.000%
Muskellunge		1					1	0.010%		1		2			3	0.046%
Northern Hogsucker		1			6	2	9	0.088%	1	1			1	2	5	0.076%
Orangespotted Sunfish	11				7	4	22	0.216%			2	1		16	19	0.291%
Quillback	1	1		1	1		4	0.039%	2	8	2	4	4	7	27	0.413%
Redear Sunfish	29	1	1	1		1	33	0.324%	11		11	1	4	2	29	0.444%
River Carpsucker	42	12	24	17	2	2	99	0.972%	5	26	53	5	13	17	119	1.821%
River Redhorse	3			3	3	8	17	0.167%			2		2	6	10	0.153%
Rock Bass		1			3		4	0.039%							0	0.000%
Sauger	11	4	8	8		5	36	0.353%	3	6	5	5	34	13	66	1.010%
Saugeye				1		2	3	0.029%							0	0.000%
Sharpnose Darter						1	1	0.010%							0	0.000%
Smallmouth Redhorse	2	9	3	20		1	35	0.344%	6	13	2	1	9	13	44	0.673%
Silver Carp	6	6					12	0.118%	5	1					6	0.092%
Silver Chub	3				3		6	0.059%	1	15	6			1	23	0.352%
Silver Redhorse			1	4	1		6	0.059%				4	4	2	10	0.153%
Skipjack Herring	33	18	11	21		3	86	0.844%	5	25	16			2	48	0.734%
Smallmouth Bass	5	8	1	6	11	11	42	0.412%	4	10	8	1	15	11	49	0.750%
Smallmouth Buffalo	65	51	95	76	2	45	334	3.278%	51	71	130	61	193	189	695	10.633%
Spotfin Shiner						2	2	0.020%	2	1				1	4	0.061%
Spotted Bass	51	26	13	30	16	6	142	1.394%	10	27	25	10	25	15	112	1.714%
Spotted Gar	11						11	0.108%	1						1	0.015%
Spotted Sucker	8	3	15	5	1	16	48	0.471%	4	4	12	9	16	20	65	0.994%
Striped Bass	4	10	21	17			52	0.510%	1	5	18	3			27	0.413%
Sunfish Family						1	1	0.010%							0	0.000%
Sunfish Hybrid	1				3	1	5	0.049%	1				1	1	3	0.046%
Threadfin Shad	9			1			10	0.098%	1			1			2	0.031%
Walleye	2						2	0.020%					1	2	3	0.046%
Warmouth	2		3	2		1	8	0.079%			8	3	1		12	0.184%
Hybrid Striped Bass	18				1	7	26	0.255%	3		4		12	21	40	0.612%
White Bass	7	1	7	10	1	9	35	0.344%	4	5	20		10	14	53	0.811%

Table 8 (cont). The number of fish captured by species and percent of total catch in six pools of the Ohio River with boat electrofishing surveys at fixed monitoring sites in 2016 and 2017. (Ohio River Pools: Cann = Cannelton; McAlp = McAlpine; Mark = Markland; Meld = Meldahl; Green = Greenup)

White Crappie	9	3	61	10	1	1	85	0.834%	3		29	17	5	3	57	0.872%
White Sucker							0	0.000%		1					1	0.015%
Yellow Bass	1						1	0.010%							0	0.000%
Totals	2865	713	1075	1222	958	3355	10188		686	1024	1614	1341	983	888	6536	

Table 9. The number of fish captured by species and percent of total catch in six pools of the Ohio River with gill netting surveys at fixed monitoring sites in 2016 and 2017. (Ohio River Pools: Cann = Cannelton; McAlp = McAlpine; Mark = Markland; Meld = Meldahl; Green = Greenup)

	2016 Fall Monitoring Gill Netting								2017 Fall Monitoring Gill Netting							
	River Pool								River Pool							
Species Captured	Cann	McAlp	Mark	Meld	Green	RC Byrd	Total	Percent	Cann	McAlp	Mark	Meld	Green	RC Byrd	Total	Percent
Bighead Carp		1					1	1.587%	9						9	8.108%
Bigmouth Buffalo		1	4	2			7	11.111%	1			1			2	1.802%
Black Buffalo							0	0.000%	2						2	1.802%
Blue Catfish			1				1	1.587%	2	1					3	2.703%
Channel Catfish							0	0.000%					1		1	0.901%
Common Carp		2	1	3			6	9.524%	2			7			9	8.108%
FlatheadCatfish				1			1	1.587%			1		1		2	1.802%
FreshwaterDrum				1			1	1.587%	1			2			3	2.703%
Grass Carp		1	2	1			4	6.349%	1						1	0.901%
Longnose Gar		2					2	3.175%	3	1					4	3.604%
Muskellunge					1		1	1.587%							0	0.000%
Paddlefish	2		9	1			12	19.048%	4		1		1		6	5.405%
Silver Carp	5	5					10	15.873%	24		2				26	23.423%
Smallmouth Buffalo		8		7	2		17	26.984%	11	2	3	25	2		43	38.739%
Totals	7	20	17	16	3	0	63		60	4	7	35	5	0	111	

Project 2: Control and Removal of Asian Carp in the Ohio River

Geographic Location: For this agreement, the removal area was Greenup Pool and R.C. Byrd Pool. To meet objectives 2 & 3 data from populations below Greenup pool were used. This area is extending from the Cannelton Lock and Dam (RM 720.7) to the Markland Lock and Dam (RM 531.5) along with some limited removal in the Smithland pool, below Cannelton.

Objectives:

1. Remove Asian carp from the Greenup Pool
2. Compare methodologies and gear types to increase efficiency of Asian carp removal
3. Provide Data for monitoring and response efforts.

Methods:

Clarification of Terminology Referenced in This Document

With the current rate of Asian carp expansion and the massive effort to study and adaptively manage carp populations across several Mississippi River sub-basins, it is important to clarify terminology used in technical documentation and annual reports. Currently, there may not be consistent terminology used across the basins when talking about basin-specific invasions. With this in mind, below are a list of terms used in this report that are solely for internal reference.

Bigheaded Carps – a term used to reference the collection of the bigheaded carps (*Hypophthalmichthys spp.*) and their hybrids, found in the Ohio River basin.
Establishment Front – the farthest upriver range expansion of Asian carp populations that demonstrates the presence of natural recruitment.
Invasion Front – the farthest upriver extent where reproduction has been observed (eggs, embryos, or larvae) but recruitment to young-of-year fish has is not been observed.
Macrohabitat – One of five habitat types used to describe the variety of fixed sites within a pool (e.g. Tributary, Tailwater, Embayment, Island Back-Channel, Main Stem River).
Presence Front – The farthest upstream extent where Asian carp populations occur, but reproduction is not likely taking place.
Targeted Sampling – sampling that uses gear and/or techniques intended to specifically target one species and exclude others (i.e. silver carp and bighead carp).

Targeting and Removal of Asian Carps

Electrofishing and gill netting for removal in 2017 were conducted over approximately 15 weeks from May through September. Because removal is the primary objective, electrofishing was not rigorously standardized, but total effort (hours) was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used most often and voltage was adjusted to target a maximum power goal for each run. Large mesh (4.0” – 5.0” square) gill nets were used with each set consisting of a minimum 180 minutes of soak time with fish being driven toward the nets with boat noise at 30-minute intervals. Nets were occasionally set overnight in areas where they did not create hazards to navigation.

Sampling efforts focused on tributaries and embayments where densities of Asian carp are highest and fish are easiest to capture. The majority of these locations were derived from monitoring sampling sites in 2016. Additional sites that were either remotely identified using map study, recommended by agency biologists, or areas that contained characteristics of typical carp habitat were also targeted. However, the majority of effort was spent in known, high-density locations where carp were consistently captured.

All Asian carps and by-catch were identified to species. Asian carp were inspected for tags (both jaw and ultrasonic VEMCO tags) before being euthanized for population control or tagged for the Ohio River

Telemetry projects. All by-catch was immediately returned to the water upon recovery. Asian carp species (bighead carp, silver carp, and grass carp) from each sampling location were measured for total length (mm) and weight (g) to provide estimates of the minimum total weight harvested. When possible, supplemental data including sex, fin spines, and otoliths were collected for each silver or bighead carp captured (Williamson and Garvey 2005, Seibert and Phelps 2013).

Exploration of Novel Sampling Techniques and Gears
A limited number of novel removal techniques were explored in 2017. These efforts were intended to identify new methods to more effectively target carp. However, because the primary goal of this project was to remove carp and reduce propagule pressure to move upriver, limited effort was expended testing the effectiveness of new techniques.

In 2016 and 2017, winged hoop nets were used to target Asian carp at known high-density locations. This gear was appealing due to their reported success in other systems and because they can be left, unmonitored for days at a time. Hoop nets were typically fished over a 36-hour period and were often placed where falling water levels and wings might corral fish into the gear. Some nets were set below the surface in flow, near woody debris, with throats facing downstream. On other occasions, throats were placed into flow, where pooled water was actively dropping after a rise in river conditions.

Over-night gill net sets were used with more frequency in 2017 due to electrofishing difficulties in dim lighting during night sampling. Gill nets were set three feet underwater in main-stem river locations and deeper tributaries or tributary mouths. Nets were large mesh (4.0” to 5.0” square) and often set perpendicular to the shoreline.

The use of boat electrofishing as a herding tool, in combination with gill nets, was also employed as a removal technique. Large mesh, gill nets were set in areas where fish could be pushed into the gear. Because of the large amount of variation between net locations, there was no effort to maintain consistency in the design or implementation of this technique. Catch between either gears was recorded together.

Collaborative work between KDFWR and USFWS was conducted using hydroacoustic equipment in an effort to identify schools of carp that could be targeted and herded into entanglement gears. Gill nets were strategically placed in sections of a tributary (Clover Creek, KY) and on the main-stem Ohio River where large schools of riverine fishes were located using a hydroacoustic, split-beam sonar array. Electrofishing boats were used in an attempt to move fish into nets after they were dropped around schools of fish. Additionally, telemetry results were used to identify high use tributaries to focus sampling efforts.

Support Creation of Asian Carp Markets
The Kentucky Department of Fish and Wildlife Resources executive leadership is currently working with private business and commercial anglers to aid in furthering the development of an Asian carp fishing industry in Kentucky. Several barriers for a successful industry start-up have been identified and multiple strategies are being developed to address some of the logistical hurdles for market growth. In Kentucky, the Asian carp Harvest Program has been developed to further incentivize commercial anglers to target bigheaded carps specifically.

Results:
Physical Removal of Asian Carps
A total of 61 hours were spent electrofishing in three pools of the Ohio River and its tributaries between Smithland and Markland Lock and Dam (Table 1). One thousand four hundred and sixty-six carp were removed using boat electrofishing over these four pools in 2017. The highest level of effort was

expended in the Cannelton pool where a total number of 1,077 carps, weighing approximately 6,077 kg (13,400 lbs), were removed. Total effort and capture numbers accounted for in this report include some time and effort placed into the Abundance and Distribution of Early Life Stages project. However, this report does not contain all effort in the pools where juvenile sampling took place. For more detail on effort and removal conducted during juvenile sampling in 2017, please refer to that report.

A total of 8,850 ft of large mesh (4" and 5" square) gill nets were used in capturing 93 invasive carps in the Cannelton and McAlpine pools (Table 2). This amounted to 777 kg (~1,712 lbs) of bighead and silver and grass carp combined. The largest amount of effort was expended in the Cannelton pool with 6,450 ft of gill net fished to remove 90 fish, weighing approximately 634 kg (~1,400 lbs).

A total of 26 hours were spent electrofishing in the four Ohio River pools and tributaries in Markland, Meldahl, Greenup and RC Byrd pool (Table 1). Six carp totaling ~54 kg (118 lbs) were removed along the upper pools within the invasion and presence fronts. The largest amount of electrofishing effort was expended in the Markland pool where all six silver carp made up the entirety of fish removed via boat electrofishing for this project. Three of those fish were tagged for the Telemetry of Asian Carp in the Ohio River project.

A total of 4,500 ft of gill net was set to capture three bighead carp, four silver carp and one grass carp in the four pools along the invasion and presence fronts (Table 2). The majority of effort was placed in Markland pool, where all four silver carp were captured. Outside of project activities, two additional bighead carp were recreationally snagged out of the old lock chambers on the RC Byrd Lock and Dam. This event caused partners to focus suppression efforts within the lower portion of the RC Byrd pool. Three bighead carp were captured near Raccoon Creek using gill nets in the RC Byrd pool after receiving these reports just upriver of the lock and dam. All three bighead were large (>47 inches) and nearing 50 lbs (Table 5.) Additionally, two bighead were captured using snagging techniques by the WVDNR hatchery staff after being sighted in the old lock chambers at the RC Byrd lock and dam complex. Data from these fish was not passed on to KDFWR.

Electrofishing allows for minimal targeted sampling and no bycatch. Gill netting bycatch was minimal, consisting of 6 non-target riverine fishes caught in Greenup and 22 non-target fishes in R.C. Byrd (Figure 6). The most common by-catch species was paddlefish in the R.C. Byrd pool, which made up 65% of landings for nets fished during the removal. Paddlefish were captured in overnight sets, with water temperatures being high and approximately 50% (4 paddlefish) were found dead-on-arrival. After this sampling effort, overnight sets were removed from the sampling protocol. All other fish captured in nets were alive after pulling the sets and released immediately upon identification. Efforts in the Greenup pool only yielded a total capture of six fish, four of which were longnose gar.

Pursuit of Novel Capture Techniques

No carp within the Cannelton and McAlpine pools have been captured using the hoop nets, and by-catch is typically high. Hoop nets are the only gear that has consistently captured sportfish species as by-catch, with the majority consisting of crappie species. Nets have been deliberately set at sites where electrofishing and gill netting have consistently caught Asian carp in the past. Plans to utilize and target strategic flood zones with hoop nets are planned for 2018. Future target sites include Clover Creek, Flint Island, Oil Creek, and McAlpine Lock and Dam tail-waters in the Cannelton.

The use of boat electrofishing in combination with gill netting appeared to increase carp catches in 2016. In 2017, gill netting while herding carp with boat electrofishing appeared to match or increase yields when compared to gill net catches without electrofishing assistance. Although three bighead carp were captured using these methods in 2016, not a single bighead was captured in 2017. Overnight gill net sets were fished with more frequency in 2017 and have resulted in more captures of bighead carp.

Support Creation of Asian Carp Markets
In 2015, over 1 million pounds of Asian carp were harvested from Kentucky waters and sold to processors within various domestic and exported markets. In 2016, commercial fisherman participating in the Asian Carp Harvest Program in Kentucky waters yielded ~1.4 million pounds of carp which were also sold to various markets. An additional 1.4 million pounds of Asian carp was reported from commercial anglers in 2017 with ~765,000 pounds being harvest through the Asian Carp Harvest Program. In addition, executive leadership in the KDFWR agency has gained an understanding of how commercial fishers and processors operate from inquiries conducted over several years and have identified and worked to lower hurdles for the growing industry. Currently, three Kentucky processers are receiving Asian carp species from commercial anglers and several restaurants in and around Kentucky are serving the fish on their menus.

Removal in Other Projects
While removal was not listed as a primary objective in other ORB projects, Asian carp captured during any sampling on the Ohio River were euthanized unless they were tagged for tracking purposes. Accounts of an additional 1,353 kg (~2,983 lbs) of fish were captured during monitoring efforts and 160 kg (~353 lbs) during containment efforts outside of this project were removed from the river. Details on these additional fish captured during non-targeted sampling are not detailed here, but are included in other ORB reports.

Discussion:
Dams along the Ohio River are likely formidable barriers to dispersal for silver carp migrating up river. Data acquired from sampling efforts in 2017 show that the average sizes of silver carp increase (Figure 2) as you move up river, while catch rates decrease (Figure 3 and Figure 4). This has been a consistent pattern in data gathered since 2015 and is an indication that fish further up river are not only lesser in number, but likely older fish that have had more time to disperse from an established front. With Cannelton being the furthest upriver pool where fish < 400 mm have been observed, it must be prioritized as a major target in terms of population control. Numbers of fish are high enough to suggest that regular fishing pressure is needed, and with the presence of newly recruited fish, it is likely the main source-population contributing to upriver population expansion. Focus on the higher density pools like Cannelton that may be important reservoirs for propagules can alleviate pressure for upriver expansion and decrease efforts expended upriver, where low densities make it difficult to catch and suppress carp populations.

Currently, electrofishing has produced the most success in capturing silver carp due to their transient nature and explosive reaction to electricity. Silver carp can be sought out quickly with boat electrofishing techniques and schools can easily be targeted when found. More aggressive movements and sinuous patterns are often used to pin fish against the bank when targeting silver carp and can be effective at getting fish to surface. However, because they are difficult to catch when airborne, CPUE is often more variable and highly dependent on both the experience of the driver and dipper. In addition, increased catch rates when electrofishing in 2017 correlated with spawning activity and increased movement into tributaries during the summer months (Figure 5). Targeting of tributary waters and tributary mouths give removal crews an advantage because gears are typically more effective in these shallower waters. Future sampling efforts should be designed to take advantage of this period to maximize catch. Additional exploratory efforts should be pursued to increase removal success outside of spawning periods (approximately May – August).

Despite lessons learned from previous years, electrofishing conducted within the removal framework in 2017 produced a lower overall total catch when compared to removal conducted in 2016. However, there was roughly a 232% increase in catch of targeted carp using improved gill netting techniques when compared to 2016. This increase is likely due to better site selection and increased experience among removal crews running gill nets. Additionally, longer soak times when targeting bighead carp has also caused an increase in overall carp captures. In the future, nets will range from 3" bar mesh to 6" bar mesh to decrease size selectivity and target a wider range of length-classes.

Due to the biology and habits of Asian carps, recommendations on utilizing herding techniques seemed like an effective way to force fish to move into gears or traps. Previously, efforts in 2016 did appear to show that a combination of boat electrofishing and gill nets produced higher success rates than single gear methods. This strategy was also productive in 2017 and will continue to be refined. In 2017, floating nets were also successful as in previous years when targeting fish at the top of the water column. One fishing technique often reference, drifting gill nets, has yet to be successful when deployed across the removal range, but likely needs to be attempted at night when carp are ram-feeding at the surface to see success.

Commercial or contract angling should be encouraged in the future to place additional pressure on Asian carp populations within these pools. Increased focus on pools with established populations and higher densities will likely allow the reduction of density dependent dispersal. Currently, participating agencies have consistently been able to remove around 9,100 kg of Asian carps per year in these relatively lower density pools (Cannelton – RC Byrd). With no indication that relative abundances have decreased, more effort must be placed in the removal of fish along the invasion front. Effective target parameters for population control cannot be developed without an indication that population numbers are being lowered, but annual yields exceeding 9,100 kg (~20,000 lbs) should be attempted in the future.

Recommendations:
Future removal effort should focus primarily on the Cannelton pool during the months of June to August when spawning activity is observed and fish begin to congregate below McAlpine Lock and Dam or in the tributaries. During this time period, special consideration should be given to Clover Creek, Oil Creek, and Yellowbank Creek where juvenile fish have been observed. Sinking Creek, Poison Creek and the Salt River, appear to harbor large groups of fish year around and are important targets within the Cannelton pool. Gill netting activity should increase overall with an emphasis on setting gears near top water during evening hours and overnight. Efforts to spur public and commercial interest within the Cannelton pool should continue and will be an important in contributing to the necessary population control efforts for the Ohio River basin.

Deliverables: Data from this project was compiled for Ohio River Basin Asian Carp Control Strategy Framework technical reports in Feb 2017 and 2018. KDFWR staff took lead on writing the Basin "Control and Removal of Asian Carp in the Ohio River" technical report, funding templates, and project planning for 2018 efforts. KDFWR staff presented the data to the basin working group Oct. 2017, participated in numerous conference calls, and participated in basin project planning in July 2018. Additionally, KDFWR hosted an Asian Carp symposium at the Southeaster Association of Fish and Wildlife Agencies Conference in Louisville, Ky in October of 2017 where data from this project was presented.

Project Highlights:

- Prevention and control are currently the best tools for limiting establishment of costly invasive species. Physical removal of Asian carps in the Ohio River basin is one of our few tools to slow their upstream expansion.

- Removal in 2016 was altered from removal conducted in 2015 in order to focus removal efforts in higher density pools were larger impacts could be made. This was continued in 2017 and efforts must be increased in order to slow and stop upriver progression of carp in the ORB.
- Electrofishing conducted in JT Myers though McAlpine pools in 2016 produced about a 100% increase in effort and a 340% increase in catch when compared to work completed in all five pools sampled in 2015. Efforts in 2017 produced slightly lower yields than in 2016, but the overall biomass removed between the two years was similar.
- Gill netting efforts in Cannelton and McAlpine alone were approximately equivalent to all the effort placed into the five pools previously targeted for removal in 2015. Total catch increased in 2016 (over 160%) and then increased again in 2017 (over 230%) as removal crews began to refine gill netting techniques.
- Effective target parameters for population control cannot be developed without an indication that population numbers are being lowered, but annual yields exceeding 9,100 kg (~20,000 lbs) have been consistent for the past two years and should be increased in the future.

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Figures:

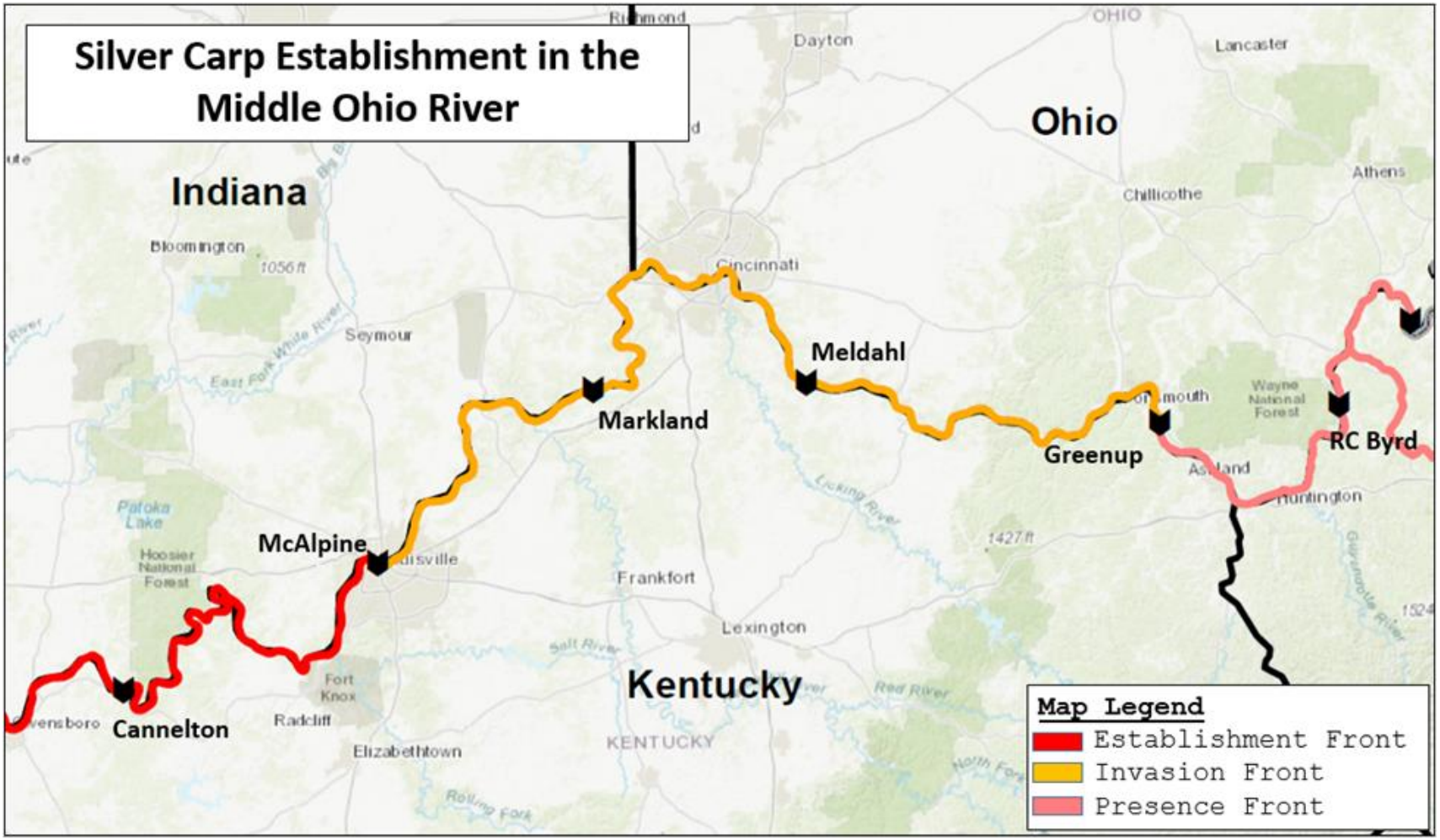


Figure 1. A map depicting the differing levels of Asian carp establishment in the middle Ohio River where targeted sampling and regular suppression is currently being conducted.

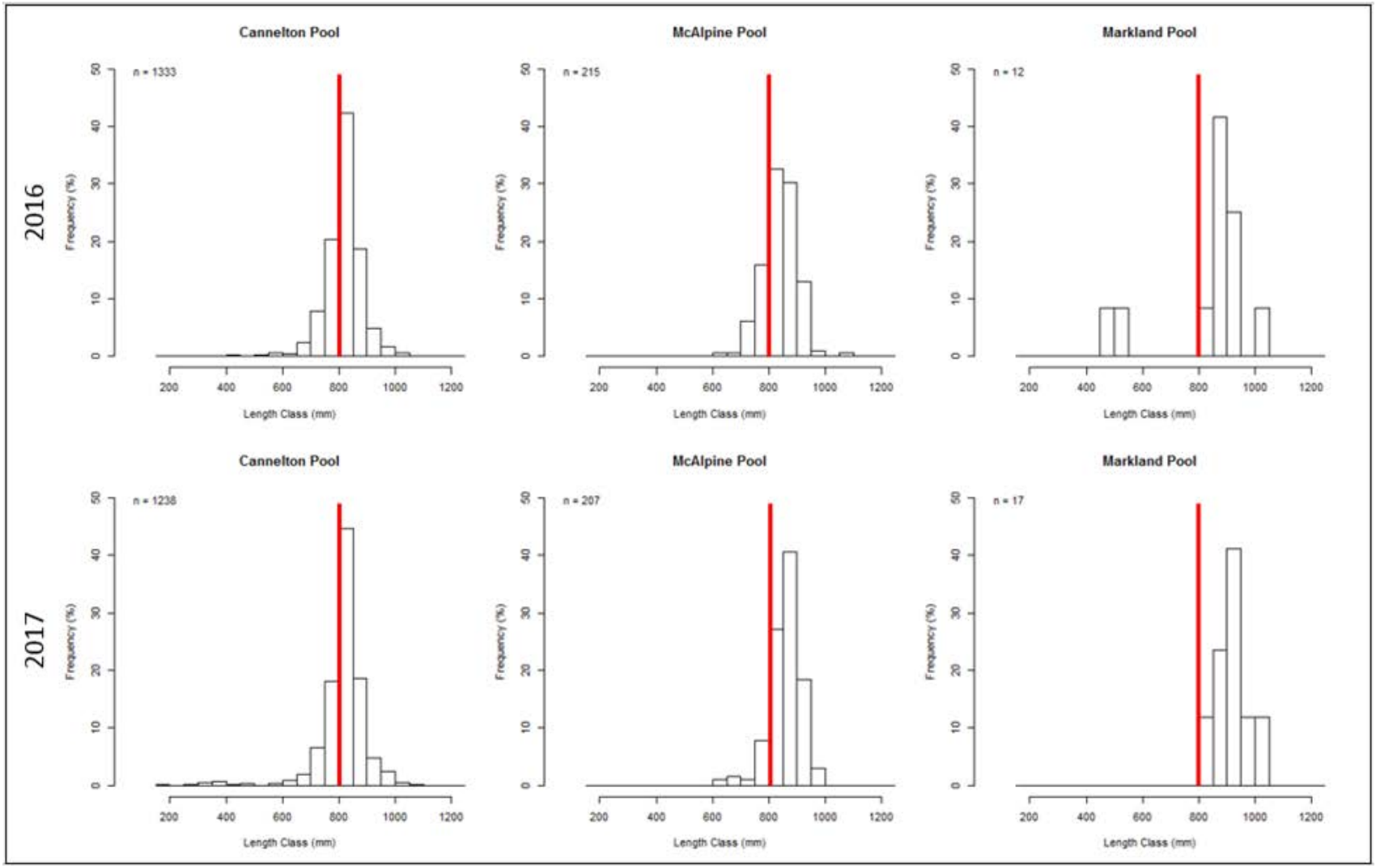


Figure 2. Length frequencies of silver carp captured during sampling efforts in 2016 and 2017. A line at 800mm highlights the change in length-classes from fish captured farther upriver with Cannelton being the farthest pool downstream and Markland the farthest pool upstream.

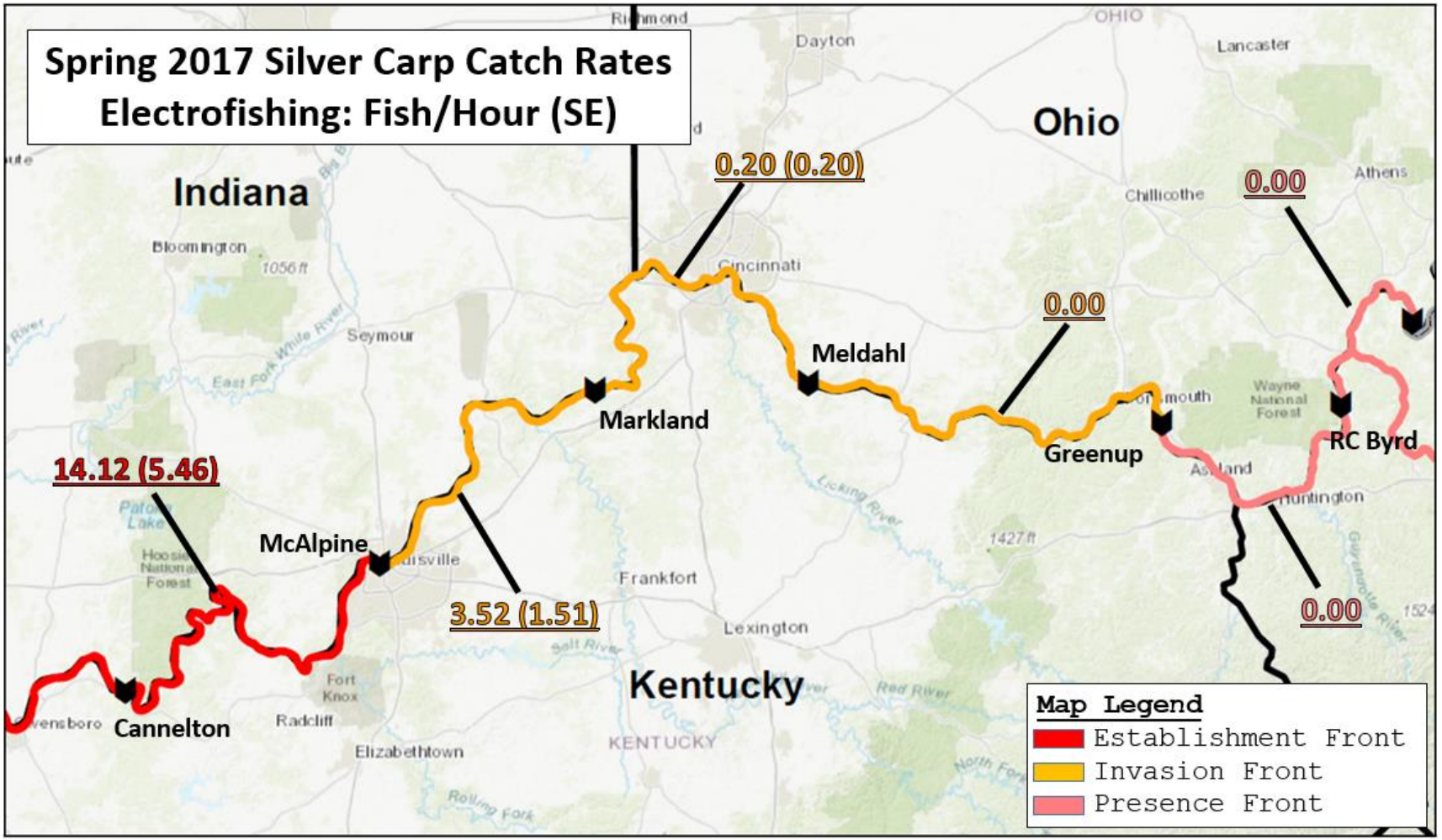


Figure 3. Mean silver carp catch rates by navigation pool using boat electrofishing during targeted sampling in 2017. Standard errors are in parenthesis.

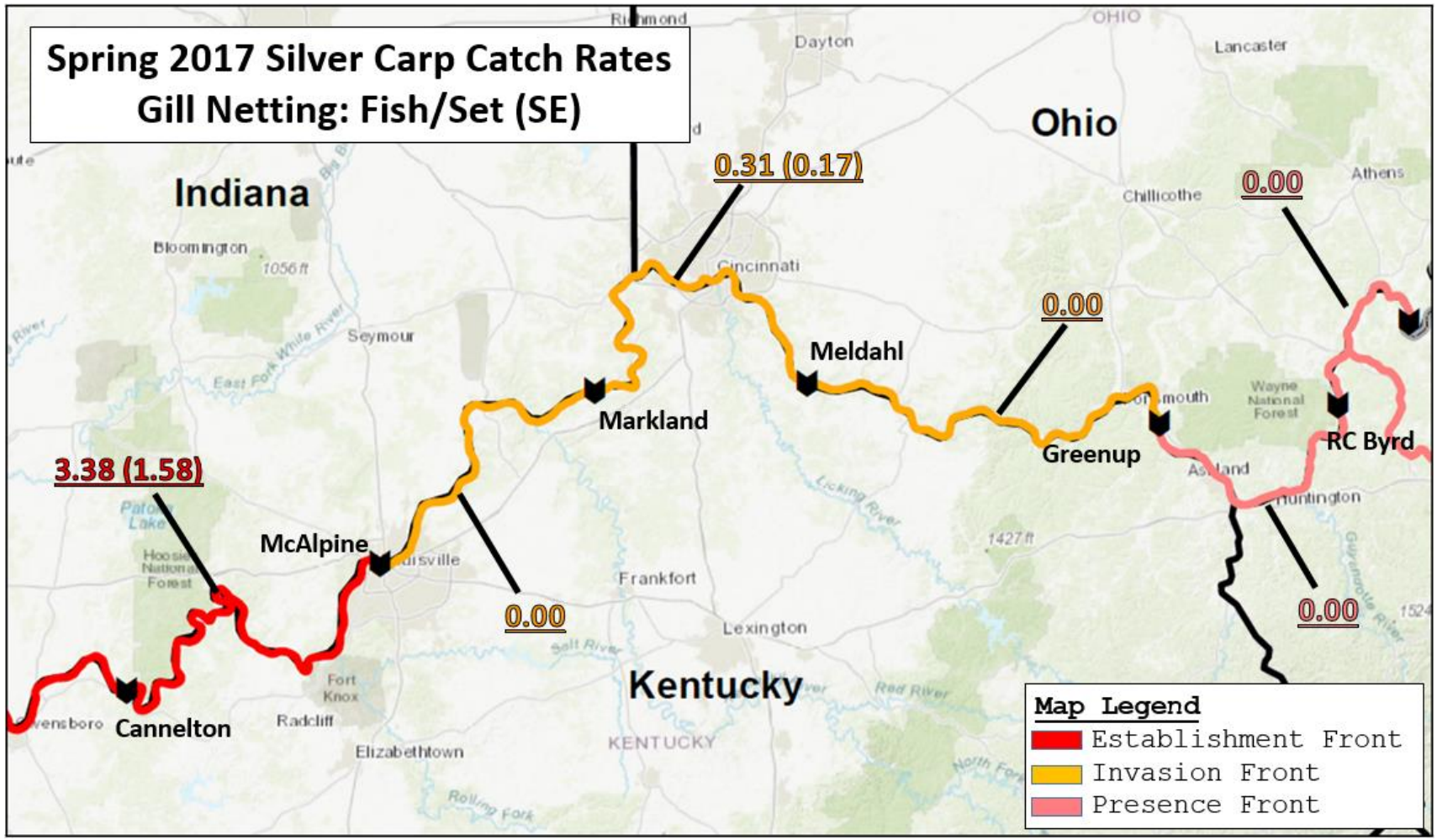


Figure 4. Mean silver carp catch rates by navigation pool using gill netting during targeted sampling efforts in Spring 2017. Standard errors are in parenthesis.

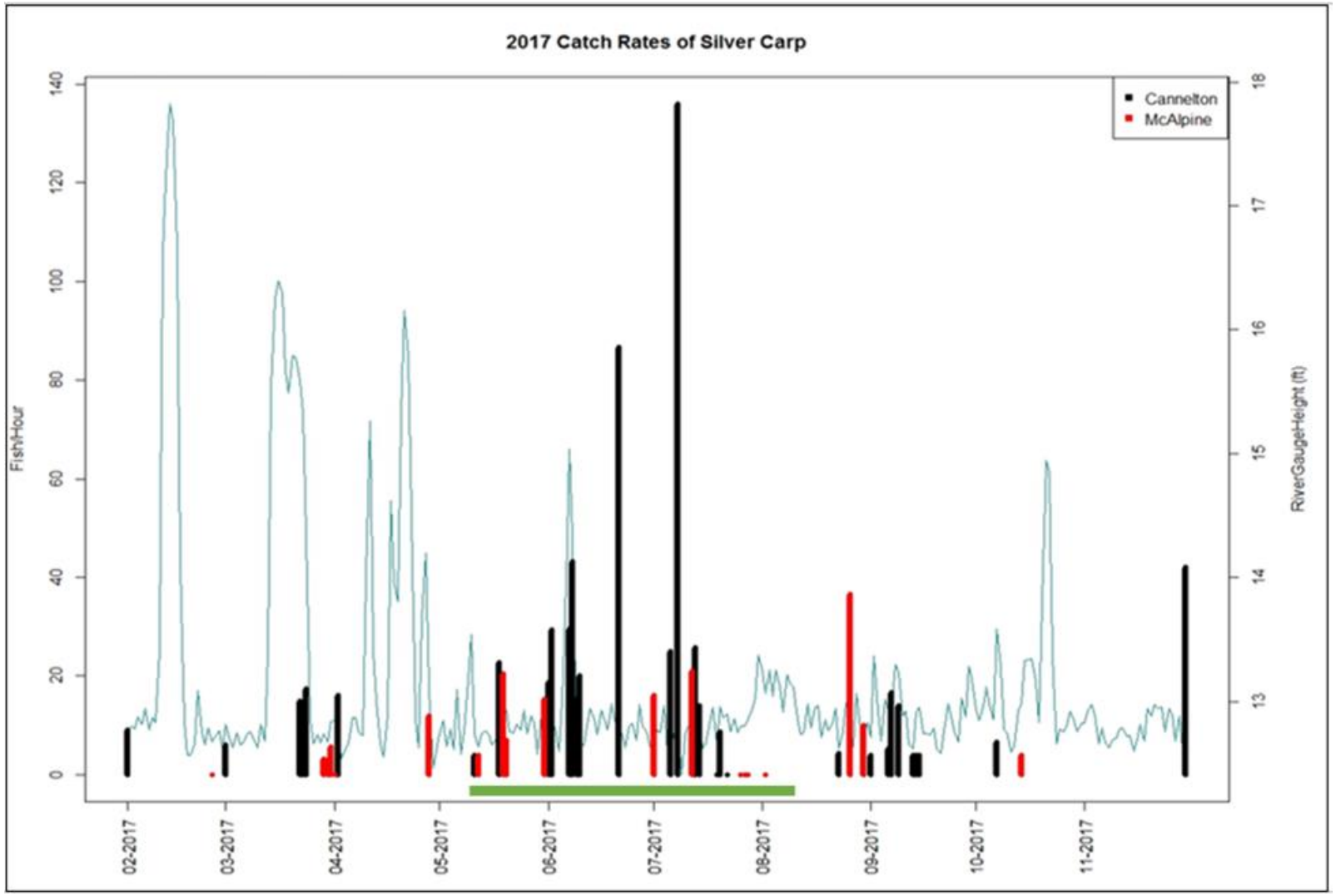


Figure 5. A histogram showing catch rates by month of silver carp captured in Cannelton and McAlpine in 2017 along with the gauge height in feet. The green line between the months of May and August indicate the period where spawning patches appear on females.

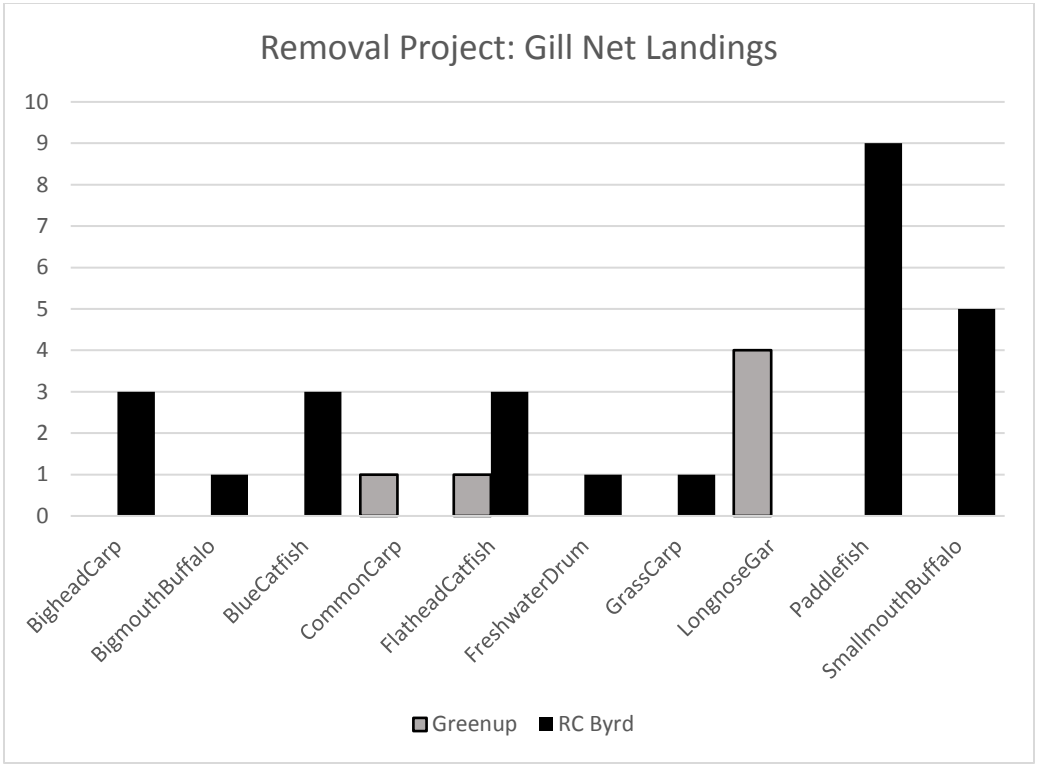


Figure 6. Summary of gill-netting landings in Greenup and R.C. Byrd Pools.

Tables:

Table 1. Electrofishing effort (hours) and resulting catch of three species of Asian carp (number and weight) for three pools of the Ohio River during Asian carp removal efforts in 2017.

Pool	Electro Hours (hr)	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Smithland	1.00	1	195	1	197	1.85	92.67	15.88	110.40
Cannelton	43.00	10	1050	17	1077	79.61	5924.24	73.27	6077.12
McAlpine	17.00	0	192	0	192	0.00	1314.13	0.00	1314.13
Total	61	11	1437	18	1466	81.46	7331.04	89.15	7501.65

Table 2. Electrofishing effort (hours) and resulting catch of three species of Asian carp (number and weight) for four pools of the Ohio River during Asian carp containment efforts in 2017.

Pool	Electro Hours (hr)	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Markland	11.00	0	6	0	6	0.00	53.79	0.00	53.79
Meldahl	7.50	0	0	0	0	0.00	0.00	0.00	0.00
Greenup	5.00	0	0	0	0	0.00	0.00	0.00	0.00
RC Byrd	2.50	0	0	0	0	0.00	0.00	0.00	0.00
Total	26.00	0	6	0	6	0.00	53.79	0.00	53.79

Table 3. Gill netting effort (feet) and resulting catch of three species of Asian carp (number and weight) for two pools of the Ohio River during Asian carp removal efforts in 2017.

Pool	Total Net Length (ft)	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Cannelton	6450	11	76	3	90	148.84	456.64	28.44	633.92
McAlpine	2400	1	2	0	3	24.58	118.38	0.00	142.96
Total	8850	12	78	3	93	173.42	575.02	28.44	776.88

Table 4. Gill netting effort (feet) and resulting catch of three species of Asian carp (number and weight) for five pools of the Ohio River during Asian carp removal efforts in 2017.

Pool	Total Net Length (ft)	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Markland	1800	0	4	0	4	0.00	32.57	0.00	32.57
Meldahl	900	0	0	0	0	0.00	0.00	0.00	0.00
Greenup	1050	0	0	0	0	0.00	0.00	0.00	0.00
RC Byrd	750	3	0	1	4	67.04	0.00	6.41	73.45
Total	4500	3	4	1	8	67.04	32.57	6.41	106.02

Table 5. Length, weight, and age data for Bighead carp captured in R.C. Byrd Pool

Date	Location	Length(in)	Weight(lbs)	Sex	Est.Age	Structure
8/31/17	Raccoon Creek	48.0	53.5	M	8	Otolith
8/31/17	Raccoon Creek	47.1	45.3	M	7	Otolith
8/31/17	Raccoon Creek	48.2	49.0	M	8	Otolith

Project 3: Limiting Dispersal of Asian Carp at Lock and Dam Facilities

Geographic Location: Markland Dam, Meldahl Dam, Greenup Dam, and RC Byrd Dam

Objectives:

1. Gather information on Asian Carp dam passage and historical conditions on the Ohio River that may impact passage.
2. Identify lock and dam complex practices that may minimize Asian Carp passage, or that create conditions that favor Asian Carp removal.

Methods:

Kentucky Department of Fish and Wildlife Resources staff reviewed United States Geological Survey (USGS) data and reached out to Lockmaster's at the United States Army Corps of Engineers to solicit input on practices that may minimize Asian Carp passage or create conditions that favor Asian Carp removal. Markland, Meldahl, Greenup and RC Byrd dam lockmaster's were contacted first by phone and then by e-mail to discuss lock and dam complex practices.

As a follow up to phone conversations, the following questions were e-mailed to lockmaster's:

1) In regards to river levels (i.e. Gage heights)...

* At what level (i.e. gage height) would the Ohio River be able to overtake the lowest point of {location L&D} and begin exhibiting free-flowing conditions? What's the specific area/component of the L&D that this would affect?

* Are there other river levels (i.e. gage heights) where additional areas of the L&D tend to start acting as passages for fish with strong swimming abilities, such as Asian Carp?

* At what gage height would the Ohio River be able flow unchecked over the top of most, if at all, of {location L&D}?

* Have there been any instances in the past 10 to 15 years where the Ohio River has reached a river level mentioned above? If so, can you recall the year(s) that they occurred?

2) Besides the lock chambers...

* Are there areas along {location L&D} that you (or your crew members) have actually observed be used by Asian Carp to gain access to the upriver pool?

* Are there alternative areas that you (or your crew members) suspect of being used by Asian Carp, but haven't been able to directly observe it?

3) Does your facility have any procedures or best practices related to the lock chambers, dam gates, etc. that could either hinder or help the ability of Asian Carp to pass through {location L&D}? If so, what part of the procedure may have the greatest impact?

4) Do you have any other observations, comments and/or opinions regarding...

* The possible passage of Asian Carp through Markland L&D (or any other facility on the Ohio River)?

* The ongoing Asian Carp Telemetry Project (i.e. receiver deployments, data analysis, results, etc)?

* The overall Asian Carp research efforts that are currently being conducted on the Ohio River?

Results and Discussion:

During 2017 the Kentucky Department of Fish and Wildlife Resources began collecting information from lock masters regarding potential barrier efforts and possible movement pathways for Asian carp through L&D facilities. The efforts to address the project's first objective began by obtaining specifications and design details for the nine L&D facilities located in close proximity to the AC population's leading edge. This section of the Ohio River starts at Cannelton L&D and then continues upstream to Willow Island L&D, and it includes the pools that contain AC populations at a variety of different stages ranging from high-density to non-existent. Aside from basic information about each L&D, the project biologist identified up to 18 gages that are actively recording the conditions along the 560 river miles that stretch between the most downstream and upstream L&D facilities within this section of the Ohio River. Since the analysis required historic water level data, the only gages selected for the project were those with at least 3 years of data available from USGS' online access to the National Water Information System (NWIS). The data that was ultimately included in the project's 2017 analysis had originated from 10 separate gages that measured river levels in eight different pools that were located between the most downstream gage at Cannelton L&D (RM 721.0) and the most upstream one near Parkersburg, WV (RM 184.5). After obtaining everything that was needed from the NWIS, all of the raw data was converted to Eastern Standard Time before they were reduced to create a total of 10 working datasets that contained hourly water levels ranging from 2007 to 2018. And then finally, the measurements from all 10 gages were reduced one last time to produce datasets of daily water levels that helped to produce simple charts that biologists could use to visualize how the river conditions changed over longer time periods of ten or more years. The project Biologists intend to continue updating the water level datasets as time goes by, and if needed, additional river levels data will also be obtained from offline sources.

Being that lockmasters are responsible for the day-to-day operations of their L&D facilities, their expertise is invaluable to both the federal and state agencies trying to combat highly invasive fish species such as Asian Carp. Furthermore, if L&D procedural changes are ever needed to help slow down the expansion of Asian Carp, lockmasters are uniquely qualified to determine if these changes could negatively affect the L&D's core function, which is to sustain the river conditions necessary for navigation. Upon recognizing the importance of the L&D's in regards to the long-term control of Ohio River AC populations, a KDFWR Biologist contacted several lockmasters during late summer of 2017. In initial discussions, KDFWR was able to frame the current issues with Asian carp on the Ohio River. In general, lock master's reiterated that any efforts to slow the Asian carp must not interfere with the primary objective of the facility: sustaining the conditions required for year round navigation. In fact, because of the L&D's main purpose and its specific design, lockmasters typically respond to flood conditions by making sure that all available dam gates are opened up as much as possible, which unfortunately leads to the open water conditions that are suspected of allowing large numbers of Asian Carp to transfer pools.

After the initial phone calls, lockmasters were also sent an emails that provided a better project description and an emphasis on the importance of their participation. Lockmasters at the Markland,

Meldahl, Greenup and RC Byrd L&D's were contacted. Information was provided supporting the concern for the pool-to-pool movements of Asian Carp and formally requested the lockmaster's assistance with a relatively new project that directly pertains to their L&D facility. In general, the lockmasters responded favorably and most seemed amenable to providing any assistance that they could even so far as offering tours of facilities.

The USGS has an invaluable historical river level data set, with water level gages throughout the middle Ohio River (Figure 2). Data from USGS suggests that fish passage through high lift lock and dam facilities on the main stem Ohio River is likely limited to passage through the lock chamber when a vessel is locking through or open river days when the gates are fully open (Knight et al., 2003) Open river days on all three pools of interest (Figures 3-6) were more frequent in the winter and spring (Knight et al., 2003). Installation of a sound, bubble curtain, or electric barrier preventing or limiting access to the locks at these facilities represents the greatest opportunity to prevent movement. If a barrier was constructed at the lock the number of open river days would be of chief concern because the barrier would be ineffective during those periods. After review of USGS water level and fish passage data the Markland facility stood out. The Markland lock is a high lift facility which, over the last 26 years, has had far fewer open river days than any other facility below the Racine pool. During that time period the facility only had 27 open river days while most other facilities had well over 100 open river days (Knight et al., 2003). This, coupled with the fact that the pool is within the invasion front of silver carp, makes it a top candidate for barrier installation.

Next steps should be to develop a basin plan for ideal barrier location from a biological perspective. Although the lockmasters were amenable to assisting where needed, they did not provide any specific suggestions for ideal barrier locations. The 2003 USGS report “Upstream Fish-Passage Opportunities at Ohio River Mainstream Dams” by Knights, Wlosinski, Kalas, and Baley may serve as a guiding document for ideal barrier placement. The report covers USGS opinions and research as to the specific ability of Asian Carp to pass through mainstem Ohio lock and dam facilities at varying water levels. The Markland lock and dam facility has potential for being an effective barrier location and more effort should be placed into identifying the technical hurdles to installing a system before seeking funding for the project.

Recommendations: KDFWR recommended at least one primary barrier facility at Markland Lock and Dam because it has the fewest number of open river days of any facility and is within the invasion front. An additional barrier facility at a lock and dam above or below Markland would further limit dispersal. Utilize the 2003 USGS Report on “Upstream Fish-Passage Opportunities at Ohio River Mainstream Dams” as a guiding document (Knights et al). Lockmaster feedback did not indicate any specific facility procedures that would limit dispersal.

Deliverables: In a July 2018 Basin meeting KDFWR led discussion on barrier locations along the Ohio River. KDFWR staff provided input they received from e-mails and phone calls with lockmasters and provided Markland L&D as an area of particular interest Recommendations from this project were made to the Basin for their consideration.

Project Highlights:

- Research of existing USGS water identified Markland Lock and Dam as having the fewest open river days over the past 26 years
- Although lockmasters did not specifically have procedural change suggestions, all shared concern with Asian Carp and a desire to work with Basin partners to limit dispersal
- Potential partnerships with the Corps were fostered through opening communication channels
- The basin working group agreed with the recommendations and will be working towards a more comprehensive deterrence report

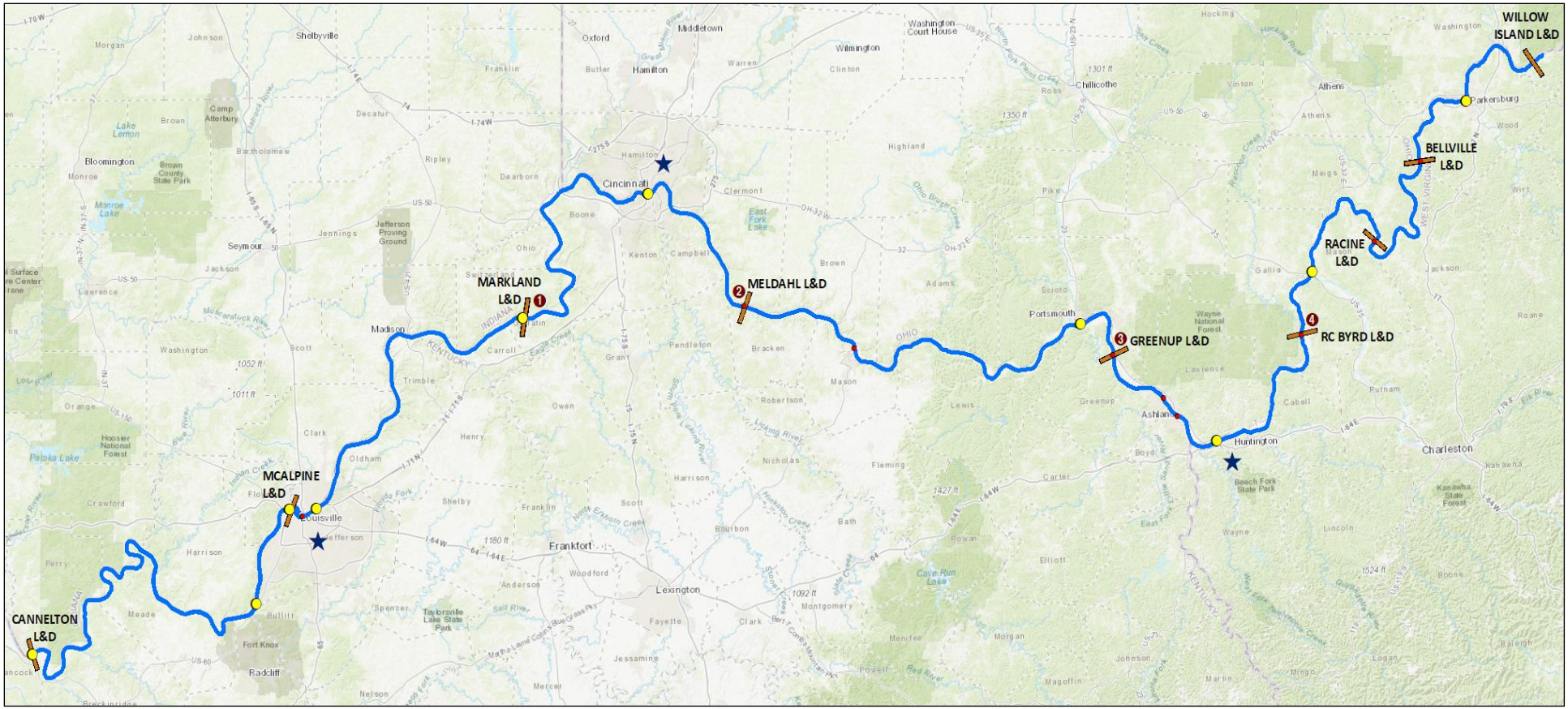


Figure 1. A project map of the 560-mile long section of the middle Ohio River (river miles 720 – 161) that included 1) all nine L&D's (orange lines) within the Leading Edge of the AC population, 2) the L&D facilities (red numbered circles) managed by the four lockmasters that have received individual emails requesting their assistance with the project, and 3) the locations of the 10 gages (yellow circles) that provided the water level data that was analyzed for the project in 2017.

Gage ID #	Location	OHR Pool	RM #	Pool Stage	Flood Stage	Gage "Zero" Elevation	Normal Pool Elevation	Flood Stage Elev.	Action Stage	Mod. Flood Stage	Maj. Flood Stage	Pool Elev.	Date of Highest	Highest Reading	Date of Lowest	Lowest Reading
03151000	Parkersburg_WV	Bellville	184.4	21.40	36.00	560.60	582.00	596.60	34.0	38.0	42.0	582.0	2015-04-12	34.67	2016-07-04	20.37
03201500	Point Pleasant_WV	RC Byrd	265.1	24.92	40.00	513.08	538.00	553.08	38.0	44.0	48.0	538.0	2011-03-12	46.68	2016-04-02	23.70
03206000	Huntington_WV	Greenup	311.5	25.84	50.00	489.16	515.00	539.16	48.0	55.0	59.0	515.0	2015-03-07	51.46	2016-07-04	24.39
03217200	Portsmouth_OH	Meldahl	354.1	15.53	50.00	469.47	485.00	519.47	35.0	57.0	66.0	485.0	2015-03-15	53.31	2014-10-03	13.45
03255000	Cincinnati_OH	Markland	470.5	26.77	52.00	428.23	455.00	480.23	40.0	56.0	65.0	455.0	2015-03-15	57.52	2015-09-02	25.85
03277200	Markland L&D	McAlpine	531.5	12.00	51.00	408.00	420.00	459.00	49.0	62.0	74.0	420.0	2015-03-15	53.02	2015-08-15	11.69
03292494	L-ville Water Tower	McAlpine	600.6	13.40	24.00	406.60	420.00	430.60	22.0	31.0	39.0	420.0	2015-03-16	31.33	2016-12-05	12.30
03293551	L-ville 31 Bridge	McAlpine	603.6	12.80	23.00	407.20	420.00	430.20	21.0	30.0	38.0	420.0	2015-03-16	30.27	2016-10-22	12.06
03294600	Kosmosdale_KY	Cannelton	627.1	10.25	54.60	372.75	383.00	427.40	52.6	64.6	72.6	383.0	2011-03-11	89.19	2011-07-28	5.02
03303280	Cannelton L&D	Newburgh	720.9	10.00	42.00	348.00	358.00	389.33	40.0	46.0	50.0	358.0	2015-03-17	47.33	2014-09-25	9.94

Figure 2. USGS Water gauges of interest on the main stem Ohio River, including typical height and highest recorded water levels.

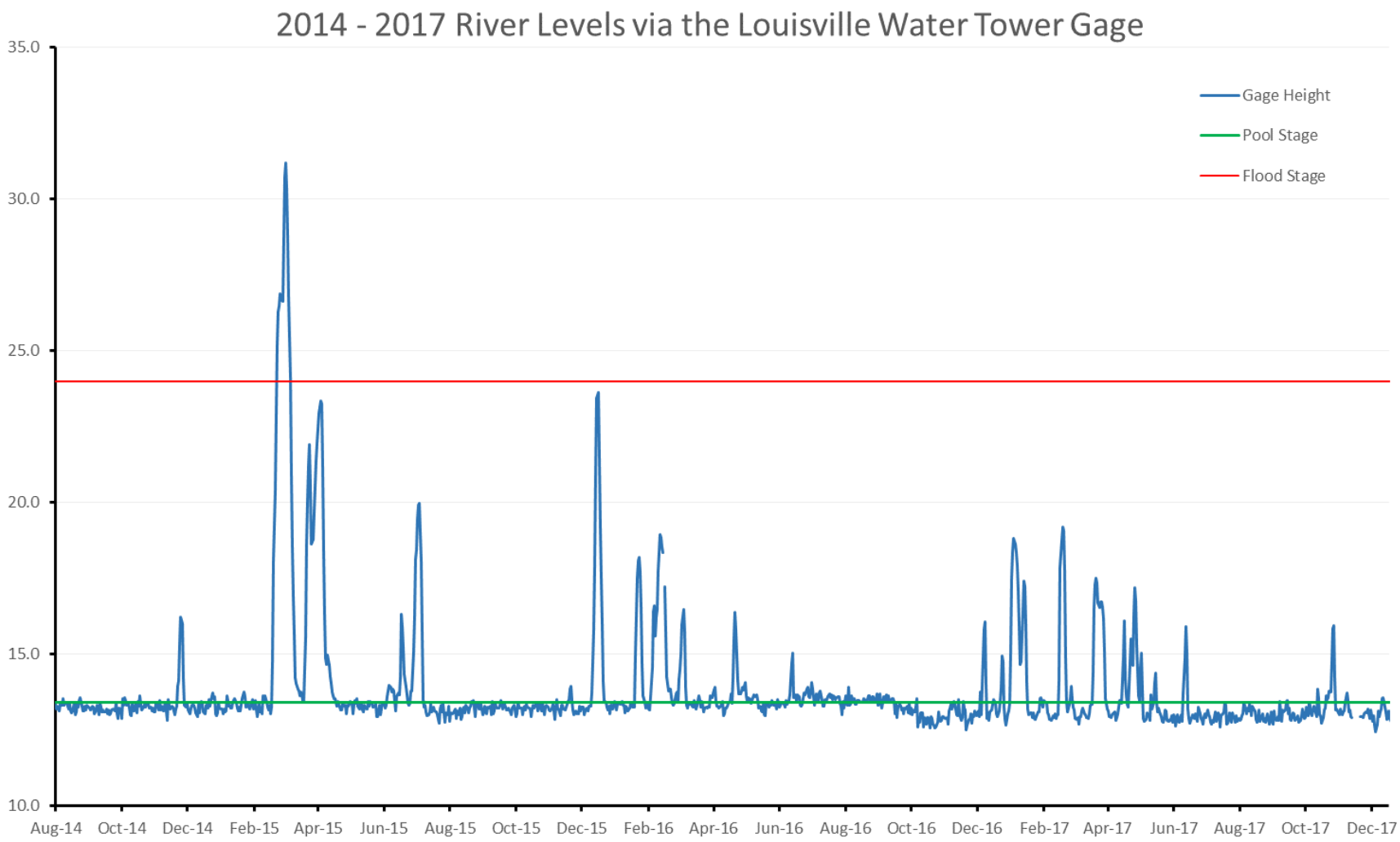


Figure 3. USGS Water level data at the Louisville water tower gauge in the McAlpine Pool.

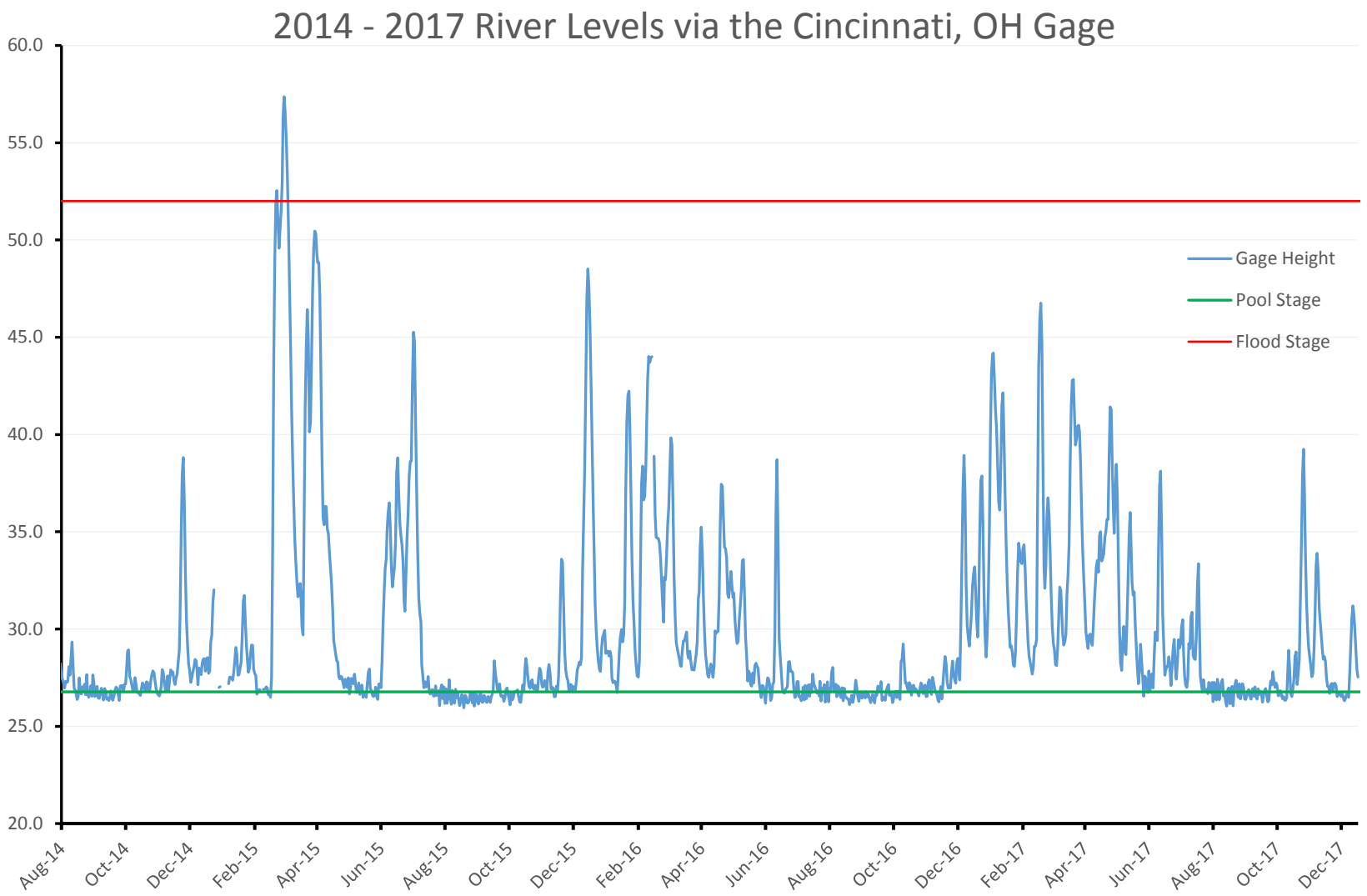


Figure 4. USGS Water level data at the Cincinnati water tower gauge in the Markland Pool.

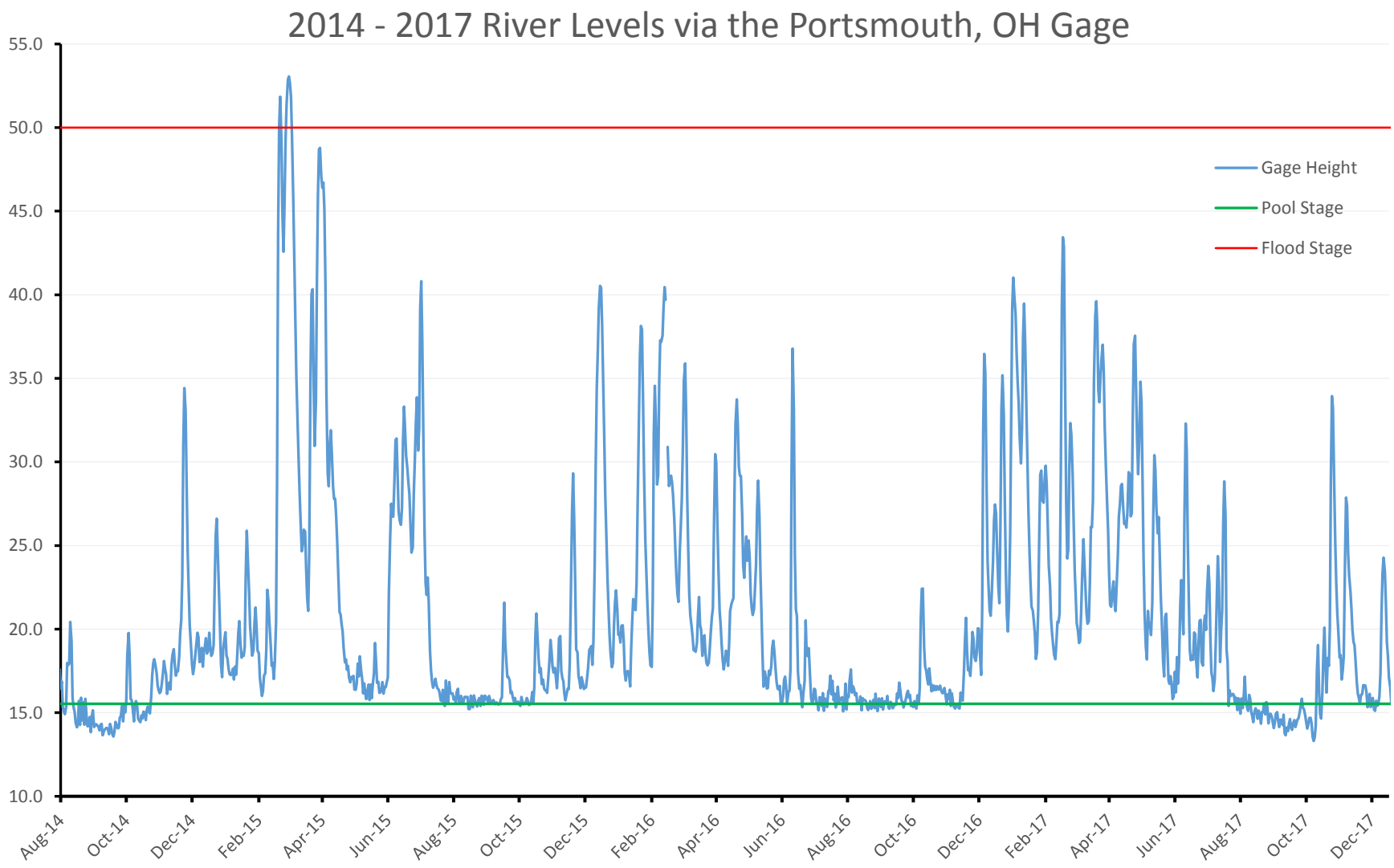


Figure 5. USGS Water level data at the Portsmouth water tower gauge in the Meldahl Pool.

Literature Cited:

Knights, B. C., J. H. Wlosinski, J. A. Kalas, and S. W. Bailey. 2003. Upstream fish passage opportunities at Ohio River Mainstem Dams. Completion report prepared for U.S. Army Engineer District, Nashville, CELRN-PM-P, P.O. Box 1070, Nashville, TN 37202-1070 by U.S. Geological Survey, Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, Wisconsin, 54603.

Project 4: Telemetry of Asian Carp in the Ohio River

Geographic Location: Middle Ohio River basin extending from the Cannelton pool (RM 720.7) to the Raccine pool (RM 54.4) and major tributaries within that stretch of river.

Objectives:

1. Understand Asian carp use of tributaries
2. Delineate the upstream-most distribution of Asian carp and potential further upstream movement.

Methods

Establishment of the Receiver Array:

The first primary component of the Asian Carp Telemetry Project is a relatively large (~500 miles) telemetry array that started to take shape in 2013 following the initial deployment of 60 VEMCO (model VR2W) ultrasonic receivers. Over the next four years, the array expanded each time an entire pool was added and field crews started populating them with new receiver stations. The KDFWR, USFWS and ODOW were responsible for maintaining the vast majority of receiver stations that were established in 2013-2017.

The new site locations were chosen according to the current density of the receivers in the area and the specific habitat types needed to accomplish one or more of the project objectives. The three habitat types required by objectives for this project are 1) the mainstem of the Ohio River, 2) tributaries that are large enough for Asian Carp, and 3) the lock chambers/approaches at Lock & Dam (L&D) facilities located within the array. The stations in the mainstem river were established by securing receivers to navigational buoys using 10'-12' steel rods. Tributaries rarely contain buoys, so the VR2W's were deployed to these sites by being attached to man-made structures (i.e. bridge piers and docks), or by being secured to metal stands that were anchored to the bottom of the creek/river. At the L&D sites, the receivers were placed in protective metal sleeves and then lowered into the ladder-wells located along the walls of the locks/approaches.

The tributary and L&D receivers remained in the river all year to continuously track the movements of the project's tagged carp. In contrast, most mainstem receivers were retrieved during mid-December 2016 and then placed in storage for the next 3 – 4 months of winter, which was when the buoys were most likely to disappear. Hence, in early 2017, the array wasn't complete until the end of March when KDFWR, USFWS and ODOW biologists had successfully returned all overwintering receivers to their respective sites in the mainstem Ohio River.

Soon after the redeployment efforts were completed, the KDFWR began working with the USFWS to identify prominent tributaries within the telemetry array that didn't have adequate receiver coverage. Also, when VR2W's were available, most navigable tributaries received two receiver stations (up to 1 mi. apart), which helped to expand the telemetry coverage and make it possible to identify the direction that each tagged carp was moving. Other improvements in 2017 included efforts to deploy a fourth receiver at all seven L&D facilities located within the array. Each new station was established in the L&D's upstream approach to work with existing receivers in both lock chambers and the downstream approach as they monitor for tagged carp that are attempting to transfer pools. The final addition to the telemetry array in 2017 involved deploying temperature (temp) loggers alongside VR2W's at the furthest upstream receiver stations that have already been established in larger tributaries. These temp loggers should

provide the data required to determine if a tributary's water temperature has any influence on the behavior/movements of tagged Asian Carp.

Implanting Ultrasonic Transmitters

During the spring and summer of 2017, KDFWR and USFWS biologists utilized a combination of pulsed DC electrofishing and gill nets to collect both Bighead Carp and Silver Carp that could be surgically implanted with ultrasonic transmitters. All gill netting effort was conducted as part of projects 1&2 of this report and all associated bycatch is reported in those sections. Most of the effort in 2017 was concentrated on the low-density AC populations in the Markland and Meldahl pools to replace tagged Asian Carp containing transmitters that are scheduled to shut down in summer 2018. Tagging efforts in 2017 were also conducted in the Cannelton Pool. The higher density of Asian Carp in this pool made it possible to collect and tag a suitable number of fish over a shorter time period.

Upon the collection of a Bighead or Silver Carp, the surgical procedure outlined by Summerfelt et al. (1990) was used to implant a VEMCO (model V16-6H) ultrasonic transmitter into the carp's abdominal cavity via an incision (~2" long) made posterior to its pelvic fin and anterior to its anus. After carefully implanting the transmitter, the incision was closed using 3 - 4 simple interrupted sutures. Following the completion of each surgery, specific details about the procedure (i.e. location, crew, transmitter #) were recorded along with the length, weight and sex of the fish. And then finally, each tagged carp was released within a mile of its sampling location after being marked with a uniquely numbered aluminum jaw tag (5/8" wide) that allows for the quick identification of the fish if it's ever recaptured.

The VEMCO model V16-6H transmitters (.625" diameter & 3¾" long) have been utilized every year from 2013 to 2017 in order to ensure that the tagged AC can be detected via all receiver in the array. Full compatibility allows the receivers to decipher the unique Tag ID encoded into each ultrasonic signal, which is randomly transmitted (@ 69 kHz) every 20 – 60 seconds. These transmitters have an above-average battery life of 5 years, which was the result of using a high-capacity lithium battery without equipping any additional sensors (i.e. temperature or pressure). For standardization purposes, all transmitters are programmed to shut down upon reaching the end of their 5-year life span, which occurs regardless of remaining battery power.

Data Collection, Management & Analysis

With the array nearly doubling in size over the past several years, the KDFWR, USFWS and ODOW worked together to develop a more efficient protocol for maintaining receiver stations and offloading new data at regular intervals. Since 2016, project biologists have utilized a method that required the array to be divided into two parts. The first was a 170-mile section of the river located on the downstream end of the array and included Cannelton, McAlpine, and the first half of the Markland Pool. In both 2016 and 2017, KDFWR's project biologist accepted responsibility for up to 40 receiver stations that were established throughout this 170-mile stretch of the Ohio River. The second part of the telemetry array covered at least some portion of seven different pools (Upper Markland, Meldahl, Greenup, RC Byrd, Racine, Bellville and Willow Island). The USFWS and ODOW ultimately shared responsibility for the 100+ receiver stations spread throughout this 330-mile section of the array.

As previously noted, most receiver work completed by participating agencies (KDFWR, USFWS & ODOW) between May and November 2017 was comprised of monthly efforts to offload new data from any of the VR2W's found throughout the two sections of the array. Upon completion of the monthly site

visits, biologists created a dataset of all recently offloaded tag detections that was shared with other participating agencies via a file transfer protocol (FTP) site. The download and compilation of new detections were completed regularly during 2017 to ensure that all parties would have access to the most up-to-date dataset possible.

Since the receiver protocol allowed agencies to be more efficient at completing their monthly downloads, it has led to the accumulation of tremendous amounts of new data that needed to be properly managed. As in previous years, the KDFWR was responsible for organizing the new telemetry data that each agency collected and uploaded to the FTP site in 2017. In order to accomplish this task, KDFWR's project biologist regularly downloaded new telemetry datasets from the FTP site and reviewed each file in order to identify/remove any incomplete, duplicate or erroneous data. If detections of tagged fish from other studies were found within the dataset, the information was forwarded to the appropriate contact(s). All data entries still present after the completion of the review process were considered valid tagged carp detections and were subsequently imported into the 2017 telemetry database. This database eventually contained all 2017 project data, including the total detections, details from each tagged carp and the locations of all active receiver stations.

On two separate occasions in 2017, the telemetry database was reduced to create two separate datasets containing tagged carp detections on an hourly or daily time scale. These smaller, more manageable datasets were often analyzed via simple spreadsheet programs in order to keep track of tagged carp movements on a broader scale (i.e. pool transfers) and/or over longer time periods (i.e. weeks & months). However, when the raw dataset (> 8 mil. detections in 2017) was required, project biologists often conducted the analysis using R statistics software with the VTrack package (v1.11), which is a collection of tools that were specifically developed to handle the large telemetry datasets often produced by VEMCO equipment. Finally, ArcMap (v10.5) software was used to create the maps and complete the other GIS work conducted for the Asian Carp Telemetry Project in 2017.

Results and Discussion

Establishment of Project's Receiver Array

The project's 500-mile telemetry array included at least a portion of nine different pools in the Ohio River and contained a total of 158 acoustic receiver stations, which were distributed over a selection of mainstem, tributary and L&D sites (Figure 1). After completing the initial efforts to redeploy overwintering VR2W's to existing mainstem sites, the focus shifted towards deploying receivers to new sites within tributaries that were suggested by regional biologists. When these targeted efforts were completed by mid-summer 2017, the project's telemetry array had gained 33 additional receiver stations located in 18 tributaries, including 15 creeks and small rivers that have never been monitored for tagged Carp (Figure 2). The final efforts to add new stations to the array were those conducted by the USFWS to improve the receiver coverage at L&D facilities. Once completed, each of the array's seven L&D's had a new site in the upstream approach that complemented its three existing stations that continuously monitor for any tagged carp trying to move into an adjacent pool.

The 2017 efforts to add new stations to the array targeted only tributaries and L&D's because the distribution of receivers across the three habitat types was already heavily skewed towards mainstem sites, which has been the case since the first year of the project in 2013. When the project's array had a total of 123 receiver stations in 2016, the mainstem sites (n = 81) represented almost 66% of that total,

while tributary (n = 21) and L&D (n = 21) sites combined to make up only 34% of those stations (Table 1). In 2017, the decision was made to avoid replacing the VR2W's that go missing from the more problematic mainstem stations and the previously mentioned focus on tributaries and L&D's has helped to improve how the receivers are distributed among the 3 primary habitat types. So by the end of 2017, the project's array contained a combination of 76 mainstem (48%), 54 tributary (34%) and 28 L&D (18%) sites for a total of 158 receiver stations, which are all used to track the project's 500+ tagged Asian Carp.

Implanting Ultrasonic Transmitters

Since the vast majority of the ~4 weeks of tagging efforts that the KDFWR and USFWS conducted through the summer of 2017 occurred in pools containing low density populations, they were only able to tag a total of 17 Asian Carp, which included both Bighead (n=2) and Silver Carp (n=15) that were collected from the Markland (n = 12) and Meldahl (n = 3) pools (Table 2). However, in October 2017, only one week of effort was required to collect and tag an additional 90 Silver Carp from the higher density population residing in the Cannelton Pool. All 107 Asian Carp tagged in 2017 will continue to be tracked via the receiver array until the transmitters shut down during 2022.

From all tagging efforts conducted in 2013 - 2017, the Ohio River Telemetry Project currently has an unadjusted total of 508 Asian Carp implanted with ultrasonic transmitters, which when broken down by species includes 464 Silver Carp (91.3%) and 44 Bighead Carp (8.7%) (Table 2). All tagged carp for this project were sampled from 5 separate pools, but as expected, the majority (83.3%) of them originated from Cannelton and McAlpine, which are the only two pools with higher density carp populations. The length frequency distribution indicates that the majority of Silver Carp collected/tagged from the higher density pools (Cannelton & McAlpine) had mean lengths of 30 - 35 in, but those from the Markland and Meldahl pools were slightly larger carp that measured 35 – 40 in long (Figure 4). A similar size evaluation of tagged Bighead Carp showed that all but two fish were > 41 in long with no noticeable differences in total length between pools (Figure 5). The original tags placed in 19 Asian Carp collected/tagged from the Meldahl Pool during 2013 are expected to begin shutting down upon reaching the end of their transmitter's 5-year battery life during the summer of 2018.

Detections of Tagged Asian Carp

In 2017, KDFWR's project biologist made numerous efforts to error-check and format telemetry datasets that were offloaded monthly by field crews from the KDFWR, ODOW, USFWS and WVDNR. Soon after importing the final error-checked datasets into the telemetry database, it was determined that between Jan 01 and Dec 14 of 2017, eighty-one (51.2%) of the 158 receivers in the array made a combined total of ~8,175,000 detections of tagged Asian Carp (Table 3). Upon further analysis, this dataset contained at least one detection from 263 (51.8%) of the 508 total carp that have been tagged during the project. The 2017 database was eventually reduced to create two separate datasets with 346,478 hourly and 35,064 daily detections that were later used to analyze the large-scale movements of the tagged carp.

The original 2017 dataset was analyzed using R statistics with the VTrack package. At its simplest level, VTrack was able to manage (i.e. sort, filter, etc) the 8+ million tagged carp detections in a manner similar to how a spreadsheet program works with smaller data files, but without having to change/reduce the original dataset. Although many receivers had similar numbers of tagged carp detections, there were still some areas where the receivers contained substantially more detections than other locations in the array

(Figure 3). The area containing the largest proportion of tagged carp detections was the McAlpine Pool, which was not unexpected from a mid-sized pool (~75 miles) that contains 22 active receivers and as many as 237 tagged carp. In total, the receivers in McAlpine combined to make 6.7 million tagged carp detections, or >80% of all those made in 2017, which is over 10 times more than the project's 2nd most detections (n = 573,578) that were recorded by receivers in the Meldahl Pool (Table 3).

All 2017 detections from the upper McAlpine Pool and the OH-Brush Creek area of the Meldahl Pool were analyzed to determine if seasons have an influence on Asian Carp habitat preferences. The analysis started by splitting the total detections, and the related numbers of unique carp, into groups based on the season that they were recorded in, which included winter (Jan - Feb), spring (Mar - May), summer (Jun - Aug) and Fall (Sep - Nov). According maps showing that the total number of tagged carp detections that receivers in the upper McAlpine Pool made during the winter (Figure 6), spring (Figure 7), summer (Figure 8) and Fall (Figure 9) of 2017, it appears that tagged carp preferred to occupy the tributaries for considerably longer time periods, regardless of season, which was also demonstrated in a map of the total detections from the entire year (Figure 10). Another notable trend from the seasonal comparisons is that mainstem receivers near the mouths of the tributaries appear to record higher numbers of both seasonal and total detections than other mainstem sites, which could indicate that tagged carp may frequently exit a tributary, but then they appear more likely to re-enter the tributary, or another one nearby, than move about the mainstem river. A similar comparison of seasonal habit preferences were conducted with the total detections from receivers located in and around the OH-Brush Creek area of the Meldahl Pool. The maps showing the total detections made by each receiver during the winter (Figure 11), spring (Figure 12), summer (Figure 13), and fall (Figure 14) produced similar conclusions regarding the tagged carp's year-round preference to either occupy tributaries or remain near mainstem site(s) that are located within close proximity of a tributary. Similarly, tagged carp appear to refrain from venturing too far upstream/downstream when there are fewer tributaries in the immediate area, which may be a reason why receivers located further away from OH-Brush Creek often detect smaller numbers of unique carp (Figure 15).

Movements of Tagged Asian Carp (including most up-stream movements)

The 2017 hourly detections were used to estimate the monthly mean ranges of both the Bighead Carp and Silver Carp. To be certain that only live fish detections were used in the estimate, any tagged carp detected by a single receiver in 2017 were not included in the range calculations. All remaining hourly detections were grouped by month and pool. A tagged carp's range is defined as the total number of river miles between its most upstream and downstream detections that were made over a specific time period (i.e. month). The mean monthly ranges were compared for tagged Bighead and Silver Carp located in the three most active pools of the receiver array, which were McAlpine, Markland and Meldahl (Figure 16). During most months, Bighead Carp appeared to traverse a larger stretch of the river, except in April 2017, when Silver Carp in Markland exhibited a mean range that was more than double that of Bighead Carp from any pool (Table 5). Regardless of pool, both species of tagged carp appeared to be most active from April to August 2017, but during this 5-month period, Bighead Carp were more likely to cover greater distances between their most upstream and downstream detections (Figure 17). Although the Silver Carp did remain active after Bighead Carp movements ended abruptly in September, their mean ranges in September thru November were considerably smaller than they were in the months of spring and summer.

Other movements that were closely monitored in 2017 included attempts by tagged carp to pass through a L&D in order to transfer into an adjacent upstream/downstream pool. A preliminary check of telemetry data from L&D receivers, and those at nearby mainstem sites, initially identified up to 16 tagged carp that were detected by receivers located in two different pools, which indicates that a transfer may have occurred. However, after the movements of each fish was thoroughly examined, it was determined that only 8, or 50%, of the 16 tagged carp had made "valid" pool transfers in 2018, which included a Bighead, 6 Silver Carp and one unknown (Table 6). Seven, or 87.5%, of the 8 valid transfers consisted of moving either upstream or downstream through McAlpine L&D. The only valid pool transfer in 2017 that didn't involve McAlpine or Cannelton was completed by a tagged carp that moved downstream through RC Byrd L&D. The close examination of the telemetry data also identified 8 tagged carp that couldn't be credited with making a "valid" transfer despite having detections in least two different pools (Table 7). In this case, seven tagged carp (a Bighead, 5 Silver Carp & one unknown) were characterized as having made a "possible" pool transfer. However, these transfers could not be validated because the only receiver to detect the tagged carp in the adjacent pool was in the upstream/downstream approach on the opposite side of the same L&D that these fish were trying to circumvent. It is possible for ultrasonic signals to bounce off the concrete walls of a lock chamber. If this scenario occurs at a high enough frequency, the transmitter's signal could eventually reach a receiver located in the opposite lock approach. All seven of these tagged carp returned to their original pool soon after being detected by receivers in the opposite approach lending credence to this hypothesis. Each of these events will ultimately be considered as "possible" pool transfers, but they can be validated if the tagged carp are ever detected by another receiver located in the adjacent pool. The remaining pool transfer involved a Bighead Carp that moved downstream into the McAlpine Pool via the Markland L&D without a single detection. The tagged carp was then detected by a receiver in the Kentucky River before making an immediate return trip to the Markland Pool, which once again required the tagged carp to pass undetected through Markland L&D. The high rate of speed needed to complete the round trip and the requirement of passing multiple receivers without detection makes it unlikely that the tagged carp ever left the Markland Pool. So ultimately, the event was officially designated an "invalid" pool transfer.

Recommendations: Telemetry efforts should continue as there remain an additional 263 tagged fish within the project area. Tributaries continue to be a high-use area for silver carp and these locations should serve as a focal area for removal efforts. Tagging efforts should increase in 2018 and 2019 to replace tags from the first year of the project that are projected to die in 2019. Future analysis effort should focus on seasonality and directionality of tributary use to further help refine removal efforts.

Deliverables: Data from this project was compiled for Ohio River Basin Asian Carp Control Strategy Framework technical reports in Feb 2017 and 2018. KDFWR staff provided data and assisted with writing the Basin "Control and Removal of Asian Carp in the Ohio River" technical report, funding templates, and project planning for 2018 efforts. KDFWR staff presented the data to the basin working group Oct. 2017, participated in numerous conference calls, and participated in basin project planning in July 2018. Additionally, KDFWR hosted an Asian Carp symposium at the Southeaster Association of Fish and Wildlife Agencies Conference in Louisville, Ky in October of 2017 where data from this project was presented.

Project Highlights:

- Over 500 Asian Carp have been tagged, with approximately 263 individuals remaining active within the project area
- Receivers spread out over a 500-mile stretch of river from Cannelton Pool upriver with the study area increasing yearly
- Receivers placed in 15 major tributaries, with dual receivers in high use tributaries to assist with understanding directionality
- Over 8,000,000 detections from tagged fish have been reported
- Telemetry data has helped identify high use tributaries for removal efforts as well as particular times of year they are in use
- Bighead carp have been found moving upstream as far Racine Pool

Table 1. Total amounts and distribution (%) of the 3 types of receiver sites that contributed to the project's telemetry array in 2016 - 2017.

Pool	RM's Added by Pool	2016								2017								2016 to 2017
		Mainstem		Tributary		L&D		Total		Mainstem		Tributary		L&D		Total		
		# Sites	% of sites in Pool	# Sites	% of sites in Pool	# Sites	% of sites in Pool	# Total Sites	% of 2016 total	# Sites	% of sites in Pool	# Sites	% of sites in Pool	# Sites	% of sites in Pool	# Total Sites	% of 2017 total	Total Change
Willow Island	3.0	1	100.0	0	0.0	0	0.0	1	0.8	1	50.0	0	0.0	1	50.0	2	1.3	1
Belleville	42.2	8	66.7	1	8.3	3	25.0	12	9.8	9	47.4	6	31.6	4	21.1	19	12.0	7
Racine	33.6	4	57.1	0	0.0	3	42.9	7	5.7	3	33.3	2	22.2	4	44.4	9	5.7	2
RC Byrd	41.7	7	46.7	5	33.3	3	20.0	15	12.2	4	36.4	3	27.3	4	36.4	11	7.0	- 4
Greenup	61.8	7	63.6	1	9.1	3	27.3	11	8.9	9	47.4	6	31.6	4	21.1	19	12.0	8
Meldahl	95.2	26	68.4	9	23.7	3	7.9	38	30.9	24	63.2	10	26.3	4	10.5	38	24.1	0
Markland	95.3	11	64.7	3	17.6	3	17.6	17	13.8	10	34.5	15	51.7	4	13.8	29	18.4	12
McAlpine	75.3	10	66.7	2	13.3	3	20.0	15	12.2	9	40.9	10	45.5	3	13.6	22	13.9	7
Cannelton	53.7	7	100.0	0	0.0	0	0.0	7	5.7	7	77.8	2	22.2	0	0.0	9	5.7	2
Totals	501.8	**81**	65.9	**21**	17.1	**21**	17.1	**123**	100	**76**	48.1	**54**	34.2	**28**	17.7	**158**	100	35

Table 2. Total numbers and species composition (%) of the Bighead Carp and Silver Carp collected from 5 pools of the Ohio River and then tagged for the AC Telemetry Project in 2013 – 2017.

Year	Asian Carp Species	Pool					Total
		Cannelton	McAlpine	Markland	Meldahl	RC Byrd	
2013	Silver Carp	-	-	0	6	-	6
	Bighead Carp	-	-	0	13	-	13
2014	Silver Carp	-	115	6	10	-	131
	Bighead Carp	-	4	4	0	-	8
2015	Silver Carp	-	22	3	5	-	30
	Bighead Carp	-	1	1	5	-	7
2016	Silver Carp	92	94	6	0	0	192
	Bighead Carp	4	1	4	2	3	14
2017	Silver Carp	90	-	12	3	-	105
	Bighead Carp	0	-	2	0	-	2
Project Totals	Silver Carp	182	231	27	24	0	464
	Bighead Carp	4	6	11	20	3	44
	Total	**186**	**237**	**38**	**44**	**3**	**508**
Species Composition (%)	Silver Carp	35.8	45.5	5.3	4.7	0.0	91.3
	Bighead Carp	0.8	1.2	2.2	3.9	0.6	8.7
	Total	**36.6**	**46.7**	**7.5**	**8.7**	**0.6**	**100.0**

Table 3. The mean lengths & weights of tagged Asian Carp collected from 5 pools of the Ohio River in 2013 – 2017.

Pool	Species	N	Mean Total Length (in)	Mean Total Weight (lbs)
Cannelton	Silver Carp	182	32.5	12.85
	Bighead Carp	4	44.9	34.24
	All Asian Carp	186	32.8	13.31
McAlpine	Silver Carp	226	33.8	15.22
	Bighead Carp	6	46.0	39.48
	Grass Carp	1	41.0	25.00
	All Asian Carp	234	34.2	15.93
Markland	Silver Carp	27	35.8	21.41
	Bighead Carp	11	46.3	50.28
	All Asian Carp	38	38.8	29.99
Meldahl	Silver Carp	24	37.8	25.01
	Bighead Carp	20	45.5	46.00
	All Asian Carp	44	41.3	34.55
Greenup	Silver Carp	0	---	---
	Bighead Carp	0	---	---
	All Asian Carp	0	---	---
RC Byrd	Silver Carp	0	---	---
	Bighead Carp	3	47.6	54.90
	All Asian Carp	3	47.6	54.90
All Pools	Silver Carp	460	33.6	15.14
	Bighead Carp	44	45.8	45.72
	Grass Carp	1	41.0	25.00
	All Asian Carp	505	34.7	17.91

Table 4. The total detections (Total Dtxns) and the numbers of unique AC offloaded from receivers in 2017 and then grouped by season, pool and site type.

Season	Site Type	Cannelton		McAlpine		Markland		Meldahl		Greenup		RC Byrd		Racine		Total	
		Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC	Total Dtxns	Unique AC
Winter	Main	77	2	30,454	10	0	0	2,553	10	0	0	0	0	0	0	33,084	22
	Trib	0	0	394,288	49	0	0	93,974	10	0	0	0	0	0	0	488,262	59
	L&D	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
	All	77	2	424,743	54	0	0	96,527	10	0	0	0	0	0	0	521,347	66
Spring	Main	7	2	73,251	124	758	6	3,934	15	0	0	14	1	8	1	77,972	149
	Trib	0	0	1,686,649	142	116,834	5	18,596	12	0	0	0	0	0	0	1,822,079	159
	L&D	0	0	77	4	0	0	1,101	8	261	6	23,331	2	0	0	24,770	14
	All	7	2	1,759,977	146	117,592	7	23,631	16	261	6	23,345	3	8	1	1,924,821	175
Summer	Main	16,041	25	169,135	128	3,360	9	75,315	17	49	2	0	0	30	1	263,930	178
	Trib	115,300	17	2,089,275	136	107,597	15	88,145	14	0	0	7,466	4	0	0	2,407,783	185
	L&D	0	0	430	3	835	1	2	1	34	2	583	2	96	1	1,980	7
	All	131,341	38	2,258,840	151	111,792	19	163,462	18	83	4	8,049	5	126	1	2,673,693	226
Fall	Main	3,146	7	337,222	99	3	1	131,704	15	64,047	1	0	0	0	0	536,122	123
	Trib	178,424	38	1,715,724	102	186,213	11	104,634	14	0	0	6,632	2	0	0	2,191,627	167
	L&D	0	0	0	0	0	0	0	0	0	0	71	1	0	0	71	1
	All	181,570	39	2,052,946	121	186,216	12	236,338	16	64,047	1	6,703	3	0	0	2,727,820	191
All	Main	19,271	28	669,292	148	4,121	10	245,975	17	96,834	2	14	1	38	1	1,035,545	201
	Trib	311,439	41	6,029,513	151	430,911	16	326,500	15	0	0	14,098	5	0	0	7,112,461	225
	L&D	0	0	508	7	835	1	1,103	8	295	8	23,985	3	96	1	26,822	19
	All	330,710	60	6,699,313	164	435,867	20	573,578	18	97,129	9	38,097	7	134	1	8,174,828	263

Table 5. Mean monthly ranges of tagged Bighead and Silver Carp that were detected by receivers in the McAlpine, Markland and Meldahl pools during 2017. The range calculations only included tagged carp that were detected by at least 2 different receiver stations over the course of the entire year.

Pool	Asian Carp Species	Mean Monthly Ranges (in River Miles)											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
McAlpine	Bighead Carp	0.00	--	--	--	7.00	56.90	--	46.80	--	--	--	--
	Silver Carp	0.47	0.41	0.87	9.37	12.49	12.05	5.43	4.59	3.79	3.24	1.65	1.16
Markland	Bighead Carp	--	--	0.00	28.43	28.43	37.78	6.54	1.40	0.00	0.00	0.00	0.00
	Silver Carp	--	--	--	68.20	0.80	9.12	0.00	0.00	0.00	0.00	0.00	0.00
Meldahl	Bighead Carp	0.40	0.47	0.13	--	22.05	57.50	13.30	9.80	5.03	0.07	0.20	0.00
	Silver Carp	0.06	0.17	0.20	32.36	11.83	10.01	12.86	18.18	6.76	1.55	0.20	0.09
All Pools	Bighead Carp	0.30	0.47	0.08	28.43	18.00	42.51	7.21	7.56	1.89	0.03	0.08	0.00
	Silver Carp	0.40	0.36	0.81	10.78	11.91	11.33	5.60	5.18	3.96	3.10	1.30	0.97

Table 6. Pool-to-Pool transfers in 2017 that were validated when the tagged AC were detected by at least one receiver (mainstem and/or tributary) located beyond the initial Lock and Dam (L&D) site that divided the two pools.

Transmitter ID	Species	Sex	Tagging Pool	Tag Year	Pool with...				Transfer Direction	Notes
					First Detection	Most DS Detection	Most US Detection	Last Detection		
A69-1601-23996	SVC	M	McAlpine	2014	McAlpine	Cannelton	McAlpine	Cannelton	DS	Moved from McAlpine into the Cannelton Pool during late June; Remained in Cannelton through the end of 2017.
A69-1601-24009	N/A	na	N/A	na	RC Byrd	Greenup	RC Byrd	Greenup	DS	Used a lock on 7/26 to move from RC Byrd to Greenup; Stayed <5 mi below RC Byrd L&D through the end of 2017.
A69-1601-27347	SVC	M	Markland	2016	McAlpine	McAlpine	Markland*	McAlpine	DS	In Markland through 2016 & then moved into McAlpine on 1/13/2017; No contact since a 1/15 detection in KY River.
A69-1601-56475	BHC	F	Markland	2017	Markland	McAlpine	Markland	McAlpine	DS	Moved from Markland to McAlpine on 8/01 via the L&D's 600-ft lock chamber; Still in lower McAlpine at end of 2017
A69-1601-57948	SVC	M	McAlpine	2016	Cannelton	Cannelton	McAlpine	McAlpine	US	Moved from Cannelton up to McAlpine in late June; Still in lower McAlpine when 2017 ended.
A69-1601-57962	SVC	F	McAlpine	2015	McAlpine	Cannelton	McAlpine	McAlpine	Both	Moved from McAlpine to Cannelton in early June 2017, but then returned to the McAlpine Pool in August.
A69-1601-57975	SVC	M	McAlpine	2015	McAlpine	Cannelton	McAlpine	Cannelton	DS	Transferred from McAlpine to the Cannelton Pool in June 2017; Detected in the Salt River by the end of the year.
A69-1601-58058	SVC	F	McAlpine	2016	McAlpine	Cannelton	McAlpine	McAlpine	Both	Moved from McAlpine to Cannelton in May 2017; Returned to McAlpine in June & was still there when 2017 ended.

Table 7. Pool-to-Pool transfers in 2017 that could not be validated. These events have been categorized either as 1) “Possible Transfers” of tagged AC that were only detected by receivers associated with the initial L&D site, or as 2) “Invalid Transfers” that were based solely on what were later identified as False detections.

Transmitter ID	Species	Sex	Tagging Pool	Tag Year	Pool with... First Detection	Most DS Detection	Most US Detection	Last Detection	Transfer Direction	Notes
POSSIBLE TRANSFERS										
A69-1601-24005	N/A	na	N/A	N/A	RC Byrd	Greenup	RC Byrd	RC Byrd	Both?	Only Greenup detection came from the lower approach of RC Byrd L&D. The other 23,834 detections in 2017 came from receivers in the RC Byrd Pool;
A69-1601-27339	SVC	na	Meldahl	2014	Meldahl	Meldahl	Greenup	Meldahl	Both?	Most of the 6000+ detections in 2017 came from Meldahl, except for the ~20 detections in early May that occurred in the upper approach of Greenup L&D;
A69-1601-27380	SVC	na	Meldahl	2014	Meldahl	Meldahl	Greenup	Meldahl	Both?	Approx. 13,000 detections in 2017 came from VR2’s in the Meldahl Pool, which doesn’t include the 18 times it was found in the US approach of Greenup L&D;
A69-1601-27381	SVC	na	Meldahl	2014	Meldahl	Meldahl	Greenup	Meldahl	Both?	Detected in Meldahl throughout 2017, except between 5/2 and 5/21 when ~30 detections were made by a VR2 in the US approach of Greenup L&D;
A69-1601-27404	SVC	na	Meldahl	2014	Meldahl	Meldahl	Greenup	Meldahl	Both?	Except for 1 detection made on 4/18 in the US approach Greenup L&D, Tagged AC #27404 spent all of 2017 in the Meldahl Pool.
A69-1601-27414	SVC	na	Meldahl	2014	Meldahl	Meldahl	Greenup	Meldahl	Both?	Aside from 8 detections in May that were made in the US approach of Greenup L&D, Tag #27414 was only detected by Meldahl VR2’s during 2017.
A69-1601-56546	BHC	F	Meldahl	2016	Meldahl	Meldahl	Greenup	Meldahl	Both?	Detected only by VR2’s from the Meldahl Pool during 2017, with the exception of a single detection made in the US approach of Greenup L&D on 6/21;
INVALID TRANSFERS										
A69-1601-57990	BHC	M	Markland	2016	McAlpine	McAlpine	Markland	Markland	US	Identified as a transfer after being falsely detected by a VR2W in the KY River; But Tagged AC #57990 actually spent the entire year in the Markland Pool;

Figure 1. A map of the project's entire 500-mile telemetry array with the eight separate Locks and Dam locations that are monitored for upstream/downstream transfers of tagged Asian Carp. The 2017 array included 158 receiver stations that were distributed across three distinct habitat types, which included the mainstem river, the tributaries, and the L&D's.

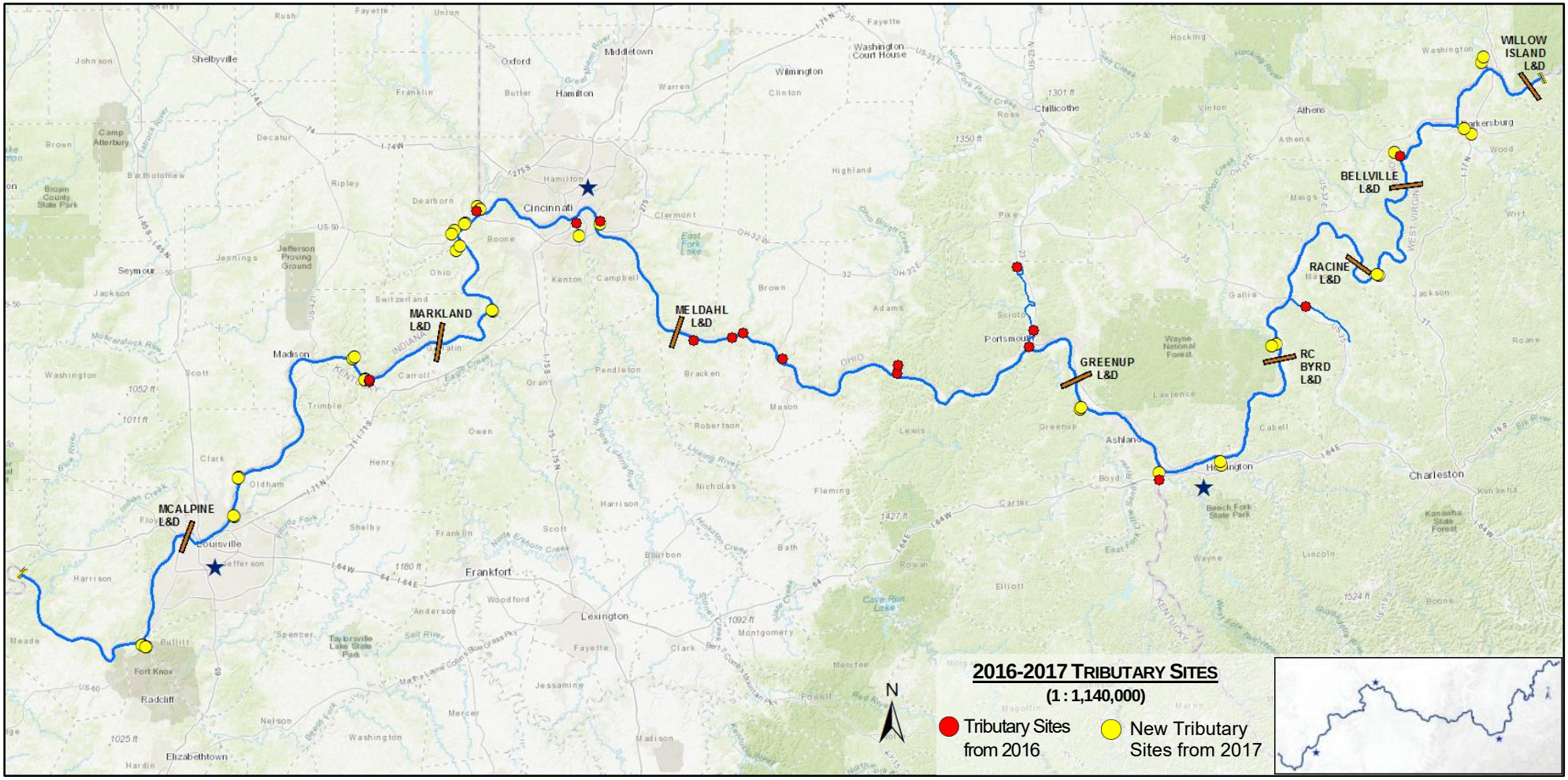


Figure 2. A map showing the distribution of the receiver stations that were established within tributaries from 2016-2017. An increased emphasis on this particular habitat type in 2017 succeeded in adding 15 new locations to the 13 tributaries that were already being monitored for tagged AC by the end of 2016.

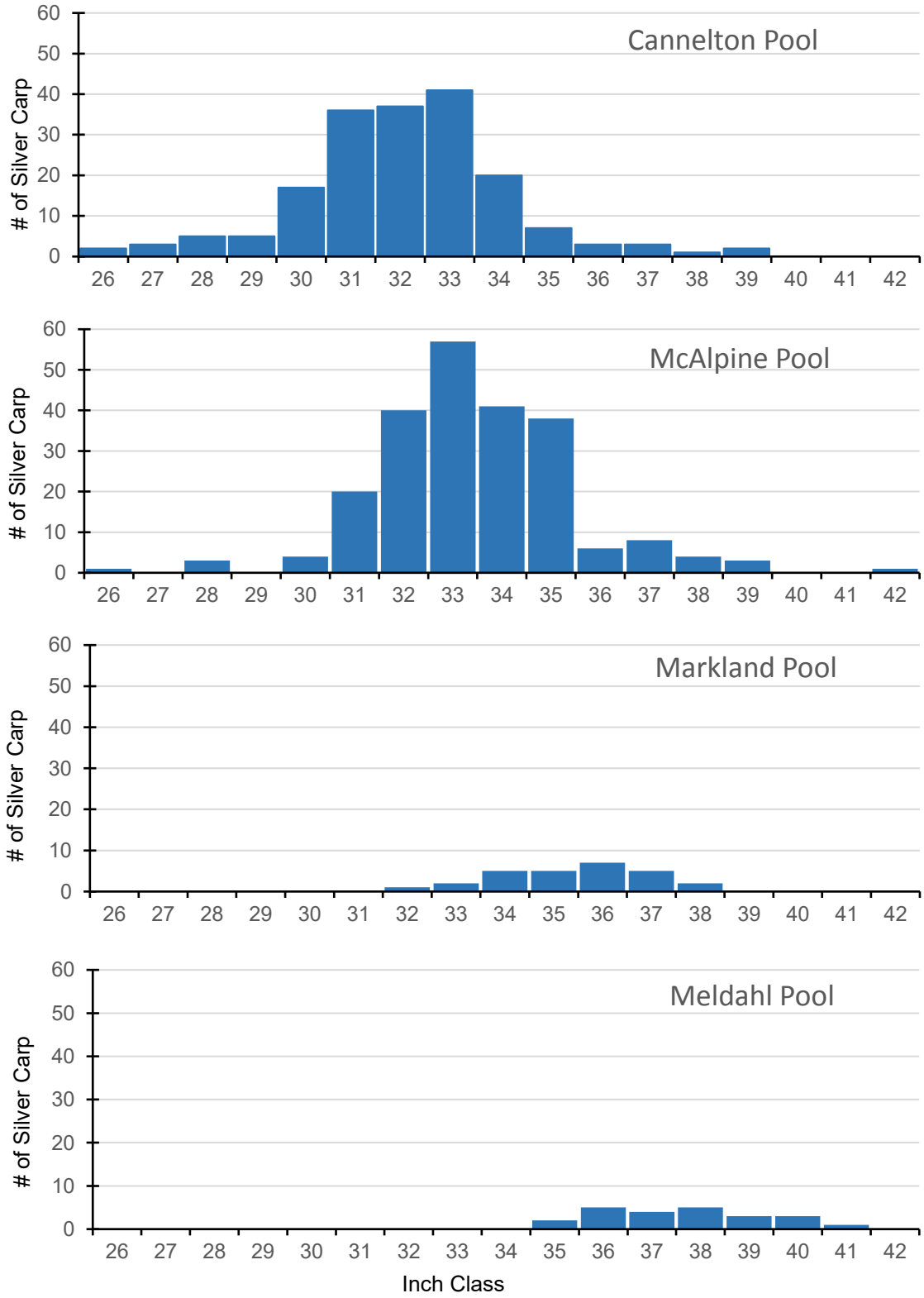


Figure 3. The length frequency of Silver Carp collected from each pool during 2013 – 2017 that were ultimately implanted with transmitters.

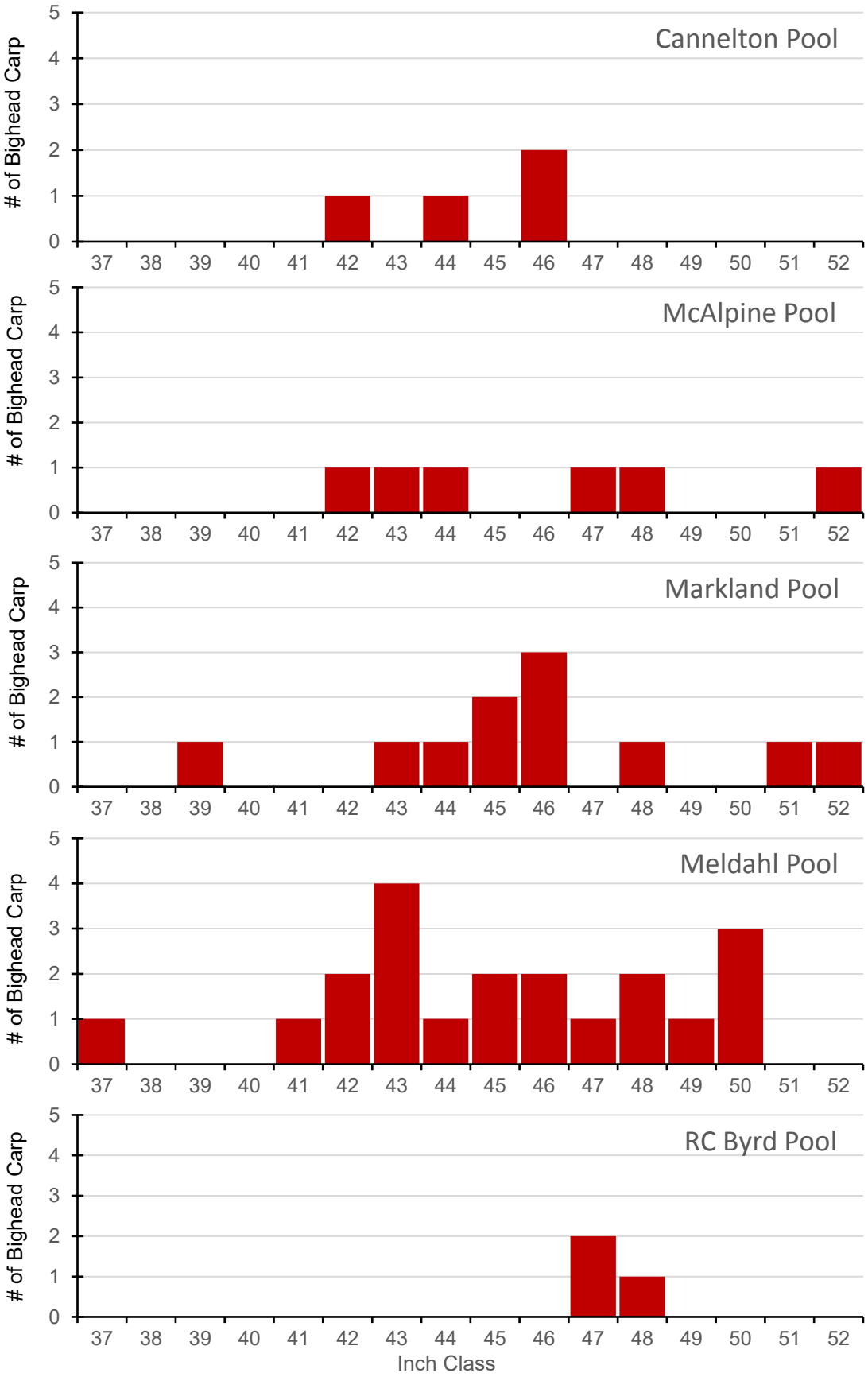


Figure 4. The length frequency of Bighead Carp collected from each pool during 2013 – 2017 that were ultimately implanted with transmitters.

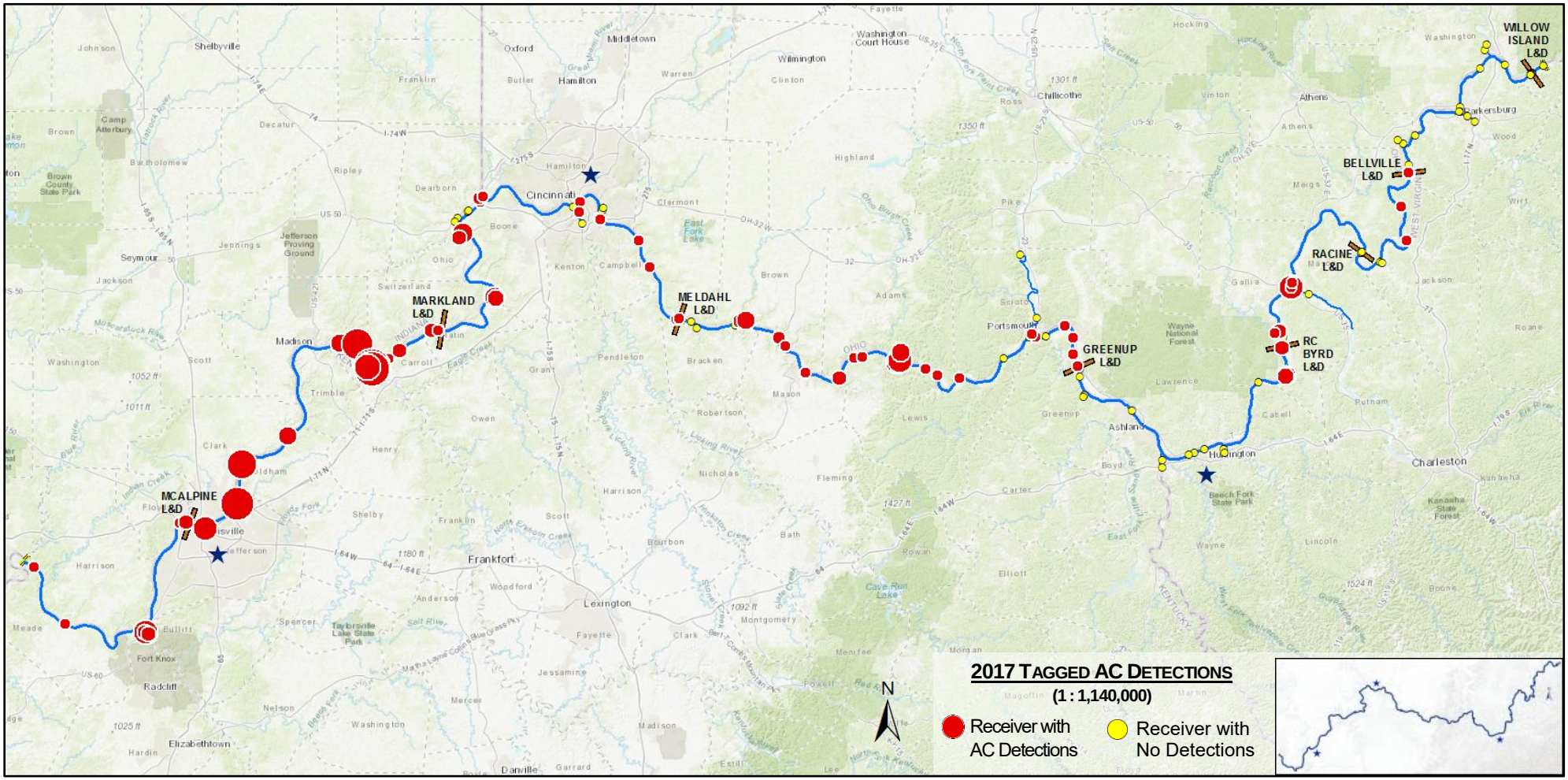
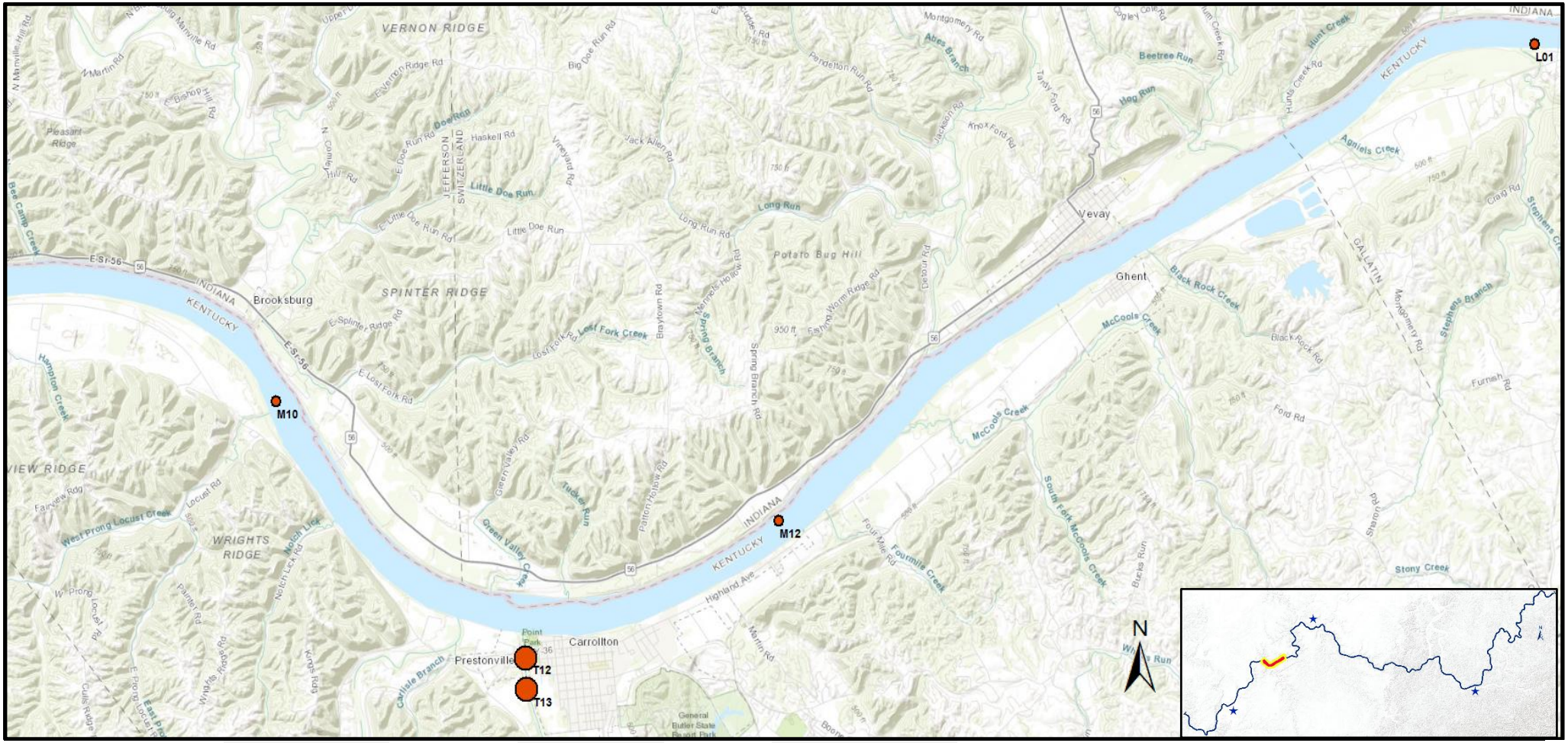
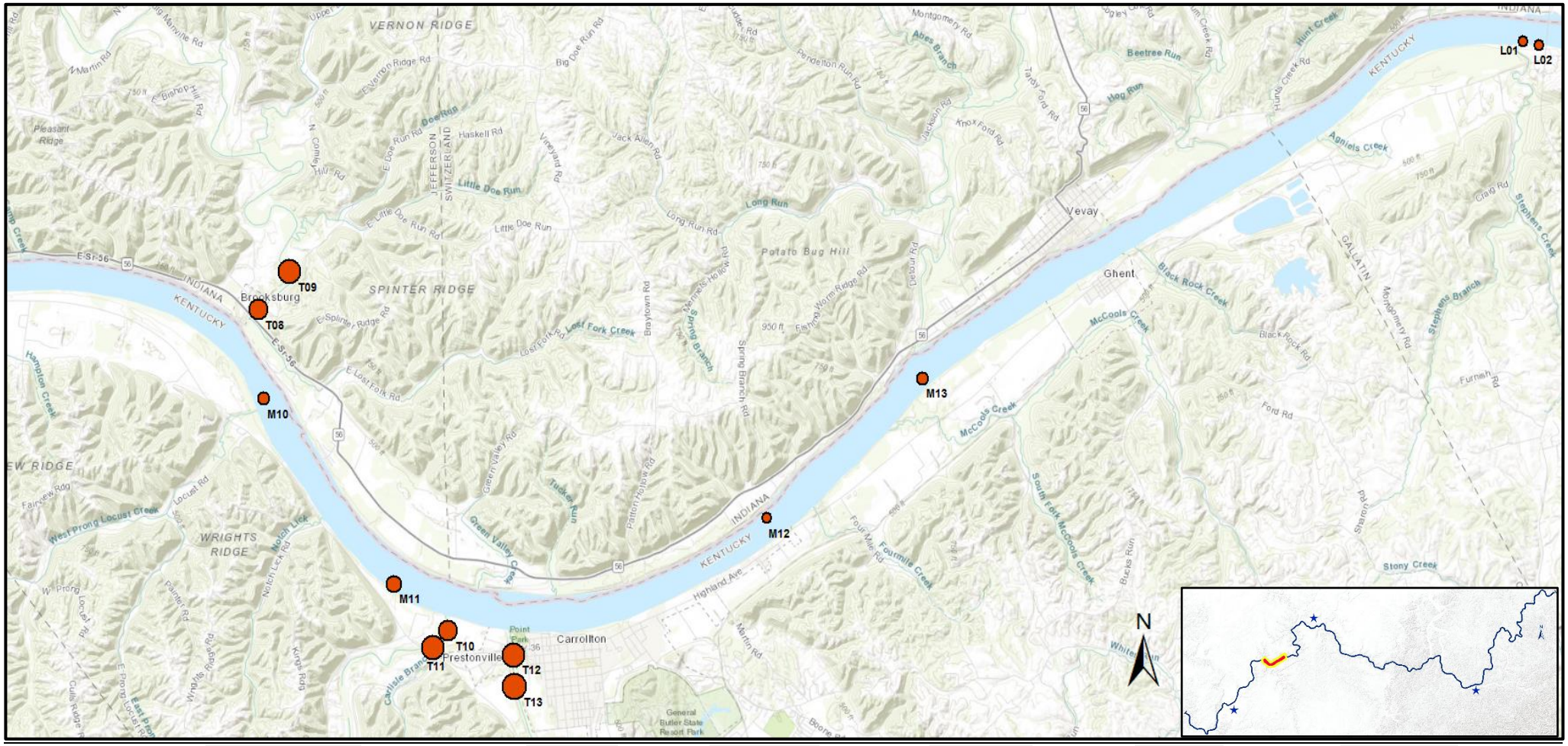


Figure 5. A map showing the distribution of the receiver stations that made detections of tagged Asian Carp in 2017. The total number of tagged AC detections made by each receiver is denoted via the diameter of its corresponding red circle.



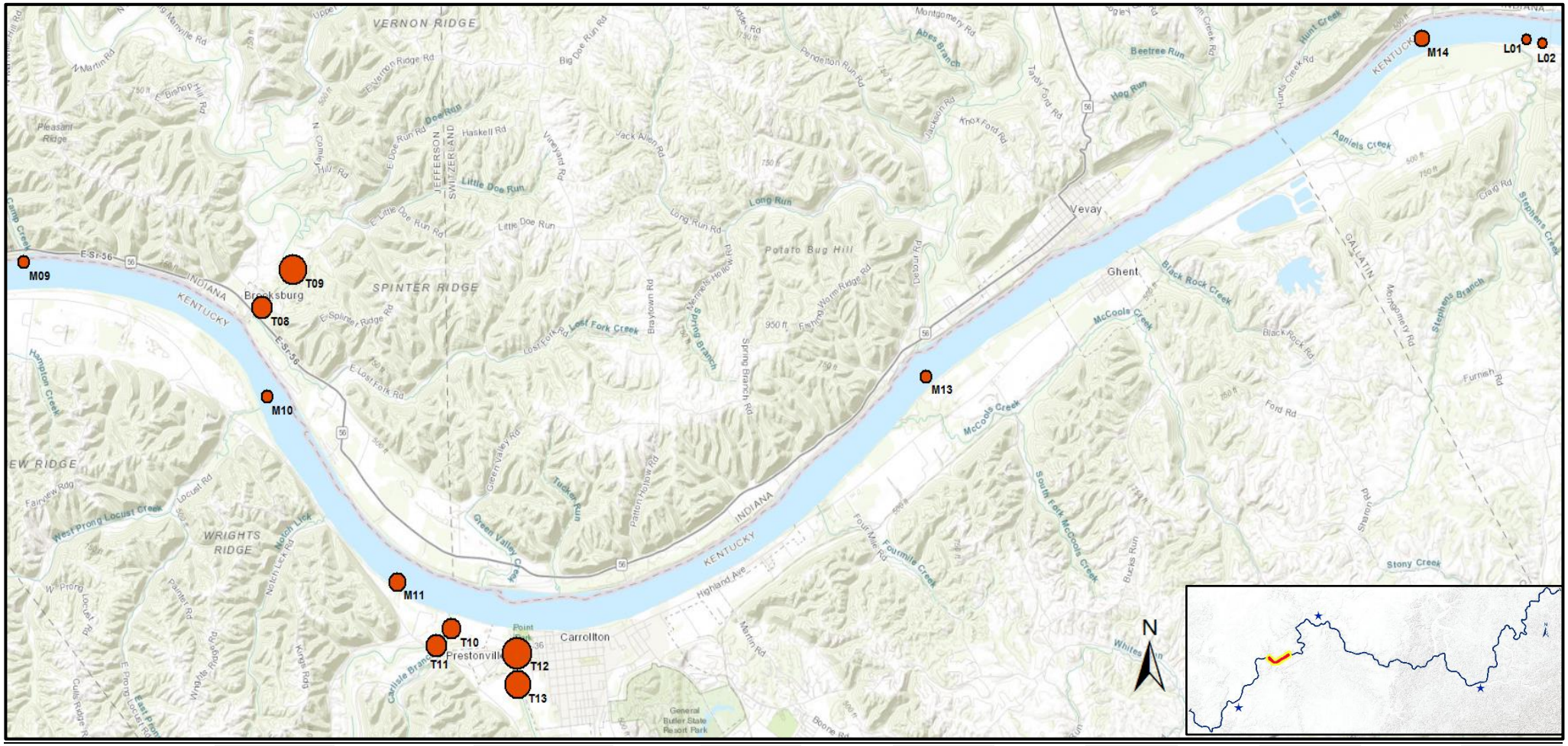
Map ID #	M10	T12	T13	M12	L01
Site Name	Near Locust Creek	KY River (lower)	KY River (upper)	Craig's Bar	Markland L&D (DS Approach)
# Winter Detections	7	185,124	209,164	15	1
# Unique Tags	1	44	44	4	1

Figure 6. A map of the receivers that were deployed to Kentucky River area of the McAlpine Pool during the winter (JAN – FEB) of 2017. The total number of tagged AC detections that the receivers recorded during this winter season were used to determine the diameter of the red circle that marks each site. Also, the Map ID # next to each circle corresponds to an entry in the table that provides additional information for each site (i.e. total # of winter detections & # of unique tags).



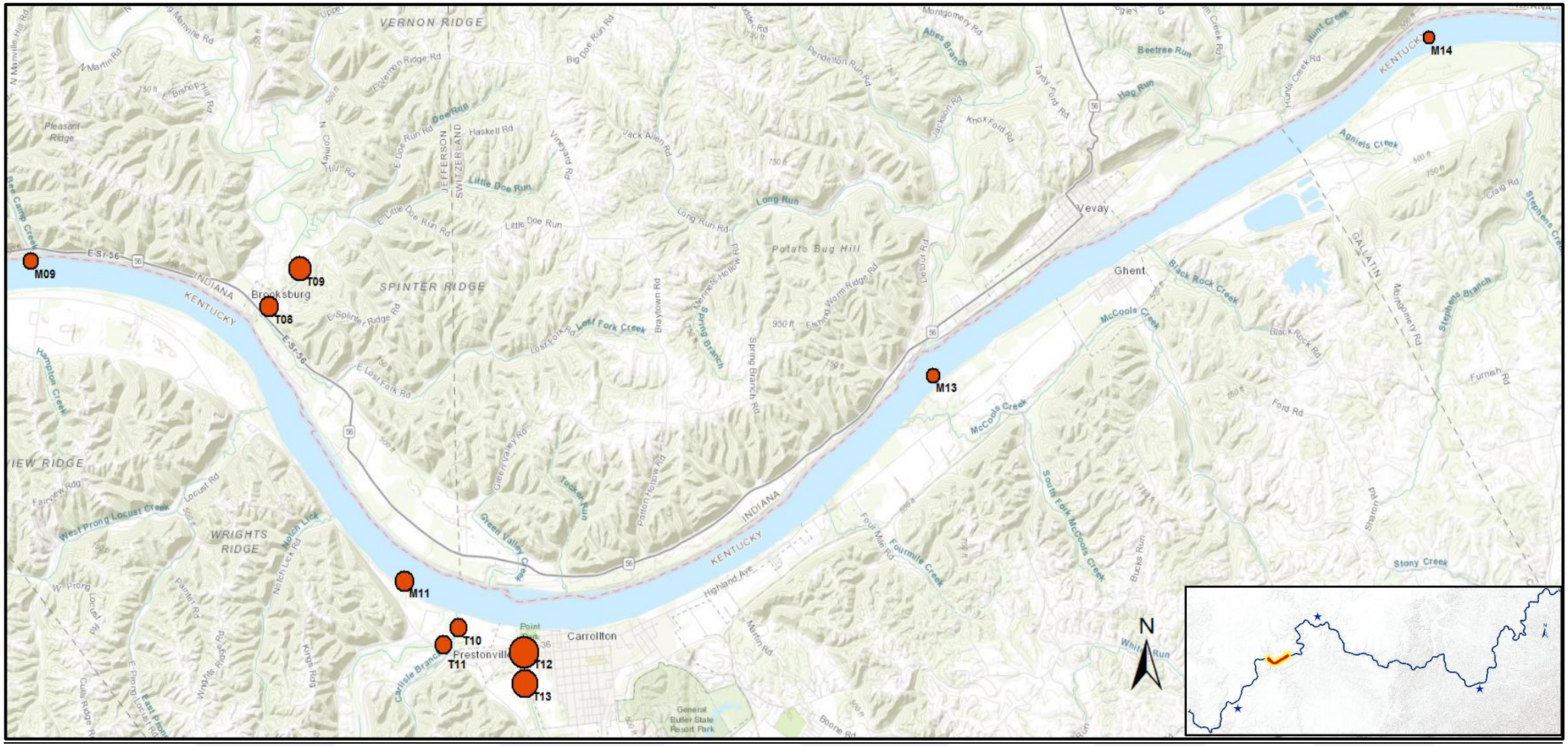
Map ID #	T08	T09	M10	M11	T10	T11	T12	T13	M12	M13	L01	L02
Site Name	Indian-Kentuck Creek (lower)	Indian-Kentuck Creek (upper)	Near Locust Creek	Below Little KY River	Little KY River (lower)	Little KY River (upper)	KY River (lower)	KY River (upper)	Craig's Bar	Near Indian Creek	L&D Approach	L&D 600' Lock
# Spring Detections	148,564	204,554	4,380	43,379	149,262	216,356	221,207	254,836	6	1,058	73	4
# Unique Tags	55	42	64	105	90	61	118	115	1	59	4	2

Figure 7. A map of the receivers that were deployed to Kentucky River area of the McAlpine Pool during the spring (MAR – MAY) of 2017. The total number of tagged AC detections that the receivers recorded during this spring season were used to determine the diameter of the red circle that marks each site. Also, the Map ID # next to each circle corresponds to an entry in the table that provides additional information for each site (i.e. total # of spring detections & # of unique tags).



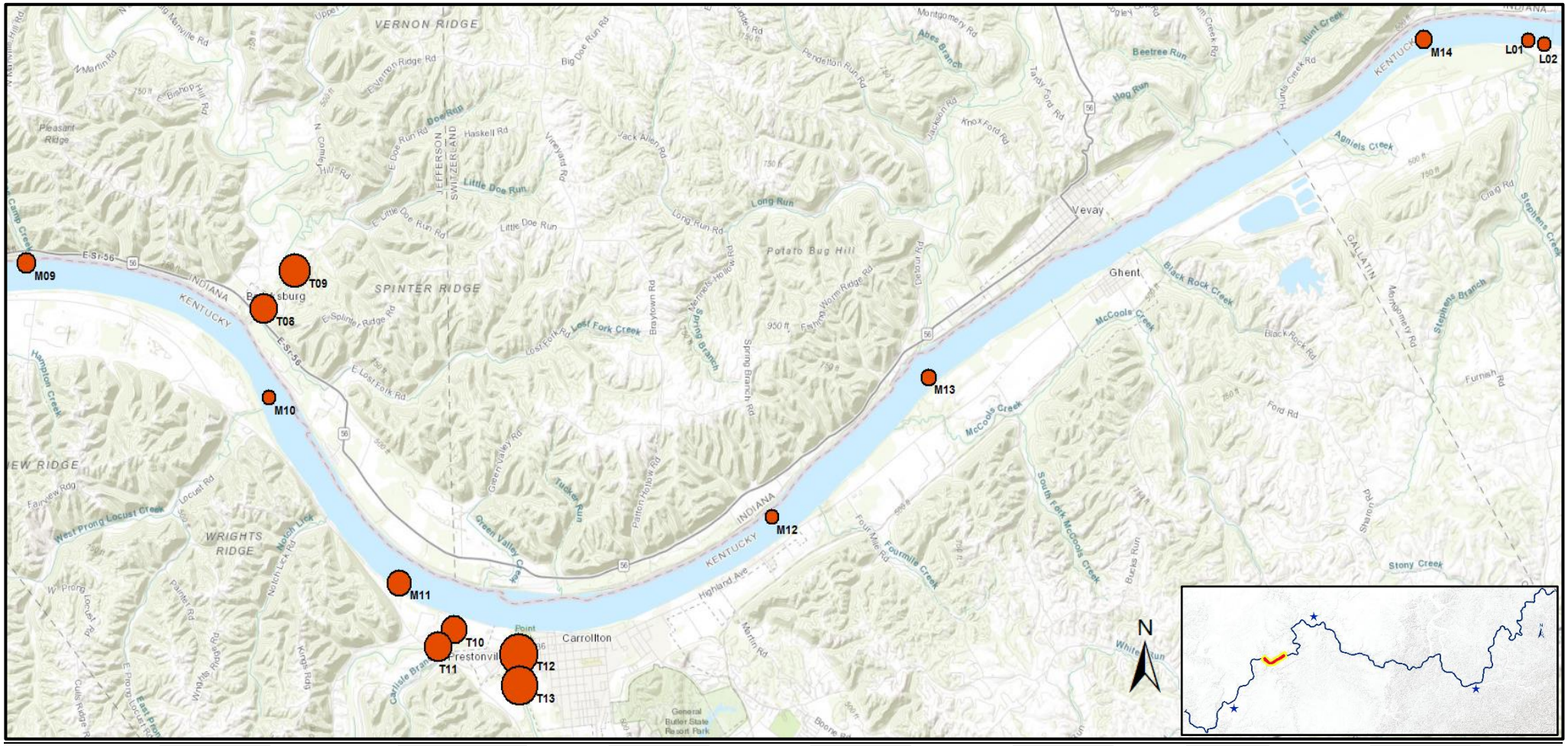
Map ID #	M09	T08	T09	M10	M11	T10	T11	T12	T13	M13	M14	L01	L02
Site Name	Near Bee Camp Creek	Indian-Kentuck Creek (lower)	Indian-Kentuck Creek (upper)	Near Locust Creek	Below Little KY River	Little KY River (lower)	Little KY River (upper)	KY River (lower)	KY River (upper)	Near Indian Creek	DS of Markland L&D	L&D Approach	L&D 600' Lock
# Summer Detections	4,680	169,428	327,905	3,519	71,929	129,956	166,809	372,945	292,262	3,612	19,343	425	430
# Unique Tags	5	56	41	26	106	69	47	92	90	56	28	3	1

Figure 8. A map of the receivers that were deployed to Kentucky River area of the McAlpine Pool during the summer (JUN – AUG) of 2017. The total number of tagged AC detections that the receivers recorded during this summer season were used to determine the diameter of the red circle that marks each site. Also, the Map ID # next to each circle corresponds to an entry in the table that provides additional information for each site (i.e. total # of summer detections & # of unique tags).



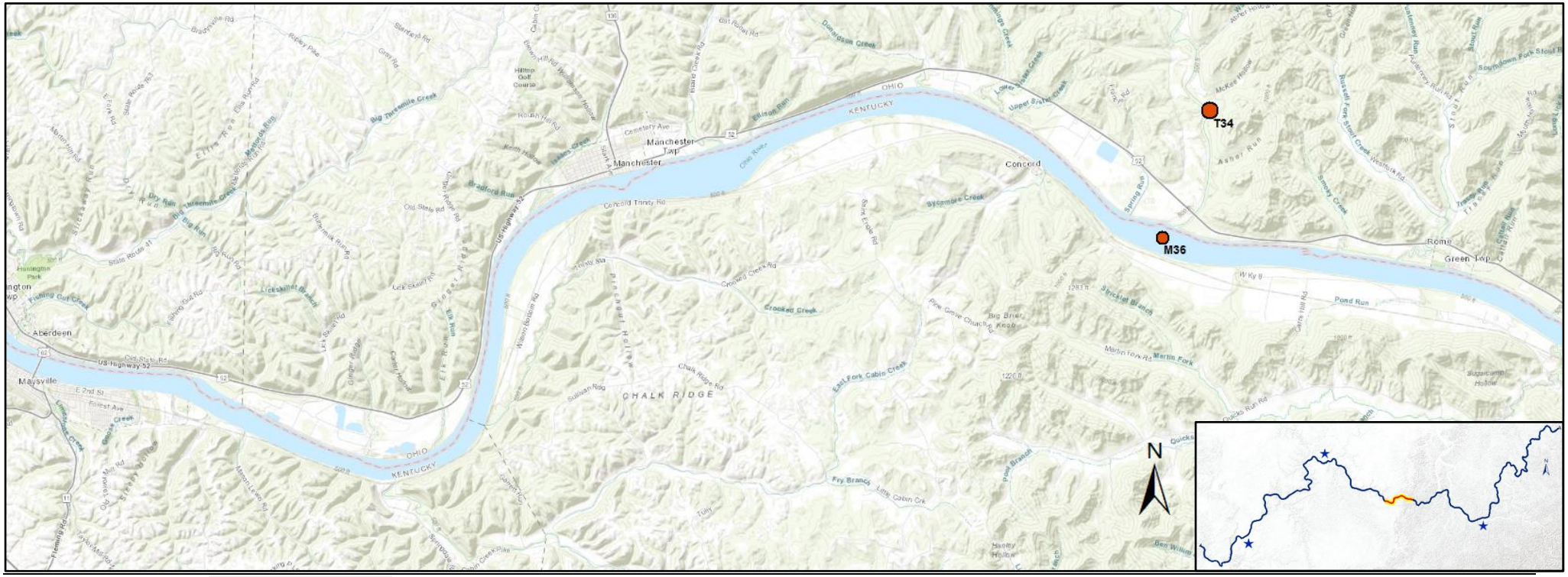
Map ID #	M09	T08	T09	M11	T10	T11	T12	T13	M13	M14
Site Name	Near Bee Camp Creek	Indian-Kentuck Creek (lower)	Indian-Kentuck Creek (upper)	Below Little KY River	Little KY River (lower)	Little KY River (upper)	KY River (lower)	KY River (upper)	Near Indian Creek	DS of Markland L&D
# Fall Detections	31,328	136,499	185,928	102,203	96,643	87,803	364,745	297,452	6,480	4,419
# Unique Tags	39	38	28	71	40	37	56	58	12	5

Figure 9. A map of the receivers that were deployed to Kentucky River area of the McAlpine Pool during the fall (SEP – NOV) of 2017. The total number of tagged AC detections that the receivers recorded during this fall season were used to determine the diameter of the red circle that marks each site. Also, the Map ID # next to each circle corresponds to an entry in the table that provides additional information for each site (i.e. total # of fall detections & # of unique tags).



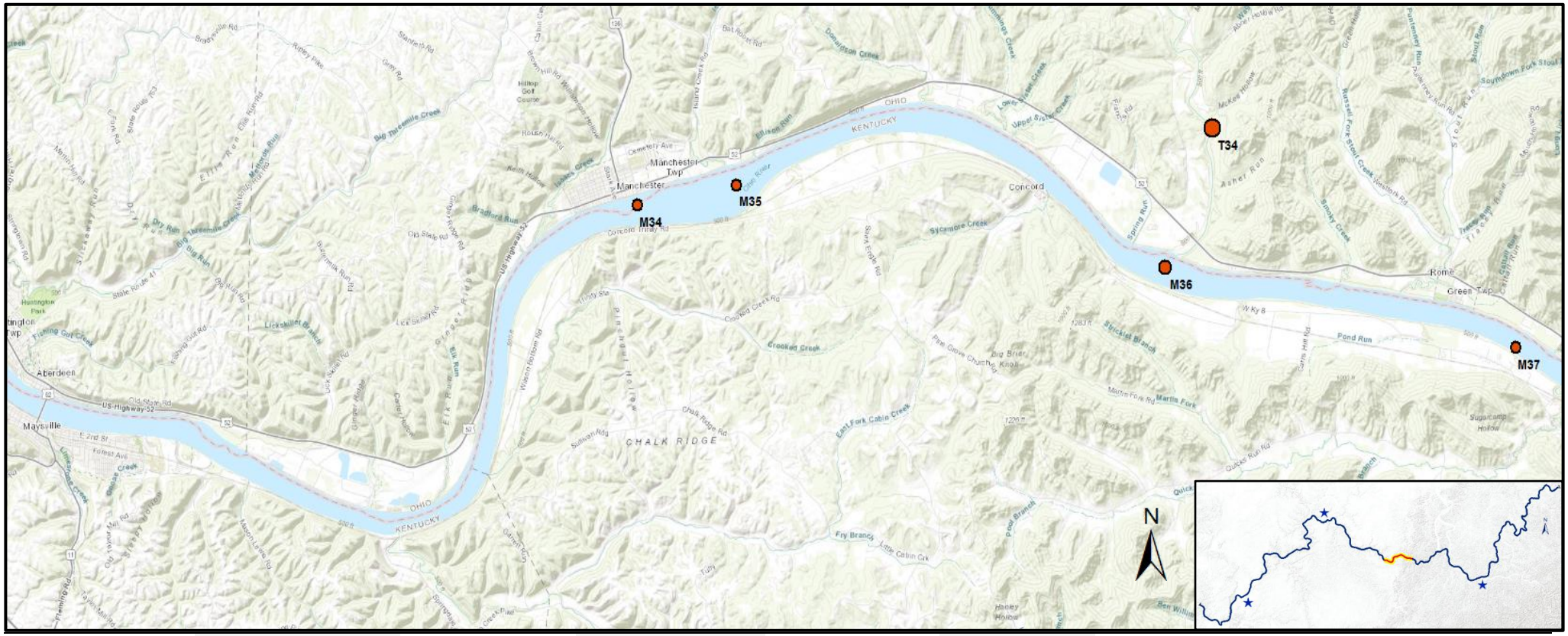
Map ID #	M09	T08	T09	M10	M11	T10	T11	T12	T13	M12	M13	M14	L01	L02
Site Name	Near Bee Camp Creek	Indian-Kentuck Crk (lower)	Indian-Kentuck Crk (upper)	Near Locust Creek	Below Little KY River	Little KY River (lower)	Little KY River (upper)	KY River (lower)	KY River (upper)	Craig's Bar	Near Indian Creek	DS of Markland L&D	L&D Approach	L&D 600' Lock
# Total Detxns	45,397	460,362	719,242	7,906	239,757	375,960	472,027	1,211,781	1,105,730	21	11,365	23,766	499	434
# Unique Tags	40	75	49	69	127	104	71	131	128	5	91	29	6	2

Figure 10. A map of the receivers that were deployed to Kentucky River area of the McAlpine Pool during 2017 (JAN – DEC). The overall number of tagged AC detections that the receivers recorded throughout 2017 were used to determine the diameter of the red circle that marks each site. Also, the Map ID # next to each circle corresponds to an entry in the table that provides additional information for each site (i.e. total # of detections & # of unique tags).



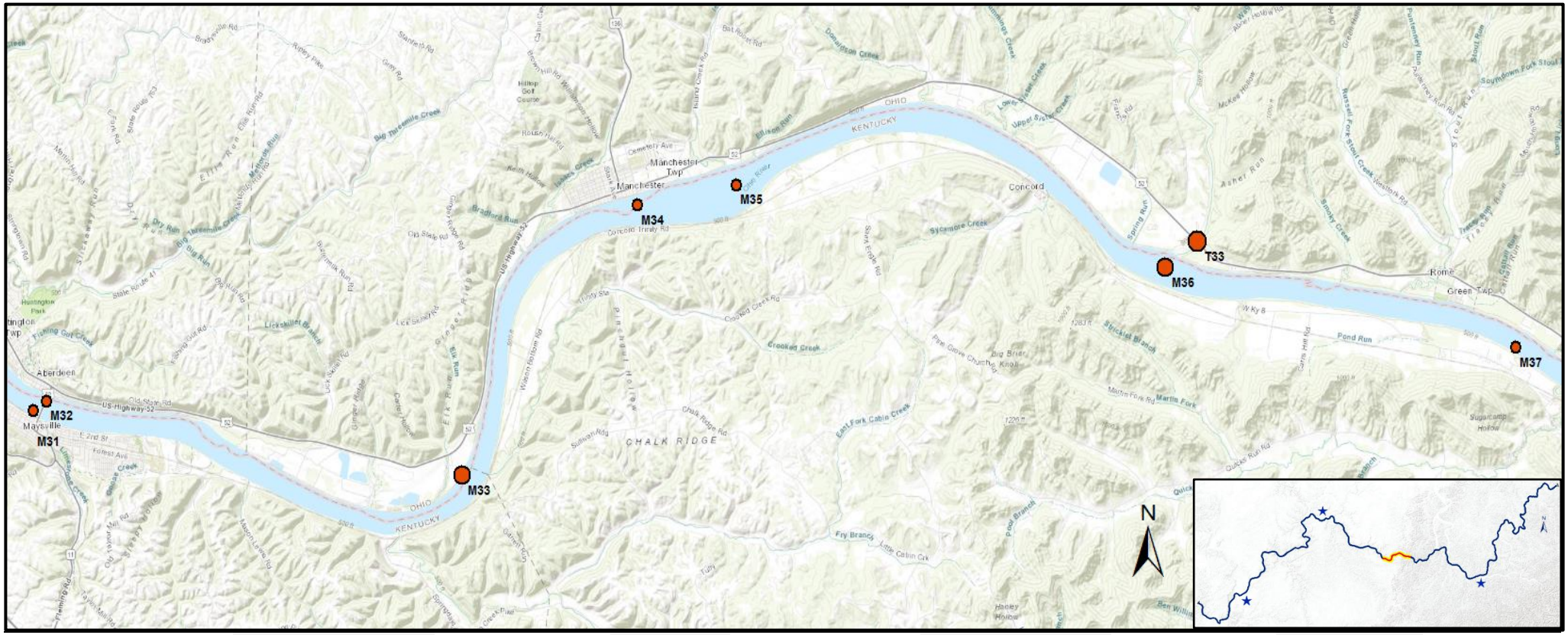
Map ID #	M36	T34
Site Name	Above OH-Brush Creek Island	OH-Brush Creek (upper)
# Winter Detections	2,362	40,004
# Unique Tags	9	9

Figure 11. The receiver stations in and around the OH-Brush Creek area of the Meldahl Pool (Maysville, KY to Rome, OH) with tagged AC detections that were made during the winter (Jan - Feb) of 2017. The diameters of the red circles used to represent these stations in the map were determined by the total number of tagged AC detections that each receiver logged during the 2017 winter season. Also, the ID #'s accompanying these circles are used to provide additional information for each site via the table located above.



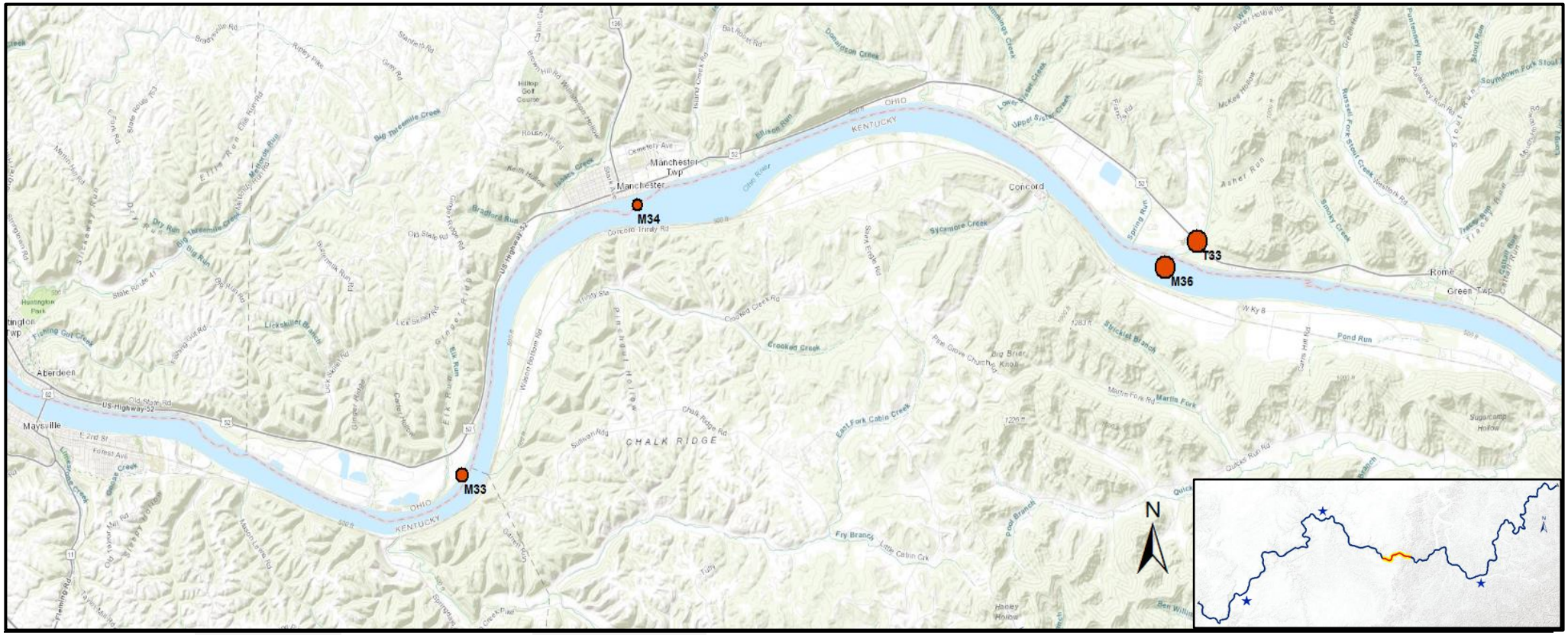
Map ID #	M34	M35	M36	T34	M37
Site Name	Below Manchester Island #2	Above Manchester Island #1	Above OH-Brush Creek Island	OH-Brush Creek (upper)	Quarry near Rome, OH
# Spring Detections	492	7	2,731	14,942	38
# Unique Tags	1	1	13	10	4

Figure 12. The receiver stations in and around the OH-Brush Creek area of the Meldahl Pool (Maysville, KY to Rome, OH) with tagged AC detections that were made during the spring (Mar - May) of 2017. The diameters of the red circles used to represent these stations in the map were determined by the total number of tagged AC detections that each receiver logged during the 2017 spring season. Also, the ID #'s accompanying these circles are used to provide additional information for each site via the table located above.



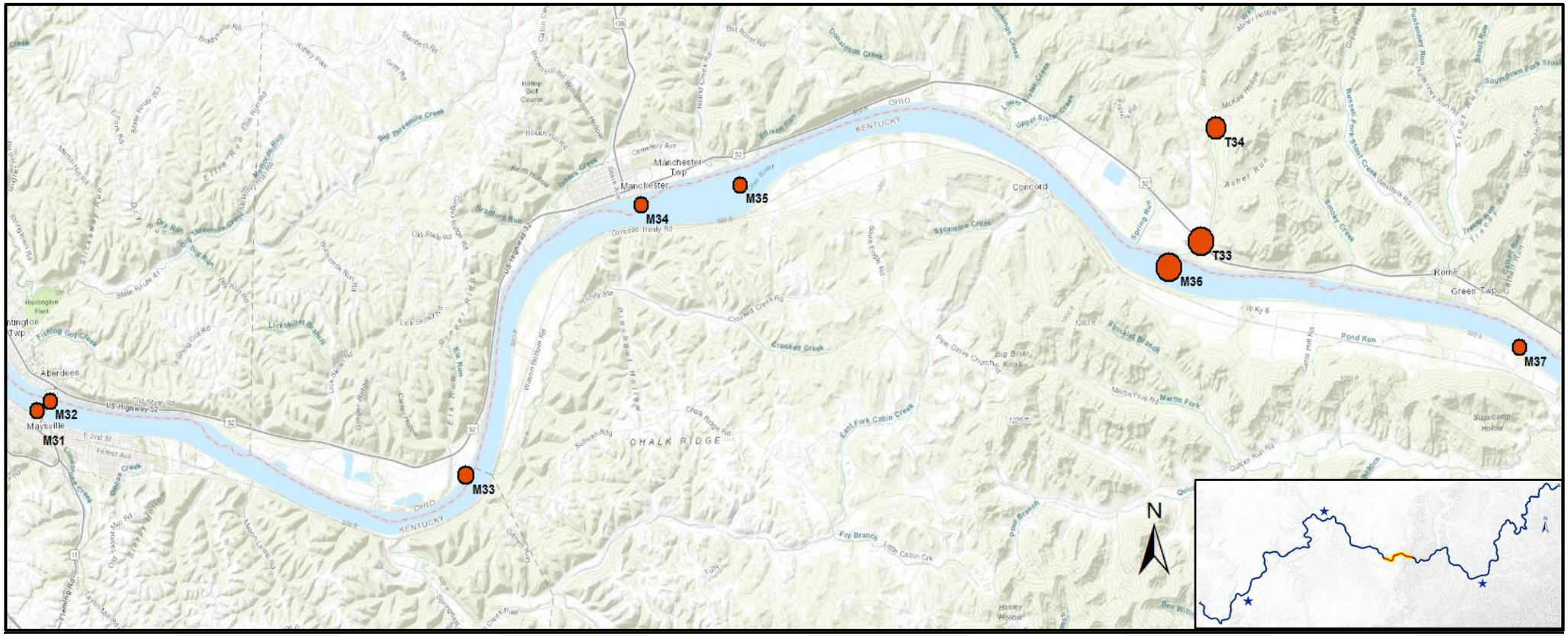
Map ID #	M31	M32	M33	M34	M35	M36	T33	M37
Site Name	Below US-62 Bridge (Maysville)	Above US-62 Bridge (Maysville)	ERSHIG Dolphin	Below Manchester Island #2	Above Manchester Island #1	Above OH-Brush Creek Island	OH-Brush Creek (lower)	Quarry near Rome, OH
# Summer Detections	35	97	15,172	712	72	42,128	84,782	611
# Unique Tags	1	2	8	10	3	12	12	8

Figure 13. The receiver stations in and around the OH-Brush Creek area of the Meldahl Pool (Maysville, KY to Rome, OH) with tagged AC detections that were made during the summer (Jun – Aug) of 2017. The diameters of the red circles used to represent these stations in the map were determined by the total number of tagged AC detections that each receiver logged during the 2017 summer season. Also, the ID #'s accompanying these circles are used to provide additional information for each site via the table located above.



Map ID #	M33	M34	M36	T33
Site Name	ERSHIG Dolphin	Below Manchester Island #2	Above OH-Brush Creek Island	OH-Brush Creek (lower)
# Fall Detections	4,344	441	115,050	103,897
# Unique Tags	4	6	11	12

Figure 14. The receiver stations in and around the OH-Brush Creek area of the Meldahl Pool (Maysville, KY to Rome, OH) with tagged AC detections that were made during the fall (Sep - Nov) of 2017. The diameters of the red circles used to represent these stations in the map were determined by the total number of tagged AC detections that each receiver logged during the 2017 fall season. Also, the ID #'s accompanying these circles are used to provide additional information for each site via the table located above.



Map ID #	M31	M32	M33	M34	M35	M36	T33	T34	M37
Site Name	Below US-62 Bridge (Maysville)	Above US-62 Bridge (Maysville)	ERSHIG Dolphin	Below Manchester Island #2	Above Manchester Island #1	Above OH-Brush Creek Island	OH-Brush Creek (lower)	OH-Brush Creek (upper)	Quarry near Rome, OH
# Total Detections	35	97	19516	1654	79	194731	209830	54950	649
# Unique Tags	1	2	8	10	3	13	12	10	9

Figure 15. The receiver stations in and around the OH-Brush Creek area of the Meldahl Pool (Maysville, KY to Rome, OH) with tagged AC detections that were made during 2017. The diameters of the red circles used to represent these stations in the map were determined by the total number of tagged AC detections that each receiver logged during 2017. Also, the ID #'s accompanying these circles are used to provide additional information for each site via the table located above.

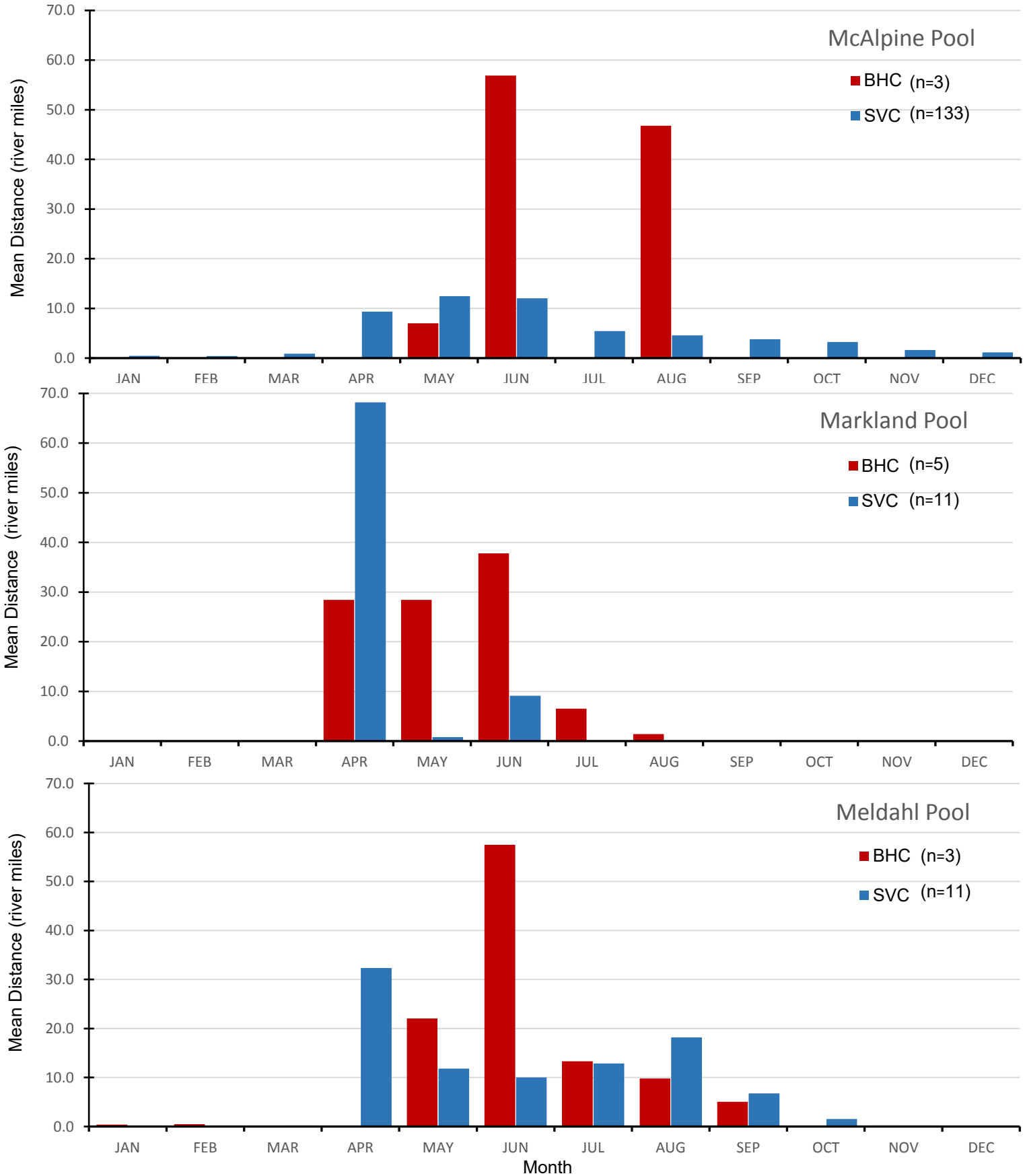


Figure 16. The mean monthly distances (in river miles) between the most upstream and downstream detections for tagged Bighead Carp and Silver Carp in the three most active pools of the telemetry project. Only tagged carp that were detected by 2 or more receivers during 2017 were included in the distance calculations.

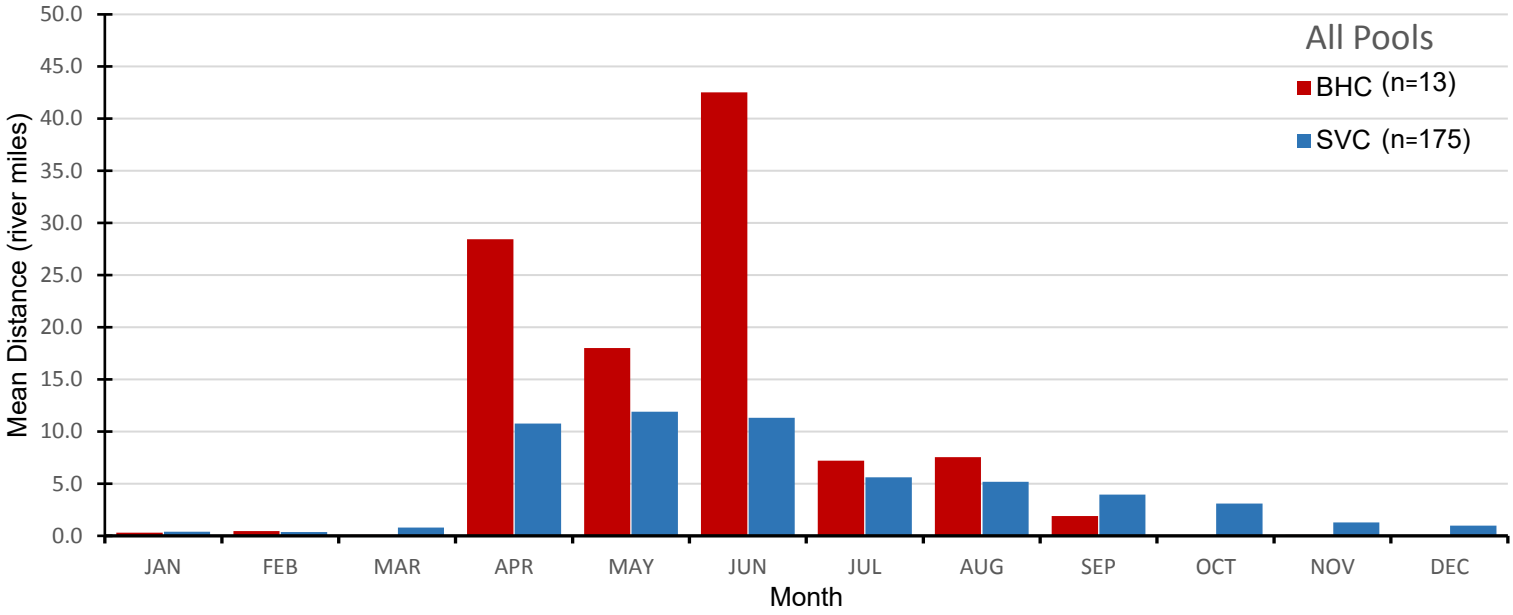


Figure 17. The mean monthly distances (in river miles) between the most upstream and downstream detections for all tagged Bighead Carp and Silver Carp that were detected by 2 or more receivers during 2017.

Project 5: Ohio River Asian Carp Coordination and Outreach

Objectives:

- Assist in development of an Ohio River basin Asian carp communication plan
- Develop web content as requested by ORFMT or identified in the Ohio River Asian carp communication plan for posting on www.Asiancarp.us

Methods:

Evaluate existing communication strategies within the Ohio River Asian Carp partnership and external communication with the general public and other Asian Carp working groups. Continue to provide web content for posting on www.Asiancarp.us. Collect ideas for a communication plan and initiate development.

Results and Discussion:

The KDFWR has gathered information and direction from the ORFMT and Ohio River Basin partner agencies for the development of an Ohio River basin Asian carp communications plan. Since this is such a large partnership, public-affairs specialist Katie Steiger-Meister with the United States Fish and Wildlife Service (USFWS) recommended not leading off with the direct development of a communications plan. Instead, efforts have focused on providing potential components to the communications plan and providing those to the basin partners for their review and consideration. Thus KDFWR efforts have focused on evaluating current internal and external communication components and how they could potentially be worked into a comprehensive basin communication plan. Early in 2017 an ORB communications conference call was held with representatives from all basin partners to get input from all partners regarding communication needs. KDFWR is continuing to work with USFWS Region 3 External Affairs staff to coordinate implementation of coordinated communications efforts in the basin and to finalize an ORB communications plan when appropriate for the partnership.

The basin has made significant strides in communicating the concern with Asian Carp and their potential impacts, however there remains significant room for improvement. Internal communication between key stakeholder groups is high, however the group still needs to focus on reaching out to the public. Kentucky Department of Fish and Wildlife Resources(KDFWR) assisted with development of a communication working group team and provided web content as needed to Ohio River Fisheries Management Team (ORFMT). Initial meetings and calls have included representatives from Kentucky, Tennessee, West Virginia, Alabama, Georgia, United States Fish and Wildlife Service, United States Geological Survey, Indiana Wildlife Federation, and the United States Army Corp of Engineers.

The existing internal basin communication is comprised of:

1. Annual in-person technical reporting meetings to share the most up-to-date data and analysis being completed on projects
2. Annual in-person planning and direction meetings to set basin priorities and assign project tasks
3. Annual fall summary report to the U.S. Congress on all basin research projects
4. Annual spring technical report analyzing and summarizing the work of all basin partners
5. Assigned project leads who coordinate field work and report writing.
6. Providing updates and reports to Asiancarp.us

In addition to internal agency-to-agency communication, the basin is also working to improve communication with other entities who are not currently partnering on Ohio River basin Asian Carp projects as well as the general public. A critical component of this outreach relies on web content to provide updates to all partners and the general public. Katie Stieger-Meister agreed to assist with updating Asiancarp.us with all Ohio River basin stories and plans as provided. This website often has above 80,000 annual views per year and is also regularly highlighted by media outlets. Not only is the site used by the general public it also provides a clearinghouse for all Asian carp information from other basins so it is the ideal location to ensure the direction of the Ohio River Basin is communicated to all other interested parties.

External communication strategies of basin partners have been largely independent, with states reaching out to constituents with varying levels of consistency and effectiveness. In Kentucky, headway has been made in reaching out to both state and national legislatures as well as the general public. KDFWR has reached out to the public through a Facebook page largely centered around Asian Carp issues in the state, filmed numerous segments of "*Kentucky Afield*" related to Asian Carp, and conducted numerous public meetings. Executive staff have spent considerable amount of time with legislatures and local governments, making them aware of the impact Asian Carp are having on local economies. In addition to tradition articles and videos, KDFWR and TWRA have partnered together to put on Asian Carp fishing tournaments (branded Carp Madness I & II). These events were beneficial in that in addition to promoting removal of carp they also generated an enormous amount of media interest. The first event, Carp Madness I, was a commercial fishing tournament and the "Kentucky Afield" segment that featured the tournament has over one million views on Youtube. These efforts have been monumentally successful in that they have made both the public and state legislatures aware of the issue and also highlighted the importance of immediate action.

The following links are just a few examples of these public communication efforts by basin partners:

> Web content produced for Asiancarp.us : "Kentucky hosts tournament for bow anglers to combat invasive carps"; "Ohio River Basin Asian Carp Control Strategy Framework"; "2017 Monitoring and Response Plan for Asian Carp in the Ohio River Basin"
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> Carp Madness Ky Afield: https://www.youtube.com/watch?v=CQYJd-7iQb8&t=987s
>
> TWRA Broadcast: https://www.youtube.com/watch?v=AC2efZxOJgA
>
> Western Kentucky Fisheries Facebook: https://www.facebook.com/westerndistrictfisheries/
>
> West Virginia Gazette: https://www.wvgazettemail.com/outdoors/researchers-fight-to-keep-asian-carp-out-of-wv-s/article_df8d8328-1183-5596-8cc6-c80c4fe61c20.html
>
> Indiana DNR and Kentucky Processors: https://www.youtube.com/watch?v=p8rBT33b0t4

While these communication efforts have raises awareness about the Asian Carp invasion, more coordinated effort is need to highlight the work that State and Federal partners have initiated to manage Asian Carp. In Kentucky, public comments are often pessimistic about the future and centered around the rhetoric that state and federal agencies are either not doing anything or not doing enough to address the problem.

A communication plan for the basin should seek to not only raise awareness of the problem but also communicate what current efforts are underway and how others can become involved. The outline below was developed from the initial group call:

- Identify communication objectives

    - Coordination in fieldwork is good so far
    - Monthly summary of what is going on basin wide either through email or conference call
- Communication with public and NGO's
    - Goals – Projects – Progresses
- Communication with state legislators and congress
    - Generic brochure of what is happening by agency or basin (emailed by Jim Bredin on 9-12-16 on behalf of ACRCC)
    - Convened Round Tables for specific issues
    - MICRA – ORB representation with federal legislature
    - Coordinated and consistent message among states
    - Clear and realistic needs for the basin
- Communication Tools
    - Asiancarp.us
    - Who starts process and courtesy review by rest of basin
    - Communication Specialist and Biologists work together to determine exactly what needs to be said
    - Use conference calls to discuss "hot topics"
    - Use emails for routine information sharing – be specific on what is expected and have a timeline
    - Use #Asiancarp on articles posted by Agency social media outlets
    - Do we want a hashtag for the ORB?
- Expectations and Implications
    - Asiancarp.us – One week to update information once provided to Katie depending on the current backlog at webmaster
- Evaluation Process

Plan Development

The basic plan outline used as a starting point for the ORB partners to review:

Step 1: Identify and prioritize natural resource or outdoor recreation issues concerning the Ohio River Basin Asian Carp partnership.

- Asian carp in the Ohio River Basin
- Impacts on sport fisheries
- Impacts on recreational boating
- Impacts on ecosystem function
- Impacts on economically important species (paddlefish, other commercial fisheries)

Step 2: Identify and prioritize information and outreach issues of interest to audiences of interest to the ORB parnershp.

- Communication among Ohio River Asian carp partnership
- Communication with constituents
- Communication with Congress
- Communication with other national AC partnerships

Step 3: Define goals and set measurable objectives.

- Maintain internal communication to facilitate annual planning and implementation of projects. Continue annual meetings in mid-summer and early winter.
- Specify the products and timing of communications for USFWS/Congress/EPA. Continue annual basin technical reports in Feb and reports to Congress in October.
- Maintain/improve public awareness of the current status of the Asian carp problem in the Ohio River Basin. Partners create an internal message board to cross promote media coverage and let other agencies within the partnership know what message is being sent to the public.
- Improve public awareness of the Ohio River Asian carp partnership and what the partnership does. Don't just promote the problem, also communicate the existence of a partnership and how it is attempting to solve the problem.
- Communicate outlets for involvement – How can constituents help?

Step 4: Develop tools and timing for messaging to each audience

- **Internal communication**:
    - Project updates, conference call or submitted text, quarterly;
    - Annual and long-term planning, face to face, June and October;
    - Annual planning, conference calls, October – November
    - Workgroups, as needed to address specific tasks (stock assessment, field level coordination, etc.)
    - Message board making others aware of what individual agencies are communicating with the publis

- **Communication with constituents**
    - Press releases, as needed by project, local TV and newspaper, social media, asiancarp.us
    - How do we make constituents more aware of what we are doing? Public meetings, congressional briefings, articles and videos that focus on the solutions being attempted.
    - Show the successes. When we remove large numbers of fish let the public know.

- **Communication with Congress**
    - Monitoring and Response Plan for Asian carp in the Mississippi River Basin: annually after April/May, websites, press release?, congressional briefing w/ MICRA
    - WRRDA Report to Congress (includes annual technical reports for all projects): annually, websites, press release?, congressional briefings
    - Contribute OHR initiatives in ACRCC Action Plan: annually when requested, fact sheet
    - Action Plan: 5 year plan that identifies current projects and future needs: written document should be shared in the same ways as the above documents.

The final portion of this plan will be to continue to evaluate the effectiveness of the communication efforts. What messages are we communicating effectively? What opportunities are we missing? Is the message resonating with our target audience? Although we are already implementing a portion of this plan there are still several large gaps where we are missing opportunities, particularly in having a unified message, communicating current efforts, and advertising our successes.

As the need for a partnership to combat Asian Carp emerged, most of our organizations had only limited funding for Asian Carp and our communication efforts did not require as much refinement as the need was simply to make the public aware that Asian Carp present a formidable threat to our ecosystems and outdoor economies. Now that our efforts are much more diversified and the partnership is receiving funding there is a greater needed for focused and coordinated messaging that informs our audiences on how we are efficiently and effectively combatting Asian Carp.

Recommendation: The ORB partners should request USFWS assistance with chairing an Ohio River Basin Communications Working Group, modeled on the process used by the Asian Carp Regional Coordinating Committee (ACRCC) for coordinated inter-agency communications in the Great Lakes Basin. The ORB can also leverage the experience gained by the ACRCC Communications Work Group to implement an effective plan. Since many communication efforts are already in place, the new working group can simultaneously evaluate the success of current communication strategies and provide specific actions needed to improve communications. Time should be carved out at annual face-to-face meetings to discuss how the plan is being implemented and how the message is being received.

Deliverables: Collaboration of partners on communication needs and ideas presented on how to meet those needs. States have taken many independent steps to communicate ongoing Carp projects with the public. Major events and reports from the basin were posted to www.Asiancarp.us including the 2016 and 2017 technical reports and Carp Madness II article coverage. The initial steps were taken to develop a communication plan.

Project Highlights:

- Conference call with all partnering agencies represented to discuss communication strategies
- Baseline communication plan laid out to be further fleshed out by partnering agencies
- Annual technical reports were provided to www.Asiancarp.us which has 80,000 annual site visits and is regularly viewed by the public
- A lot of successful communication efforts are currently underway – all partners have been reaching out to media and promoting by using their respective agency pathways (TV shows, magazines, and online articles)

Non-target species take from gillnetting conducted to complete KDFWR projects

Project 1: Monitoring and Response of Asian Carp in the Ohio River – Greenup Pool (FWS grant requires reporting for RC Byrd Pool too)

Spring targeted sampling –

- Greenup Pool: 1 grass carp
    - 1 smallmouth buffalo – Released alive
- RC Byrd Pool: 1 bighead carp and 1 grass carp
    - 6 smallmouth buffalo – Released alive
    - 1 longnose gar – Released alive
    - 2 freshwater drum – Released alive
    - 1 flathead catfish – Released alive
    - 7 common carp – Released alive
    - 1 bowfin – Released alive
    - 1 blue catfish – Released alive

Fall standardized community sampling

- Greenup Pool: No Asian carp collected.
    - 1 channel catfish – Released alive
    - 1 flathead catfish – Released alive
    - 1 paddlefish – Released alive
    - 2 smallmouth buffalo – Released Alive
- RC Byrd Pool: No non-target species captured

Project 2: Control and Removal of Asian Carp in the Ohio River – Greenup Pool (FWS grant requires reporting for RC Byrd Pool too)

- Greenup Pool: No Asian carp collected.
    - 1 common carp – Released alive
    - 1 flathead catfish – Released alive
    - 4 longnose gar –Released alive
- RC Byrd Pool: 3 bighead carp and 1 grass carp.
    - 1 bigmouth buffalo – Released alive
    - 3 blue catfish – Released alive
    - 3 flathead catfish – Released alive
    - 1 freshwater drum – Released alive

- 9 paddlefish - 4 dead on arrival due to high water temps, 5 released alive. These fish were caught on overnight sets in a single night. After this sampling day, no more nets were left overnight.
- 5 smallmouth buffalo – Released alive

Project 3: Limiting Dispersal of Asian Carp at Lock and Dam Facilities

- No gill netting conducted for this project

Project 4: Telemetry of Asian Carp in the Ohio River

- No gill-netting was conducted solely for this project. Asian Carp tagging was opportunistic and Asian carp collected from sampling in Projects 1 & 2 were utilized. In limited situations, electrofishing was used to supplement tagging needs and did not result in the capture of any non-target fishes.

Project 5: Ohio River Asian Carp Coordination and Outreach

- No gill netting conducted for this project