

INVASIVE CARP UNIT ANNUAL SUMMARY OF ACCOMPLISHMENTS, 2022

Progress Report

Courtney Weldon
Benjamin Erb
Craig Jansen
Fisheries Biologist

Indiana Department of Natural Resources
Division of Fish and Wildlife
I.G.C. – South, Room W273
402 W. Washington Street
Indianapolis, IN 46204

2023

EXECUTIVE SUMMARY

- The Invasive Carp Unit works collaboratively with the Ohio River Basin invasive carp partnership to annually prioritize basin-wide invasive carp research and management needs. Many state, federal, and university partners are involved in a suite of projects to address invasive carp at a broad scale.
- All of the Ohio River Basin invasive carp work is captured in one of four major projects: Abundance and Distribution of Early Life Stages, Early Detection and Evaluation of Removal, Movement and Habitat Use, and Control and Containment.
- Invasive carp larvae were captured in the Ohio River as far upstream as river mile 663, near Leavenworth, IN, in Cannelton Pool.
- Invasive carp young of year (YOY) were captured as far upstream as 508, near Rising Sun, IN, in Markland Pool. This is the furthest upstream YOY invasive carp have been documented since sampling began in 2016 and is over 180 miles further upstream than where YOY were found previously.
- Fish community sampling was conducted on the Wabash and Ohio Rivers in the spring and fall, respectively, to monitor for changes over time. Additionally, otoliths were collected from Silver Carp in the Ohio River and ages were estimated to evaluate population metrics.
- To evaluate invasive carp movement in response to dam removals in the Eel River, 55 additional carp were tagged with internal transmitters in the Upper Wabash River near Peru, IN.
- Telemetry receivers from J.T. Myers lock and dam to Cannelton Pool were regularly downloaded throughout the year, approximately every other month. Over 500 unique tagged fishes were logged on the receivers.
- The Kentucky Contract Fishing Program and the Illinois Enhanced Contract Fishing Program have helped substantially increase invasive carp harvest from the Ohio River basin. Additionally, INDNR staff removed over 17,000 pounds (2,319 adult invasive carp) throughout 2022 fieldwork.
- Work planned for 2023 will be similar to that of 2022. However, there will be increased efforts to evaluate YOY carp passage into Hovey Lake, and additional focus on establishing programs to increase carp harvest in Indiana waters.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF FIGURES	iii
INTRODUCTION	1
ABUNDANCE AND DISTRIBUTION OF EARLY LIFE STAGES PROJECT.....	3
Invasive carp egg and larvae sampling	3
Juvenile invasive carp sampling.....	4
Microchemistry project	5
Hovey Lake project	5
EARLY DETECTION AND EVALUATION OF REMOVAL PROJECT	5
Spring targeted sampling.....	5
Wabash River fish community sampling	6
Determining ages of Silver Carp	7
Ohio River fish community sampling.....	8
MOVEMENT AND HABITAT USE PROJECT	8
Tagging efforts.....	8
Receiver results	9
CONTROL AND CONTAINMENT PROJECT	10
PLANS FOR 2023	11
LITERATURE CITED.....	18

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Current distribution of Silver Carp in the United States. The size of the circle represents the number of individuals found in that location with larger circles representing more individuals than the smaller circles. Image taken from USGS Nonindigenous Aquatic Species Map: https://nas.er.usgs.gov/viewer/omap.aspx	13
2. The current distribution of Bighead Carp (left) and Silver Carp (right) in the Ohio River Basin. The larger circles represent more individuals at each location while the smaller circles show less individuals. Image taken from USGS Nonindigenous Aquatic Species Map: https://nas.er.usgs.gov/viewer/omap.aspx	13
3. Map of the Ohio River pools throughout the middle portion of the basin.....	14
4. Age-Length growth curve for Ohio River Silver Carp, 2022.....	14
5. Wabash River fish community sampling results, by species and number collected in 2022. The “other” category represents all fish species caught with fewer than 10 total individuals and includes Shorthead Redhorse, Northern Hogsucker, Grass Carp, Quillback Carpsucker, Channel Catfish, Goldeye, Blue Catfish, Shovelnose Sturgeon, Spotted Bass, and Highfin Carpsucker.....	15
6. Ohio River fish community sampling results, by species and number collected in 2022. The “Other” category represents all fish species caught with 15 or fewer total individuals, and includes Redear Sunfish, Orangespotted Sunfish, Green Sunfish, Longear Sunfish, Black Crappie, White Crappie, Largemouth Bass, Spotted Bass, Smallmouth Bass, Striped Bass, White Bass, Hybrid Striped Bass, Grass Carp, Sauger, Flathead Catfish, Shorthead Redhorse, Golden Redhorse, River Redhorse, Silver Redhorse, Smallmouth Redhorse, Bigmouth Buffalo, Northern Hogsucker, Blue Sucker, Spotted Sucker, Quillback Carpsucker, Common Carp, Mooneye, Freshwater Drum, and an unidentified species of Shiner and Madtom.....	16
7. Telemetry receiver locations in the Ohio River, 2022.....	17

INTRODUCTION

Invasive carp, previously referred to as Asian carp, are an established invasive species in many of the large rivers in the central United States. The term “invasive carp” refers to Bighead Carp (*Hypophthalmichthys nobilis*), Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon idella*), and Black Carp (*Mylopharyngodon piceus*). Originally imported in the 1970s for use in aquaculture ponds, three of the four species (Bighead Carp, Silver Carp, and Grass Carp) were found to have established populations in the Mississippi River by the 1980s (Stump et al. 2016). These species quickly expanded up the Mississippi River and into many of its largest tributaries including the Illinois, Missouri, and Ohio Rivers. By the 1990s, invasive carp had moved into many of the lower pools of the Ohio River and reproducing populations were found by the early 2000s (Stump et al. 2016). Due to their fast growth rate, Silver Carp become too large for most predator species in U.S. large river ecosystems after one to two years of growth. Additionally, invasive carp have a very high reproductive potential (they can have multiple spawns in a single season with thousands of eggs released per spawn). These factors make invasive carp a highly successful invader. The lower Ohio River had an established Silver Carp population by the late 2000s.

Silver, Bighead, and Grass Carp are now well established and reproducing throughout much of the Mississippi River Basin and are expanding in the Ohio River basin. For this report, invasive carp will often be referring directly to Silver Carp as most of the pressing issues and work being done in Indiana and on the Ohio River revolves around them. Silver Carp are currently the most numerous of the invasive carp species within Indiana and are found in large densities throughout the Mississippi and Ohio River Basins (Figure 1). Currently, Silver and Bighead Carp are found from the confluence of the Mississippi and Ohio Rivers up to Adams County, Ohio (Figure 2) while Grass Carp are found throughout the U.S. due to their continued use in aquaculture and private ponds. Although individuals of these species have been found even further up the Ohio River and even into Columbus, Ohio, the main force of the invasion is currently from the Ohio confluence to Markland Pool at Cincinnati, Ohio. Reproduction is known to occur in the Ohio River as far upstream as Cincinnati, Ohio. Due to a lack of the backwater habitat preferred by young invasive carps, young invasive carp are believed to be using major tributaries of the Ohio River as natal habitat (Erickson et al. 2021, Schiller 2018).

As of 2015, there have been focused efforts to collect extensive data on invasive carp in the Ohio River basin. Invasive carp pose a risk to native species through competition for food resources and habitat. There are disagreements over the effects Silver and Bighead Carp may have on Gizzard Shad (*Dorosoma cepedianum*) populations and health through competition over food (Love et al. 2018, Shields et al. 2021) but they are known to cause shifts in the zooplankton community where established (Sass et al. 2014). Additionally, Silver Carp provide a human health hazard due to their behavior of jumping into the air when startled. Concerned over the potential repercussions of continued population expansion up the Ohio River watershed, the Ohio River

Fisheries Management Team developed a control strategy framework for the Ohio River Basin (ORFMT 2014). This framework document paved the way for increased funding since 2016, allowing the Indiana Department of Natural Resources (INDNR) to devote more time towards addressing invasive carp concerns in the Ohio River basin. In 2021, INDNR was able to establish a dedicated invasive carp work unit consisting of three full-time biologists. This allows the state more opportunity to increase efforts to reduce invasive carp populations within Indiana waters.

Indiana’s invasive carp unit works collaboratively with the Ohio River Basin invasive carp partnership to annually prioritize basin-wide invasive carp research and management needs. Many state, federal, and university partners are involved in a suite of projects to address invasive carp at a broad scale. All of the Ohio River Basin invasive carp work is captured in one of four major projects: Abundance and Distribution of Early Life Stages, Early Detection and Evaluation of Removal, Movement and Habitat Use, and Control and Containment. These projects are guided by the goals and strategies outlined in both the Ohio River Basin Invasive Carp Control Strategy Framework (ORFMT 2014) and the national plan: Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (Conover et al. 2007). Interagency coordination is very important for successfully managing invasive carp populations, not only in Indiana, but throughout the Midwest.

Every year the collaborative work is summarized in comprehensive technical reports for each project, which combines all data collected from various agencies. Below are the efforts and results put forward by the INDNR Invasive Carp Unit for the Ohio River Basin projects in 2022. It is important to note that INDNR contributions outlined below are only a small portion of the actual work being done to address invasive carp in the Ohio River.

Important terms to know going forward:

Invasive carp – the group term for Bighead, Silver, Grass, and Black Carp species.

Receiver – a data logger that records information when a tagged fish swims nearby.

Transmitter – a surgically implanted internal fish tag. Receivers log data when a transmitter is nearby.

Juvenile – immature fish less than two years old, usually smaller than 15 inches long.

Young of year (YOY) – also a juvenile fish, but one that was born the same year it was captured. Size is typically 1 to 6 inches long.

Pool – a section of the Ohio River between two locks and dams, typically named after the downstream dam. Refer to Figure 3 for locations of each Ohio River pool.

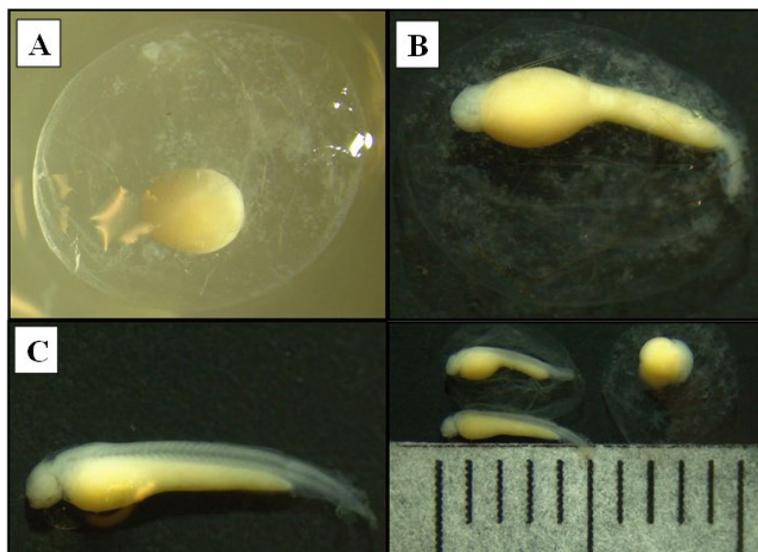
Recruitment – new fish added to a system through reproduction.

ABUNDANCE AND DISTRIBUTION OF EARLY LIFE STAGES PROJECT

Also referred to as the ‘Early Life Stages’ project, this project helps determine 1) where invasive carp spawn, 2) where young fish survive to adulthood, 3) the origin of adult invasive carp by using microchemistry, and 4) investigates why Hovey Lake attracts so many young invasive carp. INDNR is the lead agency for the project and is responsible for coordinating sampling efforts and compiling data among the other project partners. Most of the work for this project takes place in late spring and early summer.

Invasive Carp Egg and Larvae Sampling

Invasive carp usually spawn when the water temperature is over 65°F and spawning usually occurs following a rain event that causes the river to rise. INDNR, along with other project partners, looks for invasive carp eggs or larvae (freshly hatched fish) using a small net with fine mesh called an ichthyoplankton net. In 2022, 15 locations were sampled by INDNR, including sites on the White River, Wabash River, mainstem Ohio River, and Ohio River tributaries. A total of 76 net deployments took place over 5 days and totaled 3.7 hours of active sampling for invasive carp eggs and larvae by INDNR. A combined 17 suspect eggs and 3,276 suspect invasive carp larvae were captured by all project partners. A subsample of 98 specimens were sent off to Whitney Genetics Lab for species confirmation. In 2022, genetically confirmed invasive carp eggs or larvae were collected as far upstream as Ohio River mile 663, near the Blue River confluence (Leavenworth, IN) in Cannelton Pool. However, last year project partners collected invasive carp eggs much further upstream near the Little Miami River (river mile 463; near Cincinnati) in Markland Pool. Collection of invasive carp eggs and larvae allows us to both confirm where spawning is currently occurring in the Ohio River and monitor for new spawning locations over time. Our findings help to inform agencies on what areas to focus resources on to reduce successful spawning of invasive carp.



Early developmental stages of a Silver Carp; Egg (A), Advanced Egg (B), Larvae (C), and all three stages showing size in millimeters.

Juvenile Invasive Carp Sampling

Shortly after hatching in the Ohio River, small YOY invasive carp will look for slow moving backwater habitat where they can feed and grow. Because they typically feed near the surface of the water, biologists use a floating 12-foot-wide net called a surface trawl to sample for small (1 to 10 inch) invasive carp. This trawl net is made with 1/8 inch mesh and pulled with a boat to collect fish. During 2022, 18 locations were sampled across six days of effort. Nine of the locations were in Markland Pool after reports of juvenile invasive carp found there in 2021. A total of 88 juvenile invasive carp were captured in trawls, 59 were Silver Carp and 32 were Bighead Carp; all but one were YOY. No Grass or Black Carp were captured in 2022, however biologists in Kentucky captured juvenile Black Carp in the lower Ohio River near Paducah, KY. During most years, the majority of YOY invasive carp are collected near Mt. Vernon, IN in and around Hovey Lake. Seventeen of the juvenile invasive carp captured came from Markland Pool. Of those 17 invasive carp, 9 were Silver Carp and 8 were Bighead Carp. The furthest upstream juvenile invasive carp came from Arnold Creek (river mile 508), located south of Rising Sun, IN. Together with data collected by project partners throughout the Ohio River Basin, sampling for juvenile invasive carp allows us to determine where successful recruitment is occurring.



YOY Bighead (top) and Silver Carp captured in Markland Pool in 2022.

Microchemistry Project

For many river-dwelling fish species, microchemistry can be used to compare the chemical signatures found in a fish with the chemical makeup of water from different streams. Many streams have a unique chemical signature which can be used to identify where adult fish lived during the first couple years of their life. INDNR collected water samples from various sites along the Ohio River in addition to Silver Carp otoliths. These were sent to Southern Illinois University for processing and the results are still pending. This information will help us understand what rivers or tributaries are most important for Silver Carp growth and survival.

Hovey Lake Project

INDNR contracted with Ball State University to conduct research on YOY invasive carp in Hovey Lake. Hovey Lake is a highly productive floodplain lake in southwest Indiana where YOY invasive carp can be found nearly every year. It is a unique place and is suspected to contribute to the overall numbers of invasive carp in the Ohio River by providing great nursery habitat. Researchers estimated overall density of and daily mortality of YOY invasive carp within the lake. Additionally, preliminary work began to estimate the numbers and timing of small YOY invasive carp entering the lake during the spring. Silver Carp spawn in the Ohio River, after which the eggs float down the river, hatch, then the larval fish will continue floating downstream until they grow enough to swim. After the larval carp can swim, they will look for areas like Hovey Lake with plentiful food out of the rivers current. If we can determine what size the carp are when they enter the lake, and what water conditions allow them to swim in, we can determine how best to keep them out of the lake.

EARLY DETECTION AND EVALUATION OF REMOVAL PROJECT

Also referred to as the ‘Early Detection and Evaluation’ project, this project contains a variety of work including 1) spring targeted invasive carp sampling, 2) Wabash River fish community sampling, 3) determining ages of Silver Carp in different parts of the river, 4) monitoring for changes in native fish communities, and 5) documenting invasive carp spread to new waters. Kentucky Department of Fish and Wildlife Resources (KDFWR) is the lead agency for this project. The data INDNR collects is compiled with data collected by other agencies and summarized more thoroughly in an annual technical report written by KDFWR.

Spring Targeted Sampling

Targeted invasive carp sampling is conducted at the same time and locations each spring to document abundance changes through time. During 8 different sampling days, a total of 388 invasive carp, the majority of which were Silver Carp, were caught with boat electrofishing. A total of 10.9 hours were spent actively electrofishing for invasive carp. All sampling days took place in different tributaries of the Ohio River, all of which were located within Cannelton Pool – other state agencies use the same methods in different pools of the Ohio River. Average catch per unit effort (CPUE) across INDNR sites was 35.3 invasive carp per hour. Work on this

project is intended to observe any changes in relative abundances of invasive carp in the intensive management zone of the Ohio River (Cannelton-R.C. Byrd Pools). Additionally, spring targeted sampling allows for the collection of more invasive carp biometrics, like length and weight, which can be tracked for changes to the mean length, weight, or condition of invasive carp over time. Changes in these metrics can be another indication of management practices having an impact on the invasive carp population.

Wabash River Fish Community Sampling

Fish community sampling on the Wabash River occurred as part of a collaborative project with Southern Illinois University (SIU). Sampling occurred over 4 days on the Wabash River with 8 hours actively electrofishing to determine the community composition of 8 standardized sites. We caught 21 different species and a total of 793 fish (Figure 5). Of the 793 fish captured, 98 were Silver and Grass Carp. The data collected through this work is being used by SIU to determine areas of the Wabash River with high densities of invasive carp. SIU collected similar data throughout the year and will pair it with a tool called hydroacoustics to determine invasive carp hotspots, which can then be used for focusing commercial fishing efforts. They are also using hydroacoustics to determine the amount of biomass in the river that is accounted for by invasive carp.

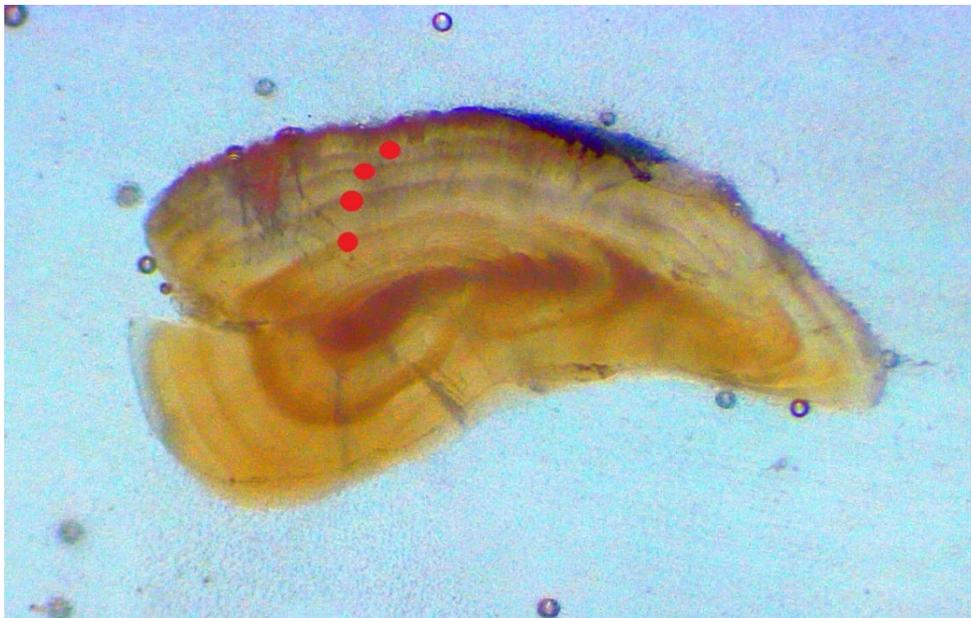


Blue Catfish collected from the Wabash River during fish community sampling.

Determining Ages of Silver Carp

Silver Carp were collected using boat electrofishing in August and September. Collecting fish during the summer allows for accurate ages to be determined. After collection, otoliths (a small inner-ear bone) are removed from each fish and are used to estimate ages. Sampling took place in tributaries of 4 pools of the Ohio River: McAlpine, Cannelton, Newburgh, and J.T. Myers. A total of 435 Silver Carp had their otoliths removed for aging. This included 21 invasive carp from McAlpine, 71 from Cannelton, 164 from Newburgh, and 179 from J.T. Myers. Sampling occurred over 8 days and had a total effort of 10.4 hours actively electrofishing.

Back in the lab, otoliths are set in epoxy and then a thin section is cut from each using a precision low-speed saw. The thin section is then viewed under a microscope and annual growth rings (called annuli) are counted to estimate how old the fish was.



A sectioned otolith of a 4-year-old Silver Carp, with red dots marking each annual growth ring.

Of the Silver Carp sampled, ages ranged from 1 to 15 years old; 4 to 5 year-old Silver Carp were the most common. The average size of Silver Carp was 27.4 inches but ranged from 13 to 37 inches (Figure 4). More specifically, McAlpine Pool Silver Carp averaged 4 years old and 30.0 inches, Cannelton Pool fish averaged 4 years and 28.1 inches, Newburgh Pool fish averaged 5 years and 26.8 inches, and J.T. Myers Pool fish averaged 4 years and 27.4 inches. Consistent and routine aging of the invasive carp population allows us to determine if fishing pressure and harvest are having the intended effect on the population. For example, if younger and smaller fish are observed over time, then we can infer that fishing harvest is removing older/larger fish from the system.

Ohio River Fish Community Sampling

Each fall, INDNR and several other agencies conduct fish community sampling on the Ohio River and its tributaries to monitor changes in fish populations. INDNR was responsible for sampling in Cannelton Pool of the Ohio River in 2022. Over 8 sampling days, a total of 44 specific standardized locations in Cannelton Pool (from just below the Falls of the Ohio to north of Cannelton Lock and Dam) of the Ohio River and its tributaries were sampled. The total time spent actively electrofishing was 11.25 hours for a total collection of 39 unique fish species (Figure 6). Of the 1,614 fish caught while sampling, 108 were Silver or Grass Carp. The data collected is shared with the United States Fish and Wildlife Service (USFWS). They use the data to inform modeling for estimating invasive carp biomass within the Ohio River.

MOVEMENT AND HABITAT USE PROJECT

Also referred to as the ‘Telemetry’ project, this project helps understand the year-around movements of invasive carp within our river systems. This includes 1) determining how many invasive carp are moving up and down river, 2) understanding when invasive carp use smaller tributaries, and 3) monitoring how far upriver invasive carp have invaded. To do this, biologists first tag invasive carp with surgically implanted transmitters, and then deploy receivers in the river to passively detect the tagged fish as they swim by. The INDNR works with other project partners in Illinois, Kentucky, Ohio, and West Virginia to cover as much of the Ohio River Basin as possible. KDFWR and USFWS compile all the tagging and receiver data from the Ohio River and write up a comprehensive annual technical report to summarize overall fish movement.

Tagging efforts

In previous years, INDNR helped tag approximately 200 Silver Carp in each pool of the Ohio River throughout the state. Biologists help USFWS and KDFWR maintain a target number of tagged fish in the river each year. Beginning in 2022, INDNR contracted with Ecosystems Connections Institute in the upper Wabash River to determine if invasive carp would start using the Eel River (a tributary of the Wabash River) once a dam was removed. Biologists spent two days in August tagging 55 invasive carp with surgically implanted transmitter tags on the Wabash River. Approximately 2.1 hours were spent actively electrofishing to collect the invasive carp. This work will allow us to document how invasive carp respond to dam removals on small rivers and will help predict fish response to future dam removals.



Stitching up a Silver Carp after implanting with an acoustic tag.

Receiver results

INDNR is responsible for receivers in J.T. Myers, Newburgh, and Cannelton pools of the Ohio River. However, other project partners maintain receivers as far upstream as Willow Island Lock and Dam in West Virginia (Figure 7). When a tagged invasive carp swims past one of these receivers, a data point is automatically logged. The INDNR and project partners then offload the data and can calculate invasive carp movement. Each receiver is offloaded about once every two months. In the tributaries of the Ohio River, including Hovey Lake, there are 38 INDNR deployed receivers collecting data from over 500 tagged invasive carp. There are an additional 10 receivers deployed on the locks and dams from J.T. Myers up to Cannelton that are checked approximately every 6 months. While many of the tributary receivers show invasive carp using the tributary year-round, there are others that show a distinct pattern of use only in the summer months and others that only see active use by a tagged invasive carp in one or two months in the fall.

The INDNR has found that very few tagged invasive carp move away from the stretch of river they were tagged in. Individual receivers logged anywhere from two to 318 individual invasive carp throughout the year. On average, each tributary receiver logged 65 individual invasive carp and had an average of 208,863 unique detections. Detections are the number of distinct times that a tagged invasive carp was logged on the receiver. Of the 10 receivers deployed on locks and dams, the range of invasive carp detected was 4 to 46 individuals. On average the lock and dam receivers logged 12 individual invasive carp and had an average of 1,148 unique detections.

CONTROL AND CONTAINMENT PROJECT

The primary goal of this project is to 1) directly reduce the population of invasive carp, 2) slow and/or stop the spread of invasive carp, and 3) focus removal efforts on areas of highest concern. Both Illinois DNR and KDFWR have contracted fishing programs that we assist with. Contracted fishers in these programs use gill nets to specifically remove adult invasive carp. These removal events are usually done in late fall and winter because Silver Carp don't jump as much in colder water, so they are more easily captured. The INDNR also occasionally conducts small scale removal events using electrofishing and gill netting. The impact of removal events on native fish populations has been very minimal, with most of the native fish bycatch consisting of Smallmouth Buffalo. There are currently incentive programs on the Wabash River and contracted fishing efforts have been focused on the leading edge of the invasive carp invasion or in areas with the highest concentration of invasive carp. An effective crew of fishermen can remove 10,000 pounds of invasive carp in a day or more.

During 2022, the Kentucky Ohio River Contract Fishing Program removed 39,130 invasive carp from the Ohio River, totaling over 400,000 pounds: 38,446 were Silver Carp, 419 were Bighead Carp, and 265 were Grass Carp. The majority of these fish came from Indiana waters of the Ohio River. Additionally, 842,252 pounds of invasive carp were removed from the Wabash River through the Illinois Enhanced Contract Fishing Program.



KDFWR Contract fishermen with Invasive Carps removed from Deer Creek

INDNR spent three days conducting targeted removals in 2022: two days in March and one day in December. Removals took place in Little Pigeon Creek a tributary of the Ohio River located in Newburgh Pool (near Yankeetown, IN) and near Elnora on the White River. A total of 4.3 hours were spent actively removing invasive carp, producing 1,274 Silver Carp, 1 Bighead Carp, and 5 Grass Carp. Approximately 9,750 pounds of invasive carp were removed through these agency removal efforts. Combined with other project sampling efforts previously described throughout 2022, INDNR crew removed 2,319 adult invasive carp for approximately 17,393 pounds.



INDNR invasive carp biologists after a removal event in Little Pigeon Creek

PLANS FOR 2023

INDNR will continue working closely with other state, federal, and university partners to prioritize and direct invasive carp management and research activities in the Ohio River Basin. Most 2023 activities will mirror the work accomplished in 2022, with a few exceptions. The early life stages project will focus more effort into sampling for larval and juvenile invasive carp further up the Ohio River due to the discovery in 2022 of juvenile Bighead and Silver Carp found in a tributary near Rising Sun, IN. Early detection and evaluation efforts will be similar to those in 2022. As part of the telemetry project, INDNR will assist USFWS in placing additional receivers

in Cannelton Pool of the Ohio River for tracking fine-scale movements of invasive carp within the pool to determine responses to contract fishing activities. INDNR will continue to check and download receivers every two months and any lost or stolen receivers will be replaced as needed. Additional invasive carp are expected to be tagged in both the Ohio and Wabash Rivers in the spring of 2023. Removal events by the INDNR are expected to continue in the spring and fall of 2023.

Starting in 2023, INDNR will be conducting additional work on studying recruitment of invasive carp in Hovey Lake. Hovey Lake is a unique, connected backwater lake that provides important recruitment habitat for several riverine species. Unfortunately, Hovey Lake also functions as great habitat for juvenile invasive carp to mature before returning to the Ohio River. Hovey Lake is primarily connected to the Ohio River by three large culvert pipes built into a flood control structure. During most of the year (except for flood events) water coming into or out of the lake flows through the culvert pipes. INDNR contracted with Ball State University in 2021 and 2022 to begin evaluating recruitment of invasive carp at Hovey Lake. In 2023, INDNR will be expanding on that research to determine what conditions and at what size juvenile invasive carp are entering the lake. Ultimately, quantifying the potential recruitment of invasive carp in Hovey Lake will help us recommend modifications or management of the flood control structure to decrease invasive carp recruitment from Hovey Lake.

Lastly, INDNR is working on ways to increase the harvest of invasive carp in Indiana waters. Invasive carp harvest is minimal in Indiana because current regulations do not allow the most effective carp harvesting methods to be used. INDNR is working to draft a new permit that would allow for special use of additional nets for taking invasive carp, while ensuring those activities will not impact our native species. INDNR is looking to work this permit through the rule-making process in 2023, during which public input is gathered prior to considering final adoption of the permit, anticipating the permit to be effective sometime in 2024. Additionally, other methods to increase invasive carp harvest from Indiana waters will continue to be explored.

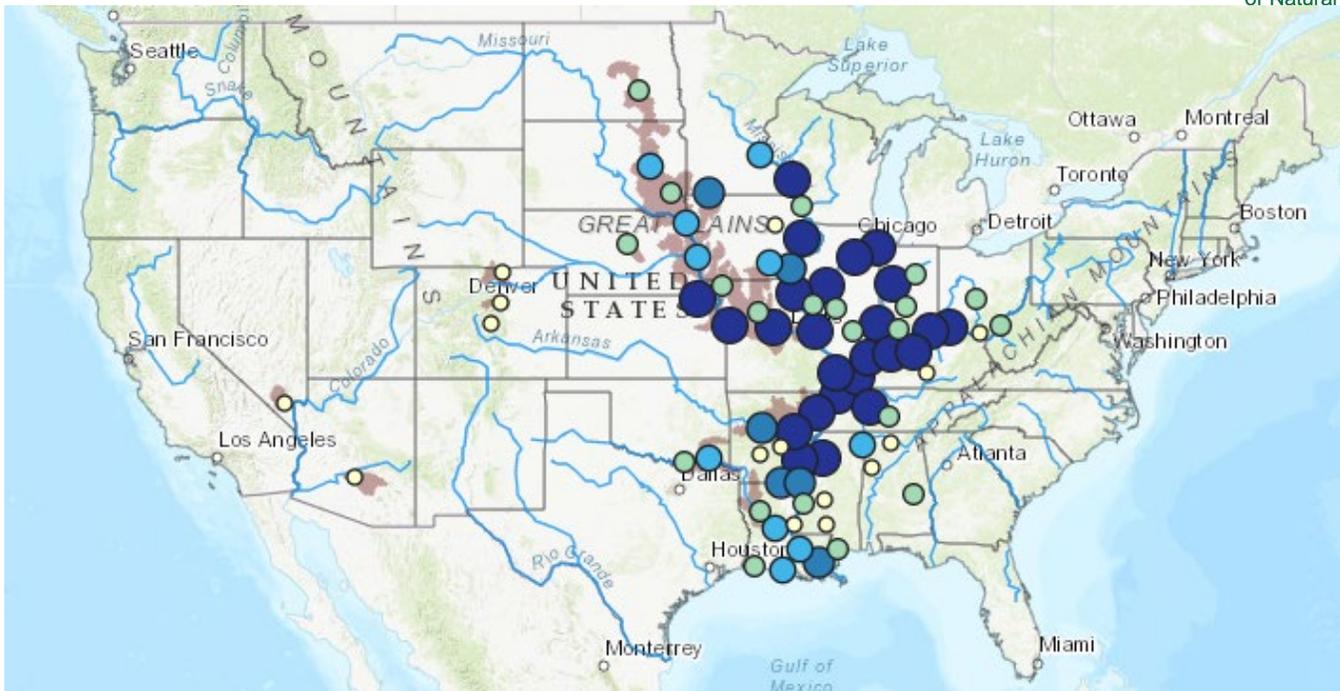


Figure 1. Current distribution of Silver Carp in the United States. The size of the circle represents the number of individuals found in that location with larger/darker circles representing more individuals than the smaller circles. Image taken from USGS Nonindigenous Aquatic Species Map: <https://nas.er.usgs.gov/viewer/omap.aspx>.

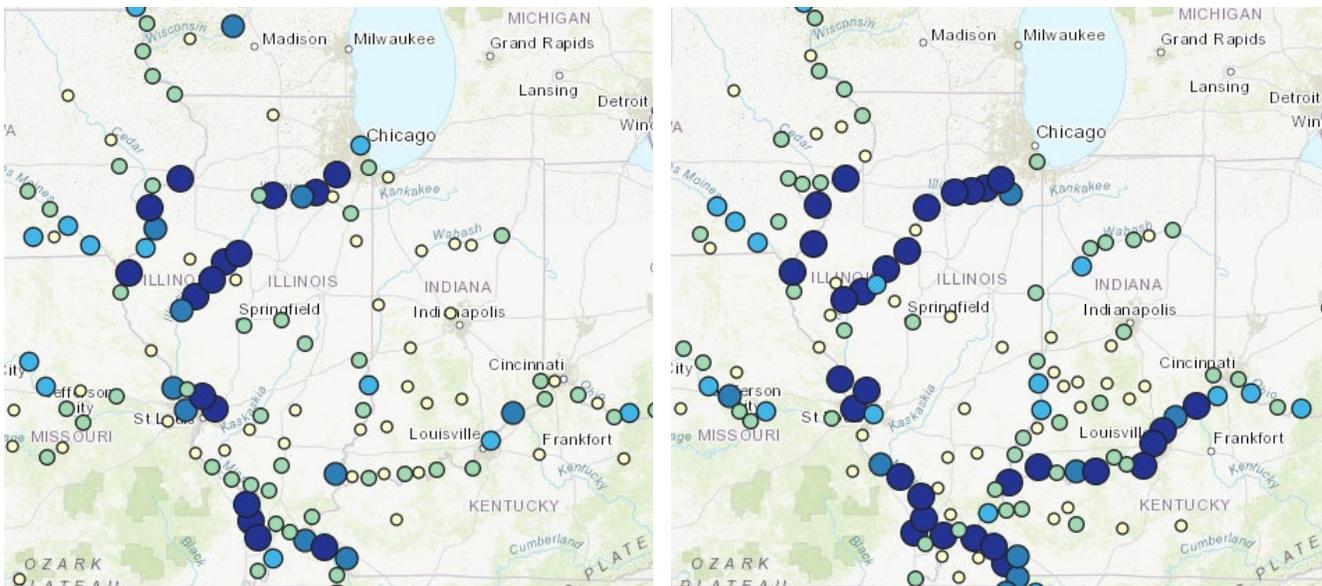


Figure 2. The current distribution of Bighead Carp (left) and Silver Carp (right) in the Ohio River Basin. The larger/darker circles represent more individuals at each location while the smaller circles show less individuals. Image taken from USGS Nonindigenous Aquatic Species Map: <https://nas.er.usgs.gov/viewer/omap.aspx>.

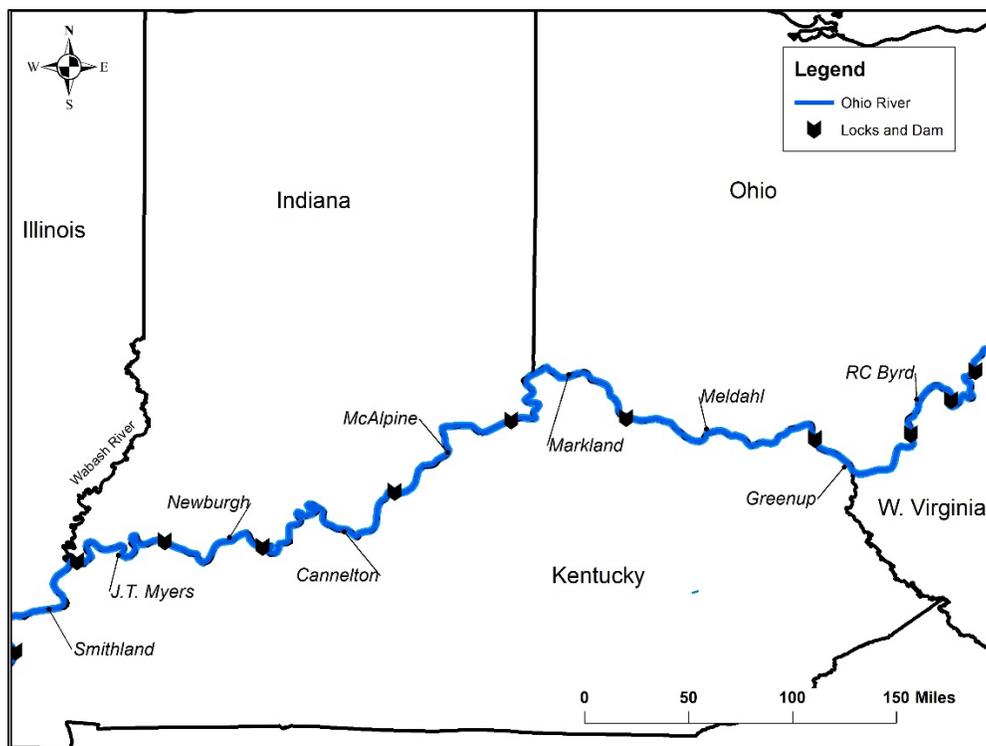


Figure 3. Map of the Ohio River pools throughout the middle portion of the basin.

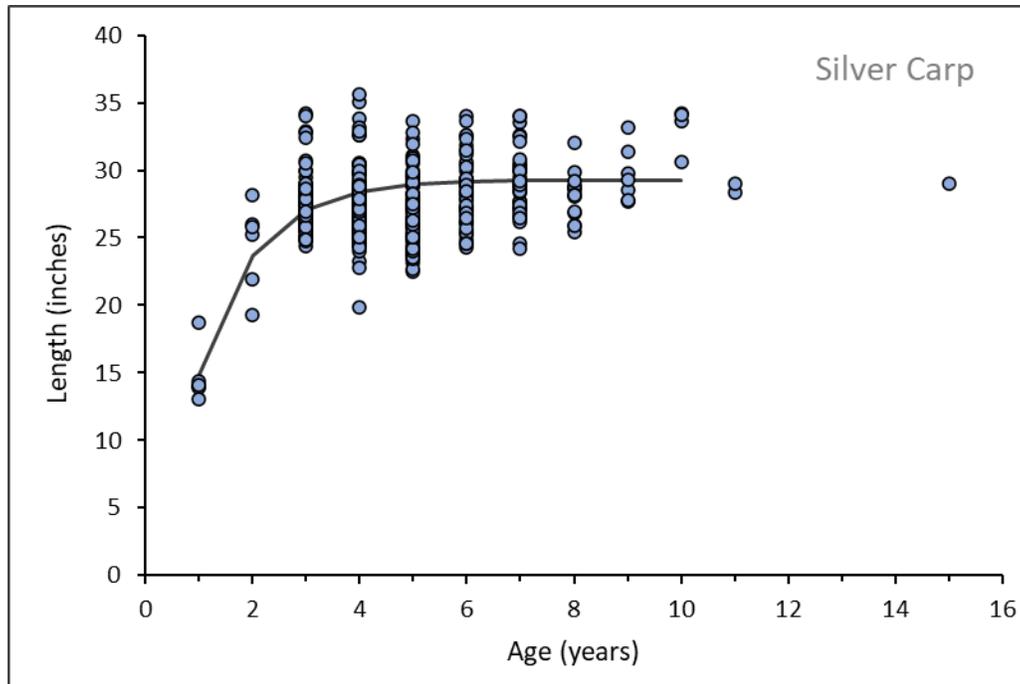


Figure 4. Age-Length growth curve for Ohio River Silver Carp, 2022.

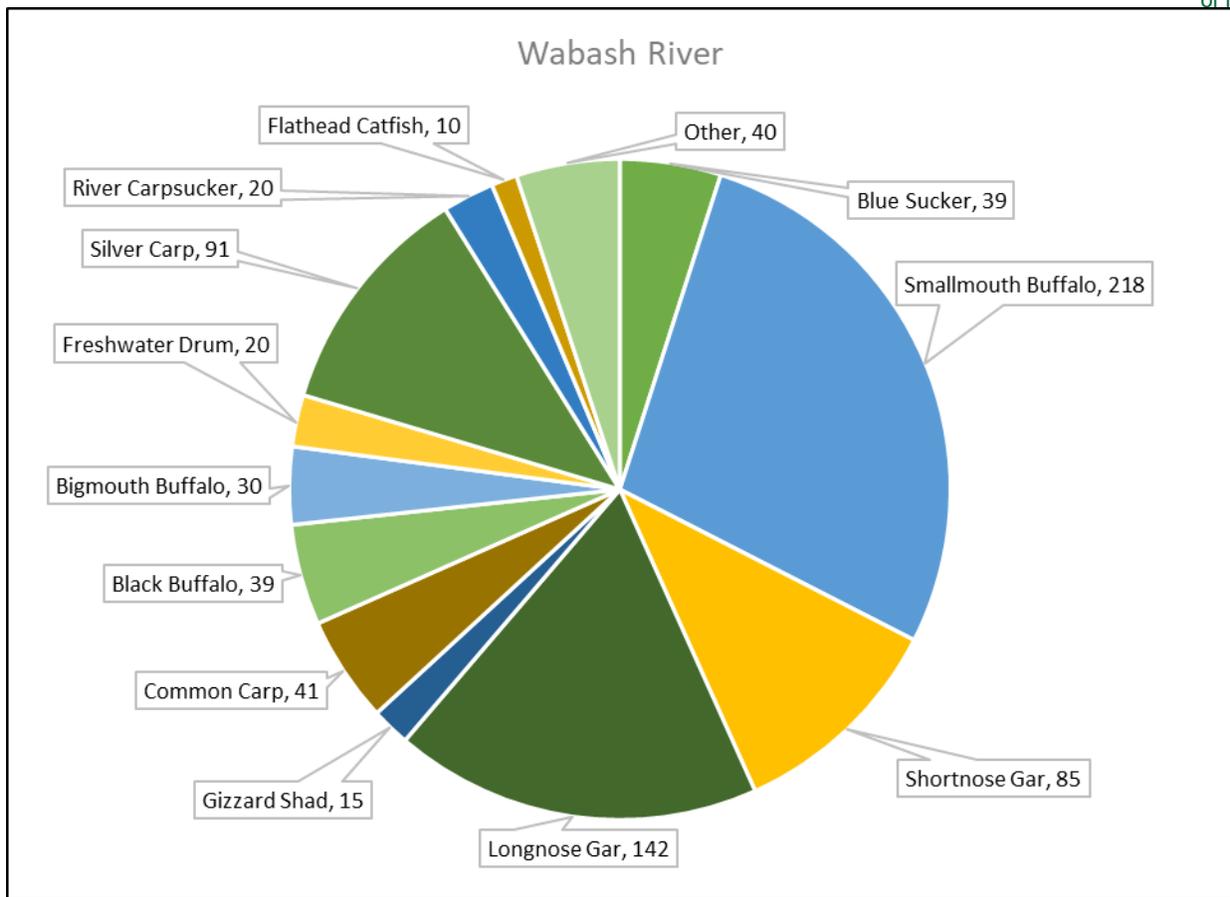


Figure 5. Wabash River fish community sampling results, by species and number collected in 2022. The “other” category represents all fish species caught with fewer than 10 total individuals and includes Shorthead Redhorse, Northern Hogsucker, Grass Carp, Quillback Carpsucker, Channel Catfish, Goldeye, Blue Catfish, Shovelnose Sturgeon, Spotted Bass, and Highfin Carpsucker.

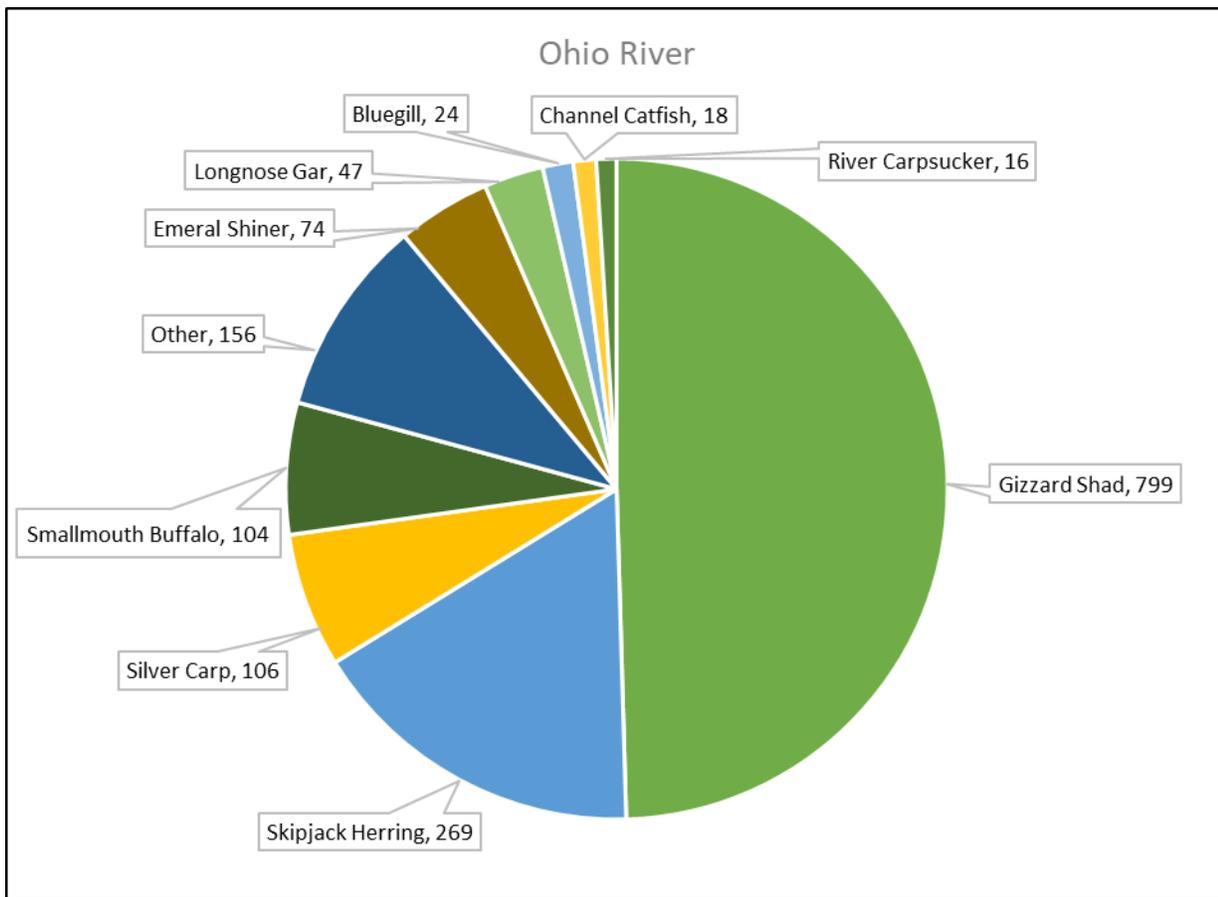


Figure 6. Ohio River fish community sampling results, by species and number collected in 2022. The “Other” category represents all fish species caught with 15 or fewer total individuals, and includes Redear Sunfish, Orangespotted Sunfish, Green Sunfish, Longear Sunfish, Black Crappie, White Crappie, Largemouth Bass, Spotted Bass, Smallmouth Bass, Striped Bass, White Bass, Hybrid Striped Bass, Grass Carp, Sauger, Flathead Catfish, Shorthead Redhorse, Golden Redhorse, River Redhorse, Silver Redhorse, Smallmouth Redhorse, Bigmouth Buffalo, Northern Hogsucker, Blue Sucker, Spotted Sucker, Quillback Carpsucker, Common Carp, Mooneye, Freshwater Drum, and an unidentified species of Shiner and Madtom.

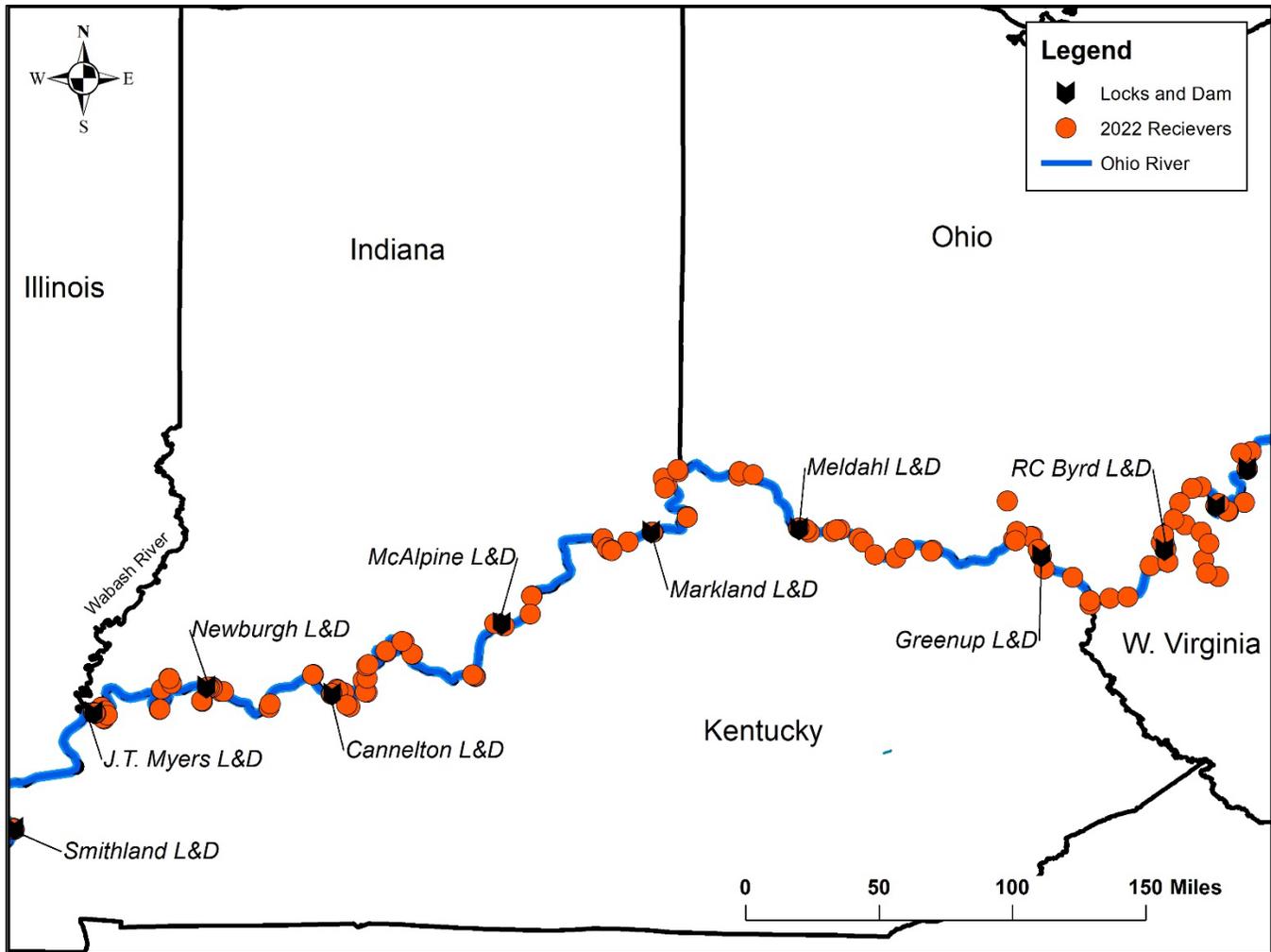


Figure 7. Telemetry receiver locations in the Ohio River, 2022.

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. 223pp.
- Erickson RA, Kallis JL, Coulter AA, Coulter DP, MacNamara R, Lamer JT, Bouska WW, Irons KS, Solomon LE, Stump AJ, Weber MJ, Brey MK, Sullivan CJ, Sass GG, Garvey JE, and Glover DC. 2021. Demographic Rate Variability of Bighead and Silver Carps Along an Invasion Gradient. *Journal of Fish and Wildlife Management* 12(2): 338-353.
- Love S, Lederman NJ, Anderson RL, DeBoer JA, and Casper AF. 2018. Does aquatic invasive species removal benefit native fish? The response of gizzard shad (*Dorosoma cepedianum*) to commercial harvest of bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*). *Hydrobiologia* 817(1): DOI:10.1007/s10750-017-3439-1
- Ohio River Fisheries Management Team (ORFMT). 2014. Ohio River Basin Asian Carp Control Strategy Framework. Found at: http://micrarivers.org/wp-content/uploads/2018/08/ORFMT_Asian_Carp_Strategy.pdf, Jan 26, 2023
- Sass GG, Hinz C, Erickson AC, McClelland NN, McClelland MA, and Epifanio JM. 2014. Invasive bighead and silver carp effects on zooplankton communities in the Illinois River, Illinois, USA. *Journal of Great Lakes Research* 40(4): 911-921.
- Schiller AL. 2018. Recruitment Sources of Asian Carps in the Ohio River Basin. Southern Illinois University at Carbondale ProQuest Dissertations Publishing. <https://www.proquest.com/openview/240ba05e2f91ad09b688a873c9d324bb/1?pq-origsite=gscholar&cbl=18750&diss=y>
- Shields R, Pyron M, Minder M, and Etchison L. 2021. Long-term trends in CPUE and relative weight of six fish species in the Wabash River, USA, prior to and following silver carp invasion. *Hydrobiologia* 848: 4453-4465.
- Stump A, Jackson N, and Zipfel K. 2016. Monitoring and Response to Asian Carp in the Ohio River: 2016 Technical Report. Found on micrarivers.org, Jan 26, 2023.