Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin

Fiscal Year 2022

Edited by Caleb A. Aldridge, Neal Jackson, Rebecca Neeley, Emily Pherigo, and Greg Conover

Mississippi Interstate Cooperative Resource Association

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Terminology

In 2021, the USFWS and USGS ceased using the term "Asian carp" in favor of the term "invasive carp". In the wake of these changes, the MICRA Executive Board decided to maintain consistency with the USFWS and the USGS and use the term "invasive carp" when collectively referring to the four species of carp referenced in this document (Bighead Carp, Black Carp, Grass Carp, and Silver Carp). However, the term "Asian carp" is used when referencing titles of specific historic documents, e.g., Ohio River Basin Asian Carp Control Strategy Framework.

Introduction

Mississippi River Basin Overview

The Mississippi River and its tributaries comprise one of the largest and most 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 (U.S.), and includes numerous large 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estimated the economic output from recreational fishing in the Mississippi River Basin at more than $19 billion (USFWS, unpublished data).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. Map of the Mississippi River Basin which drains all or a portion of 31 states and 2 Canadian Provinces. Shading indicates the six MICRA sub-basin management units and the four sub-basin invasive carp frameworks within the Mississippi River Basin (Missouri River [red], Upper Mississippi River [yellow], Lower Mississippi River including the Arkansas-White-Red Rivers [blue], and the Ohio River Basin including the Tennessee and Cumberland Rivers [green]).

Interjurisdictional Fishery Management in the Mississippi River Basin

The Mississippi Interstate Cooperative Resource Association (MICRA) is a partnership of 28 state natural resources management agencies with fisheries management jurisdiction in the Mississippi River Basin. Federal agencies and chartered entities that manage and regulate aquatic resources within the basin also participate in the MICRA partnership. The MICRA partnership was formed in 1991 to improve management of interjurisdictional fishery resources in the basin through coordination, communication, and collaboration among the responsible management entities. MICRA functions as an umbrella organization that provides basin-wide coordination among multi-state compacts and partnerships that address interjurisdictional fishery management issues within six Mississippi River sub-basins: Arkansas-Red-White, Lower Mississippi, Missouri, Ohio, Tennessee-Cumberland, and Upper Mississippi (Figure 1).

Invasive Carp Management and Control in the Mississippi River Basin

Aquatic Invasive Species (AIS) are causing negative impacts, potentially reversing progress made towards ecological rehabilitation and restoration in the Mississippi River Basin. Over the past two decades, four species of invasive carp (i.e., 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, Grass, and Black carps have established self-sustaining populations and are spreading throughout the Mississippi River Basin (Figure 2).

The Aquatic Nuisance Species Task Force approved the national *Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States* (National Plan) for implementation in 2007. MICRA actively worked with the six sub-basin groups to develop regional Asian Carp Control Strategy Frameworks (Frameworks) to step-down implementation of the National Plan throughout the Mississippi River Basin (Figure 1). The MICRA member agencies and their federal partners formed sub-basin invasive carp partnerships to develop and implement Frameworks in the Lower Mississippi River Sub-Basin (LMR), Missouri River Sub-Basin (MOR), Ohio River Sub-Basin (ORB), and the Upper Mississippi River Sub-Basin (UMRB). The LMR Framework is inclusive of the Arkansas-Red-White Rivers Sub-Basin (ARW), and the ORB Framework is inclusive of the Tennessee-Cumberland Rivers Sub-Basin (TNCR). The sub-basin invasive carp partnerships provide for collaborative implementation of the regional Frameworks throughout the Mississippi River Basin.

The Invasive Carp Regional Coordinating Committee (ICRCC), a partnership of state, provincial, and U.S. and Canadian federal agencies and other stakeholders, has coordinated the development and implementation of an annual Asian Carp Control Strategy Framework (now called an Invasive Carp Action Plan) to prevent the introduction and establishment of invasive carp populations in the Great Lakes since 2010. Many of these projects are implemented in the uppermost 175 miles (282.6km) of the Illinois River and the Chicago Area Waterway System (CAWS).

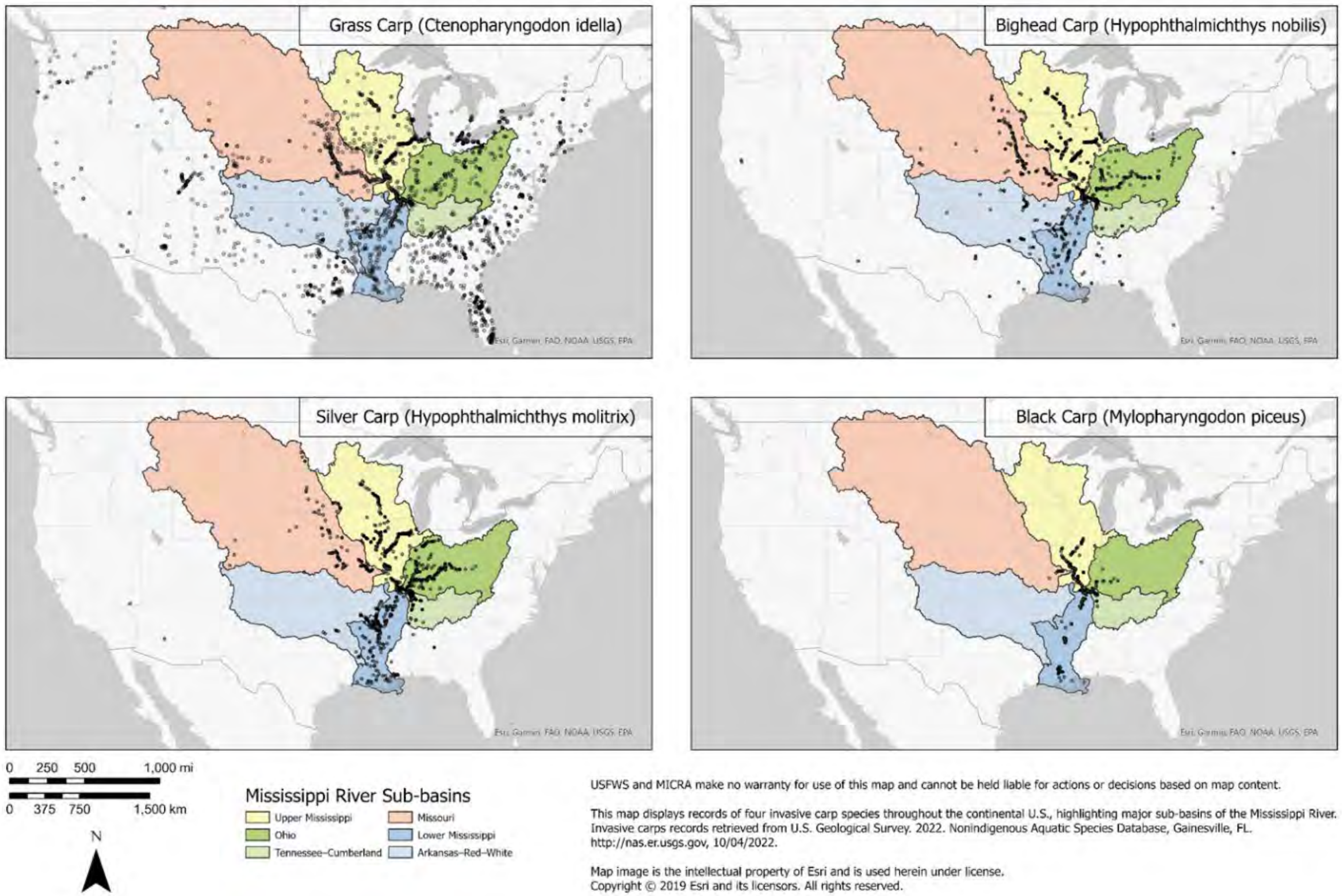


Figure 2. Distribution of Grass Carp, Bighead Carp, Silver Carp, and Black Carp in the lower 48 states of the United States as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of October 2022. Shading indicates the six MICRA sub-basin management units and the four sub-basin invasive carp frameworks within the Mississippi River Basin (Missouri River [red], Upper Mississippi River [yellow], Lower Mississippi including the Arkansas-White-Red Rivers [blue], and the Ohio River Basin including the Tennessee and Cumberland Rivers [green]).

Mississippi River Basin Invasive Carp Federal Authorization and Appropriations Overview

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 invasive carp in the ORB and UMRB. Congress appropriated $2.4 million in the USFWS's FY2015 base budget for invasive carp prevention and control in the ORB and UMRB[1], providing the first substantial funding to address invasive carp populations in the Mississippi River Basin beyond the upper Illinois River and the CAWS (Table 1). USFWS funding for invasive carp work in the ORB and UMRB increased to $2.6 million in FY2016. USFWS funding for invasive carp work in the ORB and UMRB totaled $3.1 million in 2017 with the addition of $500,000 by Congress specifically for the development and implementation of deterrence technologies in the field that are transferrable to other basins and potentially useful for other aquatic nuisance species. USFWS funding in FY2018 increased to $4.8 million and includes the addition of $1.7 million to "expand and perfect the combined use of contract fishing and deterrents" in the ORB and UMRB. FY2019 appropriations included an additional $600,000 specifically for implementation of the ORB Framework within the Tennessee and Cumberland Rivers portion of the ORB.

Table 1. Total annual appropriations to USFWS for invasive carp prevention and control work outside of the Great Lakes (beyond the upper Illinois River and the CAWS) from 2015-2022, and the amount of agency funding provided by USFWS to the MICRA sub-basin invasive carp partnerships to support implementation of priority Framework actions in the Mississippi River Basin.

USFWS / Basin	Fiscal Year							
	2015	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
USFWS	$2,400,000	$2,600,000	$3,100,000	$4,800,000	$5,400,000	$11,080,004	$11,204,594	$11,176,000
Ohio	$400,000	$500,000	$600,000	$1,150,000	$1,135,000	$8,019,996	$3,814,157	$3,903,916
Upper Mississippi	$400,000	$500,000	$600,000	$1,050,000	$1,055,000	$1,500,000	$1,710,796	$1,623,000
Tennessee Cumberland	-	-	-	-	$600,000	$1,000,000	$5,333,612	$4,728,530
Arkansas-Red-White	-	-	-	-	-	$1,000,000	$430,000	$1,147,718
Lower Mississippi	-	-	-	-	-	$1,300,000	$990,518	$1,315,832
Missouri	-	-	-	-	-	$1,100,000	$1,516,323	$1,300,000
TOTALS	**$3,200,000**	**$3,600,000**	**$4,300,000**	**$7,000,000**	**$8,190,000**	**$25,000,000**	**$25,000,000**	**$25,194,996**

[1] Although no appropriations for invasive carp management and control in the ORB or UMRB were authorized in WRRDA 2014, the USFWS base appropriations directed to invasive carp management and control in the ORB and UMRB that began in Fiscal Year 2015 are often referred to by partner agencies as "USFWS WRRDA funding".

In FY20, Congressional direction and funding was substantially expanded to be inclusive of the entire Mississippi River Basin. The *2020 DOI, Environment, and Related Agencies Appropriations Act* increased the USFWS's FY20 base budget for invasive carp management and control to $25 million, a $14 million increase above FY19. The appropriations language stated that the "increased funding should be used to control invasive carp in the Mississippi River and its sub-basins, including the Upper Mississippi River Sub-Basin, Missouri River Sub-Basin, Arkansas-Red-White River Sub-Basin, Lower Mississippi River Sub-Basin, Tennessee-Cumberland Sub-Basin, and Ohio River Sub-Basin." Appropriations have remained at $25 million in each of the years since (FY21 and FY22). In FY22, the USFWS worked closely with MICRA and the six Mississippi River sub-basin invasive carp partnerships to identify the highest priority project needs for implementation of the sub-basins' respective Frameworks. The partnerships developed collaborative project proposals for implementation with FY22 funds using targets identified by the USFWS totaling $13,919,996 (Table 2).

Table 2. USFWS target allocation of FY22 base funding for invasive carp prevention and control work in the six Mississippi River sub-basins.

Arkansas-Red-White	Lower Mississippi	Missouri	Ohio	Tennessee-Cumberland	Upper Mississippi
$1,000,000	$1,300,000	$1,100,000	$8,019,996	$1,000,000	$1,500,000

Mississippi River Basin Invasive Carp Project Coordination

To provide for state and federal agency executive level coordination on invasive carp prevention and control in the Mississippi River Basin and to ensure coordination between the six sub-basin partnerships, MICRA formed an Invasive Carp Advisory Committee (ICAC) in 2016 (Figure 3). The ICAC consists of one state agency representative from each of the six MICRA sub-basin invasive carp partnerships and a single agency representative from USFWS, USGS, National Park Service, U.S. Army Corps of Engineers, and Tennessee Valley Authority. The ICAC provides a mechanism for coordination, communication, and collaboration across the regional sub-basin efforts to provide for the most effective implementation of a Mississippi River basin-wide invasive carp prevention and control program.

MICRA works closely with USFWS to facilitate collaborative implementation of the national Plan in the Mississippi River Basin. The USFWS provides coordination support to each of the six sub-basin invasive carp partnerships to determine priority projects from their respective frameworks for implementation, identify lead and cooperating agencies for each project, and develop annual project proposals. The individual sub-basin invasive carp project proposals are compiled by MICRA, reviewed by the ICAC, and a Mississippi River Basin proposal package is then submitted by MICRA to the USFWS for funding consideration. Approved project proposals are developed into detailed annual work plans and compiled in the annual 'Invasive Carp Monitoring and Response Plan for the Mississippi River Basin' (MRP). Agencies collaborating on the USFWS-funded partnership projects provide interim annual (calendar year) reports to track and evaluate progress, report results, and inform planning for management and control actions in future years. The annual MRPs and interim annual reports are available on the MICRA website at: http://www.micrarivers.org/invasive-carp-plans-and-reports/.

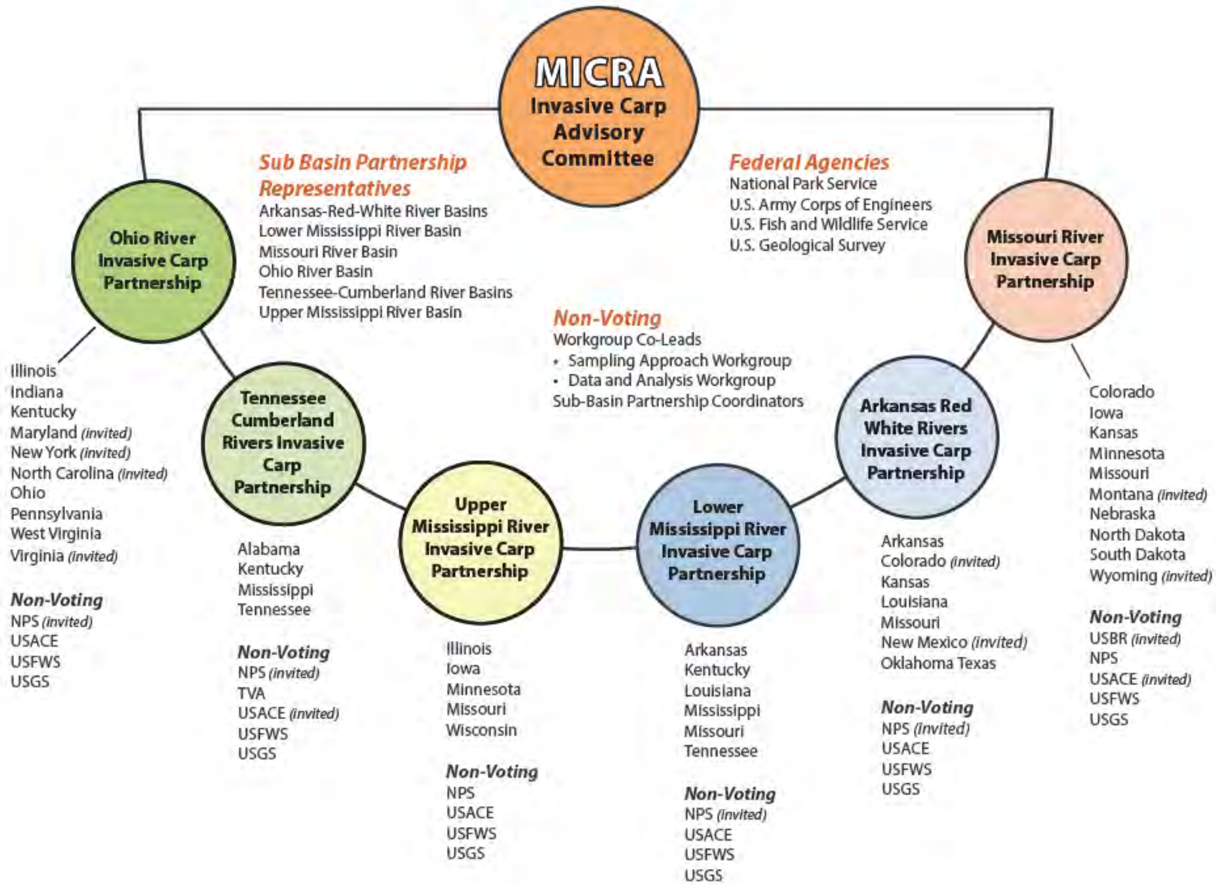


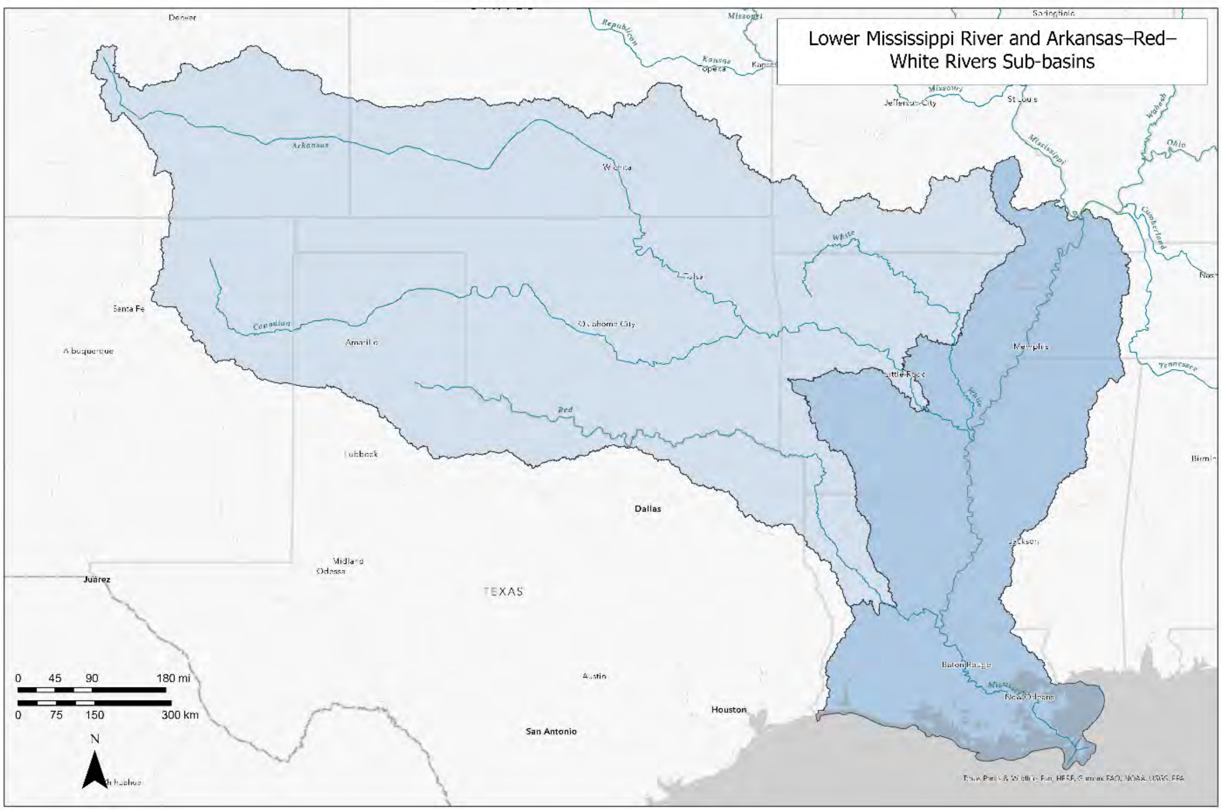
Figure 3. Structure for inter-agency coordination and implementation of Asian Carp Control Strategy Frameworks in the Mississippi River Basin. Basin-wide coordination occurs through the MICRA Invasive Carp Advisory Committee and regional coordination occurs through six sub-basin invasive carp partnerships: Ohio River, Tennessee-Cumberland Rivers, Lower Mississippi River, Arkansas-Red-White Rivers, Missouri River, and the Upper Mississippi River. The partnership shown above are inclusive of state and federal partners as voting and non-voting members. All states in each sub basin are invited to participate. Those partners that choose not to actively participate are indicated by "(invited)" after the name.

2022 Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin

The 2022 MRP includes project work plans for 30 projects collaboratively developed by state and federal agency partners throughout the Mississippi River Basin working together through six sub-basin invasive carp partnerships. In FY22, USFWS funding support was provided for 11 projects in the LMR, including the ARW (3); 5 projects in the MOR; 9 projects in the ORB, including the TNCR (5); and 5 projects in the UMRB. An overview of each sub-basin partnership and the full project work plans supported in FY22 are provided in subsequent sections for each sub-basin partnership.

Lower Mississippi River Sub-Basin and Arkansas-Red-White Sub-Basin Invasive Carp Partnerships

The LMR and ARW Sub-Basin Invasive Carp Partnerships include 11 states from the Lower Mississippi River Sub-Basin and the Arkansas-Red-White Rivers Sub-Basin. These states convened to develop the Lower Mississippi River Basin Asian Carp Control Strategy Framework, which steps down the National Plan to a local level within the two sub-basins. From the framework, the partnerships collaboratively develop priority management and control projects each year. The known status of invasive carp varies within the respective jurisdictions of states within these sub-basins. Initial projects are investigating unknown areas for basic population demographic data, but also include control efforts in locations where practicable, movement projects to better understand passage through locks and dams and between tributaries, and other high priority actions identified by the partnership.



Control of Invasive Carp in the Lower Mississippi River Basin

Lead Agency and Author: Missouri Department of Conservation (MDC), Joe McMullen (joe.mcmullen@mdc.mo.gov)

Cooperating Agencies: Arkansas Game and Fish Commission (AGFC), Jimmy Barnett (jimmy.barnett@agfc.ar.gov); Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Dennis Riecke (dennis.riecke@wfp.ms.us); Tennessee Wildlife Resources Agency (TWRA), Cole Harty (cole.r.harty@tn.gov)

Statement of Need:
While complete elimination of invasive carp is not currently feasible, management and control of these fish is necessary to reduce the impact on native species, the ecosystem, and the economy. There is a need to identify effective strategies to reduce invasive carp numbers and control the expansion of invasive carp into adjacent aquatic systems within the LMR Basin. This project uses multiple methods of removal and monitoring, in a variety of aquatic habitats providing insights into the most effective and efficient means by which to control invasive carp populations.

Previous efforts during FY20 and FY21 have provided agencies and contractors with experience managing invasive carp removal operations. Missouri contracted with Silver Fin Solutions (SFS) during FY21 who's efforts were largely experimental and a learning process. Future contracting with SFS would be expected to yield greater numbers/pounds of invasive carp removed from the mainstem LMR and perhaps expand into tributary/off channel aquatic habitats. Arkansas originally planned to hire commercial fishers to remove invasive carp from the Arkansas and Little Red Rivers. However, there was a lack of interest in participating in the Arkansas program and ultimately AGFC decided to hire seasonal employees and purchase equipment to accomplish removal objectives. Similarly, in the Missouri River Basin, the Kansas Department of Wildlife and Parks (KDWP) initially contracted with commercial fishers to remove carp from the Kansas River. Because of declining participation by commercial fishers in Kansas, KDWP has decided to move forward with hiring staff and purchasing equipment to remove carp. Mississippi has had some success subsidizing invasive carp harvest by working with processors that produce carp products, but low prices paid for fish, low demand, staffing shortages, and river conditions have diminished removal expectations. If processors become more established and markets expand the profitability of carp harvest may improve. TWRA has conducted preliminary fish population monitoring at Reelfoot Lake in anticipation of implementing removal efforts such as contracted commercial fishers and bowfishing tournaments. The work planned in Tennessee will continue to broaden our knowledge and experience with various removal options and improve our understanding of issues associated with off-channel habitats.

Project efforts outlined herein are designed to reduce invasive carp numbers, minimize range expansion, monitor the effects of removal on native species, and inform future efforts by expanding our knowledge and experience with a variety of removal methods.

Objectives:

1. Reduce overall invasive carp population numbers and alleviate propagule pressure in areas with low population density by implementing removal programs utilizing agency staff and contract fishing in the Lower Mississippi River and tributaries.

2. Reduce the overall density and determine population characteristics of invasive carp in a large natural lake.

3. Monitor fish assemblages and determine responses to targeted invasive carp removal efforts.

Missouri Department of Conservation (MDC):

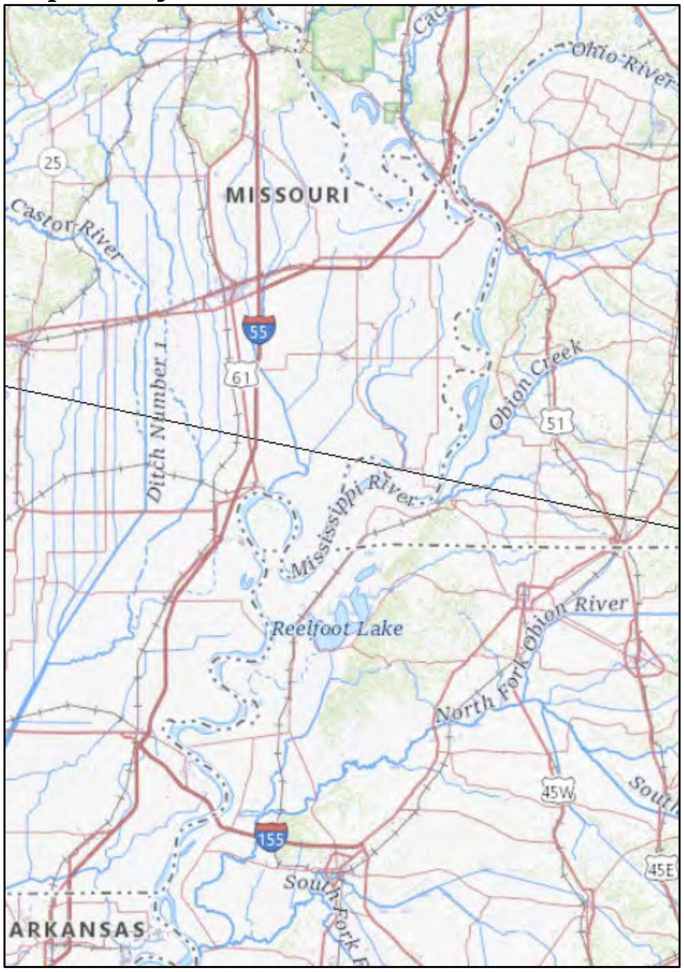
Activities and Methods:

MDC will continue an invasive carp contract removal program to support Objective 1. Removal efforts will take place on the main stem LMR as conditions permit and once agreements are in place with contracted fishers. There will be opportunities for removals in tributaries and old oxbows (only under special contract with an agency observer). Effort will be spread throughout the LMR reach. MDC staff will conduct period ride-alongs and record length and weight from a subset of invasive carp and bycatch will be identified to species, enumerated, and disposition will be recorded (i.e., healthy, moribund, dead) prior to release.

MDC will implement fish assemblage monitoring to support Objective 3. Staff will sample 16 stratified random selected sites within 4 major habitats of the LMR. The habitats will be main channel border unstructured, main channel border, wing-dike, side channel border, and tributary. Each habitat will have 4 sites sampled and each site will be sampled using daytime electrofishing during June 15-August 1. If sites are not sampleable, an alternate site will be selected. The temporal sampling aligns with 6 LTRM field stations sampling for period 1 fisheries component in the Upper Mississippi river. Sample procedures will conform to the Long Term Resource Monitoring (LTRM) fisheries component protocol (Ratcliff et al. 2014). Standardized data collection will aid in making invasive carp relative abundance and contribution comparison among and within basins.

All efforts will occur in the LMR from the Missouri-Arkansas border near Huffman Landing (RM 828) upstream to the confluence of the Ohio River (RM 953/0).

Map of Project Area:



Estimated Timetable for Activities:

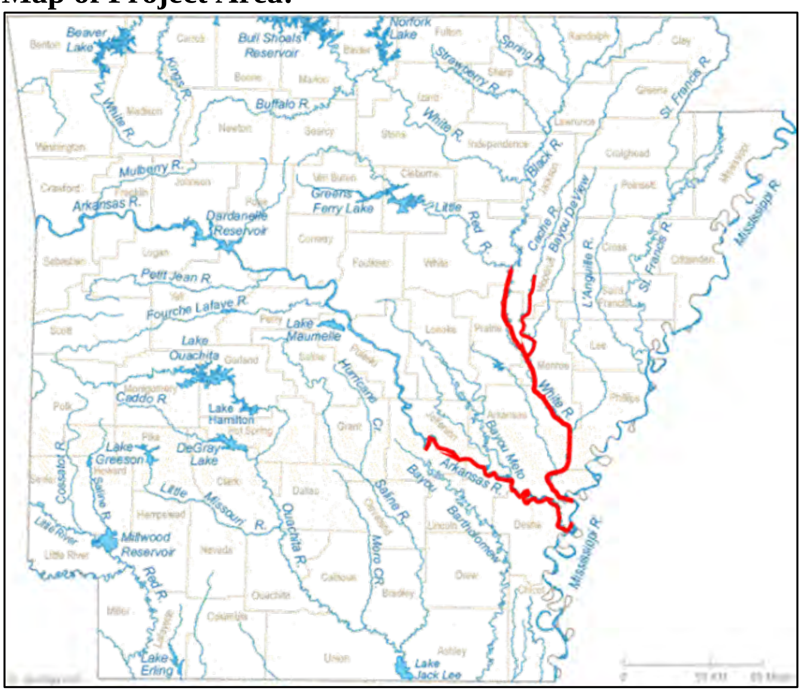
Activity	Time Period
Fish Assemblage Monitoring	Summer 2022
Invasive Carp Removal	Fall and Winter 2022
Ride-Alongs/Data Collection	Fall and Winter 2022
Data Summary/Analysis	Winter 2022/2023
Annual Report	Spring 2023

Arkansas Game and Fish Commission (AGFC):

Activities and Methods:

AGFC will continue to coordinate an invasive carp removal program in Arkansas waters. Continue funding for an AGFC Invasive Carp Biologist to oversee invasive carp removal and collect harvest and population data. Work with the Invasive Carp Removal Specialist on removal locations, fish disposal, bycatch analysis, and effects of harvest on standing populations.
It is anticipated that reducing population densities will improve recruitment of native species and reduce the likelihood that invasive carp will migrate upstream to occupy areas with lower population densities. Removal of invasive carp will occur when river levels are conducive for effective capture and removal.
The goal of this project is the removal of 150,000 to 250,000 pounds of invasive carps annually. The White River will be worked from RM176 downstream to the Mississippi River and the Cache River from Highway 38 to the confluence with the White River. The Arkansas River will be worked from RM63 downstream to the Mississippi River. Removal crews will work main stem, backwaters, tributaries and oxbows.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Removal	Fall 2022 through Summer 2023
Demographic Data Collection	Random throughout project
Annual Report	Winter 2023

Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP):

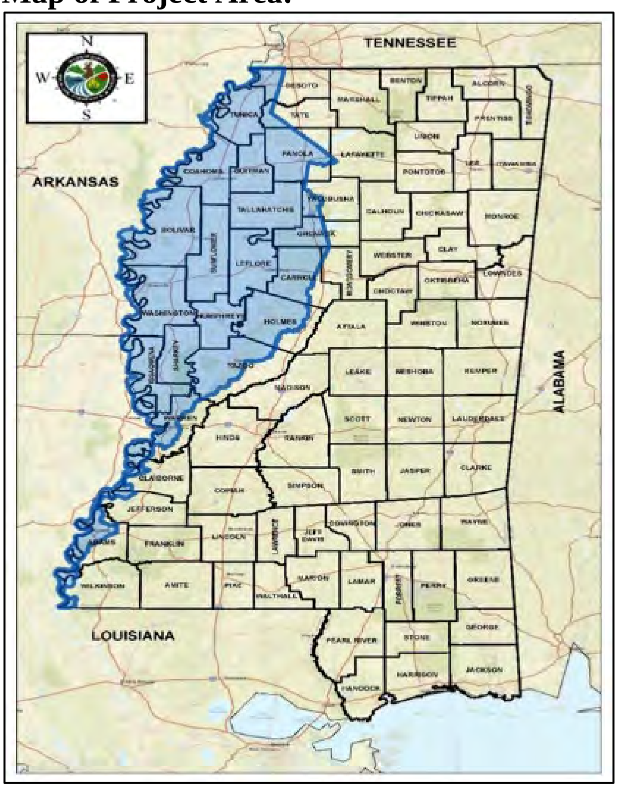
Activities and Methods:

During January – March 2022, the MDWFP intends to keep reimbursing invasive carp processors for purchasing invasive carp from two instate processors. Our processing contracts state that the MDWFP will reimburse these firms 18 cents/pound if they pay fishers at least 25 cents/pound for invasive carp harvested from the Mississippi River where it borders Mississippi and from the Yazoo River Basin.

Flood conditions during spring 2021, processor staffing shortages, and lack of markets for processed fish led to limited harvest of fish in 2021. Fish purchase reimbursement tickets will provide information on numbers and pounds of the four invasive carp species, along with harvest dates and locations. These data will be provided in an annual project report.

FY21 and FY22 funds were not requested for this effort. FY20 funds will be expended until depleted.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Reimburse Processors	January – September 2022
Data Summary/Analysis	August- September 2022
Annual Report	September-December 2022

Tennessee Wildlife Resources Agency (TWRA):

Activities and Methods:

TWRA staff will set clusters of gillnets at four sites on Reelfoot Lake. Each site will be sampled at least twice per year, once during summer (July-Sept) and again in the winter (Nov-Jan). At each site, four overnight gillnet sets will be deployed. Individual nets will be 300-ft in length with 100-ft panels of 3-, 4-, and 5-in mesh. Nets will be 12-ft deep, hobbled to 10-ft every eight feet; nets will have 0.5-in foamcore float line and 65-lb leadcore lead line. The webbing used in each of these panels will be constructed of 8 ply, 0.2-mm twist mesh. Catch of all species will be recorded by mesh size. We are not attempting to herd fish into nets using electrofishing, acoustic boats, or any other method.

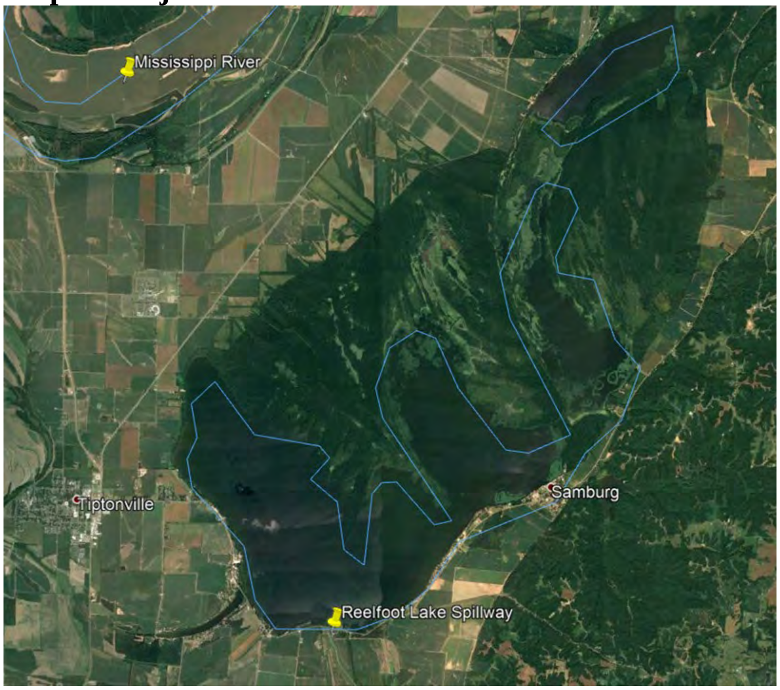
TWRA staff will sample 15 electrofishing sites on Reelfoot Lake. Sampling will occur at least twice per year (spring and fall). Electrofishing surveys will be conducted during the daytime using a high-frequency pulsed DC boat electrofishing. Voltage and amperage will be adjusted to achieve a 3,000-W power output, as possible (Stuck et al. 2015). Electrofishing transects will be conducted for 15 minutes each.

Catch rates will be calculated from agency sampling efforts. All carp species will be removed from the lake. Carp species (or a subsample) will be examined for species, length (mm), weight (g), and sex. Otoliths will be collected to estimate age and growth. Data will be used to prepare length and age frequency histograms, estimate growth and mortality, and assess condition.

TWRA may contract with licensed wholesale fish dealers, commercial fishers, or private entities to remove invasive carp from Reelfoot Lake. Payments will be made on either a per pound basis or based on a predetermined amount of removal effort. Depending on industry needs, gillnet material may be provided to commercial fishers. All removal efforts will require regular reporting to TWRA consistent with state rules. Harvest will be quantified, and subsamples may be used to determine species, length (mm), weight (g), sex, and age and growth estimates.

TWRA may organize a bowfishing tournament as a means of removal and outreach. On Reelfoot Lake, bowfishing could provide a unique opportunity to remove fish in areas where traditional removal and sampling effort are less successful (due to shallow water and an abundance of stumps). Additionally, bowfishing tournaments present an opportunity to activate and educate new stakeholders. As with other sampling and removal efforts, harvest will be quantified, and subsamples may be collected from fish as needed.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Commercial/Contract Removal	ASAP, 2022-2023
Electrofishing	Spring-Fall 2023
Gillnetting	Summer-Winter 2023
Bowfishing Tournament	TBD
Final Report	Spring 2024

Literature Cited:

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Stuck, J.G., A.P. Porreca, D.H. Wahl, and R.E. Columbo. 2015. Contrasting population demographics of invasive silver carp between an impounded and free-flowing river. North American Journal of Fisheries Management 35:114–122.

Identifying Overwintering Habitat of Silver and Bighead Carp in the Lower Mississippi River: Implications for Harvesting and Population Reduction

Lead Agency and Author: U. S. Army Engineer Research and Development Center, Environmental Laboratory, Jack Killgore, jack.killgore@usace.army.mil and Todd Slack todd.slack@usace.army.mil

Cooperating Agencies: USGS Columbia Field Office (interpretation of electronic scans), Mississippi Department of Wildlife and Fisheries (assistance in sampling overwintering carp).

Statement of Need:
Invasive Carp (i.e., Asian Carp, Bigheaded Carp) escaped into the Lower Mississippi River (LMR) in the 1970's, or possibly before, and established reproductive populations (Reeves 2019). Silver and Bighead Carp were initially documented in LMR research collections by 1990's and are now one of the most abundant large-bodied species in the Lower Mississippi River (Killgore and George 2020). After escaping into the Lower Mississippi River, their abundance and range quickly expanded into the Lower Mississippi River Valley, Missouri River, Upper Mississippi River, Ohio-Tennessee Rivers, and they now threaten to invade the Great Lakes. Federal agencies and states are implementing control measures to reduce numbers as the invasion front continues to expand. However, continuous recruitment of Invasive Carp moving upstream from the LMR may render control measures ineffective in other watersheds (Norman and Whitledge 2015). Perennial flow in the LMR provide virtually unlimited spawning sites, and extensive backwaters and lakes provide stable rearing areas with high productivity (Ochs et al. 2019). If the goal of containing and controlling the expansion of Invasive Carp in the United States is ever realized, reduction of population densities in the LMR where unfettered reproduction occurs must be addressed.

A total of 41 sites along a 58-mile reach of the Lower Mississippi River were surveyed during winter 2022 for Invasive Carp aggregations. Preliminary observations indicated that optimum overwintering habitat were scallops closest to the dike-vegetated bank interface with deeper, slow-moving water and consistent access back to the main channel. Carp avoided strong currents, and there was no trend in depth selection other than avoiding shallow (<20 ft) water. High water occurred after the initial surveys and information from a catfish guide, who accompanied us on the initial surveys, reported that most of the Carp moved out of the overwintering habitat before further sampling could be conducted. Re-surveying areas that were identified as optimum habitat during the 2022-2023 winter season is necessary to sub-sample species composition and evaluate potential removal techniques.

This project addresses multiple goals of the Lower Mississippi River Basin Asian Carp Control Strategy Framework including stopping population expansion, determining the spatial extent of Invasive Carp populations and evaluate responses to control efforts, and reducing Invasive Carp densities. Six of the seven National Plan goals and strategies are also addressed in the proposed work. Identification of large numbers of Invasive Carp in specific riverine habitats during winter temperatures when Carp are inactive provide an excellent opportunity to overharvest these invasive species to reduce population size. This study can potentially contain and control their expansion by reducing population size to levels of insignificant effects, which can minimize potential adverse effects in the Mississippi River and tributaries. This study will also provide information to the public, commercial entities, and government agencies to improve effective management and control based on accurate and scientifically valid information. Commercial entities can be established to effectively plan, implement, and evaluate management and control efforts by exploiting these vulnerable populations while overwintering in large schools.

Objectives:

Our goal is to resurvey sites over a range of river stages where high Carp abundance was observed to verify optimum habitat conditions, evaluate influence of river stage on occupancy duration, and continue to evaluate species composition and mass removal techniques as part of a management option in the Lower Mississippi River. Specific objectives are:

1. Verify that large schools of presumed Carp overwintering in the LMR at pre-defined optimum habitat are present based on electronic sonar scans.
2. Measure and characterize the hydrogeomorphic and water quality environment of each overwintering habitat
3. Sub-sample fish in overwintering habitats to determine species composition, size distribution, and relative abundance.
3. Evaluate different collecting gears to harvest Carp in large numbers at overwintering locations

Activities and Methods:
This study will begin late fall 2022 and winter 2022-23 once the Mississippi River water temperature drops below 10 °C, which is assumed to elicit overwintering behaviors of Carp. ERDC, with the possible assistance of MWFP, will re-visit sites along the 58-mile Vicksburg reach deemed optimum overwintering habitat during the previous winter survey (see Map below). Sites where carp were not observed will also be surveyed to confirm that the habitat attributes are not conducive as overwintering habitat. We will use a Garmin GPSMap 8616 to locate Carp in the study reach by observing concentrations of fish marks on the display. Prior to the survey, we will consult with USGS Columbia field office for assistance in using multibeam imaging sonar to estimate fish abundance including adaptation of statistical methodologies to calculate density.

Once the presence of large aggregations of fish are verified at any particular site, a suite of variables will be measured to determine the hydraulic (depth, velocity), spatial extent, substrate types, and water quality characteristics. Carp locations will be compared to the January-February 2022 survey to evaluate site fidelity between years. Fish collections will occur at sites with large aggregations. Crews will use different gear types to determine maximum efficiency of collecting carp focusing on set-nets of different material (monofilament versus multifilament), mesh sizes, and configurations (i.e., leaded, tie-down, and trammel). Both set gillnets and drift gillnets will be evaluated. We will also confer with Silver Fin Solutions on their mass removal techniques developed in the upper Mississippi and Tennessee River systems including Paupier boat surveys, bulk harvest, specialized electrofishing boats, seining, and unified-herding. All Carp collected will be identified to species, measured for total length, and a subset will be marked using Floy t-bar anchor tags and released for possible subsequent re-sampling efforts. Native fish species will be recorded to evaluate co-occurring fish assemblages that utilize these overwintering habitats.

A report will be prepared and maps generated that identifies number of schools located in the study reach, potential site fidelity among the two different sampling periods, and habitat attributes that define optimum overwintering locations in the Lower Mississippi River. Sub-sampling of Carp with nets, electroshocking, and other techniques will be described including catch efficiency by Carp species, size range, and co-occurring native fishes. Mark-recapture data will be analyzed to estimate abundance, and if we are successful in using the sonar to estimate abundance, these two technique will be compared for further application. Recommendations on mass removal from overwintering locations will be provided.

Map of Project Area: Study reach delineated by yellow lines extending from RM 395 (mouth of Bayou Pierre) to RM 480 (Lake Providence Harbor).

Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Survey Deep Holes	December 2022, January and February 2023
Sample Invasive Carp at representative deep holes	January and February 2023
Coordinate with USGS on application of Sonar to evaluate density	October-November 2022
Prepare Report	March – April 2023

Literature Cited:

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Reeves. A. 2019. Overrun, dispatches from the Asian Carp crisis. ECW Press, Ontario, Canada, 373 pages.

Invasive Carp Movement and Assessment to Inform Management and Removal Efforts in the Lower Mississippi River (LMR) Basin

Lead Agency and Author: Louisiana Department of Wildlife and Fisheries (LDWF), Robby Maxwell (rmaxwell@wlf.la.gov)

Cooperating Agencies: Louisiana State University (LSU), Missouri Department of Conservation (MDC), Tennessee Wildlife Resources Agency (TWRA), U.S. Fish and Wildlife Service (USFWS)

Statement of Need:

Successful containment and control of invasive species is reliant on an understanding of movements and life histories of populations in response to local conditions. Agencies involved in the LMR invasive carp movement studies are seeking to maintain and/or expand on active and passive ultrasonic acoustic telemetry and population assessments to gather data to inform efficient and effective placement of passage barriers and deterrents, as well as to guide removal efforts. Proposed projects also include monitoring of inter- and intrabasin movements in a variety of habitat types. Proposed networks of receiver arrays will build upon existing networks of compatible InnovaSea (Vemco) technology maintained by cooperating and partner agencies, with data sharing being of high priority. A value-added benefit of the proposed projects is expanded capability to detect fish involved in other movement studies, which coincides with the expanded detection capabilities of invasive carp in existing networks maintained by partner agencies.

The proposed studies address the "LMR Basin Asian Carp Control Strategy Framework" goals and strategies by identifying and utilizing habitat requirements, barriers, or deterrent technologies to control invasive carp. The proposed studies also address goals and strategies by using technology, methods, and capabilities necessary to monitor and control invasive carp, while opening lines of interagency cooperation and collaboration.

This is a continuation of a FY20 Work Plan. The only agencies requesting funding for FY22 are LDWF, MDC, and TWRA, detailed below.

Objectives:

1. Determine intrabasin and interbasin movement to inform placement of potential deterrent technologies and removal efforts.
2. Maintain and expand upon current telemetry efforts.

Louisiana Department of Wildlife and Fisheries

Activities and Methods:

In support of Objective 1, LDWF will coordinate with LSU and other partner agencies to track the movements of invasive carp in South Louisiana. This project will expand upon and continue the telemetry project funded in FY 20. The original project consisted of 40 receivers and 200 transmitters (primarily in Silver Carp) deployed along and below the Intracoastal Waterway in the Lower Mississippi River Basin of southern Louisiana. These transmitters were programmed for a battery life of 5-6 years, and thus, this project will allow for the continued monitoring of tagged carp from FY20 while expanding the receiver array northward in areas in need of more coverage in the Atchafalaya River system. This will provide additional information on the movement of carp between areas of high abundance up river and the current monitoring area. Additionally, this expansion will improve connectivity with other telemetry efforts in the Lower and Upper Mississippi River Basins and the Red River. We will tag an additional 30 fish in the Atchafalaya River in the area of expanded coverage during this funding cycle to incorporate movements of fish north of the Intracoastal Waterway. Given the relative lack of long-term data on invasive carp habitat use and movement in this region, continued monitoring and expanded coverage will greatly improve our understanding of carp distribution and seasonal movement patterns in the lower Mississippi River Basin.

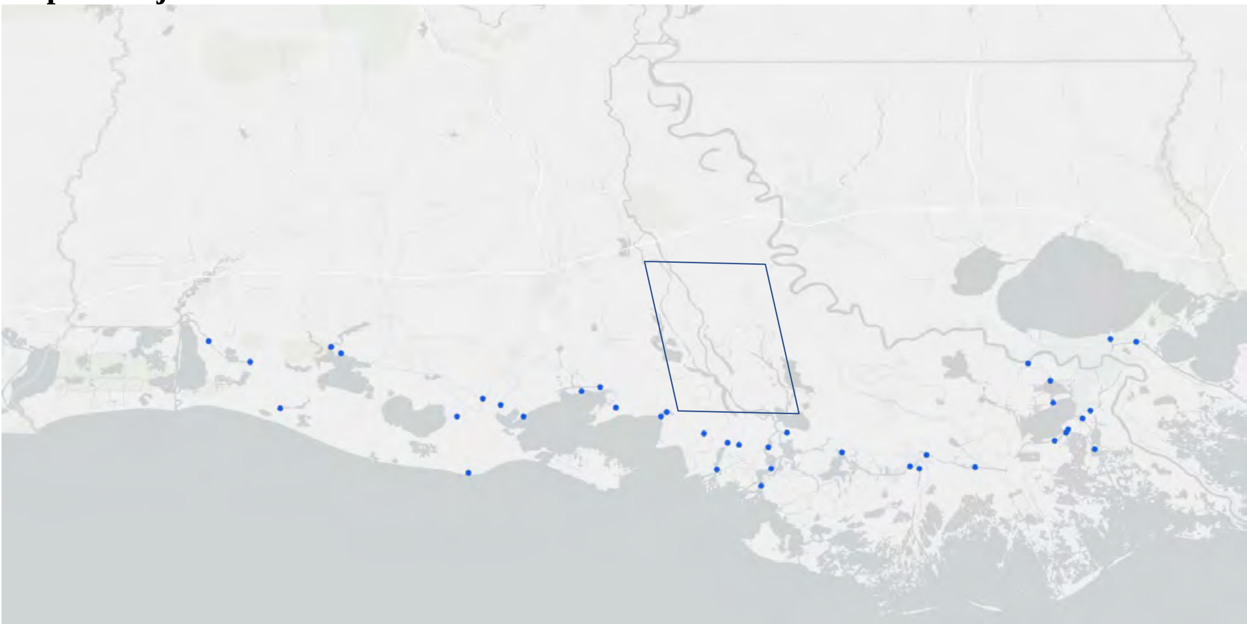
Tagging effort will be focused in the Atchafalaya River and connected waterways. A combination of electrofishing and net gears (e.g., gill nets, entanglement nets) will be used to capture invasive carp. Acoustic transmitters (Vemco V-16-4H, 69kHz) will be surgically implanted in 30 adult invasive carp in in the Atchafalaya River system north of the intercoastal waterway above Morgan City, LA. Transmitters will be programmed with a nominal delay of 90 seconds (60-120 seconds) and will have an expected battery life of 5-6 years. In addition, individuals will be tagged with an external floy tag to reduce harvest of tagged fish and encourage reporting of recaptured individuals, as commercial fishing effort is higher in this region of the Atchafalaya River (north of Morgan City). Fish will be measured to the nearest mm and placed ventral side up in a state of tonic immobility. The transmitter will be inserted in the body cavity via a small incision and closed with 1-2 interrupted sutures. Water quality parameters (e.g., temperature, dissolved oxygen, salinity) of the location of capture/release will be measured by YSI and recorded. Tagged fish will be allowed to recover following surgery, and then released in the same general area of capture. Lastly, we will engage and work closely with Louisiana commercial anglers to disseminate information about the project and to encourage release of tagged fish captured in local fisheries that are in good condition.

Fifteen acoustic receivers will be deployed by LSU in the Atchafalaya River system north of the intercoastal waterway in the winter/spring of 2023 to monitor movements of invasive carp (Figure 1, orange polygon). We will also continue to maintain the existing array of 40 acoustic receivers deployed (with FY20 funds) throughout the intercoastal waterway and waterbodies to the south (Figure 1, blue dots). Thus, our total array will consist of 55 receivers to monitor carp movements across the lower Mississippi River Basin in south Louisiana. The array will consist of Vemco VRTx receivers, which will record temperature and ambient noise in addition to transmitter detections. These receivers also contain a transmitter, which allows them to be detected by other receivers or from the surface using an active hydrophone (VR100). Areas of special interest (and a higher concentration of receivers) include major confluences, stems, and branches of the Atchafalaya River north of Morgan City. Receivers will be attached to existing structures (pilings, channel markers), or anchored to the bottom and tethered to the shoreline. Receivers and salinity loggers will be serviced by LSU approximately every 12 weeks to retrieve and download data, monitor receiver condition, clean receivers, and replace batteries (as needed). We will also leverage existing arrays operated and maintained by partners including USFWS, USACE, and LSU to provide additional receiver coverage beyond the proposed array. These areas include Lake Borgne, Pearl River, Lake Pontchartrain and the Bonnet Carre Spillway, Rockefeller Wildlife Refuge, Atchafalaya River, Red River, and the Mississippi River Delta. We will also work closely with partners throughout the Mississippi River Basin to monitor inter-state movements of invasive carp inside and outside of our study area. Data sharing will occur across agencies and partner arrays to maximize the potential coverage area.

Active tracking using a Vemco VR100 will be used, as able, to supplement receiver coverage and provide additional information on fish movement. We will conduct active surveys at point locations (5 minutes in duration) along the ICWW and other areas of high interest that are outside the detection range of passive acoustic receivers to supplement our passive monitoring efforts.

Annual reports will detail monitoring efforts and movement/habitat analyses linking environmental and temporal variables to patterns in carp occupancy, movement, and habitat/space use including probabilities of movement, distances traveled, basins crossed, seasonal movements and/or shifts in home range and habitat use, and other notable movements of all species targeted. The final report will include an assessment of carp movement in south Louisiana and recommendations for the placement of passage barriers or deterrents in the ICWW or other points of ingress/egress in south Louisiana. Recommendations for population reduction efforts based on movements will also be made.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Purchase Equipment	January 2023
Graduate student and technician start	January 2023
Deployment of Acoustic Array	February 2023
Receiver Maintenance	Quarterly (every 12 weeks) throughout the study period
Acoustic Tagging (Multiple locations)	Winter/Spring 2023
Additional Acoustic Tagging (Multiple locations), as needed	Summer/Fall 2023
Data Analysis	Ongoing as data is received, final analyses Winter 2023
Manuscript Prep and Submission	Winter 2023
Annual Report	March 2024 (covering calendar year)

Tennessee Wildlife Resources Agency

Activities and Methods:

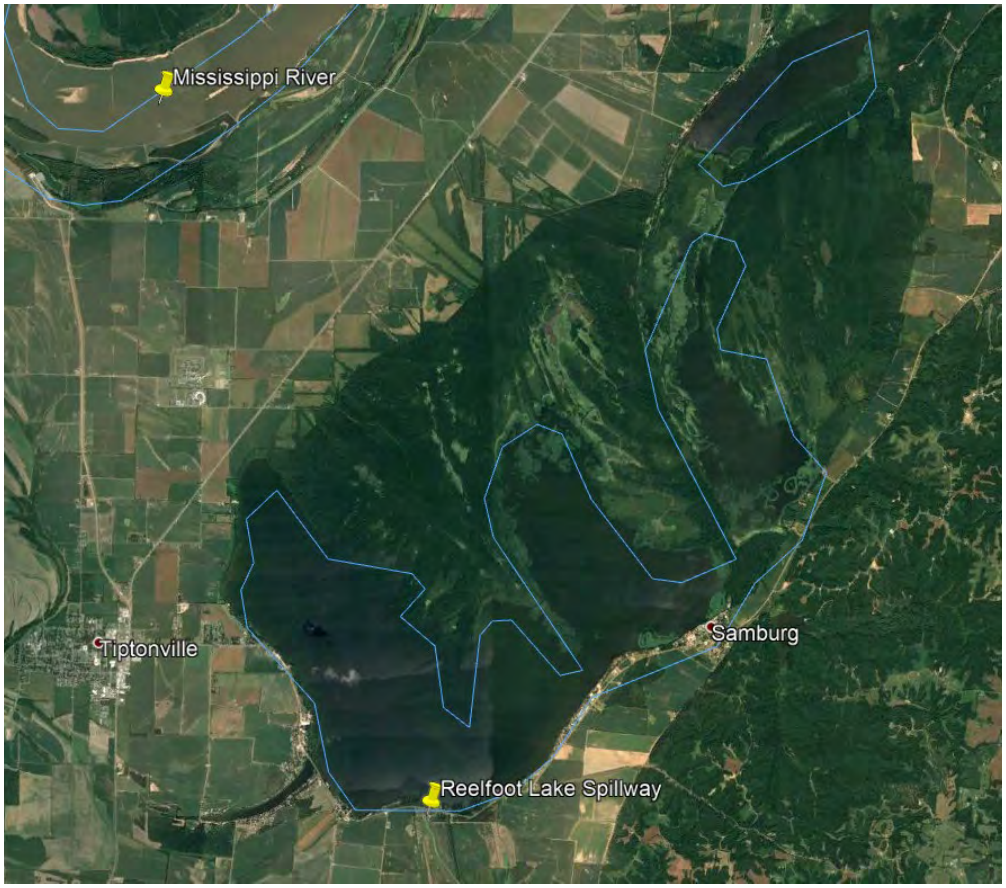
In support of Objective 2, TWRA will continue working with state and federal partners to gather information on currently available deterrent technology, and to evaluate the need for/feasibility of a deterrent system at Reelfoot Lake. Currently, invasive carp migrate into Reelfoot Lake from a connection to the Mississippi River at high water levels. The extent of this migration remains unknown. To better understand this migration, TWRA will implement an acoustic telemetry project at Reelfoot Lake.

Invasive carp will be collected, primarily by means of electrofishing and short-set gillnets, and surgically implanted with Vemco acoustic tags. Fish will be collected in Reelfoot Lake and tagged. Staff will attempt to tag 50 individuals, of which, 25 will be released in the lake and 25 will be translocated and released below the spillway. In addition to acoustic tags, carp will also be fitted with external loop tags. Total length and sex determination will be recorded for all carp encountered during this effort.

An array of stationary receivers (N=6-10) will be maintained within the lake, around the spillway, and downstream approaching the confluence with the Mississippi River. Receivers will be maintained and downloaded by TWRA staff and partners on a regular interval (~every 3 months). Data will be summarized and shared with partners in a timely manner, as numerous partners in the Mississippi Basin are conducting similar projects to evaluate invasive carp movements. Where available, data related to temperature, season, water level, discharge, and spillway operation, will be compiled and summarized to determine any correlation with invasive carp migration into Reelfoot Lake.

TWRA staff will also conduct electrofishing surveys below the Reelfoot Lake Spillway as feasible. Sites may vary due to water level fluctuations associated with the spillway. Transects will be conducted for 15 minutes with two dip netters. Only carp species will be collected and catch rate will be reported. Electrofishing data from below the spillway coupled with electrofishing, gillnet, and commercial removal data from above the spillway (to be collected as part of the LMR “Control of Invasive Carp in the Lower Mississippi River Basin” project) will provide managers with valuable information regarding the current extent of migration.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Compiling data/information from partners	ASAP, 2021-2024
Installing acoustic receiver array	Spring 2022
Tagging invasive carp	Fall 2022 - Spring 2023
Receiver downloading and maintenance	2021-2024 (approx. every 3 months)
Electrofishing	Spring-Fall, 2023
Data analysis and Final Report	Spring 2024

Missouri Department of Conservation

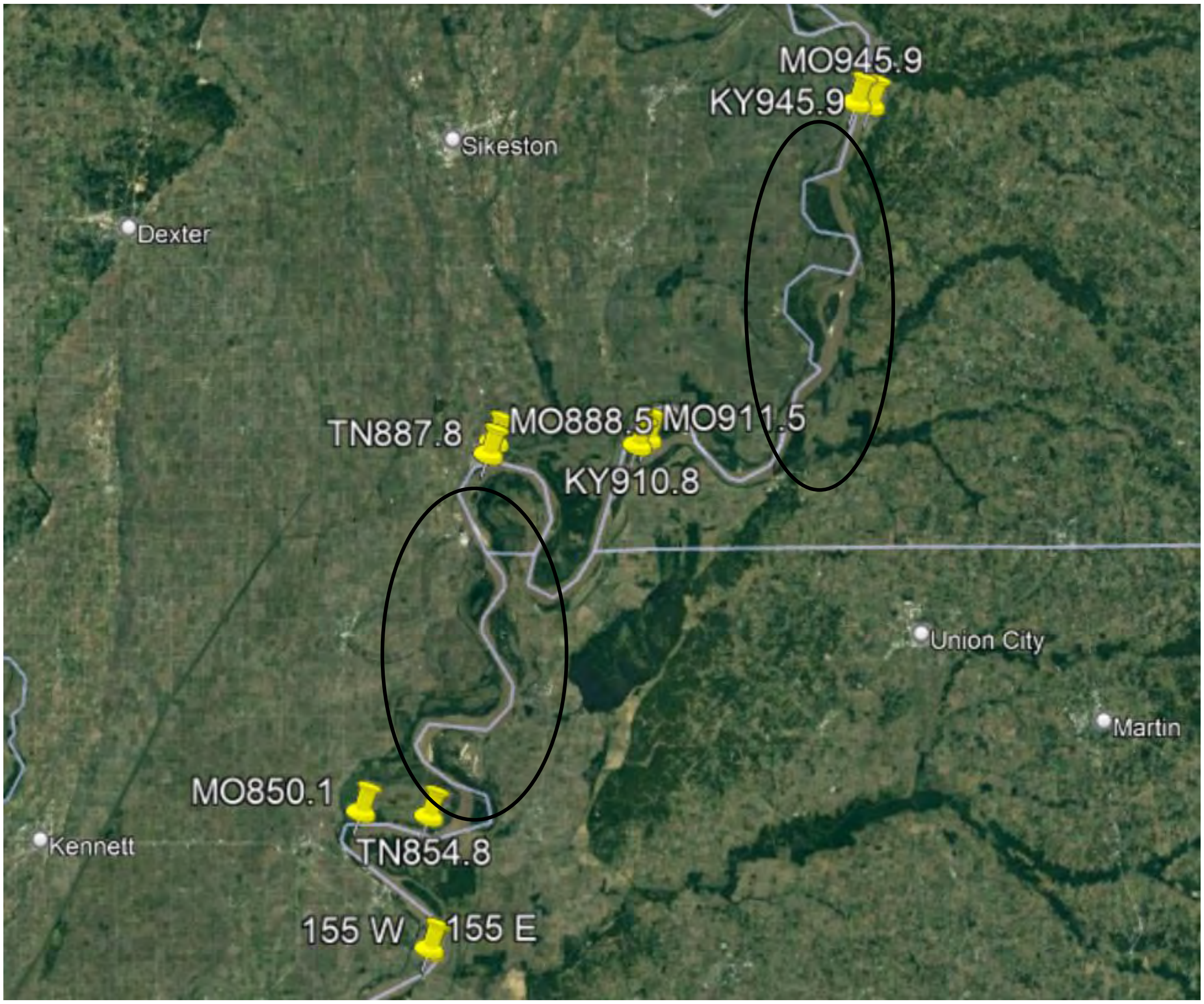
Activities and Methods:

In support of Objective 2, MDC will expand and maintain the existing stationary receiver array from the confluence of the Ohio River at Cairo, IL, to the southern Missouri border near Caruthersville, MO in the Lower Mississippi River, including associated major tributaries. Invasive carp telemetry in the Lower Mississippi River and its tributaries have added to the level of information by expanding the existing stationary receiver array into the Lower Mississippi River Basin. A pair of stationary receivers was placed every 30 miles (approx.; see map below) and has been used to track residency time and transition rates between states and basins.

Funding in FY22 will be used to expand (four additional receivers) and maintain this section of the array, which will provide additional information about movement among basins and tributary use. In the map below, the black circles indicate potential, general areas where the four new receivers are to be placed but exact locations are still to be determined. Since Missouri is centrally located between all the basins (OHR, MOR, UMR, LMR), additional data from new receivers will continue to help fill in information gaps and provide insight about mixing between basins.

Additionally, outputs from this project can help direct Invasive carp removal efforts by predicting their locations, patterns, and behaviors. These data will also be available to inform complex temporal-spatial models (e.g., SEICarP). MDC will coordinate with the LMR Sub-basin Invasive Carp Partnership to ensure data is shared and updates are provided.

Map of Project Area:



Estimated Timetable for Activities:

Project Activity	Season	Year
Enhance Acoustic Array Sample invasive carp using electrofishing	Fall	2022
Implant Acoustic Tags in Invasive Carp Complete fish ID from preserved specimens	Fall	2022
Download Receiver Data	Every 4-6 weeks	2022
Annual Report	March	2023

Spatial and Temporal Expansion of Abundance and Distribution of Early Life Stages Sampling of Invasive Carp in the Atchafalaya Basin

Lead Author and Agency: Louisiana Department of Wildlife and Fisheries (LDWF); Robert Bourgeois (rbourgeois@wlf.la.gov)

Cooperating Agencies: Nicholls State University (NSU); Quenton Fontenot

Statement of Need:
Successful management of invasive carp is dependent on a thorough understanding of life histories and interactions with local environments. Reproduction can be used to guide control efforts by identifying where large spawning aggregations occur and by identifying source and sink populations.

Most of the invasive carp sampled in previous studies by LDWF have been large adult fish. In early summer of 2021, possible young of the year (YOY) carp were captured in the Atchafalaya River. These fish seemed to be too large to be only a month or two old which suggested a possible earlier breeding period in LA than what was shown in prior early life stages studies in LA waters.

Based on larval invasive carp sampling conducted in 2013, 2014, 2019 and 2021, the Atchafalaya River Basin is potentially a source of invasive carp recruitment in the Lower Mississippi River. Up to 30 sites will be sampled within the basin to confirm habitat preference of spawning areas and look for evidence of spawning before and after the period that we have sampled in the past (April through July). Thirty fixed-sites will be selected and sampled monthly from February through November. The first year of the study will have fixed sites split in thirds among presumed favorable spawning habitat (mainstem), marginal spawning habitat (distributary), and unfavorable spawning habitat (lacustrine). This habitat classification is based on previous samples taken throughout the state and in the literature. For Year 2, a concentrated effort will be used to sample areas that had the greatest abundance of invasive carp larvae for the months April – July.

Objectives:

1. The objective of this project is to determine the time of year and habitat types that larval and juvenile invasive carp occupy within the Atchafalaya River Basin in order to determine if the breeding season is longer in LA than in the upper MS River.

Activities and Methods:

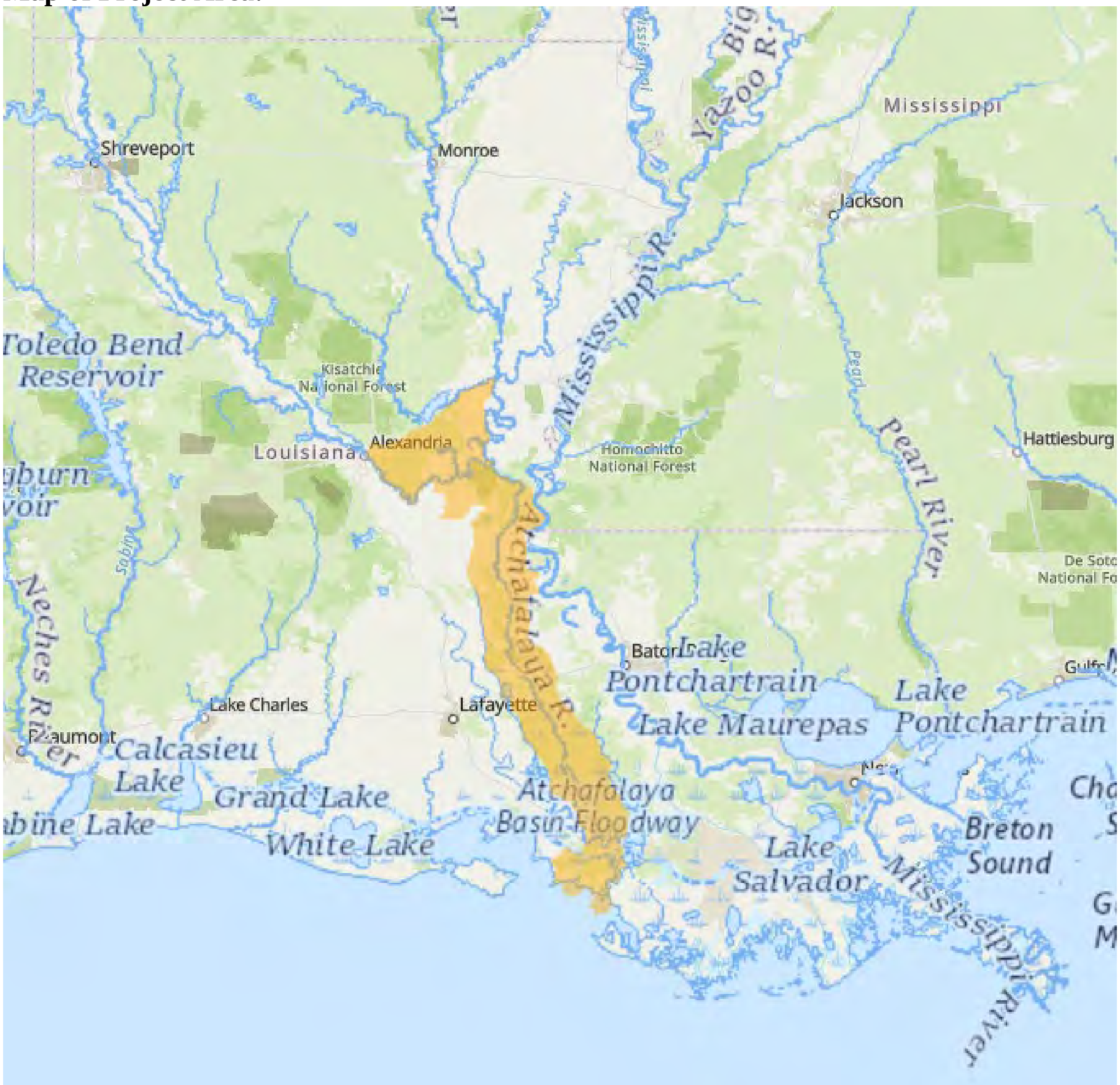
The objective of this project is to determine the time of year and habitat types that larval and juvenile invasive carp are expected to be present in the Atchafalaya River Basin. This objective will be accomplished by monthly sampling 30 fixed sites that are evenly distributed among habitats that are presumed to be favorable spawning habitat (mainstem, high current velocity), marginal spawning habitat (distributary, medium current velocity), and unfavorable spawning habitat (lacustrine, little to no velocity) from February to November in 2023. The purpose of the 2023 samples are to establish the time of year and the habitat types that are most likely to have a high concentration of invasive carp larvae. Sampling efforts in 2024 will be focused on fixed sites that had high concentrations of invasive carp in 2023 and will be sampled monthly from April to July. The 2024 samples will be used to confirm areas that invasive carp use for spawning activity.

At each fixed site, larval fish samples will be collected along each bank of the water body. Temperature will also be recorded at the start of each sample. The total number of samples collected in 2023 will be 600 (30 sites x 2 samples per site x 10 months = 600). The number of sites sampled in 2024 will be determined once the 2023 samples have been analyzed. A half-meter ichthyoplankton net (500-micron mesh) will be towed alongside a boat just below the water surface for approximately 10 minutes for each sample. A mechanical flowmeter mounted in the mouth of the ichthyoplankton net will be used to calculate linear distance sampled so that the volume of water sampled can be calculated. Sample contents will be transferred to 500 mL plastic containers and the contents will be preserved in 70% alcohol. All samples will be sorted and all fish will be identified to at least the family level. Larval cyprinids will be further delineated as invasive carp or not-invasive carp.

NSU faculty/staff will identify fishes to family based on Auer (1982). Identification of cyprinids such as invasive carp larvae will be based on Chapman (2006), Chapman and George (2011) and George and Chapman (2013). Taxonomic classification beyond family for non-cyprinids will be based on Auer (1982).

Progress reports will detail the mean number of each taxonomic group collected at each fixed site for each month. A map will be produced for each month for each year indicating the location of all sample sites delineated by the presence or absence of invasive carp collected . The final report will include all raw data, summarized data, maps, and an interpretation of our findings.

Map of Project Area:



Estimated Timetable for Activities:

Timetable for 2023.

Activity	**2023**											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Purchase Supplies	X											
Collect 2023 Samples		X	X	X	X	X	X	X	X	X	X	
Process 2023 Samples		X	X	X	X	X	X	X	X	X	X	X
Submit Progress Report												X

Timetable for 2024.

Activity	**2024**											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Purchase Supplies	X	X										
Identify 2024 Sample Sites		X	X									
Collect 2024 Samples				X	X	X	X					
Process 2024 Samples				X	X	X	X	X				
Produce Maps									X			
Analyze Data										X		
Compose Final Report											X	
Submit Final Report												X

Louisiana Department of Wildlife and Fisheries

Activities and Methods:

LDWF will provide project oversight and technical expertise. LDWF will make periodic contact with the partners via email, phone calls or in person meetings. LDWF will contract with each partner and be responsible for the all technical and progress reports to the USFWS.

Literature Cited:

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Determining Product Quality Parameters to Expand Market Potential for Louisiana Invasive Carp

Lead Agency and Author: Louisiana Department of Wildlife and Fisheries (LDWF), Robert Bourgeois (rbourgeois@wlf.la.gov)

Cooperating Agencies: Louisiana Universities Marine Consortium (LUMCON); AquaRange Research LLC; Omega Protein

Statement of Need:

Commercial harvest remains the most cost-effective control method for invasive carp. However, low prices and market demand have limited the success of this strategy as a means of controlling the impacts from these invasive species in the Lower Mississippi River. Attempts to increase demand and therefore dock-side prices through promoting human consumption of invasive carp in the region have largely been unsuccessful. This work plan represents the continuation and expansion of a project to develop non-human consumption based markets for Louisiana invasive carp.

Currently, the aquaculture industry relies heavily on marine fish species, such as menhaden and anchovies, as sources for fishmeal and fish oil; key ingredients in aquaculture feeds. However, product availability cannot match projected industry demand, with the aquaculture industry requiring an additional 37.4 million tons of aquafeed by the year 2025 (Hua et al., 2019). The inclusion of alternative ingredients as sources of protein and fat represents a cost effective and environmentally sustainable solution and these products are replacing the use of traditional marine-derived ingredients in aquaculture feeds. Preliminary results from a FY21catfish feed production project indicate that Louisiana's invasive carp may represent a sustainable source of alternative ingredients, as they are large, abundant, and express a suitable nutrient profile for fish growth (especially when compared to plant-derived products). Including invasive carp products in aquafeeds will diversify market demand, thereby promoting targeted fishing efforts, minimizing these invasive species' environmental impact, and enhancing sustainability in the aquaculture sector.

However, questions remain regarding the temporal stability (year to year as well as seasonal) of the contaminant load in Louisiana's invasive carp. Additionally, it is unclear whether contaminant loads vary with fish size and maturity status, as previous studies have shown that larger, more fatty fish are more likely to have accumulated higher contaminant loads (Streit 1998). Further, although a successful commercial market for invasive carp fishmeal and fish oil has been established in Illinois, our preliminary results from FY21 suggest that key compositional differences exist between invasive carp in Illinois and invasive carp in Louisiana.

Invasive carp fishmeal (from Illinois) was found to support similar growth and digestibility to traditional menhaden fishmeal in a variety of carnivorous fish species (Bowzer and Trushenski, 2015; Bowzer et al. 2015) and interest in incorporating invasive carp products into aquaculture feeds is expanding. Since 2020, Nobilis Aqua (Fort Collins, CO), has been selling a trout feed that incorporates invasive carp fishmeal and fish oil to Frontier Trout Ranch (Saguache, CO), one of the largest trout producers in the state. Nobilis Aqua has now received requests from additional farmers interested in purchasing their fish feed. Work to expand these initiatives to the lower Mississippi River basin and provide a balanced formulation for an invasive-carp based diet would enhance the potential availability and demand for these products as well as increasing the performance efficiency of these feeds.

Increased commercial harvest of invasive carp is the most efficient and sustainable way to control populations and limit the impacts to native fisheries and ecosystems. The low demand, and therefore prices, for invasive carp has led to the need to subsidize fishermen and contract fishing to promote harvest. Supplementing commercial fish markets can result in the abuse of subsidies and contract fishing may not be a solution to remove invasive carp over a long period of time (Conover et al. 2007). Both require money and oversight from either state or federal partners, highlighting the need to develop a consistent high volume market demand for invasive carp. The incorporation of carp fish meal and fish oil into the aquaculture industry's supply chain may result in the establishment of such market demand.

This project is a continuation and expansion of a FY21 Work Plan. In FY21, the first phase of a project to determine the feasibility of multiple markets for non-human consumption was initiated. This study compared carp product quality (i.e., proximate, amino acid, and fatty acid concentrations), and contaminant loads between carp caught in the Lower Mississippi River (i.e., Louisiana) to those caught in the Upper Mississippi River (i.e., Illinois) and evaluated the efficiency of carp-derived fishmeal and fish oil (manufactured in Illinois) in practical diets for channel catfish (an omnivore). In FY22, this project will examine the inter-annual and regional variability in and impact of size class and maturity status on contaminant loads of Louisiana's invasive carp. Additionally, initial product(s) derived from Louisiana invasive carp will be rendered at a commercial processing facility (Omega Protein, Abbeville, LA) to determine the ideal manufactured end-product(s) based on the characteristics and processing demands associated with these fish. The quality and digestibility of those product(s) will then be assessed resulting in data that will be used to formulate a practical-type aquaculture diet that incorporates invasive carp ingredients.

Objectives:

1. Characterize key contaminants of interest in Lower Mississippi River invasive carp to inform market development.

1.1. Determine how contaminant concentrations vary with time of year, region, size class and maturity status for Lower Mississippi River invasive carp.
1.2. Determine contaminant type and concentration in invasive carp products rendered from Lower Mississippi River invasive carp.

2. Assess product performance of Lower Mississippi River invasive carp products to inform market development.
   2.1. Determine whether commercial processing of Lower Mississippi River invasive carp will result in the production of high-fat fishmeal or both low-fat fishmeal and fish oil.
   2.2. Determine whether Lower Mississippi River rendered products express an advantage with regards to fatty acid profile compared to products from the Upper Mississippi basin.
   2.3. Determine apparent digestibility coefficients of Lower Mississippi River rendered invasive carp products.
   2.4. Formulate a practical-type aquaculture diet to incorporate Lower Mississippi River invasive carp products into commercial trout feeds.

Louisiana Universities Marine Consortium

Activities and Methods:

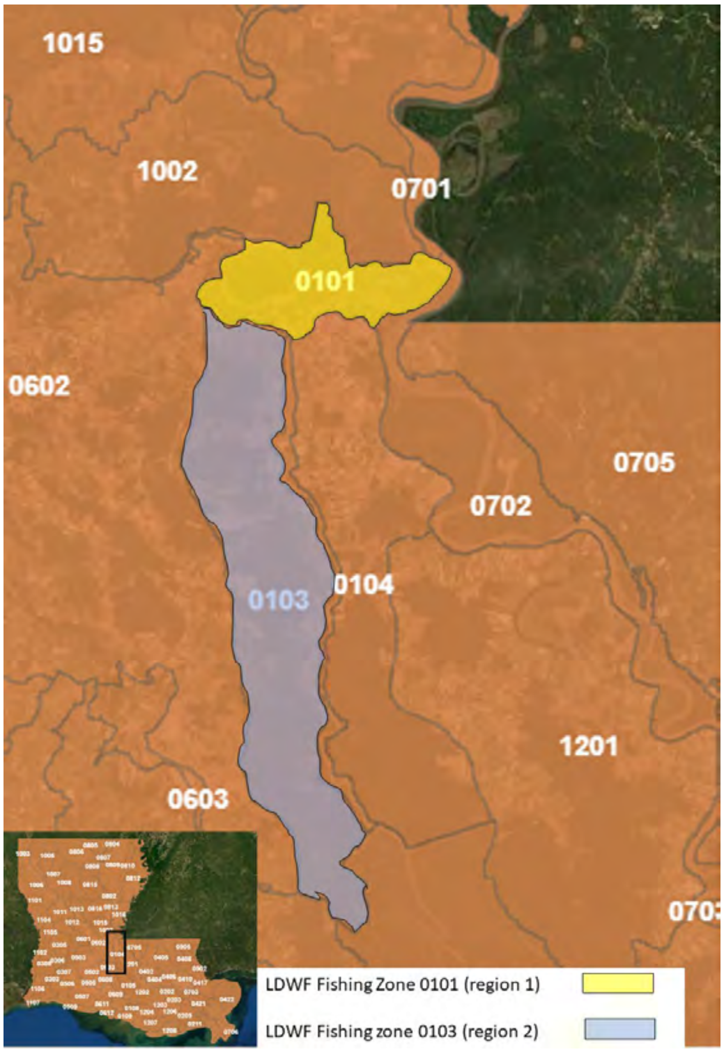
LDWF will partner with LUMCON to address Objective 1; Characterize key contaminants of interest in Lower Mississippi River invasive carp to inform market development. In this study, we will examine the influence of source location (2 regions within Louisiana), season (spring, summer, fall, winter), size (total length), and maturity status on the presence of and concentration of major contaminants (lead, mercury, cadmium, dioxins, and PCBs).

In FY21 relationships were established with commercial fishermen in two LDWF commercial fishing zones, 0101 and 0103. These fishermen reliably catch invasive carp and have agreed to supply LUMCON with n=5 whole fish per season in FY22. Whole fish will be analyzed for each study site (n=2) across four seasons (spring, summer, fall, winter) at n=5 replicates per study site per season. The length, weight, sex, and maturity status of each fish will be recorded. A sample of the muscle tissue will be collected for heavy metal analysis, then the whole fish will be homogenized and the homogenate will be analyzed for the presence and concentration of dioxins and PCBs as well as proximate composition (protein, lipid, energy, and moisture content). Analytical tests will be conducted by the Analytical Chemistry Laboratory at the University of New Orleans (New Orleans, LA) and the Agricultural Experiment Station Chemical Laboratories at the University of Missouri (Columbia, MO).

Additionally, LUMCON will collaborate with AquaRange Research LLC and Omega Protein to analyze contaminants (identity and concentrations) in the invasive carp product(s) developed to address objective 2 of this study (see below).

Results of these analyses will be combined with results from FY21 and examined using regression analysis for relationships between year of collection, region, length, weight, sex, and maturity status on each contaminant identified in our analysis.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Hire technician	January 2023
Obtain & process winter samples	February 2023
Obtain & process spring samples	April 2023
Obtain & process summer samples	July 2023
Obtain & process fall samples	October 2023
Complete contaminant analysis	November 2023
Complete statistical analysis	December 2023

AquaRange Research LLC and Omega Protein

Activities and Methods:

AquaRange Research LLC will partner with Omega Protein to address Objective 2; Assess product performance of Lower Mississippi River invasive carp products to inform market development. In this study, we will determine the processing requirements, suitable end products, quality, and digestibility of invasive carp products rendered from Louisiana carp in a commercial processing facility. Then, we will develop a practical, open-source feed formulation that incorporates these ingredients into a balanced aquaculture diet.

Invasive carp (200 lbs) will be sourced from commercial fishermen in LDWF fishing zones, 0101 and 0103 (near the Three Rivers region in Louisiana). These fish will be transported to the Omega Protein fish processing facility (Abbeville, LA) and rendered into high-fat fishmeal or low-fat fishmeal and fish oil. Omega Protein will determine the processing requirements and final end product(s) based on the compositional standards (e.g. size, bone and content) of the fish. Rendered product (minimum 20 lbs of fishmeal) will be shipped to AquaRange Research LLC (Bozeman, MT). Extruded test diets will be formulated and manufactured in accordance with the nutritional requirements of rainbow trout (NRC, 2011) on a 70:30 ratio (dry matter basis) of reference diet to test ingredient with yttrium included as an inert marker. A digestibility trial with adult rainbow trout (Troutlodge Inc., approximately 300 g each) will be run in a Recirculating Aquaculture System for two weeks. Fish will be stocked at n=20 per 320 L tank with triplicate tanks per treatment diet and fed once per day at 2% body weight. Fecal samples will be collected at the end of the trial and ingredients, diets, and feces analyzed for proximate composition and diets additionally analyzed for amino acid and fatty acid composition according to standard methods (AOAC, 1995). Apparent Digestibility Coefficients (ADCs) of the invasive carp test ingredients will be calculated and used to formulate a practical-type aquaculture diet for finfish based on the nutrient digestibility of the ingredients.

Estimated Timetable for Activities:

Activity	**Time Period** **(Season, Month/Year)**
Project purchases and acquisition of fish	January-February 2023
Render invasive carp ingredients	March-April 2023
Manufacture trout diets	May-June 2023
Trout digestibility trial	July 2023
Laboratory and analytical tests	August-September 2023
Formulate diet	September 2023
Data analysis (Obj 1 and 2)	October-November 2023
User deliverables, reports, and publications generated	November-December 2023
Investigator meetings (virtual)	monthly 2023

Louisiana Department of Wildlife and Fisheries

Activities and Methods:

LDWF will provide project oversight and technical expertise. LDWF will make periodic contact with the partners via email, phone calls or in person meetings. LDWF will contract with each partner and be responsible for the all technical and progress reports to the USFWS.

Literature Cited:

Association of Official Analytical Chemists (AOAC). (1995) Official Methods of Analysis. 17th edn. Association of Analytical chemists International, Gaithersburg, Maryland, USA.

Bowzer, J., and J. Trushenski. (2015) Growth Performance of Hybrid Striped Bass, Rainbow Trout, and Cobia Utilizing Asian Carp Meal-Based Aquafeeds. North American Journal of Aquaculture 77:59-67.

Bowzer, J., J. Trushenski, S. Rawles, T.G. Gaylord, and F.T. Barrows. (2015) Apparent Digestibility of Asian Carp- and Common Carp-Derived Fish Meals in Feeds for Hybrid Striped Bass *Morone saxatilis x M. chrysops* and Rainbow Trout *Oncorhynchus mykiss*. Aquaculture Nutrition 21:43-53.

Conover, G., R. Simmonds, and M. Whalen. (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.

Hua, K., Cobcroft, J.M, Cole, A., Condon, K., Jerry, D.R., Mangott, A., Praeger, C., Vucko, M.J., Zeng, C., Zenger, K., Strugnell, J.M. (2019) The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets. One Earth 1: 316-329.

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Streit, B. (1998) Bioaccumulation of Contaminants in Fish. Pages 353–387 *in* T. Braunbeck, D. E. Hinton, and B. Streit, editors. Fish Ecotoxicology. Birkhäuser Basel, Basel.

Effects of invasive carp larvae on the abundance, distribution, and assemblage structure of native zooplankton in Louisiana's Atchafalaya River Basin

Lead Agency and Author: Louisiana Department of Wildlife and Fisheries (LDWF), Robert Bourgeois (rbourgeois@wlf.la.gov)

Cooperating Agencies: University of Louisiana at Lafayette, Kelly Robinson

Statement of Need:

The Atchafalaya River Basin has high numbers of larval, juvenile and adult invasive carp based on larval invasive carp sampling conducted in 2013, 2014, and 2019, (pers. comm. R. Bourgeois and Q. Fontenot). Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix)*, prey on phytoplankton and zooplankton (Conover et al. 2007). By consuming zooplankton, these invasive carp have the potential to reduce energy available to upper trophic levels and to compete with native obligate and facultative planktivorous fishes such as Gizzard Shad (*Dorosoma cepedianum*) in Louisiana rivers (Kolar et al. 2007, Milstein et al. 2008). In northern U.S. rivers, the establishment of Bighead and Silver Carp was linked to significant changes in native zooplankton assemblages such as declines in copepods and cladocerns and increases in rotifers (Sass et al. 2014). This outcome aligns with the feeding ecology of Bighead Carp, who select for larger-bodied zooplankton like copepods (Fukushima et al. 1999). It also indicates that Atchafalaya River Basin zooplankton assemblages will likely shift to smaller taxa that are potentially less nutritious and not as easily consumed by native planktivorous fishes in waters where invasive carps have invaded.

Despite the potential for invasive larval Black Carp and adult Bighead and Silver Carp to alter energy flows in riverine food webs through their predation on zooplankton, field studies examining their effects on native zooplankton assemblages in the Atchafalaya River Basin are lacking. This knowledge gap limits our ability to determine if invasive carp are altering the taxonomic or size structure of zooplankton prey assemblages available to larval and adult native planktivorous fishes. To address this gap, this project proposes to quantify the effects of invasive carp (with an emphasis on larval stages) on the abundance, distribution, and assemblage structure (size and diversity) of native zooplankton in the Atchafalaya River Basin.

Processing zooplankton samples and identifying larval invasive carp is a laborious and time-intensive process. However, new sampling technologies developed over the last 10 years allow for rapid identification of plankton groups at various degrees of taxonomic resolution (Gorsky et al. 2010, Spanbauer et al. 2020). This project will test the feasibility of using a benchtop plankton imaging systems coupled with a machine-learning classifier to semi-automate the identification of larval invasive carp.

Objectives:

1. Quantify the effects of invasive carp larvae on the abundance, distribution, and assemblage structure (size and diversity) of native zooplankton in the Atchafalaya River Basin.
2. Test the feasibility of using a benchtop plankton imaging systems coupled with a machine-learning classifier to semi-automate the identification of larval invasive carps.

Activities and Methods

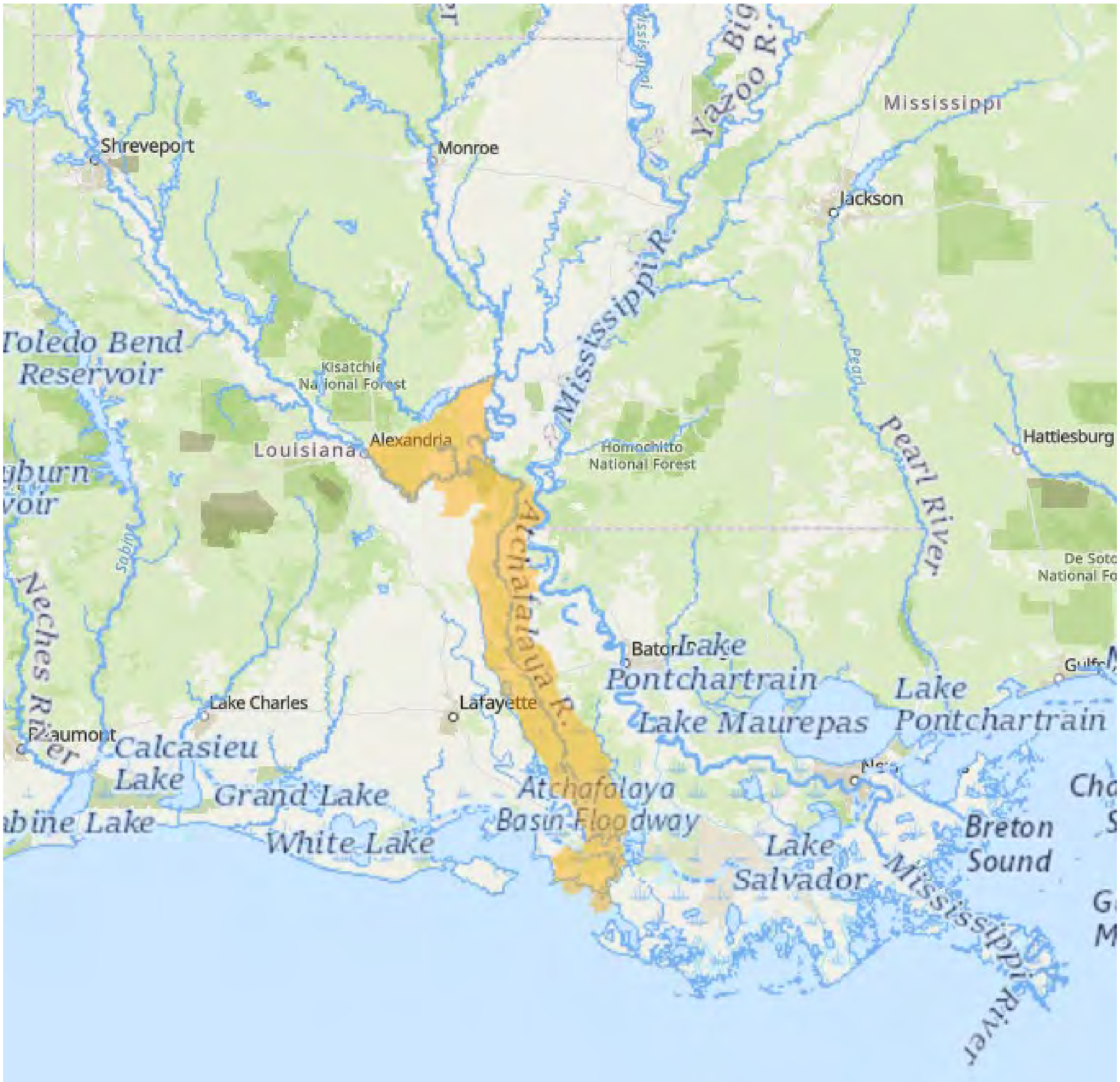
The first objective will be accomplished through monthly sampling of mesozooplankton (body size 200 µm-20.0 cm) at fixed sites in the Atchafalaya River Basin (ARB). Sites will be evenly distributed among habitats that are presumed to be favorable spawning habitat (high current velocity), marginal spawning habitat (medium current velocity), and unfavorable spawning habitat (little to no current velocity) from. The purpose of sampling among these three spawning habitat types is to determine variance in zooplankton community structure along a gradient larval carp abundance. Thirty sites will be sampled in February to November in 2023 (30 sites x 2 samples/site x 10 months = 600 samples). Fifteen sites, similarly distributed along a gradient of carp spawning favorability, will be sampled April – July 2024, yielding 90 samples (15 sites x 2 samples/site x 3 months). This study design will allow us to test how variability in larval carp concentration affects overall and taxa-specific zooplankton abundance and assemblage structure, including size and diversity metrics.

At each site, environmental conditions (water temperature, dissolved oxygen, conductivity) will be measured using an YSI multi-probe instrument A plankton bongo-frame outfitted with two, 0.5-m diameter plankton nets and two mechanical flowmeters will be towed horizontally into the current for 10 minutes. One bongo will have a 150-µm mesh net for zooplankton and the other a 500-µm mesh net for larval fish. Duplicate tows will be performed at each site. After each tow, the nets will be washed down from the outside and the zooplankton and icthyoplankton samples concentrated into separate 1-L sample jars and preserved in 70% ethanol. All samples will be sorted and zooplankton identified to the lowest taxonomic level possible in the laboratory using a Zooscan imaging system (Gorsky et al. 2010) coupled with ZooProcess and EcoTAXA software. The system also provides the equivalent spherical diameter (i.e., body size) of each individual organism.

The second objective will be achieved by scanning ARB larval fish samples, including identified larval cyprinids with a Zooscan imaging system. Larval fish samples with be provided by Q. Fontenot (Nicholls State Univ.), who is collecting them on separately funded work. In addition to ZooScan, larval fish taxa will be digitally photographed for archival purposes and to build a library of larval ARB fishes for future imaging projects.

For Objective #1, interim progress reports will include taxonomic-specific densities and size-distributions of zooplankton collected at each site-month combination. Reports will also feature secondary community structure metrics like diversity indices. Maps showing overall zooplankton densities and diversity will be produced for each sampling month. For Objective #2, interim progress reports will the number of samples scanned, example vignettes of larval fishes and larval carp, if they are found. The final report will include machine-readable files of zooplankton counts and densities for each sampling site-month combination, maps, original ZooScan images (.TIFF) and vignettes (.JPG) as well as digital photos (.JPG) of larval fish.

Map of project area:



Estimated Timetable for Activities"

Activity	**2023**											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Purchase Supplies												
Onboard Graduate Student												
Onboard Technician												
Onboard Undergraduate Student												
Collect Samples												
Process Samples												
Submit Progress Report												

Activity	**2024**											
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Purchase Supplies												
Identify 15 Sampling Sites												
Collect Samples												
Process Samples												
Analyze Data & Produce Maps												
Compose Final Report												
Submit Final Report												

Louisiana Department of Wildlife and Fisheries

Activities and Methods:

LDWF will provide project oversight and technical expertise. LDWF will make periodic contact with the partners via email, phone calls or in person meetings. LDWF will contract with each partner and be responsible for the all technical and progress reports to the USFWS.

Literature Cited:

Conover G, Simmonds R, Whalen M (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.

Fukushima M, Takamura N, Sun L, Nakagawa M, Matsushige K, Xie PING (1999) Changes in the plankton community following introduction of filter-feeding planktivorous fish. Freshwater Biology 42:719–735.

Gorsky G, Ohman MD, Picheral M, Gasparini S, Stemmann L, Romagnan J-B, Cawood A, Pesant S, García-Comas C, Prejger F (2010) Digital zooplankton image analysis using the ZooScan integrated system. Journal of Plankton Research 32:285–303.

Kolar CS, Chapman DC, Courtenay Jr. WR, Housel CM, Williams JD, Jennings DP (2007) Bigheaded Carps: A Biological Synopsis and Environmental Risk Assessment. American Fisheries Society, Bethesda, Maryland.

Milstein AB, Hepher B, Teltsch B (2008) Principal component analysis of interactions between fish species and the ecological conditions in fish ponds: II. Zooplankton. Aquaculture Research 16:319–330.

Sass GG, Hinz C, Erickson AC, McClelland NN, McClelland MA, Epifanio JM (2014) Invasive bighead and silver carp effects on zooplankton communities in the Illinois River, Illinois, USA. Journal of Great Lakes Research 40:911–921.

Spanbauer TL, Briseño-Avena C, Pitz KJ, Suter E (2020) Salty sensors, fresh ideas: The use of molecular and imaging sensors in understanding plankton dynamics across marine and freshwater ecosystems. Limnology and Oceanography Letters 5:169–184.

Invasive Carp Removal using Commercial Fishers

Lead Agency and Author: Louisiana Department of Wildlife and Fisheries (LDWF); Robert Bourgeois (rbourgeois@wlf.la.gov)

Statement of Need:

Increasing commercial harvest is a cost efficient and sustainable way to control invasive carp populations and limit their impacts on native fisheries. The low demand for invasive carp has resulted in low prices, and subsidies have been suggested to promote commercial harvest. Subsidies can be abused, and contract fishing may not be a sustainable solution to remove invasive carp over a long period of time (Conover et al. 2007). Subsidies require continual inputs of money and oversight from either state or federal partners. If the dockside price remains below a profitable level, then methods to make the fishery self-sustainable must be found. Utilizing gear that is more efficient at catching the target species is more appealing to the fishers in low-price fisheries. Gears which either cost less to use or have a higher catch per unit effort allow fishers to generate more profit, and make fishing low-price fisheries worthwhile. To address this issue, LDWF will provide a commercial braided gillnet to commercial fishers and pay them to test this gear in back channels and main channels of the Red and Atchafalaya Rivers. The intent is to increase the commercial harvest and management of invasive carp in LA.

Objectives:

1. Commercial fishermen will test commercial-style gill nets for efficacy in capture of invasive carp in backwater/off channel waters in the Red and Atchafalaya River basins. LDWF will use commercial trip tickets to track catch, effort, and sale price of the product. LDWF will also ask the fishermen to report their catch data back to the Department on a daily basis LDWF biologists will select a subsample of the catch and record biological data when observing the commercial fishermen.

Activities and Methods:

LDWF will use commercial trip ticket data to identify fishers who have previously fished for invasive carp in the study area. These fishers will be contacted by LDWF and provided information on the program and the application process for participation. Once applications with all the necessary information are submitted, fishers will be selected to participate at random. LDWF will provide the necessary fishing gear and pay a flat daily rate to commercial fishers for the removal of invasive carp at predetermined sample locations. Fishers will be randomly checked by LDWF personnel for compliance, proper documentation and reporting. The commercial fishers will be allowed to sell their catch or dispose of it in any legal way. LDWF will summarize the total catch of invasive carp removed from the study area waters. The commercial fishers will provide LDWF reports on gear efficiency in the areas they fished as well as any suggested improvements for the gear and/or technique. Those reports will be summarized by LDWF and provided to the commercial fishing industry.

Estimated Timetable for Activities:

Activity	**Time Period** **(Season, Month/Year)**
Contact fishers; purchase nets	January 2023
Select fishers and distribute nets	February to April 2023
Fishers start fishing and LDWF observing	April to November 2023
Complete report and summaries of reports	December 2023

Literature Cited:

Conover, G., R. Simmonds, and M. Whalen. 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.

Diets and Detectability of Invasive Carp

Lead Agency and Author: Louisiana Department of Wildlife and Fisheries (LDWF); Robert Bourgeois (rbourgeois@wlf.la.gov)

Cooperating Agencies: Louisiana State University Agricultural Center (LSU AgCenter), Louisiana State University, Southeastern Louisiana University

Statement of Need:

Invasive carp have been documented in the Red River system for over a decade. The pools formed by lock and dam structures in this system are popular recreational and commercial fishing destinations. More recently, recreational users have anecdotally reported an increase in sightings of invasive carp, and commercial harvesters continue to report carp in their catch. Therefore, to better target control efforts, a better understanding of invasive carp diets is needed to determine impacts to native fish, and given the difficulties in fishery-independent capture of adult fish and documentation of reproduction; eDNA methods offer an alternative sampling method to determine carp distributions. The information collected during this project will quantify the impacts of invasive carp on socio-culturally important fish species in the Lower Mississippi/Atchafalaya region.

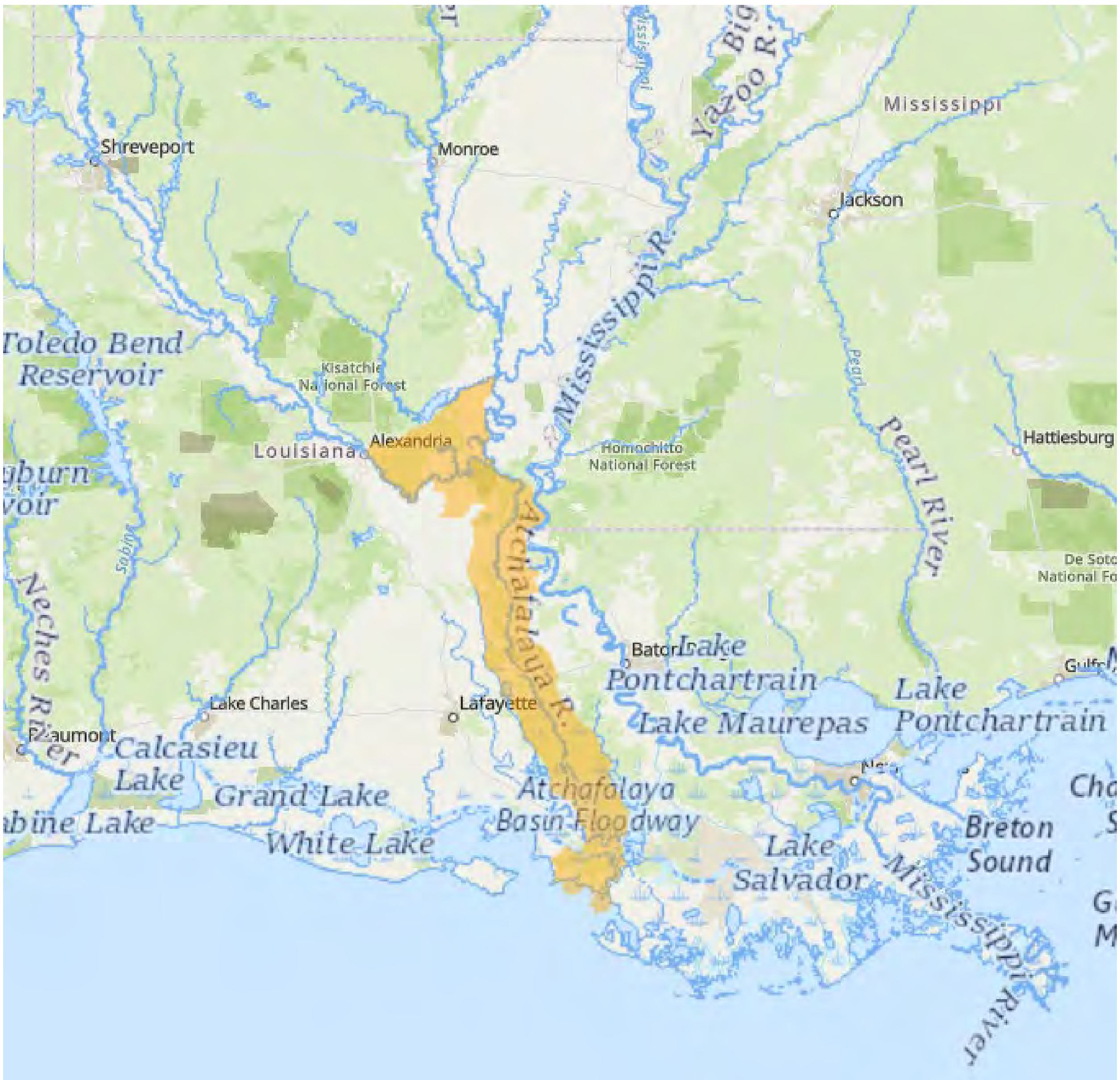
Objectives:

1. Assess methods of describing diets by DNA metabarcoding and stable isotopes on invasive carp and native fish condition and eDNA-based detectability of invasive carps, such as Black Carp and Silver Carp, in the Lower Red River and Atchafalaya River.

Activities and Methods:

This objective will focus on multiple methods of characterizing diets of invasive carp and how those diets may relate to invasive carp and native fish condition, as well as, evaluating detectability by eDNA alongside conventional capture methods. If these species are to be commercialized or utilized in other industries (e.g., fertilizer for coastal restoration plants, catfish food products), there is a need for greater autecological understanding of the fish themselves. Moreover, capture by conventional methods is difficult. Improving detectability methods to better target sampling for fisheries-independent monitoring is warranted. Therefore, we propose to quantify diets by DNA metabarcoding and stable isotopes and evaluate detectability by eDNA metabarcoding alongside electrofishing and gill netting. We will electrofish and gillnet to collect tissue samples from the Lower Red River and Atchafalaya River. Specifically, we will sample pools associated with Red River lock and dam 1 and 2 upstream to Alexandria, LA. We will sample a minimum of three times each to collect a minimum of 30 invasive carp and 30 basal food resource samples, and 30 centrarchids, as previous diets studies in Louisiana suggested some centrarchids, specifically White Crappie (*Pomoxis annularis*), may be using a significant amount of crustaceans and micro-crustaceans in their diets (total tissue/sample collection ~ 90 samples). These tissue and basal resource material samples will be analyzed for stable carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$) and sulfur ($\delta^{34}S$) isotope values and gut contents through DNA metabarcoding to describe diets using stable isotope based mixing models parametrized using priors obtained from gut content DNA metabarcoding. Invasive carp density per lake will be estimated by number of adults observed during multiple, low-speed transects. Other carp densities will be estimated from conventional gear. In addition to the above localities, personnel will sample additional localities throughout the Lower Red River and Atchafalaya River to conduct a broad scale survey of invasive carp detectability (Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*Hypophthalmichthys nobilis*), Grass Carp (*Ctenopharyngodon Idella*), and Black Carp (*Mylopharyngodon piceus*) using eDNA metabarcoding, an approach currently used in other projects. Additionally, physicochemical measurements will be taken to describe habitat variation among the sampled locations.

Map of study area



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Project Initiation	January 2023
Fish Sampling and Tissue Collection	February 2023-October 2023
eDNA Sampling	February 2023-October 2023
Stable Isotope Tissue Processing	February 2023-October 2023
Stable Isotope Tissue Analysis	October 2023-November 2023
eDNA Analysis	February 2023-November 2023
Data Analysis and Final Report Draft	December 2023

Louisiana Department of Wildlife and Fisheries

Activities and Methods:

LDWF will provide project oversight and technical expertise. LDWF will make periodic contact with the partners via email, phone calls or in person meetings. LDWF will contract with each partner and be responsible for the all technical and progress reports to the USFWS.

Control of Invasive Carp in the Arkansas-Red-White River Basin

Lead Agency and Author: Arkansas Game and Fish Commission (AGFC), Jimmy Barnett (jimmy.barnett@agfc.ar.gov)

Cooperating Agencies: N/A

Statement of Need:

Invasive Carp populations have been increasing in most of Arkansas's rivers. Bighead carp are present in the Arkansas River from the Oklahoma state line to the Mississippi River and in the White River from Batesville to the Mississippi River. Silver Carp have not been documented above Dardanelle Lock and Dam on the Arkansas River or above Dam 2 on the White River. Grass Carp are abundant in both the Arkansas and White Rivers. Black Carp have been documented in the White River up to the Devall's Bluff area. These range extensions suggest that population numbers for these species are increasing and will likely continue to increase into the future, including invasions into the larger tributaries of these rivers.

Public sightings and subsequent reports are increasing in the Arkansas and White Rivers. The increase in Invasive Carp populations is doing harm to recreation actives and is likely negatively impacting the native fishery. The task outlined in this document are designed to manage Invasive Carp and reduce Invasive Carp numbers. The AGFC will continue to use contracted removal to attempt to reduce Invasive Carp populations. Harvesting fish and the associated data collection should increase our knowledge of Invasive Carps, reduce the population size, allow us to explore possible deterrent locations, and reduce the chance for upstream range expansion.

This work plan hopes to address the following items from the Lower Mississippi River Invasive Carp Control Strategy framework. Goal 2: Monitoring and Population Status; Strategy 2.4: Implement contract surveillance or targeted Invasive carp sampling to monitor the distribution and abundance of Invasive carps. Goal 3: Population Control and Agency Response; Strategy 3.2: Utilize commercial harvest and implement contract fishing of Invasive carps to decrease densities. Strategy 3.3: State natural resources agencies will work within their authorities to increase opportunities for commercial harvest of Invasive carps. Strategy 3.5: Utilize knowledge of Invasive carp habitat requirements and preferences to target control efforts.

Objective:

1). Remove Bighead, Silver, Grass and Black Carp from the Arkansas and White Rivers.

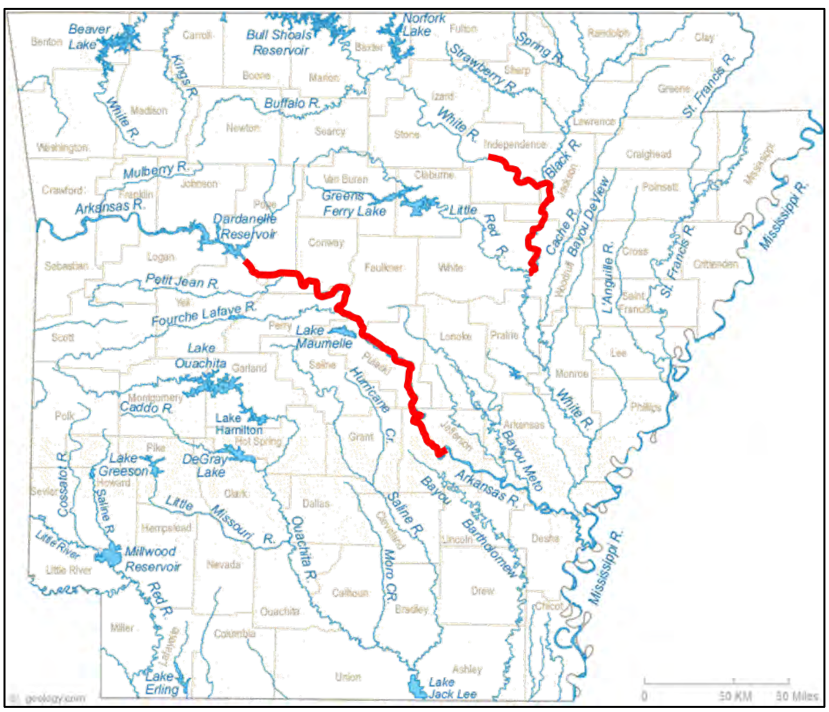
2). Development and Implementation of Invasive Carp monitoring in the Arkansas-Red-White sub-basin.

Activities and Methods:

The AGFC will use Invasive Carp funding to continue funding a full-time Invasive Carp Biologist that will oversee the removal program. Removal is being done using gill nets to catch and remove Invasive Carp from pools 4, 5, 6, 7, 8, and 9 for the Arkansas River and from Batesville downstream to the confluence of the Little Red River on the White River. The removal crew will record date, capture location, number of each Invasive Carp species captured, and tackle type used. Data on by-catch will also be collected. Netting locations will be determined from the AGFC ANS database and from information obtained from commercial fishers. All data collected should increase our knowledge of Invasive Carp and improve management and collection options in the future.

The Invasive Carp Biologist will develop a monitoring plan for juvenile Invasive Carp, continue monitoring along the leading edge of invasion and work at completing presence/absence information for the major tributaries within the current invasion front.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Arkansas River Removal	Annually
White River	When Augusta Gauge is below 24 feet.
Range Expansion Monitoring	May-June 2022
Presence/Absence	During low water
Juvenile monitoring	August-October 2022

Suppression of Bighead Carp in the Neosho River-Grand Lake System

Lead Agency and Author: Kansas Department of Wildlife and Parks (KDWP), Chris Steffen, chris.steffen@ks.gov or 785-230-2033.

Cooperating Agencies: Oklahoma Department of Wildlife Conservation (ODWC) will assist only in an advisory role.

Statement of Need:
Introduced invasive carps (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) have become established in many portions of the Mississippi River Basin (Jennings 1998; Kolar et al. 2005). The feeding habits and population densities of invasive carps cause significant ecological harm where populations become established (Schrank et al. 2003; Irons et al. 2007; Sampson et al. 2009; Solomon et al. 2015; Phelps et al. 2017). The resulting diminished opportunity for fishing (recreational and commercial), boating, and other wildlife-associated recreation causes significant negative economic impact.

Bighead carp are occasionally captured by anglers and fisheries managers within the Neosho River – Grand Lake system. This population of bighead carp represents the only known population of either species of bigheaded carps in the United States to be potentially reproducing in a reservoir completely isolated from other source populations. Pensacola Dam does not have a lock or other structure that allows for upstream migration into the Neosho River – Grand Lake system from downstream. In addition, there are two more dams downstream of Pensacola Dam (Kerr Dam and Ft. Gibson Dam) that further separate this Neosho River-Grand Lake bighead carp population from bighead carp in the Arkansas River. Resource managers are concerned that without suppression efforts that the Neosho River – Grand Lake system, as well as other invasive carp-free downstream waters, could experience the negative ecological and economic impacts documented at other locations infested with invasive carps. As the Neosho River – Grand Lake bighead carp population currently appears to be low density, there exists an opportunity to conduct management and suppression efforts now to prevent future damages.

This situation of an isolated and potentially reproducing bighead carp population provides a unique opportunity to learn about invasive carp and test and develop methods for removal or suppression of invasive carp in a reservoir system. Reservoir fisheries are incredibly important recreationally and economically in the United States. As invasive carp spread and move upstream in Mississippi River tributaries and congregate below reservoir dams, the risk of introduction of invasive carp into reservoirs (presumably through bait collection activities below dams that result in fish being released above dams) increases as does the need to learn more about how to manage invasive carp populations in reservoirs.

Very little targeted sampling of bighead carp had occurred in the Neosho River – Grand Lake system in either Kansas or Oklahoma prior to initiation of an ongoing project funded by FWS in FY 20 titled “Distribution and Population Demographics of Bighead Carp in the Neosho River-Grand Lake System to Inform Removal”. The objectives of that project are to:

1. Identify locations of presence and upstream extent of bighead carp population within the Neosho River – Grand Lake system.
2. Collect baseline population demographic information including relative abundance, age and growth, and size structure.
3. Determine broadscale movements within the Neosho River system using otolith microchemistry.
4. Identify locations within the Neosho River – Grand Lake system for containment, removal, and/or eradication efforts.

KDWP looks to build upon this previous work, particularly objective 4. The focus moving forward is to conduct suppression of bighead carp through removal with a goal of preventing bighead carp from becoming more numerous and problematic in the Neosho River – Grand Lake system and downstream waters. These suppression efforts will support Goal 3 of the Lower Mississippi River Basin Invasive Carp Control Strategy Framework to: “Reduce invasive carp densities with the ultimate goal of extirpation of invasive carps” as well as Goal 1 to: “Stop the introduction and population expansion into basin waters that do not contain invasive carps”.

Objectives:

1. Suppress bighead carp within the Neosho River – Grand Lake system by removing invasive carp

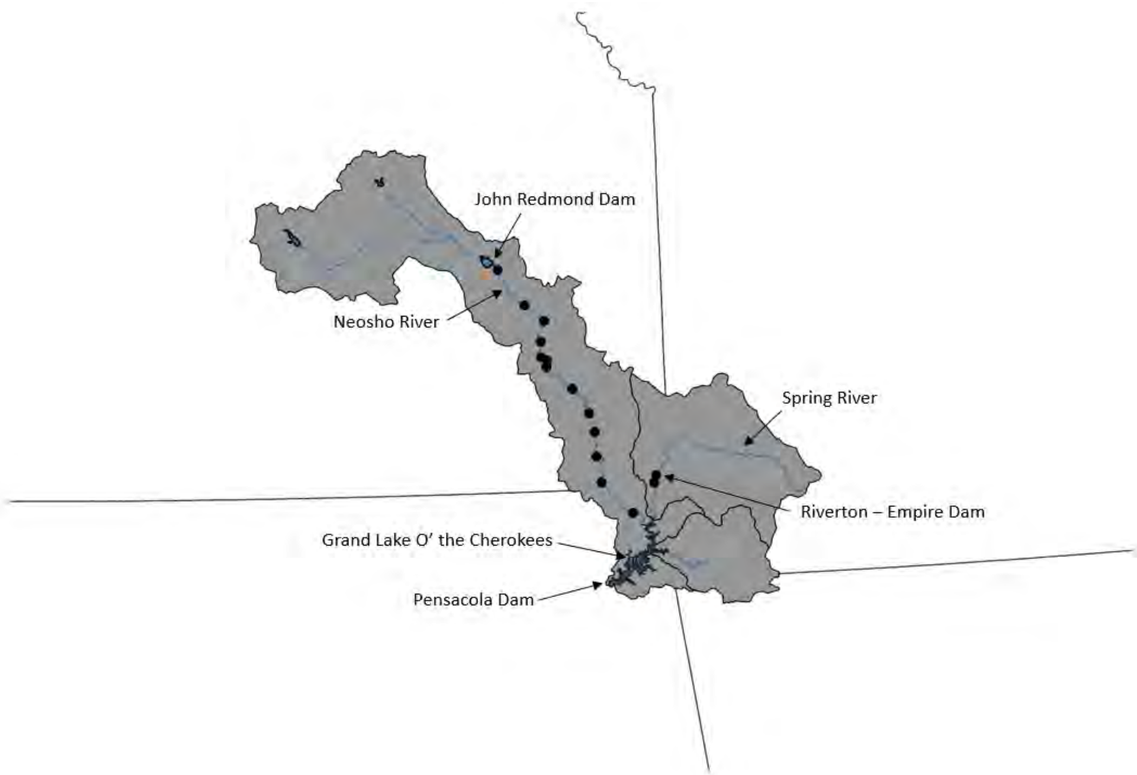
Activities and Methods:

Funds from this grant will be used to remove invasive carp from the Neosho River – Grand Lake system. We anticipate using a combination of traditional methods (various net types and configurations and electrofishing) as well as experimenting with novel gear types and techniques as we develop our knowledge of the fishery and incorporate information from our own and angler invasive carp catches. For instance, several recent angler catches have been reported using live-imaging sonar technology, which may be incorporated into our suppression efforts to increase efficiency of locating and capturing bighead carp. Suppression efforts (both traditional and novel) will require acquisition, design, and/or construction of capture gears as well as maintenance of essential fisheries management equipment such as boats and trailers.

Funds will be used to purchase necessary equipment and employ additional staff by KDWP to remove invasive carp. KDWP staff will collect demographic information on captured invasive carp. Total invasive carp removed, capture methods, and effort information will be recorded. At the conclusion of removal efforts, KDWP will prepare a final report summarizing suppression activities, successes, challenges, and recommendations for future suppression efforts in the Neosho River – Grand Lake system.

Location of actions: Neosho River Basin, extending from below John Redmond Dam to Pensacola Dam, including Grand Lake O' the Cherokees and the Spring River upstream to the Empire - Riverton dam.

Map of Project Area (unlabeled dots indicate lowhead dam location):



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
KDWP staff acquire equipment and conduct invasive carp removal efforts	October 2022 – September 2023
Submit annual technical report	March 2023
Submit annual technical report	March 2024

Literature Cited:

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Distribution and Population Demographics of Invasive Bigheaded Carp in the Lower Red River Basin

Lead Agency and Author: Texas Parks and Wildlife Department (TPWD); Monica McGarrity (monica.mcgarrity@tpwd.texas.gov)

Cooperating Agencies: Texas Parks and Wildlife Department (TPWD), Oklahoma Department of Wildlife Conservation (ODWC), Arkansas Game and Fish Commission (AGFC), USFWS Oklahoma Fish and Wildlife Conservation Office (OKFWCO); contracted researchers - Auburn Cooperative Fish and Wildlife Research Unit (ACFWRU), Texas Tech University (TTU)

Statement of Need:

Invasive carp pose significant ecological and economic threats to freshwaters around the globe, including in the Mississippi River Basin. Invasive carp research activities have primarily focused on large floodplain rivers of the upper Mississippi River basin (e.g., Illinois, Mississippi, and Missouri rivers) where substantial advances in understanding their ecology have been achieved. However, substantially less is known about invasive carp populations in tributaries of the lower Mississippi River Basin where they have been studied less frequently (Chapman and Hoff 2011; Ochs et al. 2019). Their presence has been noted across the lower Mississippi River basin for a while (Thomas et al. 2011, Rodgers 2019) and sampling and landings data suggest their prevalence is increasing in the Lower Red River basin (TPWD, ODWC, AGFC, unpublished data).

There is concern that the continued spread of planktivorous bigheaded carps will result in the degradation of aquatic food webs due to their ability to efficiently consume and alter riverine planktonic communities (Xie and Yang 2000; Lu et al. 2002; Sass et al. 2014; Collins and Wahl 2017; Collins and Wahl 2018), which are important food resources for larval, juvenile, and adult native fishes (Fletcher et al. 2019; Chick et al. 2020). Recent evidence suggests that the reduction in plankton by bigheaded carp may negatively affect native fish communities where carp populations become established (Irons et al. 2007; Solomon et al. 2016; Pendleton et al. 2017). Currently, self-sustaining populations are known to exist across the Mississippi River Basin (e.g., Tucker et al. 1996; Fuller et al. 1999). However, there is a general lack of information regarding the population dynamics of invasive carps and their effects on native fish communities of the lower Mississippi River basin, especially the Arkansas-Red-White subbasin.

Understanding occupancy by bigheaded carps in the basin, both spatially and temporally, is vital for directing management actions. There also exists a great need to understand the trajectory of the bigheaded carps' invasion to predict their influences on native fish assemblages within these large tributary basins and associated reservoirs and to collect baseline data on native fish assemblages to facilitate future assessments of impacts. Furthermore, there exists a need for a better understanding of the movements of bigheaded carps to enhance monitoring, guide any potential future control efforts, and better understand potential spawning movements.

In 2021, field sampling began for an assessment of bigheaded carp populations in the Lower Red River Basin along with characterization of the native fish assemblages with the goal of providing much-needed information about the status of these species. During that year, a total of 42 bigheaded carp were captured in the Red River and tributaries, primarily from connected oxbows, backwater locations, and tributaries. No bigheaded carp were captured in the Sulphur River although anecodotal reports and observations of these fish in the Red River near the confluence suggest they are likely present in low numbers. All bigheaded carp collected were adults, including gravid females; however, no fish younger than age 3 were collected. We were not able to successfully detect age-0 carp either due to detection, lack of spawning in 2021, or other influence such as extensive high flow events. Our 2021 sampling season may be emblematic of an extremely low capture year where adults have chosen not to reproduce and it is essential that this be a multi-year study to adequately assess the population. Sampling is currently scheduled to continue through September 2022; this work plan seeks to extend the population assessment component of the project through September 2023 to not only increase the data collection for this study overall but also to increase the likelihood of detection of both juvenile bigheaded carp and carp in the Sulphur River. This work plan also adds a telemetry component to evaluate bigheaded carp movements to enhance sampling and provide insights of relevance for any future control efforts as well as provide insights on fish movements that may be related to spawning.

During the course of the project to date, frequent, often dramatic shifts in flow regime occurred, with the river fluctuating between flood conditions that present hazardous working conditions and potential for gear loss and baseflow conditions where river access is limited.

These hydrological conditions limited gear types that could be used effectively and, at times, limited access to sampling sites. As a result, gear types and locations were refined over the course of the project with lessons learned regarding sampling in this river system. Electrofishing, including in combination with gill nets and herding, was found to be a very effective sampling method in terms of catch rates, catch precision, and fish species collected.

The objectives of this project, as outlined in this document, are aligned with and support the goals and objectives of the Lower Mississippi River Asian Carp Control Strategy Framework, particularly Goal 2 – Monitoring and Population Status and Goal 4 – Understanding Impacts and Research. This project has initiated a surveillance effort for invasive carp at a broad geographic scale across the Lower Red River Basin as well as establishing baseline data for native fish assemblages potentially impacted by invasive carp needed for future evaluations of deleterious impacts. This project addresses the general lack of knowledge of invasive carp population dynamics and native fish assemblages in this sub-basin. The intentions of this effort are to aid in early detection, assess population distribution and status, and facilitate future evaluations of deleterious impacts to native fishes. Data on invasive carp populations would also inform potential removal efforts. Collaborative efforts of multiple partners and agencies (state, federal, and university) will be implemented to accomplish the project goals and objectives. This project will provide an ongoing, coordinated effort to evaluate invasive carp distribution and status in the Lower Red River Basin that will contribute to a better understanding of the status of this species in the Mississippi River Basin as a whole.

Objectives:

1. Determine the spatial and temporal distribution and adult population demographics of invasive bigheadedcarp (Silver Carp and Bighead Carp)

2. Establish baseline native and invasive fish assemblage and habitat association data

3. Determine movement patterns of invasive carp in the Red River using telemetry

Texas Parks and Wildlife Department

Activities and Methods:

TPWD will coordinate with other agencies and universities to implement targeted sampling in the Red River and major tributaries in Texas, including the Sulphur River. TPWD will obtain and manage the USFWS grant to support this project as well as initiate and manage research contracts with ACFWRU and TTU to accomplish project objectives. TPWD may assist with sampling as time and staffing permit. TPWD will lead development of project reports in collaboration with ODWC, AGFC, OKFWCO, ACFWRU, and TTU.

Map of Project Area:

Map of project areas can be found in ACFWRU and TTU sections.

Estimated Timetable for activities

Project timetable can be found in ACFWRU and TTU sections. Timetable for report preparation will follow grant guidelines.

Oklahoma Department of Wildlife Conservation

Activities and Methods:

ODWC will coordinate with other agencies and universities to implement targeted sampling in the Red River and major tributaries in Oklahoma. ODWC may assist with sampling as time and staffing permit. ODWC will collaborate on development of project reports with TPWD, AGFC, OKFWCO, ACFWRU, and TTU.

Map of Project Area:

Map of project areas can be found in ACFWRU section.

Estimated Timetable for activities

Project timetable can be found in ACFWRU section. Timetable for report preparation will follow grant guidelines.

Arkansas Game and Fish Commission

Activities and Methods:

AGFC will coordinate with other agencies and universities to implement targeted sampling in the Red River and major tributaries in Arkansas, including the Sulphur River. AGFC may assist with sampling as time and staffing permit. AGFC will collaborate on development of project reports with TPWD, ODWC, OKFWCO, ACFWRU, and TTU.

Map of Project Area:

Map of project areas can be found in ACFWRU and TTU sections.

Estimated Timetable for activities

Project timetable can be found in ACFWRU and TTU sections. Timetable for report preparation will follow grant guidelines.

Oklahoma Department of Wildlife Conservation

Activities and Methods:

OKFWCO will coordinate with other agencies and universities to implement targeted sampling in the Red River and major tributaries in Texas and Oklahoma. OKFWCO will lead sampling in some target areas (e.g., Choctaw Creek) as time and staffing permit and contribute data from a small-scale telemetry project to ACFWRU for augmenting project data and collaborate on placement of equipment for this smaller project to the extent that project goals and objectives align/permit. OKFWCO will collaborate on development of project reports in collaboration with TPWD, ODWC, AGFC, ACFWRU, and TTU.

Map of Project Area:

Map of project areas can be found in ACFWRU and TTU sections.

Estimated Timetable for activities

Project timetable can be found in ACFWRU and TTU sections. Timetable for report preparation will follow grant guidelines.

Alabama Cooperative Fish and Wildlife Research Unit

Activities and Methods:

Objective 1: Determine the spatial and temporal distribution and adult population demographics of invasive bigheaded carp (Silver Carp and Bighead Carp)

We will sample portions of both the Red River and major tributaries of Oklahoma (i.e., lower Muddy Boggy, lower Blue River, Kiamichi River below Lake Hugo), Texas (i.e., Bois d'Arc, Pine) and the mainstem Red River of Arkansas (see map at end of section) Stream reaches sampled will be approximately 300-m in length. We worked closely with the state agencies to ensure we are sampling locations of interest. Access on extensive portions of the Red River below Texoma can be challenging; thus, sample locations were chosen to both well represent the study extent but also at locations accessed by boat or raft. Our sample sites include slackwater habitats such as forewaters, backwaters, side channels, sandbars, and pool complexes.

We will sample using electrofishing and nets during spring, summer, and autumn. Sampling during winter will be more limited because of the need to tag carp during that time (see objective 3). We will use a combination of boat electrofishing, experimental gill nets, seines, fyke nets, and hoop nets to sample different locations on the rivers. We will set 3 mini-fyke nets in <2 m of water at locations adjacent to the shoreline to target small-bodied fishes (Eggleton et al. 2010). Mini-fyke nets are commonly used to sample age-0 carp (Wanner and Klumb 2009; Gibson-Reinemer et al. 2017; Williams 2020) and sometimes capture high numbers compared to other gears (Collins et al. 2017). Next, we will use a beach seine to sample wadeable habitat across the site using a modified version of the encirclement technique (Bayley and Herendeen 2000). Transects were established throughout wadeable habitat at each site and seine hauls were completed across each transect. Seine hauls will be limited to 25-m to maintain the efficiency of the gear because longer hauls are less efficient (Lombardi et al. 2014). We will quantify total seine distance, seine width, and maximum depth for each haul to calculate the area sampled. Sub-surface 10-minute larval tows may also be used to sample for juvenile carp in representative deeper water habitats where fyke nets and seines cannot be used. Three experimental sinking gillnets (54.8-m long for mainstem and 30.5-m long for tributary sampling with 8.9, 10.16, and 10.8-cm bar-length mesh panels) and three hoop nets (4.88-m long with a 1.2-m diameter opening) will be placed throughout each site. Gillnets will be either deployed perpendicular to the shoreline or parallel if large amounts of woody debris are present near the shoreline. One gillnet will be placed near each end of the site and the third net placed in the middle of the site at the narrowest portion of the channel to restrict carp movement. Hoop nets will be placed parallel to the shoreline with the opening facing downstream in locations that include channel edges and channel crossovers but lack extensive woody debris. Both gillnets and hoopnets will be soaked for approximately 6 h. After net placement, we will electrofish using an 80-amp Midwest Lakes Electrofishing Systems shocking unit (Polo, Michigan). We will use standard AFS electrofishing settings based on conductivity. Water conductivity in the tributaries is much lower than the mainstem Red River. As such, voltage will typically be set to high range (pulsed DC current, >300 volts, 60Hz) for tributaries and low range (pulsed DC current, <300 volts, 60Hz) for the mainstem sites. Beginning at the upriver end of the site, the boat will traverse downstream in a cloverleaf pattern with electrical current applied for 10-sec with 5-sec "off peddle" intervals to increase the effectiveness of capturing Silver Carp and to attempt to drive fish into the nets and shoreline (Bouska et al. 2017). Electrofishing will continue until the entirety of the site is sampled.

Several authors have noted that combining gears and 'chasing' fish into nets often produced the best results (Thompson 2013; Bouska et al. 2017; Butler et al. 2019). One reason to combine gears is that electrofishing may be more effective on Silver Carp (Williamson and Garvey 2005), whereas use of gill nets has been one of the best approaches for sampling Bighead Carp (Garvey et al. 2012). Nets will be placed at narrow locations within the river channel to increase the likelihood of capture while electrofishing. This project, in conjunction with existing projects, will add to information on occupancy by carp in the Red River. Our goal is to document the spatial and temporal extent of carp in the Red River basin of Oklahoma, Arkansas, and tributaries in Texas.

Most captured fish (i.e., less those fish that are acoustically tagged, see Objective 3) will be sacrificed and information obtained from several structures. We will measure the total length and weight of all captured fish and determine the sex where possible (Wolf et al. 2018). Gonads of fish will be removed to later estimate fecundity (i.e., total gonad weight, and egg counts). We will also remove otoliths for later ageing and to determine recruitment patterns and estimate length at age.

An understanding of population demographic parameters is needed to assess the current status of bigheaded carp in the Red River basin. Baseline demographic data can also be used to assess future population responses to management actions (e.g., reduction efforts) and assess or model bigheaded carp responses to environmental changes (e.g., flow regime patterns) over time. We will summarize population demographics of carp using data collected during Objective 1. We will estimate catch-per-unit effort for each gear type to assess relative abundances of bigheaded carp across the Red River and tributaries. The catch per-unit-effort data will provide a baseline estimate of relative abundance to assess future changes in bigheaded carp relative abundance. We will use individual length data to summarize size structure as a means to assess potential spatial differences in recruitment or growth patterns. We will also make use of bigheaded carp hard-part structures to facilitate age determination. A subset of 10 individuals from each 10 mm TL size group will have lapilli otoliths removed (Coggins et al. 2013). We will process and age otoliths (including a second read) using light microscopes and digital photographs. The subset of aged individuals along with their respective lengths will be used to create an age-length key to predict ages from lengths of unaged individuals. Age structure data will be summarized by location (likely upper and lower portions of the basin) along the Red River.

Because bigheaded carp are highly fecund and planktivorous, they are hypothesized to compete with most all native post-larvae and fry stages of fishes (Kolar et al. 2007). Bigheaded carps may also compete for food with native adult planktivores (e.g., Paddlefish *Polyodon spathula*, Bigmouth Buffalo *Ictiobus cyprinellus*, and Gizzard Shad *Dorosoma cepedianum*; Schrank et al. 2003; Irons et al. 2007; Sampson et al. 2009). Moreover, established populations can use physical space typically occupied by native fishes and may result in species displacement leading to reductions in growth and survival.

We will focus additional sampling efforts on relatively shallow-water habitat of the mainstem Red River and major stream tributaries (i.e., especially near the confluences). Although age-0 bigheaded carp have been collected from floodplain lakes (e.g., Pegg et al. 2002; DeGrandchamp et al. 2007), most carp collected from the Illinois River used the mainstem channel rather than floodplain lakes during their early life history (Norman and Whitledge 2015). Because harvesting all sizes of carp is necessary to achieve population collapse (see Tsehaye et al. 2013), we need to understand nursery habitats of bigheaded carp in the Red River basin. This information is critical to both understanding critical removal areas (spatially and temporally) and it is also informative to understanding how changes in resources and biomass in these habitats might affect native fishes in this basin. If juveniles are detected in the study area, we will assess these variables. Lastly, identifying areas that promote juvenile survival of invasive bigheaded carp can be used to guide future management actions (e.g., targeted removal efforts of invasive bigheaded carp while minimizing harm to native fishes).

We will sample low-velocity habitats associated with the mainstem and larger tributaries of the Red River and tributaries. Sampling for invasive bigheaded carp will begin approximately June and continue through September (i.e., depending on river conditions). Larger bigheaded carp typically spawn before smaller individuals (Hintz et al. 2017); thus, sampling as early as June will allow us the opportunity to capture very small juveniles that may be hatched early in the spring. We will sample areas around sandbars, backwater habitat, pool margins, and edges using a combination of seines, fyke nets, and electrofishing. Because the habitat is both complex and diverse within the Red River and tributaries, we will use a combination of habitat classification used in sand bed and gravel-bed streams (e.g., riffles, runs, pools, chutes, slackwater, ripples, dunes, sand bar heads and tails, backwater, etc). Our classifications will be collapsed into groups of similar mesohabitat character (e.g., ripples and riffles are similar in slope and water depth but differ via dominant substrate). Habitat conditions at sampling locations with be quantified at the mesohabitat and reach scales. All bigheaded carp juveniles captured will be removed from the system and otoliths retained.

If juvenile bigheaded carp are captured, we will remove lapilli otoliths from up to 20 individuals from each occupied site on each sampling date for aging. Otoliths will be mounted in thermoplastic cement, placed on microscope slides and sanded using 1,000 grit sandpaper and (or) diamond filament paper. Ring counts on otoliths will be performed by two independent readers using a compound microscope at 100× magnification. If otolith ring counts differ by more than 10% between readers, they will be discarded. We will estimate the reproductive time period of juvenile carp.

Objective 2: Establish baseline native and non-native fish assemblage and habitat association data

Because relatively little native fish sampling has occurred in the Red River basin in recent years, we will determine habitat associations and large river assemblage structure during sampling for Objective 1. Habitat will be related to channel unit and reach structure and be tributary specific. All native warmwater fishes sampled will be identified and native fishes released unless identification needs to be confirmed in the laboratory. Sampling will be similar to described above for carp sampling (i.e., a variety of gears will be used including mini-fyke nets, seining, gill nets, electrofishing) though electrofishing settings may differ (depending on conductivity and power).

Objective 3: Determine movement patterns of invasive carp in the Red River using telemetry

Our objective is to determine movement patterns of bigheaded carp in the Red River. We will primarily focus our efforts during the spawning season but also some of the overwintering period. Our efforts will include a combination of active tracking to gain perspective on finer spatial and temporal patterns and passive tracking to provide additional information on coarse scale movements and the timing of occupancy in major tributaries. These data will be useful for improving the timing and allocation to sampling effort across the basin as well as potentially providing insights on movement of fish to potential spawning areas.

Fish tagging

Tagged fish using acoustic transmitters can be individually identified and located either actively (described below) or with passive receivers. Both methods of tracking will be used in this study with the passive receivers used primarily to determine if and when tagged fish move into the tributaries.

We will tag up to 50 fish during late autumn/winter 2022 and 2023. Captured fish will be sedated using an electrofishing sedation table as it prevents use of chemical sedation and allows for rapid recovery. We will make an incision on the ventral side of the fish, posterior to the left pelvic fin and anterior to the anal vent. The incision will be approximately 3 times the transmitter diameter, along a descaled area (3-4 rows) to allow for transmitter implantation (Lubejko et al.

2017). An acoustic transmitter (V16T-4X, InnovaSea Inc.) will be inserted into the abdominal cavity and interrupted absorbable sutures will be used to close the incision (2-0 PDO, 3/8 reverse cutting needle; Unify, AD Surgical, Sunnyvale, CA, USA). The tag burden will be < 2% of body weight. Fish with implanted transmitters will also be fin clipped for visual identification if captured and Passive Integrated Transponder tags will be inserted.

We will determine the sex of each fish based on macroscopic observation of the gonads (if possible). Following surgery and morphometric measurements, fish will be released in a slow-moving environment. Because others have expressed concern related to “fallback” (Frank et al. 2009; Vallazza et al. 2021), we will exclude all fish detections for 14 days following surgery.

Active Tracking

We will actively track tagged fish seasonally (spring, summer, winter) beginning late February 2023 through May 2024. All tracking will be conducted during the day (~0700-1900 hours) and three river sections will be tracked every 1-2 weeks from approximately Feb-July, and December-January. We will conduct tracking by boat. We will move in a downstream direction covering each study reach. Because spawning movements are of primary interest, active tracking effort will be greatest during the spawning season than during the non-spawning season. Low discharge during the non-spawning season reduces the navigability of the streams, resulting in a greater dependence on SURs. During active tracking, we will tow a hydrophone behind our watercraft at 7 – 9 km/h (i.e., slightly faster than the current) while we scan acoustic frequencies. Upon identification of a tagged carp, we will record a GPS location and the date. We will also record several habitat characteristics at each fish location.

Passive Tracking

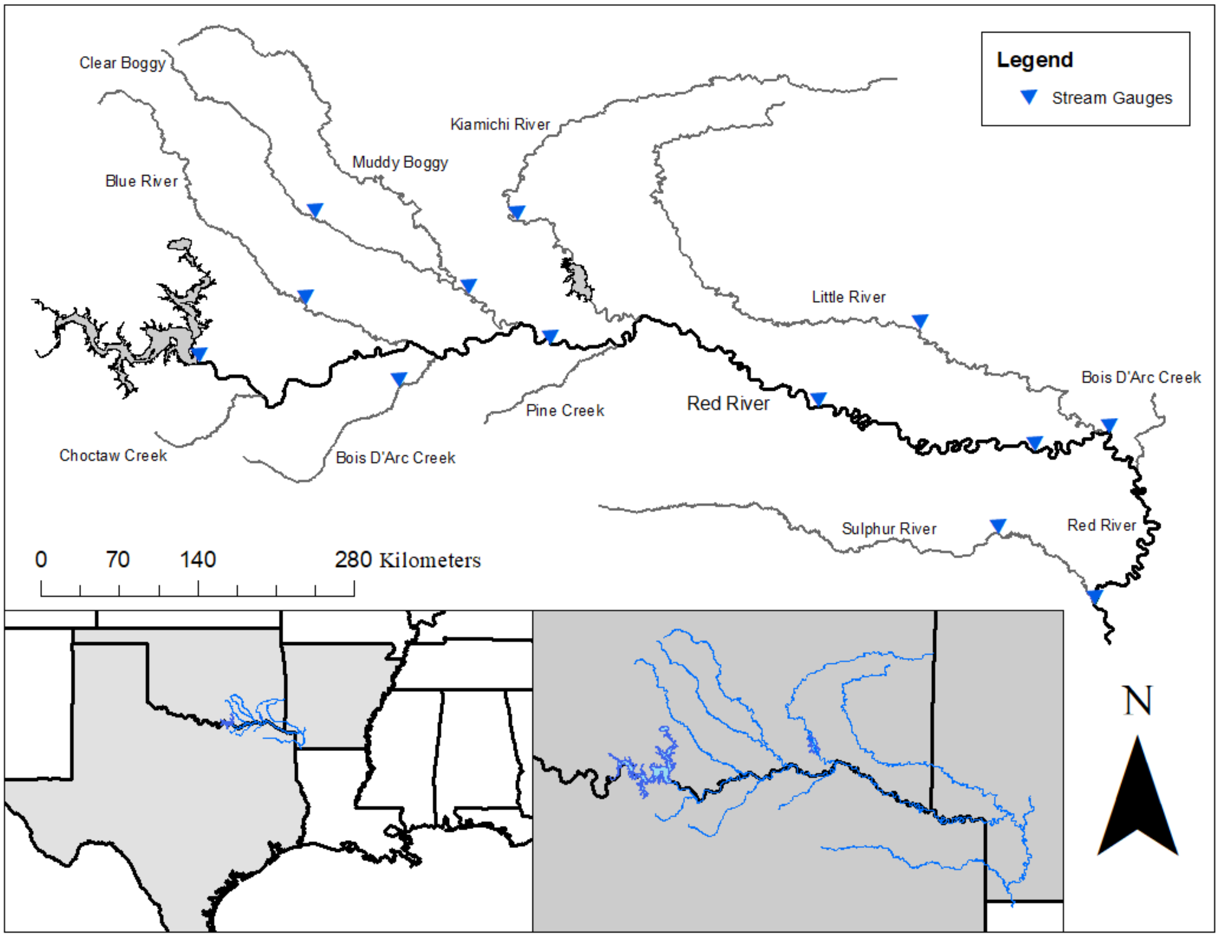
Four receiver stations (2 receivers near each station) with fixed-position antennas will be used to help monitor tagged fish in the study area. Each receiver station (4 stations with two receivers at each) will be placed in relative proximity to allow for information on the direction of fish travel (and increase detection probability given the width of the river). We will anchor two passive submersible ultrasonic receivers (SUR) (VR2Tx InnovaSea) in four locations as agreed upon with the state agencies. Paired passive receivers will be placed approximately 1-3 km apart at each station to prevent simultaneous passive detections of an individual thereby doubling the probability of an individual being detected at least once. The acoustic stations continuously scan and record the frequency, identification number, and time stamp of each detection. Because the Red River is a difficult environment in which to work, we budgeted for two extra receivers (based on previous experience working on this river). Data collected by the passive receivers will be downloaded approximately every 6-8 weeks. If high river conditions are predicted, the passive receivers will be removed from the river in an attempt to prevent gear from being washed away.

Geographic location

We will conduct active acoustic tracking on three reaches in the humid (114 -140 cm of rain annually, Woods, 2005) lower Red River catchment. The upper Red River draining 87,498 km2 was impounded to create Lake Texoma and is operated for flood control and hydropower generation. Downriver of the dam, the lower Red River flows an additional 333 km along the Oklahoma-Texas border before entering Arkansas. The lower Red River remains free flowing until it reaches a series of locks and dams in Louisiana. Although we assume carp can move freely across the mainstem Red River, we cannot logistically track this area during regular tracking events. Instead, we will focus on three active tracking reaches that will be determined based on agency consultation, access, and safe river conditions.

Passive receivers will be placed at other locations to evaluate the use and timing of migrations into tributaries or other key features along the Red River. The three major tributaries to the lower Red River in OK are the Blue, Muddy Boggy and Kiamichi rivers and drain 1,769, 6,313, and 4,719 km2, respectively. The respective major tributaries join the Red River approximately, 91, 137, and 196 rkm below Denison Dam. Approximately 50 km upstream in the Blue River, carp movement is likely obstructed by a low head dam, whereas the mainstem Muddy Boggy River is free flowing to the headwaters except for a small dam on one of the minor tributaries. The Kiamichi is also dammed but the tailwater area is a place where carp have been captured in multiple years. Therefore, placing passive receivers near the confluence of the Muddy Boggy and Kiamichi rivers seems prudent. We will also place passive receivers near the other key locations as identified by our stakeholder group while avoiding redundancy with the UWFWS activities.

Map of Project Area:



Study area of the Red River basin and major tributaries where carp occupancy, demographics, and movements will be determined.

Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Targeted Bigheaded Carp and Native Fish Sampling – Red River and tributaries in OK, TX & AR	Fall 2022, Winter 2022-2023 (limited), Spring/Summer 2023
Bigheaded Carp Telemetry – Red River and tributaries in OK, TX & AR	Fall 2022, Winter 2022-2023 (limited), Spring/Summer 2023
Project Annual Technical Report	February 2023*
Bigheaded Carp Telemetry – Red River and tributaries in OK, TX & AR	Fall 2023, Winter 2023-2024 (limited), Spring 2024
Project Final Technical Report	Fall 2024**

*Anticipated timeline; will be based on grant requirements

**Following completion of telemetry project

Texas Tech University

Activities and Methods:

Objective 1: Determine the spatial and temporal distribution and adult population demographics of invasive carp (Silver Carp and Bighead Carp) (1 yr. project continuation)

Sampling design

Sampling on the Sulphur River in Texas will occur at multiple sites along the Sulphur River waterway between Wright Patman Lake and the Arkansas border. Sampling on the Sulphur River in Arkansas will occur from the Texas border to the confluence with the Red River and sites just upstream and downstream on the Red River. (Figure 2). Bigheaded carp will be collected via a suite of sampling gears to track seasonal and annual changes in the presence and numbers of juvenile and adult life stages. The sampling required to achieve this purpose will entail repeated trips to the Sulphur River to deploy gears and collect data. Sampling locations along the Sulphur River were selected that maximize the likelihood of capturing bigheaded carp (e.g., tailwaters, connected oxbows, pools, river confluence). Additional sampling will occur within Wright Patman Lake to evaluate whether bigheaded carps may be present as a precautionary measure.

Monitoring data collected during the project will be used to evaluate the spatial and temporal extent of bigheaded carp and other native fishes within the study area. Study sites were identified as potential locations to deploy multiple gears. Gears will be distributed longitudinally to avoid trap interference (i.e., a trap affects the catch rate of another trap). The presence and abundance of bigheaded carp will be used to determine whether reproduction is likely within the Sulphur River or whether they migrate from the Red River. Information including body sizes, sex ratios, and reproductive status will be used to characterize attributes of their population. In addition to assessing bigheaded carp, catches and body condition of native fishes will provide crucial baseline information (e.g., relative abundance, body condition, assemblage composition) of the native fish community of the Sulphur River.

Fish sampling

Unlike the Mississippi and its large tributaries, the Sulphur River is comparatively smaller in channel width, discharge, and other factors. Consequently, gears that perform well in large rivers do not necessarily translate to mid-sized rivers like the Sulphur River. Recent analyses indicate that electrofishing and gill/trammel netting to be the most effective means of capturing bigheaded carp (Collins et al., *unpublished data, in review*). Tailwater and confluence habitats will be prioritized and targeted to increase the likelihood of capturing bigheaded carp in the Sulphur River. In large rivers with complex river-floodplain configurations, bigheaded carp rapidly move amongst habitats, making their capture more difficult. In smaller systems like the Sulphur River, such lateral movements of bigheaded carp are limited due to the availability of side channels, floodplain lakes, etc. A combination of gill nets, pulsed-DC electrofishing, and herding methods will be used to capture bigheaded carp and other fishes in the Sulphur River. Gill nets are commonly used by commercial fishermen and agency biologists in the upper Mississippi River basin to capture Bighead Carp (ACRCC 2016). Boat electrofishing is commonly used by agency biologists.

Pulsed-DC boat electrofishing (Smith-Root Inc, Apex) will be conducted at each sampling location (minimum 3 transects per site) to capture fishes. DC electrofishing has been the most effective means of fish sampling bigheaded carp across the Mississippi River basin

(Collins et al. 2015; Collins et al. *in review*). Moreover, it is the most efficient means of sampling fishes in the Sulphur River during both flood and base flow conditions. Juvenile bigheaded carps will be sampled concurrently with adults via pulsed-DC electrofishing. Pulsed-DC boat electrofishing has been shown to be an effective means at capturing juvenile Silver Carp (Culver and Chick 2015; Collins et al. 2017). Detection of juvenile bigheaded carp would indicate the potential for bait bucket introductions, which would alter how these carps are managed (e.g., public outreach & education) to reduce the spread of invasive fishes in Texas (Rodgers 2019, see Goals 1 and 2, pp 9-12). To date, no juvenile bigheaded carp have been collected in the Sulphur River. However, we capture similarly sized native species while electrofishing. Electrofishing settings have previously ranged from 100-375 volts, 25% duty cycle, 25% frequency, 60 pulses/s, with amps ranging from 4-10. Voltages vary based on river conductivity. Each transect consists of 10 minutes of pedal time. Each transect spans all habitats of the river channel. In doing so, we collect fish near the riverbank, channel margin, and thalweg in an integrative manner.

Entanglement gears are effective at catching carp (Collins et al. *in review*). However, gill and trammel nets are not always suitable for sampling during flood conditions because drifting logs can quickly destroy them. Because of the potential for sustained flood stages in the Sulphur River, deployment of gill nets is relegated to non-flooding conditions. Recent methodological developments have shown that hybrid herding approaches can be effective at catching and detecting bigheaded carps (Butler et al. 2019; Ridgway et al. 2021; Collins et al. *in review*). Herding approaches use sound or electricity to drive fish into a gill net. Herding has a few advantages and disadvantages. The gill net is deployed for <10 mins during herding whereas traditional gill net sets can sit for >2 hours (4-8 hours is common). Because of the shorter duration in the water, there is the reduced chance that the net will be destroyed by drifting logs. However, the shortened duration may limit gill net effectiveness. When flow conditions permit, experimental AFS gill nets (3-8 net sets per sample period; 4-hour deployment; monofilament) with large mesh panels will be deployed when river hydrology and habitat availability allow. Gill nets will be spaced no less than 250-m apart.

Surface waters will be collected (100 ml; 4 subsamples per site) to determine the concentration of phytoplankton at sampling locations. Samples will be preserved for future analysis to determine spatial patterns of plankton in relation to the dam and examine data in relation to relative abundance of bigheaded carp (Williamson and Garvey 2005). Data may be used as explanatory covariates to analyze catch rates of bigheaded carp in gears along the Sulphur River to assess whether catch rates or community composition are influenced by food availability.

Data analyses

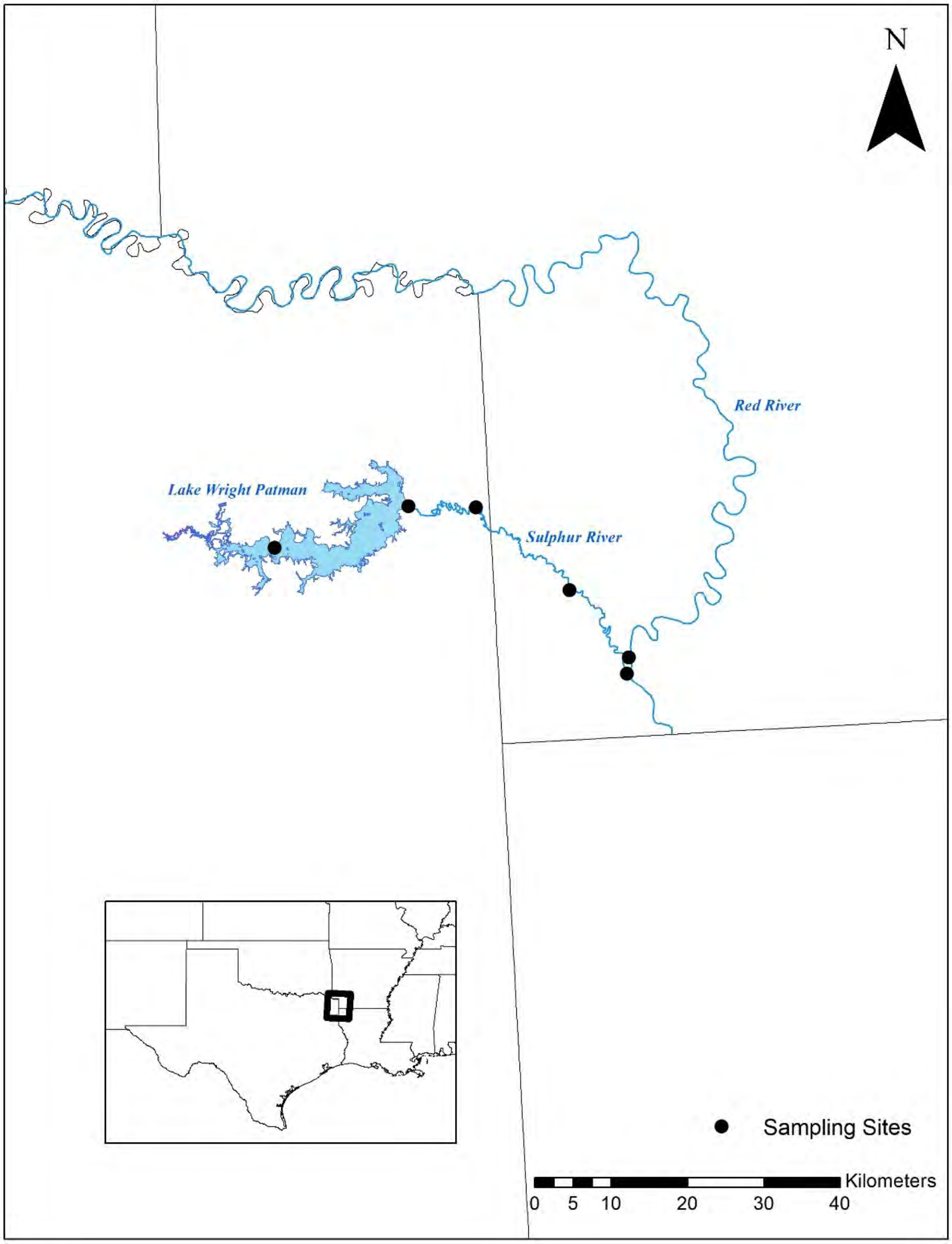
Catch rates of bigheaded carp and other fishes will be contrasted among sampling approaches to determine the most effective gear. Seasonal and annual changes in the fish assemblage will be monitored to establish an ecological baseline. Occupancy models will be developed (presence/absence at sampling sites) to estimate detection probability of bigheaded carp and other common native fishes. Models will be used to estimate and compare detection probabilities among sample approaches. Covariates will include river hydrology and chlorophyll-*a* to determine how environmental conditions affect detection of differing species. Moreover, data from Year 3 will be combined with that of Years 1 and 2 to evaluate interannual variation in the detection of invasive and native fishes. Seasonal and annual changes in the Sulphur River fish community will also be examined using non-metric multidimensional scaling (NMDS). Environmental variables (e.g., river hydrology, phytoplankton) will be included to determine whether the fish community changes based on flooding and basal food resources.

Bigheaded carp will be processed for several metrics. Body length (mm) and weight (g or kg) will be collected to determine body condition and population size structure (e.g., length-frequency histograms; mean body size). Estimates of bigheaded carp body condition will be compared with bigheaded carps from other locations and serve as a baseline. Body condition is affected by density-dependence, so rapid changes in body condition could signal a rapid increase in bigheaded carp populations. Bigheaded carps will be dissected to determine an individual's sex and population sex ratio. Gonads will be removed to determine weight and GSI values. Gonads will be weighed (g), and GSI (GSI = 100 $*$ gonad weight [g]/body weight [g]) will be calculated for males and females (Crim and Glebe 1990). Developmental stages of both genders will be assessed for collected individuals to determine reproduction potential within the Sulphur River. Such assessments can be used to identify whether females spawned once, spawned multiple times, or reabsorbed their eggs (Papoulias et al. 2006, Camacho 2016). Total numbers of eggs will be determined based on density-weight relationships for each female captured. The ova from a 1-g sample of the ovaries will be enumerated and multiplied by the weight of both ovaries to estimate fecundity (Crim and Glebe 1990). Findings will be scaled to the population to determine the potential reproductive output by the population. Otoliths will be extracted and archived for future microchemistry analysis to determine the origins of bigheaded carps and their coarse-scale movements through the Lower Mississippi River Basin. Liver tissue from each bigheaded carp will be collected, preserved in 100% EtOH, and archived for future DNA analysis to assess hybridization within the sampled population and genetic variation across the Lower Mississippi River Basin.

Objective 2: Establish baseline native and invasive fish assemblage and habitat association data (1 yr. project continuation)

Because relatively little native fish sampling has occurred in the Red River basin in recent years, we will determine habitat associations and large river assemblage structure during sampling for Objective 1. Habitat will be related to channel unit and reach structure and be tributary specific. All native warmwater fishes sampled will be identified and native fishes released unless identification needs to be confirmed in the laboratory. Sampling methods and data collected for native fish will be as described above in Objective 1 for carp sampling.

Map of Project Area:



Sulphur River invasive carp sampling sites in Texas and Arkansas.

Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Targeted Bigheaded Carp and Native Fish Sampling – Sulphur River and tributaries in TX & AR	Fall 2022, Spring/Summer 2023
Project Annual Technical Report	February 2023*

*Anticipated timeline; will be based on grant requirements

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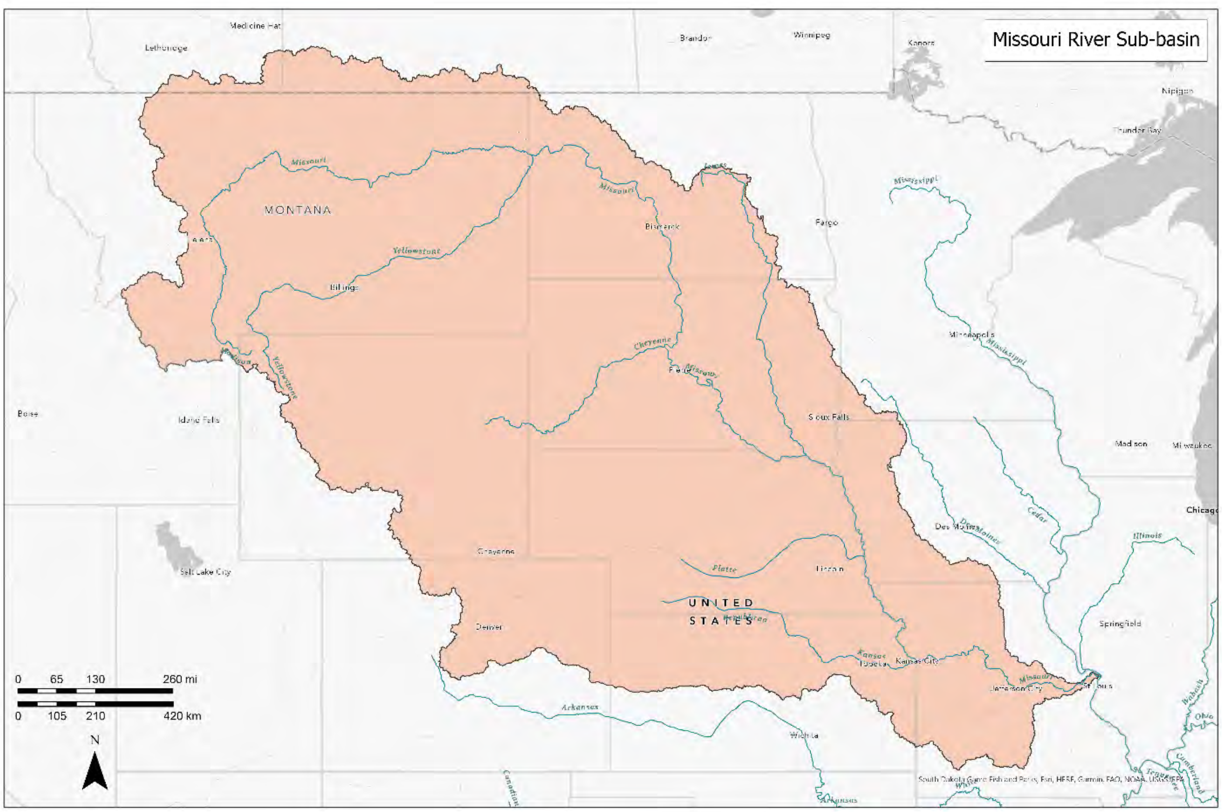
Missouri River Sub-Basin Invasive Carp Partnership

The Missouri River Sub-Basin (MOR) comprises one-sixth of the continental United States and is surpassed in area only by the greater Mississippi River Basin in the U.S. It includes all or parts of 10 states and two Canadian provinces. Recognizing the increasing threat of invasive carp in the MOR, the Missouri River Natural Resources Committee (MRNRC) hosts an Asian Carp Technical Committee (aka, Missouri River Sub-Basin Invasive Carp Partnership) made up of representatives from ten states in the basin and five federal agencies (Figure 3). The partnership finalized the *Missouri River Basin Asian Carp Control Strategy Framework* to minimize the social, ecological, and economic impacts of invasive carp to the MOR. The Framework applies the National Plan at the Missouri River sub-basin level.

Fiscal year 2022 was the third year of USFWS funding invasive carp management and control in the MOR as part of National Plan implementation. The partnership developed five projects addressing the highest priorities: defining the geographic extent and population demographics of invasive carp populations within the sub-basin; understanding bigheaded carp movements and habitat use in tributaries; investigating management actions to contain and reduce populations; research to inform communication and outreach; and assessing invasion risk in uninvaded portions of the Basin. The five projects resulted in $1.3M in grants allocated to five of the ten states in the Missouri River Basin.



Define the spatial distribution and population demographics of invasive carp populations and the associated fish community in the Missouri River Basin

Lead Agency and Author: Kirk Steffensen, Nebraska Game and Parks Commission, kirk.steffensen@nebraska.gov

Cooperating Agencies:

- Iowa Department of Natural Resources (IA DNR); Iowa State University (ISU)
- Kansas Department of Wildlife and Park (KDWP), Emporia State University
- Missouri Department of Conservation (MDC)
- Nebraska Game and Parks Commission (NGPC); University of Nebraska-Lincoln (UNL)
- North Dakota Game and Fish Department (NDGFD)
- South Dakota Department of Game, Fish, and Parks (SDGFP); East Dakota Water Development District (EDWDD); University of South Dakota (USD), South Dakota State University (SDSU), University of Idaho, Kennedy LIFE Lab
- U.S. Fish and Wildlife Service (USFWS)
    - Columbia Fish and Wildlife Conservation Office
    - Bozeman Fish Health Lab
    - Missouri River Fish & Wildlife Conservation Office
    - Great Plains Fish & Wildlife Conservation Office

Statement of Need:

The USFWS and the Aquatic Nuisance Species Task Force, in collaboration with multiple stakeholders, released a national invasive carp management and control plan (National Plan; Conover et al. 2007) to limit ecological and economic problems posed by these species. Despite tremendous progress towards achieving National Plan goals, there remains great need to develop metrics to quantify the success of invasive carp management and inform control efforts. Defining the spatial distribution and demographics of invasive carp populations in the Missouri River Basin is fundamental to prescribing and assessing management actions as outlined in the National Plan Goals and Strategies related to prevention, containment and control, and extirpation. In addition, understanding the status and trends in abundance, size or age structure, maturity schedules, or fecundity of fish in a population are central to informed decision making.

Currently, more information on the abundance and distribution of Silver *Hypophthalmichthys molitrix*, Bighead *Hypophthalmichthys nobilis*, and Black Carp *Mylopharyngodon piceus* is needed to inform the strategic placement, development, and assessment of management actions across the Missouri River Basin as population assessments provide baseline population data to inform management decisions. Early detection sampling is used to detect new introductions and the spread of existing populations and can provide managers with critical information about the speed and mechanisms of spread. By detecting new populations early, actions can more effectively be implemented to control the population.

Missouri River Basin partners identified tributaries of the Missouri River as high priority areas as they provide access to state inland waters of high recreational, economical, and ecological value. The Platte River is a major tributary to the Missouri River and Nebraska’s largest river system. The Platte River contains multiple large tributaries and a network of diversion canals for an array of water usage. Furthermore, the Platte River does not contain large main-stem impoundments to block fish movement and may act as a source for both native and non-native fishes to the Missouri River. As such, understanding the population characteristics and recruitment of Silver Carp and Bighead Carp within the Platte River system is imperative to prevent further expansion and mitigate the risks to human interests and the native fish communities.

Larval invasive carp have been documented and collected at several locations throughout their invaded range. However, juvenile invasive carp are rarely captured, and little is known about nursery habitats that juveniles occupy and how they support recruitment to the adult stage. Utilizing tools to identify natal origins can help identify spawning and recruitment sources and management actions targeting this behavior and life stage. Monitoring provides empirical data about population changes over time and space, the ability to compare multiple populations, and a basis to evaluate the efficacy of management actions. Furthermore, historical and current information on select species and fish communities can identify species that may be negatively impacted by invasive carp and priority areas where invasive carp may be having a greater impact while providing metrics to measure the success of future management actions. These efforts may require long-term commitments of 3 to 10 years, depending on the complexity and scope of the situation.

Too effectively guide efforts to manage and control invasive carp in the Missouri River Basin, managers must understand the factors influencing population dynamics. Examples of population variables that should be accounted for in management actions include numbers and locations of distinct populations within the basin, population sources and sinks, and movement into, out of, and within the basin. Technologies to answer questions about fish distribution and abundance are constantly advancing, and it would benefit managers to understand and implement emerging technologies that provide accurate and precise information. Environmental DNA (eDNA; presence/absence of DNA from the target species in the environment), otolith microchemistry, and hydroacoustics are examples that are of interest to Missouri River Basin partners. The scope of this work and the depth of specialized knowledge will require a collaborative effort among partners to develop and implement effective protocols using these tools to answer high priority questions.

Otolith microchemistry is an important tool for determining the natal origin of fishes from environments with distinct water chemistries (Campana et al 2000; Gibson-Reinemer et al. 2009; Zitek et al. 2010). An important first step is determining the variation in water chemistry among water bodies of interest. Specifically, the trace elements of barium (Ba), strontium (Sr), calcium (Ca) along with oxygen (^{16}O, ^{18}O) and strontium (^{86}Sr, ^{87}Sr) isotopes are commonly used to differentiate between waterbodies. Once the unique water chemistries are determined, signatures within fish tissues such as otoliths can be assessed for the same trace elements and isotopes to inform where a fish spent portions of their life history, including natal origins. This technique may be best applied over a large spatial scale where differences in water chemistry are evident and can retroactively determine where fish from multiple year classes captured in a single sampling season spent time, informing habitat use, movement, and, subsequently, future management actions.

The tasks outlined in this document represent development of invasive carp monitoring in the Missouri River and its tributaries. Collaborations between the U.S. Fish and Wildlife Service, the Missouri River Basin states, universities, and other state partners will work towards the objectives listed below.

Objectives:

Objective 1: Determine the geographic extent (presence/absence) of Bighead, Silver, and potentially Black Carp throughout the Missouri River Basin to evaluate current barriers, prevent further range expansion, and identify potential control/removal opportunities (Agencies involved: SDGFP, NGPC, USFWS).

- Sub-Objective 1: Develop a Missouri River Basin Invasive Carp Genetics Team to increase understanding of environmental DNA (eDNA) as a tool for the detection and measurement of invasive carp populations, host informational webinars/workshops from experienced labs to provide education and learning opportunities for labs in the Missouri River Basin, and develop a standard framework for field collection, laboratory analysis, and results communication.

- Sub-Objective 2: Implement a strategy for information sharing on the methods needed to successfully analyze eDNA samples for invasive carp primers, coordinate efforts with USFWS Bozeman Fish Health Lab in Bozeman, MT & Whitney Genetics Lab in La Crosse, WI, to integrate methods with partners already using eDNA for detection of invasive carp.

- Sub-Objective 3: Determine the feasibility and efficacy of eDNA analysis in these aquatic systems to detect the presence of invasive carp in water and/or sediment samples across various sized drainage areas.

- Sub-Objective 4: Determine the presence/absence of Bighead and Silver Carp and investigate the feasibility of using eDNA for detecting Black Carp in the Missouri River and its tributaries concentrating above and below fish movement barriers to better understand invasive carp distributions.

- Sub-Objective 5: Develop an approach pairing fishery sampling and eDNA to detect Invasive Carp in the Missouri River Basin. These protocols may be used to inform future assessment of prevention and deterrents in areas without established populations.

Objective 2: Characterize spatial (tributaries longitudinally distributed in the Lower Missouri River) and temporal (seasonal and annual) patterns in the Silver and Bighead Carp population demographics (e.g., size structure,relative abundance, and recruitment) while developing standard operating procedures that are specific for the lower Missouri River Basin to prescribe and assess population control measures (Agencies involved: NGPC, ISU, MDC, USFWS).

- Sub-Objective 1: Evaluate a suite of gears and sampling logistics to determine an effective and efficient method to sample all sizes of Silver and Bighead Carp in a variety of aquatic systems.

- Sub-Objective 2: Determine the size distribution, relative abundance, and other population characteristics of the Silver and Bighead Carp populations in a variety of aquatic systems to help identify areas where population control measures can be implemented.

- Sub-Objective 3: Pair fishery sampling efforts with and eDNA sampling sites to validate eDNA results.

Objective 3: Characterize the historic and current fish community in the inter-reservoir reach and the Lower Missouri River to assess the impacts to the fish community pre- and post-invasion as well as provide baseline data for comparison to prescribe and assess future management actions. (Agencies involved: NGPC, KDWP, MDC, USFWS).

- Sub-Objective 1: Deploy fish community assessment gears in the inter-reservoir reach and, in the lower Missouri River, use the data collected from Objective 2.1

to characterize the fish community and select native fish species (e.g., Paddlefish, buffalo species, shad).

- Sub-Objective 2: Determine the size distribution, relative abundance, and other population characteristics of select fish species to help identify potential differences between areas with and without established invasive carp populations.

- Sub-Objective 3: Utilize historic fisheries data (i.e., Pallid Sturgeon Population Assessment or Benthic Fishes) to determine changes in the associated fish community diversity, richness, size distribution, relative abundance, relative condition, and other population dynamics parameters.

- Sub-Objective 4: Empirically examine direct and indirect effects of invasive carps on native species and food-webs through use of stable isotope analysis of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) to examine seasonal food webs of high, low, and zero invasive carp density sections of the Kansas River.

- Sub-Objective 5: Compare Kansas River isotope results with similar studies in other river systems (Wabash and Illinois Rivers; Meta-analysis).

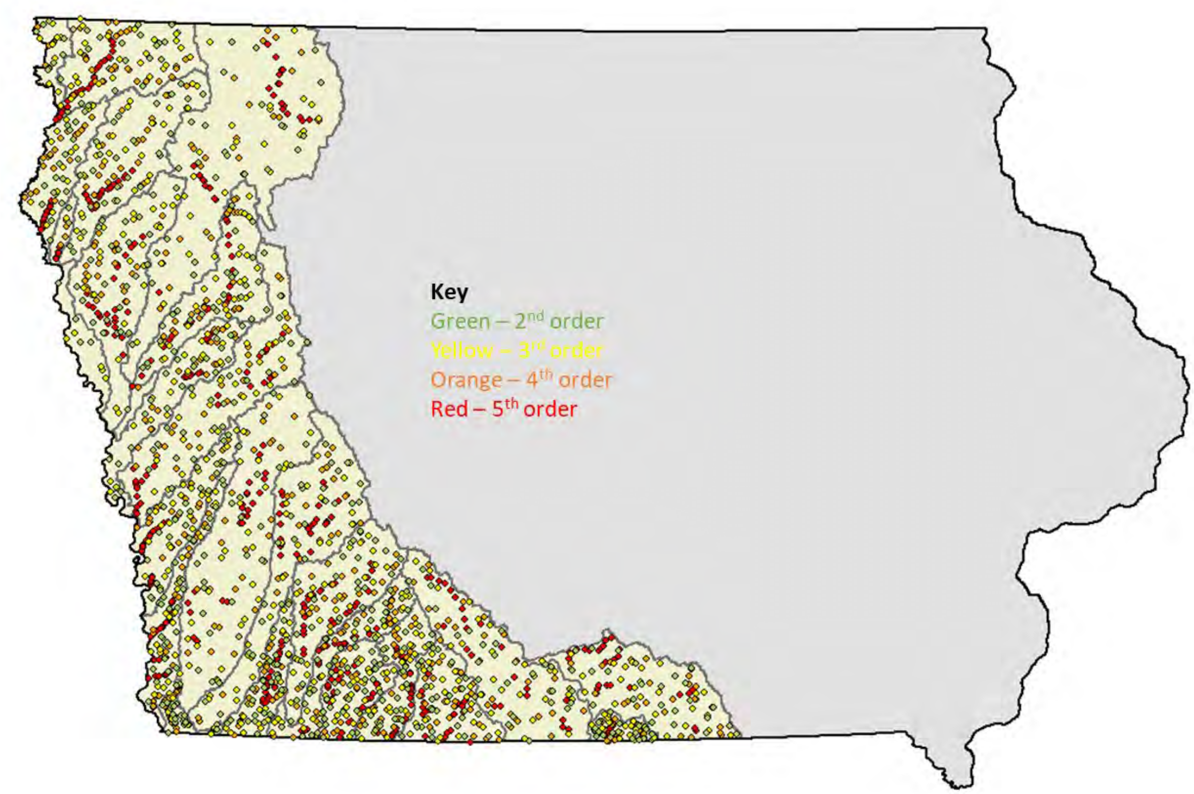
Agency: Iowa Department of Natural Resources (IA DNR) and Iowa State University (ISU)

Activities and Methods:

Objective 2: We will sample larval fishes throughout the Little Sioux River to evaluate when, where, and under what conditions Invasive carp reproduction occurs. We will conduct larval tows with an ichthyoplankton net (0.5 m diameter) with a General Oceanics flowmeter suspended in the mouth to estimate the volume of water filtered during each tow. After each tow, ichthyoplankton net contents will be rinsed toward the cod end, placed in sample jars, and preserved in 95% ethanol. Invasive carp larvae will be identified in the lab and densities will be estimated for each site and date as the number of larvae/m^3. We will use this information to assess the timing of appearance and spatial variation in larval densities throughout the Little Sioux River in association with environmental conditions (e.g., water temperature, discharge).

Larval Invasive carp have been documented and collected at several locations throughout their invaded range. However, juvenile Invasive carp are rarely captured and little is known about nursery habitats that juveniles occupy and how they support recruitment to the adult stage. We will use a variety of gears (e.g., seines, backpack electrofishers) to sample juvenile fishes throughout Missouri River tributaries in western Iowa. We will also sample habitats at each site to assess environmental conditions associated with the presence and absence of juvenile invasive carp. This data will be used to identify locations that may serve as Invasive carp population sources to the Missouri River.

Map of Project Area:



Estimated Timetable for activities:

Activity	Time Period
Hire project personnel	October-December 2021
Logistical planning, sampling preparation	January-May 2022
Ichthyoplankton sampling in Little Sioux	May-June 2022
Sample processing in the laboratory	June 2022 - March 2023
Sample juvenile fishes in MO basin tribs	May-August 2022
Summarize and analyze preliminary data, write reports	October 2022-April 2023
Sample larval and juvenile fishes in MO basin tribs	May -September 2023
Summarize and analyze data, write reports	September 2023-March 2024

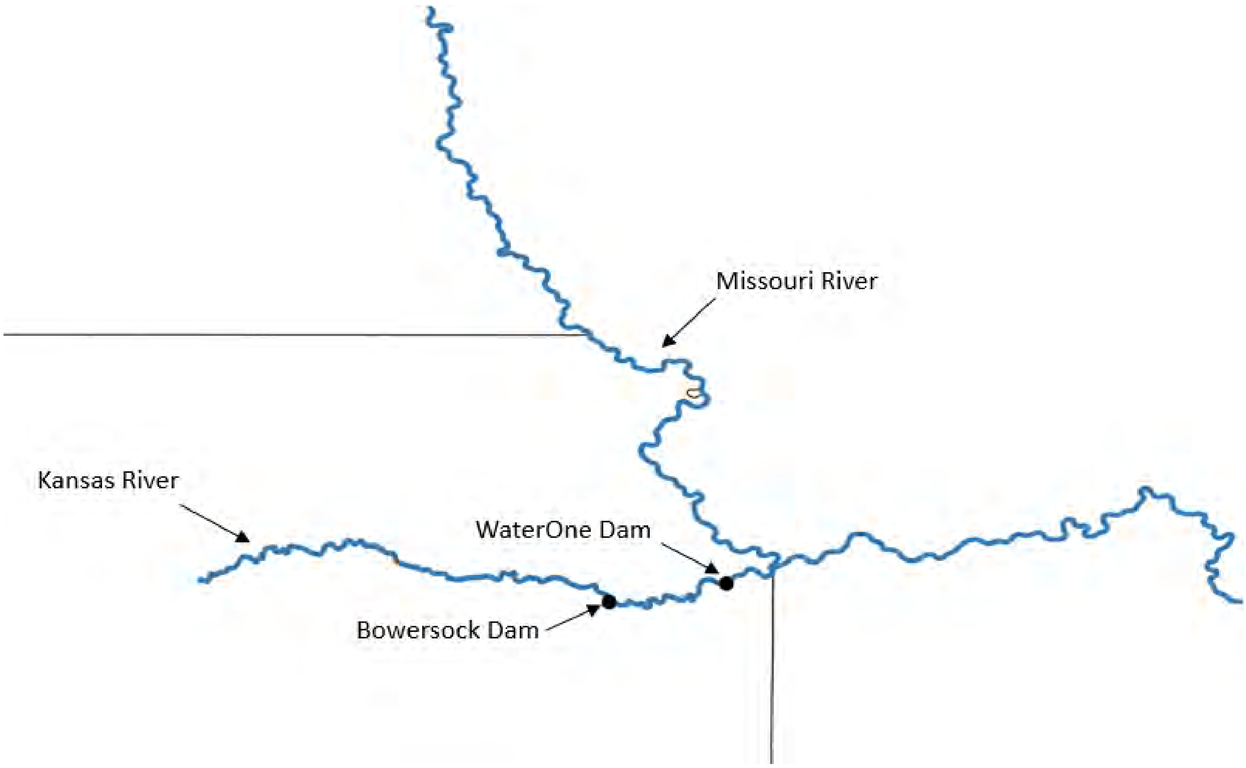
Agency: Kansas Department of Wildlife and Parks

Activities and Methods:

Objective 3: Data will be collected for two consecutive water years, in three seasons (fall, spring, summer). Collection sites will be above Bowersock dam (invasive carp absent), immediately below Bowersock dam, (moderate density invasive carp), and below the WaterOne dam (high density invasive carp). For each collection event, data will be collected from up to 10 replicates of each of 10 native species and invasive carps. Fish will be captured by electrofishing and netting and a tissue sample collected for isotope analysis (fin clips for large individuals and whole animals/muscle tissue for juveniles). Changes in consumers' isotopic niches will be determined using Bayesian mixing models (Jackson et al. 2011; Phillips et al. 2014).

Following collection and analyzation of isotope data, comparisons will be made to other river systems where similar data have been collected in the Illinois (Freedman *et al.* 2012), Wabash (Pyron *et al.* 2017), and Missouri (Wang *et al.* 2018) Rivers.

Map of Project Area:



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Field isotope collection: electrofishing, seine netting	Fall 2022
Technical report	Spring 2023
Field isotope collection: electrofishing, seine netting	Spring 2023
Field isotope collection: electrofishing, seine netting	Summer 2023
Processing of samples and isotope analysis	Summer 2023
Contact authors for isotope data (meta-analysis)	Summer 2023
Isotope data analysis	Fall 2023
Field isotope collection: electrofishing, seine netting	Fall 2023
Technical report	Spring 2024
Field isotope collection: electrofishing, seine netting	Spring 2024
Field isotope collection: electrofishing, seine netting	Summer 2024
Processing of samples and isotope analysis	Summer 2024
Isotope data analysis	Fall 2024
Meta-analysis of isotope data	Fall 2024
Summary and final report	Spring 2025

Agency: Missouri Department of Conservation (MDC)

Activities and Methods:

Objective 2:

- MDC: Conduct targeted invasive carp sampling in 4 tributaries of the Missouri River, associated Missouri River bends, and potentially 2 Missouri River oxbow lakes between river kilometers 0.0 and 885. Waterbodies will be separated into sampling units. Up to the lower 40 river kilometers of each tributary will be divided into sampling units. The Missouri River will use river bends as the sampling unit. Different suites of gears for each type of waterbody based on current literature and expert opinion (including but not limited to boat electrofishing, mini-fyke nets, and gill nets) will be deployed in the various sampling units to evaluate gear efficiencies to help develop a standardized operating procedure for invasive carp in the Missouri River basin. Sampling will also obtain population demographic data (relative abundance, size structure, age and growth, mortality, recruitment). All species will be measured and weighed. Aging structures will be collected from a subsample of fish and analyzed in collaboration with other agencies. Sampling in tributaries and Missouri River bends will also aim to be complementary to fish community sampling being done in the same sampling units. Habitat variables will be recorded to help provide insight on local environmental, hydrologic, or geomorphological variables which promote concentration, production, and/or recruitment of invasive carp that can inform future management actions.

Objective 3:

- MDC: Conduct fish community sampling in 4 tributaries of the Missouri River, associated Missouri River bends, and potentially 2 Missouri River oxbow lakes between river kilometers 0 and 885 to obtain baseline data for comparison after future management actions are implemented. Sampling units delineated for Objective 2 will also be used for fish community sampling. Tributary sampling gears and regime will be based on Dunn and Paukert 2020, while Missouri River bend sampling will be based on Welker and Drobish 2016. This will allow for comparison to other programs' fish community work to evaluate long-term trends in areas with invasive carp. Along with overall fish community sampling, selected species of interest will be sampled to monitor any impacts. Species of interest will be selected based on current literature, expert opinion, and agency priorities.

Map of Project Area:

The study area for objectives 2 and 3 on the mainstem Missouri River is between rkm 0.0 and 885. The focus will be on bends located at the mouth of the 4 selected tributaries. The two potential oxbow lakes for sampling include Big Lake located in Holt County Missouri near rkm 805 and Creve Coeur Lake located in St. Louis County Missouri near rkm 50.

Missouri Tributaries:

- Nodaway River from the confluence with the Missouri River (rkm 0.0) to 40 rkm upstream.
- Platte River (MO) from the confluence with the Missouri River (rkm 0.0) to 40 rkm upstream.
- Grand River from the confluence with the Missouri River (rkm 0.0) to 40 rkm upstream.
- Lamine River from the confluence with the Missouri River (rkm 0.0) to 40 rkm upstream.

Estimated Timetable for activities:

Activity	Time Period
Invasive Carp population demographic sampling	Summer/Fall 2023
Fish Community sampling	Summer/Fall 2023
Sample analysis, data entry, analysis, and report writing	October 2023 – March 2024
Submit Annual Report	March 2024

Agency: Nebraska Game and Parks Commission (NGPC) & University of Nebraska-Lincoln (UNL)

Activities and Methods:

Objective 1: NGPC in conjunction with UNL will assess the presence/absence of invasive carp above Gavins Point Dam using eDNA methodologies and surface ichthyoplankton drift nets. Specific study regimes will likely include bi-monthly or monthly surface water samples collected from Lewis and Clark Lake (multiple lake locations) and immediately below the Gavins Point Dam powerhouse. DNA will be extracted from each water sample and tested for primers consistent with invasive carp (collectively Silver Carp, Bighead Carp, and their hybrids). Additionally, surface ichthyoplankton drift nets will be deployed to document potential invasive carp presence and reproduction above Lewis and Clark Lake.

NGPC in conjunction with UNL will assess the feasibility of detecting the presence/absence of Black Carp in the upper segments of the lower Missouri River using eDNA methodologies. Specific study regimes will likely include bi-monthly or monthly surface water samples or sediment samples collected from Ponca State Park (rkm 1,212.6), Blair, NE (rkm 1,031.6), and Nebraska City (rkm 906.9). DNA will be extracted from each water sample and tested for primers consistent with Black Carp. This will determine the presence/absence and if present, the longitudinal distribution of Black Carp in the lower Missouri River.

NGPC in conjunction with UNL will use data gathered from fish sampling efforts (see Objective 2 below) for field verification of eDNA results collected during UNL's Nebraska Environmental Trust (NET) project 'Improving Water Quality and Surveying Fish populations using eDNA in Nebraska'. A major objective in the NET project focuses on invasive carp presence/absence using eDNA methodologies. The combined efforts (field sampling and eDNA testing) will determine the presence/absence of current and expanded distribution of invasive carp throughout the interior rivers of Nebraska. Additional efforts will be targeted upstream of known locations to detect new unknown areas of invasive carp presence.

We will employ multiple gear-types including nets, boat, and tow-barge electrofishing, and ichthyoplankton tows along the Platte River mainstem and in lower segments of major tributaries. Assessment of distribution and population characteristics for adult Silver Carp and adult Bighead Carp will occur in spring, summer, and fall 2022 using a combination of netting and electrofishing. Netting (i.e., mini-fyke nets) will focus on the occurrence and habitat uses of young-of-year for both species in the Platte River and lower reaches of major tributaries of the Platte River. Sampling for young-of-year will occur in late summer and early fall 2022 and 2023. All species collected will be identified and enumerated to provide base data on native and non-native fish assemblages. We will collect length, weight, hard-part structures (otolith and pectoral spines) used for aging and microchemistry, and gonads from each individual Silver Carp and Bighead Carp. Ichthyoplankton tows will begin after water temperatures reach at least 18° F and will continue through the summer each year. If we identify spawning aggregations, future contaminant and control efforts may be warranted.

In addition, we will employ multiple gear-types including trawls, nets, and tow-barge electrofishing. Various other electrofishing and net configurations may be attempted including airboat-mounted electrofishing. Sampling efforts will occur spring, summer, and fall starting in 2023 and continuing into 2024. Sampling (i.e., trawling, netting, electrofishing) will focus on the presence of all life-stages and sizes (i.e., lengths) of invasive carp. We will focus sampling efforts in mid-order prairie streams and rivers that are tributaries to the Missouri River and the Platte River in Nebraska. Streams and systems may include the Nemaha rivers (Big Nemaha River and Little Nemaha River), Elkhorn River, Salt Creek. Additional creeks may include Papillion Creek along the Missouri River as well as Salt Creek and Shell Creek along the Platte River. We will use information from eDNA results to direct sampling to locations with both positive and negative results for presence of invasive carp. Lower reaches of these systems may be accessible by boats using traditional sampling gears. We will sample river and stream reaches higher in the watersheds where traditional methods are not easily employed. All individuals of all species collected will be identified and enumerated to provide base data on native and non-native fish assemblages. We will collect length, and weight on all invasive carp captured and potentially hard-part structures (for aging and growth analyses), gonads, and tissue samples (for genetics to identify species for young-of-year) from each individual Silver Carp and Bighead Carp.

Objective 2: NGPC in conjunction with UNL will assess population demographics (relative abundance, size structure, age and growth, mortality, recruitment) of Bighead and Silver Carp in the Gavins Point Dam tailwaters, the most upstream infestation on the mainstem Missouri River, as well as Missouri River tributaries and periphery streams in Nebraska with a concentrated effort in the Platte River mainstem and lower segments of tributaries in this system. Sampling efforts will include a suite of gears dependent on the size of the river/stream and the existing habitat. Potential methods include boat or barge electrofishing, electrified dozer trawl, trammel nets, gill nets, mini-fyke nets, seines, electric seines, and ichthyoplankton tows. In tributaries and periphery streams, the majority of effort will be focused near pool habitats below barriers and locations where invasive carp have the potential to congregate.

In the Platte River and lower reaches of major tributaries of the Platte River, netting (i.e., mini-fyke nets) will focus on the occurrence and habitat uses of young-of-year for both Silver and Bighead carps. Sampling for young-of-year will occur in late summer and early fall 2022 and

2023. All species collected will be identified and enumerated to provide base data on native and non-native fish assemblages. Boat and barge electrofishing will also be performed. Habitat measurements will be taken at each sample location to characterize habitat use of young Silver Carp and Bighead Carp.
Silver Carp and Bighead Carp gonads as well as ichthyoplankton tows collected will be used to assess spawning phenology. We will collect length, weight, hard-part structures (otolith and pectoral spines) used for aging and microchemistry, and gonads from each individual Silver Carp and Bighead Carp. If we identify spawning aggregations, future contaminant and control efforts may be warranted.

Otoliths will be used for microchemistry analysis to assess Silver Carp and Bigheaded Carp connectivity between the Platte River and Missouri River and if spawning and recruitment are occurring in the Platte. Otoliths will be processed for microchemical analysis of Sr and Ba concentrations. Water chemistry will be assessed for Sr and Ba concentrations concomitantly to otolith microchemistry. Assessment of otolith and water microchemistry will occur in fall 2022 and spring 2023.

Objective 3: NGPC in conjunction with UNL will characterize fish communities and assess select fish species (e.g. Paddlefish, Buffalo spp.) in the Gavins Point Dam tailwaters, the most upstream infestation on the mainstem Missouri River, as well as Missouri River tributaries and periphery streams in Nebraska. Sampling methods and locations detailed under Objective 2 will be utilized for this assessment as well. Comparative fisheries assessments will be conducted at the Fort Randall Dam tailwaters to characterize the current fish community and facilitate the ability to document impacts if invasive carp infestation occurs in the future. In tributary streams and areas near the leading edge of invasive carp expansion, analyses will also focus on fish community characteristics in the presence or absence of invasive carp, and where absent will facilitate the ability to document impacts if an infestation does occur in the future and inform where prevention management activities could occur. Additionally, concurrent standard fish population surveys and historical data will be utilized to document and better understand invasive carp impacts.

Map of Project Area:

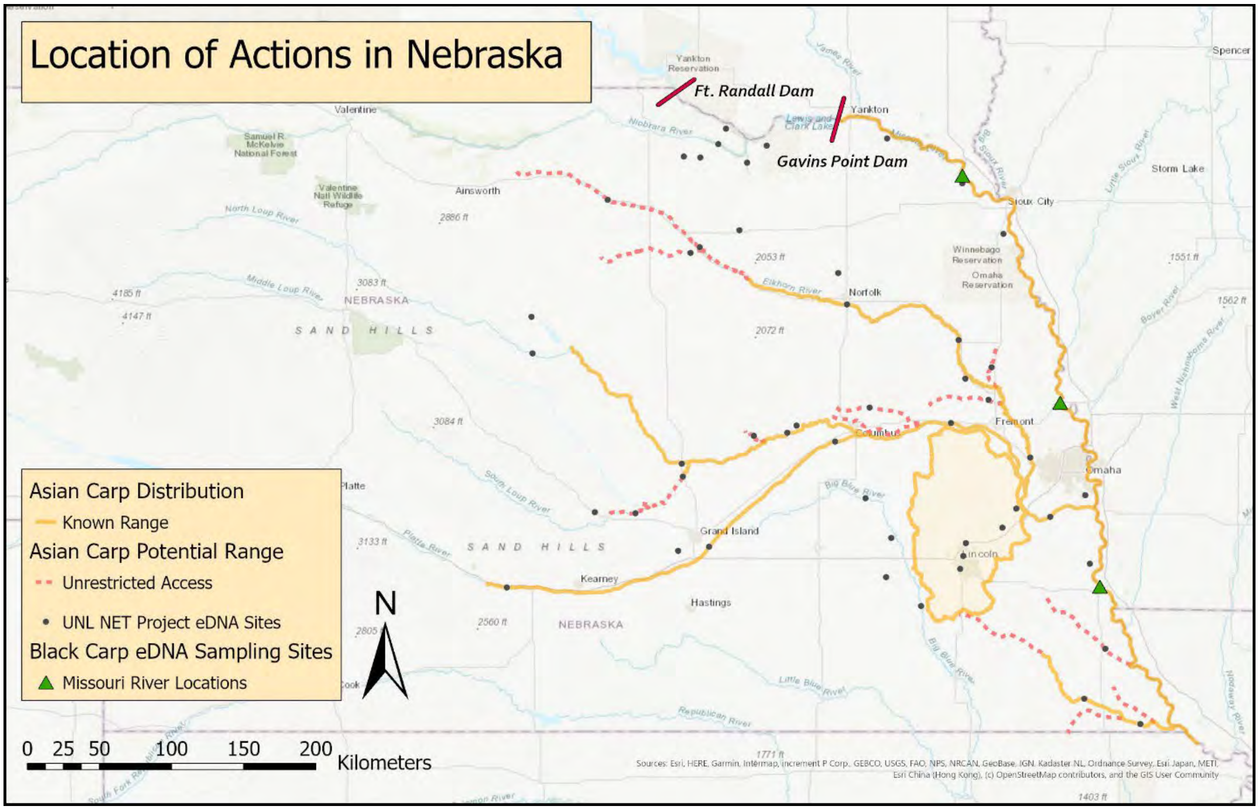
The proposed project area for work conducted by NGPC and UNL includes the mainstem Missouri River, interior tributaries, and periphery streams.

Mainstem Missouri River: This includes two reaches of the mainstem Missouri River. The upper reach is from Fort Randall Dam (rkm 1,416.2) to Gavins Point Dam (rkm 1,305.2), which includes Lewis and Clark Lake. The lower reach is from Gavins Point Dam to the confluence of the Kansas River (rkm 590.9). Gavins Point Dam is generally denoted as the start of the lower Missouri River. Gavins Point Dam is approximately 2 miles long with a powerhouse and spillway located on the south end. The Dam is a rolled-earth embankment with the powerhouse and spillway constructed of concrete. It is important to note that at multi-purpose lake levels there is approximately a 40-foot difference between the lake and river elevations, making it a physical barrier to fish movement.

Missouri River tributaries and periphery streams within eastern and central Nebraska. Potential rivers and watersheds include: Platte, Elkhorn, Loup, Niobrara, Big Nemaha, and Little Nemaha.

Nebraska Tributaries:

- Niobrara River from the confluence with the Missouri River (rkm 0.0) to Cornell Dam near Valentine, NE (rkm 230.0) -- efforts will likely be focused immediately below the dam area.
- Platte River (NE) from the confluence with the Missouri River (rkm 0.0) to the diversion dam near Paxton, NE (rkm 545.0) on the South Platte River including associated Platte River canal systems and the Salt Creek watershed.
- Elkhorn River from the confluence of the Platte River (NE) to Atkinson Lake Dam near Atkinson, NE (rkm 315.0).
- Loup River from the confluence of the Platte River (NE) to the Milburn Diversion Dam (rkm 265.0) on the Middle Loup River, the Taylor-Ord Diversion Dam near Taylor, NE (rkm 230) on the North Loup River, and associated canal systems.
- Big Nemaha from the confluence with the Missouri River (rkm 0.0) to Firth, NE (rkm 135).
- Little Nemaha from the confluence with the Missouri River (rkm 0.0) to Palmyra, NE (rkm 85).


Location of Actions in Nebraska
Ft. Randall Dam
Gavins Point Dam
Asian Carp Distribution
Known Range
Asian Carp Potential Range
Unrestricted Access
UNL NET Project eDNA Sites
Black Carp eDNA Sampling Sites
Missouri River Locations
N
0 25 50 100 150 200 Kilometers
Valentine
Ainsworth
Yankton
Sioux City
Norfolk
Fremont
Columbus
Omaha
Lincoln
Grand Island
Kearney
Hastings
NEBRASKA
SAND HILLS
Storm Lake
Spencer
Elkhorn River

Estimated Timetable for Activities:

Activity	Time Period
Hire grad student	January 2021
Training, equipment requisition, background research, historical data acquisition, sampling site reconnaissance	January – April 2021
Field sampling for Objectives 1-3 on the mainstem Missouri River, tributaries, and periphery streams	May – October 2021 May – October 2022
Sample analysis, data entry, data analysis, and report writing	October 2021 – March 2022 October 2022 – March 2023
Submit Annual Report	March 2022 & March 2023
Manuscript development	October 2022 – March 2023
Recruit Graduate Students	October – December 2021
Proposal development, training, equipment requisition, background research, sampling site reconnaissance	January – March 2022
Recruit Research Technician	January – March 2022
Field sampling for Objectives 1, 2, & 3	April – December 2022 April – September 2023
Sample analysis, data entry, data analysis, report writing	October 2022 – March 2023 October 2023 – March 2024
Submit Annual Report	March 2023 & March 2024
Manuscript development	October 2023 – March 2024
Recruit Graduate Students	October – December 2022
Proposal development, training, equipment requisition, background research, sampling site reconnaissance	January – March 2023
Recruit Research Technician	January – March 2023
Field sampling for Objectives 1 & 2	April – September 2023 April – September 2024
Sample analysis, data entry, data analysis, report writing	October 2022 – March 2023 October 2023 – March 2024
Submit Annual Report	March 2024 March 2025
Manuscript development	October 2024 – March 2025

Agency: North Dakota Game and Fish Department

Activities and Methods:

Objective 1. Collaborate with the USFWS to develop an eDNA sampling strategy for the upper James River. This project will be guided by the results of eDNA collection and analysis conducted by SDGFP and USFWS on the Big Sioux and Vermillion Rivers during FY21. Highly variable hydrological conditions often dictate traditional sampling methods, which can limit detection probability for low densities of invasive carp that exist within the upper James River. Strategic eDNA sampling should provide pertinent spatial distribution information that is crucial for management decisions. NDGFD will attempt to verify eDNA results with physical sampling techniques.

Project Area:

- Upper James River from the South Dakota Border (rkm 794.0) to Jamestown Reservoir Dam at Jamestown, ND (rkm 983)

Agency: South Dakota Department of Game, Fish, and Parks (SDGFP), East Dakota Water Development District (EDWDD), University of South Dakota (USD), South Dakota State University (SDSU)

Activities and Methods:

Objective 1: SDGFP and USD staff will participate in environmental DNA (eDNA) training with USFWS staff from the Whitney Genetics Lab and the Bozeman Fish Health Center, along with staff from other basin partners. Training will occur in eastern South Dakota, and samples will be collected from a combination of the Big Sioux, Vermillion, and James Rivers, where Silver Carp and Bighead Carp (hereafter bigheaded carp) are known to persist. Topics to be covered during the training session include proper sampling protocols, collection, and pre-processing techniques, and broader discussions on efficacy, sample sizes, preservation, and processing techniques.

Beginning in Spring 2021, a graduate student at USD will begin collecting and processing water samples in the Big Sioux, Vermillion, and James Rivers. Information obtained will be utilized to guide protocols associated with timing, number of samples, preservation, and other sampling considerations. Previous research suggests that detection probability of bigheaded carp eDNA is lowest in late summer and early fall (Erickson et al. 2017), so samples will likely be collected in spring or fall (see also Mize et al. 2019). We plan to take a total of 300 water samples across all three rivers, but a greater emphasis will be placed on the Big Sioux and Vermillion Rivers in relation to the perceived fish barriers. Water samples will be placed on ice immediately after collection, and a series of control samples with purified or distilled water will be “collected” at each site following methods similar to those described in Erickson et al. (2017).

Sampling locations in the Big Sioux and Vermillion Rivers will correspond with locations above and below presumed barriers. On the Big Sioux River, samples will be collected in Sioux Falls below the natural waterfalls (rkm 243) and/or below the manmade diversion spillway (rkm 241), where bigheaded carp are known to persist. Samples will also be taken above the barrier at locations to be determined where bigheaded carp have never been documented. One potential sample site above Sioux Falls is below Flandreau Dam (rkm 357), which acts as the next barrier to fish movement under normal water conditions on the Big Sioux River. Water samples will be collected on the Vermillion River will occur below the East Vermillion Lake spillway (rkm 192), where bigheaded carp are known to exist, and at a location to be determined above East Vermillion Lake.

A large majority of samples will be collected according to the sample design methods described in Coulter et al. (2019). A 1-2 Liter water sample will be collected at each sampling site using virgin or sterile bottles and then placed on ice until filtration can be carried out in the lab. In the laboratory, we will follow the procedures detailed in the Quality Assurance Project Plan eDNA Monitoring of Bighead and Silver Carps (QAPP; USFWS 2019) as closely as possible for storing and amplifying samples. Filtration will use Whatman 934-AHTM 1.5 mm glass microfiber filters (GE Whatman, Fairfield, CT, USA) and a polyphenylsulfone filter funnel (Pall Corporation, Port Washington, NY, USA). Filter funnels and forceps will be sterilized in 10% bleach and rinsed extensively with distilled water before use for each sample to avoid possible DNA contamination. Each filter will be stored in a 2 oz Whirl-Pak Write-On Bag (Nasco, Fort Atkinson, WI, USA) and stored at -80℃ until DNA extraction occurs. The samples will then be analyzed using replicated quantitative polymerase chain reactions (qPCRs) using bigheaded carp-specific primers (Amberg et al. 2015). Because of the smaller scale of our laboratory effort relative to those on the main stem Mississippi River, specific modifications to these procedures will be further made following discussion with the Whitney Genetics Lab.

Immediately following the collection of water samples, fish sampling will occur upstream of the water collection site to confirm the presence of bigheaded carp. Wherever possible, boat electrofishing will be used to collect adults. Locations, where boat electrofishing is not feasible, will be sampled with a variety of other gears including, but not limited to, seines and cast nets. Additionally, visual observation of jumping carp can serve as detection of bigheaded carp if two biologists make positive identification above the water sampling site. The primary goal of this sampling will be to detect the presence or absence of bigheaded carp upstream of water sampling sites, but information on the relative abundance in the form of catch per unit effort may be collected to inform detection probabilities.

Objective 2: Otolith microchemistry can provide an important tool for determining the natal origin of freshwater fishes from environments with distinct water chemistries (Campana et al 2000; Gibson-Reinemer et al. 2009; Zitek et al. 2010). To evaluate variation in water chemistry among eastern South Dakota rivers, water samples will be collected in spring and fall (2021-2023) from the James (n=2), Vermillion (n=2), Big Sioux (n=2), and Missouri Rivers (n=3). Water samples for trace element and oxygen isotope analysis will be collected in 250-mL, acid-washed, polyethylene bottles that are pre-rinsed with river water, filtered through a Whatman Puradisc PP filter (0.45 µm), and stored in sealed, acid-washed polyethylene bottles. Water samples for strontium isotope analysis will be collected in 200-mL, acid-washed, polyethylene bottles and will be stored unfiltered in a refrigerator until processing. Trace elements of barium (Ba), strontium (Sr), calcium (Ca) along with oxygen (^{16}O, ^{18}O) and strontium (^{86}Sr, ^{87}Sr) isotopes will be analyzed using inductively-coupled mass spectrometry (ICP-MS). Water samples will be analyzed by the Kennedy LIFE laboratory at the University of Idaho (^{86}Sr, ^{87}Sr) or Southern Mississippi University (Ba, Ca, Sr, ^{16}O, ^{18}O).

We will collect juvenile Silver Carp beginning in summer 2021 from the James, Big Sioux, Missouri, and, possibly, Vermillion rivers. These fish will be measured for total length (mm), and their lapilli otoliths will be removed using plastic forceps and stored in sealed plastic vials for processing. One otolith will be used to confirm the age of the individual fish while the other will be used for microchemistry analysis. For otolith microchemistry analysis, otoliths will be mounted in epoxy, transversely sectioned to create a thin section exposing the nucleus, and thin sections will be mounted to a glass slide. This pre-processing may be contracted out to a laboratory or conducted in-house by SDGFP staff. Laser-ablation ICP-MS will be performed along a transect of the otolith beginning at the nucleus and ending at the margin to measure chemical signatures throughout the lifespan of the fish. The targeted chemical signatures for otolith ICP-MS will be dependent upon the results of the water sampling conducted in 2021, and the laboratory conducting the laser-ablation ICP-MS will be chosen after water chemistry data have been analyzed. Additionally, a small sample of adult Silver Carp otoliths will be collected and processed to assess microchemical signatures.

The natal origin of Silver Carp will be evaluated by comparing strontium and oxygen isotopic and trace-elemental markers measured from otoliths to those from water samples collected in the James, Big Sioux, Missouri, and Vermillion rivers. To screen for potential markers, we will use correlation analysis to evaluate relationships between element concentrations in water samples and otoliths. Trace element or isotopic markers in lapilli otoliths that are correlated to water concentrations will be included in a model-based discriminant function or cluster analysis, such as *k*-nearest neighbor (KNN; Rosing et al. 1998). To evaluate classification error for assigning natal stream origin to carp, we will use a cross-validation approach. Trace element or isotopic concentration in otolith cores from juvenile/adult Silver Carp collected in the Missouri River will be used as a test data set, in an attempt to classify these fish to a natal stream and assess the relative contribution of the James, Big Sioux, and Vermillion rivers on Silver Carp abundance in the Missouri River.

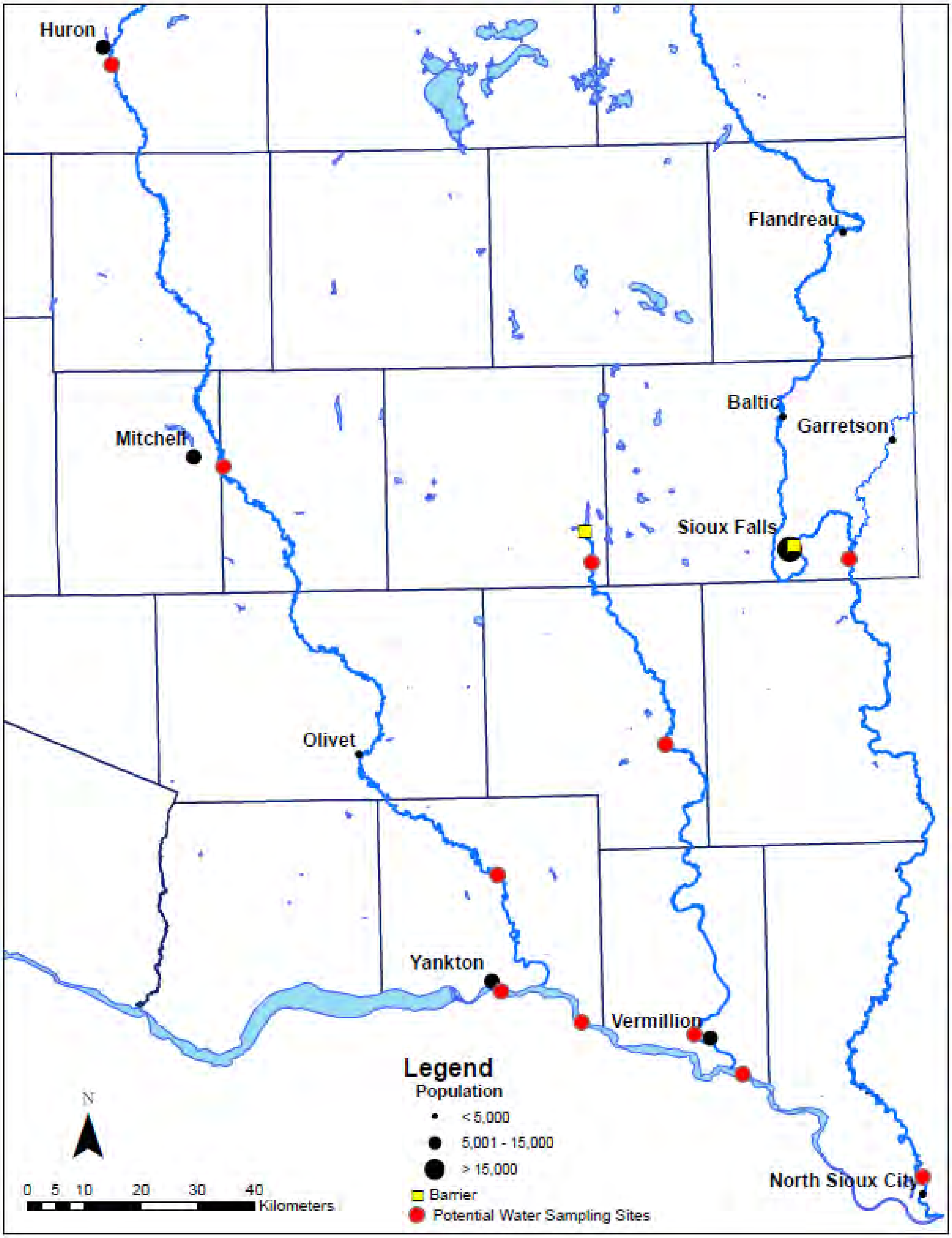
To validate results from otolith microchemistry, age-0 Silver Carp may be targeted from the eastern South Dakota rivers to provided known signature matches to each system. Several age-0 or age-1 fish were collected from the Missouri and Big Sioux rivers in 2020 and may be used to provide water chemistry validation. If Sr isotopes vary across river systems, surrogate species (such as Channel Catfish) may be collected to increase the sample size of age-0 fish from known sampling locations. Since Sr 87/86 is not biologically fractionated, signatures within fish tissues such as otoliths should be incorporated at the same rate at which they exist in the environment. (Kennedy et al. 2000). Using a surrogate species which consumes a similar diet at age-0 could allow for increased interpretation of the Sr isotopic and, potentially, trace-element signatures, which would be especially important given the historic difficulty of sampling age-0 Silver Carp in eastern South Dakota rivers. Microchemical signatures from the otoliths of these known location individuals may be used as a training set for discriminant function analysis alongside the available water data (Hegg and Kennedy 2021).

Map of Project Area:

Missouri River tributaries within eastern South Dakota, including: James, Vermillion, and Big Sioux Rivers.

South Dakota Tributaries:

- Lower James River from the confluence with the Missouri River (rkm 0.0) to Huron, South Dakota (rkm 358.0) where there is a small low-head dam that acts as a barrier during low water conditions.
- Vermillion River from the confluence with the Missouri River (rkm 0.0) to East Vermillion Lake spillway (rkm 192.0) where there is a physical barrier that prevents fish movement. Samples will also be taken above the barrier at a location to be determined where invasive carp have never been documented.
- Big Sioux River from the confluence with the Missouri River (rkm 0.0) to Sioux Falls, SD where there is a natural fish barrier (rkm 247.0). Samples will also be taken above the barrier at locations to be determined where invasive carp have never been documented.



Estimated Timetable for activities:

Activity	Time Period
Process eDNA samples	Summer-Fall 2021
Interim progress report	Fall 2022
Data analysis and synthesis	Winter 2021-2022

Development of thesis	Winter 2022-2023
Final Report	Fall 2023
Water samples collected	Fall 2021
Otoliths collected and prepped for analysis	Fall 2021
Water Samples Processed	Winter 2021
Preliminary otoliths sent for processing	Winter 2021
Water Samples Collected	Spring 2022
Water Samples Processed	Summer/Fall 2022
Lab selected for otolith processing	Summer/Fall 2022
Otoliths sent for processing	Falls 2022
Interim report	Fall 2022
Water Samples Collected	Spring 2023
Water Samples Processed	Summer/Fall 2022
Final Report Submitted	Fall 2023

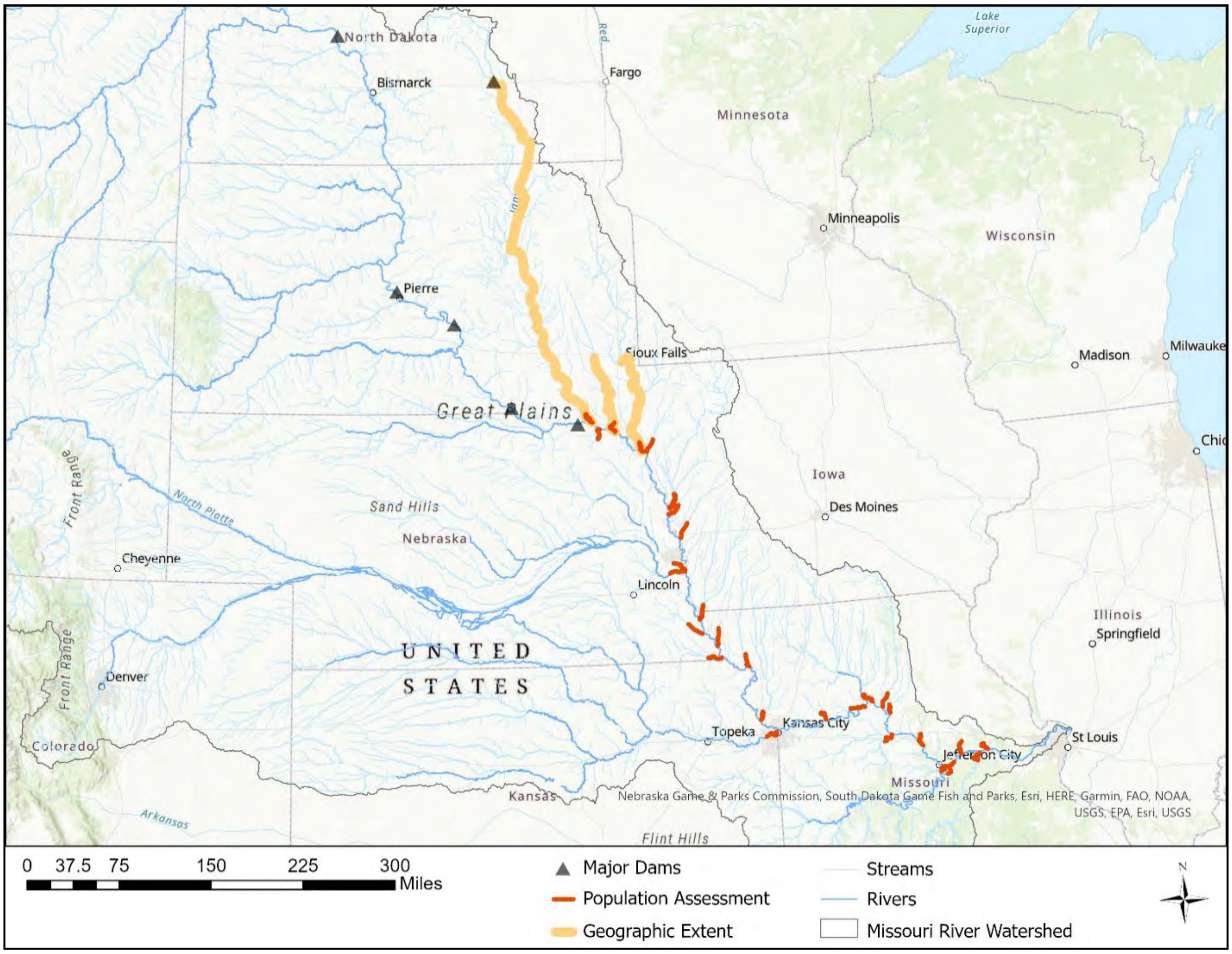
Agency: U.S. Fish and Wildlife Service (USFWS) including the Columbia Fish and Wildlife Conservation Office, Bozeman Fish Health Lab, Missouri River Fish, and Wildlife Conservation Office, and the Great Plain Fish and Wildlife Conservation Office

Activities and Methods:

Objective 2:

- Confluence areas of major Missouri River tributaries will be sampled in the fall using hydroacoustics and electrified dozer trawl to gather abundance and population demographic information for bighead and silver carp. Dozer trawl sampling will be conducted in tributaries below Gavins Point Dam (RM 811; upper limit of known bighead and silver carp presence). Tributaries will be selected based on navigability (at least 800 km^2 watersheds; Flotemersch et al. 2006). Hydroacoustics sampling to estimate bighead and silver carp abundance will be implemented in certain tributaries, including Osage, Lamine, Grand, and Kansas rivers, during year one of this effort. Dozer trawl sampling will include the confluences up to the lowest 20 river km will be sampled to focus results on confluence assemblages (Thornbrugh and Gido 2010) whereas hydroacoustics sampling will include the lowest 5 river km that can be effectively sampled with the gear. Sampling (dozer trawl, hydroacoustics) will be conducted in the fall to allow for more stable water levels, reduce the impact of reproduction on length-weight relationships, and coincide with annulus formation on otoliths (Thompson and Beckman 1995), in addition to providing the highest and therefore more consistent catch rates of silver carp (Sullivan et al. 2017). An electrified dozer trawl (described in Hammen et al. 2019) will be the primary means of collecting bighead and silver carp. At each tributary, total length (mm), weight (g), and sex will be recorded, and aging structures extracted for a subset of bighead and silver carp. Any additional bighead or silver carp as well as any bycatch will be measured for total length (mm) and enumerated for relative abundance estimates. Aging will be conducted in a centralized location using accepted protocols. For each tributary with adequate data, relative abundance, sex ratio, body condition, recruitment, growth, and mortality for each species will be calculated, then compared longitudinally and across tributaries. Relative standard error will provide an estimate of precision for catch rates (Dumont and Schlechte 2004) and, in combination with field observations, will be used to conduct power analyses and adapt protocols in the future as needed.

Map of Project Area:



Estimated Timetable for activities:

Project Activity	Time Period
Project development and sample site selection	February – April 2022
Field collections	September – October 2022
Partner update	November 2022
Lab analysis	September 2022 – February 2023
Data analysis	November 2022 – March 2023
Final report	April 2023
State-specific fact sheets	May 2023

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Invasive carp movement and habitat use in the Missouri River Basin to inform containment and control management actions.

Lead Agency and Author: South Dakota Department of Game, Fish and Parks, BJ Schall, benjamin.schall@state.sd.us

Cooperating Agencies: Iowa Department of Natural Resources (IADNR) & Iowa State University (ISU), Missouri Department of Conservation (MDC), South Dakota Department of Game, Fish, and Parks (SDGFP) & University of South Dakota (USD), USFWS – Great Plains Fish & Wildlife Conservation Office (USFWS – GPFWCO)

Statement of Need: Containment (Goal 2 in the National Plan and Goal 3 in the Missouri River Framework) prevents Invasive carp from expanding a known population confined to its current geospatial distribution. Invasive Carp are well established throughout the Missouri River and tributaries downstream of Gavins Point Dam. Knowing when and under what environmental conditions adult Bighead and Silver carp are moving into the tributaries will help inform when to monitor the population as well as implement management actions. Understanding the movement range of Bighead and Silver Carp in the Missouri River basin, the environmental conditions associated with movements, and the conditions associated with congregations at deterrent barriers currently present in the Missouri River Basin will allow for the identification of locations where deterrence technologies, concentrated removal efforts, physical barriers, or other emerging technologies can be utilized for containment and control. Identification and evaluation of containment opportunities can facilitate the implementation of deterrent and/or removal systems that may limit dispersal, reproduction, or recruitment of Invasive carp. A better understanding of the movement and behavior of Invasive carp in tributaries and in association with barriers as outlined in this proposal is critical to devising strategies for successful containment. As stated in National Plan Goal 6, scientifically valid research is necessary to provide accurate information for the effective management and control of Bighead and Silver carp. This research will be used to develop criteria for deterrent barriers, harvest regulations, or other management activities.

Invasive carp populations extend into the interior waters of Missouri River Basin states such as Minnesota via the Little Sioux River in northwestern Iowa and North Dakota via the James River. The Little Sioux and James rivers have barriers that act as deterrents under certain conditions. Flooding in 2012 allowed Invasive Carps to invade the Iowa Great Lakes that are comprised of seven different waterbodies that are extremely important recreationally and economically. The Iowa DNR, Minnesota DNR, and local partners responded to the invasion by installing an electric barrier on the outlet of Little Gar Lake, the most downstream lake in the Iowa Great Lakes chain with a 352 km^2 watershed that includes both Iowa and Minnesota. Additionally, the Little Sioux River originates in southwestern Minnesota and in December 2019, a Silver Carp was captured in the Ocheyedan River, about 100 yards from the Iowa border in southwestern Minnesota.

The electric barrier on the outlet of the Iowa Great Lakes is 49 m wide and 8 m long and consists of eight electrodes and seven pulsers that span the width of the outlet with a gradient of electrical intensity. The barrier is only activated when water on the barrier surpasses 3”, which typically occurs in the spring when Invasive Carps migrate upstream for spawning but can also occur periodically during the summer and fall, albeit less frequently. While the barrier has been in place since 2013, no evaluations have occurred to determine how effective it is at slowing or stopping upstream movements of Invasive Carp. Invasive Carp are frequently observed below the barrier and anecdotal evidence suggests that they may have passed the barrier during high water in 2018, as individuals are occasionally captured in the Iowa Great Lakes; however, it is unknown if these fish are new individuals that have recently passed the barrier or fish that were part of the initial invasion. Downstream movement of fishes past the barrier from the Iowa Great Lakes is commonly observed; thus, upstream fish passage through the barrier may also be possible.

A number of different Invasive Carp barrier evaluations have been conducted to date using a variety of different deterrents. However, most of these evaluations have occurred in laboratory settings due to the cost and regulations associated with installing barriers in natural environments. Electrical barriers hold promise for limiting or stopping the upstream movement of Invasive carp and the barrier currently in place on the Iowa Great Lakes is only one of a few systems available in the world that provides an opportunity to test its effectiveness under natural conditions. However, no evaluations of this barrier have been conducted to date and it is currently unknown how effective the barrier is at preventing upstream movement of fish. Additionally, no information is available regarding the seasonal presence of Invasive Carp at the barrier or the source of these fish (e.g., Little Sioux River residents or migrants from the Missouri River). Further, the timing and frequency of Invasive Carp movements further upstream into Minnesota is unknown but could provide information about invasion phenology. Thus, more information regarding tributary movements of Invasive Carp and potential effectiveness of electric barriers at minimizing or stopping their upstream movements is needed.

Objectives:

1. Determine Silver Carp and Bighead Carp residence time and movement in the Missouri River and its tributaries in association with season, environmental conditions, and barriers to inform containment and control management actions.
    a. Determine if Silver Carp and Bighead Carp have extended presence in tributaries and directional movement into and out of Missouri River tributaries.
    b. Evaluate effects of environmental factors (e.g., season, temperature, discharge) on Silver Carp and Bighead Carp movements in select Missouri River tributaries.
    c. Assess fish behaviors in association with an electric barrier at the outflow of the Iowa Great Lakes, a concrete spillway at Creve Coeur Lake, and dams on the Kansas River (WaterOne Dam and Bowersock Dam), particularly how fish approach, challenge, and pass the barriers.
    d. Evaluate seasonal congregations of Silver Carp and Bighead Carp in Missouri River tributaries, particularly as they relate to fish barriers.

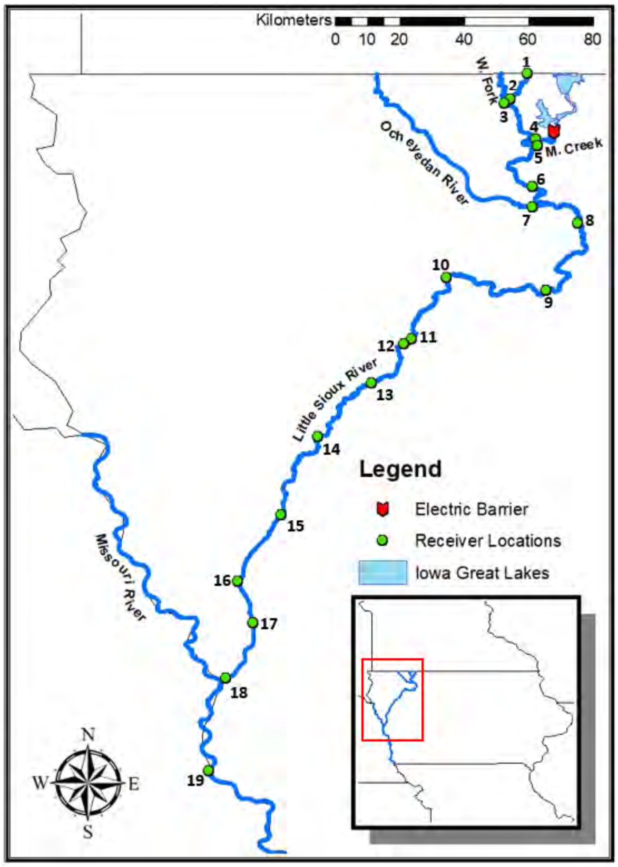
Invasive carp movement and habitat use in the Missouri River Basin to inform containment and control management actions.

Agency: Iowa Department of Natural Resources (IADNR) & Iowa State University (ISU)

Activities and Methods: Continuing work funded in FY20, acoustic receivers will be placed around the electric barrier at the Iowa Great Lakes and range testing will be conducted to evaluate the potential for this technology to monitor 2D movements of fish. Acoustic receivers will also be placed at locations throughout the Little Sioux River from the confluence with the Missouri River all the way upstream into Minnesota. Receivers will be placed in the Missouri River upstream and downstream of the Little Sioux, if possible, to obtain directional information for fish that leave the Little Sioux. Acoustic tags will be implanted in Silver and Bighead Carp below the electric barrier. Acoustic receivers will be maintained, batteries will be replaced, and data will be downloaded to evaluate seasonal movements within the Little Sioux River, congregations of fish near the barrier, and movements of fish upstream into Minnesota as well as downstream out of the Little Sioux and into the Missouri River. This acoustic receiver array will also be used to assess potential upstream movement of Invasive Carp and other fishes tagged by basin collaborators (e.g., USFWS, MDC, SDGFP).

Map of Project Area:

The Little Sioux River joins the Missouri River at approximately rkm 1,077 and extends into Iowa and Minnesota by way of the Iowa Great Lakes, which are comprised of seven different waterbodies that are extremely important recreationally and economically. This study will focus on the 415 rkm from the confluence with the Missouri River to the electric barrier on the outlet of the Iowa Great Lakes and upstream to the Iowa-Minnesota border.



Nineteen sites on the Little Sioux River, Iowa where acoustic receiver housing were installed summer 2021 and receivers were installed spring 2022.Reciever 19 was placed in the Missouri River downstream of the Little Sioux to obtain directional information for fish that leave the Little Sioux.

Estimated Timetable for Activities:

Activity	**Time Period** **(Season, month/year)**
Download acoustic receivers, tag additional fish	October-November 2022
Telemetry data QA/QC, evaluate preliminary carp movement patterns	December 2022 – March 2023
Tag fish, download acoustic receivers and change batteries	April – August 2023
Telemetry data QA/QC, evaluate preliminary carp movements, write annual report	September-October 2023
Submit annual report	March 2024

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: Continuing work funded in FY20, 2 additional stationary receivers will be added to the array within four of the five tributaries in Missouri (Creve Coeur, Moreau, Lamine, and Grand rivers; Kansas River already has 5 receivers) and 10 stationary receivers will be added to the Missouri River mainstem around tributary confluences of interest to allow for more detailed information on directional movement in and out of each tributary. Additional tags will be purchased to maintain a target of 50 tagged bigheaded carps in each tributary. Receivers will continue to be downloaded on a regular basis and active tracking may be employed to inform removal efforts in tributaries. Downloaded data will be shared with partnering agencies as appropriate and analyzed for Silver Carp tributary use and movement in relation to season and environmental conditions.

By the winter of 2022/2023, stationary receiver arrays will be deployed at each of the five tributaries in Missouri (Creve Coeur, Moreau, Lamine, Grand and Kansas rivers). Each tributary array will consist of four to five stationary receivers. Near the mouth of each tributary, two receivers will be deployed so that the direction of movement (entering or exiting) can be determined, and the remaining two to three receivers will be placed further upstream depending on access and presence of invasive carp. Range tests will be completed at each receiver location to evaluate performance and adjustments will be made as needed. A minimum of 50 Silver Carp or Bighead Carp will be surgically implanted with V16 (6H or 4H, depending on fish size) transmitters in each system. Up to 100 additional Silver and Bighead Carp will be added to the tributaries as needed to attempt to maintain the goal of 50 bigheaded carp per tributary. Receivers will be downloaded on a regular basis (every 4-6 weeks) and active tracking may be employed to inform removal efforts. Downloaded data will be shared with partnering agencies as appropriate and analyzed for Silver Carp tributary use and movement in relation to season and environmental conditions.

Data collected from the stationary receivers in the tributaries will be used to fulfill Objective 1 by providing the residence time and movement of invasive carp in tributaries. All of this information will be used to inform future removal efforts and also inform decisions in locations where barriers occur (Bowersock Dam and Creve Coeur).

Map of Project Area:

Map of Missouri project area.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Deploy Acoustic Array	Fall/Winter 2022
Implant Acoustic Tags in Invasive Carp	Fall/Winter 2022
Download Receiver Data	Every 4-6 weeks 2022/2023
Annual Report	March 2023

Agency: South Dakota Department of Game, Fish, and Parks (SDGFP) and University of South Dakota (USD)

Activities and Methods: SDGFP in coordination with a USD graduate student will continue work started in 2021 to assess Silver Carp movement in the James River. Activities include setting, replacing, or removing receivers, downloading data from telemetry receivers as well as water level loggers and temperature loggers, and sharing significant findings. Additionally, the graduate student will map habitat characteristics in the lower James River to identify preferred habitats or spawning suitability.

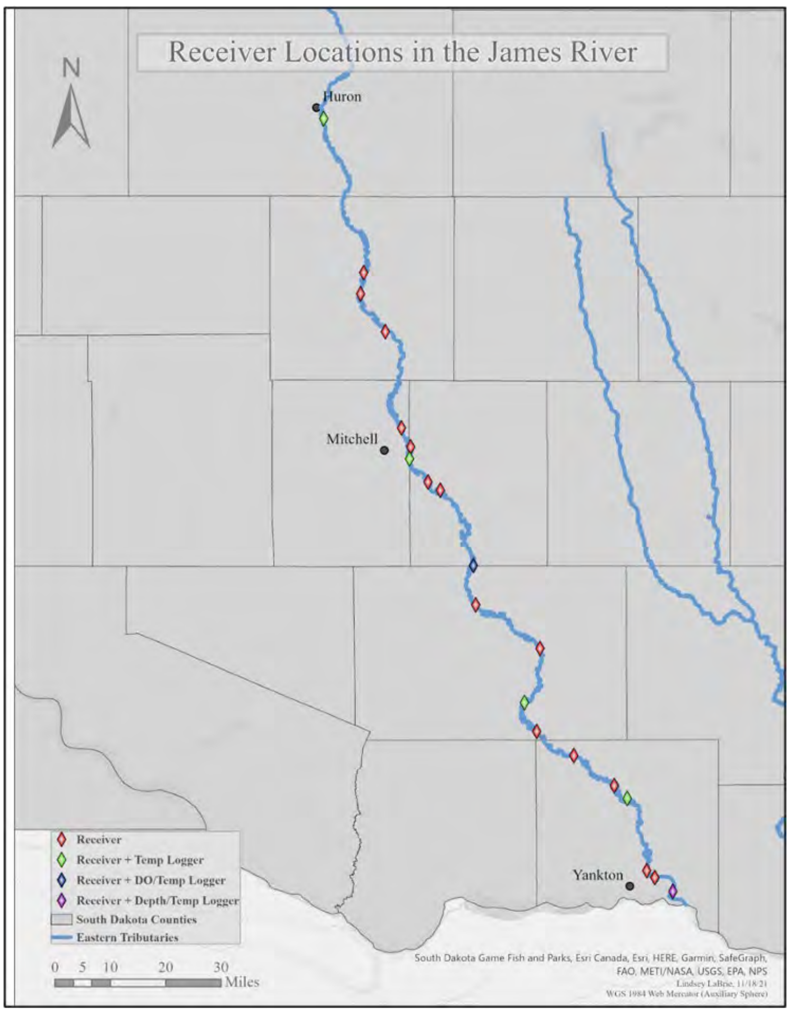
Eleven acoustic receivers (6 Vemco VR2W, 5 VR2Tx) were deployed in the James River between the 303rd Street bridge near Yankton, South Dakota (rkm 27) and Huron, South Dakota (rkm 358). A receiver array including an additional 10 VR2Ws exists downstream of Olivet, SD (rkm 105) on the James River to the confluence of the Missouri River as part of an ongoing Blue Sucker telemetry project. VR2W receivers will be attached to the downstream side of bridge pilings and secured inside 4” PVC tubing, and a subset of VR2Tx receivers will be submerged mid-river in areas with large holes in the detection grid between bridges.

Water temperature loggers were deployed near the confluence and at several upstream locations and a water level logger was placed near the confluence of the James River to monitor the impact of backflow from the Missouri River into the James River. Data will be downloaded from the acoustic receivers, temperature loggers, and water level loggers in fall 2022, spring and fall 2023, and spring and fall 2024, at a minimum. Available habitats will be mapped in the James River using side scan sonar in 2022, assuming water levels permit boat access and travel. Discharge and gage height data will be collected from the USGS National Water Information System website. Analysis of movement and environmental data will be conducted following data retrieval each fall.

New additional funding is requested for this objective in FY22. The SDGFP will purchase an additional 50-75 acoustic tags and deploy them beginning in the spring of 2023. Limited water levels in the James River in 2021 limited inference about fish movements, and dry conditions during winter 2021-22 has resulted in below normal flows in early spring 2022. Telemetry data retrieved from these additional fish will provide insight into movement patterns associated with varying water levels in an eastern South Dakota tributary. Additionally, funds will be used to partially offset the salary of a contracted biologist hired at a location TBD.

Silver Carp will be collected in spring/summer 2023 and surgically implanted with Vemco V16 acoustic transmitters. Tags will only be implanted if the tag weight is <2% of the total mass of the individual fish. Tags will be implanted following similar procedures as described in DeGrandchamp et al. (2008) and Coulter et al. (2016) A small incision will be made on the ventral side of the fish between the pelvic and anal fins such that the tag can be inserted into the coelomic cavity. The incision will be closed with 2-3 absorbable sutures. Silver Carp tags will be distributed at locations between the confluence of the James River with the Missouri River and Huron, SD. Likely tagging locations include the James River confluence, the Shramm boat access (rkm 41), Olivet, and Mitchell but tag distribution will likely be determined by Silver Carp availability and boat access.

Map of Project Area:



Map of the lower James River, South Dakota with acoustic receivers and habitat logger locations.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Retrieve data from acoustic receivers and environmental loggers	Fall 2022
Data analysis and synthesis	Winter 2022-2023
Annual Report	March 2023
Retrieve data	Fall 2023
Data analysis and synthesis	Winter 2023-2024
Final Report	March 2024

Agency: US Fish and Wildlife Service Great Plains Fish and Wildlife Conservation Office (GPFWCO)

Activities and Methods: Great Plains FWCO: The USFWS will continue work started in 2021 in the Vermillion and Big Sioux Rivers including setting, replacing, or removing receivers, downloading data, and sharing significant findings.

Acoustic Transmitter Tagging

In addition to tracking 80 tagged silver carp from 2021, 27 new silver carp will be implanted with transmitters. Fish will be caught using electrofishing methods beginning at the confluence of the Vermillion and Big Sioux rivers, continuing upstream until 27 fish total (i.e., 14 in the Vermillion River and 13 in the Big Sioux River) are captured and implanted with a transmitter. Captured fish will be held in a tank with a continuous flow of fresh river water. Each fish will be anesthetized with Aqui-S 20E prior to surgery, weighed (g), measured for total length (mm), sexed, and implanted with acoustic transmitter tags (Vemco model V16-4H; 69kHz, 16 mm diameter, 68 mm length, 24 g). A Floy T-bar anchor tag (Model FD-94; Floy Tag & Mfg. Inc.) with a unique identification code and contact information (CARP@FWS.GOV) will be attached to each fish near its dorsal fin base. Following surgery, fish will be placed into a tank with a continuous flow of fresh river water until the fish is recovered enough to maintain equilibrium and swim independently. Once recovered, each fish will be released near its point of capture.

Acoustic Receiver Array

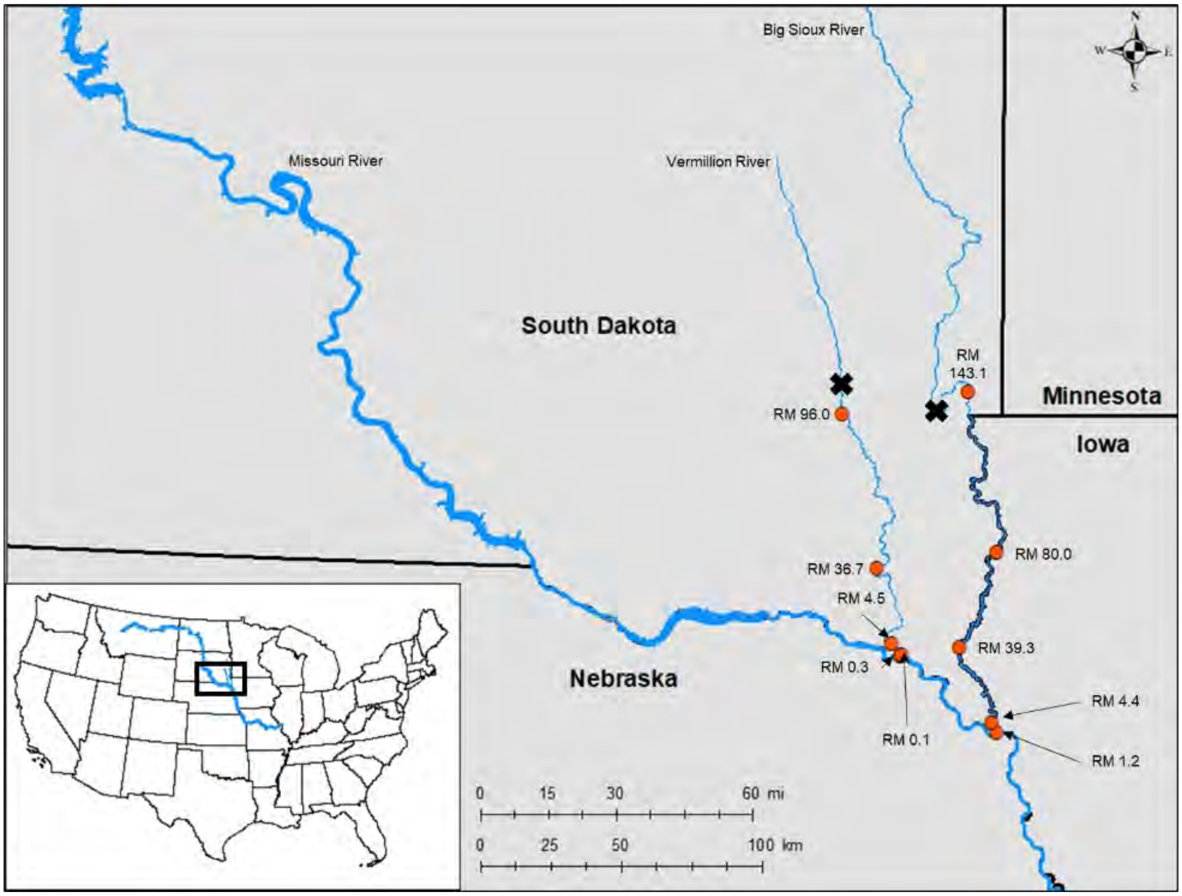
We will continue to monitor the passive telemetry receiver array we developed in the Big Sioux and Vermillion rivers to track movement and distribution of tagged silver carp. The array will consist of 10 Vemco VR2W acoustic receivers (n=5 per river). Each receiver will be fastened to a steel frame, placed on the bottom of the river, and attached to a secure object on shore (e.g., large tree) with ⅛-inch steel cable. A HOBO temperature logger will be attached to the furthest upriver and downriver receiver frames to collect water temperature data for each tributary.

In the Big Sioux River, receivers will be placed from 1.2 river miles upriver from its confluence with the Missouri River to 10 river miles downriver of Falls Park, Sioux Falls, SD (i.e., impassable fish barrier) where sufficient water depth is available. Total river distance spanned will be 141.8 river miles.

In the Vermillion River, receivers will be placed from 0.1 miles upriver of its confluence with the Missouri River to 6.5 miles downriver of Lake Vermillion dam (i.e., impassable fish barrier) where sufficient water depth is available. Total river distance spanned will be 95.9 river miles.

Map of Project Area:

- The Vermillion River confluences the Missouri River at rkm 1,242. The study area will focus on the lower 192 rkm of the Vermillion River (i.e., from the confluence upstream to the East Vermillion Lake dam, SD).
- The Big Sioux River confluences the Missouri River at rkm 1,181. The study area will focus on the lower 255 rkm of the Big Sioux River (i.e., from the confluence upstream to the Sioux Falls in Sioux Falls, SD).
- Locations of stationary VR2W receivers and HOBO water temperature loggers in the Vermillion and Big Sioux rivers are indicated. Water levels may require selection of alternate receiver and logger locations.



Location of passive receivers (orange circles) and barriers to fish movement (black "X") in the Big Sioux and Vermillion rivers during 2021. Receiver locations labeled by approximate river mile (RM).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Silver Carp tagging efforts	May/June 2022
Deployment of VR2W receivers and HOBO temperature loggers	April 2022
Data entry and analysis, annual report	October- December 2023
Data offload of receivers and HOBO loggers	Monthly 2022
Annual report	January 2023

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Control and containment of invasive carp in the Missouri River Basin

Lead Agency and Author: Missouri Department of Conservation (MDC), Joe McMullen, joe.mcmullen@mdc.mo.gov

Cooperating Agencies:

- Kansas Department of Wildlife and Parks (KDWP), Chris Steffen, chris.steffen@ks.gov, 785-230-2033
- Missouri Department of Conservation (MDC), Kasey Whitman, kasey.whiteman@mdc.mo.gov
- USFWS – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia), Jason Goeckler, jason_goeckler@fws.gov

Statement of Need:

Kansas Department of Wildlife and Parks (KDWP)

The Kansas River drains approximately the north half of the state of Kansas and a portion of south-central Nebraska and flows east to its confluence with the Missouri River at Kansas City. The Bowersock Dam at Lawrence, Kansas serves as a barrier to the upstream movement of invasive carp except during periods of exceptionally high flow (approximately >120,000 cfs). Only six bighead carp have been documented upstream of this barrier. These fish likely passed over the Bowersock Dam during extreme flooding in 1993. At that time, the invasive carp population in the Kansas River was very low and the number of fish that migrated upstream over the dam was insufficient to establish a breeding population in the upper portion of the river basin. Upstream of the Bowersock Dam, a relatively intact native prairie river fish community exists.

Removing invasive carp downstream from the Bowersock Dam would reduce the number of fish that may attempt to pass over the dam during a high flow event, decreasing the potential for a breeding population to establish upstream of the dam.

In addition to the upstream barrier (Bowersock Dam), there is a downstream semi-passable barrier (WaterOne Dam at Edwardsville, KS) that limits further upstream movement in the Kansas River from the Missouri River during normal flows. Data from a 2017-2018 study found that the demographic data for silver carp in the section of Kansas River proposed to be fished are different than those of silver carp in the lowest portion of the Kansas River. Therefore, we do not expect harvested fish to be quickly replaced by migrants. In addition, very few juvenile invasive carp have been encountered in the section of river proposed to be fished; most fish will be of a size vulnerable to harvest.

This project will support Strategy 1.3 of the Missouri River Basin Invasive Carp Control Strategy Framework to: “Identify locations and implement efforts to prevent Asian carp expansion where feasible”, Strategy 3.2 to: “Identify containment opportunities and implement efforts to control Asian carp expansion where feasible”, and Strategy 4.2 to: “Utilize management approaches to eradicate or reduce to levels of insignificant effect Asian carp populations”.

Missouri Department of Conservation (MDC)

Based on findings from the Defining Asian Carp Populations study, locations for testing removal efforts will be selected. Age and size structure data from these selected sites will be used to estimate pre-removal mortality. At these locations MDC, in cooperation with USFWS – Columbia, will apply variable levels of effort using multiple bighead carp and silver carp gears, techniques, and removal methods. Gears will include commercially available nets (e.g., gill nets, trap nets) as well as gears being used by state and federal agencies (e.g., dozer trawl). Size structure data will be collected post removal to estimate post-removal mortality. Based on results of removal efforts on the population structure, estimates of the amount of effort needed to achieve published exploitation rates in Siebert et al. 2015, Tripp and Phelps 2018, and ACRCC 2019 using top-performing removal techniques will be calculated. This information will be used to determine the feasibility of a fishery-induced collapse of invasive carp at these locations. This project will be a multi-year assessment and efforts conducted during fiscal year 2020 were focused on pilot evaluations of removal methods, site identification, and gear procurement. First year removal efforts took place in 2021 and an annual report over current progress submitted by March 2022. Further removal efforts will be needed in 2022 and 2023 to fully evaluate exploitation.

Objectives:

1. Remove invasive carp below Bowersock Dam to provide a buffer against range expansion should dam be inundated during a high flow event (KDWP).
2. Determine the feasibility and exploitation of various removal techniques on adult and juvenile bighead and silver carp and the effects on other fish species in the Lower Missouri River to inform control actions (MDC).
    a. Compare the catchability of different size classes of bighead carp and silver carp among multiple removal methods in the mainstem Missouri River, mid-sized tributaries, and floodplain waterbodies.
    b. Estimate the amount of fishing effort required to achieve targeted exploitation rates among top-performing removal techniques.
    c. Assess the feasibility of a fishery-induced collapse of bighead carp and silver carp.

Activities and Methods:

Kansas Department of Wildlife and Parks (KDWP)

Funds from this grant will be used to direct fishing efforts to remove invasive carp from the Kansas River downstream of the Bowersock Dam (Lawrence, KS, RKM 60). The Kansas River is generally shallower and more braided than other locations in the Mississippi River basin where commercial and suppression invasive carp fishing efforts have occurred. Therefore, continued experimentation with gear types, techniques, and deployment locations is necessary. Traditional fishing gears such as gill-nets and hoop-nets in a suite of configurations and mesh sizes will be deployed. Electrofishing equipment may also be used to herd invasive carp into static gears.

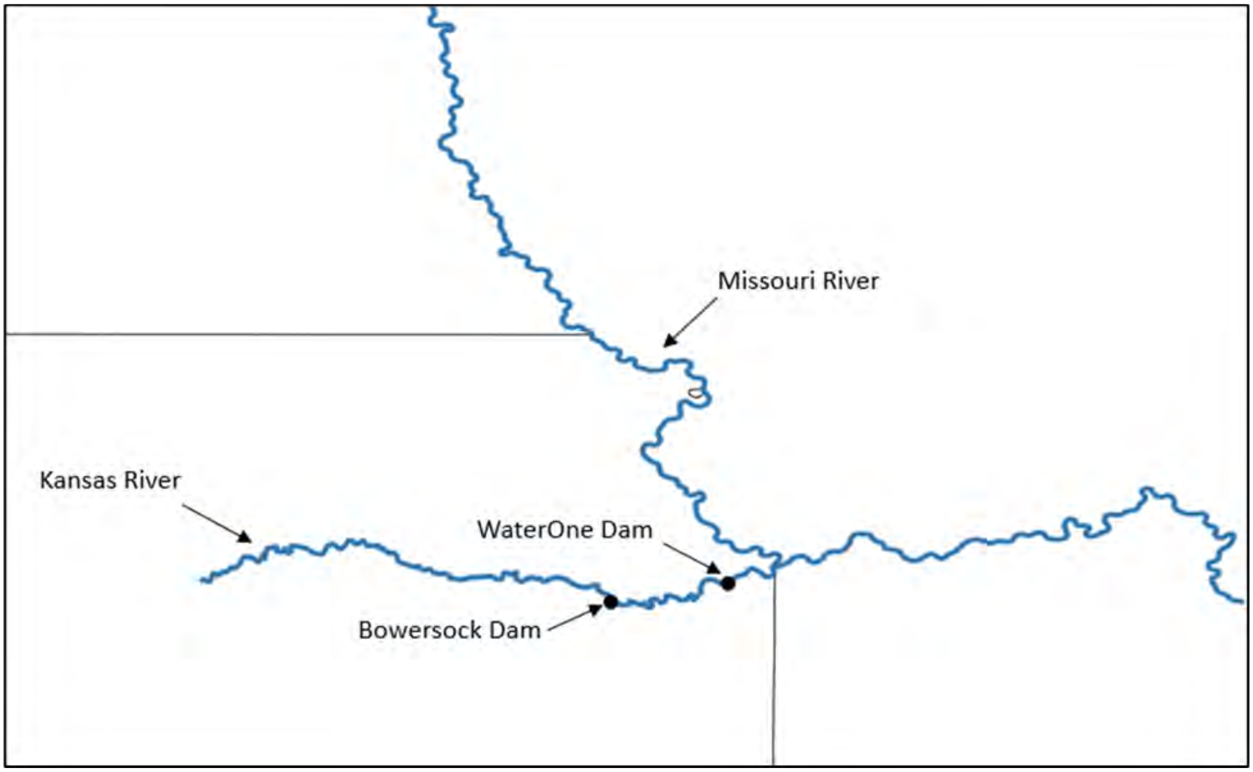
KDWP intends to meet the objective of population reduction by either hiring and equipping additional KDWP staff (preferred) or contracting with a commercial fisher. If a commercial fisher is used, we anticipate implementing an effort-based (rather than catch-based) payout to prevent a reduction in fishing effort in conjunction with an expected reduction in harvest. KDWP will collect data on amount of invasive carp removed, removal methods (net type, dimensions, set location, duration, etc.), and relative effectiveness of strategies employed. In addition, KDWP may pursue an assessment invasive carp removal effectiveness. At the conclusion of removal efforts, KDWP will prepare a final report.

Missouri Department of Conservation (MDC)

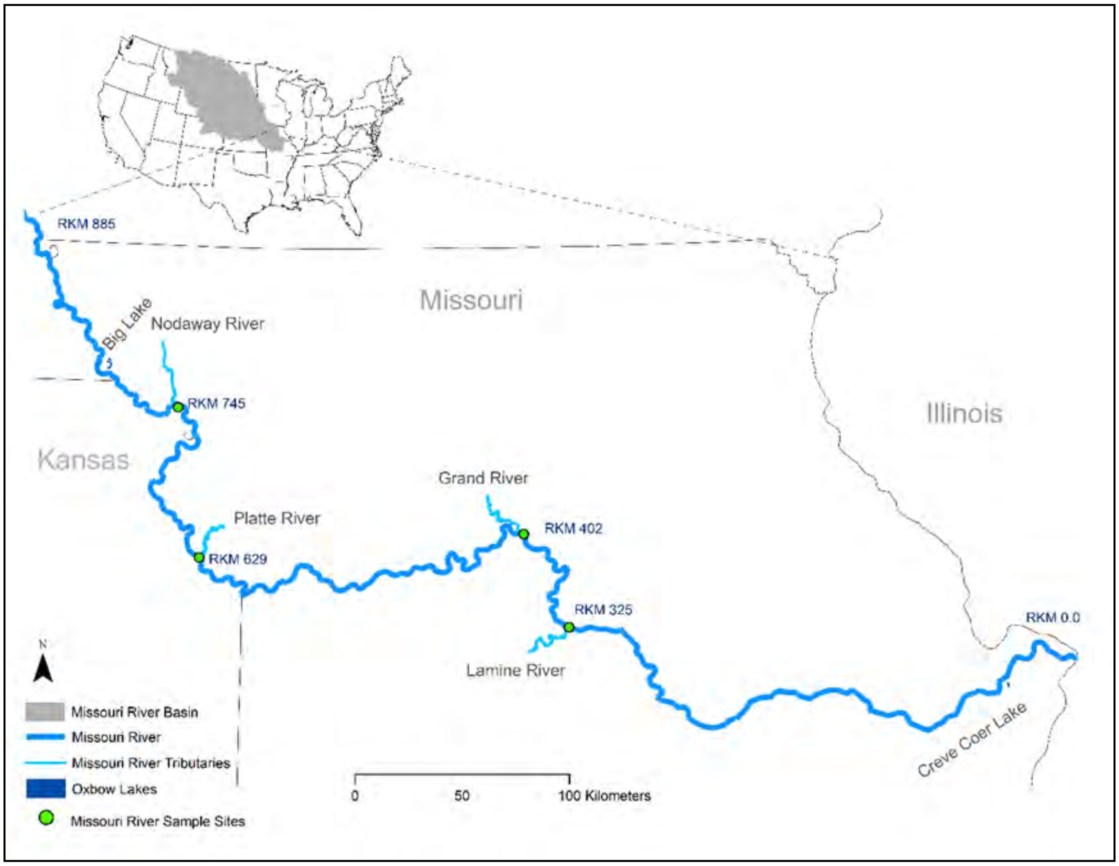
Based on findings from the Defining Asian Carp Populations study, locations for testing removal efforts will be selected. Age and size structure data from these selected sites will be used to estimate pre-removal mortality. At these locations MDC, in cooperation with USFWS – Columbia, will apply variable levels of effort using multiple bighead carp and silver carp gears, techniques, and removal methods. Gears will include commercially available nets (e.g., gill nets, trap nets) as well as gears being used by state and federal agencies (e.g., dozer trawl). Size structure data will be collected post removal to estimate post-removal mortality. Based on results of removal efforts on the population structure, estimates of the amount of effort needed to achieve published exploitation rates in Siebert et al. 2015, Tripp and Phelps 2018, and ACRCC 2019 using top-performing removal techniques will be calculated. This information will be used to determine the feasibility of a fishery-induced collapse of invasive carp at these locations. This project will be a multi-year assessment. Initial efforts have focused on pilot evaluations of removal methods, site identification, and gear procurement. First year removal efforts took place in summer/fall 2021 and an annual report over current progress submitted by March 2022. Second year removal efforts will be in summer/fall of 2022 and 2023 to fully evaluate exploitation.

Map of Project Area:

Kansas Department of Wildlife and Parks (KDWP)



Missouri Department of Conservation (MDC)



Map of proposed actions by Missouri Department of Conservation including sampling locations on the Missouri River, sampling stretches of selected tributaries (lower 40km highlighted with blue) and potential oxbow lakes (identified in dark blue).

Estimated Timetable for activities

Kansas Department of Wildlife and Parks (KDWP)

Activity	Time Period (Season, month/year)
KDWP staff acquire equipment and conduct invasive carp removal efforts	October 2022 – September 2023
Submit annual technical report	March 2023
Submit annual technical report	March 2024

Missouri Department of Conservation (MDC)

Activity	**Time Period** **(Season, month/year)**
Pilot removal efforts and gear procurement	September 2020 – March 2021
Removal efforts and post removal evaluation	September 2021 – March 2022
Data entry, analysis and report writing	February 2022 – March 2022
Submit Annual Report	March 2022
Removal efforts and post removal evaluation	September 2022 – March 2023
Data entry, analysis and report writing	February 2023 – March 2023
Submit Annual Report	March 2023
Removal efforts and post removal evaluation	September 2023 – March 2024
Data entry, analysis and report writing	February 2024 – March 2024
Submit Report	March 2024

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Invasive carp communication and outreach in the Missouri River Basin

Lead Agency and Author: Emily Pherigo, U.S. Fish and Wildlife Service, Emily_pherigo@fws.gov

Cooperating Agencies:

- Iowa Department of Natural Resources (IDNR), Kim Bogenschutz, kim.bogenschutz@dnr.iowa.gov
- Kansas Department of Wildlife and Parks (KDWP), Chris Steffen, chris.steffen@ks.gov
- Nebraska Game and Parks Commission (NGPC): Kirk Steffensen, kirk.steffensen@nebraska.gov; U.S. Geological Survey—Nebraska Cooperative Fish and Wildlife Research Unit (NCFWRU): Kevin Pope, kpope2@unl.edu, Jonathan Spurgeon, jpspurgeon2@unl.edu, and University of Nebraska-Lincoln (UNL), Christopher Chizinski, cchizinksi2@unl.edu
- South Dakota Department of Game, Fish, and Parks (SDGFP), Tanner Davis, tanner.davis@state.sd.us, BJ Schall, benjamin.schall@state.sd.us, Jason Sorensen, jason.sorensen@state.sd.us; South Dakota State University (SDSU), Alison Coulter, alison.coulter@sdstate.edu
- U.S. Fish and Wildlife Service – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia FWCO), Emily Pherigo, Emily_pherigo@fws.gov; USFWS-Bozeman Fish Health Center, Lacey Hopper, lacey_hopper@fws.gov

Statement of Need:

Invasive carp do not stop at state boundaries. A coordinated basin-wide approach with communication among partners and agencies is critical to the management of these invasive species. Moreover, it is important for managers on the ground to effectively communicate with each other to ensure that the most up-to-date science and techniques are being shared. Efforts need to be made to prevent the spread of Invasive carp and to manage these species in their current localities with a coordinated approach across the Missouri River Basin. This workplan outlines research to assess impacts of Invasive carp on recreation and evaluate bait shops as a vector of human-mediated spread as well as outline coordination and communication priorities for the Missouri River Basin Invasive Carp Partnership to effectively communicate with each other to achieve the best overall management of Invasive carp possible.

Though Invasive carp are known to dramatically impact our aquatic resources, little is understood about how these species affect recreationalists and anglers who use these resources. As Invasive carp spread and impact waterways, users can be affected through several pathways. Invasive carp may prevent boating or impact the quality of a fishery. Therefore, it is critical to obtain information from these users to not only better understand how Invasive carp affects them, but to gain insight into potential management techniques. Information obtained can also be used to direct specific outreach efforts for all AIS and allow for increased dialogue with aquatic users and managers.

One pathway for Invasive carp expansion that has not been fully investigated is human-mediated movement. Invasive carp (primarily as young-of-year) closely resemble common baitfishes, such as Gizzard Shad *Dorosoma cepedianum* and Alewife *Alosa psuedoharengus*, used by anglers and sold commercially. Several Missouri River Basin states allow anglers and bait dealers to collect their own bait, resulting in a high risk of human-mediated movement of Invasive carp especially if bait is improperly released.

Spread of aquatic invasive species (AIS) via dumping of live bait is a known vector for spread. Targeted educational campaigns, in specific regions or at particular bait shops, could help reduce the risk of AIS spread by anglers using live bait. Additionally, understanding the relative risks posed by bait shops regionally and how the characteristics of each bait shop (e.g., proximity to AIS established population, regulations of particular states, sources of baitfish) influence risk will help increase effectiveness of educational programs by targeting interventions. In the Missouri River Basin, Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis*) are particular AIS of concern. They are established in the mainstem Missouri River below Gavins Point Dam which limits their upstream expansion. Additional dams on tributaries to the Missouri River (e.g., Big Sioux River Falls and East Vermillion Lake spillway in South Dakota, the Jamestown Reservoir spillway in North Dakota, Bowersock, and Clinton dams in Kansas) have likely inhibited upstream expansion of these AIS. However, introduction of these species above dams that currently inhibit their spread via bait dumping is a serious concern. While all states in the basin prohibit dumping of unused live bait, some states such as Kansas have added new live bait regulations in recent years. States such as South Dakota are taking additional steps such as distributing bags for live bait purchase that remind anglers not to release unused live bait. In the Great Lakes region, Silver Carp eDNA was previously documented in bait shops that were located outside of the current range of Silver Carp (Nathan et al. 2014) indicating that Silver Carp were currently present or may have passed through bait shop tanks. Recent work from around the Great Lakes Basin suggests that as many as 50% of anglers have released live baitfish at some point (Snyder et al. 2020).

In addition, even in localities with regulations restricting live bait collection, illegal collection and subsequent selling of live bait cannot be ruled out. Thus, it is imperative to not only investigate all methods of human-mediated movement of Invasive carp, but to develop pragmatic management solutions to prevent or reduce the risk from this pathway.

Objectives:

1. Support coordination and communication among partners regarding Invasive carp outreach and management in the Missouri River Basin and beyond for the most efficient use of resources.
2. Evaluate recreational satisfaction and Invasive carp knowledge in areas of the Missouri River Basin with Invasive carp to inform management actions and increase the effectiveness of outreach messaging.
3. Assess human-mediated pathway risks for Invasive carp movement to prevent the introduction and further spread of Invasive carp into and within the Missouri River Basin.
   a. Collect and process samples to assess the risk of Invasive carp (Silver Carp and Bighead Carp) spread in the Missouri River Basin via the live bait trade and

identify risk factors associated with particular bait shop operations (e.g., state regulations, proximity to established Invasive carp populations).

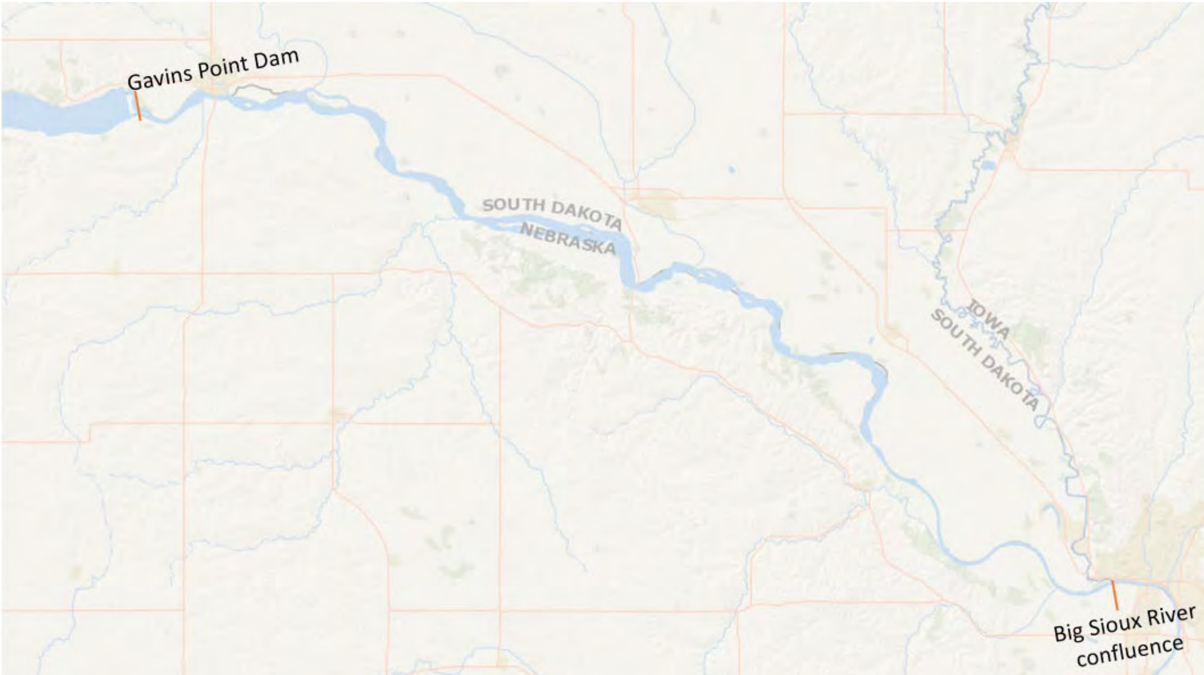
Agency: Nebraska Game and Parks Commission (NGPC): Kirk Steffensen, kirk.steffensen@nebraska.gov; U.S. Geological Survey—Nebraska Cooperative Fish and Wildlife Research Unit (NCFWRU): Kevin Pope, kpope2@unl.edu, Jonathan Spurgeon, jpspurgeon2@unl.edu; University of Nebraska-Lincoln (UNL), Christopher Chizinski, cchizinksi2@unl.edu

Activities and Methods:

Objective 2.

- NGPC: The Nebraska Game and Parks Commission in conjunction with the South Dakota Fish, Game, and Parks oversee two Paddlefish-fishing seasons annually in the mainstem Missouri River between Gavins Point Dam and the Big Sioux River. The Invasive carp has steadily increased in abundance in this reach during the past several decades, anecdotally negatively affecting anglers' satisfaction. Currently, we rely on a postcard survey to monitor this fishery and judge anglers' satisfaction from the comment section of the returned postcards. We are proposing an in-person creel survey during our June-archery and October-snagging seasons of 2022 and 2023. These creel surveys would quantify catches (target and non-target) and efforts during paddlefish seasons mainly around Gavins Point Dam as anglers are highly concentrated in this area.
  Satisfaction generally is as an attitude-like judgment following an event based on pre-event expectations. The confirmation or disconfirmation of expectations is the essential determinant of satisfaction. Thus, confirmed expectations lead to moderate satisfaction, positively disconfirmed (exceeded) expectations lead to high satisfaction, and negatively disconfirmed (underachieved) expectations lead to dissatisfaction. In many cases, experience-based norms derived from past personal experiences or information received from influential acquaintances determine the pre-event expectations. Thus, in addition to in-person creel surveys, we will send mail (or internet) surveys to previous year's license holders to quantify anglers' expectations as a basis for understanding stated satisfactions. Further, we will ask questions targeted at general knowledge about Invasive carp and understanding of potential consequences of human-mediated spread; similar questions will also be asked of a random draw for the general public through the annual survey conducted by the Bureau of Sociological Research (housed at UNL). Finally, we will qualitatively assess the comment section of previously returned postcards to determine the nature of the long-term trend in anglers' satisfactions (i.e., gradual decline or sudden decline associated with appearance of Invasive carp).

Map of Project Area:



The border water area between Nebraska and South Dakota where Paddlefish archery and snagging seasons occur annually. Open area includes the lower Missouri River from Gavins Point Dam to the Big Sioux River confluence.

Estimated Timetable for activities

Activity	**Time Period (season, month/year)**
Recruit Graduate Students	October – December 2021
Proposal development, training, equipment requisition, background research, sampling site reconnaissance	January – March 2022
Recruit Research Technician	January – March 2022
Field sampling for Objectives 1 & 2	April – December 2022 April – September 2023
Sample analysis, data entry, data analysis, report writing	October 2022 – March 2023 October 2023 – March 2024
Submit Annual Report	March 2023 March 2024
Manuscript development	October 2023 – March 2024

Agency: South Dakota Department of Game, Fish, and Parks (SDGFP), Tanner Davis, tanner.davis@state.sd.us, BJ Schall, benjamin.schall@state.sd.us, and Jason Sorensen, jason.sorensen@state.sd.us; South Dakota State University (SDSU), Alison Coulter, alison.coulter@sdstate.edu

Activities and Methods:

Objective 3

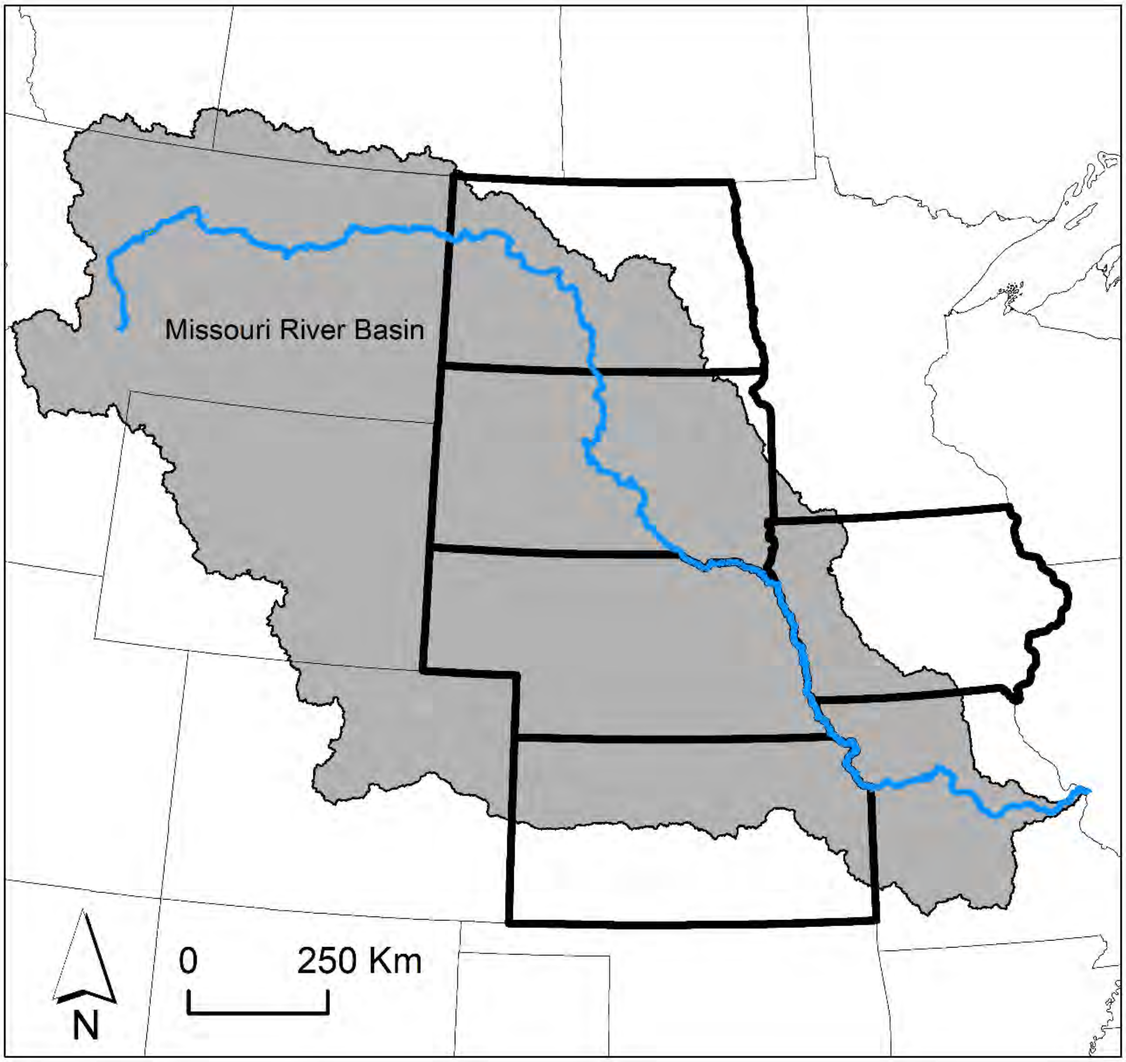
- SDGFP & SDSU: We propose to assess the risk for Silver Carp and Bighead Carp to spread via live bait by assessing the presence of eDNA in bait shops in multiple states within the Missouri River Basin. Bait will be purchased from multiple bait shops across North Dakota, South Dakota, Nebraska, Kansas, and Iowa along a gradient of Invasive carp abundances including areas they have not yet invaded. Bait will be identified to species and bait water will be evaluated for the presence of Silver Carp and Bighead Carp eDNA. Risk posed by particular bait shops will be evaluated by modeling the risk of Silver Carp of Bighead Carp eDNA presence in conjunction with possible risk factors (i.e., state regulations, proximity to established populations, sale volume, baitfish source, existence of a bait inspection program). FY 2023 work will continue data analysis started in FY 2022, and FY 2024 work will focus on dissemination of project results. This project addresses the basin objective of "communication" and the sub-objective of the "Prevention of human-mediated expansion."

  The previous round of funding for this project allowed eDNA surveillance of bait shops in five Missouri River Basin states as well as resampling of bait shops that were positive for Silver Carp or Bighead Carp eDNA. In FY 23, Graduate student Hannah Mulligan will complete statistical analyses to identify risk factors that may link with positive results from previous eDNA surveillance. These results will be shared directly with collaborating states, at a national fisheries meeting, in the graduate student's thesis, and in a peer reviewed publication.

  This request for continued funding covers a final semester for graduate student Hannah Mulligan, hourly pay for an undergraduate student to help finish analyses, travel to present results at a conference, and publication fees.

Map of Project Area:

Sampling of bait shops will occur in the Missouri River Basin within the states that are boldly outlined (North Dakota, South Dakota, Nebraska, Iowa, and Kansas).



Estimated Timetable for Activities

Activity	Time Period(Season, month/year)
Collaborative Annual Technical Report	March 2023
Analyses to identify risk factors	Summer and Fall 2023
Conference presentation	August 2023
MS thesis completion	December 2023
Grant Annual Report	Fall 2023
Collaborative Annual Technical Report	March 2024
Grant Final Report	Fall 2024

Agency: USFWS – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia FWCO), Emily Pherigo, Emily_pherigo@fws.gov; USFWS-Bozeman Fish Health Center, Lacey Hopper, lacey_hopper@fws.gov

Activities and Methods:

Objective 1.

- USFWS – Columbia FWCO: Provide guidance to Missouri River Basin Invasive carp partnership on the planning, implementation, and reporting process to ensure coordination with other regional and national plan implementation structures. Assist with implementation of conference symposium to provide opportunities to exchange ideas among Missouri River sub basin, regional and national partners conducting research, management, and control of Invasive carp. Coordinate with other aquatic research taking place in the Missouri River Basin that may have an impact on or be impacted by the management of Invasive carp.

Objective 3

- USFWS: Bozeman Fish Health Center will provide support in analyzing baitfish study samples for Invasive carp eDNA.

Estimated Timetable for activities

Activity	**Time Period (Season, month/year)**
FY23 Proposals	Fall 2022/Winter 2023
2022 Annual Technical Reports	Spring 2023
FY23 Work Plans & Grants	Spring/Summer 2023
Annual meeting	Summer 2023
FY24 planning	Fall 2023
FY24 Proposals	Fall 2023/Winter 2024

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Nathan et al. 2015. The use of environmental DNA in invasive species surveillance of the Great Lakes commercial bait trade. Conservation Biology 29: 430-439.

Snyder et al. 2020. Detecting aquatic invasive species in bait and pond stores with targeted environmental (e)DNA high-throughput sequencing metabarcode assays: Angler, retailer, and manager implications. Biological Conservation 245: 108430.

Understanding invasion risk to more effectively allocate monitoring and management

Lead Agency and Author: Emily Pherigo (emily_pherigo@fws.gov), USFWS Columbia Fish and Wildlife Conservation Office

Cooperating Agencies:
Nebraska Game and Parks Commission (NGPC), Kirk Steffensen, kirk.steffensen@nebraska.gov; University of Nebraska – Lincoln, School of Natural Resources, Mark Pegg, mpegg2@unl.edu; U.S. Geological Survey—Nebraska Cooperative Fisheries and Wildlife Research Unit, and School of Natural Resources, University of Nebraska-Lincoln, Jonathan Spurgeon, jspurgeon2@unl.edu

South Dakota Game, Fish, & Parks (SDGFP), Tanner Davis (tanner.davis@state.sd.us) and BJ Schall (benjamin.schall@state.sd.us); South Dakota State University (SDSU), Alison Coulter (alison.coulter@sdstate.edu), Dave Coulter (david.coulter@sdstate.edu), and Steve Chipps (steven.chipps@sdstate.edu)

USFWS – Columbia FWCO, Jason Goeckler (jason_goeckler@fws.gov), Emily Pherigo (emily_pherigo@fws.gov), and Pablo Oleiro (pablo_oleiro@fws.gov)

USGS South Dakota Water Sciences Center, Ryan Thompson (rcthomps@usgs.gov)

Statement of Need:

Minimizing the risk of invasive carp from spreading to new areas in the Missouri River basin requires an understanding of which sites are most vulnerable to invasion. This knowledge will allow limited management resources (e.g., prevention efforts, surveillance, removal) to be prioritized to the most at-risk locations and can aid in the development of proactive response plans. A site's vulnerability to invasive carp depends on a suite of factors. Permanent or temporary connectivity to systems where invasive carp occur increases a site's invasion risk due to the potential for movement or dispersal. The Missouri River basin has a diverse network of rivers, streams, and diversion canals which connect river systems, yet information is lacking regarding the hydrological connectivity that could allow invasive carp to move among these systems, especially during high-water events. A site's invasion risk also depends on whether habitat conditions (e.g., thermal conditions, flow regime, prey availability) are suitable to allow invasive carp to grow and survive once they have become introduced, regardless of the mechanism of introduction. Past habitat suitability assessments have been conducted over a broad spatial scale using climate matching approaches (e.g., Herborg et al. 2007). Instead, fine-scale habitat suitability predictions are needed so sites can be compared and ranked based on relative risk. Additionally, understanding whether site conditions are suitable only for certain sizes or life stages can refine site relative risk comparisons and inform gears needed for surveillance efforts. Finally, a site's invasion risk depends on whether conditions are suitable for spawning. The ability of invasive carp to capitalize on environmental conditions conducive to spawning greatly contribute to their ability to invade an area and become the dominant fish species (Kolar et al. 2007; Irons et al. 2007). Applying previously developed models (e.g., Garcia et al. 2015) to quantify spawning potential will be an essential component for determining invasion risk in uninvaded rivers.

The primary goal of this work is to limit the spread of invasive carp in the Missouri River basin. The tasks described here will develop quantitative risk assessments that will identify site vulnerability to invasive carp in the Missouri River basin. These results will allow for the efficient use of management resources by identifying locations where movement deterrents can be placed, determining locations and life stages (eggs, juveniles, adult size classes) monitoring efforts should target and appropriate sampling gears to use, and informing or developing response plans if invasive carp are observed in new locations.

Objectives:

1. Assess hydrologic connectivity in the Missouri River Basin to identify locations at risk of Silver and Bighead carp movement into new areas.
2. Define relative risk based on habitat suitability for Silver and Bighead Carp invasion in uninvaded areas of the Missouri River Basin.
3. Define relative risk based on the system's ability to support spawning, drift, and hatch of Silver and Bighead Carp in uninvaded areas of the Missouri River Basin.

Understanding invasion risk to more effectively allocate monitoring and management

Agency: Nebraska Game and Parks Commission, Kirk Steffensen,
kirk.steffensen@nebraska.gov

Cooperating agencies:
University of Nebraska – Lincoln, School of Natural Resources
Mark Pegg
mpegg2@unl.edu

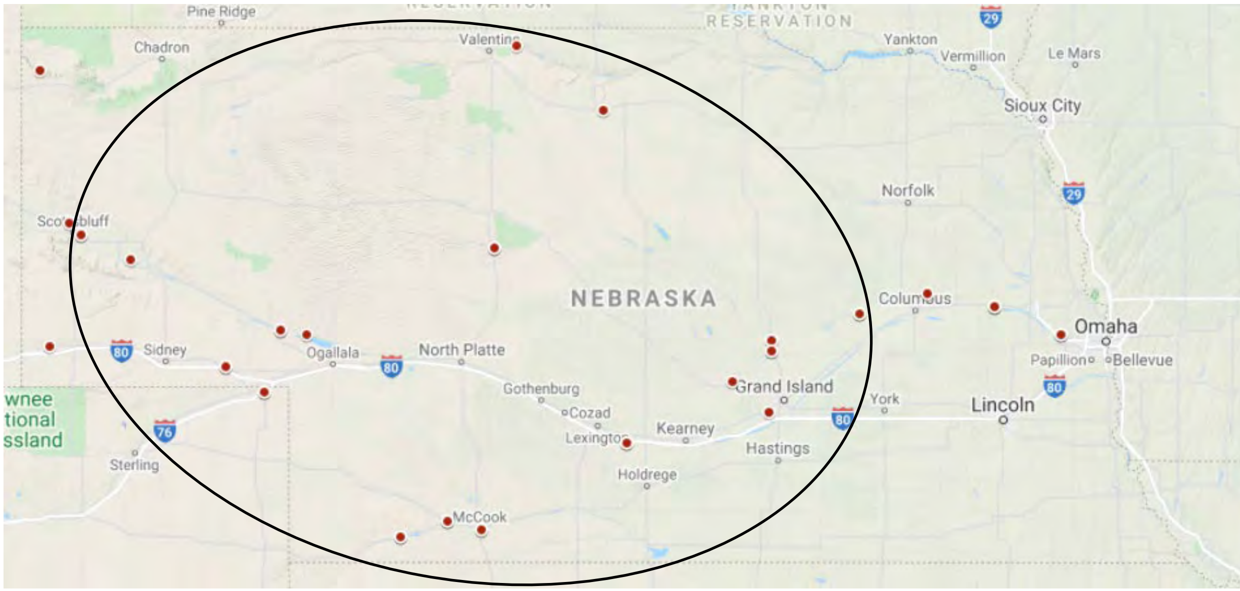
U.S. Geological Survey—Nebraska Cooperative Fisheries and Wildlife Research Unit, and School of Natural Resources, University of Nebraska-Lincoln
Jonathan Spurgeon
jspurgeon2@unl.edu

Activities and Methods:

Objective 1. Nebraska has a diverse network of rivers, streams, and diversion canals which connect river systems and impoundments throughout the State as well as among states within the Missouri River basin. The current distributions of Silver Carp and Bighead Carp in Nebraska are being investigated through a combination of eDNA and traditional fish sampling. However, an understanding is lacking regarding the hydrological connectivity among systems where Silver Carp and Bighead Carp currently occur as well as in locations along and beyond the leading edge of their distributions. Such information will benefit understanding regarding potential dispersal pathways of invasive carp and highlight areas susceptible to ecological and economic threats posed by Silver Carp and Bighead Carp.

We will employ a GIS based assessment to detail the current invasive carp distribution and document barriers for upstream movement. The connectivity of the canal network throughout Nebraska will be extensively mapped to identify the “risk” of further invasive carp range expansion and then identify discharge levels that provide connectivity between systems, which may allow further invasive carp upstream movement and determine risk of range expansion. Areas containing sufficient habitats for all life-stages of Silver Carp and Bighead Carp will also be mapped. Additional field assessments of population sizes near potential access points will also be assessed to gauge the propagule pressure (i.e. greater numbers = greater risk) as part of the risk assessment. We will designate areas where management actions to control certain life-stages of carp (i.e., recruitment) could be feasible. For instance, if carp are determined to use canal networks there may be opportunities for water management to limit expansion.

Map of Project Area:



Map of the state of Nebraska. Red dots indicate potential locations of invasive carps. Black circle highlights the area where most of the assessment of movement capacity and propagule pressure will be assessed (i.e., the leading edge of expansion into new waters).

Estimated Timetable for Activities:

Activity	Time Period (season, month/year)
Hire Postdoctoral Researcher	October – December 2022
Compile data currently available and GIS coverage information	January – March 2023
Stakeholder Meetings	April-June 2023
GIS analyses and modelling	July –December 2023
Annual Report	January-February 2024
GIS analyses and final report writing	March– Sept 2024
Final report and manuscript development	October -December 2024

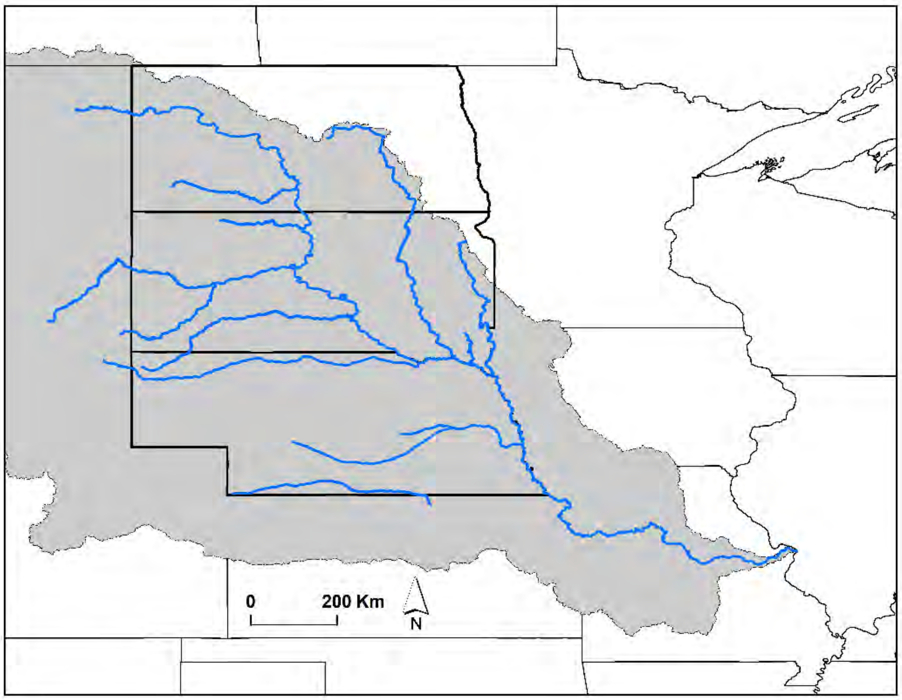
Agency: South Dakota Game, Fish, & Parks (SDGFP), Tanner Davis (tanner.davis@state.sd.us) and BJ Schall (benjamin.schall@state.sd.us); South Dakota State University (SDSU), Alison Coulter (alison.coulter@sdstate.edu), Dave Coulter (david.coulter@sdstate.edu), and Steve Chipps (steven.chipps@sdstate.edu); USGS South Dakota Water Sciences Center, Ryan Thompson (rcthomps@usgs.gov)

Activities and Methods:

Objective 1. This project will be a collaborative effort between SDGFP, North Dakota Game and Fish, and the USGS Dakota Water science Center to assess the potential for interconnectivity of these eastern North Dakota and South Dakota tributaries to the Missouri River. Hydrological connectivity between uninvaded waterbodies with currently invaded locations in South Dakota and North Dakota will be identified using past remote sensing data. The current location of invasive carp will be determined from the USGS Nonindigenous Aquatic Species database and via the Missouri River Basin invasive carp partnership. Years representing typical and extreme water levels will be determined from the USGS stream gaging network for the Missouri River Basin. Remotely sensed imagery, such as digital elevation models (LIDAR based) and USGS's Dynamic Surface Water Extent products, will be obtained for typical and extreme water level years. GIS analyses will be used to identify the spatial extent of surface water that is connected to reaches currently harboring invasive carp. Deliverables from this work will include maps and GIS layers identifying waterbodies that are hydrologically connected to invaded habitats under 1) typical water levels, and 2) extreme low- and high-water levels.

Objective 2. This project will assess invasion risk of Bighead and Silver Carp in the Missouri River Basin by quantifying habitat suitability. High invasion risk will be assigned to locations where adult and young-of-year (YOY) carp can grow and survive, whereas sites with low invasion risk will be characterized by poorly suited habitat for growth and survival of adult and/or YOY. Site-specific risk will be evaluated across all sizes of fish (YOY – adults) that could become introduced, thereby assessing risk regardless of the mechanism of introduction (e.g., live bait dumping, dispersal of adults, or spawning). Long-term growth and survival will be quantified using a bioenergetics-based approach based on reach-specific observations of water temperature, velocity, and plankton density. This study will initially target mid-order tributaries (e.g., 3^{rd} to 5^{th} order streams) to the Missouri River that lack established invasive carp populations. Water temperature, velocity, and plankton density will be collected from river reaches where historical data are unavailable and used as model input to evaluate carp growth. Growth predictions will be validated by modeling growth at locations where carps are present and comparing predicted long-term growth rates to observed carp length-at-age data (using existing data or capturing and aging fish if data are unavailable). Model output will include a database listing for each river and species: percent of individuals surviving, minimum size capable of surviving, growth of surviving individuals, and YOY introduction dates resulting in survival. Deliverables will include maps and GIS layers indicating relative invasion risk for Bighead and Silver Carp in Missouri River tributaries. Results from this project will provide stakeholders the information they need to (1) allocate signage or outreach to prevent bait dumping in areas where YOY can survive, (2) develop monitoring plans that prioritize locations based on relative risk and focus sampling gears on the size of fish expected to survive, and (3) inform actions when a Bighead or Silver Carp is observed (e.g., support for no action if individuals are found in a low risk area). This risk assessment will be valuable for identifying suitable areas that can be prioritized for management actions and for identifying areas where low survival and negative fish growth lead to a population sink that reduce risk priority. Elements of this risk assessment are additive to ongoing risk assessments focused on hydrologic connections or spawning potential in the basin.

Map of Project Area:



Hydrological connectivity and habitat suitability risk assessments will be conducted in large tributaries of the Missouri River Basin.

Estimated Timetable for activities

Activity	**Time Period (Season, month/year)**
Hire graduate student	January 2023
Meet with stakeholder groups	Spring 2023
Compile historical environmental data / collect field observations	Spring, Summer 2023
Develop habitat suitability model for MO River tributaries	Summer 2023 – Fall 2024
Validate model growth predictions	Summer – Fall 2024
Annual report	January – February 2024

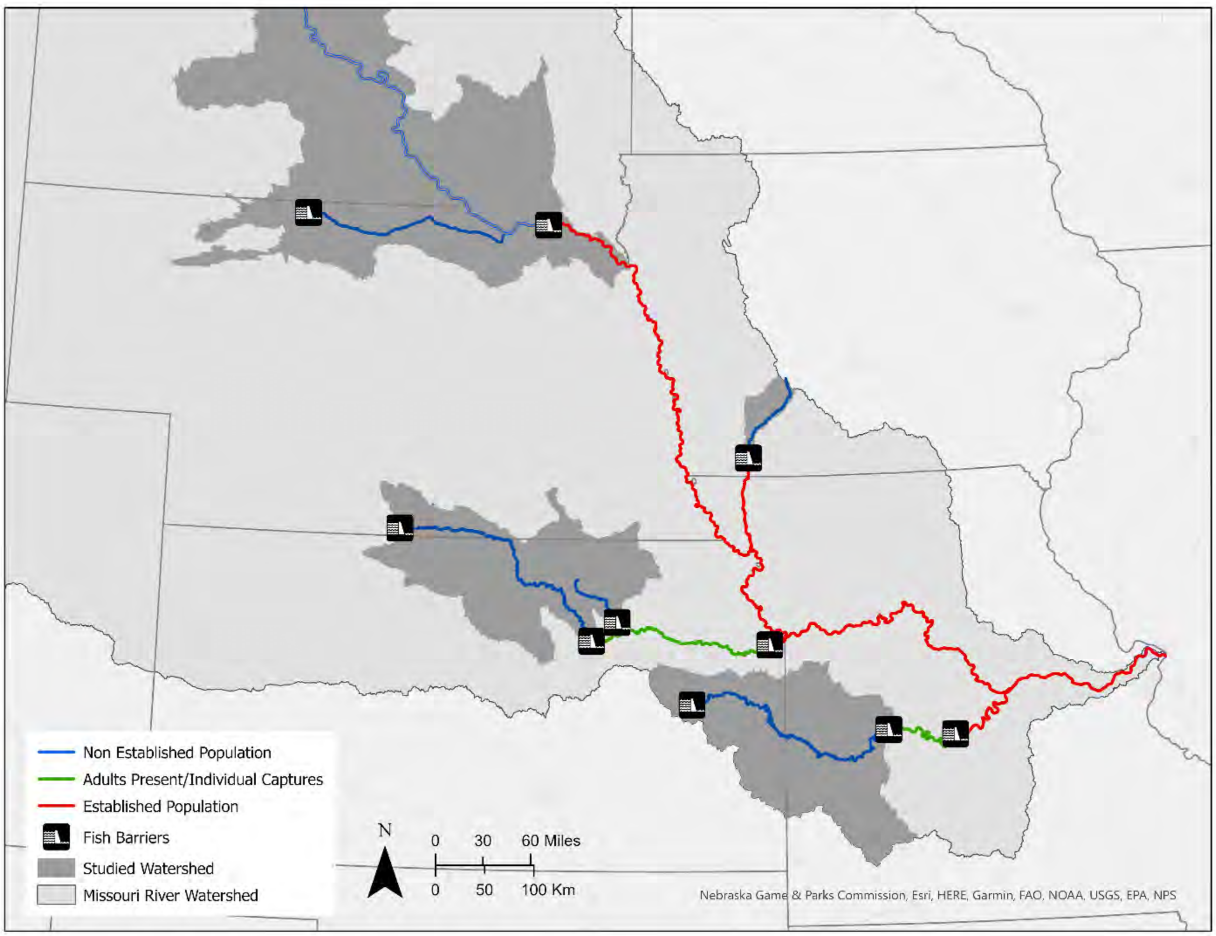
Final report	Fall 2024

Agency: USFWS – Columbia FWCO, Jason Goeckler (Jason_goeckler@fws.gov), Emily Pherigo (emily_pherigo@fws.gov), Pablo Oleiro (pablo_oleiro@fws.gov)

Activities and Methods:

Objective 3. To understand the risk of colonization we'll explore hydrologic and thermal characteristics in addition to flowing stream habitat availability needed to support successful spawn, development, and hatch of Silver Carp. We'll use this information to create a tool that defines relative risk of establishment in uninvaded areas

Map of Project Area:



Spawning risk assessments will be conducted in areas without established populations of Invasive Carp in the Missouri River Basin such as those identified in the above map. Additional areas may be identified through conversations with stakeholders.

Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Identify priority waterways with input from state partners to evaluate spawning potential	Winter 2023
Compile hydrologic, thermal, and geospatial data for identified waterways	Spring, Summer 2023
Present preliminary results to Invasion Risk Team	Summer 2023
Ranked list of streams with potential for establishment	Summer-Fall 2023
Annual Report	Winter 2024

Literature Cited:

Garcia, T., Murphy, E. A., Jackson, P. R., & Garcia, M. H. (2015). Application of the FluEgg model to predict transport of Asian carp eggs in the Saint Joseph River (Great Lakes tributary). *Journal of Great Lakes Research*, *41*(2), 374-386.

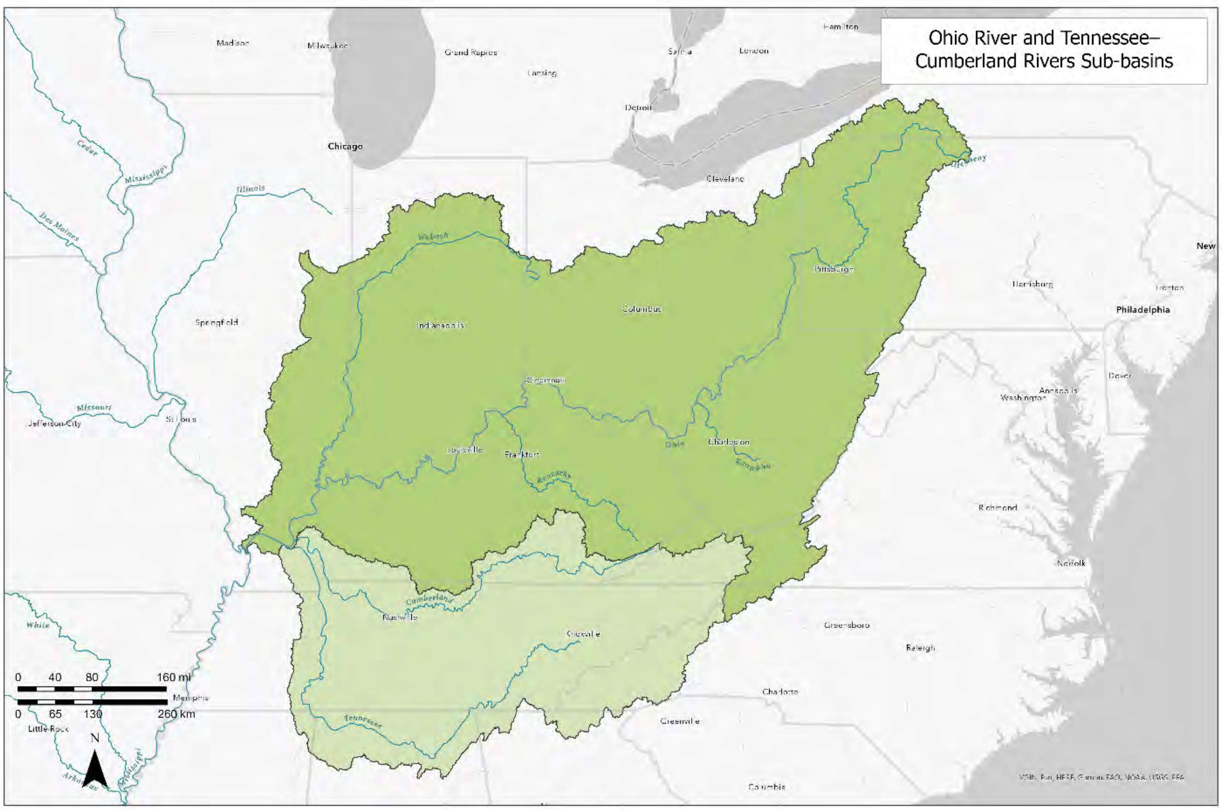
Herborg, L. M., Mandrak, N. E., Cudmore, B. C., & MacIsaac, H. J. (2007). Comparative distribution and invasion risk of snakehead (Channidae) and Asian carp (Cyprinidae) species in North America. *Canadian Journal of Fisheries and Aquatic Sciences*, *64*(12), 1723-1735.

Irons, K. S., Sass, G. G., McClelland, M. A., & Stafford, J. D. (2007). Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River, USA Is this evidence for competition and reduced fitness? *Journal of Fish Biology*, *71*, 258-273.

Kolar, C. S., Chapman, D. C., Courtenay Jr, W. R., Housel, C. M., Williams, J. D., & Jennings, D. P. (2005). Asian carps of the genus *Hypophthalmichthys* (Pisces, Cyprinidae)—a biological synopsis and environmental risk assessment.

Ohio River Sub-Basin and Tennessee Cumberland Sub-Basin Invasive Carp Partnerships

The Ohio River (OHR) flows through or along the border of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia; these six states collaboratively manage fisheries in the mainstem OHR through the Ohio River Fisheries Management Team (ORFMT). The ORFMT recognized the magnitude of the invasive carp threat and the need for coordinated efforts to limit the negative impacts of invasive carp in the ORB. The ORFMT engaged the remaining ORB states and key federal partners in the development of an Ohio River Basin Asian Carp Control Strategy Framework (ORB Framework) to prevent further range expansion, reduce populations, better understand and minimize impacts of invasive carps, and improve communication and coordination in the basin. The Tennessee and Cumberland rivers are major tributaries to the mainstem OHR, flowing through Kentucky, Tennessee, Mississippi, and Alabama. The ORB and TNCR partnerships collaborate to implement the ORB Framework.



Early Detection and Evaluation of Invasive carp Removal in the Ohio River

Lead Agency and Author: Kentucky Department of Fish and Wildlife Resources, Andrew Stump (andrew.stump@ky.gov)

Cooperating Agencies: Illinois Department of Natural Resources (ILDNR), Indiana Department of Natural Resources (INDNR), Pennsylvania Fish and Boat Commission (PFBC), Southern Illinois University (SIU), U.S. Fish and Wildlife Service (USFWS), West Virginia Division of Natural Resources (WVDNR), West Virginia University (WVU)

Statement of Need:

Invasive species are responsible for undesirable economic and environmental impacts across the nation (Lovell and Stone 2005, Pimentel et al. 2005, Jelks et al. 2008). Negative impacts of Invasive carp in the United States are a major concern because of their tolerance and adaptability to a wide range of environmental conditions (Kolar et al. 2005, Zhang et al. 2016). Their ability to quickly colonize novel habitats with dense populations have caused significant impacts on tourism and recreation, and potentially threaten native ecosystems throughout the entire Mississippi River basin, including the Ohio River sub-basin. In response, it is necessary to gather information on invasive carp distributions, behavior, and population characteristics in the Ohio River basin (ORB). This information will be used to assess management actions related to their removal, suppression, and containment.

The tasks outlined in this document would add a sixth year of multi-agency and university surveillance and data collection focused on Invasive carp early detection and removal primarily above Cannelton Dam. Collaborative efforts have included fish community sampling, targeted Invasive carp sampling, and incorporation of unique data such as hydroacoustics. The primary goal of these projects is to provide an accurate population trend assessment of Invasive carp control and response efforts. In addition, fish community data may aid in determining impacts of carp on native fish assemblages. This project provides an ongoing, coordinated approach to assess Invasive carp management and suppression in the ORB.

Objectives:

1. Evaluate management actions using changes in relative abundance, population characteristics, and distribution of invasive carps within intensive management zones.
2. Monitor long-term trends in native fish communities as indicators of change due to Invasive carp invasion.
3. Survey Invasive carp presence in upstream areas where they are rarely detected to inform response and containment efforts.
4. Determine spatial distributions (hotspots) and densities of Invasive carps in the lower Wabash River to inform and assess harvest.
5. Utilize hydroacoustics surveys to determine biomass densities and verify patterns of relative abundance for Invasive carp species within strategic management zones.

Agency: Kentucky Department of Fish and Wildlife Resources (KDFWR)

Activities and Methods:

Federal funding for this project for FY2022 will enable KDFWR in determining the effects of removal efforts on Invasive Carp populations. In prior years, high variability in annual sampling data, along with relatively high occurrences of zero-catch events indicated the need for increased effort to examine trends. For FY22, KDFWR will place additional effort into designing and implementing a protocol to determine occupancy of invasive carps in the Cannelton Pool along with a more rigorous investigation into the age distributions and population growth estimates.

Objective 1 – Evaluate management actions using changes in relative abundance, population characteristics, and distribution of carps within intensive management zones.

KDFWR will continue to track relative abundances and population characteristics independently and through coordination with other state agencies to conduct targeted sampling for Invasive carp along several pools, upriver of the Cannelton Locks and Dam complex (See map). Pulsed-DC boat electrofishing will be utilized to target bigheaded carps (those invasive carp included in the genus *Hypophthalmichthys*) along the Ohio main stem river for approximately 48 crew days to maintain consistency with efforts from previous years. Electrofishing will be conducted during the day (0800 to 2100 hours local time) with one driver and one staff in the bow of the boat dip-netting fish (dipper). Sampling is conducted in the spring of each year when water temperatures are 50°F – 65°F. Electrofishing is conducted in a general downstream direction for 900 seconds. Carp will be targeted with pulsed-DC electricity at 80 pulses per second (PPS) and a 40% duty-cycle (or comparable settings). A power goal allowing the minimum transfer of 3,000 Watts from water to fish will be targeted (Burkhardt and Gutreuter, 1995). Adjustment to the electrical output will be made as needed to increase effectiveness. Driving speed adjustments and pursuit of individual carp is allowed upon fish sightings. Non-target fish species should be ignored during sampling; however, all small, shad-like species should be dipped and examined thoroughly before being released to avoid misidentifying young invasive carps. Banks and any structure within the sampling area are to be shocked thoroughly and the boat's pilot is free to modify the forward and backward boat movement to permit the most effective fish collection method. The straight-line distance attained during electrofishing should be approximately 400 m (~0.25 miles) of shoreline.

In addition to expanding targeted efforts within the Ohio River pools, Kentucky will use additional funds and new equipment to begin occupancy modeling programs within the intensive management zone of the Ohio River (120 sampling events) and in the Kentucky (120 sampling events) and Green rivers (120 sampling events). The Kentucky and Green rivers are large contiguous tributaries of the Ohio River and may be important to reducing carp numbers and controlling ORB populations. The Kentucky and Green River systems have limited data on the extent of invasive carp infestation or invasion progression, and we hope to use these surveys to determine control points and recommendations for further population control. Surveys are planned to be conducted as presence-absence counts using defined ½ mile transects. Sampling efficiency will be determined using detection probabilities.

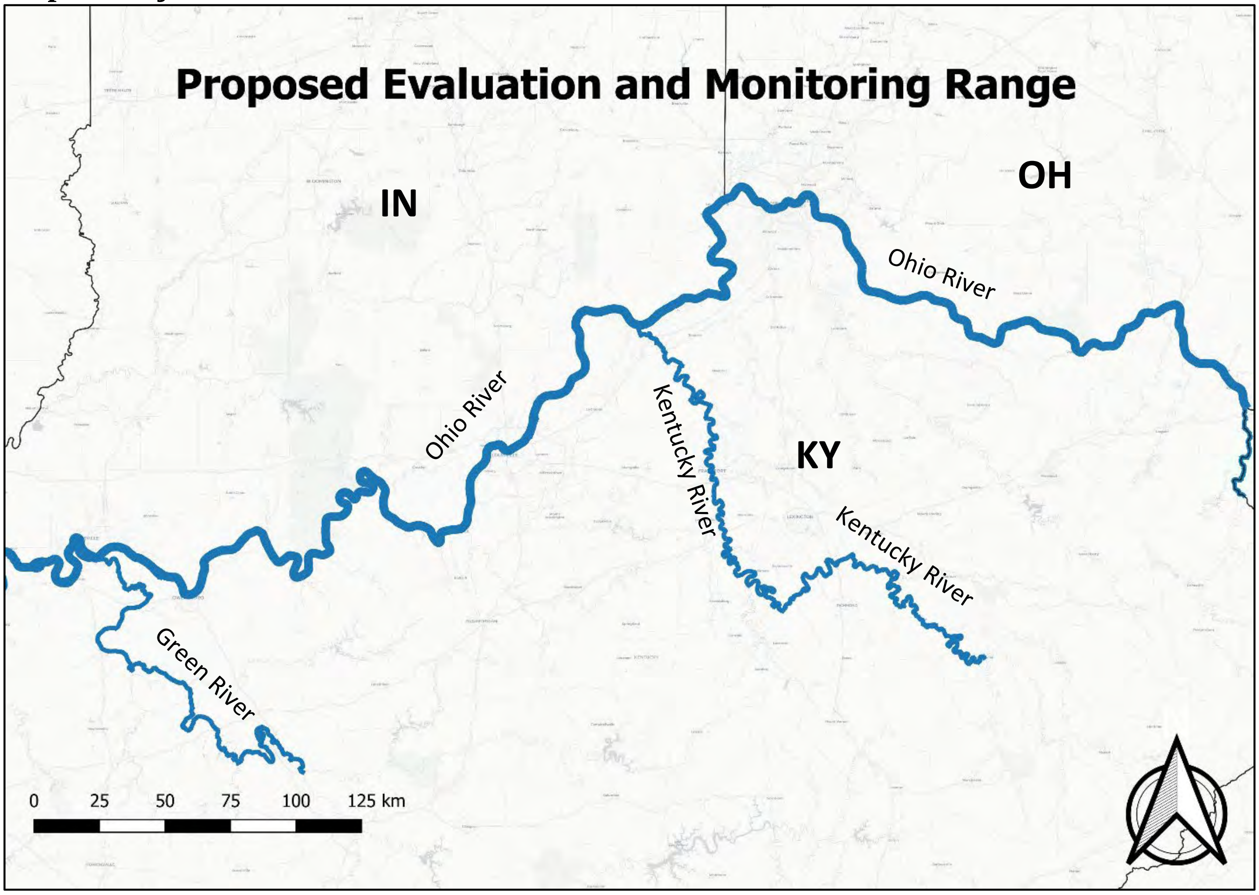
All information will be used to track changes in bigheaded carp populations. All invasive carps captured during sampling will be euthanized and lengths, weights, and sex will be recorded. In addition, an initiative to collect population characteristic information during a discrete time interval from August through September will be conducted and lead by Kentucky. Bigheaded carps will be collected from Cannelton, McAlpine and Markland pools in an attempt to obtain more reliable aging structures and population demographics data. Approximately 250 fish will be targeted in Cannelton and McAlpine pools and two weeks of effort will be used to collect as many fish in Markland as possible. This information will be used to obtain a snapshot of age distributions, mortality estimates, body condition, and length-weight data.

Data collected outside of this project during activities focused around invasive carp in the ORB will also be compiled and used to inform field sampling and analyses on bigheaded carp distributions. ORSANCO's annual sampling data and the USGS Nonindigenous Aquatic Species (NAS) database will be sourced to provide additional information on the range and confirmed sightings of invasive carps along the Ohio River and its tributaries. Additional data sources may become relevant for this project and will be considered and incorporated when possible.

Objective 5 – Utilize hydroacoustics surveys to determine biomass densities and verify patterns of relative abundance for invasive carp species within strategic management zones.

The KDFWR will also provide approximately 60 crew-days dedicated to fish community sampling. The data from this analysis will be used by USFWS for analysis of hydroacoustics data. Boat electrofishing will be utilized to aid in determining community composition and data will be passed off to USFWS to determine carp biomass estimates using hydroacoustic analyses.

Map of Project Area:



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Targeted Sampling on the Ohio River	Spring, April/2023
Occupancy Modeling on Ohio River	Summer, June/2023
Population Demographics Sampling	Fall, August to September/2023
Hydroacoustics Survey Sampling	Fall, September/2023
Inland River Surveys	Fall, September to October/2023
WRDA Report to Congress	Fall, October/2023
Annual Technical Report	Spring, March/2024

Agency: West Virginia Division of Natural Resources (WVDNR)

Activities and Methods

Federal funding for this project for FY2022 will enable WVDNR to continue monitoring invasive carp populations in the R.C. Byrd and Greenup pools of the Ohio River as well as assess the baseline fish community in some Ohio River pools ahead of the invasion. Congress and the USFWS require justification for funding projects. Continued evaluation of the invasive carp population in areas of low density is necessary to assess the rate at which the invasion is progressing as well as assessing the effectiveness of the removal efforts downstream on reducing upstream movement. Also, the continued learning process of adapting sampling techniques to catch invasive carps where they are present in low densities will improve efficiency for the future.

Objective 1 – Evaluate management actions using changes in relative abundance, population characteristics, and distribution of carps within intensive management zones.

WVDNR will track relative abundance and population characteristics of invasive carp independently and in coordination with other state agencies by conducting targeted sampling for invasive carp along several pools, upriver of the Cannelton Locks and Dam complex. WVDNR will conduct targeted samples in the Greenup and R.C. Byrd pools. Both pulsed-DC boat electrofishing and gill netting techniques will be utilized to target bigheaded carps along the Ohio river main stem and the mouths of tributaries to maintain consistency with efforts from previous years. Sampling will occur during the spring (water temperatures at 50°F – 65°F) at fixed sites previously identified in earlier years' sampling. Electrofishing surveys will consist of timed 15-minute shoreline transects in a downstream direction during the daytime at fixed sites throughout the R.C. Byrd and Greenup pools (N=26 and 20, respectively). Electrofishing settings will be dependent upon river conditions. Driving speeds will vary and varying boat maneuvers will be employed to increase the likelihood of landing a fish. Pursuit of individual carp is also allowed upon fish sightings. Non-target fish species will be ignored during sampling; however, small, shad-like species will be dipped on occasion and examined thoroughly to ensure identification of young invasive carps. The straight-line distance attained during electrofishing should be approximately 400 m (~0.25 miles) of shoreline. All feral invasive carps captured during sampling will be removed from the system. Otoliths and fin rays will be removed as needed from invasive carp for analyses as identified in other objectives.

Gill net sets will be conducted during the same time frame as boat electrofishing. Gill net sets will consist of two-hour sets during the daytime at fixed sites throughout the R.C. Byrd and Greenup pools (N=11 and 10, respectively) . Nets will be either 300ft or 150ft in length with 5" bar mesh. A minimum of 300ft of net will be set at each site. Gill nets will primarily be set perpendicular to the shoreline but may need to be set parallel to shore when water flow is excessive. Each net set will be actively monitored, and effort will be expended to run fish into the nets with boat noise and herding techniques. All feral invasive carps captured during sampling will be removed from the system. Otoliths and fin rays will be removed as needed from invasive carp analyses as identified in other objectives or projects. All by-catch will be recorded and any non-target fish will be released immediately after capture.

Objective 2 – Monitor long-term trends in native fish communities as indicators of change due to invasive carp presence.

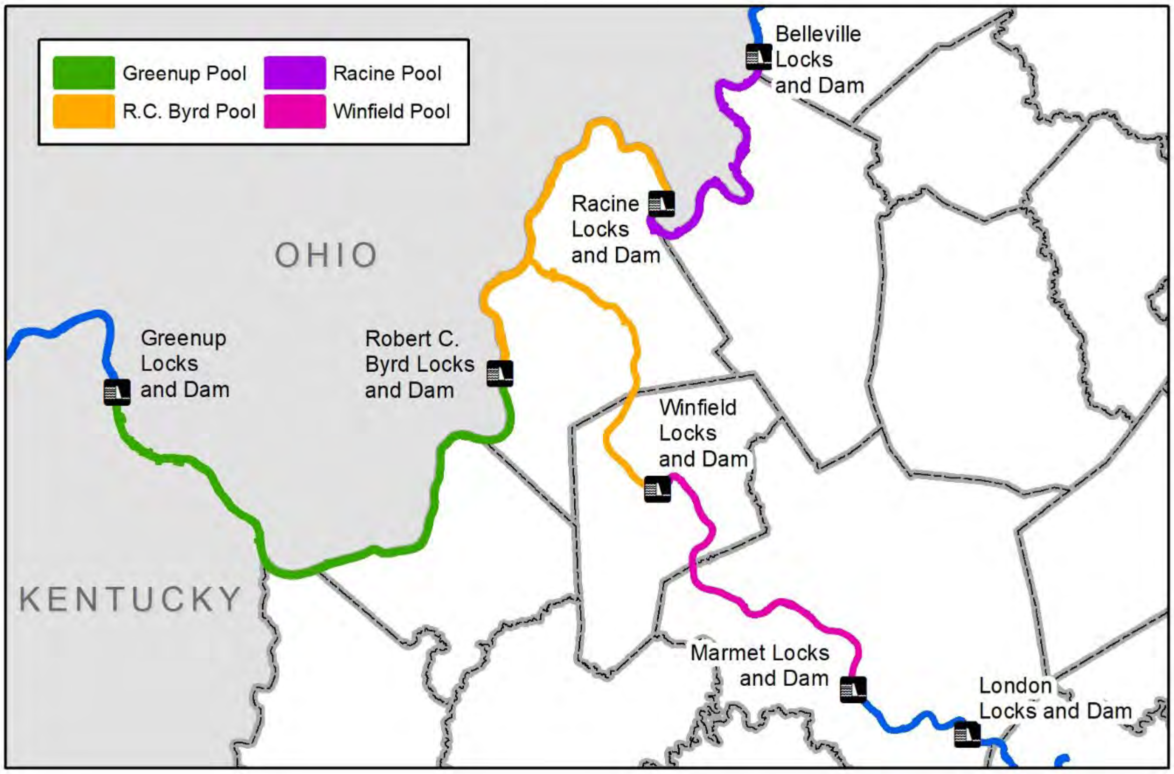
WVDNR will conduct community surveys in the Racine Pool of the Ohio. Pulsed-DC boat electrofishing and gill netting techniques will be utilized primarily. Surveys will be conducted in the fall when water temperatures are 55°F – 65°F. Electrofishing surveys will consist of 15-minute shoreline transects in a downstream direction during the day at fixed sites throughout each pool. Gill nets will consist of two-hour sets during the day at fixed sites throughout each pool. Nets will be either 300ft or 150ft in length with 5” bar mesh. A minimum of 300ft of net will be set at each site. Gill nets will primarily be set perpendicular to the shoreline, but may need to be set parallel to shore when water flow is excessive. Each net set will be actively monitored and effort will be expended to run fish into the nets with boat noise and herding techniques. All fish will be identified to the lowest possible taxonomic level and a total length (mm) and weight (kg) will be taken. Condition (Wr) will be evaluated on appropriate species (i.e. a relative weight equation has been published for that species).o. Any invasive carp without surgically implanted transmitters will be exterminated upon capture.

Boat ramp seine hauls and benthic trawls may also be employed to more effectively sample the small and benthic fish community. Boat ramp seine hauls will be conducted at boat ramps located directly or adjacent to the mainstem Ohio River. One seine haul will be conducted at each ramp with a 30ft seine with 3/16” mesh and a 6ft bag (1/8” mesh). Benthic trawling may also be conducted following agency protocols. The number of samples completed will be dependent upon staff availability and environmental conditions. Fish easily identified in the field will be enumerated and released. All other fish collected will be retained for identification and enumeration in the laboratory.

Objective 3 – Survey Invasive carp presence in upstream areas where they are rarely detected to inform response and containment efforts

To assess movement of Invasive carp beyond the currently identified “invasion front”, WVDNR will assist USFWS to conduct eDNA surveillance surveys in the upper Ohio River. Specifically, WVDNR will participate in sample collection in the Racine Pool. WVDNR staff will assist with collecting and processing water samples on site according to USFWS sampling protocols. New or concerning positive results of Invasive carp DNA may lead to a targeted sampling effort to collect fish.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Community Fish Surveys in Racine Pool	Fall, October 2022
WRRDA Report to Congress	Fall, October/2022
Annual Technical Report	Spring, March/2023
Targeted Invasive carp Sampling	Spring, April 2023
eDNA Sampling	Spring, May/June 2023

Agency: Pennsylvania Fish and Boat Commission (PFBC)

Activities and Methods:

Objective 2 – Monitor long-term trends in native fish communities as indicators of change due to Invasive carp invasion.

The PFBC will conduct additional fish community surveys in the Montgomery Pool in August 2023 and September/October 2023. Monitoring in August will be conducted using seines (20 m length, 6 mm mesh) at six historic sites in one day. All fish captured, with the exception of larger individuals, will be retained for identification in the laboratory. The September/October fish community surveys will consist of randomized pool wide sampling in two pools (Dashields andEmsworth) of the Ohio River. Gear types used in this fall community sampling event will include both gill nets and boat electrofishing. This sampling will consist of 40 electrofishing runs (15 minutes per run) and 40 gill net sets (24 hr) per pool conducted from mid-September through the end of October. All fish captured during these community sampling events will be enumerated and measured; larger individuals will be identified in the field and released whereas smaller individuals will be retained for laboratory identification.

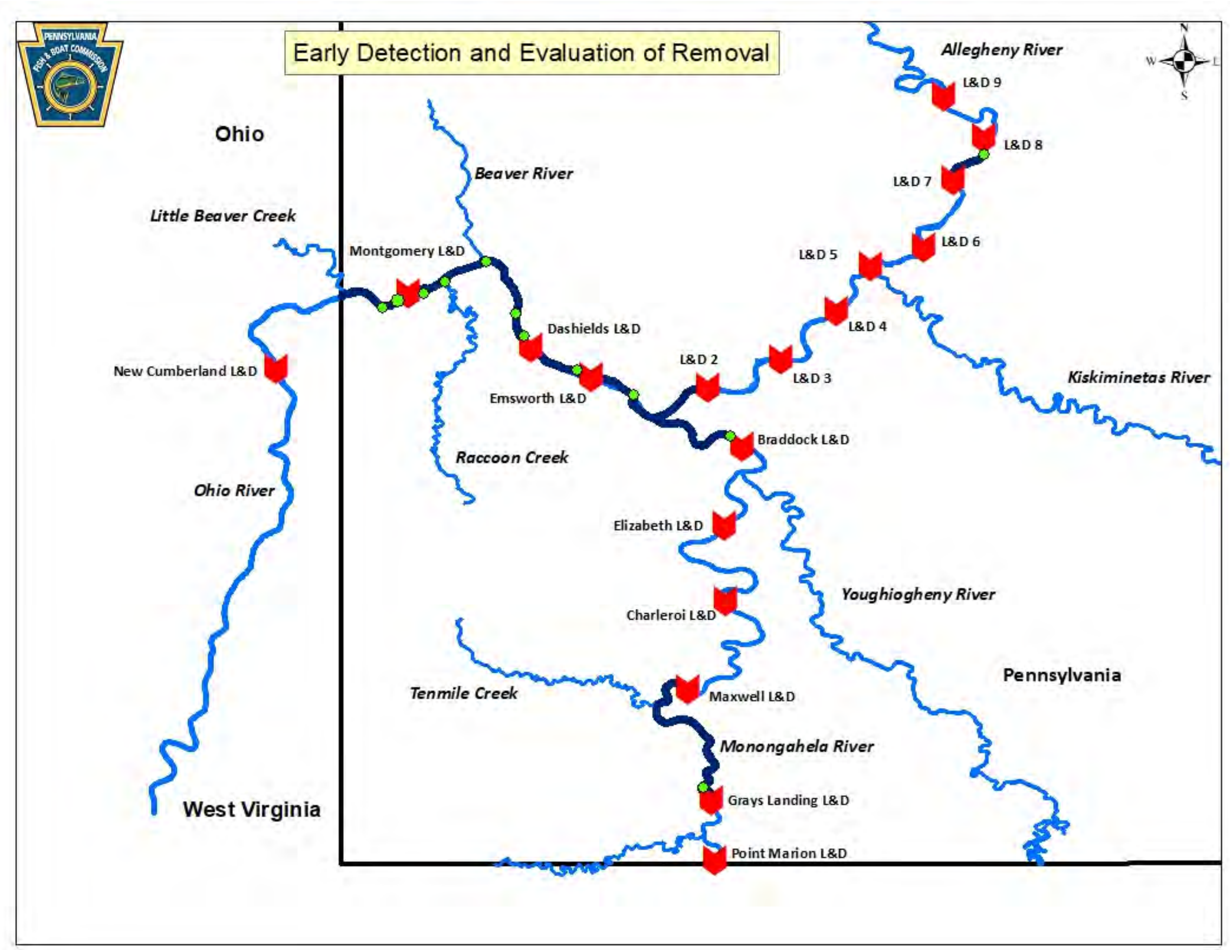
The PFBC conducts additional targeted sampling for various gamefish throughout the Ohio, Allegheny, and Monongahela Rivers on an annual basis. Incidental invasive carp captures will be recorded during these surveys. Incidental sampling includes 13 fixed black bass electrofishing sites on the Allegheny and Monongahela Rivers and between 24 and 64 targeted Sander electrofishing sites on the Allegheny, Ohio, and Monongahela Rivers. These surveys typically occur in March, October, and November. Electrofishing effort varies for the black bass surveys; effort is 10 minutes per site for the targeted Sander surveys.

Objective 3 – Survey Invasive carp presence in upstream areas where they are rarely detected to inform response and containment efforts.

The PFBC will assist the USFWS in conducting eDNA sampling on the Ohio River in the spring/fall of 2023 as needed. Locations of positive eDNA hits for Bighead and Silver Carp, including locations with positives from previous years, will be used to guide targeted gill net sampling. Additional locations for targeted gill net sampling will include backwater areas, thermal discharges, and creek mouths. Targeted sampling will be performed in the New Cumberland and Montgomery Pools of the Ohio River and will consist of ~24 hour gill net sets in the fall of 2022 and 2023. Gill nets used will be 91.4 m long, 3.7 m in depth, with either 76, 102, or 127 mm mesh. All fish species captured in gill nets will be recorded. Any Invasive Carp species will be euthanized. A minimum of 12 gill net sets will be fished in the fall of each year.

Tailwater community fish surveys from 2008-2016 will be used to establish and refine future sampling locations. A second round of such surveys began in 2018 and will continue until 2023. Boat electrofishing (60 pps, 25% duty cycle, typically 200-500 volts) at each tailwater will consist of 10 minute transects across 17 fixed tailwater sites in total for the duration of the project. Ten transects will be sampled at each site with five transects conducted on each bank. Sampling will begin on the right descending bank as close as possible to the dam and will proceed downstream for five consecutive runs. The same procedure will then be conducted on the left descending bank for a total effort of 100 minutes per tailwater We will conduct fish community surveys in the spring of 2023 at a minimum of five tailwaters on the Ohio, Allegheny, and Monongahela Rivers. All fish will be netted and those large enough to identify in the field will be enumerated and measured; small individuals will be retained for identification in the laboratory.

Map of Project Area:



Dark blue areas represent pools to be surveyed in FY22 and green dots represent approximate locations

Estimated Timetable for activities:

Activity	Time Period (Season, month/year)
Targeted Sampling Field Work	Fall, November/2022
Community Surveys Field Work	Spring, May/2023
Community Surveys Field Work	Summer, August/2023
Assist eDNA sampling	Spring or Fall, May or September/2023
Community Surveys Field Work	Fall, September-October/2023
Targeted Sampling Field Work	Fall, November 2023
Executive Technical Report	Spring, March/2024

Agency: USFWS

Activities and Methods

Objective 5 - Utilize hydroacoustics surveys to determine biomass densities and verify patterns of relative abundance for Invasive carp species within strategic management zones.

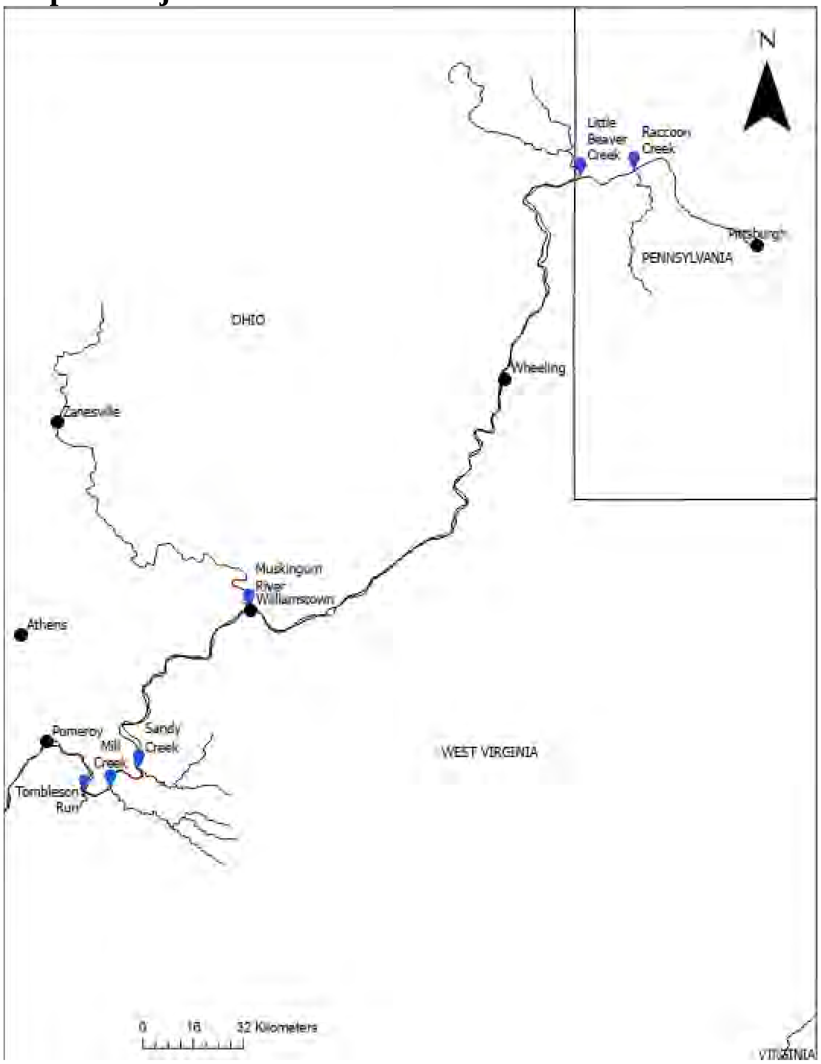
The Carterville FWCO will implement the Region 3 hydroacoustic standard operating procedure (SOP) in conjunction with increased community sampling to estimate pool-wide density (# • $1000m^{-3}$) of Silver Carp in three Ohio River pools during fall (September and October), 2022. Community sampling i.e., boat electrofishing) will be conducted by state agencies (KDFWR, INDNR). To facilitate the increased sampling, we have limited hydroacoustic sampling to pools with established Silver Carp populations (J.T. Myers, Newburgh, Cannelton, McAlpine). Three pools will be sampled during fall, 2022 (Newburgh, Cannelton, and McAlpine). We will use a random sampling design to select sites (i.e., a 1-mile stretch of river) for community sampling and hydroacoustic transects within the main channel with the goal of collecting a more representative sample of the pelagic fish community inhabiting each pool. The number of 1-mile transects in Cannelton and McAlpine pools will be approximately 35% of the available main channel sites (# sites = 2 • length of pool; one site on each bank). Hydroacoustic transects will be completed along the entire length of the third pool (Newburgh). Data gathered from the third pool will be used to determine the minimum number of sites needed to produce precise density estimates for future sampling events. Within each pool, up to five tributaries will also be sampled using hydroacoustics (and physical capture gears) to monitor tributary use by Silver Carp. Transect design will differ between main channel and tributary habitat. Main channel transects will include both shore- and- thalweg-facing transects whereas tributary transects will be shore facing only. Hydroacoustic survey equipment will be comprised of two BioSonics split-beam transducers. The transducers are calibrated at 200-kHz and oriented such that one transducer samples the shallow portion of the water column and the other samples the deep portion of the water column. Hydroacoustic processing will be completed in Echoview Version 11.0 following the Region 3 hydroacoustic SOP. Silver Carp densities will be reported within each habitat type (e.g., main channel, tributary), within each pool.

To supplement community sampling by state partners, the Carterville FWCO will conduct electrified dozer trawls within the same sites (1-mile stretch of river) as other community sampling efforts. Dozer trawls will be deployed following methods outlined in Hammen et al. (2019). Briefly, a conical trawl is pushed in front of a boat at approximately 4.5 km • h^{-1}. Three electrofishing anodes are deployed in front of the net to stun fish, thus increasing the number of fish captured. Electrofishing settings are standardized at 30 Hz and a 15% duty cycle with amperage adjusted based on water conductivity at each site. Preliminary results suggest that the dozer trawl is more efficient than other community sampling tools at targeting the pelagic fish community (Hammen et al. 2019), making it an ideal gear for informing the apportionment of hydroacoustic targets and, therefore, understanding the density and distribution of Silver Carps in the Ohio River basin.

Objective 3 - Survey invasive carp presence in upstream areas where they are rarely detected to inform response and containment efforts.

The Lower Great Lakes and Carterville Fish and Wildlife Conservation Offices (FWCOs) will conduct environmental DNA (eDNA) sampling in six locations in the Upper Ohio River. Because eDNA sampling allows managers and researchers to detect the presence of a species without physical capture, it is an excellent early detection tool, especially for invasive species for which there is concern about range expansion. To determine if Silver or Bighead Carps are present in tributaries of the Upper Ohio River, the Lower Great Lakes FWCO will collect 100 water samples from each of five tributaries: Raccoon Creek (Montgomery Pool), Little Beaver Creek (New Cumberland Pool), Mills Creek, Tombleson Run and Sandy Creek (Racine Pool) during spring 2022. The Carterville FWCO will also collect 352 water samples from the Muskingum River during fall 2022. All eDNA sampling will follow the USFWS Quality Assurance Project Plan. Following collection, eDNA samples will be shipped to the USFWS Whitney Genetics Lab for processing and results reported to state partners.

Map of Project Area



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Hydroacoustics Surveys	September/October 2022
Data Processing and Analysis	Winter 2022
Results and Reporting	Spring 2023
Raccoon Creek eDNA Sampling	Spring, April/May 2022
Little Beaver Creek eDNA Sampling	Spring, May 2022
Mills Creek, Tombleson Run, Sandy Creek eDNA Sampling	Spring, May 2022
Muskingum River eDNA Sampling	Fall, Sept/Oct 2022
eDNA Processing and Results	Winter, 2022
eDNA Reports	Spring, 2023

Agency: Indiana Department of Natural Resources

Activities and Methods:

Objective 1 - Evaluate management actions using changes in relative abundance, population characteristics, and distribution of invasive carps within intensive management zones.

INDNR will utilize pulsed-DC boat electrofishing to target bigheaded carps within Cannelton Pool of the Ohio River. Effort will include sampling at least 24 sites on two separate occasions totaling approximately eight crew-days of effort. Electrofishing will be conducted during the day (0800 to 2100 hours local time) with one staff in the bow of the boat dip-netting fish (dipper). Sampling is conducted in the spring of each year when water temperatures are 50°F – 65°F. Electrofishing is conducted in a general downstream direction for 900 seconds. Carp should be targeted with pulsed-DC electricity at 80 pulses per second (PPS) and a 40% duty-cycle (or comparable settings). A power goal allowing the minimum transfer of 3,000 Watts from water to fish will be targeted (Burkhardt and Gutreuter, 1995). Adjustment to the electrical output will be made as needed to increase effectiveness. Driving speed adjustments and pursuit of individual carp is allowed upon fish sightings. Non-target fish species should be ignored during sampling; however, all small, shad-like species should be dipped and examined thoroughly before being released to avoid misidentifying young Invasive carps. Banks and any structure within the sampling area are to be shocked thoroughly and the boat's pilot is free to modify the forward and backward boat movement to permit the most effective fish collection method. The straight-line distance attained during electrofishing should be approximately 400 m (~0.25 miles) of shoreline.

All information will be used to track changes in bigheaded carp populations. All invasive carps captured during sampling will be euthanized and lengths, weights, and sex will be recorded. An initiative to collect population characteristic information during a discrete time interval from August through September will be conducted and led by Kentucky. INDNR will assist with collections of bigheaded carps from Cannelton, McAlpine and Markland pools in an attempt to obtain more reliable aging structures and population demographics data. Otolith sampling effort will include approximately six crew-days targeting 200-300 otolith samples per pool where possible. INDNR will then assist in processing and aging a portion of the Ohio River otoliths. This information will be used to obtain a snapshot of age distributions, mortality estimates, body condition, and length-weight data. In addition, INDNR will provide approximately eight crew-days of effort in assisting KDFWR with occupancy modeling sampling within the intensive management zone of the Ohio River. Surveys are planned to be conducted as presence-absence counts using defined transects. Sampling efficiency will be determined using detection probabilities.

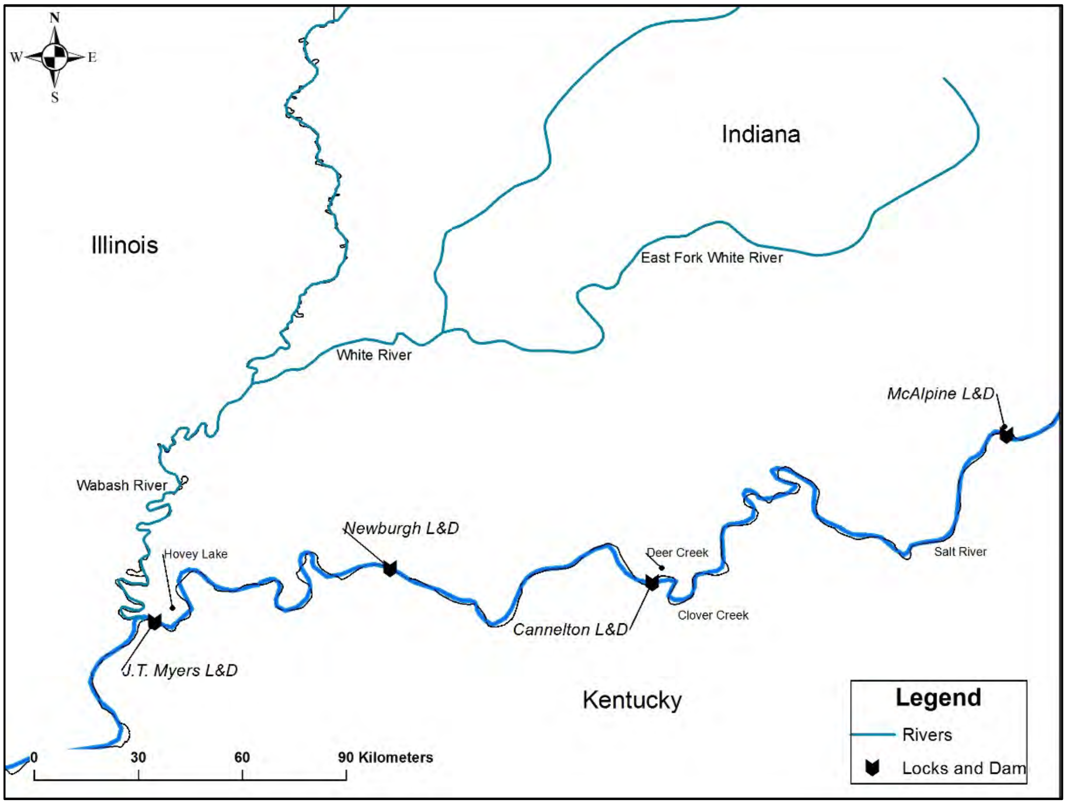
Objective 4 - Determine spatial distributions (hotspots) and densities of Invasive carps in the lower Wabash River to inform and assess harvest.

To determine spatial distributions and densities of Invasive carps in the lower Wabash and White rivers, INDNR will conduct fish sampling at eight locations (four crew days) throughout the lower Wabash River. SIU will conduct hydroacoustic sampling at eight to sixteen sites, and INDNR will collect fish community data at a subsample of sites to "ground truth" the hydroacoustic data. INDNR will utilize electrofishing and gill netting at each site. One hour of electrofishing (two 15-minute transects down each bank) will be conducted in a general downstream direction at each site using one dipper. All fish should be dipped except when large schools of fish (e.g. Clupeids or Cyprinids) are encountered. When large schools blanket the water column, fish should be dipped continuously at a constant rate in a straight-line distance until the school is passed. Sampling is conducted with pulsed-DC electricity at 60 pulses per second (PPS) and a 25% duty-cycle (or comparable settings). A power goal allowing the transfer of 3,000 Watts from water to fish should be targeted (Burkhardt and Gutreuter, 1995). The straight-line distance covered during one 15-minute electrofishing transect should be approximately 200 m (~0.125 miles) of shoreline. Where possible, gill netting will be conducted at sites in the same timeframe as boat electrofishing. Each site will include 300 ft of 4-in square net and 300 ft of 5-in square net for a targeted length of net fished at each site equal to 600 ft. All fish captured using either gear will be identified to the lowest possible taxonomic level and total length (mm) and weight (kg) with be recorded for all species. Invasive carp will be euthanized.

Objective 5 - Utilize hydroacoustics surveys to determine biomass densities and verify patterns of relative abundance for Invasive carp species within strategic management zones.

INDNR will provide approximately 20 crew-days dedicated to community sampling in J.T. Myers, Newburgh, and/or Cannelton pools for hydroacoustics analysis. Boat electrofishing (using similar methods as described above) will be utilized to aid in determining community composition and data will be forwarded to USFWS in order to determine carp biomass estimates using hydroacoustic analyses.

Map of Project Area:



Estimated Timetable for Activities:

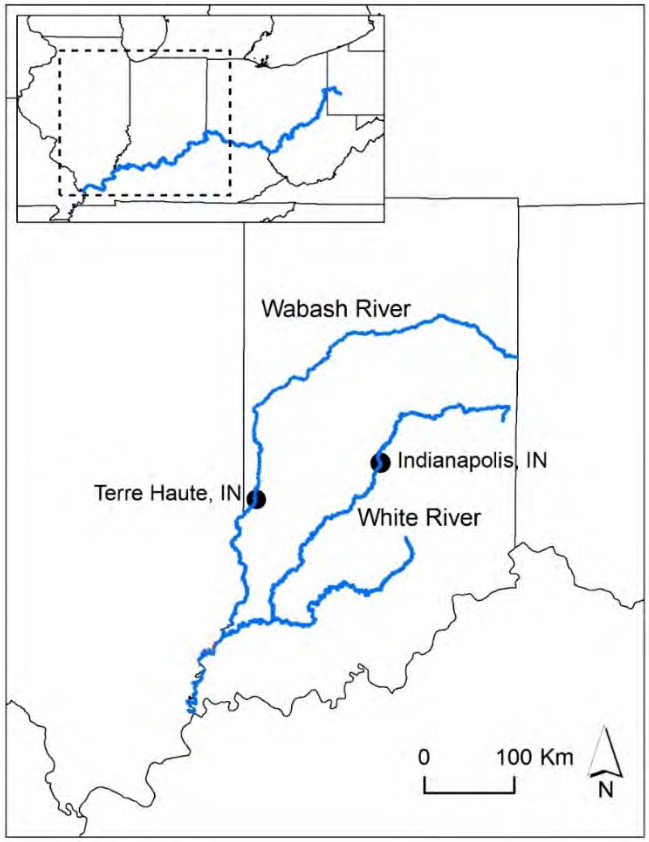
Activity	Time Period (Season, month/year)
Targeted Sampling Field Work	Spring, April/2023
Wabash River Fish Community Work	Spring, April and May/2023
Occupancy Modeling Sampling	Summer, June/2023
Population Demographic Sampling	Summer, Aug and Sept/2023
Hydroacoustics Community Surveys	Fall, October/2023
Process and Age Otoliths	Fall, Nov and Dec/2023
Executive Technical Report	Spring, March/2024

Agency: Southern Illinois University (SIU)

Activities, and Methods:

SIU will be contracted by the Illinois Department of Natural Resources (ILDNR) to complete hydroacoustic sampling in the lower Wabash River to quantify bigheaded carp spatial distributions and identify density hotspots to inform and assess harvest efforts (objective 4). Densities will be assessed in the lower Wabash River between the confluence with the Ohio River and Terre Haute, IN in June of 2023. Hydroacoustic sampling equipment will consist of two 200-kHz split-beam BioSonics transducers that will be horizontally oriented toward the center of the river while sampling. The horizontal positioning of the transducers will be offset so that one transducer will sample the shallower portion of the water column and the second transducer will sample the deeper portion. Mobile surveys will consist of 4-mile long transects parallel with the shoreline, with two nearshore transects (one upstream and one downstream) conducted at each site. Across all sites, up to 128 miles of survey transects will be sampled, with 8-16 sites sampled throughout the lower Wabash River, depending on river conditions. Physical capture data used in hydroacoustic data analysis will be collected by INDNR. Species-specific proportional abundance will be calculated by size class from capture data. These data will then be applied to the number of fish observed within the same size classes from hydroacoustic sampling, along with the volume of water ensonified, to estimate species-specific densities. Sampling and data analysis techniques follow established protocols for assessing Invasive carp densities in rivers (MacNamara et al. 2016; Coulter et al. 2018). Resulting data include species-specific density estimates for each site, as well as site-specific bigheaded carp density heat maps to identify spatial distributions for removal efforts.

Map of Project Area:



Timetable of Activities:

Activity	Time Period (Season, month/year)
Executive Technical Report	Spring, March/2023
Conduct Wabash River Hydroacoustic Sampling	Summer, June/2023
Executive Technical Report	Spring, March/2024

Agency: West Virginia University (WVU)

Activities and Methods:

Objective 2 – Monitor long-term trends in native fish communities as indicators of change due to Invasive carp invasion.

Federal funding for this project for FY2022 will enable WVU work with state partners (KDFWR, WVDNR, PFBC, and USFWS) to collate existing boat electroshocking fish community data for community size spectra (CSS) analyses. We will compare CSS parameters (slope and elevation) to existing indices (CPUE) of invasive carp abundance (e.g. spring gillnet catches, unless partners identify a better index data set). CSS will be used to compare community size structure pre- and post-invasion in impacted pools to unimpacted (invaded vs not-invaded pools). This initial analysis will allow the development of baseline conditions throughout all pools (e.g. mean CSS parameter values and degree of natural inter-annual and inter-pool variation). We will assess Cannelton, McAlpine, Markland, Meldahl, Greenup, and R.C. Byrd pools for all years with available data between 2015 and 2022. We will utilize earlier years in impacted pools as well as long-term averages in upstream unimpacted pools to serve as a reference (historic target condition). We will be able to assess ‘normal’ or expected interannual variation in CSS from the upstream unimpacted (or lightly impacted) pools to provide a range in target values. WVU will use this first year and the community electrofishing data to more deeply develop the methodology to establish targets with a longer term goal to develop similar approaches for hydroacoustic surveys in future years. The primary product of this FY22 work will be a report providing a statistical description of annual pool-specific community size structure and an evaluation of the potential effectiveness of a community size spectra framework to establish management targets for invasive carp based on food web condition.

Timetable of Activities:

Activity	**Time Period (Season, month/year)**
Data analyses	Spring, March/2023 – Winter, February 2024
Report preparation	Spring, March/2024

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Abundance and distribution of early life stages of invasive carp in the Ohio River

Lead Agency and Author: Indiana Department of Natural Resources (INDNR), Craig Jansen (cjansen1@dnr.in.gov)

Cooperating Agencies: Kentucky Department of Fish and Wildlife Resources (KDFWR), West Virginia Division of Natural Resources (WVDNR), West Virginia University (WVU), United States Fish and Wildlife Service (USFWS), Southern Illinois University (SIU), Ball State University (BSU)

Statement of Need:

Acquiring a full understanding of the early life history information is imperative for evaluating the population status (i.e., extent of invasion). Identifying the specific locations that differentiate both the extent of spawning and recruitment is crucial information for implementation of management or control efforts (e.g. targeted removal efforts, informing barrier or deterrent placement, etc). In order to identify these locations, quantifying abundance and distribution of invasive carp early life stages is needed. For the purposes of this plan, the term 'invasive carp' is referring to Silver Carp and Bighead Carp (*Hypophthalmichthys* species), also known as bigheaded carp.

In order to limit the negative impacts of invasive carp populations and their further spread, efforts have increased to understand the distribution and abundance of invasive carp in the waters they currently inhabit. Previous sampling efforts on the Ohio River have documented adult invasive carp presence as far upstream as Robert C. Byrd Dam near Gallipolis Ferry, West Virginia. Densities of adult invasive carp are highest downstream of McAlpine Lock and Dam (Louisville, KY) and substantially decline farther upstream. In 2021, YOY and juvenile invasive carp were captured in Cannelton and Markland pools, respectively. However, since 2016 the majority of Ohio River YOY have been consistently captured in J.T. Myers Pool.

Suspected reproduction of non-indigenous bigheaded carp, through the morphometric identification of invasive carp-type larvae, was documented in Meldahl Pool in 2016 by EA Engineering. In addition, genetically confirmed bigheaded carp eggs and larvae were collected as far upstream as Markland Pool in 2021. Previous efforts have been successful in collecting invasive carp eggs, embryos, and larvae in the Ohio River. However, defined spawning locations and the spatial extent of spawning in the Ohio River remains a knowledge gap. Multiple years of data collection covering a broader spatial extent under a variety of environmental conditions will be necessary to fully understand invasive carp early life history among pools.

Project Objectives:

1. Determine the upstream extent of invasive carp spawning activity in the Ohio River above Markland Dam.
2. Identify locations of the Ohio River in which spawning occurs.
3. Determine the extent and locations of invasive carp recruitment in the Ohio River.
4. Identify characteristics of potential invasive carp nursery areas when juvenile invasive carp are encountered.

5. Evaluate the feasibility of drain structure modifications to limit invasive carp recruitment from Hovey Lake.
6. Determine the propagule source of invasive carp in large tributaries of the Ohio River.

Agency: Indiana Department of Natural Resources

Activities and Methods:

Objective 2 - Identify locations of the Ohio River in which spawning occurs.

Indiana DNR will conduct and coordinate sampling for invasive carp eggs, embryos, and larvae at high priority sites of J.T. Myers, Newburgh, Cannelton, and McAlpine pools. Locations will include suspected areas of spawning in tributaries based on current information, and locations in the mainstem river to inform future FluEgg model's ability to back-calculate spawning locations. Conical ichthyoplankton tows (0.76m, 500 µm mesh) will be conducted at least twice at each site during ideal spawning conditions, when water temperatures are between 17 to 27°C (64 to 80°F) with moderate to high flows from May to July, 2023. Field staff will coordinate closely with KDFWR personnel to communicate when spawning patches begin to develop on female invasive carp and will use that knowledge as another indicator to sample. A single ichthyoplankton net will be deployed on the side of the boat facing upstream, with each tow lasting 3 minutes. A flow meter will be used to determine water volume sampled. At each site, the main stem Ohio River will be sampled via three ichthyoplankton tows - one on each right and left descending portions of the river and one in the middle of the river. At tributary sites, three tows will be taken within the tributary at least one-half mile upstream of the Ohio River confluence. Depth (m) and water temperature (°C) will be recorded using a boat-mounted depth sounder at each sampling site. All contents will be preserved in non-denatured 95% ethanol for identification in the lab. Morphometric characteristics developed by Chapman and George (2011) will be used to identify suspected bigheaded carp eggs, embryos, and larvae. If necessary, a subsample of suspected bigheaded carp eggs, embryos, and/or larvae can then be sent to Whitney Genetics Laboratory for confirmation of species. Results will be used to locate spawning locations in the Ohio River Basin and thus will guide future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

Objective 3 - Determine the extent and locations of invasive carp recruitment in the Ohio River

Indiana DNR will conduct targeted sampling for juvenile invasive carp in Cannelton, McAlpine, and Markland pools of the Ohio River. Because typical nursery habitat in the form of shallow backwater areas is less prominent in the Ohio River, flooded creek mouths and tributaries likely serve as a substitute. Previous sampling efforts regularly captured YOY in J.T. Myers Pool, and occasionally captured them in Newburgh Pool. In 2021, YOY were captured at multiple sites within Cannelton Pool, and two juvenile carp were captured in Craigs Creek within Markland Pool. Surface trawling will be conducted at suitable sites because it has proven effective for capturing young-of-year invasive carp. Surface trawl samples will consist of at least two 5-minute tows at each sample site. The surface trawl is constructed of an inner bag of 32 mm, number 12 netting, and an outer bag of 4.8 mm, 35 lb Delta style knotless mesh. The trawl is approximately 3.7 meters wide and 0.6 meters tall at the mouth, and is 5.5 meters long. Floats were added to the otter boards (30.5 x 61 cm) and the float line of the trawl mouth to suspend the net on the surface. Tow lines are attached to the bow of the boat and the boat is motored in reverse between 0.7 to 0.9 meters/second. Time permitting, INDNR will also use pulsed DC electrofishing during July and August to target juvenile carp. Electrofishing samples will consist of at least one 15-minute transect at each sample site, using an MLES Infinity control box set at 80 pulses per second and 40% duty cycle. Output will be standardized based on water conductivity. Juvenile invasive carp collected will be identified to species, geo-located, enumerated, and lengths and weights will be recorded. Results will be used to estimate the extent of invasive carp recruitment in the Ohio River and thus will directly inform future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

In addition to sampling, participating agencies will collaborate with other fisheries professionals to inform them to report back with any confirmed findings of juvenile invasive carp within the basin. State partners will reach out to other biologists within their respective states and if a new instance is reported, will gather data and site location information if possible. These data will be compiled by the project lead and will be used to inform future planning efforts.

Objective 4 - Identify characteristics of potential invasive carp nursery areas when juvenile invasive carp are encountered.

Indiana DNR will collect a suite of habitat measurements at each sample site during targeted juvenile efforts to describe both the morphology characteristics (average depth, maximum depth, tributary width, presence/absence of woody debris and aquatic vegetation) of the tributary as well as water quality parameters (water temperature, Secchi disk visibility, conductivity, pH, dissolved oxygen). Data will be compiled with previous year's data to help categorize and identify areas that may provide the necessary habitat for invasive carp growth and development.

Objective 5 - Evaluate the feasibility of drain structure modifications to limit invasive carp recruitment from Hovey Lake.

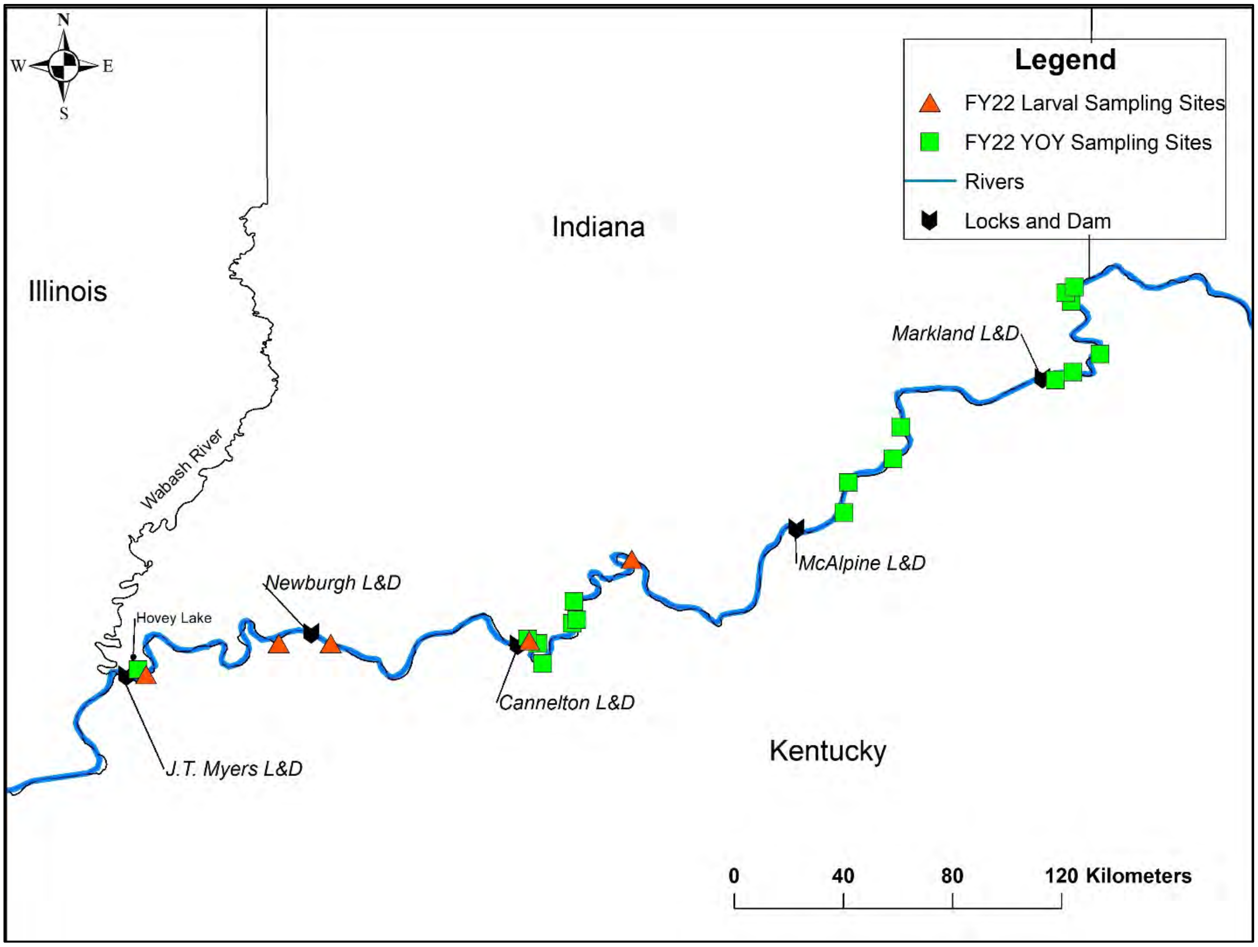
To estimate the recruitment potential of Hovey Lake, Indiana DNR will contract with a research university to complete this work. Specific work will include quantifying the input of larval invasive carp from the Ohio River through the drain structure into Hovey Lake. Using larval nets and/or fine mesh bait nets, the drain will be sampled across a variety of flows and conditions in May, June, and July to estimate YOY invasive carp passage into the lake. These data will be used to estimate a total number of YOY that have passed into the lake. Throughout June, July, and August, surface trawls, electrofishing, or other methods will be used within Hovey Lake to capture YOY invasive carp and estimate abundance/density. All YOY captured will be euthanized and taken back to the lab where otoliths will be extracted. Daily growth rings will be counted on otoliths to develop daily survival estimates of YOY invasive carp. Survival data will then be paired with estimates of YOY invasive carp in the lake to determine Hovey Lake recruitment contribution to the Ohio River basin invasive carp population. INDNR will contract with USGS to install a stream gage that monitors stream stage and velocity to compute streamflow in Bayou Drain (the connection between Hovey Lake and Ohio River), as well as two stream stage gages nearby (one at a possible flood connection between the Wabash River and

Hovey Lake, and one at a possible flood connection between Hovey Lake and the Ohio River). These gages will provide insight to the hydraulic pathways YOY carp use to access Hovey Lake, as well as the velocities, stages and flows that YOY carp can access Hovey Lake through the Bayou Drain structure. Finally, the data collected from the streamgage could provide hydraulic data to aid in the design of modifications to the Bayou Drain structure that would reduce invasive carp recruitment.

Objective 6 - Determine the propagule source of invasive carp in large tributaries of the Ohio River.

To determine the propagule source of invasive carp in the Ohio River, Indiana DNR will contract with a research university to complete this work. Lapilli otoliths will be removed from bigheaded carps collected in the upper Ohio River and its tributaries and analyzed trace element:calcium ratios (Sr:Ca, Ba:Ca, Mg:Ca). One otolith from each fish will be embedded in epoxy and sectioned in the transverse plane (otoliths from age-1 and older fish) or affixed directly to a glass microscope slide with a drop of cyanoacrylate glue and gently sanded to expose the otolith core (otoliths from age-0 fish). Otolith samples will be analyzed for Sr:Ca, Ba:Ca, and Mg:Ca using laser ablation-ICPMS. The laser will be used to ablate a transect extending from one side of the otolith primordium to the edge of the opposite side of the otolith along the longest axis of the otolith cross-section; this will enable identification of natal environment and movement among chemically-distinct locations during the fish's lifetime. Water chemistry data and published relationships between water and otolith chemistry for bigheaded carps will be used to estimate expected, multivariate otolith chemical "signatures" for all potential natal rivers for bigheaded carps in the study area. Otolith core chemistry data for bigheaded carps will be compared with these expected chemical "signatures" to identify natal environment for each fish. At a minimum, this approach will enable us to distinguish fish spawned in the Ohio River from those that originated in Ohio River tributaries; we will also assess whether finer-scale resolution of locations in the Wabash River basin may be possible.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Executive technical report for 2022 data	Spring, March/2023
Larval IC Sampling	Spring, May-June/2023
Hovey Lake drain sampling	Spring, May-June/2023
Hovey Lake juvenile sampling and daily growth	Summer, June-Sept/2023
Process otoliths for microchemistry	Summer, June-Sept/2023
Juvenile IC Sampling	Summer, July-Aug/2023
Nursery Habitat Assessment	Summer, July-Aug/2023
Process larval samples	Summer, July-Aug/2023
Submit genetic samples to WGL	Fall, September/2023

Agency: Kentucky Department of Fish and Wildlife Resources

Activities and Methods:
Objective 2 - Identify locations of the Ohio River in which spawning occurs.

KDFWR will conduct sampling for invasive carp eggs, embryos, and larvae using conical tows during peak spawning periods in the Ohio River. The main stem Ohio River will be sampled at locations in collaboration and under the direction of the INDNR project lead to document invasive carp spawning in the main stem Ohio River. Some tributaries believed to be important to spawning will also be investigated using similar sampling protocols.

Three-minute conical ichthyoplankton tows (500 µm mesh) will be conducted on at least two dates from May through July during ideal spawning conditions (water temperatures from 64° to 80°F with moderate to high flows). To determine optimal sampling periods, field staff will coordinate with INDNR personnel to identify when spawning patches begin to develop on female invasive carp. At each sampling site, 3 ichthyoplankton net sets will be deployed for 3 minutes near each descending bank and one located in the middle of the river or tributary. A flow meter will be used to determine the volume of water sampled. All contents will be rinsed into a 500-µm sieve and preserved in 95% ethanol for identification in the lab. Morphometric characteristics will be used to identify suspected bigheaded carp, eggs, embryos, and larvae (Chapman and George 2011). If necessary, a subsample of suspected bigheaded carp eggs, embryos, and/or larvae will be sent to Whitney Genetics Laboratory for species confirmation. Results will be used to identify pools and tributaries where spawning is successful and will be to help develop population status changes that will guide future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

Objective 3 - Determine the extent and locations of invasive carp recruitment in the Ohio River.

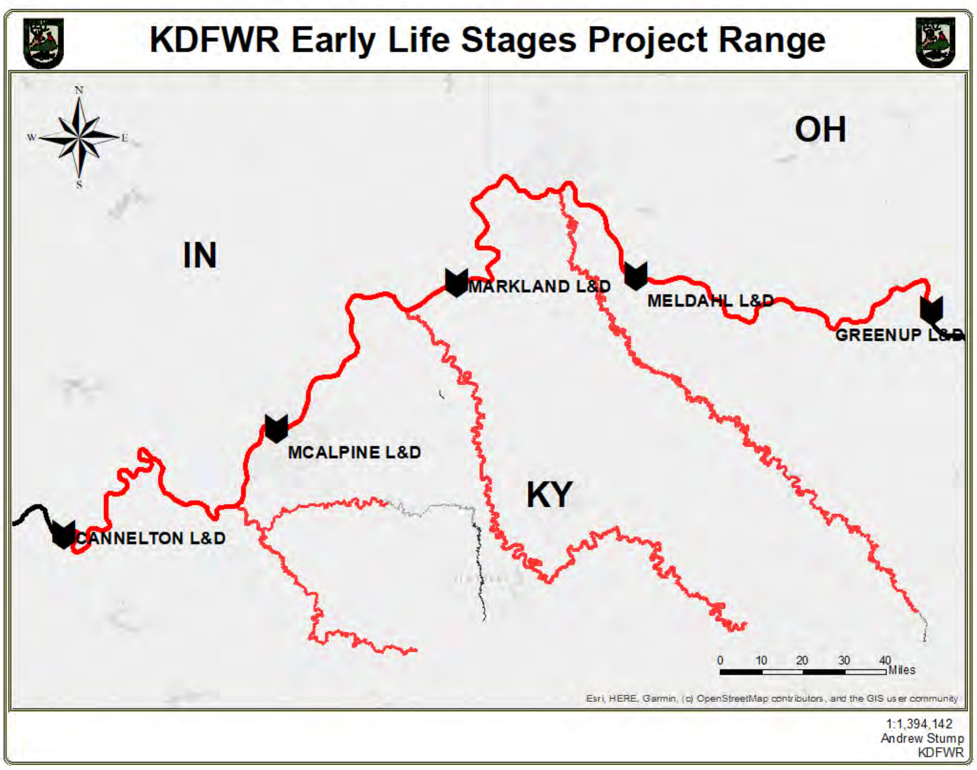
KDFWR will survey the McAlpine and Markland pools for young-of-year (YOY) invasive carp. Because typical nursery habitat (shallow backwater areas) is less prominent in the Ohio River, flooded creek mouths, embayments, and tributaries likely serve as a substitute. Previous sampling efforts have regularly captured YOY in JT Myers Pool with occasional captures in Newburgh Pool; and 2021 represents the first documented year where YOY invasive carp have been observed in Cannelton Pool. Suspected locations believed to be important for recruitment will be targeted with pulsed DC electrofishing during July and August. Additional gears (trap nets, surface trawls, and seines) may be used to confirm juvenile carp presence or absence.

If juvenile invasive carp are encountered, lengths and weights will be recorded and a subsample of aging structures will be collected; Otoliths will be taken in the field from fish > 200 mm while fish < 200 mm will be frozen whole for dissection and collection of aging structures in a lab setting. A suite of habitat measurements will be collected at each site to describe both the characteristics (average depth, maximum depth, tributary width, presence/absence of woody debris, and aquatic vegetation) of the tributary as well water quality parameters (water temperature, Secchi disk visibility, conductivity, pH, dissolved oxygen). Data will be shared with INDNR for compilation with previous data to help categorize and identify areas that may provide the necessary habitat for invasive carp growth and development.

KDFWR will conduct targeted sampling for YOY Black carp in the lower Ohio river from the confluence with the Mississippi river to Smithland lock and dam. Sampling locations will be chosen based on the hydrologic similarity to the location where YOY Black carp were collected previously in Kentucky. Sampling effort will not exceed 10 days. Areas will be sampled with beach seine, mini fykes and backpack electrofishing as available. If YOY or juveniles are collected; length and weight will be recorded, and the specimens will be preserved for additional analysis as needed.

In addition to sampling, participating agencies will collaborate with other fisheries professionals to inform them to report back with any confirmed findings of juvenile invasive carp within the basin. State partners will reach out to other biologists within their respective states and if a new instance is reported, will gather data and site location information if possible. These data will be compiled by the project lead and will be used to inform future planning efforts.

Map of Project Area:



Estimated Timetable for activities:

Activity	Time Period (Season, month/year)
Collection of Eggs, Embryos, and Larval Fish	Spring, May 2023 – July/2023
Survey for YOY Carp in Cannelton and McAlpine pools	Summer, August/2023 – September/2023
Eggs, Embryos, Larval Fish Isolated from Samples and Potential Carp Identified	Summer, July/2023
Data and Suspect Samples Sent to INDNR/USFWS for Molecular Verification	Fall, September/2023
Black Carp YOY sampling lower Ohio River	Fall 2022/2023
WRRDA Report to Congress	Fall, October/2023
KDFWR Contribution to Annual Technical Report	Spring, March/2024

Agency: West Virginia University

Activities and Methods:

Objective 1 - Determine the upstream extent of invasive carp spawning activity in the Ohio River above Markland Dam.

West Virginia University's (WVU) primary role will be to determine the extent of bigheaded carp spawning activity in the Ohio River above Markland Dam. WVU will conduct approximately biweekly ichthyoplankton tows from mid-May through July 2023 at traditional fixed points, i.e. Kyger Creek Plant (R.C. Byrd Pool), Guyandotte River (Greenup Pool), Scioto River and J.M. Stuart Plant (Meldahl Pool), and Little Miami River and Hogan Creek (Markland Pool). Between the biweekly fixed site sampling we will initiate a pilot study to test a stratified random sampling design focusing on the Meldahl and Markland pools (these were selected because they represent the strong invasion front zone and most likely location to encounter invasive carp eggs and/or larvae). Depending on timing relative to high flow events (believed/assumed to trigger spawning) fixed sites can 'miss' episodic spawning events that travel in a dispersed cluster downstream, a spatially stratified random sample can increase the likelihood of detecting such episodic events. We will focus on three strata for each pool: upstream tailwaters (not inclusive of the tailwaters alone), middle pool, and lower pool. We will work with project partners to define these reaches for each pool and will also limit the sampling stretches to vicinities within approximately 20 river miles from a public boat launch. We will endeavor to sample 2-3 transects (identified river mile) within each reach of each pool using the standard (traditional), right, center, left triplicate samples at each transect. This will be a pilot year to fine-tune methodologies and work out travel and sample processing feasibilities.

To evaluate relative abundance of invasive carp eggs, embryos, and larvae, conical ichthyoplankton tows (0.76m, 500 µm mesh) will be conducted at each site (water temperatures 64 - 80°F with moderate to high flows). The ichthyoplankton net will be deployed on the side of the boat facing upstream, with each tow lasting 3 minutes. A flow meter will be used to determine water volume sampled. All contents will be rinsed into a 500 µm sieve and preserved in 95% ethanol for identification in the lab. At each site on the main stem Ohio River we will sample at the right descending, center, and left descending portions of the river. A fourth sample will be taken at each site either at the intake structure (power plant sites) or within the tributary mouth as tributaries may serve as a refuge for newly hatched larvae to escape the main channel flow. If possible, velocity (m/s) will be measured using a flow meter and depth (m) and water temperature (^{0}C) will also recorded using a boat-mounted depth sounder at each sampling site.

Approved morphometric characteristics will be used to identify suspected invasive carp eggs, embryos, and larvae. WVU will send a subsample of suspected invasive carp eggs, embryos, and/or larvae to Whitney Genetics Laboratory for confirmation of species. Results will be used to estimate the extent of spawning activity in the Ohio River and thus will guide future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

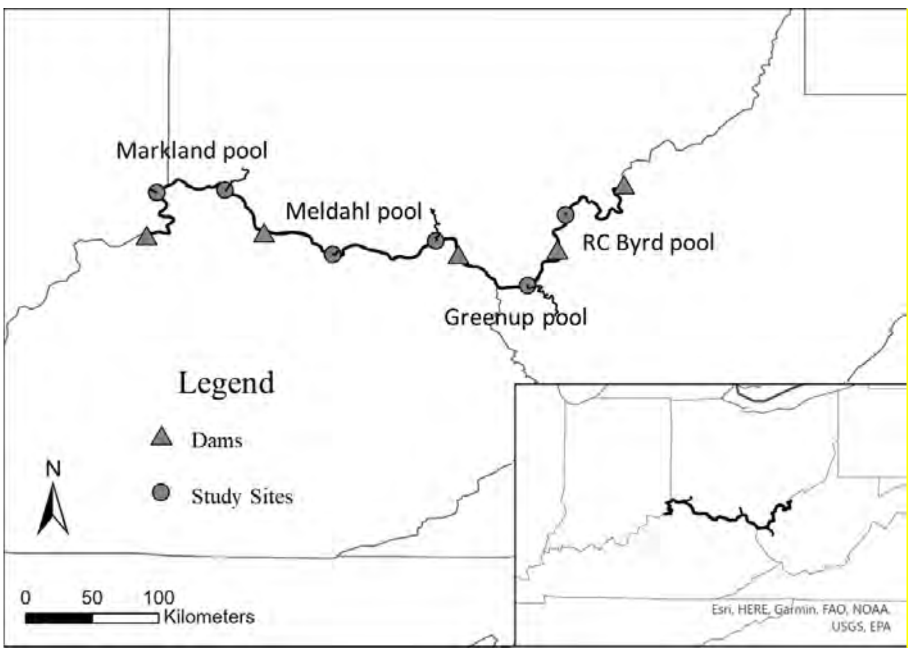
WVU will also identify and enumerate all larval fish collected and subsample larval lengths to assess phenology and growth rates of larval fish by species. This will be compared across pools relative to environmental drivers, e.g. flow, water temperature, day length, and lunar period and density of invasive carp and zooplankton.

WVU will also collect plankton community data concurrently with larval fish collections. WVU has adopted standard tube sampling methodology presently being used by the Illinois Natural History Survey as components of their invasive carp monitoring and other inland waters surveys. As the opportunities arise WVU will visit lower river reaches where invasive carp are more abundant to collect samples to compare/contrast plankton communities across gradients of invasive carp density and as described above will use plankton community variables (e.g. abundance and timing of specific taxa, and community body size metrics) to explain variation in fish larval abundance and growth rates among pools and relative to environmental gradients and invasive carp density.

Objective 3 - Determine the extent and locations of invasive carp recruitment in the Ohio River

WVU will use spatial and habitat data collected by partners in the lower pool to prioritize targeted sampling for juvenile invasive carp within upstream reaches of the river representing the invasion front and presence zone. Specifically, the Markland (e.g. Hogan's Creek and Little Miami tributaries), Meldahl (e.g J.M. Stuart), Greenup, and R.C. Byrd (e.g. Raccoon Creek)) pools of the Ohio River. Most of these sites are flooded creek mouths of tributaries, believed to be the best available nursery habitat, however, as stated, we will use information from downstream (presence/absence of carp, habitat, and spatial location) to optimize our upstream surveillance monitoring. During the summer 2021 sampling of ichthyoplankton, we documented invasive carp eggs in the Markland Pool Little Miami tributary, this and similar sites will be a focus of our juvenile monitoring. Surface trawling will be conducted at identified sites using the same gear and approaches at IN DNR. Surface trawl samples will consist of at least two 5-minute tows at each sample site. The surface trawl is constructed of an inner bag of 32 mm, number 12 netting, and an outer bag of 4.8 mm, 35 lb Delta style knotless mesh. The trawl is approximately 3.7 meters wide and 0.6 meters tall at the mouth, and is 5.5 meters long. Floats were added to the otter boards (30.5 x 61 cm) and the float line of the trawl mouth to suspend the net on the surface. Tow lines are attached to the bow of the boat and the boat is motored in reverse between 0.7 to 0.9 meters/second.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
WVU Larval IC Sampling	May-July 2023
WVU Process larval samples	July 2023 – March 2024
WVU Send carp data to INDNR	Nov 2023
Project Report Technical Document	March 2024

Agency: West Virginia Division of Natural Resources

Activities and Methods:

Objective 1 - Determine the upstream extent of invasive carp spawning activity in the Ohio River above Markland Dam.

WVDNR will assist and coordinate with WVU in conducting sampling for Invasive carp eggs, embryos, and larvae in R.C. Byrd and Greenup pools using conical tows during peak spawning periods.

Objective 2 - Identify locations of the Ohio River in which spawning occurs.

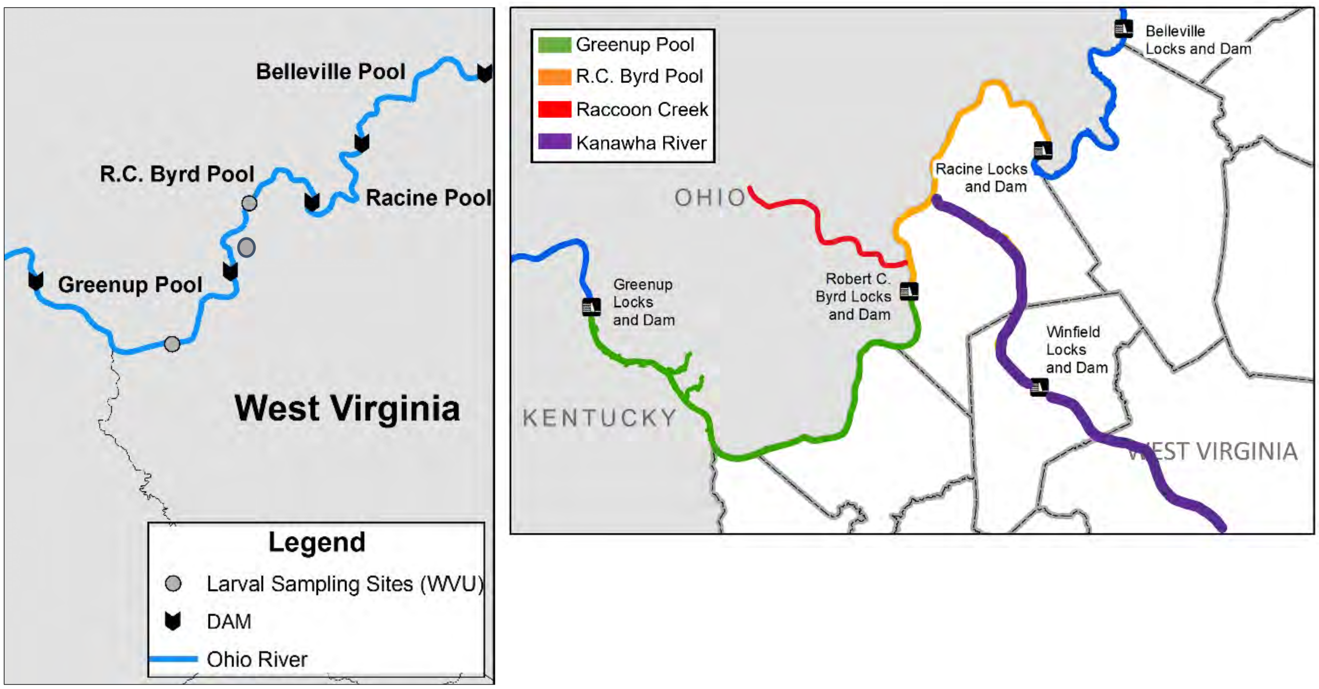
WVDNR will also conduct and coordinate sampling for Invasive carp eggs, embryos, and larvae in Raccoon Creek and Kanawha River in the R.C. Byrd Pool using conical tows during peak spawning periods to determine if spawning is occurring. Raccoon Creek is a highly productive tributary of the Ohio River where the majority of bighead carp are captured during targeted surveys. Several female bighead carp with mature ovaries (eggs) have been captured in this creek leading to a concern that a successful spawn could take place at this location. Several telemetry tagged carp have moved upstream in the Kanawha River to Winfield Dam during suspected periods of potential peak spawning conditions leading to a concern that a spawn could also take place in this tributary.

Conical ichthyoplankton tows (0.76m, 500 µm mesh) will be conducted on at least four dates during ideal spawning conditions from May through July (with moderate to high flows). To determine ideal spawning conditions, WVDNR staff will stay in contact with KDFWR and INDNR staff on when spawning patches begin to develop. Optimal river conditions will also include the crest of a river rise as well as water temperatures 64 - 80°F. At each site, three tows will be conducted within the tributary at least one-half mile upstream of the mouth. A single ichthyoplankton net will be deployed on the side of the boat facing upstream, with each tow lasting 3 minutes. A flow meter will be used to determine water volume sampled. Depth (m) and water temperature (°C) will be recorded using a boat-mounted depth sounder at each sampling site. All contents will be preserved in 95% ethanol for identification in the lab. WVDNR will sort ichthyoplankton samples for larval fishes and transfer those to a smaller container for shipping to INDNR for identification. Results will be used to locate spawning locations in the

Ohio River Basin and thus will guide future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

In addition to sampling, participating agencies will collaborate with other fisheries professionals to inform them to report back with any confirmed findings of juvenile Invasive carp within the basin. State partners will reach out to other biologists within their respective states and if a new instance is reported, will gather data and site location information if possible. These data will be compiled by the project lead and will be used to inform future planning efforts.

Maps of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Collection of Eggs, Embryos, and Larval Fish	Spring, May 2023 – July/2023
Eggs, Embryos, Larval Fish Isolated from Samples and Potential Carp Identified	Summer, July 2023
Data and Suspect Samples Sent to INDNR/USFWS for Molecular Verification	Summer, August 2023
WRRDA Report to Congress	Fall, October 2023
WVDNR Contribution to Annual Technical Report	Spring, March 2024

Literature Cited:

Chapman, D. C. and A. E. George. 2011. Developmental rate and behavior of early life stages of Bighead Carp and Silver Carp. U.S. Geological Survey Scientific Investigations Report 2011-5076. 62p.

Control and Containment of Invasive carp in the Ohio River Basin

Lead Agency and Author: Kentucky Department of Fish and Wildlife Resources, Andrew Stump (andrew.stump@ky.gov)

Cooperating Agencies: West Virginia Division of Natural Resources (WVDNR), Illinois Department of Natural Resources (ILDNR), Indiana Department of Natural Resources (INDNR), Southern Illinois University (SIU)

Statement of Need:

Invasive species are continually responsible for undesirable economic and environmental impacts across the nation (Lovell and Stone 2005, Pimentel et al. 2005, Jelks et al. 2008). Invasive carp rapidly colonize river reaches in high densities, affecting the native food webs important to ecosystem functions (Irons et al. 2007, Freedman et al. 2012) and inflicting significant impacts on recreation and natural aesthetics. The Ohio River basin (ORB) provides a broad variety of potential habitats for invasive carp, putting the entire basin at considerable risk. In response, funding has been allocated to agencies, which manage fish in the basin to limit the impacts of Invasive carp where they exist, as well as halt their spread into uninhabited waters.

Tasks outlined in this document add a sixth year of multi-agency efforts to remove and contain carp populations in the Ohio River. Collaborative efforts have included large-scale removal events, consistent agency efforts to target and remove carp year-round, and an expanding contract-fishing program. The goal of this project is to slow and reverse the expansion of Invasive carp populations up the Ohio River system.

Aside from state matching funds, these projects have been funded because of Congressional appropriations to the US Fish and Wildlife Service (USFWS) for purposes of working with state agencies to implement plans outlined in the ORB Framework. The USFWS has provided states across three federal regions within the ORB with funding, equipment, and staff time, and all the agencies partner to implement the ORB Framework devised in 2014. To date, basin partners have successfully established methods and locations for targeting and harvesting fish, developed a contract fishing program designed to encourage the accomplished commercial fishers to target and harvest invasive carp, and identified several hot-spots in lower density pools where fish can continually be targeted for removal.

Objectives:

1. Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.
2. Implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin.

Agency: Kentucky Department of Fish and Wildlife Resources (KDFWR)

Activities and Methods:

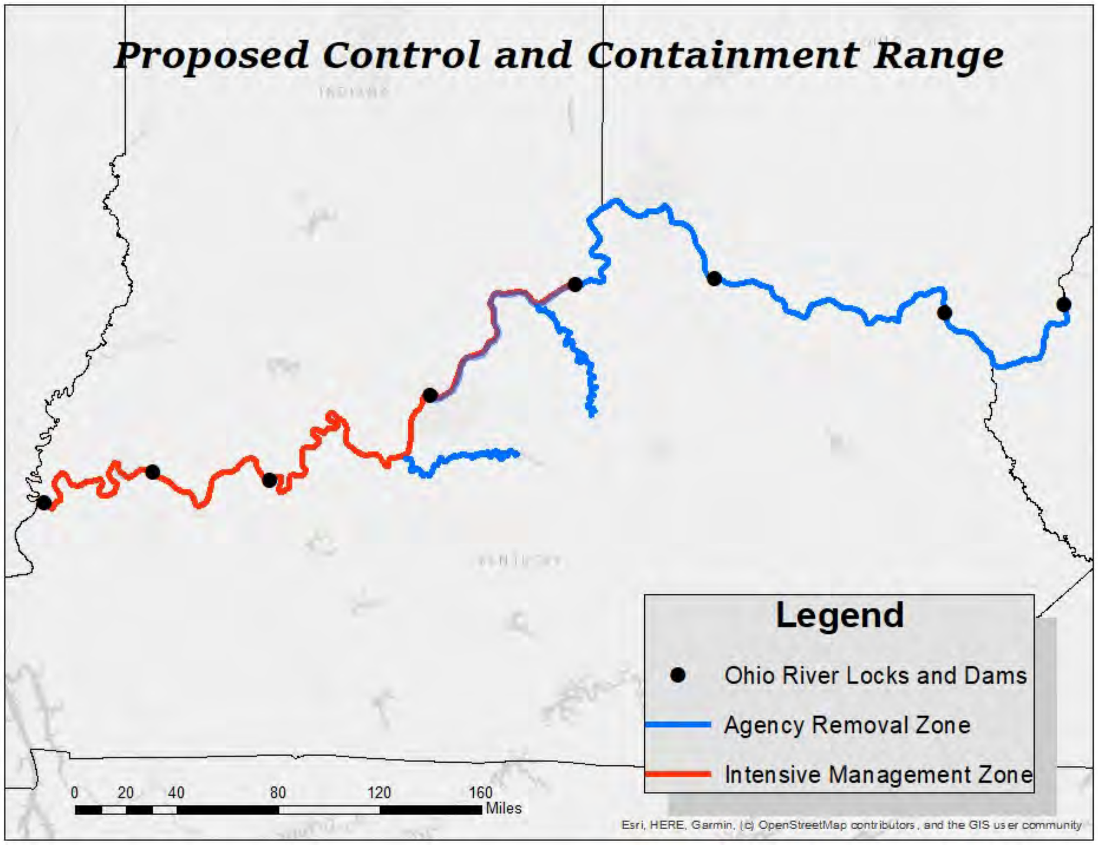
Objective 1 - Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.

Agency crews will remove Invasive carps from the Ohio River and large inland tributaries and embayments for approximately 125-150 fishing days, focusing on known or suspected areas where invasive carps congregate. Agency efforts will rely on pulsed-DC or AC boat electrofishing and gill nets, but other gear types may be used to increase catchability depending on sampling circumstances. Information from literature, expertise of researchers, and references from contract or commercial fishers will be investigated when possible to improve yields. Samples of harvested fish may be used to provide otoliths for aging depending on the season in which they are taken (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). All by-catch and collected fish will be identified, counted, geo-referenced, and disposition of bycatch will be noted. The majority of nonindigenous carps will be euthanized upon capture, but some fish may be surgically implanted with a sonic transmitter to augment the Ohio River telemetry project.

Objective 2 – Implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin.

Previously, agency crews have focused removal efforts in high density pools such as Cannelton. However, midway through the 2019 calendar year, KDFWR and INDNR implemented a contract fishing program to increase carp harvest numbers in Cannelton pool. Contracted fishers will be employed to conduct regularly scheduled removal, and using a suite of collaborative Kentucky and Indiana regulations (301 KAR 1:153 and Emergency Rule 312 LSA # 22-4), were given access to otherwise net-restricted waters in order to target Invasive carp species. KDFWR plans to continue this program and will track daily progress using impartial, on-board observers, GPS trackers, and harvest records from fishing efforts. Invasive carp subsamples will be taken from the harvests to track sex ratios and length distributions of landings. With the proposed funding level, this program is expected to provide approximately 550 contract fishing days and reach a minimum benchmark of 400,000 lbs of carp harvested within the intensive management zone (currently J.T. Myers, Newburgh, Cannelton, and McAlpine pools). Additionally, KDFWR will track gear used, locations and conditions surrounding removal efforts, and record all bycatch information including disposition upon release.

Map of Project Area:



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Contract removal within the intensive management zone (IMZ)	Spring, January/2023 – May/2023
Agency Removal in McAlpine and above the IMZ	Spring, Summer, Fall, and Winter, May/2023 – December/2023
Agency Removal in Inland Waters including Salt River and Kentucky River	Spring, Summer, Fall, and Winter, May/2023 – December/2023
WRDA Report to Congress	Fall, October/2023
Contract removal within the intensive management zone (IMZ)	Fall and Winter, October/2023 – December/2023
Project Report Technical Document	Spring, March/2024

Agency: Indiana Department of Natural Resources (INDNR)

Activities and Methods:

Objective 1 - Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.

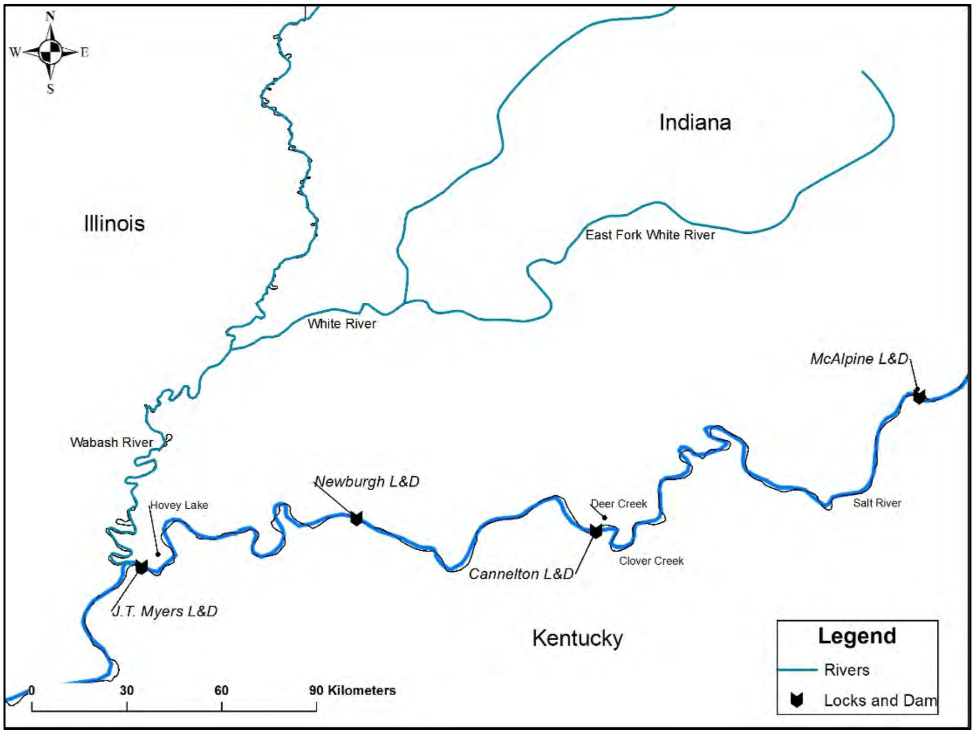
INDNR will use agency crews to target and remove invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin. Crews will work with KDFWR, ILDNR, and contract fishers to conduct coordinated removal efforts in areas with large numbers of invasive carp (portions of the White, Wabash, and Ohio rivers). INDNR will plan or assist at least 10 multi-boat removal events within the Wabash River basin (including the White River), and at least five removal events within the Ohio River basin. Some removal events may require multiple days of effort. Agency efforts will primarily consist of pulsed-DC electrofishing and gill nets, but other gears may be utilized to increase catchability. Block nets will be used where applicable to minimize carp escapement and increase yields. All by-catch and collected fish will be identified, counted, geo-referenced, and disposition of bycatch will be noted upon release. The majority of nonindigenous carps will be euthanized upon capture, but some fish may be surgically implanted with a sonic transmitter to augment the Ohio River Telemetry Project.

Objective 2 – Implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin.

INDNR will help implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin. In 2019, KDFWR and INDNR implemented a contract fishing program to increase carp harvest numbers in Cannelton Pool and this program will be continued into 2023. Contracted anglers will be employed by KDFWR to conduct regularly scheduled removal, and using a suite of special Kentucky and Indiana regulations (301 KAR 1:153 and Emergency Rule 312 LSA # 22-4), will be given access to otherwise net-restricted waters in order to target invasive carp species. INDNR will continue developing a program similar to the Kentucky Asian Carp Harvest Program to allow additional invasive carp harvest opportunities in Indiana waters. This program will allow INDNR to bring contracted fishers into otherwise closed waters for the purpose of additional invasive carp harvest. INDNR will work closely with ILDNR to increase contract removal effort on the Wabash River while providing observers to collect ride-along data.

INDNR will work with current contract and commercial fishers to determine the most suitable avenues for facilitating increased invasive carp harvest in the lower Wabash River area. State regulations will be developed and/or modified to promote and allow more harvest of invasive carp through allowing additional gear types to be used on inland waters. INDNR will provide enough oversite to ensure native fish populations are not impacted as a result of an expanding carp fishery.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Agency Removal and Aid to Contract Fishers	Start Fall, October/2022 (Continue through 2023)
Create/modify regulations to promote more invasive carp harvest	Start Fall, October/2022 (Continue through 2023)
Project Report Technical Document	Spring, March/2023
Removal and ride-alongs in the Wabash River	Start Spring, March/2023
Agency based removal efforts in White, Wabash, and Ohio Rivers	Start Spring, March/2023

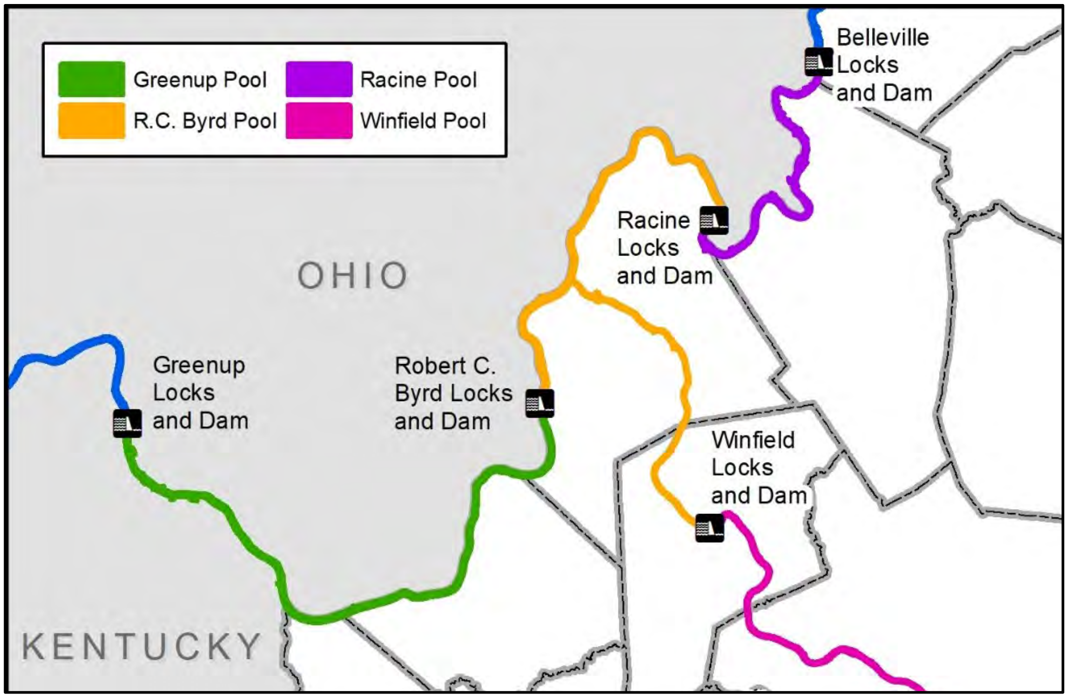
Agency: West Virginia Division of Natural Resources (WVDNR)

Activities and Methods:

Objective 1 - Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.

To target and remove Invasive carp WVDNR crews will remove Invasive carps from the R.C. Byrd and Greenup pools of the Ohio River, focusing on known or suspected areas of occurrence (i.e. Raccoon Creek, Guyandotte R.). Angler and public reports of sightings will also be taken into account to locate potential locations for removal. A minimum of five removal trips will be completed during the sampling period. Agency efforts will rely on pulsed-DC electrofishing and gill nets, but other gear types will be utilized to increase catchability depending on sampling circumstances. Active acoustic telemetry tracking techniques will also be employed to locate fish for removal. Results from the telemetry project indicate three tagged Silver carp currently residing in the R.C. Byrd Pool. Effort will be expended to locate these fish and then attempt to remove them. Information from the literature, expertise of researchers and success of contract angler techniques will be employed to investigate improvements in capturing Invasive carps. Exterminated fish will be used to provide otoliths and/or pectoral fin rays for aging. All by-catch and collected fish will be identified, counted, and geo-referenced for reporting purposes. Most nonindigenous carps targeted throughout this project will be euthanized upon capture, but a few fish may be surgically implanted with a sonic transmitter to augment the Ohio River Telemetry Project.

Map of Project Area:



Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Agency Removal in R.C. Byrd Pool	Summer, Aug 2022-July 2023
Agency Removal in Greenup Pool	Summer, Aug 2022-July 2023
WRRDA Report to Congress	Fall, October/2022
Project Report Technical Document	Spring, March/2023

Agency: Illinois Department of Natural Resources

Activities and Methods:

ILDNR continues operation of an Invasive carp removal program utilizing contract fishing, enhanced contract fishing, and facilitation allowing a customized approach to removal based on local conditions to meet management objectives of increasing Invasive carp removal in key locations.

Contract Fishing, where fishers will be under contract to ILDNR directly will be undertaken in late 2022 and early 2023 as necessary. These fishers, already under contract with ILDNR will be directed to fish the Wabash/White rivers in IL and IN with observers on board. As an extension of the agency, these fishers will likely fish entanglement gear (gill and trammel nets), which is currently not permitted in the Wabash River, to inform agencies on 1) carp densities, 2) efficacy of the gear in these waters, and 3) by-catch. All non-Invasive carps will be enumerated and released back into the water, while all Invasive carps will be disposed of through markets, processors, or landfill as needed. Fisherman will not be compensated for catch but will work 4 full days in a week as constrained by a response contract with ILDNR. Payments to contracted commercial fishers for weekly fishing is the sole use of these contract fishing funds; agency and university staff will attend these efforts under separate funding. While removal of quantities of Invasive carp is desired, these efforts overall will inform managers of both Illinois and Indiana regarding future management goals and considerations.

Enhanced Contract Fishing includes payments to commercial fishers by pounds removed and allows agencies to direct and enhance the fishing effort in places where commercial removal already exists. The program initiated in September 2019 on the Peoria Pool of the Illinois River has been expanded to include the commercial waters of the following rivers: 1) the Wabash River that runs along the borders of Illinois and Indiana from the mouth of the Ohio River to the point south of Terre Haute where it departs from Illinois; 2) Little Wabash River, 3) Embarras River, except from Route 130 in Coles County upstream to the Harrison Street Bridge, including Lake Charleston, 4) Skillet Fork River, 5) Ohio River from McAlpine Dam to the mouth of the Ohio, 6) the lower Cumberland River from Barkley Dam to the confluence with the Ohio River, and 7) the lower Tennessee River from Kentucky Dam to the confluence with the Ohio River.

Original enhanced fishing contracts are continuing to be executed with inclusion of the new water bodies referenced above and are being made available to any legally licensed commercial fishers who wish to participate in the program. Contracts provide up to $.10 per pound payments for Invasive carp caught in the authorized waters stated above and sold to processors or other buyers for a minimum price of $.07 per pound. Prior to reimbursement, fishermen are required to present to the program a summary cover sheet and receipt for each catch. Cover sheets include fisher name, address, commercial fishing license, equipment used, catch location (by pool), affidavit, signature, and date. Receipts must contain name and address of both fisher and buyer, fisher's license number, catch location (by pool), invoice number, date, listing of each species, each species weight, and price per pound and buyer signature.

Prior to each fishing day, fisherman are required to notify the program of their intended fishing location and boat ramp they expect to use. Program monitoring is performed to provide spot checks of reported fishing activity to verify that fishing is occurring in reported location(s).

Data collected through this program includes fish weight by species, catch locations, dates and equipment used. These will be measured against hydroacoustic and other fish population analyses to determine population changes and effects of removal on population characteristics. Removal goal for Enhanced Contract Fishing for the period of performance is 2 million pounds of Invasive carp.

<u>Contracted Facilitation</u> will continue offloading of Invasive carp catches from commercial vessels at designated locations within 10 miles of the shoreline to support increased removal where contract and enhanced contract harvest is ongoing. This effort encompasses regional river systems including: 1) Peoria Pool of the Illinois River, 2) Pools 20 - 22 of the Upper Mississippi River, 3) Wabash River, and 4) Ohio River from McAlpine Dam to the mouth of the Ohio including the Green River 6) the lower Cumberland River from Barkley Dam to the confluence with the Ohio River, and 7) the lower Tennessee River from Kentucky Dam to the confluence with the Ohio River. (See maps below.) A similar contract to the Enhanced Contract Fishing program is available to any licensed buyer authorized to operate in Illinois, Indiana, Missouri, and Kentucky, for offloading in their respective states. Companies/buyers are required to enter this contract to pick up fish within these watersheds to be eligible for facilitation funding. Considerations for pickup locations are coordinated with state and local managers. Companies/buyers are not restrained by where their facilities are located, just the locations/distance they are picking up fish from target waterbodies. The contract provides payment of up to $.10 per pound depending on location for Invasive carp offloaded from commercial fishers in the designated areas, while funds are available and/or additional funds are refreshed.

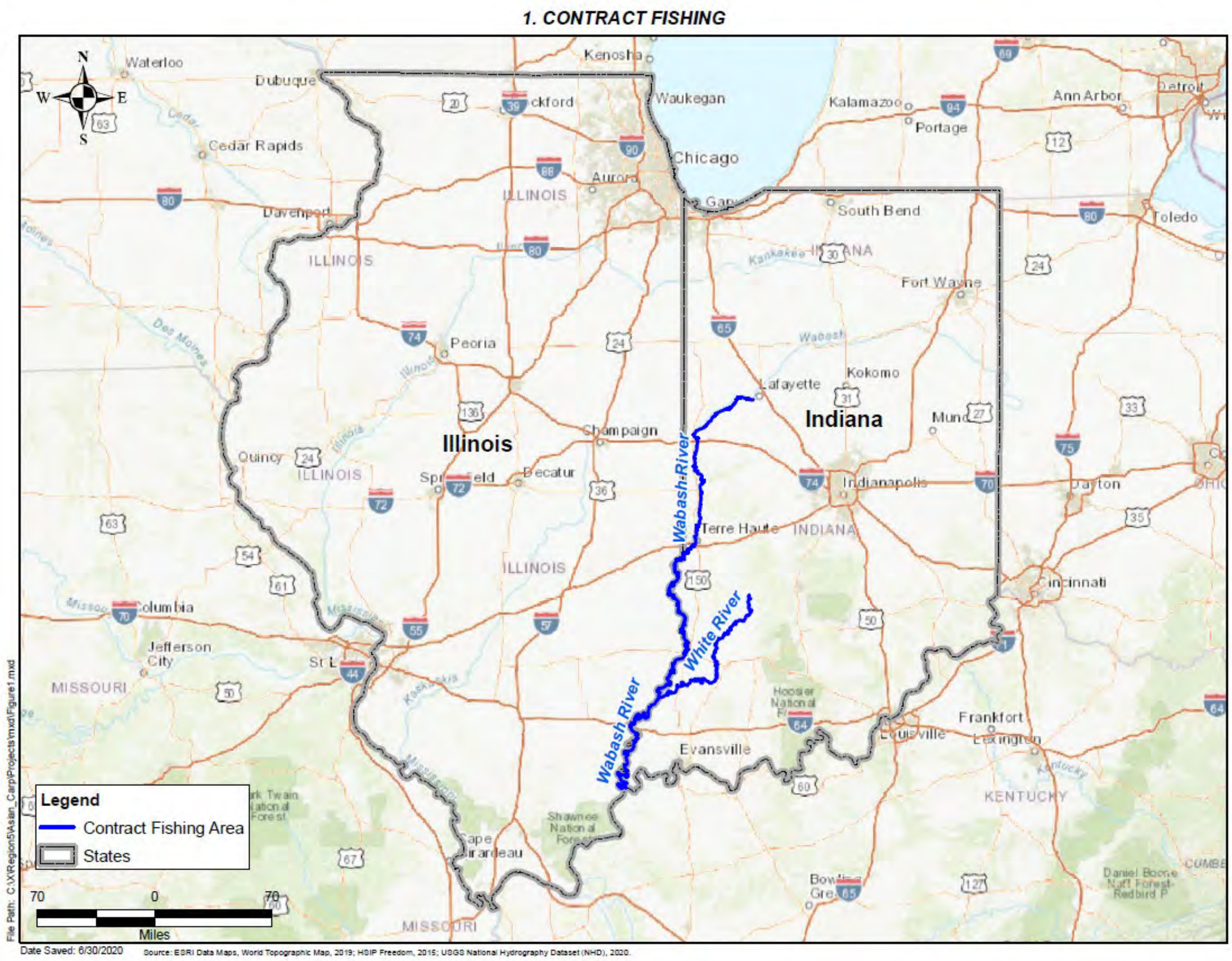
Payment is made for fish caught in commercial waters associated with the shoreline location. These locations are established on or near the referenced water bodies above and are required to be pre-approved by the program prior to use. Locations may include public boat launches or other locations up to 10 miles from the shoreline. Buyers are required to pay the same minimum price of $.07 per pound established for the Enhanced Contract Fishing program and are required to present copies of receipts for Invasive carp purchased at a designated location. These receipts must contain the same information as for the Enhanced Contract Fishing program and are required to be accompanied by a similar cover sheet.

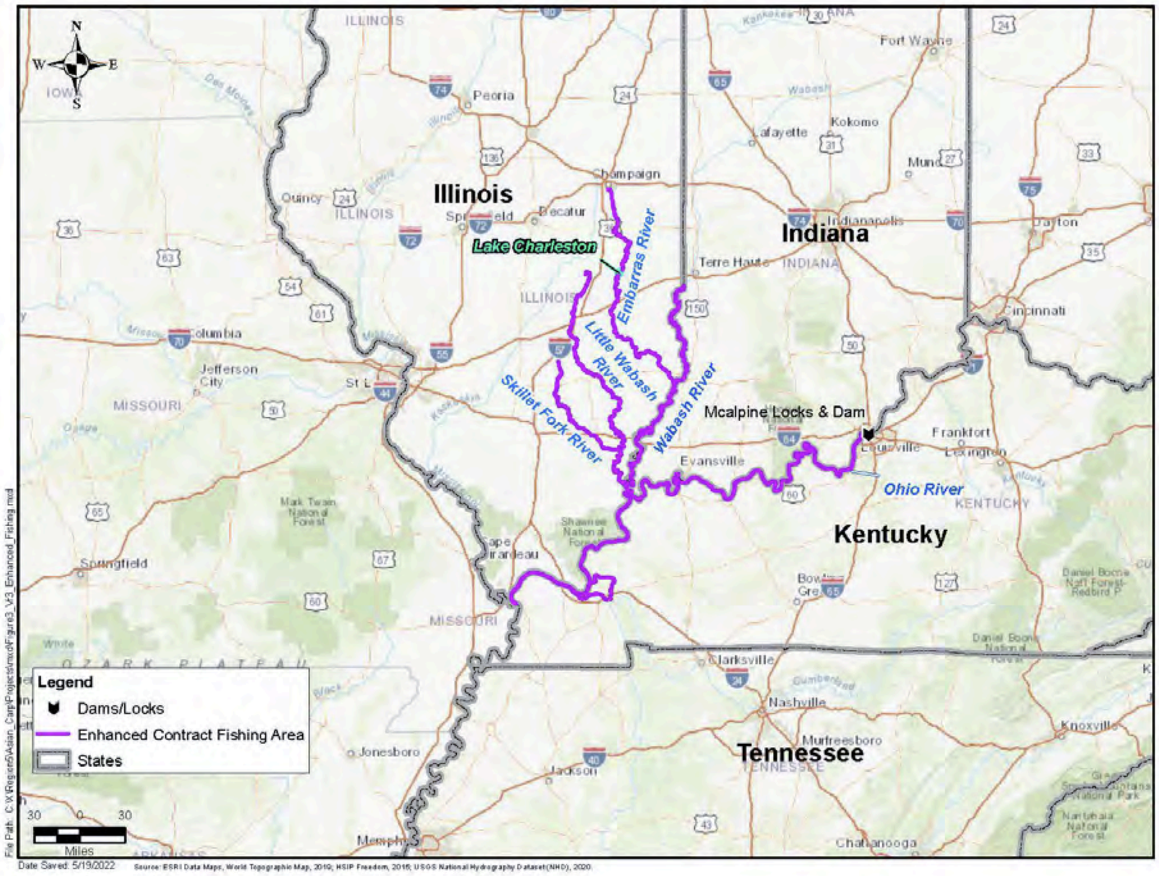
Prior to pick up, the buyer is required to notify the program of the intended pick-up location and (if applicable) license plate of the truck to be used. Program monitoring is performed of reported pick-up and fishing activity.

Facilitation efforts under this program are complementary and additive (but not redundant) to contract fishing efforts identified in the ACRCC Action Plan as well as ongoing state Invasive carp removal programs including KDFWR Invasive Carp Harvest Program. Removal goal for Contracted Facilitation for the period of performance is 6 million pounds of Invasive carp.

This project supports SIU's efforts to evaluate contracted facilitation as a method of increasing Invasive carp harvest to increase ability to manage/reduce these invasive species while informing future investments in these and other basins. Data collected will not duplicate data collected in the Enhanced Contract Fishing program, though will include the same information of fish weight by species, catch locations, dates and equipment used. These will be measured against hydroacoustic and other fish population analyses to determine population changes and effects of removal on population characteristics.

Maps of Project Areas




Illinois
Indiana
Kentucky
Tennessee
Lake Charleston
Embarras River
Little Wabash River
Skillet Fork River
Wabash River
Mcalpine Locks & Dam
Ohio River
Legend
Dams/Locks
Enhanced Contract Fishing Area
States
30 0 30
Miles
Date Saved: 5/19/2022

Estimated Timetable for Activities

Activity	Time Period (Season, month/year) *
Contract Removal	Start October 2022 (Continue through March 2023)
Enhanced Contract Removal	2022 through 2023
Contracted Facilitation	2022 through 2023

* Timelines subject to funding availability and participation in contracts.

Quantifying lock and dam passage, habitat use, and survival rates of invasive carps in the Ohio River Basin

Lead Agency and Author: U.S. Fish and Wildlife Service **(**USFWS)

Collaborating Agencies: Southern Illinois University (SIU), Eastern Illinois University (EIU), Indiana Department of Natural Resources (INDNR), Illinois Department of Natural Resources (ILDNR), Kentucky Department of Fish and Wildlife Resources (KDFWR), Ohio Division of Wildlife (ODOW), West Virginia Division of Natural Resources (WVDNR), U.S. Army Corps of Engineers (USACE), and U.S. Geological Survey (USGS)

Statement of Need: Silver and Bighead Carp (*Hypophthalmichthys molitrix* and *H. nobilis*, respectively), hereafter "invasive carp", populations are well-established in the lower and middle reaches of the Ohio River and are known to reproduce as far upstream as Louisville, Kentucky. Invasive carps are capable of long-distance dispersal (Peters et al. 2006; DeGrandchamp et al. 2008) and high reproductive potential (i.e., high fecundity and potential for protracted spawning period) (Garvey et al. 2006; Lenaerts et al. 2021) which, when combined with rapid individual growth rates and short generation times, allows for near-exponential population growth. Therefore, establishment of populations in novel habitats is of the utmost concern. Additionally, the high consumptive rates of invasive carps (Williamson and Garvey 2005) gives these fishes the ability to outcompete native species (Irons et al. 2007; Sampson et al. 2009) disrupting food web dynamics (Sass et al. 2014; Collins and Wahl 2017) and commercial and recreational fisheries (Pimentel et al. 2000, 2005). Because of their potential to cause economic and ecological damage, the need exists to prevent the establishment of invasive carp populations in the upper portions of the Ohio River basin. By understanding the movement and dispersal of invasive carps in the Ohio River basin, we can better inform management actions that limit their spread into additional habitats.

To prevent the spread of invasive carps into the upper portions of the Ohio River basin, we must understand their propensity for upstream movement, habitat use, and the probability of among-pool transitions. These monitoring efforts will reveal the timing and conditions most likely associated with pool transitions and entry into novel habitats. Additionally, mass movements to "preferred" habitats may reveal the timing and locations of spawning aggregations. Knowledge of these movements will be used to create management strategies designed to limit population expansion and inform management actions such as mass removal efforts and the location of deterrents to upstream movement.

Invasive carp locations will be recorded using a stationary receiver array throughout the study area (i.e., mainstem Ohio River from Smithland to Willow Island pools and major tributaries such as the Wabash River). Observations from the stationary receiver array will be supplemented with active tracking at specified locations (e.g., Wabash and White rivers and the Markland and Cannelton pools). Broad-scale (among-pool) movement data will be used to evaluate the dispersal and invasion dynamics of invasive carp, their ability to navigate the lock and dam systems, and the contribution of the Wabash River basin to Ohio River populations of invasive carps. Fine-scale (within pool) movement data will be used to identify areas in which invasive carps congregate in the Ohio River and its tributaries and to relate habitat use to environmental conditions such as temperature, flow, and light that are related to daily or seasonal transitions as well as stochastic events (e.g., rainfall). Understanding the relationships between environmental conditions and the habitat use and movement of invasive carps will improve the management of invasive carps by informing the locations for movement deterrents and mass-removal efforts that can slow range expansion and increase capture efficiency. Moreover, increased efficiency of removal efforts will allow for the assessment of changes in the movement and habitat use of invasive carps in response to decreased population densities.

The approach outlined here will support the Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States (National Plan) and the Ohio River Basin Asian Carp Control Strategy Framework (Sub Basin Plan). Specifically, telemetry data collected at the spatial scale represented in this project plan will inform management efforts designed to control the expansion of invasive carp populations within the Ohio River basin, detect and minimize range expansion and early invasion fronts, guide efforts to establish sustainable and effective control methods, evaluate potential locations for deterrent barriers, and identify how lock and dam operations may be used to deter passage of invasive carps. This project relies on the strong relationships established within the Ohio River basin and relies on inter-agency coordination to implement field work and provide results on an annual basis. This design allows for timely dissemination of data and analysis to further our understanding and guide management actions.

Project Objectives:

1) Understand tributary use by invasive carps and the role of tributaries as potential sources for recruitment and routes of invasion into adjacent basins.

2) Delineate the upstream population distribution of invasive carps.

3) Quantify passage of invasive carps through Ohio River locks and dams.

4) Quantify movement patterns of invasive carps within the Wabash River basin including assessing movement between the Wabash and Ohio rivers (i.e., the contribution of Wabash River populations to those of the Ohio River) and between the White and Wabash rivers.

5) Inform invasive carp removal efforts by quantifying fine-scale habitat use and how habitat use changes through time in the Wabash and White rivers.

Agency: Kentucky Department of Fish & Wildlife Resources

Activities and Methods:

From October 2022 through September 2023, the Kentucky Department of Fish & Wildlife Resources (KDFWR) will continue to collaborate with other agencies towards the maintenance of a large (680+ mile) stationary receiver array that is essential to the project’s first three objectives. The majority of KDFWR’s efforts will be focused on a group of nearly 30 receiver sites that are located throughout a 140-mile stretch of the Ohio River, which begins in the middle Markland Pool, extends downstream through McAlpine Pool and eventually comes to an end near river mile (RM) 630 in the upper Cannelton Pool (Figure 1). All receiver stations within this stretch of the array are distributed among three primary habitat types that include tributaries, mainstem river, and lock & dam sites (Table 1). KDFWR staff will visit the stations at least once in October-November 2022 to offload telemetry data and complete any necessary maintenance tasks (i.e., replace batteries, cables, etc.). During December 2022, these locations will be visited again to conduct year-end offloads and other activities as determined by each site's habitat type. When river conditions are favorable in spring 2023, crews will return to each location in KDFWR's section of the array to resume data offloads and conduct other standard site maintenance. Following the initial spring efforts, field staff will visit each site at least once every two months through the end of September 2023. The specific activities conducted during these visits are often determined by a site's habitat type. When combined with other information (i.e., pool location), habitat type can be used to accurately identify the project objective behind each of these receiver stations.

Objective 1 - Understand tributary use by invasive carps and the role of tributaries as potential sources for recruitment and routes of invasion into adjacent basins

In an effort towards completing the first objective, the KDFWR will visit all tributary sites in their section of the array according to the aforementioned schedule, which begins during fall 2022 and continues through September 2023. The overall lower risk of seasonal losses at tributary sites allows the receivers to remain active year-round, but this requires that KDFWR complete additional tasks at these locations. During site visits in December 2022, field staff plan to offload any new telemetry data, replace batteries, if needed, and then ultimately reset each VR2W for the next project year. Water temperature data will also be offloaded from any remaining HOBO temp loggers that were deployed to upper tributary sites during 2017.

During fall 2022 and spring 2023, KDFWR plans to resume some active tracking efforts that were originally designed to complement the results obtained from receiver stations that had already been established in most of the Ohio River's primary tributaries. These efforts will continue to be focused in upstream areas of tributaries that have an increased chance of being used by invasive carp to emigrate from the mainstem Ohio River (e.g., Kentucky River, Salt River, etc.). The amount of active tracking that field crews are likely to complete in 2022-2023 is not only based on river conditions and available staff, but also on the amount of time that KDFWR will require to complete their expansion of the stationary receiver array into two of Kentucky's larger tributaries.

By fall 2022, KDFWR will have already begun efforts to extend the project's stationary receiver array into the upper reaches of both the Kentucky (RM 545) and Salt (RM 630) rivers, which are two important tributaries to the middle Ohio River. Preliminary telemetry results indicated that tagged carp regularly use both tributaries. However, the detailed information regarding carp movements once they enter either water body is insufficient, and any available data has come from receivers deployed to locations that are within a mile of the mainstem Ohio River. During fall 2022, KDFWR staff intend to complete their ongoing efforts to improve telemetry coverage in both the Kentucky and Salt rivers via the successful establishment of up to 8 additional receiver stations in each water body. Although some previously tagged carp do occupy these waterbodies, it is not known how many are currently present, or how much of each tributary they use. Hence, KDFWR will resume the ongoing efforts to bolster the overall numbers of tagged carp that occupy the upstream areas of both tributaries, which will most likely require an increase in sampling pressure at each location. These tagging efforts will continue until at least 20 invasive carp from each water body have been successfully implanted with transmitters. If this target is not reached by the end of 2022, any additional tagging efforts in 2023 will be shifted downstream to areas closer to the mainstem Ohio River and thus are more likely to contain higher numbers of invasive carp.

Objective 2 - Delineate the upstream population distribution of invasive carps

As was the case in previous years, KDFWR's telemetry work in 2022 – 2023 will primarily occur within the lower half of the current receiver array and this effectively limits the amount of effort it can commit towards completing the project's 2nd objective. Despite the potential limitations, KDFWR staff still plan to maintain a small group (n = 6) of stationary receivers located upstream of Markland Lock & Dam, which is considered to be the most downstream extent of a low-density invasive carp population that occupies the upper Ohio River. As was already mentioned, between October 2022 and September 2023, field crews will visit each of these sites at least once every other month to offload detection data and conduct any required maintenance. Aside from multiple visits to these sites, the only other work that KDFWR expects to conduct for this specific objective is related to the management/analysis of the 2022 – 2023 telemetry data that will consist of tag detections that are offloaded from receivers located throughout the upper Ohio River.

Objective 3 - Quantify passage of invasive carps through Ohio River locks and dams

The only other receivers located in KDFWR's section of the array are those distributed between sites in the mainstem Ohio River and two separate Lock & Dam (L&D) locations. During fall 2022, site visits and receiver offloads will be conducted as part of the ongoing efforts to complete this project's 3rd objective. Field staff will then return to the Markland and McAlpine L&D sites in December 2022 to offload any recent tag detections and finish maintenance tasks that are similar to the year-end activities being conducted at receiver stations in nearby tributaries. Each mainstem site will also be visited again before the end of 2022, but unlike others, the purpose of these efforts is to simply retrieve the VR2W's that will be stored off-river for the remainder of the winter season. When favorable conditions return to the Ohio River in early spring 2023, the receivers will be redeployed to their previous mainstem sites. Between early spring through September 2023, KDFWR field staff will return to the L&D and mainstem receiver sites at least once every two months in order to offload the latest tag detections and complete any other required maintenance.

In addition to the activities being conducted in some tributaries, KDFWR also intends to continue active tracking efforts at multiple locations in the mainstem Ohio River. During this study period, field staff will continue to conduct active tracking in specific areas located within the direct vicinity of either the Markland or McAlpine L&D sites. These sections of the array have proven to be difficult when it comes to maintaining adequate receiver coverage, and yet they are vital to the ongoing efforts to identify any tagged carp that have successfully transferred into an adjacent pool. Hence, active tracking within these specific areas is expected to resume in fall 2022 and spring 2023 in order to continue the search for evidence of any tagged carp that may have transferred pools without detection by stationary receivers. Results of these efforts should help confirm whether invasive carp are readily passing through either the McAlpine or

Markland L&D sites. The current data continues to suggest that invasive carp can pass through McAlpine L&D rather easily, while Markland appears to be a more formidable barrier to their movements. The active tracking efforts should help confirm whether or not these early conclusions are representative of what's taking place in the river.

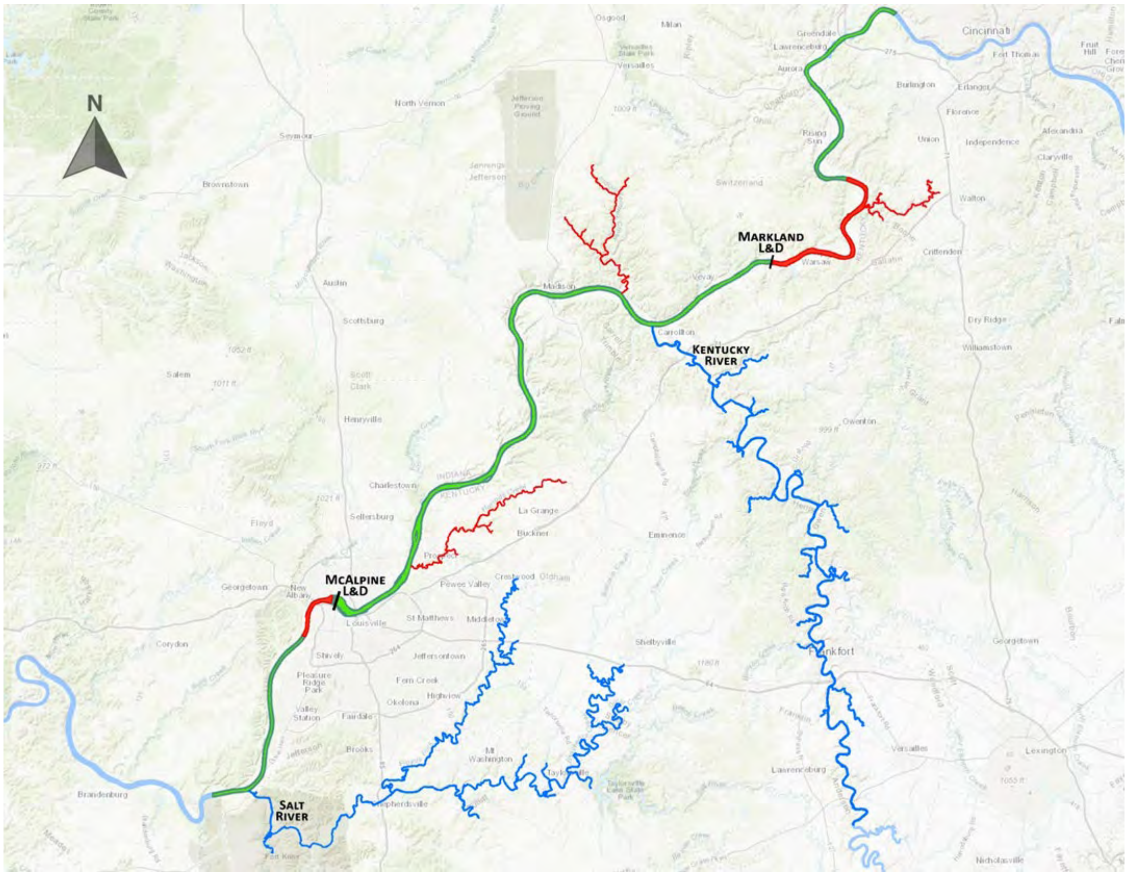
Management & Analysis of data

KDFWR will continue to serve as the primary data manager for the Ohio River Invasive Carp Telemetry Project. Throughout the year, KDFWR staff will make several efforts to retrieve, process & archive files that project partners (INDNR, ODOW, WVDNR, USFWS, KDFWR) have recently offloaded from stationary receivers and then uploaded to one of the locations where project files are shared with other agencies (i.e., ODOW FTP site, Google Drive, etc.). Upon retrieval, each dataset is error-checked and compiled before it's imported into an overall project database that consists of all tag detections recorded since 2013. Aside from the detection data obtained from stationary receivers, KDFWR also compiles/maintains other datasets for the telemetry project, including information about receiver site locations and details about invasive carp that were implanted with transmitters. KDFWR staff will also continue to compile and update a supplemental database that consists of several environmental parameters that were recorded at various sites within the project's study area. The environmental database is expected to play a major role in upcoming modeling efforts that will attempt to determine if there are any environmental factors that influence the movements of invasive carp populations that reside primarily within the Ohio River Basin.

Receiver counts (by site type) for KDFWR's section of the 2022 telemetry array.

	River mile		Receivers		
Pool	US	DS	Mainstem	Tributary	L&D
Cannelton (upper)	605.0	630.0	3	2	-
McAlpine	531.7	605.0	5	8	3
Markland (lower)	491.0	531.7	-	6	3

Map of Project Area:



During this study period, KDFWR will maintain all receiver sites located within a ~140-mile stretch of the Ohio River that begins in middle Markland, and then continues downstream until it reaches the upper Cannelton Pool (green). Field crews will also conduct active tracking in mainstem areas around lock and dam sites and in some tributaries where tagged carp continue to be most active (red). And finally, KDFWR staff will continue efforts to extend the stationary receiver array into both the Salt and Kentucky rivers (dark blue).

Estimated Timetable for activities:

Activity	Time period (season, month/year)
Visit receiver stations in Cannelton, McAlpine & lower Markland to offload data from VR2's & complete other site maintenance tasks.	Fall, Oct-Nov 2022

Cont. active tracking efforts in tributaries of the OHR & specific areas of the main stem river (Markland L&D & Cannelton Pool).	Fall, Oct-Nov 2022
Conduct invasive carp tagging efforts in upstream areas of the Kentucky & Salt rivers; Finish efforts to establish new stationary receiver sites in these same water bodies.	Fall, Oct-Nov 2022
Assist tagging efforts in the Markland & Meldahl pools.	Fall, Oct-Nov 2022
Complete year-end efforts to offload temp loggers & tributary receivers; Retrieve mainstem VR2's for overwinter storage.	Winter, Dec 2022
(If needed) Finish tagging invasive carp in the Kentucky & Salt rivers by shifting the efforts closer to mainstem Ohio River.	Spring, Mar-Jun 2023
Redeploy VR2's to mainstem sites in the Cannelton, McAlpine & Markland pools; Resume monthly offloads of all receivers.	Spring-Summer, Apr-Sep 2023
Cont. active tracking efforts in some tributaries & mainstem areas of the Ohio River.	Spring-Summer, May-Sep 2023

Agency: Indiana Department of Natural Resources

Activities and Methods:

Objective 1 - Understand tributary use by invasive carps and the role of tributaries as potential sources for recruitment and routes of invasion into adjacent basins

To understand the use of tributaries as potential sources for recruitment of invasive carps, INDNR will help maintain and offload at least 39 receivers positioned in select tributaries of J.T. Myers (N = 13), Newburgh (N = 8), and Cannelton pools (N = 18). A pair of receivers will be deployed in most major tributary or backwater areas in each of the three pools; paired designs will allow for determining directionality of invasive carp movements within the tributaries. Prior telemetry work on the Ohio River has primarily focused on areas upstream of Cannelton Pool to determine invasion rates throughout areas with less dense carp populations. In 2021 and 2022, the existing array was expanded to include lower pools. Work conducted by INDNR in 2023 will focus on maintaining the expanded array in the lower pools and further adding receivers to the array as needed with the goal of completing a comprehensive array throughout most of the Ohio River. The invasive carp populations in the lower pools are thought to act as sources for pools farther upstream. Understanding tributary use in these lower pools will help managers determine potential spawning locations and determine productive areas for removal efforts.

Objective 3 - Quantify passage of invasive carps through Ohio River locks and dams

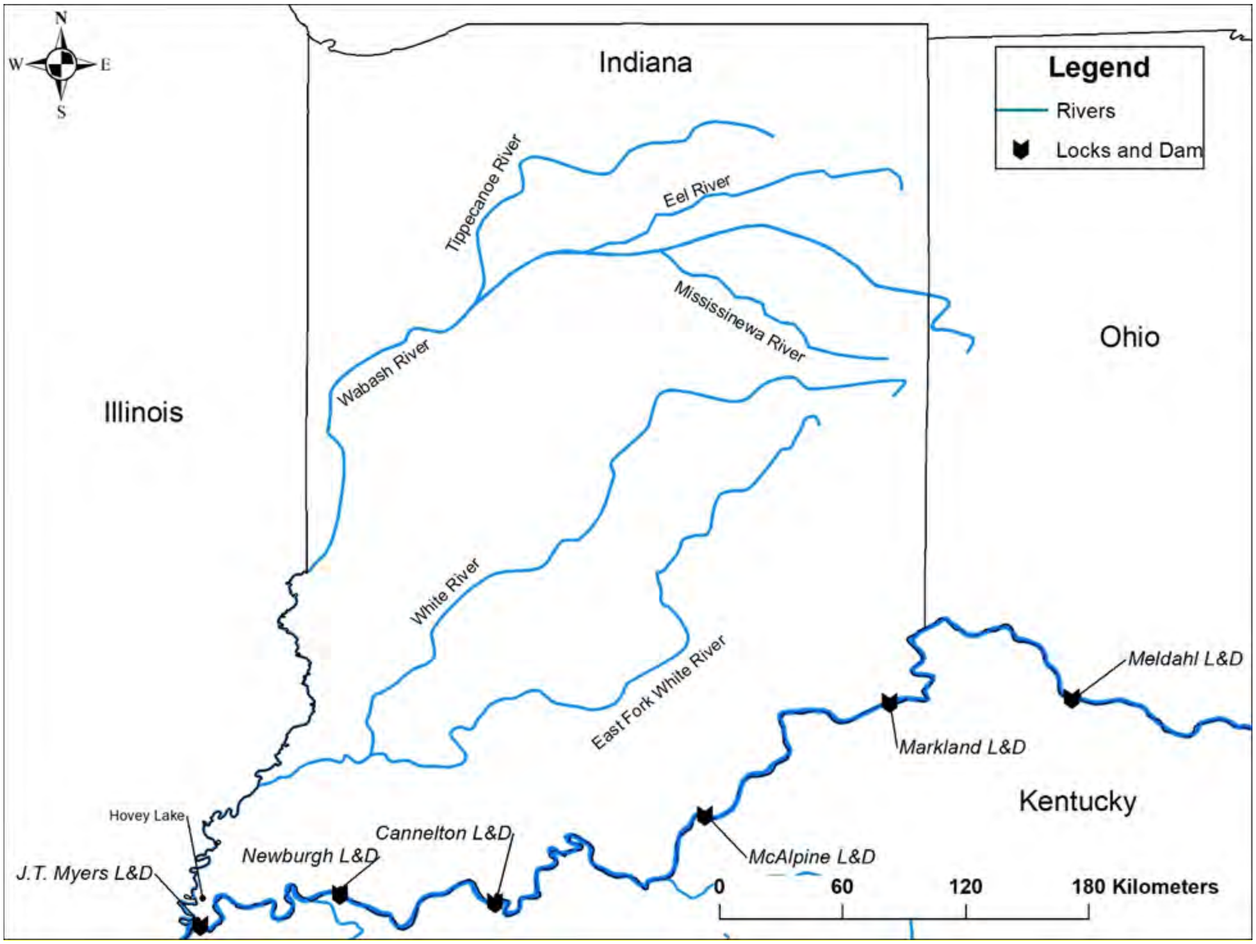
To quantify passage of invasive carp through Ohio River locks and dams, INDNR will maintain and offload four receivers at each J.T. Myers, Newburgh, and Cannelton pools. The J.T. Myers and Newburgh locks and dams differ from most locks and dams upstream of Newburgh pool because they have fixed weirs that allow free-flowing water conditions during moderate flows. These areas may provide easy passage upstream and understanding how invasive carps use them will help managers determine if barriers at these locations would be feasible. INDNR will coordinate with project partners to deploy additional receivers in mainstem areas to provide comprehensive coverage throughout the target pools. Receivers will be deployed in the Ohio River on navigation buoys or bridge piers from RM 848 (Wabash River confluence) to RM 709 (lower Cannelton Pool) to track inter-pool movement and help determine survival rates of tagged fish. INDNR will offload receivers monthly and send data to KDFWR for compilation with existing data.

Objective 4 - Quantify movement patterns of invasive carps within the Wabash River basin including assessing movement between the Wabash and Ohio rivers (i.e., the contribution of Wabash River populations to those of the Ohio River) and between the White and Wabash rivers.

To quantify movement patterns and inform invasive carp removal efforts within the Wabash River basin, INDNR will assist SIU with receiver offloads and active tracking of fish. SIU will lead this project and INDNR will provide support when needed. Active tracking of invasive carps will allow determination of fine-scale habitat use which will assist in identifying locations for removal events. INDNR will send all receiver and tracking data to SIU for compilation. SIU will share data with other basin partners.

INDNR will contract Ecosystems Connections Institute to continue quantifying invasive carp movements throughout the upper Wabash River and its major tributaries in addition to the Eel River post dam removal. Ecosystems Connections Institute will offload and maintain 6 receivers in the mainstem Wabash River as well as two receivers in each tributary (Eel, Mississinewa, Tippecanoe, and Salamone Rivers). INDNR will provide support and assistance when needed.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time period (season, month/year)
Ecosystems Connections Institute download receiver data monthly	Start December 2022 (continue through 2023)
Maintain and download receivers	Monthly, Jan-Dec/2023
Assist SIU with receiver offloads	Summer, June-Aug/2023
Assist SIU with active tracking in Wabash, and White rivers	Summer, June-Aug/2023
Pull receivers from all mainstem sites for overwinter storage	Winter, December/2023

Agency: West Virginia Division of Natural Resources (WVDNR)

Activities and Methods:

Objective 1 - Understand tributary use by invasive carps and the role of tributaries as potential sources for recruitment and routes of invasion into adjacent basins.

To understand the use of tributaries as potential sources for recruitment of invasive carps, WVDNR will maintain the receivers positioned in select tributaries of Belleville, Racine and R.C. Byrd pools. This includes deployment of receivers during spring, offloading data, and retrieving receivers during late fall as well as replacing any lost receivers. A pair of receivers will be deployed in each tributary or backwater area; paired designs will allow for determining directionality of invasive carp movements within the tributaries. Prior telemetry work on the Ohio River has indicated invasive carp occupy tributaries a significant amount of time and likely use these areas for spawning and nursery areas. Previous monitoring and telemetry work in these pools has indicated carp frequent these tributaries. These efforts are designed to gain a better understanding of tributary use by invasive carps. The primary objective is to identify any areas in these tributaries that the carp regularly inhabit and then determine if there is a combination of habitat use and behavior that would make them vulnerable to future removal efforts.

Objective 2 - Delineate the upstream population distribution of invasive carps.

To delineate the upstream population distribution of invasive carps, WVDNR will maintain the array of mainstem receivers located in the Belleville, Racine and R.C. Byrd pools. WVDNR also houses a receiver array located in the R.C. Byrd pool for other fish movement projects. Data from these receivers will be monitored for invasive carp detections. All data collected on invasive carp will be shared with project partners. As schedules allow, WVDNR will also assist USFWS with tagging efforts in McAlpine, Markland, and Meldahl pools of the Ohio River to tag new fish and replace lost or expired tags within the system. These efforts are designed to gain a better understanding of invasive carp in the upper pools where the invasion front is located. Data will be used to indicate locations of frequent use of carps and river conditions that incite increased movement.

WVDNR will also incorporate active tracking of tagged invasive carps in the R.C. Byrd pool to increase the efficiency of our removal efforts.

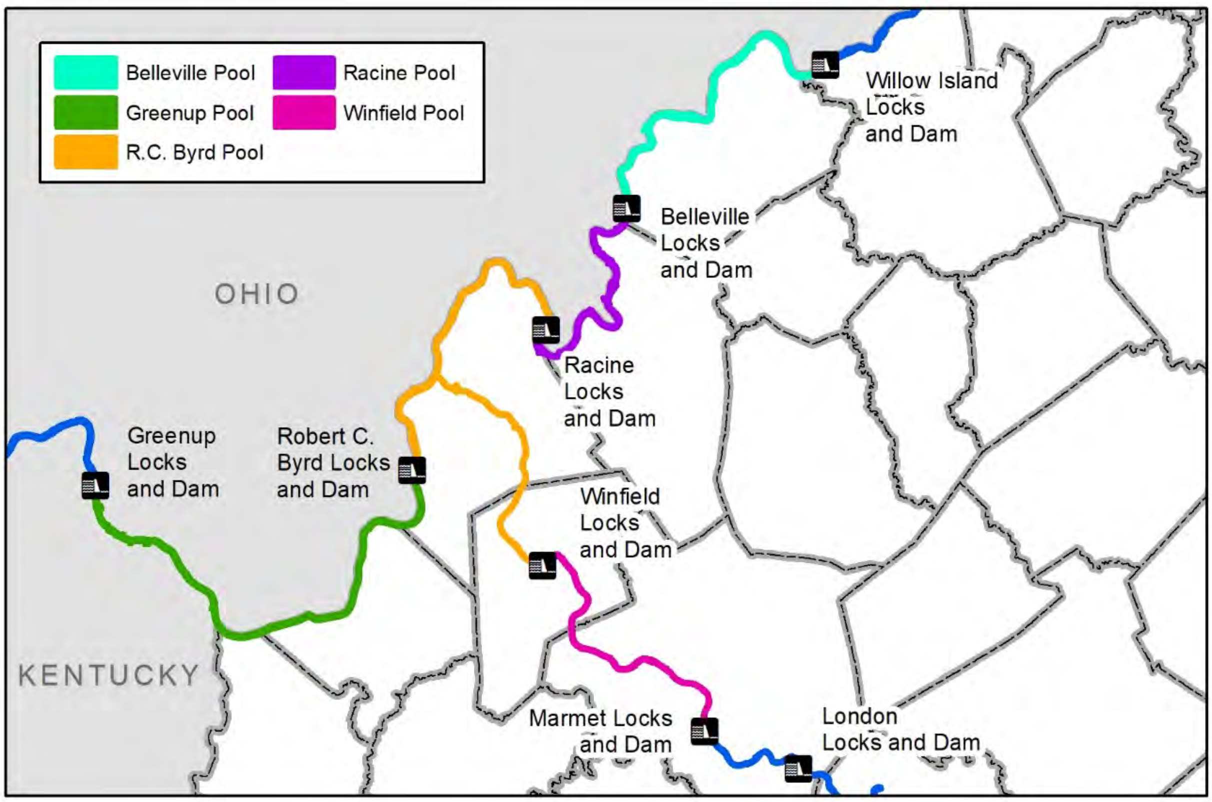
Objective 3 - Quantify passage of invasive carps through Ohio River locks and dams

To quantify passage of invasive carp through Ohio River locks and dams, WVDNR will maintain the receiver arrays at Willow Island, Belleville, Racine and R.C. Byrd lock and dams. Dam locks and gates may provide easy passage upstream and understanding how invasive carps use them will help managers determine if barriers at these locations would be feasible.

Estimated Timetable:

Project activity	Pool	Dates	Year
Mainstem receiver deployment	R.C. Byrd – Willow Island	March-April	2023
Invasive carp tagging	McAlpine, Markland and Meldahl	October, April	2022-23
Lock and dam receiver download	R.C. Byrd – Willow Island	August-July	2022-23
Mainstem receiver retrieval	R.C. Byrd – Willow Island	August-July	2022

Map of Telemetry Project Area:



Agency: ILDNR, Southern Illinois University (SIU)

Activities and Methods:

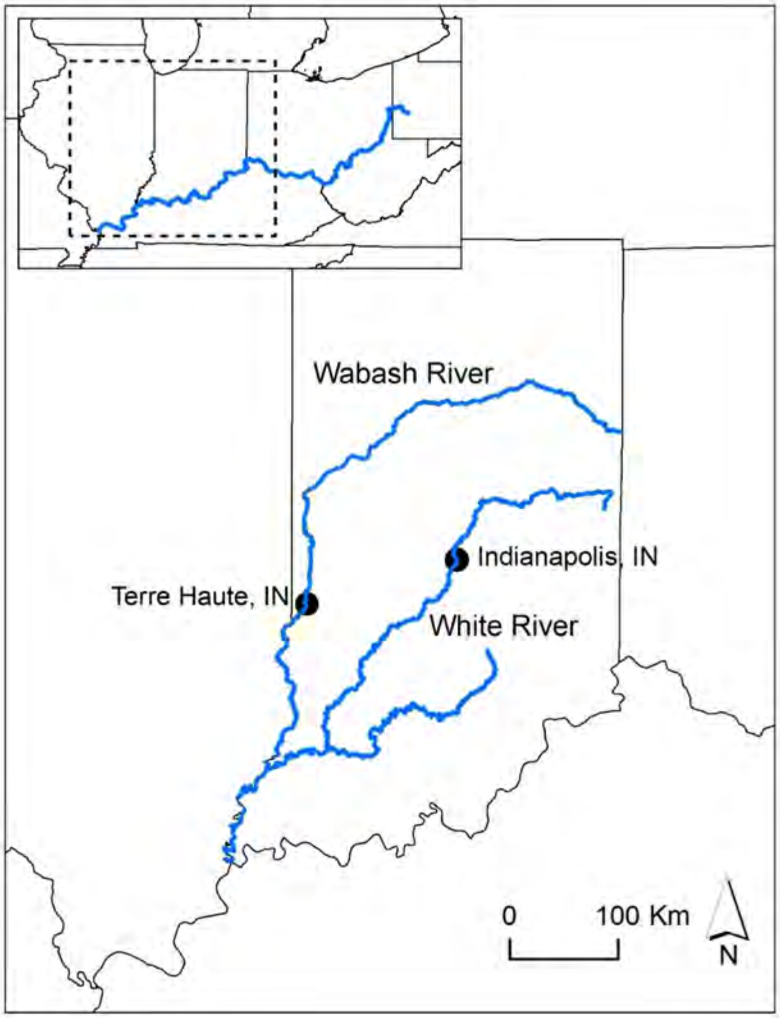
SIU will be contracted by Illinois Department of Natural Resources (ILDNR) to complete work on acoustic telemetry of invasive carps in the Wabash and White rivers (Objectives 4 and 5). SIU and EIU will collect and tag Silver and Bighead Carps from the Wabash River, from its confluence with the Ohio River to Terre Haute, IN, and within the White River from its confluence with the Wabash River to Indianapolis, IN. One hundred invasive carp (75 from the Wabash River and 25 from the White River) will be collected via boat electrofishing and implanted with Vemco V16 69kHz tags using surgical procedures as outlined in Lubejko et al.

(2017). Fish total length and weight will be recorded, and each fish will receive an external tag with an SIU phone number to identify individuals with internal telemetry tags and to facilitate tag returns of harvested fish. Tags will be distributed in at least two locations along the White River and four locations along the Wabash River. Information about tagged fish (length, weight, tag location, species) will be shared with other groups engaged in telemetry in the Ohio River Basin.

SIU will deploy a series of five pairs of acoustic stationary receivers (Vemco VR2Ws; 10 total receivers) in the Wabash and White rivers to monitor the movements of tagged invasive carps. Stationary receiver pairs will be located on opposite sides of the river channel, staggered ~100 m upstream/downstream of each other. Staggering the pairs helps ensure that, as a tagged fish swims through the area, the fish's acoustic tag will ping when it is within range of at least one stationary receiver. If fish are detected on both receivers in a pair, then the direction of travel can also be determined. Receiver pairs will be deployed in the Wabash River to supplement existing receivers (spaced approximately 25 km from other receiver pairs). However, stationary receivers function best in deeper water with hard substrate and so placement will depend on available habitat.

Data from stationary receivers will be downloaded during spring and late summer 2023. Exact timing of downloads will depend on water levels. SIU will QA/QC data to identify and remove false detections from the dataset and then combine with other telemetry data from the Ohio River Basin (dependent on sufficient numbers of fish moving/not moving). Telemetry data will be used to quantify movement probabilities among the Ohio, Wabash, and White rivers following the same analysis procedure described in Coulter et al. (2018). Additionally, information on movement patterns, including distances and directions traveled and seasonal patterns (Coulter et al. 2016) within the White and Wabash rivers, will be quantified. This project will contribute to the existing acoustic telemetry network in the Ohio River Basin.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time period (season, Month Year)
Deployment of Stationary Receivers	Spring, April 2023
Acoustic Tagging of Invasive Carps	Spring, April 2023
Interim Progress Report and Executive Technical Report	Spring, March 2023
Stationary Receiver Downloads	May 2023, September 2023

Agency: ILDNR, Eastern Illinois University (EIU)

Activities and Methods:

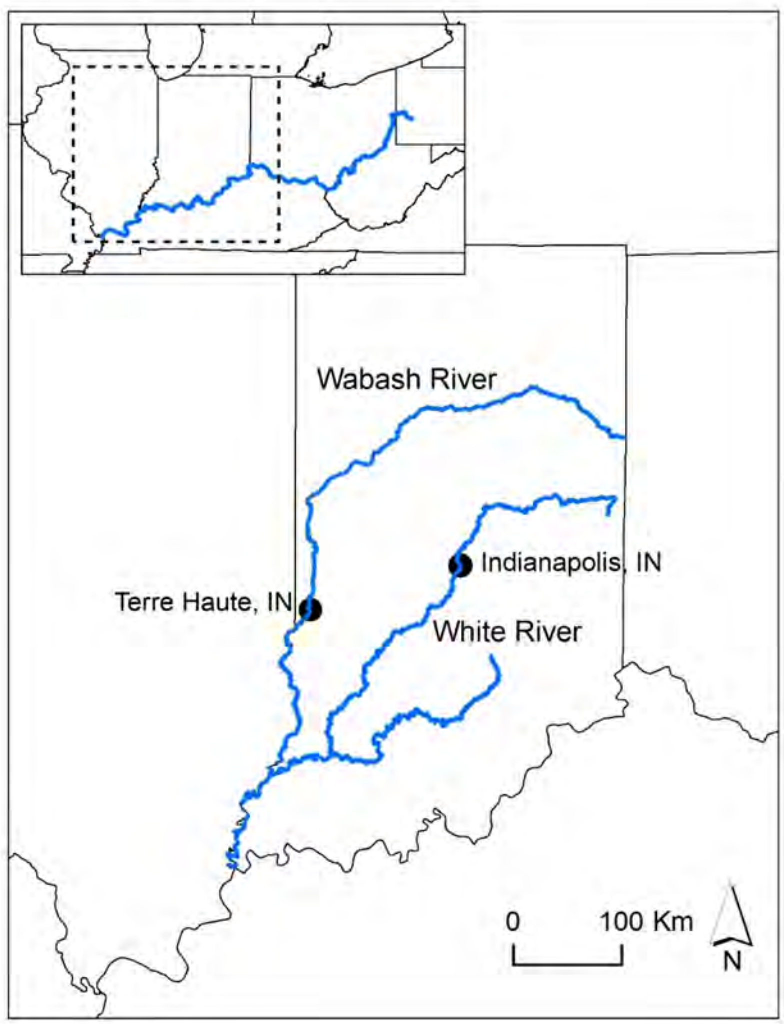
EIU will be contracted by ILDNR to complete work on the acoustic telemetry of invasive carps in the Wabash and White rivers (Objectives 4 and 5). EIU will assist with acoustic tagging of invasive carps (described in SIU section) and will collect active tracking and habitat use data from acoustically tagged fish.

Monthly, EIU personnel will actively track the lower Wabash River (termed, ‘reach tracking’). Beginning at the Terre Haute boat ramp and continue down the middle of the river, ending at the confluence of the Ohio River. This methodology will also be accomplished on the lower White River to the confluence with the Wabash River. This method of reach tracking will be conducted during daylight hours only. The end tracking point for each day will become the starting point for tracking the following day. During active tracking, we will maneuver the boat between 6 and 11 km per hour downstream while towing an omnidirectional hydrophone. When a transmitter is detected, we will triangulate the position using a submersible directional hydrophone. For every fish detection, we will record the time, date, GPS location (Garmin GPSmap62s), river depth (m) (Lowrance depth finder), secchi depth (m) (secchi disk), substrate type (petite ponar), temperature (°C) (YSI-85 multi-meter), conductivity (µS) (YSI-85 multi-meter), dissolved oxygen (mg/L) (YSI-85 multi-meter), flow (m/s) (Marsh-McBirney hand held flow meter), habitat, and microhabitat as well as the identification number and behavior (active or sedentary) of the fish.

To analyze fish habitat use, we will differentiate habitat types based on a modification of Cobb (1989), as suggested by Koch et al. (2012). Shoreline habitats include outside bend (OB), channel border open (CBO), and inside bend (IB). Microhabitat categories were defined as follows; logjam is a shoreline with woody debris/terrestrial structure in the water, run is a shoreline with swift-flowing water and no debris/structures (includes eddy, eroded banks and non-eroded banks), rip rap is a shoreline that contains large boulders, sand bar is a sand or gravel shoreline caused from sediment deposition, and the thalweg is the deepest, fastest flowing part of the river. To determine if habitat and microhabitat of fish locations were randomly distributed annually and within seasons, we will use likelihood ratio chi-squared analysis using the proportion of observations per habitat (and microhabitat) type.

To determine if invasive carps are selective in their habitat use, we will calculate habitat selection ratios following Manly et al. (1993). To calculate the proportion of each habitat type, we will use ArcMap to measure the total area of each site (extent of site was dependent on range of fish locations) and the area of each habitat type (m2). Data generated from the habitat assessment will be used to determine areas of the Wabash and White Rivers that are likely harboring invasive carps in high numbers.

Map of Project Area:



Estimated Timetable for activities:

Activity	Time period (season, month/year)
Acoustic Tagging of Invasive Carps	Spring, April 2023
Interim Progress Report and Executive Technical Report	Spring, March 2023
Active Tracking	April – September 2023 (monthly)

Quantifying lock and dam passage, habitat use, and survival rates of invasive carps in the Ohio River Basin

Agency: USFWS

Activities and Methods:

Carterville FWCO will lead tagging efforts within the mainstem Ohio River to replace expiring tags in Meldahl, Markland, and Cannelton pools. All tagging will take place during spring and fall when water temperatures are most conducive to fish survival. Fish will be collected using daytime electrofishing and short-term gill/block net sets. Total length (mm), weight (g), sex, and species will be recorded along with an external tag to identify individuals with internal telemetry tags and to facilitate tag returns from harvested fish. Vemco Model V16-6H acoustic transmitters (69 kHz 16mm diameter, 96 mm length, 34g), programmed to transmit on a random delay from 20 to 60 seconds with a battery life of 1,825 days will be used to document movement of tagged fish. Tags will be tested for recognition with a mobile receiver (VR-100-200) prior to use and surgically implanted according to procedures outlined in Lubejko et al. (2017).

Tagging efforts will be directed within pools where tags are expected to expire and/or are deficient of minimum active tag goals (Table 1). These efforts are aimed at maintaining 200 active tags in J.T. Myers pool, 200 in Newburgh pool, 200 in Cannelton pool, 150 in McAlpine pool, 50 in Markland pool, and 50 in Meldahl pool. Tagging efforts will be allocated throughout each pool and its tributaries to prevent oversaturation of tagged fish in any given area.

In addition to tagging fish, Carterville FWCO will assist in deploying and maintaining the telemetry array associated with the mainstem Ohio river. See the KDFWR and WVDNR sections of this document for information regarding the existing array. Additional information about the expansion of the telemetry network is provided in the INDNR section of this document.

All tagging and telemetry data will be sent to KDFWR for initial processing and uploaded to ODOW's FTP site for use by all partners. Carterville FWCO will analyze data from the mainstem telemetry array to estimate pool-to-pool transition probabilities, annual survival, and detection probabilities using RMark (Laake 2013), an R-based interface with Program MARK (G.C. White, Dept. of Fish, Wildlife, and Cons. Bio., Colorado State University, Fort Collins, CO). The Carterville FWCO will also use the telemetry data to examine tributary use and movements between tributaries and the mainstem Ohio River. A report of January 1 to July 1, 2022, activity and analysis will be available March 2023.

TABLE 1. Number of acoustic tags expiring and needing deployment to reach minimum active tag goal by pool at the end of 2022.

	Pool					
Tags	JT Myers	Newburgh	Cannelton	McAlpine	Markland	Meldahl
Expiring	0	0	90	0	14	3
To deploy	0	0	108	0	8	39

Estimated Timetable for Activities

Activity	Time period (season, month/year)
Assist with receiver deployment into mainstem Ohio River and replacement of batteries in tributary and L&D receivers	Spring, April – May 2022
Assist with offloading data and maintenance of all receivers	Spring – Fall, May – November 2022
Invasive carp tagging	Spring, March – May 2022 Fall, September – November 2022
Assist with retrieval of receivers from the mainstem Ohio River. Assist with final data offload from tributary and L&D receivers	Winter, December 2022
Report	Spring, March 2023

2022 Mainstem Ohio River Download Schedule:

	Month							
Pool	April	May	June	July	August	September	October	November
Willow Island	------------------------------------- WVDNR --------------------------------------							
Belleville	------------------------------------- WVDNR --------------------------------------							
Racine	------------------------------------- WVDNR --------------------------------------							
R. C. Byrd	------------------------------------- WVDNR --------------------------------------							
Greenup	-------------------------------------- OH D5 --							
Meldahl	-------------------------------------- OH D5 --							
Markland	-------------------------------- OH D5 & KDFWR----------------------------------							
McAlpine	-------------------------------------- KDFWR ---------------------------------------							
Cannelton	-------------------------------- KDFWR & INDNR --------------------------------							
Newburgh	------------------------------------- INDNR ---------------------------------------							
J.T. Myers	------------------------------------- INDNR ---------------------------------------							

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Relative Population Densities of Invasive Carp in the Tennessee River and Cumberland River, Tributaries of the Ohio River

Lead Agency and Author: Tennessee Wildlife Resources Agency (TWRA; Cole Harty, cole.r.harty@tn.gov)

Cooperating Agencies: TWRA, Kentucky Department of Fish and Wildlife Resources (KDFWR), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Alabama Department of Conservation and Natural Resources (ADCNR), and Tennessee Tech University (TTU)

Statement of Need:

Adult bigheaded carp (that include Silver Carp *Hypophthalmichthys moltrix* and Bighead Carp *H. nobilis*) have been collected in the Tennessee and Cumberland rivers (tributaries to the Ohio River) for the last ten to fifteen years and have been documented in Tennessee beginning three decades ago. These waterways are multi-jurisdictional and include waters within Kentucky, Tennessee, Mississippi, and Alabama. Thus, bigheaded carp invasion is a threat to multiple agencies and the valuable sport fisheries and ecosystems in their respective states. Bigheaded carp reports suggest increasing immigration upstream in both systems, however there are many uncertainties regarding their abundance, their movement rates and timing, and if they are reproducing within the rivers. Master's theses completed in 2016 and 2018 were the first rigorous evaluation of relative abundance and age and growth of Silver Carp and Bighead Carp in Kentucky and Barkley reservoirs. Currently, sub-basin agencies and universities are collaborating to enhance that preliminary work by surveying relative densities to inform control needs. The proposed projects described below will fill knowledge gaps necessary for understanding the distributions and habitat use of bigheaded carp populations in the Ohio River sub-basin, the extent of spawning occurring within the systems, movement within the systems, and will provide better life history and population dynamics data for informing Tennessee River specific-models that are being applied in the Ohio River and other basins for estimating control needs and invasion impacts.

In 2017, TTU commenced standardized, systematic sampling on Kentucky, Barkley, Cheatham, and Pickwick reservoirs to evaluate relative densities of bigheaded carp using gill nets and electrofishing. This project will fund another year of systematic sampling conducted in spring, summer, and fall at those reservoirs.
This ongoing work also aims to increase samples (e.g., otolith, sex, length, and weight data) used to characterize populations (e.g., age, growth, mortality analysis). Tennessee Wildlife Resources Agency and KDFWR commenced inter-agency carp sampling in spring 2019. In 2020, TTU worked with those agencies to continue sampling to further support data collection on bigheaded carp populations in the Tennessee and Cumberland rivers so that data are comparable to past sampling efforts and useful to evaluating demographics. Sampling will continue in 2023 to supply spatiotemporally-comparable data that can be used to fulfill the objectives and goals of the sub-basin framework. The specific purpose of the project is to provide demographics data that can effectively inform managers and stakeholders about populations of bigheaded carp in reservoirs of the Tennessee and Cumberland rivers.

Project Objectives:

1. Determine relative density, population characteristics, and sampling needs for invasive carp across spatial, temporal, and productivity gradients in the Tennessee and Cumberland rivers.

Agency: TWRA (Tennessee Tech University)

Activities and Methods:

Objective 1. Determine relative density, population characteristics, and sampling needs for invasive carp across spatial, temporal, and productivity gradients in the Tennessee and Cumberland rivers.

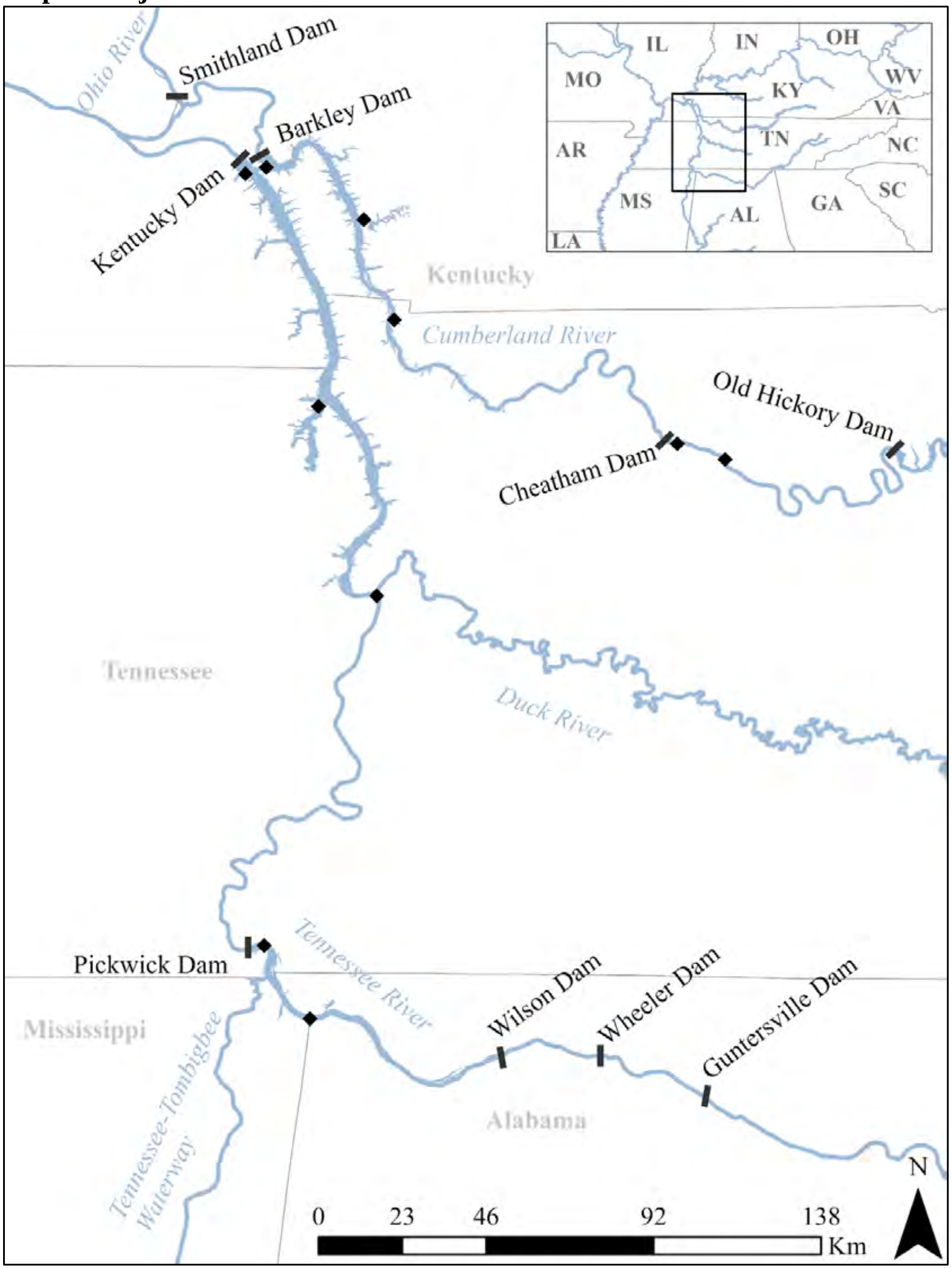
Multi-season sampling with gill nets and electrofishing will be used to evaluate relative abundance and density of adult bigheaded carp in Kentucky, Barkley, Cheatham and Pickwick reservoirs. Experimental gill nets will consist of mesh-sizes measuring 3.00, 3.50, 4.00, or 4.25 inches (bar measure) of 8-ply twisted monofilament mesh. These nets were chosen to maximize retention and minimize gear destruction following discussion with commercial fishers that target bigheaded carp. Gill net soak times will be over-night — approximately 14.5 hours —after seeing improved catches relative to short (2-hour) net sets. Three gangs will be set in each sampling site within each reservoir and gillnetting sampling season (see below). Summer sampling will utilize an electrified dozier trawl to capture fish and possibly detect young-of-year in late summer. All electrofishing will use pulsed-DC current (5-8 Amps, 535 Volts, 120 pulses per second). Survey sites will be stratified by lake area (e.g., downstream versus upstream) following the study design from previous years (see Map 1). Three strata in Kentucky and Barkley reservoirs where abundances are higher than in Cheatham and Pickwick reservoirs, which will have two spatial strata. Dozier trawl transects will have fixed time periods (e.g., 900 seconds); all collected fish will be identified, and length and weight taken; otoliths will be taken from a subsample of collected fish in each length bin (i.e., 100 mm grouping) in each reservoir to allow later extrapolation to an age-length key. Target otolith sample sizes will be 10 fish per group. Sampling will enhance estimates of total mortality and survival for these reservoirs, which is a needed input for population models and stock assessment. Sex-ratio and a gonadosomatic index (female gonad weight to body weight ratio) data will continue to be collected to help inform population models and potential spawning time.

Sampling gears, locations, and timing of deployments for all objectives will be adapted to seasonal water temperatures to ensure minimal mortality of bycatch, valuable sportfish, and prevent any detrimental effects to endangered species or valuable landscape features.

Estimated Timetable:

Project Activity	Reservoir	Month	Year
Gill Netting	Kentucky, Barkley, Cheatham, and Pickwick	Spring (March-June), Fall (September-November)	2023
Adult Density Electrified Dozier Trawling	Kentucky, Barkley, Cheatham, and Pickwick	Summer (late June to early September)	2023
Final Report		Spring	2024

Map of Project Area:



Standardized, systematic sampling areas for measuring relative density and population characteristics of Invasive carp in the Tennessee and Cumberland rivers. Estimated sampling site locations indicated by ◆, and locks and dams indicated by ▮.

Deterrent Strategy Planning for Invasive Carp in the Ohio River Basin

Lead Agency and Author: Kentucky Department of Fish and Wildlife Resources (KDFWR; Jessica Morris, jessica.morris@ky.gov)

Collaborating Agencies: KDFWR, Tennessee Wildlife Resources Agency (TWRA), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Alabama Department of Conservation and Natural Resources (ADCNR), U.S. Army Corps of Engineers (USACE), Tennessee Valley Authority (TVA), Murray State University, Mississippi State University, Tennessee Technological University (TTU), U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS).

Statement of Need:

Adult bigheaded carp (i.e., Bighead Carp *Hypophthalmichthys nobilis* and Silver Carp *H. moltrix*) have invaded the Ohio River and tributaries of the Ohio River including the Tennessee and Cumberland rivers. Efforts to deter invading bigheaded carp and minimize future invasions are increasing. However, decisions on placement of bigheaded carp deterrents and the ability to evaluate efficacy of implemented deterrents requires baseline data and monitoring of bigheaded carp movements and abundance. Within the Ohio River, movement data have been collected to inform pool-to-pool movement and estimate trade-offs between deterrent location, deterrent effectiveness, and removal efforts for population control. Increased data within the Ohio River would further support these evaluations. In the Tennessee and Cumberland rivers, baseline movement and lock and dam passage data are at initial phases of collection. Therefore, continued collection of these data is critical to understanding potential deterrent locations and deterrent effectiveness warranted.

Adult bigheaded carp have been recognized in the Tennessee and Cumberland rivers (tributaries to the Ohio River) for the last three decades. A large recruitment event in 2015 caused a significant increase in abundance within the Tennessee and Cumberland rivers. These waterways are multi-jurisdictional and include waters within Kentucky, Tennessee, Mississippi, and Alabama. Thus, bigheaded carp invasions are a threat to multiple agencies and the valuable sport fisheries and ecosystems in their respective states. Bigheaded carp reports suggest increasing immigration upstream in both tributaries, however there are many uncertainties regarding abundances, movement rates and temporal patterns, and local recruitment of bigheaded carp in the Tennessee and Cumberland rivers. Currently, sub-basin agencies and universities are collaborating to enhance that preliminary work by surveying relative densities to inform control needs, monitor movements through locks and dams to inform lock management and deterrents, and determine if local recruitment is occurring in the reservoirs. The proposed projects described below will fill knowledge gaps necessary for understanding movement within the Ohio River tributaries and lock and dam passage.

Efforts to understand and control invasive carp in the Tennessee River and Cumberland River have been increasingly supported in the last few years and federal funding has the ability to further enhance control and management capabilities. Cooperative efforts by partners have resulted in over 1200 Silver Carp implanted with acoustic transmitters and a cooperative group is engaged for data sharing and informing movements and potential deterrent placement. Cooperators include ADCNR, Murray State University, Mississippi State University, KDFWR, TWRA, USGS, TTU, MDWFP, and USFWS.

The project will support goals and strategies of the sub-basin framework including prevention, monitoring, and mitigation. The specific strategy supported is to evaluate the use of deterrent barriers at strategic locations to limit further dispersal of invasive carp in the Ohio River Basin.

Project Objectives:

1. Develop recommendations of deterrent types and locations to control movement of invasive carps
   - 1.1. Specific to the Tennessee and Cumberland Rivers
   - 1.2. Specific to the Ohio River
   - 1.3. Specific to the Tennessee- Tombigbee Waterway
2. Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.
3. Provide support to research activities associated with deterrent development and testing.

Agency: Tennessee Wildlife Resources Agency

Activities and Methods:

Objective 1: Develop recommendations of deterrent types and locations to control movement of invasive carps

1.1: Specific to the Tennessee and Cumberland Rivers

TWRA will participate in meetings with collaborating agencies to provide updates on the distribution of Invasive Carp populations, identify available deterrent methods, and prioritize installation and maintenance of deterrents in the TNCR. The product of these meetings will be to identify and make necessary changes to the prioritized list of where deterrents to Invasive carp movement are needed. Deterrent placement will be characterized by locations that will strategically reduce the potential of Invasive carp expansion upstream in the Tennessee, and Cumberland rivers. Locations for field testing of available deterrent strategies will also be considered.

Objective 2. Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.

Required methods support monitoring, maintenance, and increasing capacity for acoustic telemetry movement data for bigheaded carp. Receivers will be monitored and maintained on a seasonal frequency (e.g., once every three months), depending on flows and river conditions. Vemco telemetry receivers are in place at all locks and dams in the Tennessee River from Kentucky Dam to Guntersville Dam and in the Cumberland River from Barkley to Old Hickory Dam to inform movement among locks and dams and across reservoirs. Receiver downloading and maintenance is a multi-organization effort by KDFWR, TWRA, TTU, MDWFP, and ADCNR. Additional bigheaded carp have been tagged each year since 2017, and focused efforts to tag fish at further upstream locations initiated in 2022 (e.g., Cheatham Reservoir) will continue.

Capture of bigheaded carp to be implanted with acoustic telemetry transmitters is completed using short-set gill nets (e.g., 20 minutes) or electrofishing during cool water conditions. Transmitter implantation is completed with minimal handling including electro-anesthesia and immediate release. Tagging fish on the leading edge of invasion (i.e., at upstream reservoirs such as Pickwick and Cheatham reservoirs [Map 1]) is preferable to inform movement and lock and dam passage at locations that bigheaded carp are not currently established. Therefore, tagging will be attempted at upstream reservoirs. If sufficient numbers of fish (minimum number of 50) are not captured at upstream locations, more tags will be implanted at local proximity areas. Collaboration with USGS partners on ongoing projects will enhance movement information and modeling to inform deterrents in the Tennessee and Cumberland rivers.

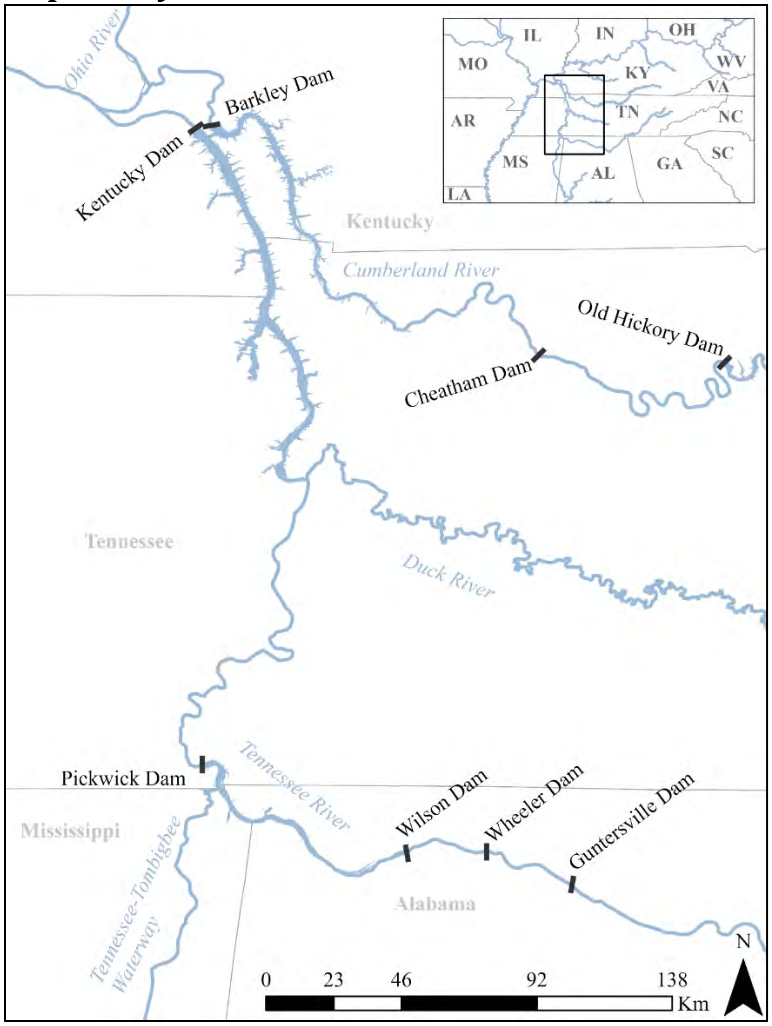
Acoustic telemetry receivers are currently deployed at the three most downstream dams on the Cumberland River and at the five most downstream dams on the Tennessee River (Map 1). Receivers at these locations will continue to be maintained and monitored. Additionally, more receivers will be deployed as necessary, and receiver arrays will be tested using tag-drags to verify reasonable tag detection efficiency (i.e., no major blind spots, obstructions, or other equipment failure).

Data will be evaluated to determine conditions that allow fish passage through locks (e.g., temporal patterns) and how and when deterrents could best limit further upriver movements through locks and dams. Previous data shows individual fish moving through Pickwick Dam, however no passage at Wilson Dam or Wheeler Dam has been detected. A Tennessee River acoustic telemetry network of biologists has been established to facilitate communication of receiver locations and positive tag detections and the network is in communication with invasive carp telemetry collaborations in the Mississippi River and other basins to facilitate data sharing.

Estimated Timetable:

Project Activity	Reservoir	Month	Year
Acoustic Tag implantation	Kentucky, Barkley, Pickwick, and Cheatham reservoirs	water temperature dependent	fall 2022 and spring and fall 2023 (until all tags are at-large)
Acoustic Receiver deployment and maintenance	Kentucky, Pickwick, Wilson, Wheeler, Cheatham, Old Hickory	Seasonally (minimum of 4X annually) and as needed for maintenance	2022 and 2023
Data summarization/reporting	TNCR	Quarterly updates in congruence with data downloads	2022 and 2023

Map of Project Area:



Map of the project area including dams on the Tennessee and Cumberland rivers, which are monitored for Invasive carp passage using acoustic telemetry indicated by ▮.

Agency: Murray State University

Activities and Methods:

Objective 2: Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.

MSU will continue to provide assistance with data collection and analysis of telemetry records within the Tennessee, Cumberland, and Ohio Rivers. MSU will provide associated reports on invasive carp and native fish species passage at locks and dams and movements throughout the receiver array.

Estimated Timetable:

Project Activity	Location	Month	Year
Data management and analysis	N/A	As needed	2022-2023
Project Technical Report	N/A	February	2023

Agency: Kentucky Department of Fish and Wildlife Resources

Activities and Methods

Objective 1: Develop recommendations of deterrent types and locations to control movement of invasive carps

1.1: Specific to the Tennessee and Cumberland Rivers

KDFWR will participate in meetings with collaborating agencies to provide updates on the distribution of Invasive Carp populations, identify available deterrent methods, and prioritize installation and maintenance of deterrents in the TNCR. The product of these meetings will be to identify and make necessary changes to the prioritized list of where deterrents to Invasive carp movement are needed. Deterrent placement will be characterized by locations that will strategically reduce the potential of Invasive carp expansion upstream in the Tennessee, and Cumberland rivers. Locations for field testing of available deterrent strategies will also be considered.

1.2: Specific to the Ohio River

KDFWR will further investigate priority locations in tributaries of the Ohio River that may warrant an Invasive carp deterrent structure. In 2021, evidence of invasive carp reproduction and recruitment was documented in tributaries further upstream than any previous years. Additionally, KDFWR is expanding the use of occupancy modeling to tributaries on the Kentucky side of the Ohio River and will use this data to inform carp presence in waters that have not been sampled for carp previously. Therefore, these endeavors being conducted through other USFWS funded projects will continue to advise the priority locations and tributaries where deterrents are needed.

Objective 2: Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.

Ohio River
KDFWR continues to work with multiple agency partners to monitor and report on the pool-to-pool movements of invasive carp in the middle and lower Ohio River through a separate project entitled, Quantifying Lock and Dam Passage, Habitat Use, and Survival Rates of Invasive Carps in the Ohio River Basin.

Tennessee and Cumberland Rivers
KDFWR will continue partnering with MSU to conduct tracking of tagged Invasive Carp within Kentucky and Barkley lakes, through the lock and dams and interactions with the Ohio River. Parameters considered for this project include seasonal and diurnal movements, distances traveled, passage via dam or lock, direction of travel, and speed of travel. The VEMCO stationary receiver array will continue to be maintained and improved as needed. Passage of Invasive carp through other lock chambers on the Tennessee and Cumberland rivers is also being assessed by partners and sharing of data is essential. In order to quantify fish passage and ultimately assess deterrence strategies in these river systems, tagging of additional Invasive carp and placement of supplementary receivers is essential.

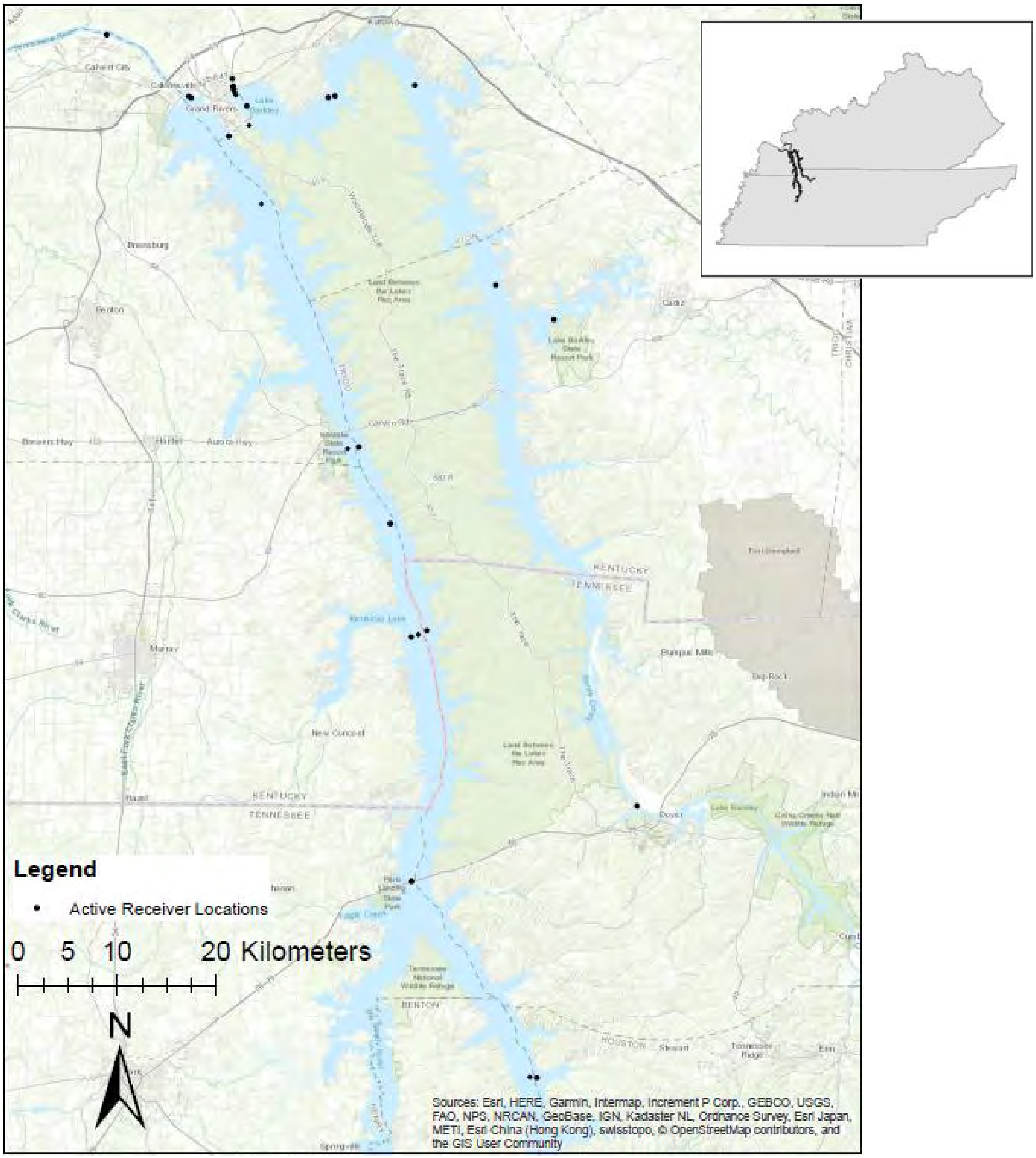
Objective 3: Provide support to research activities associated with deterrent development and testing.
KDFWR is engaged in assisting the USFWS with testing of a Bio-Acoustic Fish Fence (BAFF) technology on the downstream approach to Lake Barkley Lock chamber (Map 2). In spring and fall, KDFWR will tag an additional 75 silver carp below the lock structure with VEMCO transmitters. Some native fish species will also be implanted with VEMCO acoustic transmitters to assess movement around and through the lock structure throughout testing of the BAFF system. These will include 20 smallmouth buffalo, 20 paddlefish, and 20 freshwater drum in fall of 2022. Fish will be collected by electrofishing and gill netting, and then surgically implanted with transmitters. All VEMCO telemetry receivers will be maintained, and data collected monthly. Analysis of data collected in the Kentucky portions of the Tennessee and Cumberland rivers will continue to be a joint effort with Murray State University. Receiver locations, acoustic tag numbers, and data collected will be promptly communicated to project partners. Data collected by all partner agencies will be analyzed to determine when fish passage through lock chambers is greatest and how deterrents could best be utilized on the Tennessee and Cumberland rivers.

KDFWR will continue to provide assistance for monitoring the efficiency of the BAFF at deterring Invasive carp movement through the lock structure and its effect on native fish species. KDFWR staff will lead efforts to implant silver carp with acoustic transmitters from HTI. The number of fish implanted, and timing of efforts will be determined by the BAFF research group. The HTI 3-D movement detection system requires a complex array of hydrophones around Barkley Dam. KDFWR will assist with deployment of hydrophones and maintenance of the array throughout the study. The equipment associated with the BAFF is contained in two conex containers on Barkley Lock. KDFWR will perform maintenance on the equipment onsite including changing filters, monitoring oil levels, and adjusting pressure released by the air compressor as needed. The BAFF research team has study design requiring the BAFF to be turned on and off at weekly intervals, for which KDFWR will be responsible. To prevent damage to the BAFF, a fishing and boating restriction zone has been defined in KDFWR regulations which includes the lock canal approaching the system (Evaluation of a Bio-Acoustic Fish Fence (BAFF) at Barkley Lock and Dam: Study Design, USFWS).

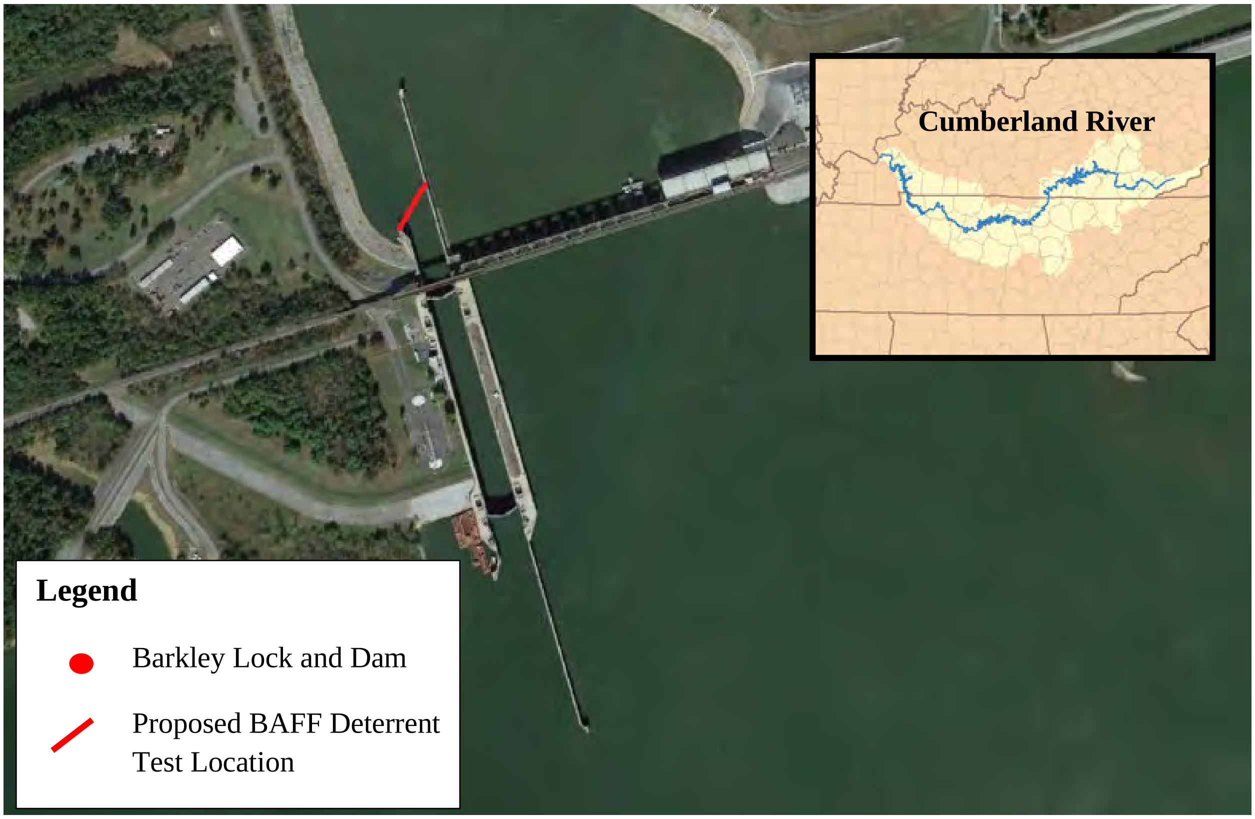
Estimated Timetable:

Project Activity	Location	Month	Year
Receiver Deployment	Tennessee River	as needed	2022-2023
Receiver Deployment	Cumberland River	as needed	2022-2023
Implantation of Transmitters	Barkley Dam Tailwaters	March, April, October, November	2022-2023
Downloading of Receivers	Kentucky Lake & Lake Barkley	Bi-Monthly	2022-2023
Downloading of Receivers	Kentucky Lock & Dam, Barkley Lock & Dam, Tailwaters	Monthly	2022-2023
Project Technical Report	N/A	February	2023

Map of Project Area:
See map above for reference to multi-state collaborative telemetry work in the Tennessee and Cumberland rivers.



Stationary receiver locations in Tennessee and Cumberland rivers that are maintained by KDFWR to measure Invasive carp upstream invasion.

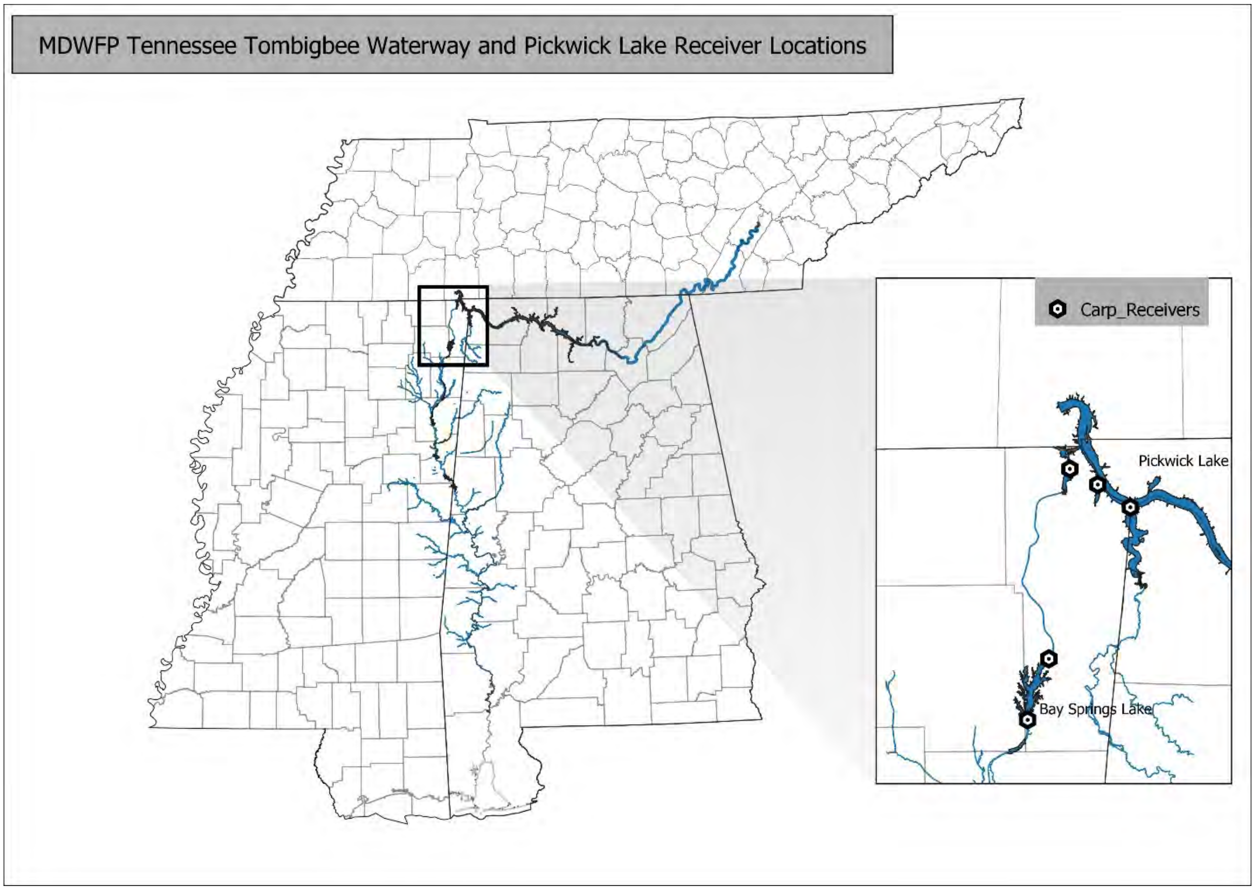


Location of Bio-Acoustic Fish Fence (BAFF) deterrent system being tested at Lake Barkley Lock and Dam on the Cumberland River. Kentucky Department of Fish and Wildlife Resources assists with equipment maintenance, telemetry array, and monitoring of system effectiveness.

Agency: Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP)

Activities and Methods:
MDWFP has an array of hydroacoustic receivers in the Tennessee River (Pickwick Lake) as well as one at the upper end of Bay Springs Reservoir (Crow's Neck), and one at the Jamie Whitten Lock and Dam on the Tennessee-Tombigbee Waterway (TTW) since 2017. MDWFP personnel will continue to maintain and monitor the existing receiver array. Receivers will be checked monthly, and any new detections will be downloaded. Receiver logs will be uploaded to the Tennessee and Cumberland Rivers Sub-Basin Partnership (TNCR) Google Drive site or shared with partners as requested. Missing receivers will be replaced as needed and batteries changed annually. MDWFP will continue to provide agency personnel and equipment to assist partner states with tagging efforts as needed.

Map of Project Area:



Estimated Timetable:

Activity	Location	Month	Year
Data Downloads	Pickwick Lake, Bay Springs Reservoir, TTW	Monthly	2022-2023
Receiver Replacement and Maintenance	Pickwick Lake, Bay Springs Reservoir, TTW	As needed	2022-2023
Annual Report	N/A	March	2023

Agency: U.S. Geological Survey

Activities and Methods:

Objective 2: Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.

The USGS Upper Midwest Environmental Sciences Center will continue to work with state and federal partners to conduct a fine-scale assessment of fish behavior near Kentucky (Figure 4), Pickwick (Figure 5), and Cheatham locks and dams (Figure 6) on the Tennessee and Cumberland rivers. This component of the project will translocate silver carp from upstream reservoirs, then tag and release the fish in the tailwaters. USGS will analyze VEMCO depth-sensor data from silver carp to determine vertical positioning within the water column and how fishes respond to changing environmental variables and to the operation of locks for river vessels. No USFWS Ohio/TNCR funds are requested for this translocation and depth-tag component of the study; transmitters will be supplied by USGS in support of the deterrent project. Partners will continue to share data on fish tagged and detections, and coordinate data analysis and report writing. Fish passage through lock and dam structures will be compared to flow regimes, lock operations, water temperature, season, and other factors identified by partners that may influence movements. USGS will procure detailed Lock Queue Reports from the U.S. Army Corp of Engineers Lock Performance Management System on a quarterly basis for all locks on the Tennessee and Cumberland rivers.

Estimated Timetable:

Project Activity	Location	Month	Year
Receiver Maintenance	Kentucky, Pickwick, Cheatham Dams	As needed	2022-2023
Gate Sensors and HOBO Depth Logger Maintenance	Kentucky, Pickwick, Cheatham Dams	As needed	2022-2023
Implantation of Transmitters	Kentucky, Pickwick, Cheatham Dams	March, April, October, November	2022-2023
Data management and analysis	N/A	As needed	2022-2023

VEMCO telemetry array deployed at Kentucky Lock and Dam.

VEMCO telemetry array deployed at Pickwick Lock and Dam.

VEMCO telemetry array deployed at Cheatham Lock and Dam.

Evaluation and Removal of Invasive Carp in the Tennessee and Cumberland Basins

Lead Agency and Author: Tennessee Wildlife Resources Agency (TWRA), Cole Harty (cole.r.harty@tn.gov)

Cooperating Agencies: TWRA; Kentucky Department of Fish and Wildlife Resources (KDFWR); Alabama Department of Conservation & Natural Resources, Wildlife & Freshwater Fisheries Division (ALWFF); Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); U.S. Fish and Wildlife Service (USFWS); U.S. Army Corps of Engineers (USACE); Tennessee Valley Authority (TVA); Murray State University (MSU); and Tennessee Cooperative Fisheries Research Unit, Tennessee Technological University (TTU).

Statement of Need:

All four species of invasive carp have been collected in the Tennessee and Cumberland rivers (TNCR). The states of Kentucky, Tennessee, Mississippi, and Alabama have significant recreational and ecological resources at risk due to invasive carp. This project is needed to help implement portions of the National Management and Control Plan for Invasive Carp (Conover et al. 2007) and portions of the Ohio River Basin Invasive Carp Control Strategy Framework (Ohio River Fisheries Management Team 2014). The project objectives and descriptions below consist of important steps to monitor, control, and better understand the impacts of invasive carp in the TNCR, all of which are identified goals of the sub-basin management plan. As individual TNCR states have initiated their carp programs, agencies have recognized the need to align sampling methods to collectively address invasive carp on a basin-wide scale. Partners in the TNCR are committed to identifying and reconciling differences in methodology to meet the broader goals of a basin-wide framework.

This project will further develop standardized protocols to assess abundance and population dynamics of invasive carp and determine effectiveness of control measures. TWRA and KDFWR have invested in commercial carp removal programs, and the USFWS has funded a sound barrier experiment at Barkley Lock. To measure the success of these control measures, agencies need standardized sampling methods that will allow comparisons among water bodies and over time. Foundational research on carp sampling has been conducted by USFWS, KDFWR, TWRA, and TTU using USFWS Invasive Carp base funds and local funding sources. These projects have tested many sampling methods, identifying the best available methods for sampling carp. This project will increase capacity for standardized sampling in TN, KY, and AL. Ultimately, while Mississippi Department of Wildlife, Fisheries, and Parks is not requesting funding for this project for FY 2022, they are coordinating with TNCR states and will benefit from this project. The inclusion of all four states is critical for the evaluation of carp populations in the TNCR.

The commercial fishing industry has been successful at harvesting carp using gillnets and has benefitted from harvest incentive programs developed by KDFWR and TWRA. Increasing harvest rates remains important if commercial fishing will be used as a means of population control. Due to cost and restrictions on commercial gear types, the private sector cannot easily test new methods. Development of more efficient carp removal methods would greatly benefit the TNCR and potentially other basins. As part of this project, the KDFWR and MSU will continue to evaluate new gears that could be used by resource managers and commercial fishers. This work will benefit all partners in the TNCR as we need highly effective removal methods that are designed for the habitats associated with the TNCR.

Objectives:

1. Estimate invasive carp relative abundance and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.

2. Examine variables affecting habitat usage by invasive carp to inform removal efforts.

3. Target and remove invasive carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

4. Evaluate new and/or experimental methods and gears for targeting invasive carp for harvest.

5. Determine feasibility of conducting a large-scale exploitation study.

Agency: Kentucky Department of Fish and Wildlife Resources

Activities and Methods:

Objective 1: Estimate invasive carp relative abundance, and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.

KDFWR will use a combination of standardized sampling and monitoring of commercial harvest to evaluate relative changes in Invasive carp abundance in Kentucky and Barkley lakes. Standard sampling with gill nets will be conducted at sixteen sites on Barkley and Kentucky reservoirs. These standard sites were selected to provide adequate sampling parameters, decrease conflict with anglers, and provide static locations to monitor changes in catch per unit effort (CPUE). Four embayment sites and four main channel sites were selected on each reservoir. These sites will be sampled once during the following seasons; spring (April), summer (July), and fall (October). A total of four nets will be fished at each location during sampling periods and in orientations specific to each location. Sampling will occur when the lake level is greater than 354’ in areas where water depth is a minimum of 13’. Nets will be deployed one hour before sunset and retrieved one hour after sunrise the following morning (according to the official rise and set tables). Specific coordinates will be determined for all sets, and nets will be set at the same locations each season and for each subsequent year of gill netting effort. Sinking experimental gill nets 10’ deep, 300’ total length, with 100’ panels of 3”, 4”, and 5” mesh will be fished overnight. Gill nets will be 12’ deep tied down to 10’ every 8’. Each of the 100’ panels of webbing will be hung with 30” stretch in 16” ties (3” square, 5 meshes per 16” of linear net; 4” square, 4 meshes per 16” of linear net; and 5” square, 3 meshes per 16” of linear net). Webbing used in each panel will be constructed of 8 ply, 0.2-mm twist mesh. Cross ties for these nets will be constructed from #15 white bonded twine through the webbing. Catch rates and species captured will be recorded for each gillnet mesh size.

KDFWR will continue to partner with the USFWS to conduct Paupier net and Dozer trawl sampling in Kentucky Lake to further inform relative abundance calculations and population demographics. KDFWR will provide staff and tender boats to increase efficiencies as needed. KDFWR is considering incorporating a Paupier net boat and development of a standard sampling design with this gear type for Kentucky and Barkley lakes, extending into Tennessee state waters. KDFWR will continue to explore Paupier experimentation with USFWS Columbia FWCO. Sampling design will be informed by previous efforts with this gear type by the USFWS and agreed upon by basin partners.

The KDFWR Asian Carp Harvest Program (ACHP) requires commercial fishermen to report total weights of harvested Invasive carp species daily. Occasionally the agency also provides observers to record harvests as the nets are retrieved (ride-alongs). KDFWR anticipates conducting ~100 ride-alongs per calendar year. Data collected during ride-alongs with commercial fishers allows KDFWR to estimate average weights of individual silver carp commercially harvested. This value will be used to determine the number of individual silver carp harvested during the study. This information will be an additional metric in the assessment of Invasive carp population demographics.

During the standard sampling described above, total lengths (mm), weights (g), sex and gonad weights (g) will be recorded from a subsample of 10 silver carp and 10 bighead carp at each sample site. During fall sampling, pectoral fin rays and otoliths will be extracted from approximately 100 silver carp from each reservoir for aging. Data will also be collected weekly from commercial markets. Total lengths (mm), total weights (g) and total gonad weights (g) will be collected from twenty female silver carp. Observations of spawning patches on bigheaded carps will also be recorded during field work. Demographics data may also be collected from Invasive carp captured through other KDFWR sampling efforts and included for analyses. Silver carp movement information will be used to assist with estimating periodicity of silver carp spawning attempts, and the data will be aligned with environmental factors to examine potential correlations.

Objective 2: Examine variables affecting habitat usage by invasive carp to inform removal efforts.

KDFWR will provide support to Murray State University and USGS researchers investigating the environmental variables that may affect habitat usage of silver carp in Kentucky Lake and Lake Barkley. KDFWR will assist with coordinating a communication effort to relay information gained to commercial fishers. KDFWR anticipates monthly downloads and data transfers from passive telemetry receiver array within the TNCR. This will require approximately 120 personnel days per year.

Objective 3: Target and remove invasive carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

KDFWR will continue to dedicate staff time towards observing commercial fishing and facilitating efforts to assess the impacts of targeted removal of Invasive carp on non-target native species. Commercial fishers requesting to fish in the ACHP are required to provide daily reports including amount of fishing effort, the type of gear used, pounds harvested, and bycatch. Fishers are also required to list the number of fish caught for each species, fish released, and disposition. The information will be used to assess impacts of commercial harvest on bycatch species.

To verify commercial fishers' reports, KDFWR anticipates providing an observer to record harvests (ride-alongs) on 100 unique fishing outings per year. Observers collect all data required on commercial harvest logs and record GPS fishing locations, water temperature, and net soak times. Staff observe several individual fishers throughout the year. Ride-alongs are conducted as fishers pull their nets to harvest fish. When commercial fishers use short net soak times or drifting net sets, KDFWR staff will observe during the entire effort. Ride-alongs are conducted from an agency boat located near the commercial fishers. Observation records will be compared to fishers' daily reports to assess commercial reporting accuracy. ACHP data will be analyzed to determine the number of fishing trips, amount and disposition of bycatch by species, and total pounds of Invasive carp harvested.

KDFWR will continue to offer contract fishing in Kentucky and Barkley lakes to ensure commercial fishing effort targeting Invasive carp remains strong. Commercial fishers must apply for the contract program and once approved, will receive a designated price per pound for Invasive carp species harvested from Kentucky or Barkley lakes, and their tailwaters. The ACHP is one of two programs Kentucky has implemented to increase commercial removal of Invasive carp in the reservoirs. In 2018, KDFWR purchased and maintains an industrial flake ice machine. The ice is free to commercial fishers targeting Invasive carp. As harvests continue to increase, upgrades and additional storage capacity for the ice machine and freezer will be required.

KDFWR staff will conduct targeted removal of Invasive carp through electrofishing and gillnetting for a maximum of 20 events per year.. Electrofishing will occur on the lower Cumberland River below Barkley Dam and the lower Tennessee River below Kentucky Dam. These areas have high densities of Invasive carp in confined areas and will be targeted when conditions are most conducive for mass removal with this gear (i.e. low water elevation, warm water temperatures, reduced barge traffic). Gillnetting effort will be focused on Kentucky and Barkley lakes and may coincide with training new commercial fishers. Active sets will be used primarily, targeting large schools of Invasive carp that can be encircled with nets and harvested. Data collected on fish captured through all removal efforts will be used to inform Objective 1.

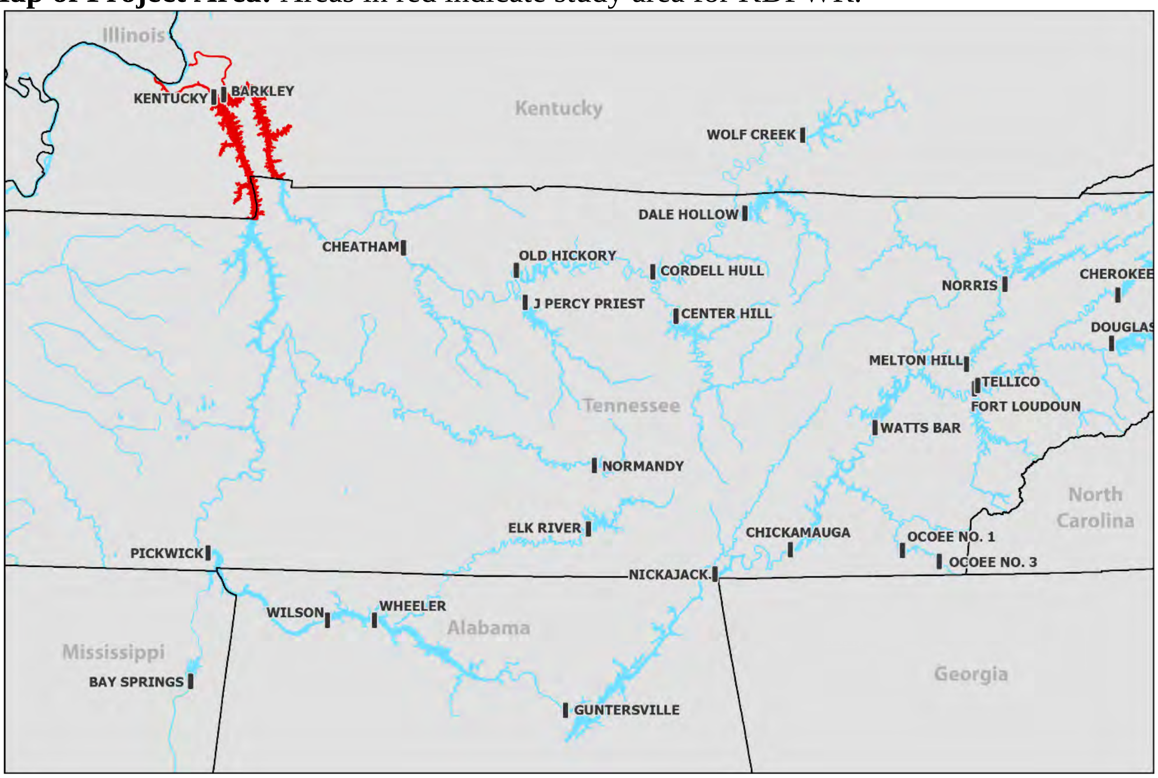
Objective 4: Evaluate new and/or experimental methods and gears for targeting invasive carp for harvest.

KDFWR will offer a contract program under which entities may test methods of Invasive carp harvest that are not currently legal in Kentucky. Contracts awarded will be limited to 5 per year of which require direct oversight of a KDFWR staff member for observation and data collection. Contractors will be required to hold a commercial fishing license and will be eligible to sell any Invasive carp harvested during testing efforts. After one year of testing with KDFWR oversight, contractors may be eligible to apply for a tier 2 contract which would allow them to utilize their methods or gear without further oversight from KDFWR, but with standard reporting requirements. Fish population demographics will be recorded to assess gear efficiencies and bycatch. KDFWR will use various media forums to provide public awareness and ensure law enforcement is aware of all special projects testing experimental gears. Data collected on fish captured through all removal efforts will be used to inform Objective 1.

Objective 5: Determine feasibility of conducting a large-scale exploitation study.

KDFWR will collaborate with partners and provide data as requested to support an exploitation study of silver carp in the TNCR.

Map of Project Area: Areas in red indicate study area for KDFWR.



Estimated Timetable:

Project Activity	Pool	Month	Year
Standard Invasive Carp Sampling	Kentucky / Barkley	Spring, Summer, Fall	2022 - 2023
Collection of Invasive Carp Demographics Information	Kentucky / Barkley	All Seasons	2022 - 2023
Ride Alongs with Commercial Fishermen	Kentucky / Barkley	All Seasons	2022 - 2023
Ride Alongs with Commercial Fishermen	Lower Tennessee / Cumberland Rivers	All Seasons	2022 - 2023

Testing of Experimental Harvest Gears	Kentucky / Barkley	All Seasons	2022 - 2023
Purchasing and Acquisition of Equipment	Kentucky / Barkley and their respective tailwaters	All Seasons	2022 - 2023
Paupier Net Sampling for Relative Abundance	Kentucky / Barkley	Fall	2022 - 2023
KDFWR Removal Efforts: Gill nets, Electrofishing, Paupier Net Boat	Kentucky / Barkley and their respective tailwaters	All Seasons	2022 - 2023
Contract with Commercial Fishers Harvesting Invasive Carp	Kentucky / Barkley and their respective tailwaters	All Seasons	2022 - 2023
Maintenance of Industrial Ice Machine	Kentucky / Barkley	All Seasons	2022 - 2023

Agency: Murray State University

Project Activities and Methods:

Objective 2: Examine variables affecting habitat usage by invasive carp to inform removal efforts.

MSU will conduct fine-scale tracking of invasive carp (24-hour movement and seasonal macrohabitat use) to search for patterns which can be exploited to enhance removal. If a sufficient number of tagged carp are not available, Silver Carp will be captured and tagged from within the reservoirs. Diel activity will be measured by following a single carp for 24 hours and recording its location every hour. Macrohabitat use will be studied by conducting large tracking runs and recording the precise location of each fish encountered during those runs. Both diel activity and habitat use will be analyzed by comparing movement rates and locations to environmental parameters such as water temperature, season, discharge, wind, etc.

Estimated Timetable:

Project Activity	**Pool**	**Month**	**Year**
Fine-scale Silver Carp Tracking	Kentucky / Barkley	All	2022-2023

Agency: Tennessee Wildlife Resources Agency

Activities and Methods:

Objective 1: Estimate invasive carp relative abundance, and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.

*In recent years, utility of relative abundance metrics for invasive carp population evaluation in the TNCR and elsewhere has come into question due to high variability and low power to detect change given current sample sizes. As further analyses are completed on data from previous years and similar sampling efforts, the methods below may be adjusted to fit the best available information. Significant deviations from the sampling methodology provided below will be thoroughly vetted through the TNCR partners and described in the annual interim report.

<u>Gillnetting</u> – TWRA staff will identify fixed sites in Kentucky (6 sites), Pickwick (2), Barkley (3), and Cheatham (2), lakes to set clusters of gillnets. Each site will be sampled at least twice a year, once during summer (July-Sept) and again in the winter (Nov-Jan). At each site, four overnight gillnet sets will be deployed. Nets will be distributed in embayments from the mouth to the back of the embayment (approximately 10-foot depth). Individual nets will be 300-ft in length with 100-ft panels of 3-, 4-, and 5-in mesh. Nets will be 12-ft deep, hobbled to 10-ft every eight feet; nets will have 0.5-in foamcore float line and 65-lb leadcore lead line. The webbing used in each of these panels will be constructed of 8 ply, 0.2-mm twist mesh. Catch of all species will be recorded by mesh size. We are not attempting to herd fish into nets using electrofishing, acoustic boats, or any other method.

<u>Dozer Trawl</u> – TWRA staff will conduct electrified dozer trawls as a standard method of sampling. Dozer trawl sites will be established in Kentucky, Pickwick, Barkley, and Cheatham, lakes. Multiple factors, such as logistics, feasibility, and scientific and statistical robustness, will be used in determining number and location of sampling sites. Specifications of the dozer trawl will be similar to those currently operated by TTU and USFWS's Columbia Field Office. Dozer trawl surveys will be conducted during the daytime. Sampling transects may include a variety of habitat types (i.e., backwaters, channel borders, shoreline areas, open water). Each trawl sample will be conducted for 5 minutes. All species will be counted, and catch rates will be calculated as fish/5-min. Though electrified dozer trawls will replace boat-mounted electrofishing as the standard method, boat-mounted electrofishing will still be utilized on an as needed basis and in special circumstances; boat-mounted electrofishing will remain the standard method on Old Hickory Lake, where invasive carp abundance appears very low, and encounters are rare.

<u>Fish Collected During Surveys</u> – All carp species will be removed from the lake. Carp species (or a subsample) will be examined to determine species, length (mm), weight (g), and sex. Sex of bigheaded carp will be determined based on the morphology (serrated pectoral spines are males). During this project, TTU will be conducting complementary samples that will yield otoliths to estimate age and growth, and gonad measurements to determine gonadosomatic index. All non-carp species will be released. Gillnetted buffalo (*Ictiobus spp.*) and paddlefish (*Polyodon spathula*) will be measured (length and weight) to monitor condition of these species and disposition will be recorded to track bycatch mortality. These data will be used to prepare

length and age frequency histograms, estimate growth rates, assess recruitment variability, and estimate mortality.

Commercial Market Surveys – Through the TWRA's Carp Harvest Incentive Program (TCHIP), commercial fishers and buyers are required to report the total weight of invasive carp that are harvested and purchased daily. To qualify for TCHIP, fish must be harvested from TWRA specified lakes. TWRA staff will characterize the size structure of carp harvested through TCHIP by collecting a subsample of harvested fish. TWRA staff will meet commercial fishers as they arrive at the market to offload catch, or conduct ride-along surveys. Commercial fishing surveys will be conducted at least 3 times a year. We will record capture location and examine a subsample of carp to determine species, length (mm), and weight (g). During this project, TTU will be conducting complementary samples that will yield otoliths to estimate age and growth, and gonad measurements to determine gonadosomatic index. Unless additional samples are requested, we will not be removing otoliths or measuring gonads during commercial surveys.

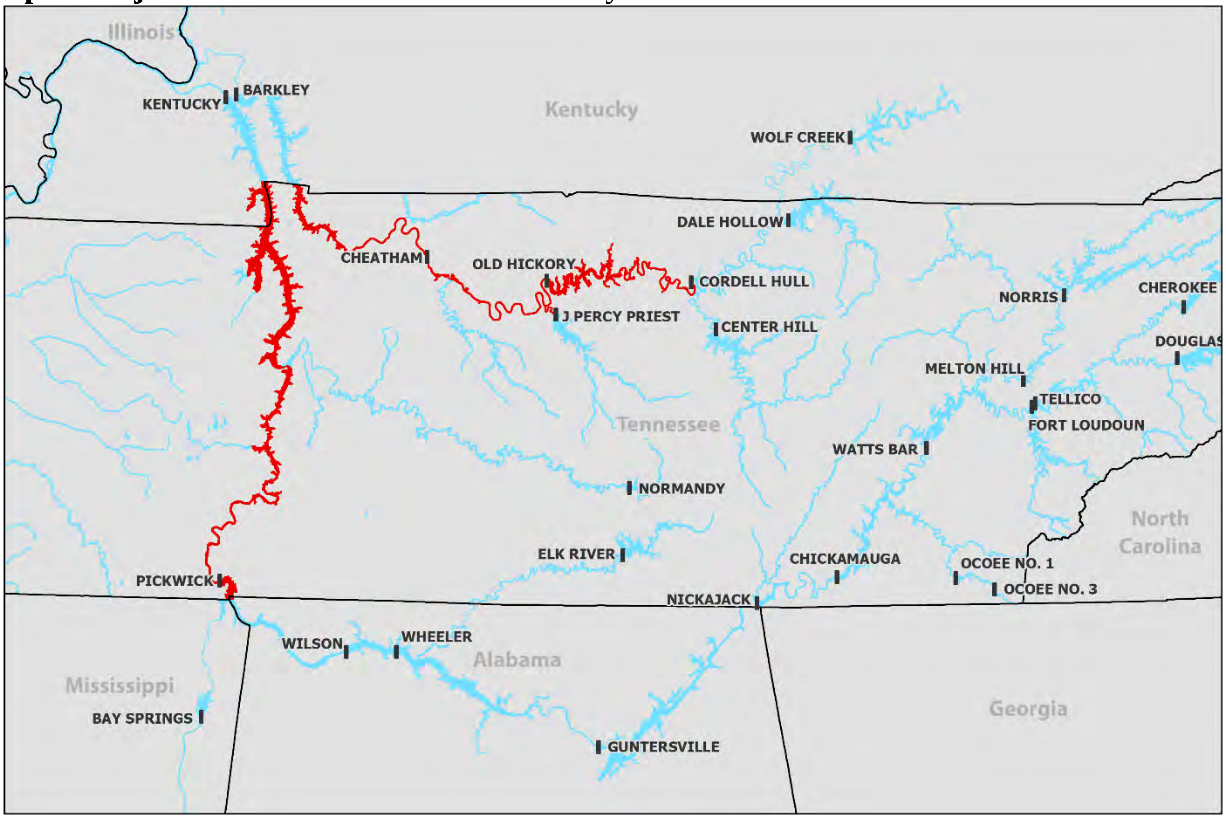
Objective 3: Target and remove invasive carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

TCHIP – TWRA will contract with licensed wholesale fish dealers to remove invasive carp from waters specified by the agency. Wholesale dealers are licensed by TWRA to purchase fish from commercial fishers. Payments will be made on a per pound basis, and rates may vary by location. Depending on industry needs, gill net materials may be provided to commercial fishers. By state rule, wholesale fish dealers and commercial fishers submit monthly reports that are then used to verify all TCHIP purchases and quantify harvest.

Objective 5: Determine feasibility of conducting a large-scale exploitation study.

TWRA will work with partners to gather information and describe objectives for a large-scale exploitation study of invasive carp. Partners will solicit expert advice regarding project scale, tagging options, capacity needs, technological aspects, funding requirements, and analytical support. TWRA and partners will utilize the information gathered to describe a variety of study options, each option complete with pros, cons, and significance to described objectives.

Map of Project Area: Areas in red indicate study area for TWRA.



Estimated Timetable:

Project Activity	Pool	Month	Year
Electrofishing/Dozer Trawl	Kentucky, Pickwick, Barkley, Cheatham, and Old Hickory lakes	July-Sept and Nov-Jan	2023
Gillnet	Kentucky, Pickwick, Barkley, Cheatham, and Old Hickory lakes	July-Sept and Nov-Jan	2023
Commercial Surveys	Sample carp harvested within TCHIP program (Agency specified lakes)	Year-round	2023
Targeted removal (TCHIP)	Agency specified lakes	Ongoing; year-round	2022-2023
Scope Exploitation Project	N/A	Year-round	2022-2023

Agency: Alabama Division of Wildlife and Freshwater Fisheries (ALWFF)

Activities and Methods:

Objective 1: Estimate invasive carp relative abundance and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.

The majority of field work (i.e., biological collections) will focus on the region stretching from the state border with Tennessee and Mississippi eastward to Guntersville Dam (see map); however, Guntersville Reservoir may also be included if deemed necessary. Currently, Guntersville Dam and the lower pool is monitored by ALWFF staff using telemetry. ALWFF will survey invasive carp populations using a variety of standardized sampling methods, primarily gillnetting and electrofishing, to estimate relative abundance and population demographics. Surveys will be conducted for both fixed monitoring and targeted (i.e., historically successful) sites throughout the Alabama portion of the Tennessee River. Information obtained will be used to help define the "invasion front" of invasive carp in the Tennessee River basin within Alabama. All information from fixed monitoring sampling will be used to track future changes in relative abundance. Additional information may also be obtained through interaction with commercial and recreational anglers. Any data sources deemed relevant for this project will be reviewed and incorporated when possible. ALWFF staff will also be available to assist partner state agencies with sampling in their waters for tagging, cooperative sampling or training purposes.

<u>Gillnet Sampling</u> – ALWFF will conduct gillnet sampling at predetermined sites on Pickwick Reservoir (3 sites), Wilson Reservoir (2 sites), and Wheeler Reservoir (3 sites). At each site, four gill nets will be set and fished overnight. Each site will be sampled a minimum of twice per year; once during the spring, summer (Pickwick only) and fall. Individual nets will be 300-ft in length with 100-ft panels of 3-, 4-, and 5-in mesh. Nets will be 12-ft deep, hobbled to 10-ft every eight feet; nets will have 0.5-in foam-core float line and 65-lb lead-core lead line. The webbing used in each of these panels will be constructed of 8 ply, 0.2-mm twist mesh. Catch of all invasive carp species will be recorded by mesh size.

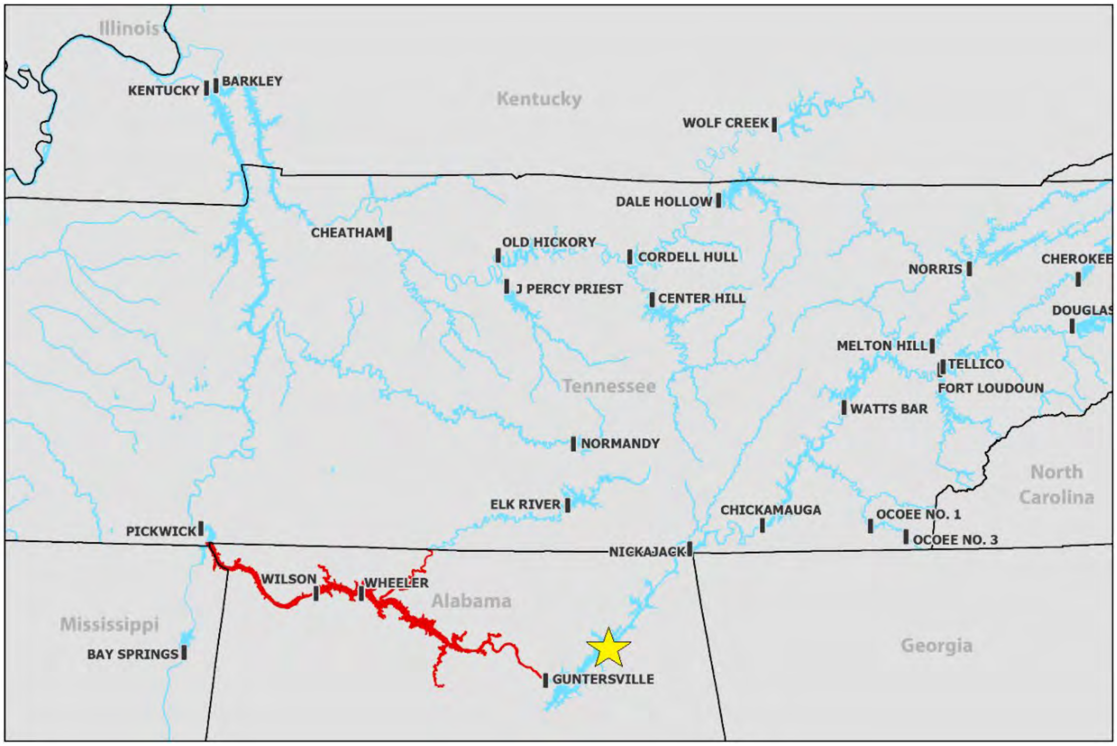
<u>Boat Electrofishing and Dozer Trawl</u> – ALWFF staff will conduct boat electrofishing with and without electrified dozer trawls as a standard method of sampling. Thirty-five sites will be established in each of Pickwick, Wilson, and Wheeler Reservoirs. Multiple factors, such as logistics, feasibility, and scientific and statistical robustness will be used in determining number and location of sampling sites. Specifications of the dozer trawl will be like those currently operated by TTU and USFWS's Columbia Field Office. Electrofishing surveys will be seasonal, similar to gill netting, and conducted during the daytime. Sampling transects may include a variety of habitat types (i.e., backwaters, tributaries, main channel borders and embayments). Each sample will be conducted for at least 5 minutes. Invasive carp species will be counted, and catch rates will be calculated as fish/5-min. Though electrified dozer trawls will replace much of the boat-mounted electrofishing as the standard method, boat-mounted electrofishing will still be utilized on an as needed basis and in special circumstances.

Fish Collected During Surveys – All individual invasive carp collected, or an appropriate subsample, will be examined to determine species, length (mm), weight (kg), sex and ovary mass (one half, g). Otoliths and one pectoral fin ray will be removed from individual carp for age and growth analysis. Other metrics may be collected if needed. Similar data will be collected for known, ecologically sensitive fish species (e.g., Paddlefish, Bigmouth Buffalo and Gizzard Shad).

Objective 3: Target and remove invasive carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

Sample efforts to specifically target invasive carp in previously successful areas or sites will be implemented whenever possible and in addition to Objective 1 sampling. Additionally, all invasive carp collected during the project sampling period will be removed during fish survey work described in Objective 1. However, any invasive carp collected with a tracking device will be documented and released immediately. Active removal of fish will be especially important to slow the upstream migration of invasive carp, since the leading edge of their migration in the Tennessee River basin is likely located in Alabama. All non-target by-catch for gill nets will be recorded and released immediately after capture. Ecologically sensitive species (e.g., Paddlefish, Bigmouth Buffalo and Gizzard Shad) will be enumerated and biological data taken for all gears.

Map of Project Area: Areas in red indicate study area for ALWFF. The yellow star indicates where additional work may be conducted, if needed.



Estimated timetable for activities

Activity	Time Period (Season, month/year)
Gillnetting	All Seasons
Electrofishing with and without Dozer trawl	Spring Summer, Fall

Literature Cited:

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Early Detection of Invasive Carp Reproduction and Population Expansion in the Tennessee and Cumberland Rivers

Lead Agency and Author: Tennessee Wildlife Resources Agency (TWRA; Cole Harty, cole.r.harty@tn.gov)

Cooperating Agencies: TWRA, Tennessee Technological University (TTU), Kentucky Department of Fish and Wildlife Resources (KDFWR), Alabama Division of Wildlife and Freshwater Fisheries (ALWFF), and Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP)

Statement of Need:
Invasive carp have been present in the Tennessee and Cumberland rivers for over two decades. They negatively impact fisheries where they are present and pose a significant threat to waters upstream of their leading edge. In response to the ongoing invasion, state and federal wildlife agencies have undertaken efforts to reduce the current populations and are working to prevent further invasion. An increased understanding of invasive carp reproduction where the species' occur and increased surveillance for population expansion beyond the leading edge have significant implications for informing management actions such as targeted removal efforts and deterrent strategies.

Invasive carp reproductive success has not been definitively confirmed above Kentucky and Barkley dams in the Tennessee and Cumberland rivers (TNCR) despite the observation of large numbers of young of year carp during the fall of 2015. Limited evidence of successful invasive carp reproduction, including collection of eggs by Tennessee Valley Authority and one genetically identified larval silver carp from TWRA, has been detected during larval sampling efforts and the 2015 year class remains the dominant cohort of fish captured during sampling efforts since 2016. The larval and juvenile sampling in this plan are critical for understanding the source of carp in the TNCR and making relative management decisions (location and amount of harvest and deterrence projects).

In addition to monitoring for invasive carp recruitment in reservoirs with existing populations, surveillance and monitoring efforts are needed in waters upstream of the existing leading edge, including in adjacent, connected basins such as the Tennessee-Tombigbee Waterway. Reports/encounters with individual invasive carp in upstream reservoirs and connected basins are infrequent, but important to informing our understanding of the invasion front and documenting range expansion.

The Tennessee–Tombigbee Waterway is a 234-mile (377 km) navigation system that connects the navigation systems of the Tennessee, Ohio, and Mississippi Rivers with navigable waters of the Mobile River Basin and the Gulf of Mexico via a cut canal in northeast Mississippi and ten lock and dam structures (Supplemental Map; Green, 1985). Currently, the invasion front of bigheaded carps in the Tennessee River is Pickwick Dam (Post van der Burg, 2021), approximately 8 miles (12.9 km) from the cut canal of the Tennessee–Tombigbee Waterway.

Targeted bigheaded carp sampling efforts between Pickwick Dam and Jamie L. Whitten Lock and Dam (Bay Springs Lake) have resulted in a few carp detections, although those detections have increased in Pickwick Reservoir since 2020 as targeted invasive carp efforts have increased (C. Harty, Tennessee Wildlife Resources Authority, pers. comm.; S. Miranda, Mississippi State University, pers. comm.). The Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) and the Alabama Division of Wildlife and Freshwater Fisheries (ALWFF) are concerned the risk of bigheaded carps invasion into the Tennessee–Tombigbee Waterway and subsequent waters of the Mobile River Basin warrant continued and expanded sampling. This project will serve as a monitoring program for early detection of invasive carp beyond the currently recognized leading edge of the invasion. It will provide pertinent information on the status and distribution of invasive bigheaded carps in the Tennessee–Tombigbee Waterway, which will aid in the development of a management and control strategy for invasive carps in the Tennessee-Tombigbee Waterway, preventing further invasion into the Mobile Basin.

Objectives:

1. Conduct systematic sampling to monitor for and document invasive carp and recruitment.
2. Develop and implement monitoring programs for early detection of invasive carp in waters upstream of the current presence front.
3. Determine invasive carp relative densities and assess sampling needs in the Tennessee-Tombigbee Waterway.

Agency: Tennessee Wildlife Resources Agency

Activities and Methods:

Objective 1. Conduct systematic sampling to monitor for and document invasive carp recruitment.

TWRA staff and interns will conduct larval and juvenile fish sampling on Kentucky and Barkley reservoirs. Sampling efforts will include larval tows, larval light traps, mini fyke nets, and electrified dozer trawls. Sampling efforts will incorporate the best available information from FlueEgg modeling to determine sampling locations and utilize a combination of fixed and random sites.

Larval tows will be conducted from April through August. Crews will conduct approximately 40 tows per week. Tows will be conducted using a 500-micron net attached to a 1-meter square frame. Tows will be conducted moving upstream and will utilize a flowmeter to standardize collections by volume with each sample consisting of 10,000 – 12,500 units. Samples from each tow collection will be divided into two jars, one with formalin and one with 100% ethanol, and prepared for either visual identification or genetic analysis.

Larval light traps will be set from May through August. Approximately 40 light traps will be run each week. Traps will be set in the hour prior to sunset and retrieved after approximately 1.5 hours of soak time. Traps will be distributed from the mouth to the back of embayments, with preference for depths of less than 8-ft. Samples from each trap will be divided and prepared like those collected via larval tows.

Mini fyke nets will be deployed during August. Approximately 40 nets will be run each week. Net leads are typically set oriented perpendicular to shore with the cod end stretched lakeward, preferably in less than 8-ft of water. Daytime sets of approximately 6 hours soak time will be used. Catch will be examined for presence of invasive carp and any suspect individuals will be taken to the lab for further processing.

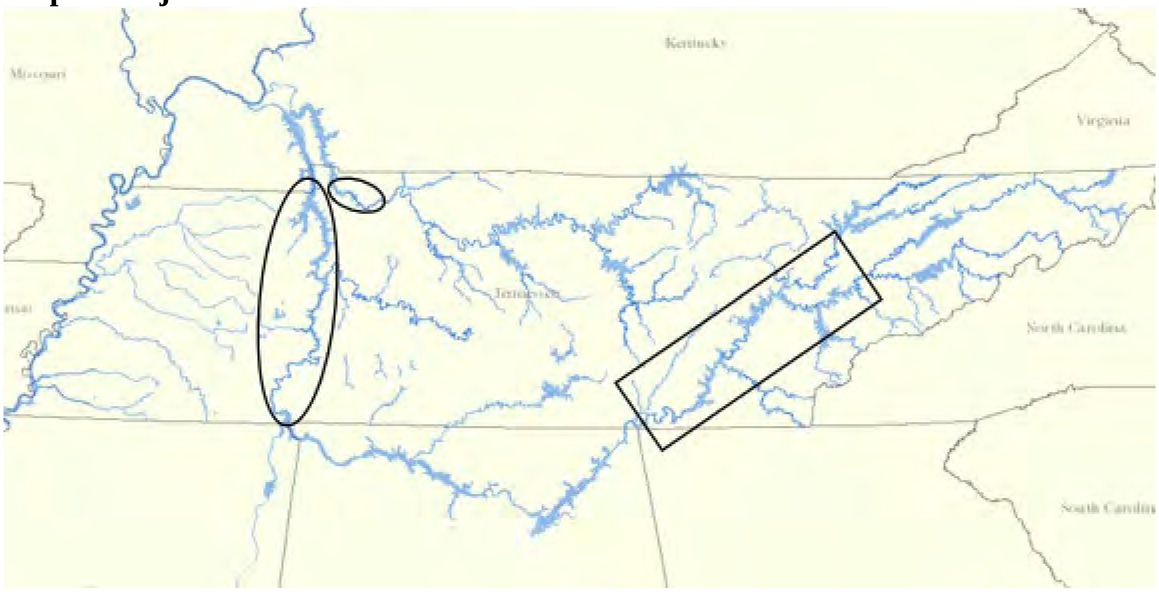
Electrified dozer trawls will be conducted by both TWRA and TTU. Dozer trawl methods are further described for TWRA in the “Evaluation and Removal of Invasive Carp in the Tennessee and Cumberland Basins” project and for TTU in the “Relative Population Densities of Invasive Carp in the Tennessee River and Cumberland River, Tributaries of the Ohio River” project.

Objective 2. Develop and implement monitoring programs for early detection of invasive carp in waters upstream of the current presence front.

Crews will conduct surveillance below Nickajack, Chickamauga, Watts Bar, Ft. Loudoun, and Melton Hill dams in the eastern portion of Tennessee via electrofishing. All locations, except for Melton Hill Dam, will be sampled once every two weeks. Melton Hill will be sampled once every month. Any invasive carp encountered during this sampling effort will be documented and, if collected, further processed (i.e., length, weight, sex, otoliths).

TWRA staff may utilize a combination of methods in addition to electrofishing to monitor for the presence of invasive carp above the current presence front. Additional sampling, including dozer trawls, gill nets, and eDNA collection, will depend upon staff and partner (TTU) availability.

Map of Project Area:



Map depicting Tennessee waters. The large oval (Kentucky Lake; Tennessee River) and small oval (Lake Barkley; Cumberland River) have existing populations of invasive carp and will be the focus of efforts to monitor for successful carp reproduction. The rectangle encompasses waters of the Tennessee River above the current presence front of invasive carp and will be the focus of efforts to monitor for population expansion.

Estimated Timetable for Activities:

Activity	Location	Time Period (Season, month/year)
Larval tows	Kentucky and Barkley reservoirs	April-August, 2023
Larval light traps	Kentucky and Barkley reservoirs	May-August, 2023
Mini fyke nets	Kentucky and Barkley reservoirs	August, 2023
Dozer trawls	Kentucky and Barkley reservoirs	June-December, 2023
Electrofishing	Nickajack, Chickamauga, Watts Bar, Ft. Loudoun, and Melton Hill dams	April-September, 2023
eDNA collection	Guntersville, Nickajack, Chickamauga, Watts Bar, and Ft. Loudoun reservoirs	TBD, 2023

Agency: Alabama Division of Wildlife and Freshwater Fisheries (ALWFF)

Activities and Methods:

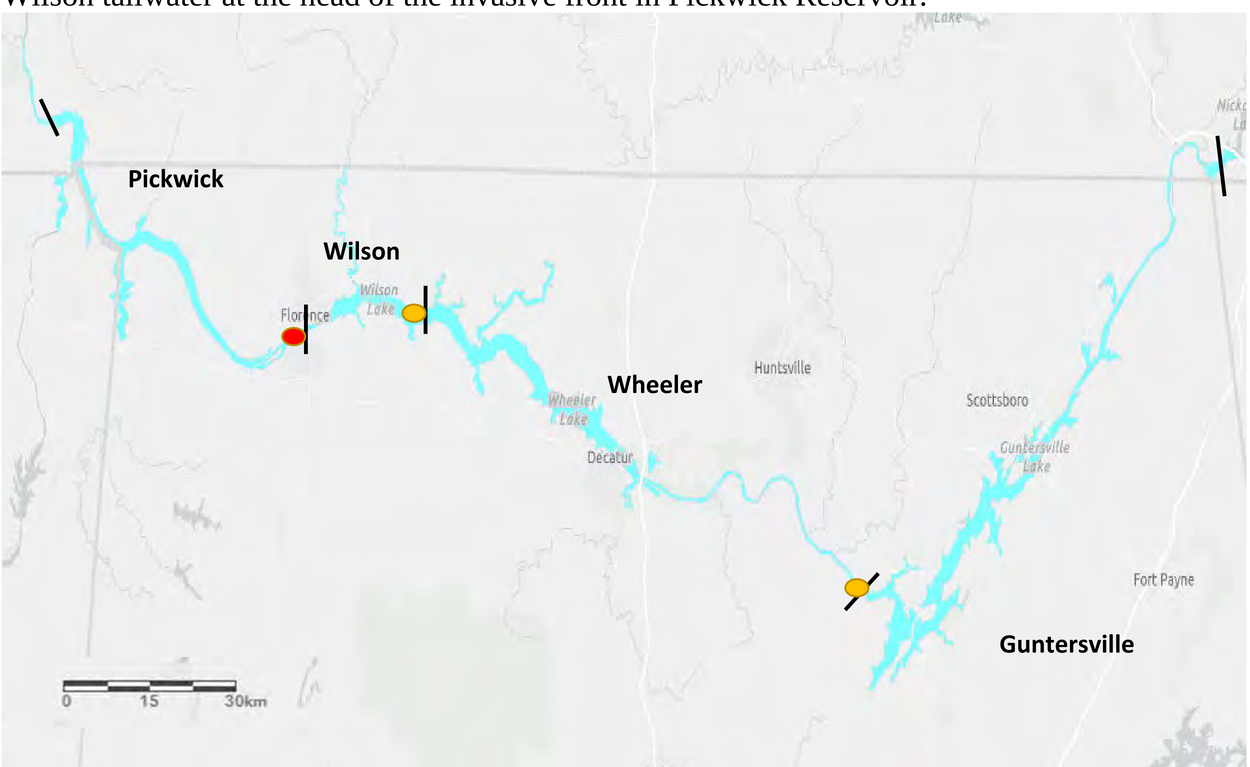
Objective 2. Develop and implement monitoring programs for early detection of invasive carp in waters upstream of the current presence front.

ALWFF staff will conduct surveillance below Wheeler and Guntersville dams in the Alabama portion of the Tennessee River via electrofishing. Locations will be sampled once every month, April through September. Because Wilson Dam drains into Pickwick Reservoir where the invasion front exists, sampling here will be done less frequently as time and staff availability allows. Invasive carp encountered during this sampling effort will be documented, including individual fish positively identified but not captured. Individual carp that are collected will be processed for vital biological data (i.e., length, weight, sex, ovary weight and otoliths).

Staff may utilize a combination of methods in addition to electrofishing to monitor for the presence of invasive carp above the current leading edge. Additional sampling may include dozer trawls or gill nets and will depend upon field conditions and staff availability.

Map of Project Area:

Alabama portion of the Tennessee River. Yellow circles represent tailwater portions of Wheeler and Guntersville dams where confirmed sightings within each reservoir above are very infrequent (i.e., above the leading edge of the known invasion front). The red circle denotes Wilson tailwater at the head of the invasive front in Pickwick Reservoir.



Estimated Timetable for Activities:

Activity	Location	Time Period (Season, month/year)
Electrofishing	Wheeler and Guntersville dams	April-September, 2023

Agency: Kentucky Department of Fish and Wildlife Resources (KDFWR)

Activities and Methods:

Objective 1. Conduct systematic sampling to monitor for and document invasive carp recruitment.

KDFWR will sample for invasive carp young of year in Barkley and Kentucky reservoirs. This work will be conducted for one week on each reservoir in the fall. Each reservoir will be sectioned off and sampled via a stratified random design. If YOY invasive carp are collected, then length and weights will be recorded, and specimens will be kept for further analysis if desired. Sampling gears will include boat electrofishing and mini-fyke netting. Environmental parameters such as water surface temperature, reservoir elevation, discharge, and dissolved oxygen will be recorded for the sample locations.

Boat electrofishing will be conducted during the daytime. Transects will not exceed 15 minutes of peddle time. The electrofishing output will be determined based on the water quality and fish response.

Mini fyke nets will be fished for one week in both Barkley and Kentucky reservoirs. Net leads are typically set oriented perpendicular to shore with the cod end stretched lakeward, preferably in less than 8-ft of water. Catch will be examined for presence of invasive carp and any suspect individuals will be taken to the lab for further processing.

Map of Project Area:

Estimated Timetable for Activities:

Activity	Location	Time Period (Season, month/year)
Electrofishing	Kentucky and Barkley reservoirs	September-October 2022 & 2023
Mini fyke nets	Kentucky and Barkley reservoirs	September-October 2022 & 2023

Agency: Mississippi Department of Wildlife Fisheries and Parks

Activities and Methods:

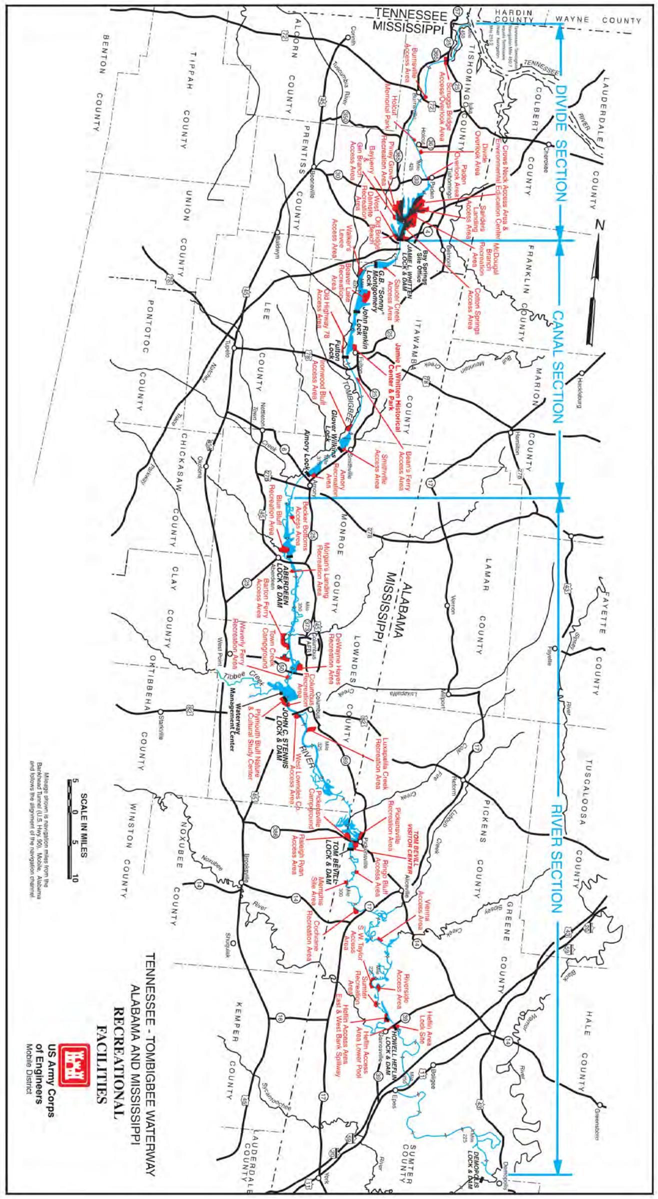
Objective 3. Determine invasive carp relative densities and assess sampling needs in the Tennessee-Tombigbee Waterway.

Sampling for invasive bigheaded carp will occur in the fall/winter seasons in pools below Bay Springs Lake. A “two-pool” rule will be implemented into the early detection sampling design of this project. The two-pool rule establishes that monitoring for invasive bigheaded carps should be conducted in all pools with previous detections and the first two pools distal to the leading-edge pool. In this instance, because bigheaded carps have been detected in Bay Springs Lake, sampling will be conducted to at least the two pools below Jamie L. Whitten Lock and Dam on the first sampling event—Pool E (G. B. "Sonny" Montgomery Lock) and Pool D (John Rankin Lock). The two-pool rule will be applicable within and among sampling events. To illustrate, if a silver carp is detected in Pool E, but not Pool D, during the first sampling event, sampling will be extended into Pool C (Fulton Lock) for that sampling event. Continuing the illustration, assuming that bigheaded carps were only detected in Pool E of the previous sampling event, sampling would be conducted in Pools E–C. And, if bigheaded carps are detected in Pools E–C during the current sampling event, sampling would be extended through to Pool A (Amory Lock).

Modified electrofishing protocols will follow the procedures outlined in Bouska et al. (2017). This protocol affords the boat operator the ability to selectively apply power to encircle or trap invasive carp. Modified electrofishing transects will be ten minutes in duration. Power output at each site will be standardized to a power goal based on water temperature and conductivity of the sampling area. Recreational-grade sidescan sonar will be used to locate fish and aid in site selection. Gear deployment is subject to change depending on gear acquisition, gear efficiency, and environmental variables.

Sex will be determined for all captured bigheaded carps. Bigheaded carps greater than stock-size (Silver carp: 25 cm, Bighead carp: 30 cm) will be sexed following the procedures identified in Wolf et al. (2018). Sub-stock fish will be sexed by examination of reproductive organs. If a determination is not possible, sex will be classified as immature. Lapilli otoliths will be extracted from all captured carps. Otoliths will be stored in coin envelopes to dry until further processing in the lab. Genetic tissue samples will be collected, stored in coin envelopes to dry, and catalogued for future genetic analyses. Other data collection requests will be determined by state and federal partners.

All statistical analyses will be conducted in program R (R Core Team, 2021). Results will be communicated to partners through written and oral summarizations.



Map of Project Area:

Estimated Timetable for activities

Activity	Time Period (Season, month/year)
Waterway Sampling	Winter, January-February/2023
Annual Report	March 1, 2023

Literature Cited:

Bouska, W. W., D. C. Glover, K. L. Bouska, and J. E. Garvey. 2017. A refined electrofishing technique for collecting Silver Carp: implication for management. North American Journal of Fisheries Management 37:101–107.

Green, S. R. 1985. An overview of the Tennessee-Tombigbee Waterway. Environmental Geology and Water Sciences 7: 9–13

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Monitoring Invasive Carp Impacts on Native Fish Communities

Lead Agency and Author: Kentucky Department of Fish and Wildlife Resources (KDFWR)

Cooperating Agencies: Murray State University (MSU)

Statement of Need:

In this project, KDFWR will evaluate the response by the native fish community and their fisheries in the presence of invasive carp. The establishment of invasive carp in new areas have been shown to alter native fish communities (Irons et al. 2007) and result in shifting food webs (Collins and Wahl 2017). Fisheries managers seek to understand these dynamics to evaluate the effectiveness of control measures, and to keep stakeholders informed. This work will complement ongoing projects in the Tennessee and Cumberland Rivers (TNCR). In this new project, the KDFWR will evaluate the response of native fishes, such as gizzard shad, buffalo, and paddlefish, which compete directly with bigheaded carp for zooplankton.

Objectives:

1. Assess invasive carp impacts on native species that may compete for food resources with invasive carp
2. Examine invasive carp impacts on fish community assemblages in the tailwaters of dams on the Tennessee and Cumberland rivers
3. Determine impacts of invasive carp on sport fisheries
4. Monitor bycatch of native fish species collected through invasive carp harvest programs

Agency: KDFWR

Activities and Methods:

Objective 1: Assess invasive carp impacts on native species that may compete for food resources with invasive carp

During standard sampling for invasive carp conducted in the TNCR Evaluation and Removal Project: objective 1, total length and weight data will be collected from bigmouth buffalo and paddlefish. During Paupier net sampling, total length and weight data will be recorded for gizzard shad as well. Measurements will be used for determining condition factors through relative weight analysis. Values will be monitored over time to determine if they will be useful to assess impacts that invasive carp may have on conditions of the native fishes. The species chosen for this assessment are often captured in gill nets and have been recognized as being vulnerable to competition for resources with invasive carp species (Irons et al. 2007, Schrank et al. 2003).

KDFWR will be conducting targeted sampling for gizzard shad with pulsed DC boat electrofishing in Barkley and Kentucky reservoirs. Sampling will occur for one week in each reservoir. Electrofishing runs will not exceed 15 minutes of peddle time. Length and weight will be taken from individuals collected.

Objective 2: Examine invasive carp impacts on fish community assemblages in the tailwaters of dams on the Tennessee and Cumberland rivers

Kentucky and Barkley lakes' tailwaters will continue to be sampled with pulsed DC electrofishing in the fall to assess species composition, relative abundance, and condition of represented fish species. Sampling below Kentucky Lake (Tennessee River) will consist of three 15-minute transects, moving downstream along each bank of the river. Sampling below Lake Barkley (Cumberland River) will consist of two 15-minute transects, moving downstream along each bank of the river. Fall sampling will be conducted one day each month in September, October, and November. Two staff will collect fish from the bow, and all fish of every species will be targeted. Data will include species, total lengths (mm), and weights (g). When large numbers of a species are collected, measurements on a subsample of at least 25 individuals will be taken and extrapolated for that species. The data will be compared to historical data collected by the KDFWR WFD personnel to assess changes in fish community over time.

Objective 3: Determine impacts of invasive carp on sport fisheries

Invasive carp harvest continues to increase from Kentucky and Barkley lakes, driven by the Asian Carp Harvest Program (ACHP) and the additional processors purchasing Invasive carp from western Kentucky. KDFWR will continue to monitor conditions of sport fish species to identify trends that may be associated with the increased removal of carps. Information on sport fish has been gathered routinely throughout the past few decades by KDFWR's Western Fisheries District (WFD). Lengthy data sets on black bass, crappie, and catfish in the two lakes are collected from standardized annual sampling. The information will be used to compare sport fish conditions (*W*r) with harvest rates of Invasive carps to determine if there is a correlation.

In summer and fall of 2022, KDFWR will continue the creel survey in the tailwaters of Kentucky and Barkley lakes. Random, non-uniform probability creel surveys will be conducted from February 16, 2022 through November 15, 2022 in the Kentucky Tailwater and the Barkley Tailwater. The Kentucky Tailwater survey extends from the Kentucky Lake Dam downstream to the Interstate 24 bridge. The Barkley Tailwater survey extends from the Lake Barkley Dam downstream to the US Hwy 62 bridge. Dates and periods for surveys each week are randomly selected, and creels are conducted in each tailwater at least 10 days per month in each tailwater, including a minimum of 3 weekend days. Each day is divided into three periods: morning, afternoon, and late evening. The late evening period is only utilized for a portion of the survey to collect snagging and bow fishing data. Daily, access point surveys consisting of instantaneous angler counts and angler interviews will be conducted from the bank; no boat will be used.

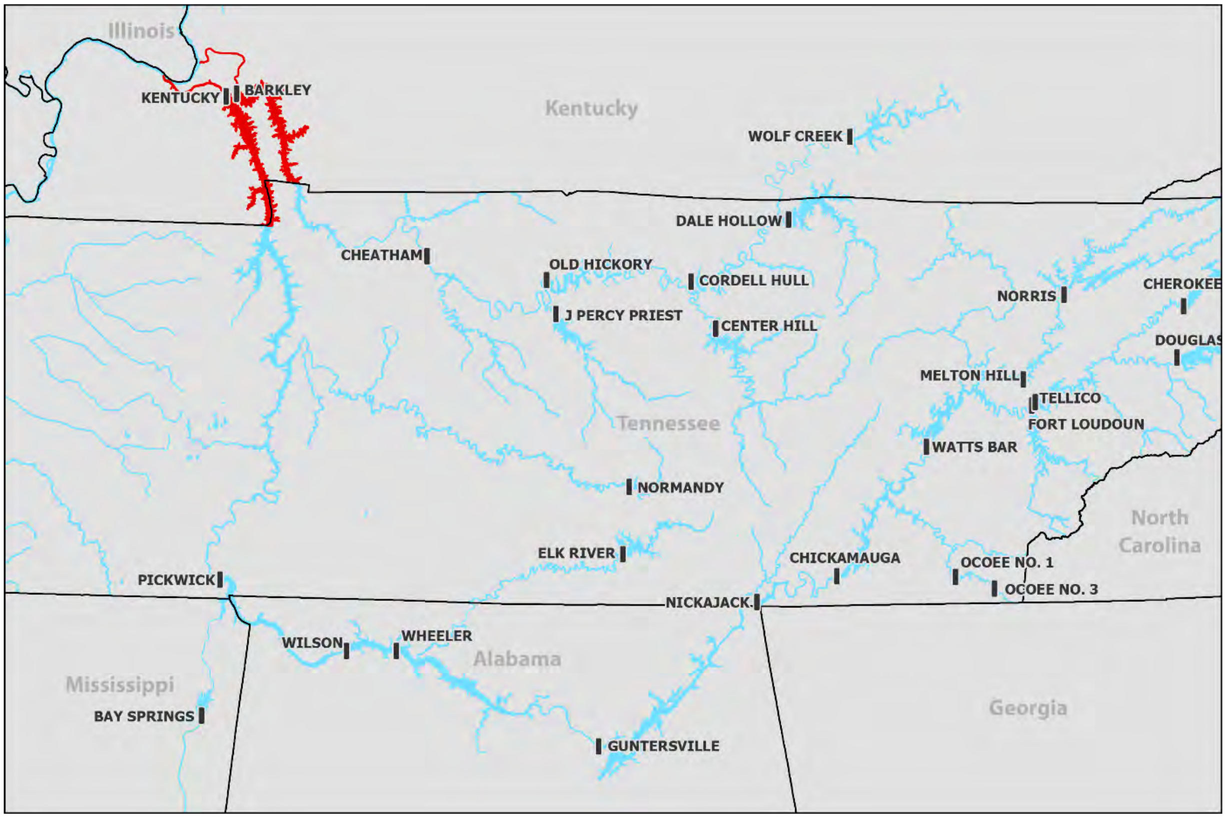
Timing of recreational fishers' counts are randomly chosen daily, and data is extrapolated accordingly to calculate daily average and total effort. An attempt to interview all recreational fishers each day will be made. Data collected during the creel surveys will be compared to historical surveys to determine changes in fish community, catch rates, angler use, and success. Recreational fishers will also be administered an angler attitude questionnaire to gauge opinions regarding their levels of satisfaction with the fishery and on current or proposed regulations. Increasing Invasive carp numbers in the tailwaters over the past decade has perpetuated a significant increase of bow fishing. During 2019, regulations were enacted in Kentucky to allow the sale of Invasive carp harvested by recreational fishers. The 2022 creel survey will provide data to assess the effects of the new regulation.

In spring of 2023, KDFWR will resume a random, non-uniform probability, roving creel survey on the Kentucky portion (51,000 a) of Kentucky Lake 16 February through 15 November 2023. The Kentucky portion of the lake is divided into ten creel areas. The survey is conducted five days per week, six hours per day. One hour each day is randomly chosen to conduct an angler count. The remaining five hours are dedicated to interviewing anglers actively fishing. The overall temporal sampling scheme is twenty days per month, consisting of six weekend days and fourteen weekdays. Varying time period probabilities are assigned to each month. Higher geographic probabilities, resulting in more frequent interviews, are assigned to the Johnathan Creek and Blood River areas from March through May, and October and November, than are assigned to the other eight areas. Equal probabilities are assigned to all areas from June through September. An angler attitude questionnaire concerning fishing on Kentucky Lake and Invasive carp specific information is conducted by the creel clerk throughout the survey period. Data collected during the creel survey will be compared to historical surveys to determine changes in fish community, catch rates, angler use, opinions, and success. Changes occurring over the past decade when Invasive carp populations have become more abundant in Kentucky Lake will be reviewed thoroughly.

Objective 4: Monitor bycatch of native fish species collected through invasive carp harvest programs

KDFWR continues to administer the Asian Carp Harvest Program (ACHP) and an Experimental Fishing Methods contract program to encourage largescale removal of invasive carp. As fishing effort and techniques develop and increase, there is potential for these activities to negatively impact native fish through excessive bycatch when fishers are attempting to target invasive carp. Commercial fishers on the ACHP are required to submit daily reports indicating species of bycatch, harvest status, or condition of bycatch upon release. KDWFR staff also collect this information during ride alongs with commercial fishers. These two data sets will be analyzed independently to determine if commercial fishing efforts are negatively impacting native fish species.

Map of Project Area: Areas in red indicate study area for KDFWR.



Estimated Timetable:

Project Activity	**Pool**	**Month**	**Year**
Standard Sampling (Gill Net)	Lake Barkley & Kentucky Lake	April, July, October	2022-2023
Paupier Net Sampling	Lake Barkley & Kentucky Lake	Fall	2022
Electrofishing for Gizzard Shad	Lake Barkley & Kentucky Lake	Fall	2022/2023
Electrofishing Community Survey	Kentucky & Barkley Tailwaters	September, October, November	2022
Creel Survey	Kentucky & Barkley Tailwaters	Summer – Fall	2022
Creel Survey	Kentucky Lake	February – November	2023

Ride Alongs	Kentucky Lake, Lake Barkley, Ohio River, Mississippi River	All Seasons	2022-2023

Literature Cited:

Collins, S.F., and D.H.Wahl. 2017. Invasive planktivores as mediators of organic matter exchanges within and across ecosystems. Oecologia 184: 521–530.

Irons, K. S., G. G. Sass, M. A. McClelland, and J. D. Stafford. 2007. Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River, U.S.A. Is this evidence for competition and reduced fitness? Journal of Fish Biology 71:258-273.

Agency: Murray State University

Activities and Methods:

Objective 1: Assess invasive carp impacts on native species that may compete for food resources with invasive carp

Murray State University (MSU) will use VEMCO acoustic transmitters to track the movement of Paddlefish and Smallmouth Buffalo within Kentucky Lake and Lake Barkley. Large-scale movement patterns will be studied based upon the existing network of passive receivers, and small-scale movement will be observed by using boat-mounted hydrophones. Small-scale movement includes diel activity patterns and daily macrohabitat use. Movement rates will be analyzed relative to environmental parameters such as water temperature, season, discharge, wind velocity, etc. Macrohabitat use will be analyzed relative to these parameters as well as relative to the available habitat.

MSU will also conduct standardized sampling for Gizzard Shad and Threadfin Shad within Kentucky Lake and Lake Barkley. Shad will be sampled with nighttime pulsed DC boat electrofishing as well as surface trawling. All shad will be measured in order to calculate relative weights for each fish. The otoliths will be removed from a subsample of Gizzard Shad in both the spring and fall for aging purposes which will allow us to calculate growth and mortality rates.

Estimated Timetable:

Project Activity	**Pool**	**Month**	**Year**
Native Fish Tracking	Lake Barkley & Kentucky Lake	All	2022-2023
Standard Sampling (boat electrofishing	Lake Barkley & Kentucky Lake	Spring – Fall	2022
Standard Sampling (surface trawl)	Lake Barkley & Kentucky Lake	Summer-Fall	2022

Upper Mississippi River Sub-Basin Invasive Carp Partnership

The Upper Mississippi River Conservation Committee (UMRCC) is a partnership of the five mainstem Upper Mississippi River (UMR) states. The UMRCC Fisheries Technical Section, which includes federal agency partners, completed a revised *Upper Mississippi River Fisheries Plan* in 2010. Goal 4 in the 2010 Fisheries Plan is to 'slow or eliminate the spread or introduction of aquatic nuisance species, including pathogens to the UMR.' The UMRCC Fisheries Technical Section formed an Ad-hoc Asian Carp Team (aka, Upper Mississippi River Sub-Basin Invasive Carp Partnership) to develop an Upper Mississippi River Basin Asian Carp Control Strategy Framework (UMRB Framework) to coordinate invasive carp prevention and control efforts in the UMRB. The UMRB Framework was completed in August 2018 as a regional stepdown plan from the National Plan and is based on the UMRCC's 2010 Fisheries Plan Goal 4.

Detection of and response to invasive carp in the presence front and at the invasion front in the Upper Mississippi River

Lead Agency and Author: Minnesota Department of Natural Resources (MNDNR), Heidi Wolf (Heidi.Wolf@state.mn.us)

Cooperating Agencies: Iowa State University through the Iowa Department of Natural Resources (IADNR)

Statement of Need: Bighead Carp *Hypophthalmichthys nobilis*, Black Carp *Mylopharyngodon piceus*, Grass Carp *Ctenopharyngodon idella*, and Silver Carp *H. molitrix* (collectively called invasive carp) are non-indigenous fishes that were introduced to the USA in the 1960s and 1970s from Asia for human consumption and biological control. Since that time, invasive carp have expanded their range (e.g., escaping secure facilities) and are now occurring more frequently throughout the Upper Mississippi River Basin. Current scientific evidence supports a strong likelihood of negative impacts to native species (Kramer et al 2019, Nico et al 2019, Phelps et al 2017, Solomon et al 2016). Preventing population expansion is the most cost effective way to limit negative impacts. Understanding current population dynamics and employing response actions are a key component in a deterrent and control strategy.

Partners continue adaptive development and implementation of a comprehensive and complementary early detection and response program for Bighead, Silver, Grass, and Black carps in the Upper Mississippi River Basin. This early detection program helps define the current presence, invasion, and established fronts and evaluate how these fronts change through time, important knowledge for management decisions. Additionally, this effort helps evaluate the effects of management actions: a commercial harvest program and the Upper Mississippi River Deterrent Strategy (USFWS 2017). Sampling uses a diverse array of traditional and novel gears to sample all potential life stages in targeted areas. Responding to invasive carp captures has also been part of the program but has taken on an increased significance in 2020 with the capture of 51 invasive carp in Pool 8 in March 2020.

Prior to 2018, the monitoring project included the entire Upper Mississippi River. Using data collected from the monitoring project in 2015-2017, there is a better understanding of invasive carp populations throughout the river and the UMR Invasive carp partnership has identified zones of river where population differences exist for each species (USFWS 2017). There is an established zone, a management zone, a presence but unestablished zone, and the section where carp have not been found. Given the different objectives and sampling strategies in each zone, the UMR partnership decided to split the monitoring project into two projects. Though split, monitoring participants will still coordinate and communicate efforts throughout the basin. Overlap does occur between the sections of river to ensure there are no gaps.

Understanding the population status in the presence zone is important for a variety of reasons. At this time, there are no deterrents in place on the Mississippi River. While lock and dams likely slow the upstream movement, invasive carp are still able to make it upstream as evidenced by the capture of 51 invasive carp in Pool 8 in March 2020. It is important to know where carp are established or reaching spawning thresholds to decide when and where to implement management strategies such as deterrents or removal efforts. Also, response removal efforts may help delay populations from reaching numbers that result in successful spawning events. Lastly, having a strong data set helps managers measure the success of management efforts.

Objectives:

1. Estimate relative population characteristics and distribution along the invasion front to help devise management strategies that minimize propagule pressure and population expansion of invasive carp.
2. Track invasive carp movement to inform sampling methodology to increase detection probability in low abundance areas.
3. Deploy commercial fishing in Pools 6, 7, 8, and 9 to maintain invasive carp populations below reproductive thresholds

Agency: Minnesota Department of Natural Resources (MNDNR)

Activities and Methods:

Larval Trawling

Larval trawling will be conducted from mid-May through mid-July at potential indicator sites in the UMR and its tributaries. If a peak in the hydrograph is observed or once water temperatures reach 62-65º F (17 or 18º C), larval sampling will be conducted to sample during conditions believed to be required for invasive carps to spawn. A bow mounted icthyoplankton net (0.75 m x 3 m) consisting of 500 um mesh will be pushed near the surface into the current so that the velocity of the water entering the net is between 1.0 to 1.5 m/s. At sampling locations where no water current exists (e.g. backwaters), sampling will occur towards a random direction that will allow for a complete sample to be taken in a relatively linear path. A mechanical flow meter will be placed in the mouth of the net to determine the volume of water sampled. Trawling locations will target areas biologists consider, based on current knowledge, a high probability for sampling invasive carp eggs and larval fish if they are present. Sample contents will be placed in containers labeled with sample location, name of water body, and date, and will be preserved in 10% buffered formalin for 24-48 hours, will be rinsed with water, and preserved in 90% ethanol. All eggs and fishes will be identified to the lowest taxonomic category until they are deemed either positive invasive carps or negative invasive carps.

Purse seine

A large purse seine will be used to sample deep water habitats for adult invasive carp throughout the year. A purse seine is an invaluable tool to sample previously under sampled deep habitats both for invasive carp and native planktivores. From our acoustic tagging results of the first Bighead Carp, this fish inhabited Lake St. Croix from Hudson, WI to Afton, MN throughout the year in water that was routinely deeper than 50 feet but only ventured to depths below 20 feet on rare occasions. While sampling for the tagged Bighead Carp, crews were also able to sample and tag an increased number of Paddlefish, a native planktivore with similar movement patterns and similar feeding niche.

The seine measures 2,000 ft. long and 40 ft. deep with 5 inch stretched mesh (2 ½” square mesh). The seine will also be constructed in panels connected with ½” braided poly rope and snap links to allow for reconfiguration to allow crews to use the seine as a standard commercial beach seine. The seine will be set using a small boat pulling one end of the net in a circular manner from another boat carrying the remainder of the seine. Once the seine is deployed, a purse line on the bottom of the net will be pulled tight to entrap the fish present within and the net will be hauled by winch or by hand to allow for the sorting of the enclosed fish. It is expected that the state contract commercial fisherman will transport and haul this seine due to its size and the expertise commercial fishermen have with setting a commercial-sized net of this complexity.

Electrofishing

Electrofishing will occur from May through September in a variety of habitats including backwaters, side channels, main channel borders, and over wing dikes. Sampling locations will be determined at the discretion of the sampler in a manner to target potential congregations of invasive carp throughout the field season. During large sampling events, electrofishing will be done in conjunction with gill netting to better push fish into large mesh gill nets.

A smaller electrofishing boat with an outboard jet motor will be used to sample shallow backwaters, in conjunction with the larger electrofishing boat. It is believed that juvenile invasive carps are a limiting life stage to their populations’ growth and that juvenile invasive carps likely overwinter in anoxic backwaters.

Gill Netting

Gill netting and trammel netting will occur from March through December as time and conditions allow. Stationary large mesh gill nets of depths from 8 to 24 ft. with square mesh sizes of 3.5 to 6 in. will be used to target adult invasive carps. Stationary experimental gill nets 250 ft. in length and 6 ft. deep consisting of 50 ft. compliments of net with square mesh sizes 0.75, 1, 1.25, 1.5, 2 in. will be used to target juvenile invasive carps. Nets may be set either short term or overnight, with short-term sets favored when water temperatures are greater than 60º F.

Commercial Fishing

Commercial fishermen will be contracted to target invasive carp with both gill nets and seines on all monitored systems. MN DNR personnel will accompany contracted commercial fisherman to direct sampling locations and monitor efforts. Netting will occur at the discretion of MN DNR personnel in likely invasive carp habitats or as a response to captures. Fish collected that are also needed for age and growth analysis or tagging may be utilized. The number of fish caught by species will be recorded during gill netting operations and total weight harvested will be requested from the commercial fisherman for both gill netting and seining operations.

In addition, private commercial gill net and seine operations will be monitored when possible to observe for invasive carp. Sampling site locations, sampling dates, gear description, effort, habitat type (main channel border, backwater, wing dike, etc.), water depth, and crew details will be recorded for each net set.

Invasive Carp Tracking

Pursuant to Minnesota Statute 84D.05, invasive carp collected in Minnesota waters can be tagged and released by Minnesota Department of Natural Resources staff: “Permit for invasive carp. The commissioner may issue a permit to departmental divisions for tagging bighead, black, grass, or silver carp for research or control. Under the permit, the carp may be released into the water body from which the carp was captured. This subdivision expires December 31, 2021.” MNDNR is working through the legislative process to remove the sunset clause on this statute. Based on the tagging results, researchers will gain a better understanding of movement patterns and habitat preferences, while posing a very low risk to native fish populations or risk of increasing invasive carp populations. This information will be used to inform detection and removal efforts.

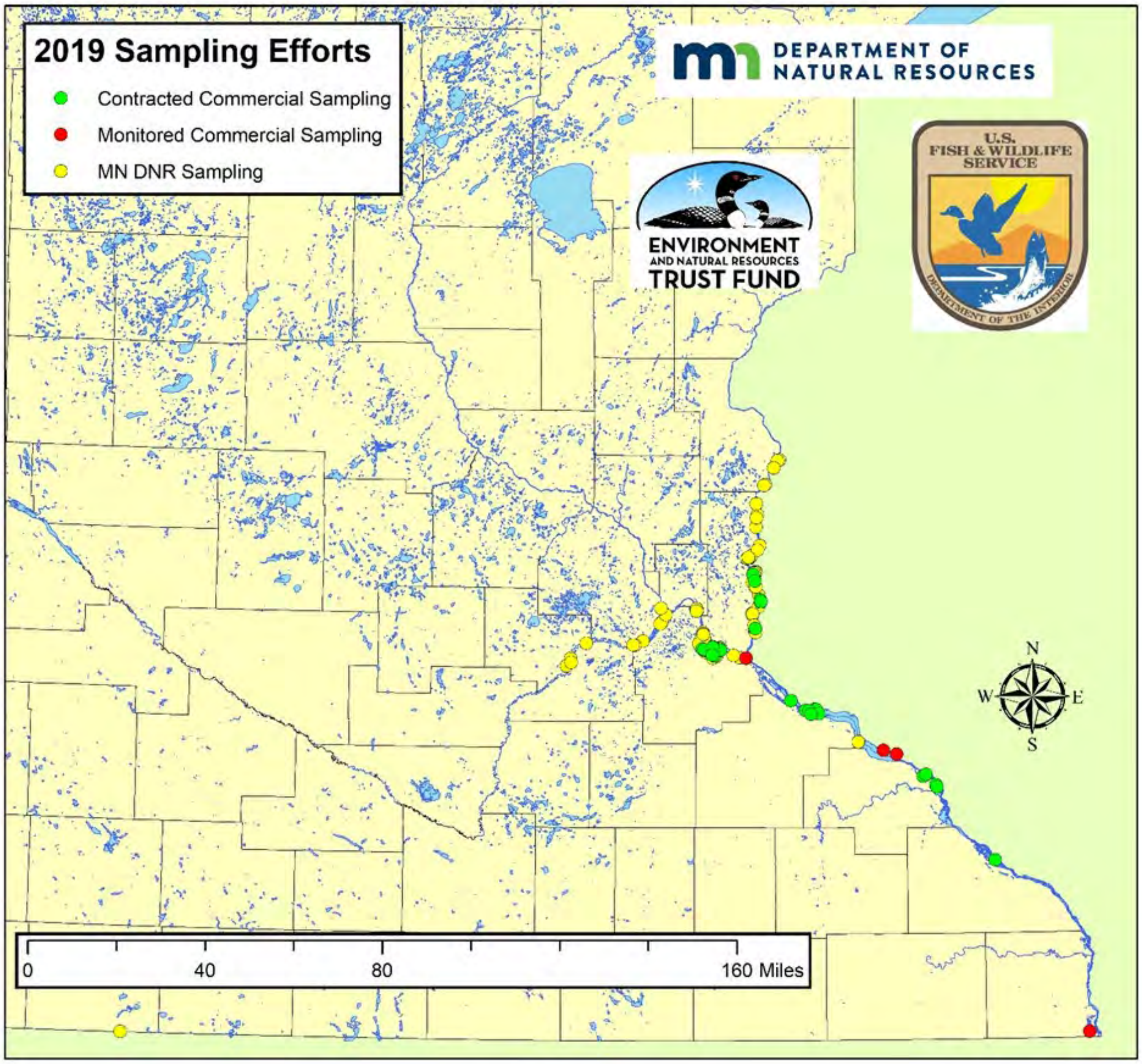
In 2020, multiple invasive carp were permitted to be tagged, released and then tracked by both passive telemetry (using an elaborate receiver array already in place) and active tracking (using finer scale tracking techniques) to determine preferred habitats and movement patterns. Ultimately the goal is to re-capture tagged fish and remove other invasive carp caught. Invasive carp caught, tagged, and released in Minnesota waters follow protocols defined in the MN DNR invasive carp tagging permit (MNDNR 2020).

In 2020, a real-time receiver was be deployed on the St. Croix River to provide the details of the tagged Bighead Carp (or subsequent tagged invasive carp) through emails and/or text messages. Similar to acoustic receivers already in place, the receiver (a VEMCO VR2C cabled receiver) is able to receive, decode, and log transmissions from tagged fish in the area including the fish’s unique identification number. In addition, this receiver is fitted with solar panels and a modem to transmit the data of specific fish electronically through 4G telecommunications to the MN DNR invasive carp crew without the need to be in the field actively tracking the fish. This real-time receiver was placed in an area that can be effectively blocked off and extensively sampled to provide the best opportunity for recapture or the capture of additional invasive carp schooling with the tagged individual. Additional real time receivers will be built and deployed in strategic locations.

The described activities require a special permit issued by DNR Division of Ecological and Water Resources (EWR; MNDNR 2020). For more details regarding this permit, please contact the MN DNR for a copy. For results from the first tagged invasive carp in Minnesota, see the 2017- Present invasive carp sampling reports.

Invasive Carp Response Actions
An appropriate combination of the above activities will be used to respond to captures of invasive carp in the presence front. In addition, the MN DNR implemented a Modified Unified Method exercise in Pool 8 as a test for this developing tool. Planning for the MUM began in July 2020 and involved weekly internal meetings between project managers and project sponsor, and monthly to bi-monthly meetings with partner agencies including USGS, USFWS and WI DNR. Planning and preparation for the MUM continued until the project occurred April 5 - 9, 2021. Substantial administrative and field-based planning and preparation was required to pull off this project. Thirty-one silver carp were captured and removed during the five day MUM event. All project partners were satisfied with the outcome of the project and expressed interest in continuing the partnership for future invasive carp management projects on the Mississippi River. All intentions set at the beginning of the project were met.

Map of Project Area:



Minnesota DNR 2021 invasive carp sampling area. Map depicts 2019 sampling locations which will be similar in 2021 with added effort in the furthest downstream reach (Pool 8).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Gill/Trammel Netting	March – November (2021/22)
Electrofishing	May – September (2021/22)
Larval Trawling	May – July (2021/22)
Commercial Seining	Year round (2021/22)
Commercial Gill Netting	Year round (2021/22)
Carp Tracking	Year round (2021/22)
Data Analysis	November – March (2021/22)

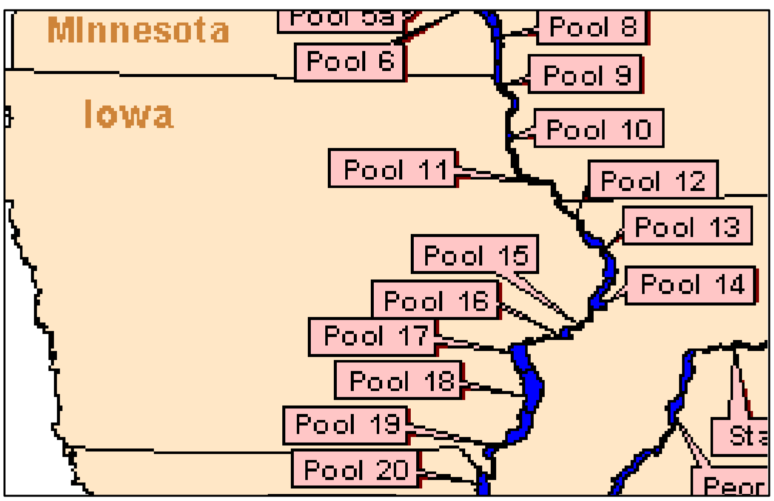
Agency: Iowa State University (IADNR)

Activities and Methods: Ichthyoplankton tows (0.5 m diameter net) will be conducted at the surface at a constant boat speed relative to the shoreline up to four minutes depending on debris load every 10 days during May and June 2022 in pools 14-16 of the Mississippi River. A General Oceanics flowmeter will be mounted in the mouth of the net to estimate volume of water filtered during each tow. Three tows will be conducted at each site parallel to river flow. At tributary confluences, samples will be collected 1 km upstream, 1 km downstream, and 1 km up tributary mouths to evaluate the contribution of tributaries to Invasive carp reproduction. The first tow at each location will be in the main thalweg for drifting eggs and larvae (<24 hours post fertilization), the second in the middle of the river, and the third will be in an adjacent side channel for mobile larvae (>24 hours post fertilization). After each tow, ichthyoplankton net contents will be rinsed toward the cod end, placed in sample jars, and preserved in 95% ethanol.

Zooplankton will be collected in conjunction with each ichthyoplankton tow every 10 days. Samples will be collected from a stationary boat position in side channel and backwater habitats. Triplicate zooplankton samples will be collected at each site with an integrated tube sampler (5 cm diameter, 50 cm length), filtered through a 63-µm mesh sieve, combined into a composite sample, and preserved using Lugol’s solution. In the laboratory, zooplankton samples will be identified to suborder or family and enumerated for total density (number/L).

Map of Project Area:

Map depicting pools in the Upper Mississippi River in Iowa. Ichthyoplankton will be sampled in pools 14, 15, and 16 at the mouths of the Wapsipinicon and Rock (Illinois) rivers and in pool 16 in the UMR. Map was obtained from https://www.umesc.usgs.gov/images/maps/rivers/all_pools_marked.gif



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Ichthyoplankton tows and zooplankton sampling	May-June 2022

Sample processing in the laboratory	May - October 2022

Literature Cited:

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Evaluation of controls on density and behaviors of invasive carp in the lower UMR

Lead Agency and Author: US Fish and Wildlife Service (USFWS), Wesley Bouska (wesley_bouska@fws.gov) and Mark Fritts (mark_fritts@fws.gov)

Cooperating Agencies: Illinois Natural History Survey (INHS), and Illinois Department of Natural Resources (Western Illinois University), Missouri Department of Conservation (MDC), US Geological Survey (USGS).

Statement of Need: In the Upper Mississippi River, Lock and Dam 19 (LD19) in Keokuk, IA (rkm 2122), is a barrier to upstream fish movement except for movement through the navigation lock chamber (Wilcox et al. 2004). Contracted fishing and research funded through the UMR Invasive carp partnership show high densities of invasive carps below LD19 while populations above the dam exhibit drastically lower densities with limited reproduction (WIU & ILDNR 2018; MDC 2017). The Upper Mississippi River (UMR) invasive carp partnership has identified the area from LD 15 downstream to LD 19 as the Intensive Management Zone (IMZ) for Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*). Contracted removal efforts have been implemented in this zone since 2016, but the impacts of those efforts are largely unknown. Furthermore, additional contract removals in pools 20-22 were slated to begin in FY20 but were not fully implemented due to Covid-19 safeguards. A robust stock assessment program is needed to more directly evaluate how populations of invasive carps may be affected by current contract removals and to forecast their future response to alternative removal strategies. A robust stock assessment program should incorporate information from multiple fishery-dependent and independent sources to provide the least-biased composite estimate of carp abundance, biomass, demographic distributions, and migratory tendencies. Therefore, the primary objective of this plan is to describe a unified stock assessment program that will provide a system of data-driven feedback loops that managers can use to evaluate the impacts of their previous management decisions and consider alternative management strategies for the future.

Sampling planned for 2020 was largely canceled due to work and travel restrictions related to covid-19. Hydroacoustic surveys and the accompanying physical sampling, did not occur. Attempts to evaluate invasive carp populations with hydroacoustics and physical sampling were last conducted in 2019 at pools 16-19. High water conditions and low carp densities resulted in no invasive carp being collected. Consequently, we did not have the robust fish community data necessary to calculate species specific density and abundance estimates, but hydroacoustic data across all pools showed significantly greater densities of large-bodied fishes occupying backwater habitats compared to side channels and main channel borders.

In FY21, stock assessment efforts, including hydroacoustics and fishery-independent physical sampling, will be shifted downstream to Pools 18-20. Pool 20 in particular has much higher densities of invasive carp. Physical sampling effort that will inform hydroacoustics will also be increased 2-3 fold within these pools. In addition to INHS collecting fishery-independent data with traditional electrofishing, and, to ensure the collection of robust fish community data that will be able to accurately describe the invasive carp population relative to other fishes, the USFWS will also be conducting sampling with a novel gear designed to increase catches of invasive carp, the electrified dozer trawl (Hammen et al. 2018). Over time, these data will help us gain a better understanding of the amount of physical sampling necessary to accomplish this work across UMR pools of varying invasive carp densities and annual effort can then be adjusted accordingly.

Objectives:

1. Determine Silver and Bighead Carp population densities via hydroacoustics surveys in Pools 18-20.
2. Conduct fishery-independent monitoring to support hydroacoustics surveys and deliver data on demographic parameters of Silver and Bighead Carp in Pools 18-20.
3. Monitor spatial and temporal trends in Silver and Bighead Carp movements in response to contract removals and environmental changes using sonic telemetry in Pools 5A-20
4. Use light traps to establish an annual index of spawning activity by Invasive carps in Pool 19.

Agency: U.S. Fish and Wildlife Service (USFWS)

Activities and Methods:

Hydroacoustics surveys in Pools 18-20

In support of Objective 1, the USFWS will conduct hydroacoustic surveys to obtain data on the relative abundance, size distribution, spatial distribution, and biomass of Bighead Carp and Silver Carp in Pools 18-20. Hydroacoustic sampling is the least size-biased sampling gear currently available to fisheries professionals, thereby providing more accurate relative abundance and size distribution information for stock assessment purposes. Furthermore, the large spatial coverage capabilities of hydroacoustics can provide more precise and accurate relative abundance estimates, particularly for patchily distributed fish such as invasive carp. However, hydroacoustics is not a stand-alone gear, and does require physical fish sampling to separate the overall fish community size distribution into species-specific distributions. Hydroacoustics should be considered as a component of a larger comprehensive stock assessment program that is required for monitoring invasive carp populations and evaluating control efforts.

USFWS will conduct mobile hydroacoustic surveys in pools 18-20 of the UMR. Hydroacoustic data will be collected similar to that described in MacNamara et al. (2016). USFWS will use two horizontally oriented split-beam transducers (200 kHz; BioSonics, Inc.) offset in angle to maximize water column coverage. Prior to each survey, each transducer will be calibrated on-axis following Foote et al. (1987). Surveys will be conducted from mid-September into October at selected areas of the main channel, side channels, bays and backwaters of pools 18-20. These pools will be subsampled using approximately four-mile long transects along the main channel such that a minimum of 35% of the main channel length of each pool will be sampled, in addition to adjacent off-channel habitats, similar to other large river hydroacoustic monitoring programs (Coulter et al. 2018).

Hydroacoustic data will be analyzed following MacNamara et al. (2016) using Echoview 11.2.3. Single targets will be detected using parameter values from Parker-Stetter et al. (2009). Multiple targets from a single fish will be grouped using Echoview's fish tracking algorithm to reduce the potential of over counting fish targets. The size of fish targets (total length; cm) will be estimated from mean acoustic target strength (dB) using a function specific to side-looking hydroacoustics (Love 1971). Hydroacoustic data will be informed by pool-specific fish community data that will be collected using several fisheries gears. Specifically, pool-specific proportions of fish will be determined for each 1 cm length group from 15-120 cm TL for Silver Carp, Bighead Carp, and other fish species. Length-specific proportions will then be used to categorize acoustically detected fish. Pool-specific length-weight regressions will then be used to estimate length-specific biomass for each species of interest, and density (numeric and mass) will be estimated.

In addition to pool-wide population surveys, additional surveys may also be conducted in FY21 at removal areas that feature real-time receivers. Using the same data collection methods as the pool-wide surveys, these surveys would be conducted before and after contracted harvest events to evaluate harvest efficacy and establish the relationship between hydroacoustic density estimates, harvest CPUE, and real-time fish detection data. Hydroacoustic surveys may also occur along MN/WI border waters of Pool 8 and areas requested by MN DNR upstream of Pool 8 may also be surveyed in an attempt to guide contracted fishers to invasive carp for removal.

Fishery-Independent Monitoring
In support of Objective 2, the USFWS will conduct fishery-independent sampling to collect information on the relative abundance of invasive carp within the UMR fish community. Additionally, physical captures of fishes will facilitate collection of important demographic information (aging structures, individual lengths and weights, sex, tissue samples for genetic and physiologic studies, etc.). Furthermore, hydroacoustics gear requires physical sampling to separate the overall fish community size distribution into species-specific distributions. Fishery-independent sampling, using traditional sampling gears like electrofishing, will be less size selective than commercial netting, and provide more complete estimations of the fish community size structure. The ability to detect small fishes could enhance the capacity to detect sources of invasive carp recruitment and deliver additional data to build mathematical models exploring the response of the UMR population to future contract harvest scenarios.

In FY21, the USFWS will conduct sampling in pools 18-20 using the electrified dozer trawl. The use of an experimental gear (the electrified dozer trawl) will complement the traditional LTRM style electrofishing that will be occurring simultaneously in these pools by INHS (see sections below) with the intent of increasing the capture probability of invasive carps. Dozer trawling sites will be selected through a stratified random sampling design that will cover main channel border, side-channel, and backwater habitats in each pool. In August and September of 2021, the USFWS will conduct fishery-independent dozer trawl surveys at up to 35 sites in pool 18, 50 sites in Pool 19, and 25 sites in Pool 20.

USFWS staff will be following an adaptive monitoring approach while implementing this program as an intertwined component of the larger comprehensive stock assessment. Sampling protocols may be re-evaluated in the future to include additional gears, and to expand or contract effort among pools depending on data needs and funding availability. Data generated via fishery-independent sampling will be integrated into a regional database designed to facilitate rapid data processing and sharing with invasive carp researchers. These data will also be available to other researchers studying elements of UMR fish communities. The USFWS will submit a brief annual report to summarize the data.

Telemetry

In support of Objective 3, the USFWS will continue to maintain an extensive acoustic telemetry network in Pools 5a-20. Over 500 Silver Carp and Bighead Carp currently carry functional tags and provide information on the movements of invasive carp throughout the UMR. The primary function of the telemetry program is to provide information about congregations of invasive carp to maximize contract harvest efforts, identify priority locations for potential deterrent technologies and determine both individual and mass movements of invasive carp among pools and tributaries of the UMR. Real-time receivers will be deployed in Boston Bay (Pool 18), Cleveland Slough (Pool 17), Big Timber (Pool 17), and Credit Island (Pool 16) to provide daily updates to INHS and the contracted commercial fishers from March-Nov 2021. This specialized technology allows INHS personnel to accurately direct the timing and location of fishing efforts to maximize harvest rates. The USFWS will coordinate efforts with multiple agencies including MDC, who maintain receivers in the UMR below Pool 20; MN DNR, who maintain receivers in the UMR above Pool 5a (see sections below); INHS, who use stationary and real-time receiver data to direct commercial fishing removals; and USGS who also maintain telemetry equipment on the UMR and house the telemetry database.

Data generated from the telemetry program are being used to monitor spatial and temporal trends in Silver and Bighead Carp movements in response to contract removals, actively direct contract removal efforts, and increase the efficiency of control and deterrence techniques and technologies. These data are also being used to generate complex temporal-spatial analyses that will be used to produce scientific manuscripts during FY 21-22.

Map of Project Area:

Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Hydroacoustic evaluation concurrent with removals	16-19	Spring	2021
Hydroacoustic Pool Surveys	18-20	Fall	2021
Hydroacoustic Surveys in MN/WI Border Waters	8	Spring	2021
Fishery-Independent Data Collection	18-20	Aug/Sept	2021
Deploy Acoustic Array	5a-20	Spring	2021
Capture and Tag Additional Invasive Carp	TBD	TBD	2021
Download Data from Stationary Receivers	5a-20	Every 4-6 weeks	2021
Annual Report	3-21	March	2022

Agency: Iowa State University (IADNR)

Activities and Methods: In support of Objective 3, Iowa State University will install acoustic receivers in the Des Moines, Iowa, and Cedar rivers to provide better detection coverage of existing receivers (n=3 in Des Moines River, n=5 in Iowa and Cedar rivers) within the rivers currently operated by Missouri Department of Conservation and US Fish and Wildlife Service. We will then tag 60 invasive carp in the Des Moines River (30 between Red Rock and Ottumwa, 30 below Ottumwa) and 30 in the Iowa River during the summer and fall when individuals from the Mississippi River would not be migrating up tributaries for spawning. Battery life of Vemco V16 acoustic tags is up to 10 years. We will monitor movement of fish for multiple years to assess seasonal movement under various annual flow regimes. We can then evaluate movement patterns of these fish compared to those already tagged in the Mississippi River to test for variation in movement and behaviors and upstream and downstream passage through the Ottumwa Dam among the different groups.

Map of Project Area:

Potential acoustic receiver deployment locations in the Des Moines, Iowa, and Cedar rivers in southeastern Iowa.

Estimated Timetable for Activities:

Project Activity	Season
Deploy acoustic receivers in tributaries	Summer 2021-Spring 2022
Tag invasive carp with acoustic tags	Fall 2021-Spring 2022

Download acoustic receivers and assess movements	Summer 2022

Agency: Illinois Natural History Survey (INHS) and the Illinois Department of Natural Resources (IL DNR)

Activities and Methods:

Fishery-independent sampling

In support of Objective 2, the INHS will conduct fishery-independent sampling to collect information on the relative abundance of invasive carp within the UMR fish community. Physical captures of fishes will facilitate collection of important demographic information (individual lengths and weights, etc.), and additionally will provide the information needed to separate the hydroacoustics overall fish community size distribution into species-specific distributions. Fishery-independent sampling using traditional sampling gears like electrofishing will be less size selective than commercial netting, and provide more robust estimations of the fish community size structure. The ability to detect small fishes could enhance our capacity to detect sources of invasive carp recruitment and deliver additional data to build mathematical models exploring the response of the UMR population to future contract harvest scenarios.

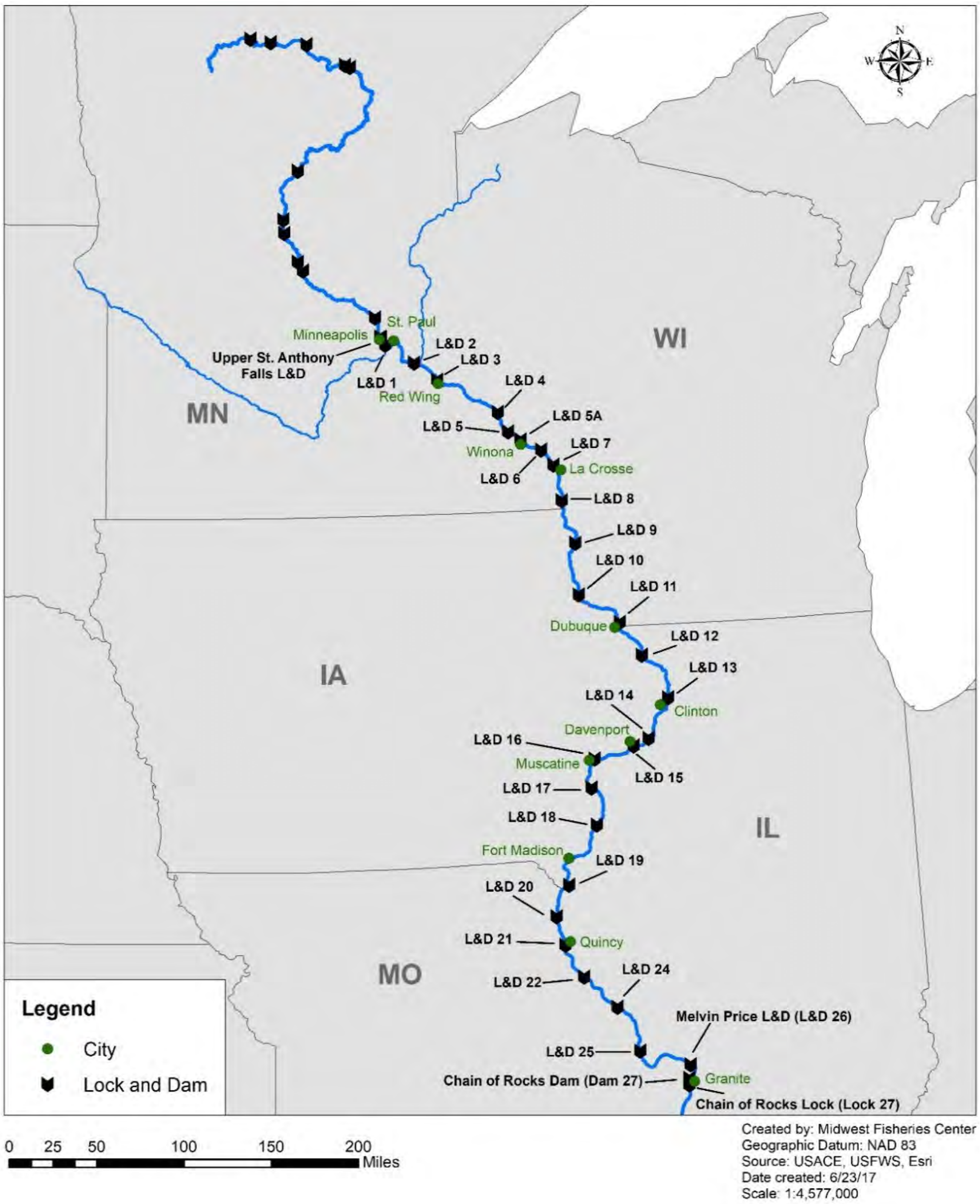
The INHS Illinois River Biological Station currently maintains an extensive standardized electrofishing program called the Long-term Survey and Assessment of Large River Fishes in Illinois or the Long-term Electrofishing Program (LTEF). The program uses pulsed-direct current electrofishing to sample fish communities at randomly selected locations throughout Pools 16-21 of the Mississippi River. The program operates on a tri-annual sampling schedule and traditionally has limited sampling to main channel border habitats. However, starting in FY19, additional funding was provided to expand sampling in Pools 16-19 to backwater and side-channel habitats that represent preferred habitats for invasive carp.

After a covid-related hiatus in 2020, the LTEF program in FY21 will again provide supporting data that can be used to calibrate estimates of invasive carp derived from hydroacoustics surveys as well as a source of information about the relative abundance of invasive carp in the UMR. Expanded LTEF effort in FY21 will be focused on Pools 18-20. Electrofishing sites will be selected through a stratified random sampling design that will represent main channel border, side-channel, and backwater habitats in each pool. In the fall of 2021, the INHS will conduct additional fishery-independent electrofishing surveys at up to 30 sites in pool 18, 40 sites in Pool 19, and 20 sites in Pool 20.

Larval light trapping

Evidence of invasive carp reproduction was detected as early as 2009 in pool 19 of the Upper Mississippi River, indicating that areas of the UMR above LD19 are capable of providing the hydrological requirements needed for successful invasive carp spawning, egg maturation, and development. This also indicates that adult invasive carp have reached densities high enough to allow potential mates to find each other and spawn successfully. Monitoring for larval and juvenile invasive carps in pool 19 will detect and quantify invasive carp reproduction and any potential reproductive response by invasive carp to control strategies. Sampling will be conducted with light traps at specific sites in pool 19 as an annual index of spawning activity. Data processing (e.g., larval sorting and identification, and data analysis) will occur during the fall and winter months.

Map of Project Area:



Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Fishery-Independent Data Collection	18-20	Fall	2021
Larval Light Trapping	19	Spring	2021
Executive Summary	14-19	October	2021
Annual Report	14-19	March	2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods:

Telemetry

In support of Objective 4, MDC will continue to maintain an extensive acoustic telemetry network from Pool 20 downstream into the Lower Mississippi River. MDC has over 200 Silver and Bighead Carp with active transmitters in Pool 20. The primary function of the telemetry program below Lock and Dam 19 is to provide information about invasive carp passage above Lock and Dam 19 into the Intensive Management Zone and to identify potential deterrent locations, but it also provides information about movements of invasive carp among pools and tributaries of the UMR and other basins. Specifically, the funds requested this fiscal year will allow MDC to increase coverage in the lower pools (20-26). A pair of stationary receivers will be placed above and below each lock and dam to track the number of tagged invasive carp within each pool, individual residency time, and transition rates between pools and basins.

Data from the lower pool telemetry efforts will help fill in information gaps, inform removal efforts, and describe movements of invasive carp in response to contract removal. These data will also be available to inform complex temporal-spatial models (i.e., SEACarP) that could be developed for the UMR.

MDC will coordinate with the UMR Partnership to ensure data is shared and updates are provided.

Map of Project Area:

Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Deploy Acoustic Array	20-26	Summer/Fall	2021
Capture and Tag Additional Invasive Carp	20-26	Fall	2021
Download Data from Stationary Receivers	20-26	Every 4-6 weeks	2021/2022
Annual Report	20-26	March	2022

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Contract Fishing for Invasive Carp Detection and Removal

Lead Agency and Author: Illinois Department of Natural Resources (ILDNR) / Illinois Natural History Survey (INHS), Jim Lamer (lamer@illinois.edu)

Cooperating Agencies: Missouri Department of Conservation (MDC), Iowa Department of Natural Resources(IADNR), US Fish and Wildlife Service (FWS)

Statement of Need: Adult bighead, grass, and silver carps are present in varying abundance in Upper Mississippi River (UMR); however black carp have not been collected above Lock and Dam 19 (LD19). Dense populations of bighead, grass, and silver carps with reproduction do exists in the lower pools of the Upper Mississippi River (20-26) and moderate populations with limited reproduction/recruitment occur in Pools 18 and 19, with some recent commercial catches being reported as far upstream as the Rock River and Pool 14. Bighead carp and silver carp (Invasive carp) populations are increasing in abundance and expanding their upstream range within the Upper Mississippi River (UMR). Limited fish passage at Lock and dam 19 (LD19) has slowed their progression and establishment in UMR reaches above Keokuk, IA. However, the detection of young-of –year Invasive carp above LD19, especially a large year class in 2016, indicates that Invasive carp populations have reached densities capable of detectable reproduction. To combat this population expansion and decrease Invasive carp densities at the established front (pools 16, 17, 18, and 19), additional measures are needed to monitor, control and manage Invasive carp while densities are still low and manageable. We propose to use commercial fishers to intensively target Invasive carp species for removal at the established front and invasion front (reaches above pool 16) and determine population abundance to determine the effects of harvest. This reduction in densities will alleviate upstream pressure on potential pinchpoints at Lock and dam 14 and 15, which provide an additional defense to slow the spread and establishment upstream. Removal efforts in pools below Lock and Dam 19, may not directly affect the reduction in reproduction and recruitment in the Intensive Management Zone, but it will reduce the overall density of Invasive carp in the pools in the secondary management zone (Pools 20-22). This reduction in density below Lock and Dam 19 will decrease the number of Invasive carp attempting to pass upstream into the Intensive Management Zone, which will be key in aiding the upstream removal efforts.

Decreasing the abundance and removal of Invasive carp by commercial fishers has been successfully executed in the upper IL River to decrease pressure on the electric dispersal barrier. This targeted system of removal is needed in the UMR above LD19 as populations have attained densities high enough to support reproduction and continue to be detected in far northern reaches of the UMR in Wisconsin and Minnesota. Lock and dam 19 is a high head dam with a maximum head difference of 38 ft, restricting all upstream fish passage to the 1200 foot lock chamber. Even though this limited passage has slowed the infiltration and establishment of Invasive carp above LD19, they have now reached densities that are increasingly detectable (jumping silver carp), capable of finding mates to support reproduction, and can be sufficiently targeted in known areas of aggregation throughout their established front. The targeted removal of 100,000 – 200,000 lbs of Invasive carp annually will help reduce their ecological impact, slow their spread and establishment in the UMR above LD19 and decrease their effective population size. Furthermore, by decreasing their population size we will reduce their opportunities to find mates

(Allee effect) and reduce the probability of successful spawning interactions. Total counts and biomass will be recorded from all locations and fish will be available for further scientific inquiry (e.g., age and growth studies, genetic identity, morphometric identification, condition factor, etc.). Total counts and biomass will be directly correlated with recovered jaw tags and population estimates.

Evidence of Invasive carp reproduction was detected as early as 2009 in pool 19, and indicates that areas of the UMR above LD19 are capable of providing the hydrological requirements needed for successful Invasive carp spawning, egg maturation, and development. This is reinforced with FWS/USGS telemetry movement information. Furthermore, this indicates that Invasive carp have reached densities high enough to allow for potential mates to find each other and spawn successfully. The highest abundance of adult Invasive carp above LD19 occurs in pools 17, 18, and 19, and larvae and young-of-year Invasive carp have been detected from pools 16, 18, and 19.

With efforts in the Pools above Lock and Dam 19 to reduce abundance and eliminate reproduction potential, reducing the number of Invasive carp attempting to pass upstream from lower pools will also be a component in this effort. The Illinois River has experienced success with contract removal in the Upper Pools reducing pressure on the electric barrier and stopped the upstream expansion, but an effort to reduce the population below the invasion front has also been shown to reduce the overall relative abundance (2020 Invasive carp Action Plan). Learning from the Illinois River model, a multipronged approach with removal above the invasion front in Pools 14-19 and removal efforts below Lock and Dam 19 in Pools 20-22 will not only reduce the likelihood of upstream expansion and but also reduce the overall abundance of Invasive carp.

Objectives:

1. Targeted removal of Invasive carp species in UMR pools 14-22 using contracted commercial fishers and intensive agency netting in Pools 14-19.
2. To intensively target backwaters in Pools 14-19 for Invasive carp removal by contracted commercial fishers during periods of peak backwater aggregation for 4 weeks in March and April, 2022
3. Collect Invasive carp demographic information that can be used to inform harvest from Pools 16-22.

Agency: Illinois DNR (Illinois Natural History Survey)

Activities and Methods: The sampling design includes agency sampling and the use of contracted commercial fishers to intensively capture Invasive carp species using a variety of trammel nets, gill nets, hoop nets, and a commercial seine. Nets used will be large mesh (3.0-5.0 inches (76.2-127 mm)) trammel or gill nets 8-10 feet (2.4-3 m) high and in lengths of 200 yards (182.9 m). Sets will be of short duration and include driving fish into the nets with noise (e.g., plungers on the water surface, pounding on boat hulls, or racing tipped up motors). In lower density areas, dead sets may be set over night (no more than 15 hours and only in water temperatures below 75 F) and emptied first thing each morning. Otherwise, nets will be attended at all times. Captured fish will be identified to species and enumerated. Species, numbers and condition (i.e., healthy, moribund, dead) of all non-target species captured in nets will be recorded and reported in interim reports. Locations of net sets will be recorded with GPS coordinates (decimal degrees preferred). An INHS or IL DNR biologist or technician will be assigned to each commercial net boat to monitor operations and record data. Netting efforts and locations of sets will be guided by the expertise of the commercial fishers and will also be informed by telemetry efforts by USGS and USFWS conducted as part of the intensive monitoring efforts within this reach.

INHS biologists will be assigned to each commercial net boat to monitor operations and record data. These duties will include recording species, length (mm), and weight (g), on up to 100 Invasive carp species per boat, per week. Total length will be recorded for all or a subset of bycatch per boat, per week. Invasive carp species will be counted and weighed in bulk to determine a total biomass removal for each day for each species. Duties also include monitoring the safe return of native bycatch, recording water quality data, tagged fish information and site information, monitoring for telemetered and tagged fish, and working with USFWS and USGS telemetry crews to help inform netting efforts. All telemetered fish captured will be returned to the water immediately. The tags will be decoded if possible before returning the fish to the water, and the information provided to the respective agency. All non-target bycatch will be identified to species, enumerated, and condition recorded (i.e. healthy, moribund, dead). All native bycatch will be returned to the water upon removal from the nets and all other non-native species will be removed, but total weights kept separate from Invasive carp biomass. Body condition and gonad weight will be collected monthly and aging structures collected in November through January to be consistent with previous sampling. These data will be used to monitor for declining trends in density dependent response variables in response to harvest and also to help inform spatially explicit models to help direct fishing effort.

All fish removed throughout the study will be transported daily to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA) where all fish will be iced down in large totes and used as fertilizer or as cut bait. Fish cannot be marketed and sold by the contracted commercial fishers and the fish cannot be used for human consumption. All INHS biologists and technicians participating in the removal will be required to possess an Illinois sportfishing license.

Objective 1: Targeted removal of Invasive carp species in UMR pools 14-19 using contracted commercial fishers and intensive agency netting

Following the initial four weeks of capturing, tagging, and releasing Invasive carp in pools 17-19, two contracted commercial fishing crews will operate for a total of 17 weeks in pools 14-19 for targeted removal of Invasive carps. Targeted removal efforts will alternate between pools, with approximately 15 of the 17 weeks of effort split between pools 17-19 (pool 17 = 4 weeks, pool 18 = 4 weeks, pool 19 = 7 weeks). Two weeks of effort will be devoted to pools 14-16, where Invasive carp are present but not in high enough densities to effectively target large numbers of Invasive carp.

Each commercial fisher boat crew will fish every other week from 8 am to 5 pm, Tuesday – Friday. Additional INHS watercraft will be used to assist commercial netting efforts, especially shallow water vessels capable of driving fishes from shallow American lotus beds and shallow backwaters.

The goal for targeted removal of Invasive carp species above LD 19 is 200,000-300,000 lbs.

Length and weight will be recorded from each Invasive carp prior to being sacrificed; individual jaw tag numbers will be recorded for all recaptured Invasive carp. Non-target bycatch will be identified to species, enumerated, and condition recorded (i.e. healthy, moribund, dead) prior to release. All non-native species, other than Invasive carp species, will be removed and transported to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA) for use as liquid fertilizer

Objective 2: To intensively target backwaters in Pools 14-19 for Invasive carp removal by contracted commercial fishers during periods of peak backwater aggregation for 4 weeks in March and April, 2021

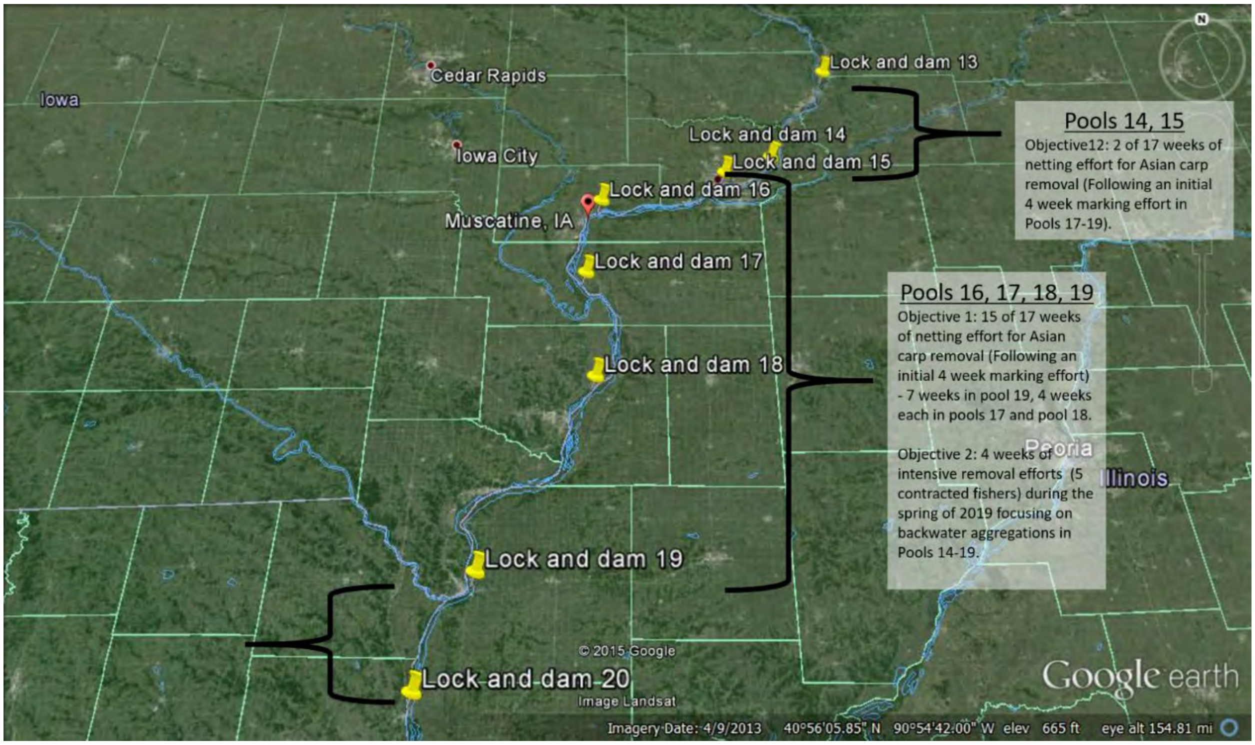
Three additional fishing crews will fish and remove Invasive carp for a 4 week period in March and April in Pools 14-19 (time period of high density Invasive carp backwater aggregation). This four week window has consistently been shown by USFWS-La Crosse to be a time of high density Invasive carp aggregation in backwaters as they stage, conserve energy, and feed, prior to leaving the backwaters to spawn. This is the most predictable time to intensively target Invasive carp populations in Upper Mississippi River backwaters. Given the large spatial scale of the Upper Mississippi River, this is a difficult distance to fish intensively and dedicate adequate fishing coverage during the spring high density backwater aggregation. Multiple crews spread out between the pools will allow for a much more effective and efficient harvest from Pools 17-19 and allow for mass removal within a small time frame. Additionally, since this is a predictable backwater staging time for the intensively fished lower pools (higher density pools), it is likely that upper pools that contain very low, hard to target densities, contain similar Invasive carp backwater use and behavior during this time period. This would provide personnel to dedicate effort to these upper pools in this 4 week window, which would greatly enhance our success of removal in these areas. The unpredictable behavior of Invasive carp outside of this time period, makes targeting low concentrations very difficult, especially in the absence of acoustically tagged fish in these areas. Commercial fishers during this time will also be required to assist with pound net deployment and emptying if these gears are utilized during this time.

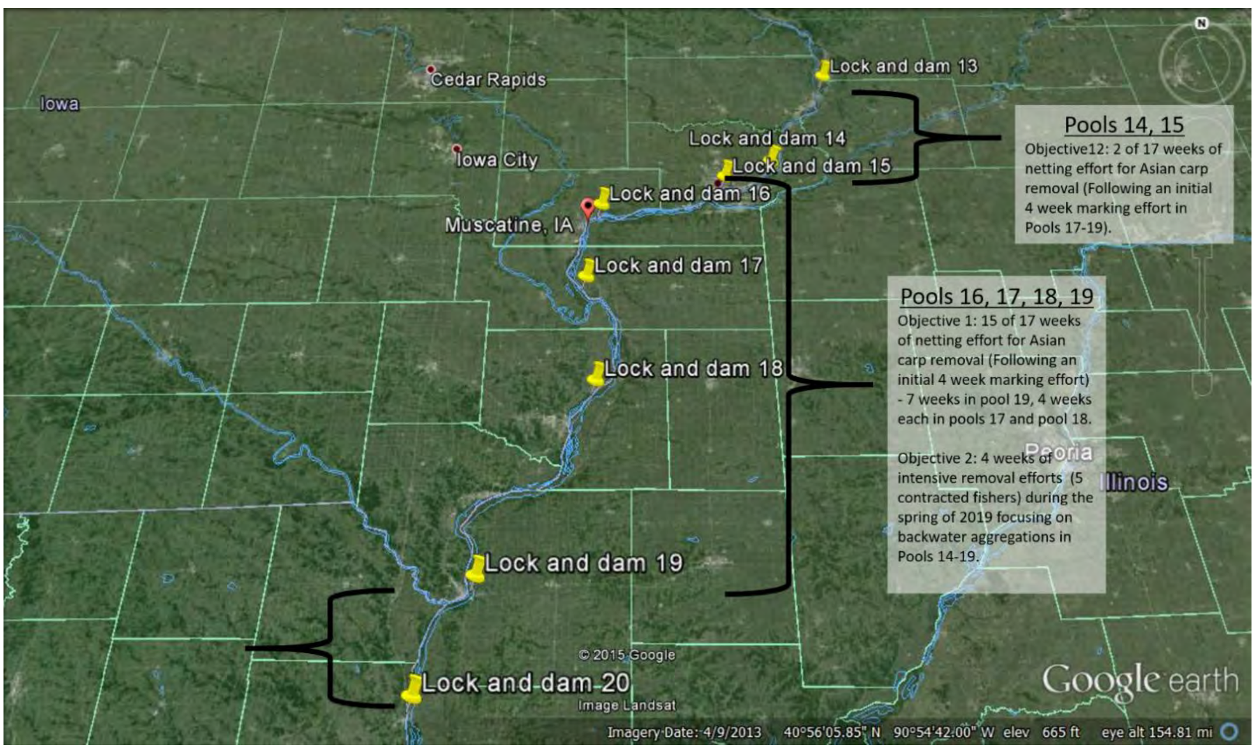
Length and weight will be recorded from each Invasive carp prior to being sacrificed; individual jaw tag numbers will be recorded for all recaptured Invasive carp. Non-target bycatch will be identified to species, enumerated, and condition recorded (i.e. healthy, moribund, dead) prior to release. All non-native species, other than Invasive carp species, will be removed and transported daily to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA).

Objective 3: Collect Invasive carp demographic information that can be used to inform harvest from Pools 16-19

During contracted fishing, INHS crews will monthly collect up to 100 bighead carp and silver carp (50 per species) from Pools 16-19. Fish length and weight will be recorded to incorporate into body condition and vital rates analysis. All fish will be dissected, gonads visually staged, removed and weighed for GSI and egg condition analyses. Additionally, within the time range of November through January, 100 fish of each species from Pools 16-19 will be collected and aging structures removed (pectoral spines, postcleithra, and lapillus otoliths) to be used in model growth and vital rate analyses. These data will be used to monitor for declining trends in density dependent response variables in response to harvest and also to help inform spatially explicit models to help direct fishing effort. All results will be summarized in the annual report and formatted for SEACARP modeling.

Map of Project Area:





Estimated Timetable for Activities:

Project Activity	Pool	Month	Year
Harvest	14-19	August-July	2021-2022
Intensive harvest	16-19	April	2021
Demographics	14-19	Yearly	2021-2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: MDC will continue an Invasive carp harvest program that will employ contract fishing to support Objective 1. Methods have been employed since 2020 and by neighboring states and will inform the most effective approach for 2023 Missouri Invasive carp control and management. Missouri removal efforts will occur in Pools 20, 21, and 22 to alleviate upstream pressure on Lock and Dam 19 and further spread into the Intensive Management Zone above Lock and Dam 19. Removal efforts will take place in the fall and winter of 2021 as river conditions permit and contracts are in place. Effort will be spread throughout the three pools with an overall goal of removing at least 1,000,000 pounds.

In support of Objective 3, the agency will cost share to support a biologist that will be coordinating removal efforts, pick up for harvested Invasive carp by contractor (coordinating with IL and KY for pick up if a certain number of pounds are harvested), and the collection of fishery dependent demographic data. Similar to what INHS and IDNR will be doing in the upper pools, length and weight will be recorded from Invasive carp prior to being sacrificed and bycatch will be identified to species, enumerated, and disposition will be recorded (i.e., healthy, moribund, dead) prior to release. MDC biologist will collect up to 100 Bighead and Silver carp (50 per species) to collect more specific data such as sex, GSI, and fecundity. The aging structure (lapilli otoliths) will be collected from those 100 individuals from in Pool (20-22) to be used to populate harvest models and also serve as a measure to look at trends through time to evaluate the effects of harvest.

Map of Project Area:

Estimated Timetable for Activities:

Activity	Pool	Time Period (Season, month/year)
Invasive carp removal	20,21,22	Fall and Winter 2021
Demographic Data Collection	20,21,22	Fall and Winter 2021
Data Summary/Analysis	20,21,22	Winter 2021/2022
Annual Report	20,21,22	Mar-22

Literature Cited:

2020 Asian Carp Action Plan. http://www.asiancarp.us/PlansReports.

Evaluation of fish passage for assessment of invasive carp deterrents at locks in the Upper Mississippi River

Lead Agency and Author: US Geological Survey, UMESC, Andrea Fritts (afritts@usgs.gov)

Cooperating Agencies: Illinois Natural History Survey (INHS), Missouri Department of Conservation (MDC), US Fish and Wildlife Service (USFWS), US Army Corp of Engineers (USACE)

Statement of Need: Invasive carp are established in the upper, middle, and lower Mississippi River and their expansion upstream threatens a variety of aquatic ecosystem services including fishing and recreational boating. The physical and operational characteristics of Lock and Dam (LD) 19 restrict upstream migration of fishes because the only upstream fish passage route is through the lock chamber. This restriction might be hindering consistent reproduction and recruitment of invasive carps enough to reduce their abundance upstream of LD19. Locks and Dams 14 and 15 (upriver of LD19) are infrequently at open-condition and may also be limiting the continued upstream expansion of invasive carps. Upstream passage of fishes at these locations would be limited to the lock chamber for the majority of the year (Wilcox et al. 2004; Bouska 2021).

Acoustic deterrents have been developed for limiting the range of fish, and those systems show promise in deterring invasive carps. To date, small-scale acoustic deterrents have been tested on many native fishes and invasive carps in labs, outdoor ponds, and small rivers (Vetter et al. 2015, 2017; Murchy et al. 2017). Federal, state, and local partners approved the opportunity to test an experimental underwater Acoustic Deterrent System (uADS) at LD19 on the Mississippi River and this system was installed during Jan-March 2021. Testing of an uADS at a pinch-point dam, such as LD19, may help to prevent immigration into the Intensive Management Zone (IMZ) from Pool 20 and minimize the continued expansion of invasive carp populations in the UMR (Whitledge et al. 2019).

Lock and Dam 19 is an optimal location to test an experimental uADS because fish can only move upstream through the lock chamber and because this location has five years of historical fish passage data that has been collected by the UMR Invasive Carp Team. The partnership has successfully evaluated the seasonal timing of passages of invasive carps and native fish species and evaluated the relation of fish upstream passages with the operation of the lock for river vessels (Fritts et al. 2021). A pivotal discovery from the ongoing work has been the identification of a differential motivation of invasive carps to complete upstream passage at LD19. Invasive carps that were originally tagged upstream of LD19 and moved downstream on their own volition were much more likely to complete upstream passage than invasive carps tagged downstream of LD19 in Pool 20 (Fritts et al. 2021). This observation prompted an experimental translocation effort in 2019, which confirmed the increased likelihood of upstream passage of fish that had prior experience in locations upstream of LD19. In addition, the partnership has gained insights into behavior of invasive carps tagged with depth-sensitive transmitters. Data from these tags provided information about the position of a fish within the water column at LD19 and how fishes interact and respond to river vessel presence in the downstream lock approach and the lock chamber. During spring 2021, four native species (i.e. bigmouth buffalo, lake sturgeon, paddlefish, flathead catfish) were dual tagged with depth-sensitive transmitters to improve understanding of how native species react to the uADS and river vessels at LD19.

Passage data for invasive carps and native species (i.e., paddlefish, bigmouth buffalo) has also been studied at LD15 over the past four years. Locks and Dams 14 and 15 have both been considered as potential locations for deterrents and it is critical to have baseline information on behavior of native and invasive species to inform management decisions including the potential development of uADS at these sites (Upper Mississippi River Asian Carp Partnership 2018).

State and federal partners have identified evaluating the effects of an uADS on native species as a high priority. Vemco telemetry data are currently being collected by MDC, INHS, USFWS and USGS from previously tagged fish (invasive carps and native species) moving through longitudinal and fine-scale arrays of Vemco acoustic receivers at LD 19 and LD 15 (Fig. 1-4). Many of the previously tagged fish will continue to be tracked in addition to the newly tagged fishes. FY21 funds are requested to purchase acoustic transmitters (n = 200) and to provide funding for 1/3 time for an INHS staff member to assist with the deterrent project (e.g., tagging and downloading receivers). Our project proposes continued collection of movement data using Vemco receiver arrays and acoustically tagged fish in the UMR to evaluate the effects of the uADS at LD 19 on invasive carps and native species. Vemco transmitters (n = 100) will be used to tag native fishes in Pool 20 (e.g., bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye) to evaluate native fish response to the uADS. The additional Vemco transmitters (n = 100) will be used to tag invasive carp in proximity to LD 14 and 15 to increase the amount of baseline passage information available at these locations that may be considered for future deterrent implementation. Paddlefish and bigmouth buffalo tags are still active in this area and will continue to provide information on native fish passage at LD 14 and 15.

This project directly addresses multiple aspects of the UMR sub-basin framework, including providing information on evaluating and implementing deterrent measures at strategic pinch points to prevent dispersal of invasive carp and supporting research to develop new containment technologies. This project also closely aligns with the goal of containing expansions of invasive carps in the UMR while minimizing impacts to native species movement.

Objectives:

1. Assess fish behavior and passage rates of invasive carps and native fishes at LD19 to evaluate the performance of an experimental underwater Acoustic Deterrent Systems (uADS) to deter invasive carps while minimizing effects to native species
2. Analyze depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD19
3. Evaluate fish passage dynamics (e.g., route, timing, relation with environmental

variables) for baseline information at LD15 and LD14

4. Use USACE Lock Queue Reports to inform the relationship between fish movements and behavior in relation to lock structures and operation at LDs 14, 15, and 19

Agency: Illinois Natural History Survey (INHS)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14 (Fig. 2-4). In 2021, depth-sensitive transmitters were implanted into 4 paddlefish, 19 bigmouth buffalo, 25 flathead catfish, and 3 lake sturgeon in P20. USGS and partners translocated invasive carps and bigmouth buffalo from locations upstream of LD19 to Pool 20 during spring of 2021 for the uADS evaluation. These fish will be monitored to evaluate the response of invasive carps and native species to the uADS.

FY2021 funds will be used to purchase 200 Vemco transmitters to enhance understanding of native fish behavior in response to the uADS and to collect baseline data on invasive carp passage at LD14 and LD15. (Cost per transmitter = $350; cost for 200 transmitters = $70,000.) Native fish species that may be tagged at LD19 include bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye. Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate. All acoustic transmitters will operate at the same frequency as existing tags in this stretch of the river. FY2021 funds will also be used to provide funding for 1/3 time for an INHS staff member to assist with the deterrent project (e.g., tagging and downloading receivers).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: US Fish and Wildlife Service (USFWS)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14. The USFWS longitudinal receiver array will be redeployed in pools 5A-19 in the spring of 2021 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate.

Tagged fishes will continue to be acoustically tracked to determine the frequency of dam passage and environmental conditions associated with passage.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Deploy longitudinal receiver array	Spring, summer 2021, 2022
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14. The USFWS longitudinal receiver array will be redeployed in pools 5A-19 in the spring of 2021 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate. Tagged fishes will continue to be acoustically tracked to determine the frequency of dam passage and environmental conditions associated with passage.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Maintain longitudinal receiver array	Spring, summer, winter 2021, 2022
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: US Geological Survey (USGS)

Activities and Methods: Fine-scale arrays have been deployed at LD19 (Fig. 2) and LD15 (Fig. 3). During 2021, an additional array was deployed at LD14 (Fig. 4). These arrays will be maintained during 2021-2022. The USGS and the USACE-Engineer Research and Development Center (ERDC) will operate and maintain the experimental uADS at LD19 for up to three years. In collaboration with partners, USGS will analyze telemetry data from the Vemco arrays and the HTI telemetry system deployed at LD19. These telemetry data will be used to evaluate how environmental conditions (e.g., flow, water temperature, season, diel period), lock operations, and operation of the uADS affect native species and invasive carp movement and behavior (including passages) at LD19. USGS will analyze Vemco depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD19 and how fishes respond to the uADS and the operation of the lock for river vessels. In collaboration with INHS, MDC, and USFWS, USGS will tag and translocate bigmouth buffalo and invasive carps (i.e., silver carp, bighead carp, and grass carp) from Pool 19 to Pool 20 with HTI tags during spring 2022 to evaluate the performance of the experimental uADS. No USFWS UMR funds are requested for this translocation component of the study; transmitters will be supplied by USGS in support of the deterrent project.

Silver carp and bighead carp will be tagged in proximity to LDs 14 and 15 to evaluate fish passage dynamics (e.g., route, timing, relation with environmental variables) for baseline information at these locks and dams that are infrequently at open river condition (Wilcox et al. 2004; Bouska 2021). These data will help to inform future decisions on the need for and how to go about deploying deterrents for invasive carps at these locations, while minimizing impacts to native fishes.

Estimated Timetable for Activities:

Activity	**Time Period (Season, month/year)**
Maintain Vemco arrays at LDs 19, 15, 14	Quarterly during 2021, 2022
Tagging	Fall 2021, Spring 2022
Analyze fish behavior, passages, and depth data	Winter 2021, Summer 2022

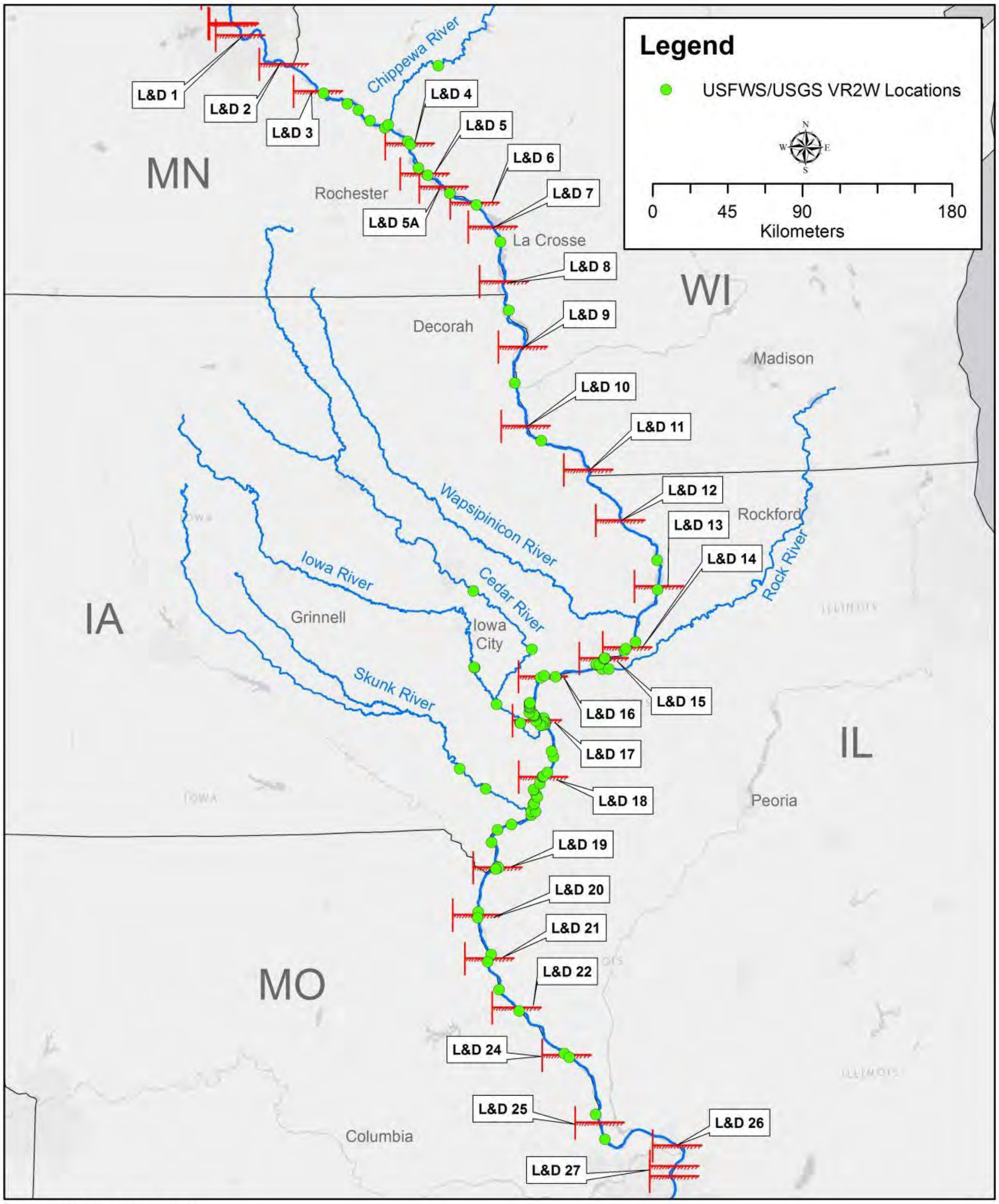
Agency: US Army Corp of Engineers (USACE)

Activities and Methods: In collaboration with partners, the USACE will support studies at strategic locations (e.g. pinch-point dams) to better understand how to deploy deterrents at lock chambers to deter invasive carp while minimizing effects to native species. The USACE will provide Lock Queue Reports for LD19, 15, and 14 on a quarterly basis to evaluate fish movements in relation to lock structures and operation.

Estimated Timetable for Activities:

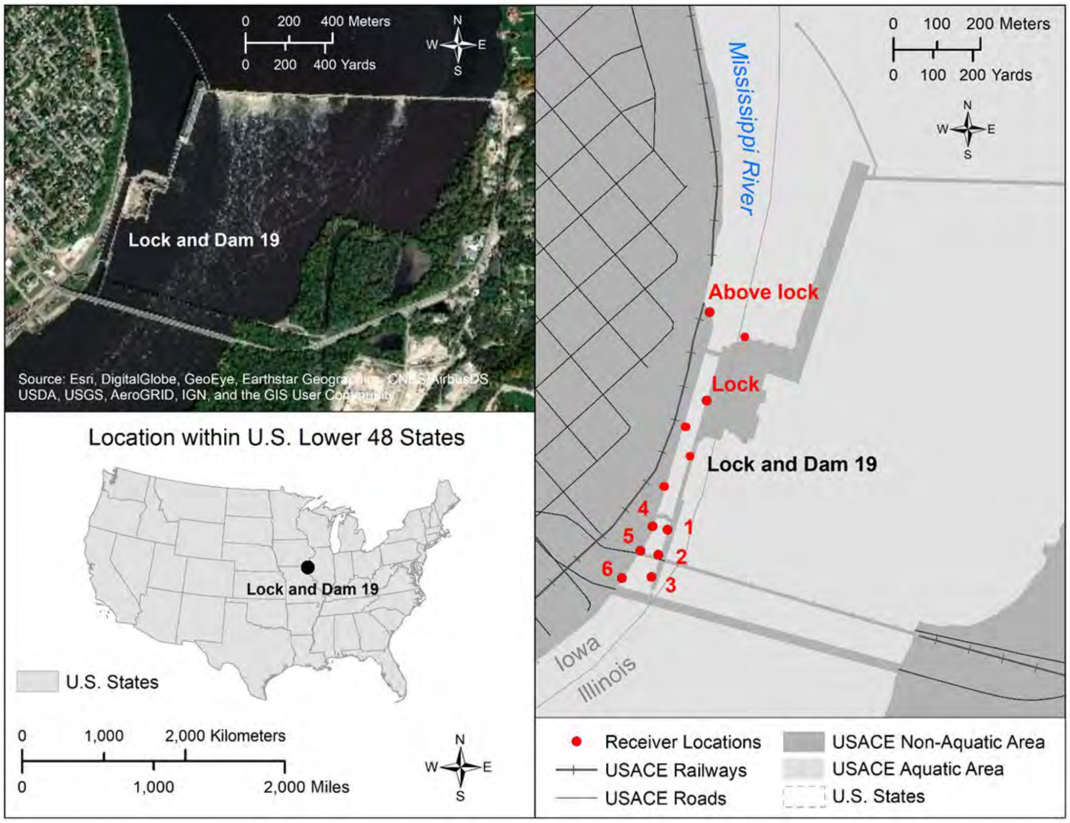
Activity	**Time Period (Season, month/year)**
Provide Lock Queue Reports for LDs 19,15,14	Quarterly during 2021, 2022

Map of Project Area:

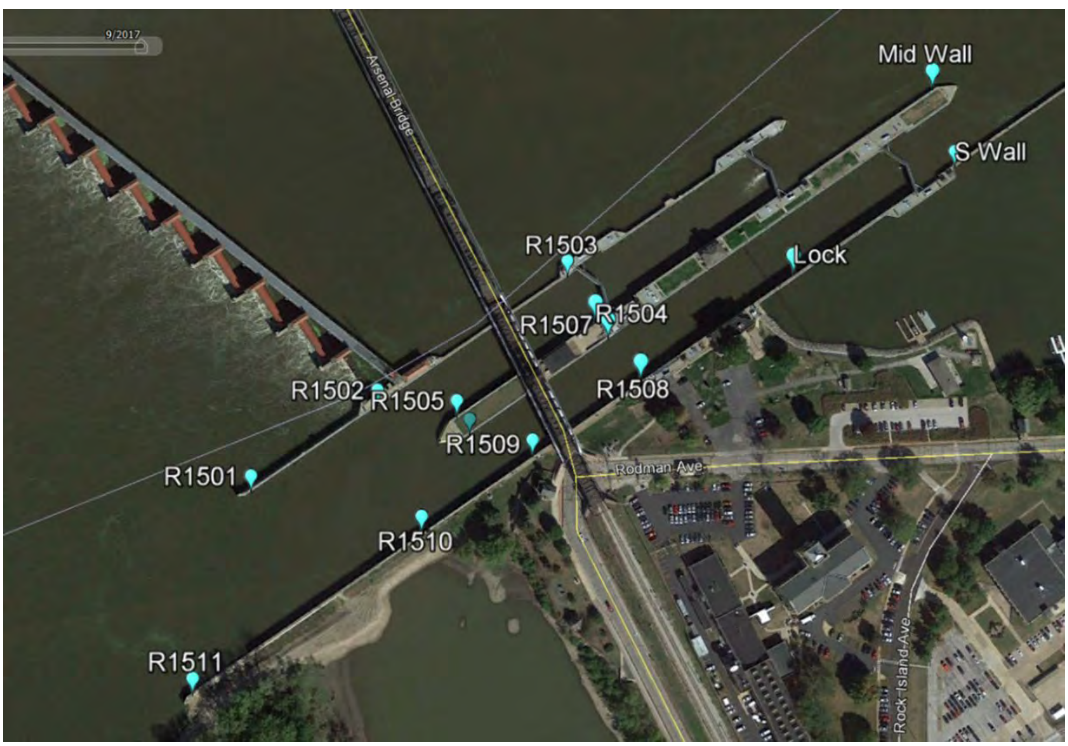


Map created by: Jeena Credico
Sources: USFWS, USGS, and Esri
Scale: 1:3,050,000
Projection: NAD 83 UTM Zone 15N

Locations of stationary receivers in the large-scale longitudinal array deployed in the Mississippi River basin. Receivers are maintained by USFWS and Missouri Department of Conservation.



Location of receivers completing the fine-scale array in the lock approach at Lock 19.



Location of receivers completing the Vemco array in the lock approach at Lock 15.

Location of receivers completing the Vemco array in the lock and lock approaches at Lock and Dam14.

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eDNA Monitoring in the Upper Mississippi River Basin

Lead Agencies and Authors: U.S. Fish and Wildlife Service, Jenna Bloomfield (Jenna_Bloomfield@fws.gov); U.S. Geological Survey, UMESC, Stephen Spear (sfspear@usgs.gov)

Statement of Need: The Intensive Management Zone (IMZ) for Invasive carp (Silver and Bighead carp specifically) in the Upper Mississippi River (UMR) encompasses pools 16-19. Within this zone, a diverse array of management actions and monitoring strategies are being implemented to control and research the established Invasive carp population present there. Hypothetically, a shift in the established population of Invasive carp would first be detectable in the pools immediately upstream of the IMZ. Pools 13 and 14 represent this transitional zone between where Invasive carp are established and reproducing, and where they are more scarce. While Invasive carp are captured and observed in these pools, there is not believed to be an established population. These two pools are not rigorously sampled by other USFWS Invasive carp monitoring efforts. When utilize as part of a long-term monitoring program, eDNA can potentially give evidence to changes in Invasive carp presence over time or a shift in the upstream front of the established population. Unpublished telemetry data from Pool 18 show that tagged fish move into backwater habitats in the spring, when water temperatures are between about 8-15 °C, and reside there prior to making spawning runs to tributaries (Kyle Mosel, USFWS, personal communication). Mize et al. (2019) showed that the probability of detecting eDNA was greater in a UMR habitat characterized by low flow (e.g. a backwater) in the spring and fall. Pools 13 and 14 contain abundant backwater and off-channel habitat that may be suitable for spring congregations of Invasive carp. The goal of sampling Pool 13-14 is to assess trends in eDNA presence in backwaters over time, which may indicate changes in the Invasive carp population in those pools. These data may also be used to prioritize areas to implement or ramp up efforts with traditional capture gears to support Invasive carp telemetry tagging and removal efforts outside of the IMZ, if desired in the future. This project relates to Goal 2 of the Upper Mississippi River Basin Framework, specifically *Strategy 2.1: Continue the UMR comprehensive monitoring program to maintain a current understanding of Asian carp distribution at all life stages for early detection, prevention, response, control and containment* and *Strategy 2.5: Develop and implement new early detection and monitoring tools to supplement eDNA.* Additionally there is a need to continually refine eDNA technology and sampling strategy. Collecting samples from areas of confirmed Invasive carp presence at the time of sampling can help to continually refine and strengthen our understanding of eDNA detection probability and utility. The Credit Island backwater in Pool 16 offers an ideal location for this due to the presence of a real-time telemetry receiver which constantly detects and logs the presence of tagged invasive carp and transmits data to biologists in real-time.

Further upstream in the UMR in Pool 8, there has been an increase in the number of Silver carp captures. Due to the recent and repeated captures of numerous Silver carp in the spring of 2020, and the continued sporadic captures throughout 2020 and into 2021, USFWS will also sample for Invasive carp DNA in targeted backwaters of Pool 8 of the UMR in coordination with efforts by the Minnesota Department of Natural Resources and the U.S. Geological Survey to conduct a Modified Unified Method (MUM) for Invasive carp removal. eDNA will be collected in March, after ice out, and will immediately precede the MUM removal efforts. eDNA data from this effort will inform MN DNR of potential Invasive carp presence and those data will be compared to actual capture data from the MUM to infer detectability of Silver and Bighead carp in Pool 8.

Objectives:

1. Monitor for Invasive Carp eDNA in targeted backwaters within the pools immediately upstream of the Intensive Management Zone
2. Inform managers of potential trends in Invasive carp presence and provide data to support the prioritization of new backwaters to target with traditional capture methods
3. Refine detection probability and optimal sampling design of eDNA in the UMR

Agency: U.S. Fish and Wildlife Service (USFWS)

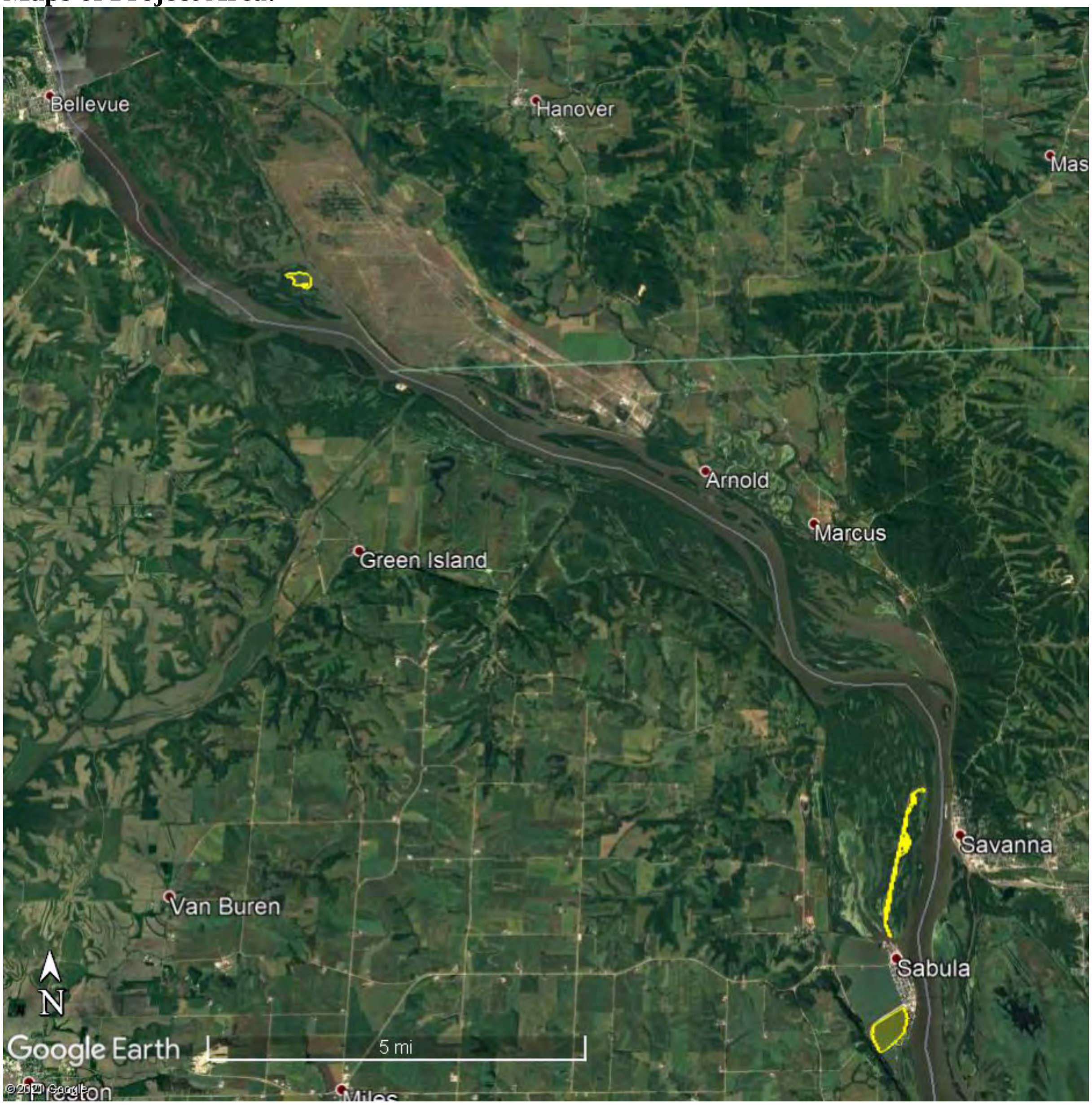
Activities and Methods: In FY21, eDNA samples will be collected from pools 13, 14 and 16 of the UMR primarily in the spring, as that is the season where Invasive carp are congregated in these habitats. If personnel and lab capacity allow, samples will also be collected in the fall to serve as a secondary time point for collection, with the recognition that Invasive carp may not be as abundant in these locations at that time of year. Due to prolonged flooding and the pandemic in recent year, spring eDNA data collections have not occurred since 2018 in these pools. Fall collections have occurred each year since 2018, although at a limited capacity in 2020 due to the pandemic. Sampling in the intended pools is expected to be completed as normal in 2021. Pools 13 and 14 will be sampled to fulfill objective 1 and 2 of this work plan. Three and five backwaters will be targeted in Pools 13 and 14, respectively (see maps below), and 80 samples will be collected per backwater, plus 8 quality control field blanks. Sampling and preservation procedures will follow the USFWS Quality Assurance Project Plan (QAPP 2020, https://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf).

The Credit Island backwater in Pool 16 (see map below) will be sampled for Invasive carp DNA in fulfillment of objective 3. Sampling will occur at the same time points and follow the same procedures as Pool 13 and 14 sampling. Data will be compared with real-time telemetry detections of tagged Bighead and Silver carp. Over time, those data will be analyzed to determine relative trends and observed relationships between Invasive carp presence and eDNA detections. Those data will be used to refine eDNA sampling strategy and inform realistic detection probability. Additionally, those data may be used in the future to infer minimum Invasive carp presence in regularly monitored eDNA backwaters in other pools.

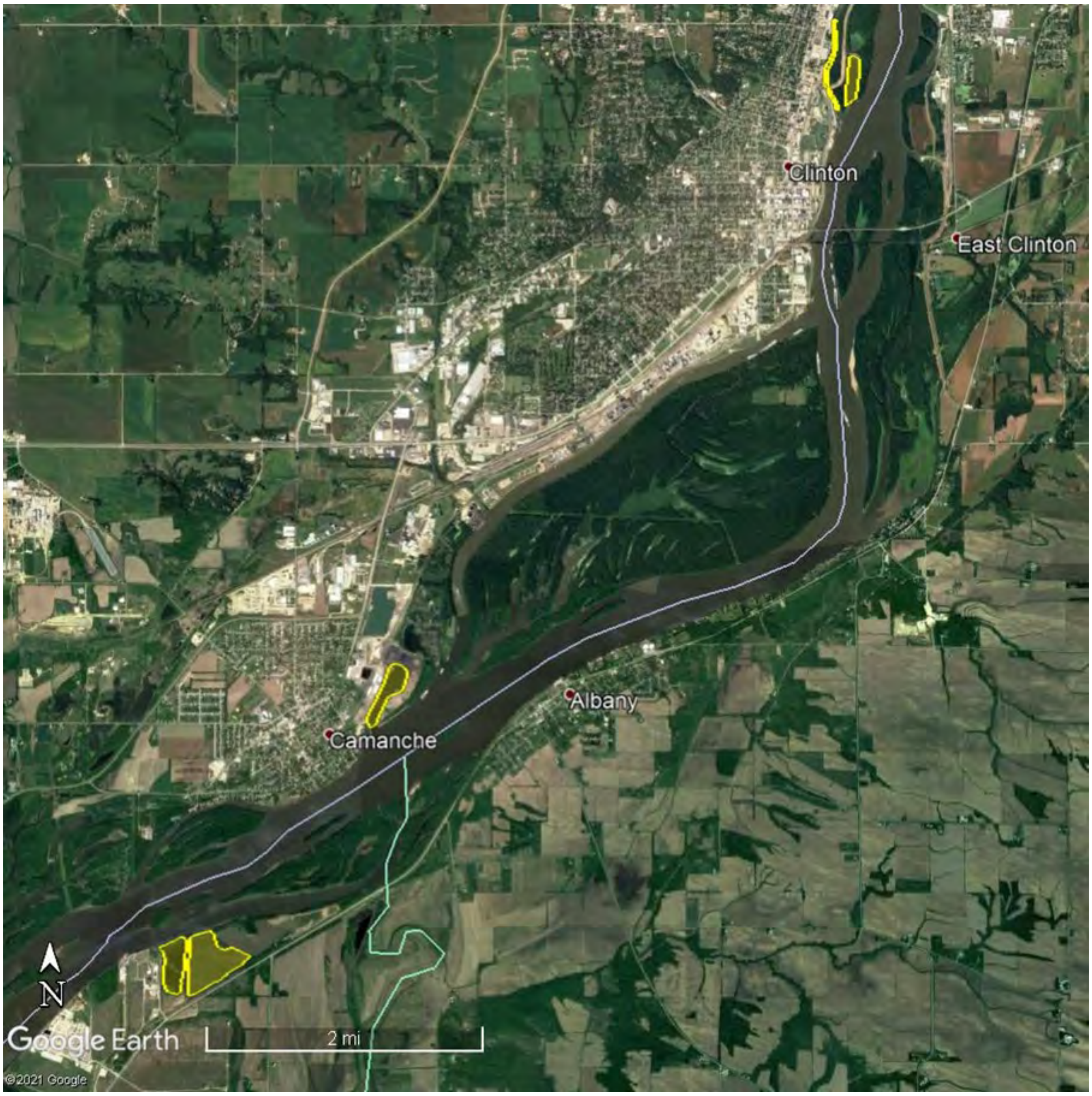
Additionally, five backwaters in Pool 8 (Figure 5) will be targeted and sampled for Invasive carp DNA in March, following ice out. In each backwater, 100 samples and 10 quality control field blanks will be collected. Sampling and preservation procedures will follow the QAPP.

Results of eDNA sampling in the UMR will be reported as positive/negative for Invasive carp DNA. The possible results can include No Detection, Invasive carp detection (not specific to species, Silver carp detection, Bighead carp detection, and Both Silver and Bighead carp detection together. Results will be provided to the partner state(s) in the form of sampling summaries with accompanying maps, and then posted online. Data will be summarized for an annual report and results will be used to advise the need for physical sampling and/or recommend changes to the eDNA sampling design in future years.

Maps of Project Area:



Three backwater areas in Pool 13 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.



Five backwater areas in Pool 14 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.

One of five backwater sites in Pool 14 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021

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Credit Island backwater, in Pool 16, where Bighead and Silver carp eDNA samples will be collected in 2021.

Five backwater areas in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Pool 8	March
Pool 13, 14, 16	April-May
Pool 13, 14, 16	October-November

Agency: U.S. Geological Survey (USGS)

Activities and Methods: In FY21, we will collect water samples for eDNA isolation from Pools 8, 10, 12, 13, 17, and 19 in both summer (June-July) and fall (October-November). At each pool and time point, we will collect 50 samples, plus field blanks for negative controls. Sampling points will remain the same as previous years; should exact locations not be accessible due to water conditions, we will attempt to sample the nearest point. Each sample will consist of a 50 ml grab sample that will be centrifuged, and eDNA extracted from the resulting pellet. Carp eDNA will be amplified using a quantitative PCR assay that can differentiate between bighead carp and silver carp (Erickson et al. 2017). These methods will address objectives 1 and 2.

In Spring 2021, we sample 10 sites across Pool 8 that represent the location of MUM efforts. Each site will have samples collected at 5 different points. Note that the exact sampling locations related to the MUM are different than the exact points for Pool 8 multiyear monitoring for objectives 1 and 2, although there is some overlap in area. Sampling will occur 1-2 weeks before the MUM and 1-2 weeks following the MUM. If a MUM occurs in Fall 2021, we plan to sample at the same time interval pre- and post-MUM. Water collection for MUM eDNA sampling will consist of filtering up to 500 ml (or until filter clogs) using 1.2 micron PCE filters (qPCR amplification will not change). This will allow our results to be consistent with sampling conducted at Pool 8 MUM sites in Fall 2020. These methods will address our Objective 3.

Finally, we will directly compare grab samples/centrifugation and filtering during our summer and fall monitoring in Pool 8. At each of the 50 sampling points, we will concurrently collect a grab sample for centrifugation while simultaneously filtering a water sample. These methods will address Objective 4.

For all objectives and methods, results will be categorized as positive and negative by each species. Therefore, there are four different outcomes for each method (negative, positive both species, positive bighead carp, positive silver carp). For objectives 1-3, we will summarize and map results to share with cooperating agencies and for publication. Objective 4 will serve as a basis for estimating detection probability between the two methods, although additional sampling years may be necessary to precisely estimate detection.

Map of Project Area:

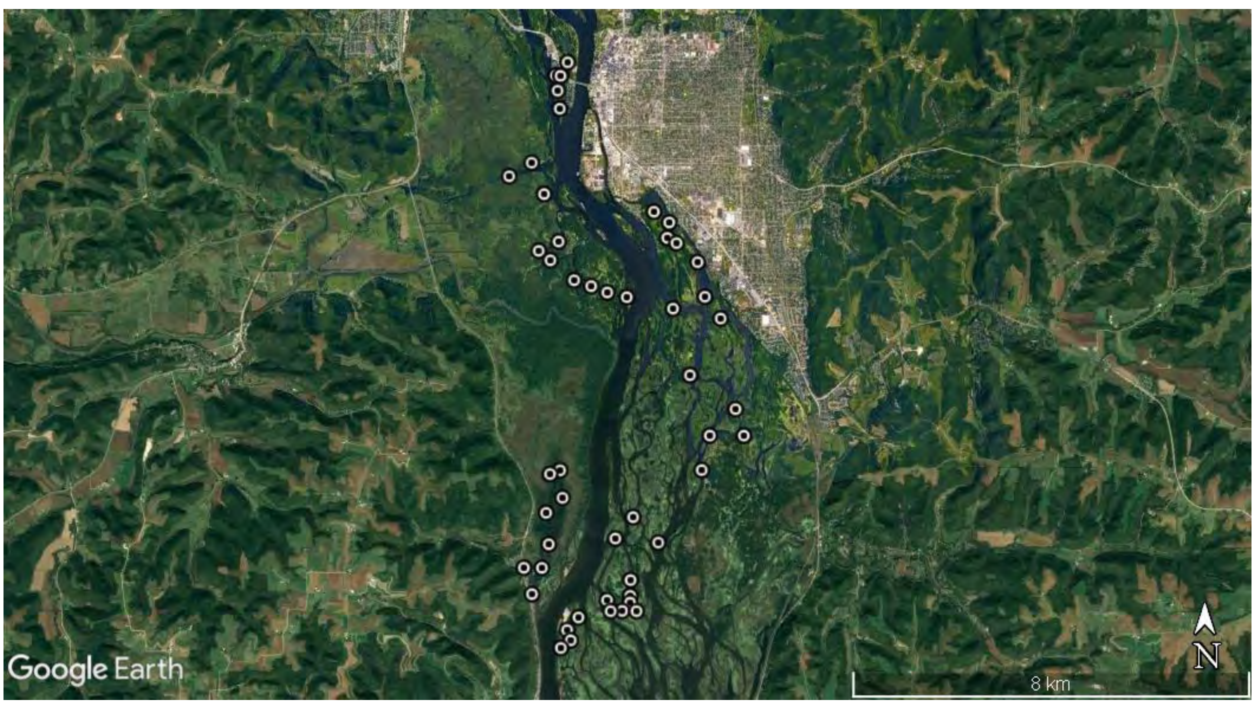
Sampling points in Pool 19 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 17 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 13 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 12 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 10 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.



Sampling points in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of monitoring around the Modified Unified Method (MUM) capture events.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Pool 8	March (pre-MUM)
Pool 8	April (post-MUM)
Pool 8, 10, 12, 13, 17, 19	June-July
Pool 8	September-October (pre- and post-MUM if Fall MUM
Pool 8, 10, 12, 13, 17, 19	October-November

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Resource Association
http://www.micrarivers.org

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