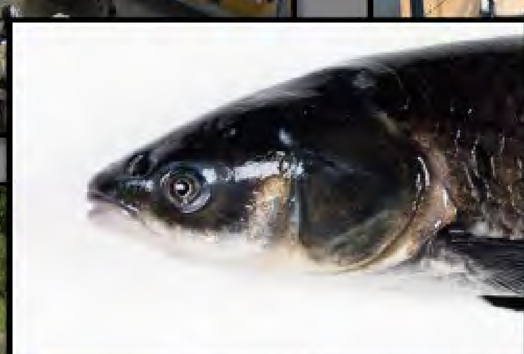
Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin

Fiscal Year 2023



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Fiscal Year 2023

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

Mississippi Interstate Cooperative Resource Association

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Suggested citation:

Aldridge, C.A., N. Jackson, R. Neeley, E. Pherigo, and G. Conover, editors. 2023. Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin, Fiscal Year 2023. Invasive Carp Advisory Committee. Mississippi Interstate Cooperative Resource Association, Carbondale, IL, 321 pp.

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 Illinois, Missouri, Ohio, Tennessee, Cumberland, Arkansas, 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estimated the economic output from recreational fishing in the Mississippi River Basin at more than $19 billion (USFWS, unpublished data).

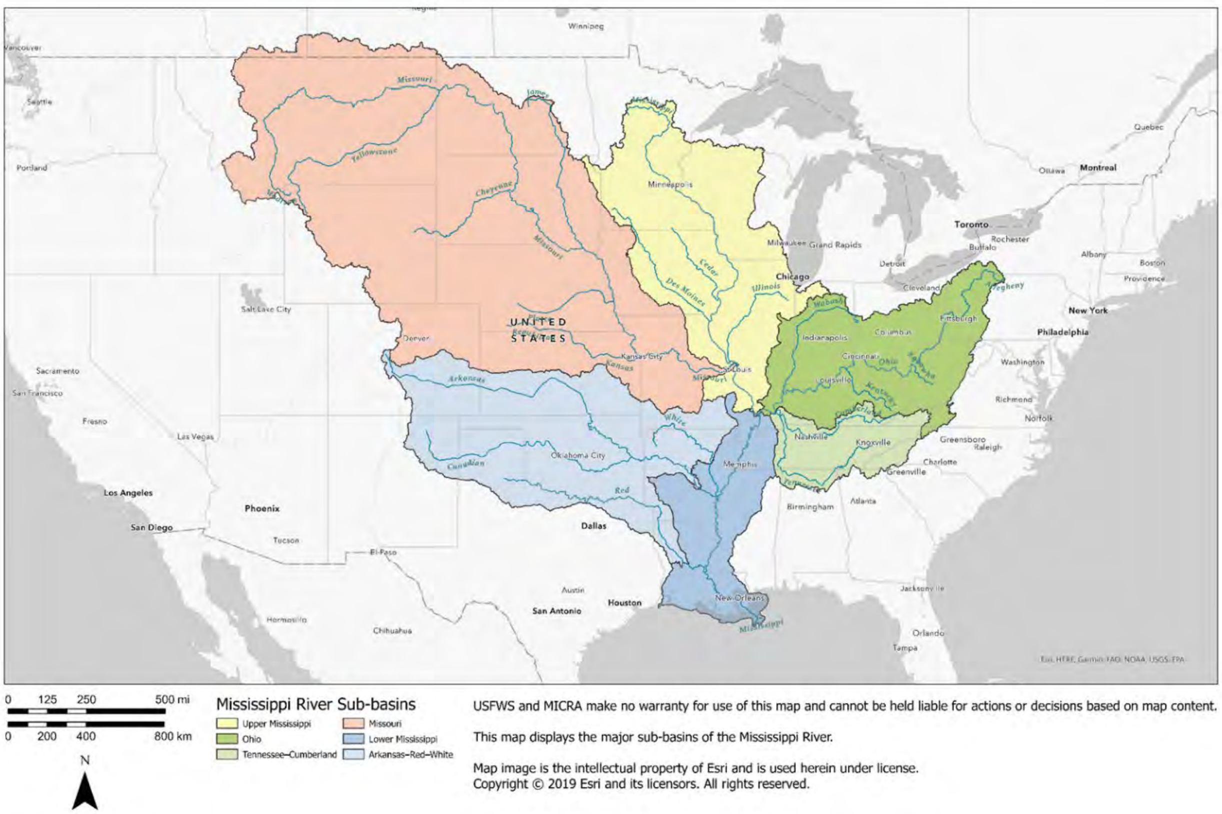

Figure 1. Map of the Mississippi River Basin which drains all or a portion of 31 states and 2 Canadian Provinces. Shading indicates the six MICRA sub-basin management units and the four sub-basin invasive carp frameworks within the Mississippi River Basin (Missouri River [red], Upper Mississippi River [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).

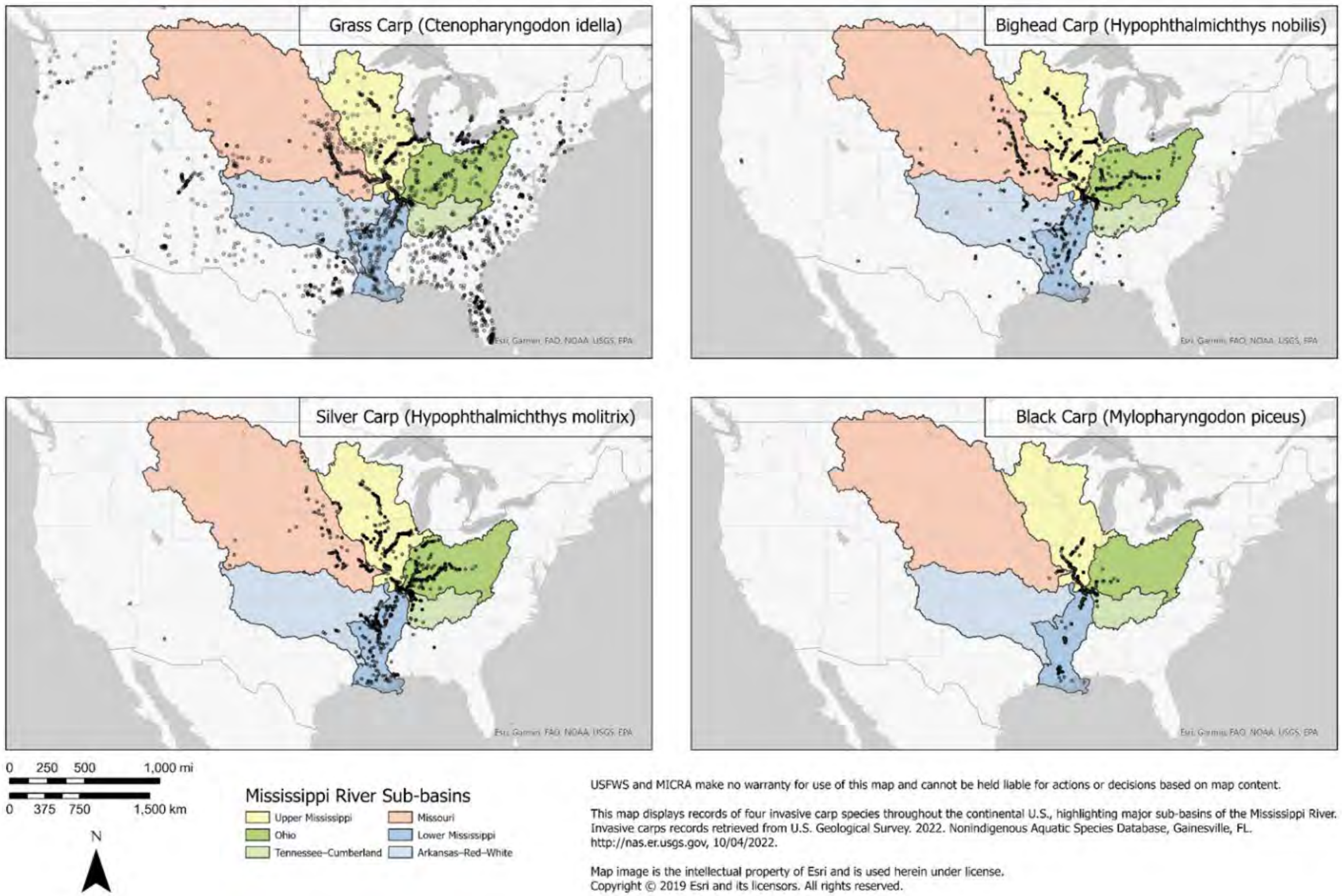

Figure 2. Distribution of Grass Carp, Bighead Carp, Silver Carp, and Black Carp in the lower 48 states of the United States as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of October 2022. Shading indicates the six MICRA sub-basin management units and the four sub-basin invasive 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. 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.

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 remained at $25 million in FY21 and increased by $200,000 in FY22. In FY23, the USFWS received additional funds ($6M) to support implementation of the National Plan within the Mississippi River Basin.

Each year, USFWS base funds are distributed among the invasive carp partnerships across the Mississippi River Basin for implementation of their priority projects. As USFWS base funding has increased since 2015, the scope and scale of funding made available to the invasive carp partnerships has also increased (Table 1).

In 2023, 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 FY23 funds totaling $18,658,997.

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[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".

Table 1. Total annual appropriations to USFWS for all invasive carp prevention and control work from 2015-2023, 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.

Basin	Fiscal Year								
	2015	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***	***2022***	***2023***
Ohio	$400,000	$318,488	$328,488	$996,039	$1,135,000	$5,503,861	$3,814,157	$3,903,916	$4,887,681
Upper Mississippi	$400,000	$500,000	$600,000	$1,050,000	$932,000	$1,500,000	$1,710,796	$1,623,000	$2,754,264
Tennessee Cumberland	-	$181,512	$271,512	$153,961	$803,000	$3,516,135	$5,333,612	$4,728,530	$5,379,718
Arkansas-Red-White	-	-	-	-	-	$1,000,000	$430,000	$1,147,718	$1,270,936
Lower Mississippi	-	-	-	-	-	$1,300,000	$990,518	$1,315,832	$2,858,537
Missouri	-	-	-	-	-	$1,100,000	$1,516,323	$1,300,000	$1,507,861

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.

In 2023, the ICAC engaged partner agency representatives in discussions about developing a cohesive national strategy for invasive carp management and initiated the development of a national monitoring approach through the creation of three work groups (Sampling Approach Workgroup, Data Analysis Workgroup, and Control Actions Workgroup). The workgroups are developing management and monitoring approaches that can be implemented in the future to increase efficiency and consistency in invasive carp actions across the Mississippi River Basin.

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 annual (calendar year) summary reports to track and evaluate progress, report results, and inform planning for management and control actions in future years. The annual MRPs and annual summary reports are available on the MICRA website at: http://micrarivers.org/invasive-carp-plans-and-reports/.

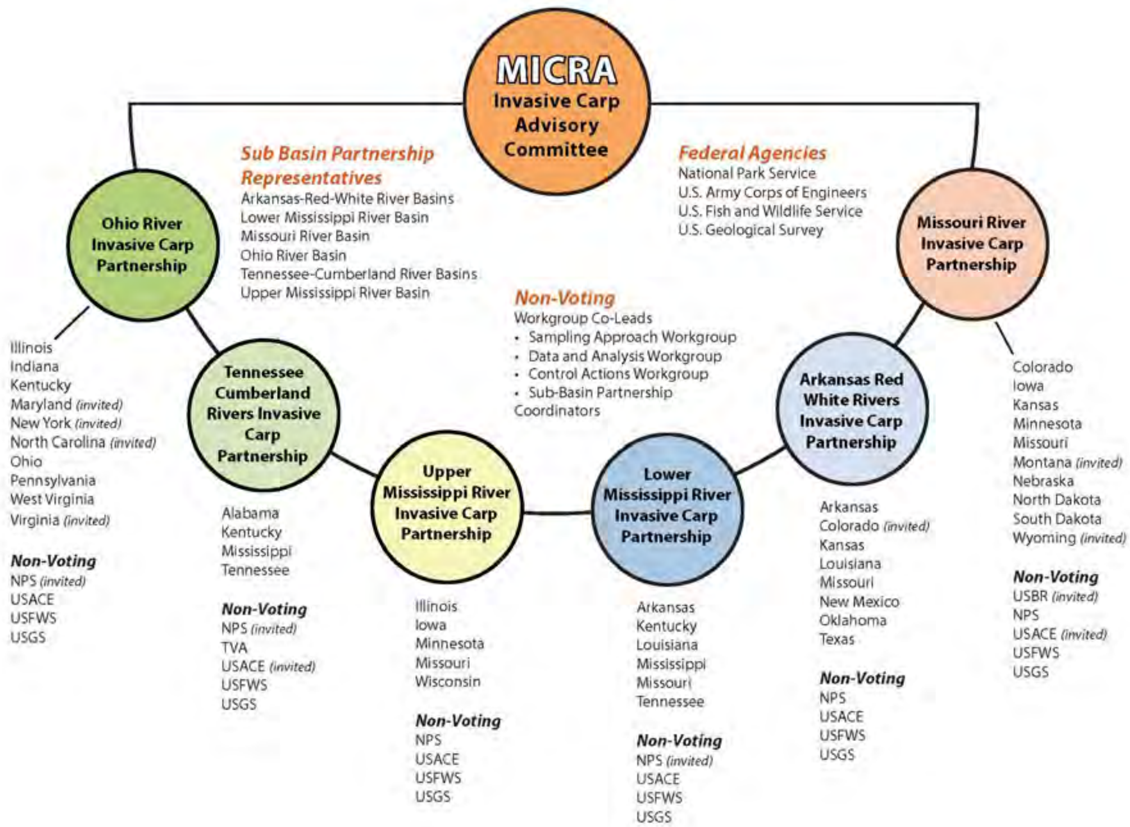


Figure 3. Structure for inter-agency coordination and implementation of Invasive Carp Control Strategy Frameworks in the Mississippi River Basin. Basin-wide coordination occurs through the MICRA Invasive Carp Advisory Committee and regional coordination occurs through six sub-basin invasive carp partnerships: 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.

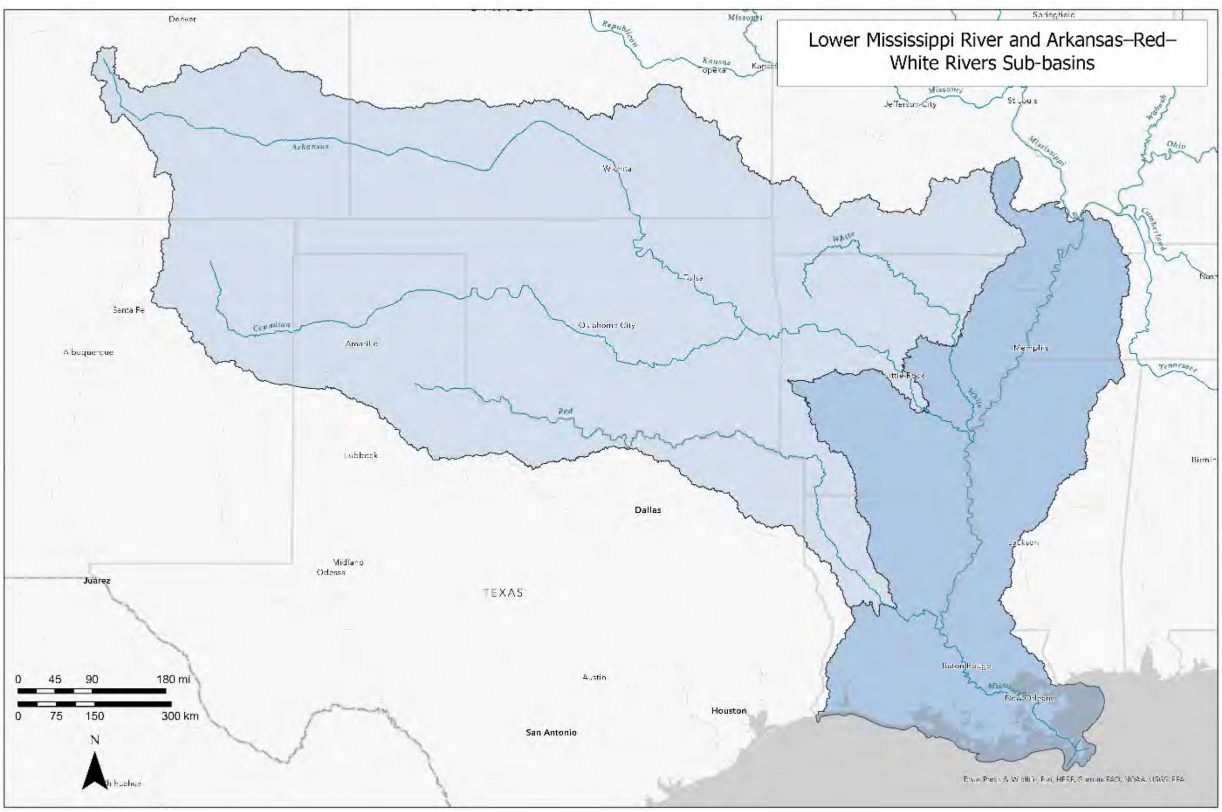
2023 Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin

The 2023 MRP includes project work plans for 39 projects collaboratively developed by state and federal agency partners throughout the Mississippi River Basin working together through six sub-basin invasive carp partnerships. In FY23, USFWS funding support was provided for nine projects in the LMR, seven in the ARW; five projects in the MOR; four projects in the ORB and five projects in the TNCR; and nine projects in the UMRB. An overview of each sub-basin partnership and the full project work plans supported in FY23 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.

Fiscal year 2023 was the fourth year of USFWS funding invasive carp management and control in the LMR and ARW as part of National Plan implementation. The 16 projects in the LMR ARW resulted in $2,858,537 for the LMR and $1,270,936 for the ARW in grants allocated to nine of the eleven states in the Lower Mississippi River and Arkansas-Red-White Basins.



Juvenile recruitment and habitat use of Silver Carp in the lower Arkansas and lower White Rivers

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

Cooperating Agencies: University of Arkansas at Pine Bluff

Statement of Need: According to the National Plan Goals and Strategies, Strategy 3.6.1. is to "Develop sampling gears and monitoring methods for all life stages of Asian carps in both standing and flowing water environments." While there is anecdotal information to support juvenile recruitment of Silver Carp in the lower White River, no specific sampling effort has produced solid evidence of recruitment of late-stage larvae or early-stage juveniles to backwater habitats in the Lower White River or Lower Arkansas River. This research project specifically addresses this data gap. Identifying backwater habitats where recruitment of juvenile Silver and Bighead Carp occurs can help inform future management, such as targeted removal, of these species.

The University of Arkansas at Pine Bluff has conducted fieldwork in the Lower Arkansas River and Lower White River during a previous research project. Adult Silver Carp and Bighead Carp were collected in both rivers, and gravid females were confirmed in both systems. However, previous sampling gears did not include those proposed herein. Furthermore, sampling did not specifically target mid to late summer and early fall, times when early juveniles would be recruiting to backwater habitats. Such activities are proposed in this project.

In addition to Strategy 3.6.1, the National Plan includes Strategy 3.6.2. which reads "Assemble information about the distribution, biology, life history, and population dynamics of bighead, black, grass, and silver carps." This research project addresses this strategy and would provide specific distribution data for early life history stages of Silver Carp, and possibly Bighead Carp, in Arkansas.

Objectives:

1. Monitor young of year fish and small-bodied fishes in backwaters of the lower Arkansas and lower White Rivers during periods of likely Silver Carp spawning to document Silver Carp juvenile recruitment and backwater habitat use in Arkansas.
2. Use otolith microstructure to document growth rates of juvenile Silver Carp relative to various backwater habitats of the lower Arkansas and lower White Rivers.
3. Use otolith microchemistry to infer natal spawning systems of juvenile Silver Carp collected in backwaters of the lower Arkansas and lower White Rivers.

Agency: University of Arkansas at Pine Bluff

Activities and Methods: Adult populations of Silver Carp exist in both the Arkansas River and the White River in Arkansas. Telemetry studies indicate that Silver Carp use backwater and main channel habitat throughout the White River and move into tributaries of the White River, such as the Black River. Silver Carp in the Arkansas River move in and out of backwaters but move longitudinally within the Arkansas River less than the White due to the lock and dam complex of the McClellan Kerr Arkansas River Navigation System (MKARNS). Gravid females are found in both systems and spawning probably occurs in both systems. Spawning usually occurs when rivers are rising, when water temperatures exceed 18°C (Kolar et al. 2005), and when flow is > 0.7 m/s (Krykhtin and Gorbach 1981). Silver Carp eggs are semi-buoyant and need moving water to remain in suspension (Kocovsky et al. 2012; Williams et al. 2021).

The combination of rising river levels, appropriate temperatures, suitable discharge rates, and lengths of unimpeded reaches raise the possibility that although spawning is likely occurring in the Arkansas and White Rivers, little juvenile recruitment is occurring in the lower Arkansas and lower White Rivers. Chapman and George (2011) present a model for larval development relating ambient temperature, time, and a thermal minimum for Silver Carp to the Critical Thermal Units (CTUs) necessary to reach the swim bladder inflation stage. It is only after development to the swim bladder inflation stage that Silver Carp larvae actively move to backwater nursery habitats (George and Chapman 2013). Water temperatures, discharge rates, associated water velocities and CTUs necessary to reach swim bladder inflation stage indicate that the distance an egg with its developing embryo would need to travel surpasses the greatest distance between locks and dams for any pool in the MKARNS during any month of the spawning season. When eggs reach a downstream dam, they likely settle and ultimately expire. Hence, recruitment of juveniles to backwaters in pools of the Arkansas River is unlikely.

In the White River, the same combination of variables indicates that in the spring and early summer (April-June), eggs with developing embryos spawned just below the low head dam at Batesville, Arkansas would be swept from the White River into the Mississippi River before hatching, reaching the swim bladder inflation stage, or moving to back water juvenile nursery habitat. It appears that only during late summer and early fall (July-September), when flow rates and temperatures are appropriate to see larvae reaching the swim bladder inflation stage before being swept into the Mississippi River, that recruitment to backwaters in the lower White River are likely. Generally, in late summer, the White River is falling, and the river is below flood stage. Much of the backwater habitat (e.g. floodplain oxbow lakes) in the White River is inaccessible to late-stage larvae and early-stage juveniles. Only backwaters connected to the main channel below flood stage during falling river conditions would likely be occupied by early-stage juvenile Silver Carp.

We propose to sample backwaters of the lower White River and lower Arkansas River during summer and fall. Backwaters will be selected from a pool of candidate backwaters (see Table 1 for candidate sample sites). Backwater habitat will be characterized according to depth, velocity and substrate type (per Haupt and Phelps 2016) and according to the backwater habitat classification scheme of Baker et al. (1991). The sampling gears used will be some combination of mini-fyke nets and minnow seines, depending upon local conditions. Small-bodied fish species will be identified, enumerated, and released in the field. The exception to this will be any juvenile Silver Carp or Bighead Carp, which will be weighed, measured, and returned to the laboratory for otolith removal. We will compare relative abundances of Silver Carp between systems and among habitat types using general linear models. Furthermore, we will compare relative abundances of young of year native and small-bodied fishes within the planktivore feeding guild (e.g. shad, minnows) to relative abundances of invasive carps.

Lapilli otoliths will be removed, processed, and used to age Silver Carp based on microstructure. We will calculate growth rates for Silver Carp and compare growth rates between systems (White and Arkansas) and among backwater habitat types using general linear models.
A subsample of otoliths will be processed and sent to a commercial lab for otolith microchemistry analysis. Specifically, the elemental composition of the nucleus of the otoliths will be compared to previous water samples and processed Silver Carp otoliths from the White River, the Arkansas River, and the Mississippi River (Cooper Barshinger unpublished data). These comparisons will be an attempt to determine whether juvenile Silver Carp collected in the lower Arkansas and lower White Rivers are the product of spawning that occurred in those same systems.

Map of Project Area: Lower Arkansas River (Pool 4 to Pool 2 and the Arkansas Post Canal) and Lower White River (from Des Arc to the confluence of the White and Mississippi Rivers; see Figure 1). Specific locations will be randomly chosen from a pool of possible locations (Table 1).

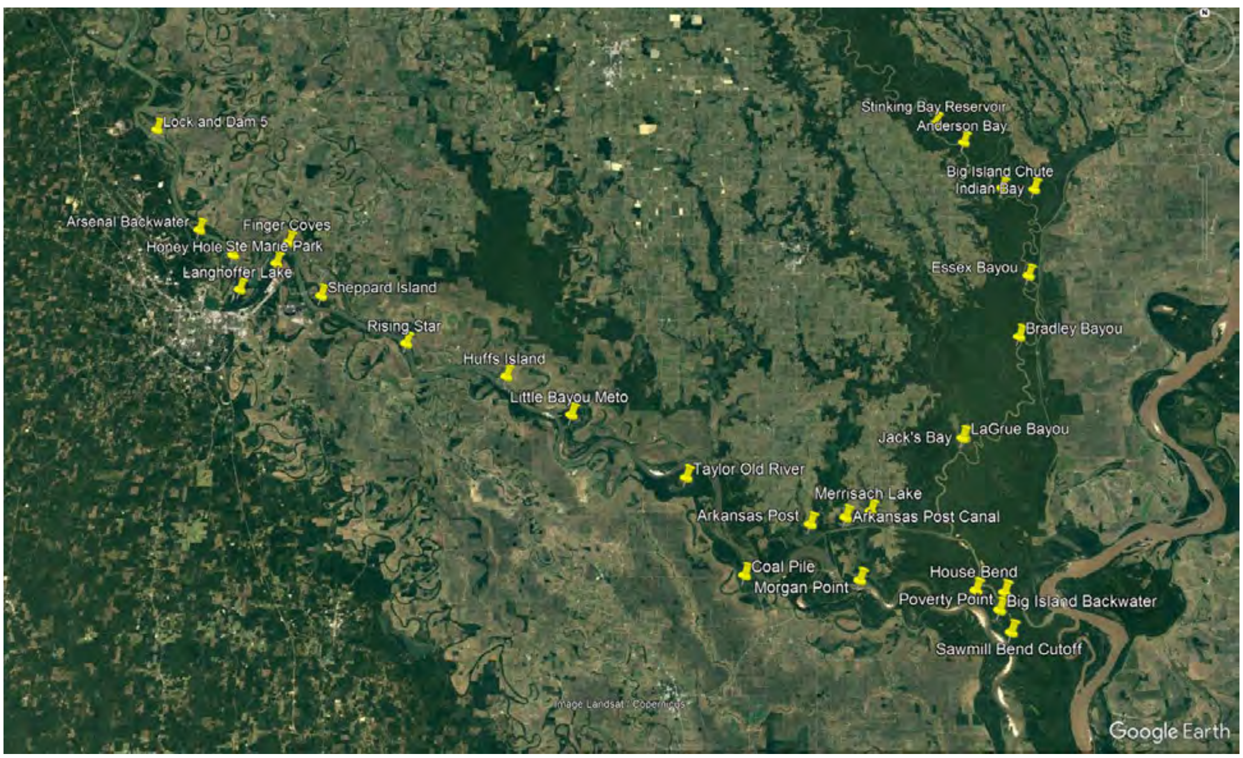


Figure 1. Possible sample sites (indicated with yellow pins) to seine or net for juvenile Silver Carp in the Lower White River and Lower Arkansas River, in Arkansas.

Table 1. Candidate backwater areas where sampling might occur in the lower White River and lower Arkansas River, Arkansas.

System	Backwaters
White River	Stinking Bay Reservoir Anderson Bay Big Island Shute Indian Bay Big Creek Essex Bayou Bradley Bayou un-named creek left descending bank Jack's Bay LaGrue Bayou Poverty Point
Arkansas River	Coal Pile Big Bayou Meto Arkansas Post Merrisach Lake Little Bayou Meto Mores Bayou Arkansas Post Canal Big Island Backwaters Sawmill Bend Cutoff House Bend Morgan Point Taylor Old River Bayou Meto Confluence Huffs Island Pool Three just above dam, east side of river Above Rising Star west side of river Opposite side of river from Mulberry Grove Church Below Sheppard Island, east side of river Above Sheppard Island, east side of river (pool 4) Ste Marie Park Regional Park Below Langhoffer, east side of river behind island Finger coves, west side of river below Langhoffer Honey Hole Arsenal Backwater Lock and Dam 5

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Year 1 Seining/sampling backwaters of the Arkansas River and White River.	Late Summer-Fall/2024
Year 1 Picking and Sorting	Winter/2024
Year 1 Otoliths microstructure	Spring 2025
Year 1 Otolith Microchemistry	Early Summer 2025
Year 2 Seining/sampling backwaters of the Arkansas River and White River.	Late Summer-Fall/2025
Year 2 Picking and Sorting	Winter/2025
Year 2 Otoliths microstructure	Spring 2025
Year 2 Otolith Microchemistry	Early Summer 2025
Year 2 Data Analysis & Interpretation	Late Summer-Fall 2025 to Winter 2025
Year 2 Manuscript Prep/Report Prep	End of Project

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Arkansas Invasive Carp Market Stimulation Project

Lead Agency and Author: Arkansas Game and Fish Commission, Matt Horton (Matthew.Horton@agfc.ar.gov)

Cooperating Agencies: Arkansas Economic Development Commission (AEDC)

Statement of Need: Populations of invasive carp (silver, bighead, black, and grass carp) have rapidly expanded throughout the Mississippi River Basin and continue to increase their distribution in Arkansas waters. Management and control of invasive carp is necessary to reduce their impact on native species, the ecosystem, and the economy. In response to these threats, many states within the Mississippi River Basin have been working to find effective strategies to manage existing populations and control range expansion into adjacent aquatic systems. Recognizing commercial harvest was the most efficient and effective means to remove invasive carp, the Arkansas Game and Fish Commission (AGFC) attempted to implement a contract fishing program in 2020, utilizing federal invasive carp grant funds. The goal was to hire up to four commercial fishermen to remove 800,000 pounds of invasive carp from the Arkansas and White River systems, within the Lower Mississippi River (LMR) and Arkansas-Red-White River (ARW) Sub-basins. At the time, Arkansas did not have a fish processor or other buyers that would accept invasive carp from our commercial fishermen, nor was there an established market for invasive carp in Arkansas. Contractors would be paid 20 to 30 cents per pound, which increased as poundage goals were met, to remove invasive carp. Free gear tags were offered to incentivize removal. Contract stipulations were restrictive, and included only allowing harvest of invasive carp, other commercial gear could not be fished within 15 miles of the access point, and all commercial tackle had to be provided by the commercial fisherman. In October 2020, letters were sent to all current commercial fishing permit holders (approximately 1,350), advising them of the contract availability. Nineteen commercial fishers communicated interest and were sent an RFQ. No commercial fishermen submitted proposals by the deadline date. Subsequently, the AGFC amended the 2020 grants to implement an in-house removal program (AGFC Invasive Carp Removal Program). Removal efforts started in fall of 2021 and has continued to date. The program has removed over 138,000 pound of invasive carp and contributed valuable information such as range distribution, density, and size structure of invasive carp in the Arkansas and White River systems. However, there is still a need improve effectiveness of removal efforts and significantly increase biomass removal from Arkansas waters.

Over the past three years, the states of Tennessee, Kentucky, and Illinois have successfully utilized harvest incentive programs to increase commercial harvest and processing capacity, which has resulted in millions of pounds of invasive carp being removed. Those states created a subsidy for invasive carp but use somewhat different ways to inject it into the market through existing commercial fishers and processors. In Arkansas, we have commercial fishers but no processors or developed market uses for invasive carp. This limits the commercial value of invasive carp, motivation for fishers to harvest invasive carp, and opportunities for fishers to sell large quantities of invasive carp harvested in Arkansas. To increase effectiveness of removal efforts, the AGFC desires to create an incentive program which provides subsidies to commercial fishers for harvesting and selling invasive carp, and encourages collaboration between fishers and wholesale fish dealers, processors, or other buyers to develop markets which increase demand and processes to receive carp caught in Arkansas. In addition, AGFC will partner with the Arkansas Economic Development Commission (AEDC) to help interested businesses expand processing capacity and market development into Arkansas. This project differs from past AGFC projects by allowing any licensed commercial fisher to receive subsidies for harvesting and selling invasive carp; all Arkansas waters, within the LMR, open to commercial fishing can be utilized; fish can be sold to any buyer for any price; fishers receiving incentives may also harvest and sell native commercial fish species; and a limited supply of start-up fishing supplies and equipment will be provided on a first-come-first-served basis to help incentivize harvest and aid fishers with providing quality fish for market product use. The AGFC has proposed an identical project in the Arkansas portion of the ARW Sub-basin this fiscal year, to cover all waters in Arkansas harboring invasive carp.

The activities outlined in this work plan address the following goal and objectives of the National Plan: Goal 3: Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass and silver carps in the United States; Strategy 3.3.2. Increase the commercial harvest of Asian carps; Strategy 3.3.2.2. Increase the number of commercial fishers; Strategy 3.3.2.3. Examine commercial fishing regulations and consider changes to increase harvest; Strategy 3.3.2.4. Provide financial incentives to commercial fishers to increase harvest of Asian carps. It also addresses the following goals and objectives of the Lower Mississippi River Basin Asian Carp Control Strategy Framework: Goal 3. Population Control and Agency Response: Reduce Asian carp densities with the ultimate goal of extirpation of Asian carps; Strategy 3.2. Utilize commercial harvest and implement contract fishing of Asian carps to decrease densities; Strategy 3.3. State natural resource agencies will work within their authorities to increase opportunities for commercial harvest of Asian carps. States will work with commercial fishers, industry, and local communities to alleviate limiting factors (e.g., regulatory hurdles, low price, and proximity of processing plants) that might encourage more commercial fishers to target Asian carps; Strategy 3.4. States can assist, where appropriate, in the development of new markets for Asian carps. Markets should be expanded both within the United States and abroad.

AGFC is working to phase out the in-house removal program (agency removals) and shift removal efforts to commercial harvest. AGFC will outline conversion of agency removal efforts to re-direct existing staff, equipment, and future federal funding requests to support monitoring of commercial harvest to directly inform commercial fishing effectiveness and optimize control strategies. This project is needed to build capacity of commercial harvest as a primary means of biomass removal in Arkansas waters ahead of this planned transition.

Objectives:

1. Stimulate the commercial market for invasive carp in Arkansas through incentivizing subsidies to help control invasive carp populations.
    1. Implement a subsidy for invasive carp sales to attract commercial operators such as processors and wholesale fish distributors to Arkansas.
    2. Incentivize commercial fishers to target and harvest invasive carp.
2. Provide start-up supplies and access to equipment for licensed commercial fishers, wholesale fish distributors, or processors.

    1. Provide start-up fishing supplies such as gill nets, rope, and anchors to licensed commercial fishers.
    2. Provide licensed commercial fishers, access and use of equipment such as ice machines to help ensure wholesale fish distributors, processors, or other buyers receive quality fish for market product uses.
3. Create and administer subsidy program within the AGFC Fisheries Division.
    1. Provide salary for one staff to track invasive carp sales and other reporting mechanisms and submit forms for payments to commercial fishers. This staff addition will also work to administer requests for equipment start-ups.
4. Scope standards for monitoring invasive carp populations in Arkansas to evaluate the effectiveness of commercial fishing.
    1. Outline conversion of the Arkansas invasive carp control program to include monitoring which would:
        1. Develop an invasive carp population standard monitoring protocol.
        2. Revise invasive carp control program staff roles, as appropriate, to collect data which directly informs commercial fishing effectiveness and optimal control strategies.
        3. By 2026, phase out AGFC Fisheries Division invasive carp control program (agency removals) once invasive carp commercial fishing is established and invasive carp population monitoring protocol can be implemented by existing Fisheries Division programs.

Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods: To increase effectiveness of invasive carp removal efforts in Arkansas, the AGFC will create and administer an invasive carp harvest incentive program which provides a per-pound subsidy to qualified commercial fishers, start-up fishing supplies to commercial anglers, and access to equipment that helps fishers and buyers provide and receive quality fish for desired market product uses.

Locations where fishers can harvest invasive carp and receive subsidies through this program include all waterbodies of Arkansas, within the Lower Mississippi River Sub-basin, which are open to commercial fishing, and portions of the Mississippi River sharing a border with Tennessee and Mississippi. These waters include the Mississippi River (RM 828 at the Arkansas-Missouri border to RM 507 at the Arkansas-Louisiana border), Arkansas River (from its confluence to Emmett Sanders Lock and Dam, near Pine Bluff), White River (from its confluence to the mouth of the Little Red River), Ouachita River (from the Louisiana state line to the US Hwy 79 Bridge in Camden), Saline River (from its confluence to the US Hwy 278 Bridge), Bayou Bartholomew, Bayou Meto, Cache River, L'Anguille River, St. Francis River (from its confluence to the Left Hand Chute of Little River); their tributaries, backwaters, and oxbow lakes (Figure 1).

The AGFC will mail a letter to all people who obtained an Arkansas Resident Commercial Fishing Permit in 2022 and 2023, to solicit participation in receiving subsidies for invasive carp (Bighead, Black, Bighead and Silver Carp) sold to any buyer, residing within or outside of Arkansas. Qualified applicants must have a valid Arkansas Resident Commercial Fishing Permit, Resident Fisheries Conservation License, provide a W-9 From to the State of Arkansas, and sign an affidavit agreeing to comply with the terms of the program, including eligibility for harvest subsidies and start-up fishing supplies, access to program equipment, reporting requirements, and any other program eligibility requirement. The AGFC will provide at least 30 days for individuals interested in the program to register before distributing any subsidies or start-up fishing supplies.

A per-pound subsidy of 18 cents per pound will be paid to qualified fishers who provide required reporting documents for invasive carp caught by them, and sold to any buyer, for any price. Fishing supplies (nets, anchors and rope) will be purchased by AGFC and provided to program applicants on a first-come-first-served basis and will be distributed in a manner which allows opportunity to multiple applicants. Equipment, such as ice machines, will be purchased by AGFC, and placed in strategic locations which allow access to participating fishers. Equipment will be installed and maintained by AGFC. Cooperative agreements will be made between AGFC and other government agencies or private entities, as needed, to ensure equipment is in convenient, accessible, and safe locations.

Subsidy payments for invasive carp sold by fishers will be contingent on fishers submitting a bill of sale (sales receipt) and cover sheet. The bill of sale must include the fisher’s name, AGFC customer identification (CID) number, catch location (waterbody), date, buyers name and address, receipt number, species, total weight by species, and price paid per pound. The cover sheet will include the fishers name, address, CID number, fishing gear used (gear type and mesh size), catch location (waterbody), date of harvest, species, total weight by species, fisher’s signature, buyers’ signature and date.

A part-time employee will be hired by the AGFC Fisheries Division to track invasive carp sales, verify receipts submitted by fishers, submit payment forms, and administer requests for start-up fishing supplies and access to equipment. This person will be housed at the AGFC Headquarters in Little Rock. This person will be directly supervised by the AGFC Fisheries Division Bookkeeper.

AGFC Fisheries Division staff will use data collected by the in-house removal program, mandatory commercial fishing reports, and bills of sale submitted for this harvest incentive program to identify and prioritize waterbodies for population assessment. AGFC Fisheries Division staff will develop a population assessment protocol for Arkansas, which directly informs effectiveness of commercial harvest and optimal control strategies for invasive carps after MICRA’s ICAC Population Assessment Workgroup provides guidelines. AGFC Invasive Carp Removal Program staff and equipment, in addition to any other resource needs will be identified and considered for future federal invasive carp funding opportunities to support program monitoring needs.

Agency: Arkansas Economic Development Commission (AEDC)

Activities and Methods: The Arkansas Economic Development Commission (AEDC) has agreed to cooperate with AGFC, by providing support to businesses interested in expanding processing capacity and market use of invasive carp in Arkansas. AEDC will assist prospects in the site location process, workforce pipeline development, and collection of helpful information regarding invasive carp populations in Arkansas. They will help make connections with key stakeholders and service providers such as local governments, utility providers, and financial and legal support, and facilitate connections with stakeholders that might be able to help with increasing efficiency and effectiveness of fish acquisition. In addition, AEDC will help identify appropriate incentives and in-state grant opportunities to fill business needs.

Map of Project Area:

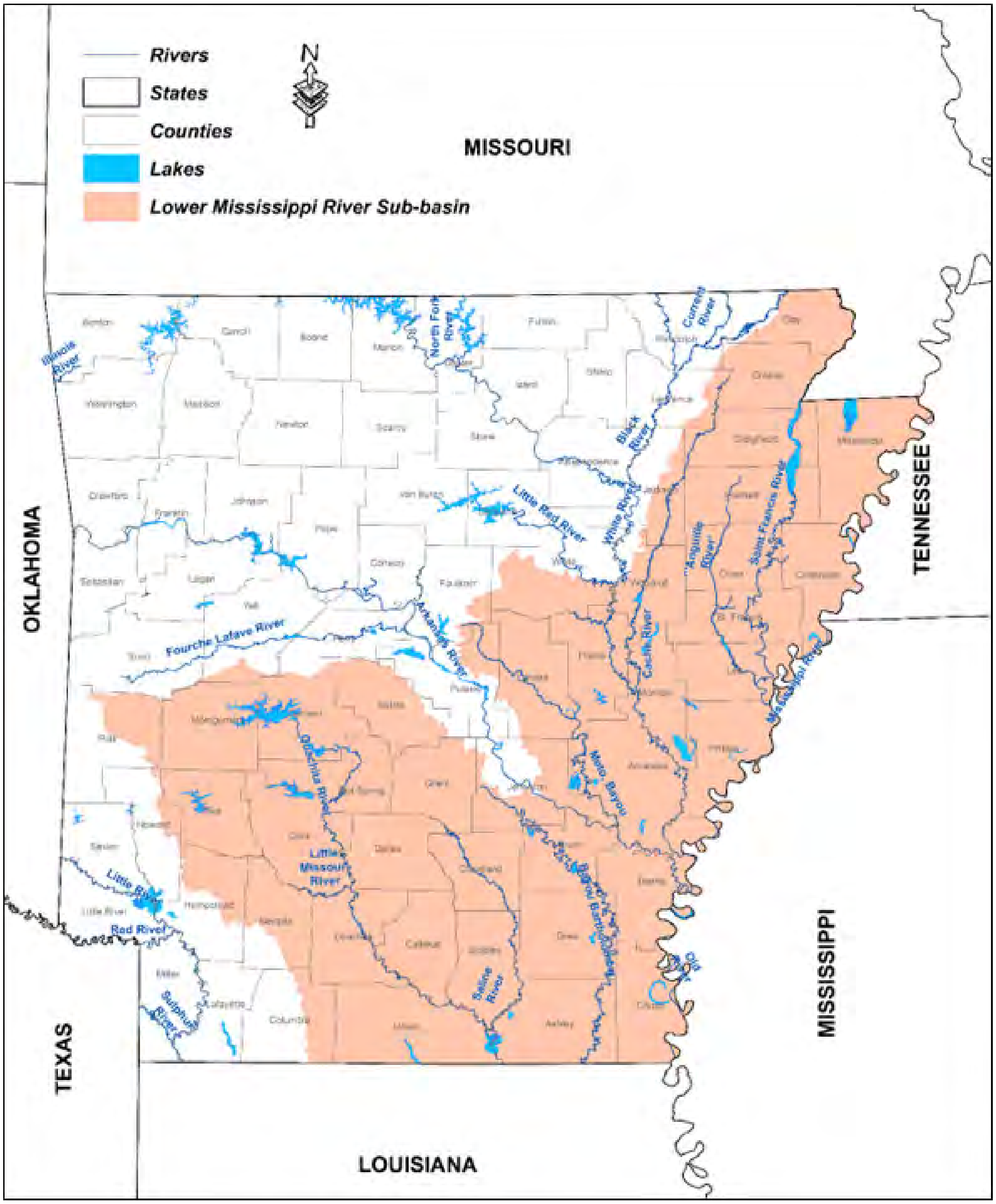


Figure 1. *Lower Mississippi River Sub-basin in Arkansas (highlighted in orange), which delineates the area where participating commercial fishermen can harvest invasive carp for*

subsidies provided through the Arkansas Game and Fish Commission's Invasive Carp Market Stimulation Project.

Estimated Timetable for Activities:

Activity	Time Period
Send sign-up letter to commercial fishers	As soon as the grant is approved
Purchase start-up fishing supplies and equipment	As soon as the grant is approved
Hire part-time employee to administer the subsidy program	As soon as the grant is approved
Implement invasive carp harvest subsidy program	July 15, 2023 – June 30, 2024
AEDC aids with building invasive carp processing capacity and market development in Arkansas	July 15, 2023 – June 30, 2024

Literature Cited: N/A

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 Corps of Engineers (USACE), Engineer Research and Development Center, Environmental Laboratory (ERDC), Nicky Faucheux (nicky.m.faucheux@usace.army.mil), Todd Slack (todd.slack@usace.army.mil), and/or Jack Killgore (jack.killgore@usace.army.mil)

Cooperating agencies: Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Mississippi State University (MSU), U.S. Geological Survey (USGS), Mississippi Cooperative Fish and Wildlife Research Unit (MSCRU), and U.S. Geological Survey (USGS), Columbia Environmental Research Center (CERC)

Statement of Need: A total of 41 sites along a 58-mile reach of the Lower Mississippi River were surveyed during winter 2022 for invasive carp aggregation. We identified 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.

Objectives:

1. Verify that large schools of presumed Carp overwintering in the LMR at pre-defined optimum habitat are present based on electronic sonar scans (Completed)
2. Measure and characterize the hydrogeomorphic and water quality environment of each overwintering habitat (75% Completed)
3. Sub-sample fish in overwintering habitats to determine species composition, size distribution, and relative abundance (FY22-23)
4. Evaluate different collecting gears to harvest carp in large numbers at overwintering locations (FY22-23)

Agency: U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory (ERDC).

Activities and Methods: In FY23, we will work with partners (USGS Columbia) to develop a more quantitative assessment of carp abundance based on sonar technology and data interpretation. 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. Logistics of mass removal techniques during the winter in the Lower Mississippi River will be evaluated and recommendations 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, sub-sampling fish assemblage	December 2023, January and February 2024
Compare gears	December 2023, January and February 2024
Prepare Report	March – April 2024

Literature Cited:

Killgore, K. J. and S. G. George. 2020. Comparison of benthic fish assemblages along revetted and natural banks in the Lower Mississippi River: a 30-year perspective. MRG&P Report 29, Mississippi River Geomorphology and Potamology Program, Mississippi Valley Division, Vicksburg, MS, 26 pp.

Norman J. D. and G. W. Whitledge. 2015. Recruitment sources of invasive bighead carp (Hypopthalmichthys nobilis) and silver carp (H. molitrix) inhabiting the Illinois River. Biological Invasions 17:2999–3014.

Ochs, C.A., O. Pongruktham, J.J. Hoover and K.J. Killgore. 2019. Phytoplankton prey selection by Hypophthalmichthys molitrix Val. (Silver Carp) in a Lower Mississippi River backwater lake. The Southeastern Naturalist 18(1):113-129.

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

Feeding competition between invasive carp (Bighead Carp) and a native planktivore (Paddlefish)

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

Cooperating agencies: Army Corps of Engineers, Engineer Research and Development Center (ERDC)

Statement of Need: Silver and Bighead Carp are invasive species that have invaded the Mississippi River and its tributaries. In addition to acting as a menace to boat traffic, invasive carps threaten commercial fisheries of Buffalo and clupeids through potential competition as filter feeders (Murray et al. 2020). The significance of this study is to understand if Silver and Bighead Carp are negatively impacting native planktivores through direct competition for food resources.

The ERDC Fish and Invertebrate Ecology Team has previously partnered with Mississippi State University to address how invasive carp are impacting the native community in oxbow lakes within the batture by comparing contemporary and historical electrofishing data. Additionally, LDWF has ongoing field-based efforts to identify dietary overlap through isotope studies that compare invasive carps to another native planktivore, Bigmouth Buffalo, in the Mississippi and Atchafalaya River basins. This research project was derived from earlier studies due to the difficulty using field research to detect statistically significant downward trends due to many confounding factors (VanderBloemen et al. 2022, Pendleton et al. 2017).

The current proposal would complement ongoing work and help with understanding the impact invasive carp have on native planktivores by investigating the interactions of invasive carp and native planktivores in a controlled mesocosm. Difficulties in sampling invasive carp, as well as the high lipid content of both Bigmouth Buffalo and Silver Carp, have provided some challenges in the LDWF Dietary Overlap study. The ERDC Fish and Invertebrate Ecology Team did not observe differences in the oxbow lake fish communities following > 30 years of Silver and Bighead Carp introductions, but sites were limited to open systems (i.e., lakes connected to the Mississippi River). This project will gather critical data that is missing between the interactions of Silver Carp and Bighead Carp and native planktivores (Strategies 3.6.2.3, 3.6.5.1, and 3.6.5.2 of the National Plan Goals and strategies). Understanding this interaction and determining if competition at the juvenile life stage is a mode that impacts native populations will provide guidance for structuring management strategies that aim to minimize impacts and control Silver and Bighead carp populations (Strategy 4.4 of the Sub-basin Goals and Strategies).

Objectives:

1. Conduct a feeding competition trial between Bighead Carp and Paddlefish in order to determine potential impact between native and non-native planktivores.
2. Provide a report detailing the results of interspecific competition for zooplankton resources between invasive carps and native planktivores. Validation of modeling efforts (Kinlock et al. 2020) that can be used to inform harvest and management of native planktivores in the future.

Agency: US Army Corps of Engineers, Engineer Research and Development Center (ERDC)

Activities and Methods: The intent of the study is to test for interaction effects between juvenile invasive carps and native planktivores using mesocosms to measure differences in condition and growth rates over a growing season. The study will be conducted at the ERDC, Vicksburg, MS (Figure 1).

Studies will be carried out in 15, 300-gal mesocosms equipped with an under-gravel filtration system. Fish will be housed in a greenhouse to accommodate natural variations in light and temperature over seasons. The experiment will begin in March and conclude in October. The experiment will consist of three treatments: 100% Paddlefish, 50/50 Paddlefish/Bighead carp, and 100% carp. Each mesocosm will be stocked with 12 fish. To ensure similar sizes, standard length of stocked Bighead Carp and eye to fork length of the Paddlefish will be 100-140 mm. Each fish will be individually marked to track growth throughout the season. Fish will be weighed and measured biweekly. Daily feeding rate will equate to 3% biomass/day of rotifers (controlled) in addition to naturally occurring zooplankton in the water column. Water quality parameters (temperature, specific conductivity, turbidity, pH, and dissolved oxygen) and background zooplankton density will be measured weekly.

Treatment effects on condition factor, growth rates, and mortality rates will be assessed using repeated measures analysis of variance tests between treatments, followed by Tukey’s HSD or other tests as appropriate as a post-hoc analysis to determine direction of effects.

Agency: Louisiana Department of Wildlife and Fisheries (LDWF)
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 all technical and progress reports to the USFWS.

Map of Project Area:

Figure 1. Area and location of where the proposed project will be conducted. The square outlined building on the picture (right side) is a greenhouse where Fish and Invertebrate Ecology Teams will conduct feeding competition trials located at the Engineer Research and Development Center in Vicksburg, MS.

Estimated Timetable for Activities:

Activity	**Time Period (Season, Month/Year)**
Begin competition trials	March 2024
End competition trials	October 2024
Final Report	December 2024

Literature Cited:

Kinlock, N. L., A. J. Laybourn, C. E. Murphy, J. J. Hoover and N. A. Friedenberg. 2020. "Modelling bioenergetic and population-level impacts of invasive bigheaded carps (*Hypophthalmichthys* spp.) on native paddlefish (*Polyodon spathula*) in backwaters of the lower Mississippi River." *Freshwater Biology* 00:1-15.

Murray, D. N., D. B. Bunnell, M. W. Rogers, A. J. Lynch, T. D. Beard Jr., and S. Funge-Smith. 2020. Trends in inland commercial fisheries in the United States. *Fisheries* 45(11): 585-596.

Pendleton, R. M., C Schwinghamer, L. E. Solomon, A. F. Casper. 2017. Competition among river planktivores; are native planktivores still fewer and skinnier in response to the Silver Carp Invasion? *Environmental Biology of Fishes* 100:1213-1222.

VanderBloemen, S. N. 2022. The invasion of bigheaded carps in the Tennessee River and Tennessee – Tombigbee Waterway. Mississippi State University Thesis and Dissertations. 5452. https://scholarsjunction.msstate.edu/td/5452

2023 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); Robert Bourgeois (rbourgeois@wlf.la.gov)

Cooperating agencies: Louisiana State University, Missouri Department of Conservation (MDC)

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 use 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 and depth use in a variety of habitat types. The proposed studies continue the first collaborative tracking efforts of this scale conducted on invasive carp across the LMR. The proposed network of receiver arrays will build upon existing arrays funded during previous cycles, and are compatible with arrays maintained by cooperating and partner agencies. Data sharing is high priority in this series of projects and necessary for understanding of the range wide habits of the species. Therefore, 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 Invasive 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 and FY22 Asian Carp Movement and Assessment to Inform Management and Removal Efforts in the Lower Mississippi River (LMR) Basin Work Plan.

Objectives:

1. Continued monitoring of invasive carp tagged with funds granted since FY20 to determine intrabasin and interbasin movement to inform placement of potential deterrent technologies and removal efforts.
2. Deploy 30 additional transmitters and 5 acoustic receivers to improve coverage and sample size in the upper Atchafalaya River.
3. Deploy 20 depth coded transmitters on Black Carp to assess habitat use and better identify depth use of Black Carp in the lower Mississippi River basin.
4. Analyze long-term and large-scale movement data for invasive carp tagged over a four year period.
    1. Assess seasonal movement patterns of invasive carp in the region.
    2. Identify key movement corridors that facilitate dispersal throughout the region and evaluate the potential role of estuaries in carp habitat and movement.

3. Characterize the influence of environmental variables (e.g., temperature, river level, etc.) on carp movement and presence.

Agency: Louisiana Department of Wildlife and Fisheries (LDWF)

Activities and Methods: In support of Objective 1, LDWF will coordinate with Louisiana State University (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. In FY22, the array was expanded northward in the Atchafalaya River system to provide additional information on the seasonal movement of carp between areas of high abundance upriver and the original monitoring region, and an additional 30 carp were tagged in within the expanded array. These transmitters were programmed for a battery life in excess of 6 years, and thus, this project (FY23) will allow for the continued monitoring of tagged carp from FY20 and FY22 while filling in gaps in the receiver array in the Atchafalaya River system between Morgan City and the Old River Control Structure near the confluence with the Mississippi and Red Rivers. This will build on objectives from FY22 to improve information on the movement of carp between areas of high abundance up river and the original monitoring area in southern Louisiana. Additionally, this expansion will improve connectivity with other telemetry efforts in the lower and upper Mississippi River Basins and the Red River.

In support of Objective 2, we will tag an additional 30 Silver Carp in the Atchafalaya River in the area of expanded coverage during this funding cycle to build on FY22 efforts to incorporate movements of fish north of the Intracoastal Waterway. Up to 5 receivers will be deployed in areas of high importance along the Atchafalaya River to fill in gaps in the array (either due to need or receiver loss) while continuing monitoring of movements of the 230 carp tagged with previous funding (FY20 and FY22) that remain at large in the lower portions of the basin.
In support of Objective 3, we will tag 20 Black Carp with pressure transmitters to examine depth use of Black Carp in the lower Mississippi River basin. If we are unable to capture 20 Black Carp, additional Silver Carp will be tagged with pressure transmitters. All tagged carp will also receive an external loop tag. Telemetry data will be analyzed to examine seasonal movement patterns, identify key movement corridors and evaluate use of estuaries as habitat and/or movement corridors, and characterize the influence of environmental variables on movement, depth use and presence of carp in the lower Mississippi River basin. 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 efforts 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 6 years. In addition, individuals will be tagged with an external loop 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.

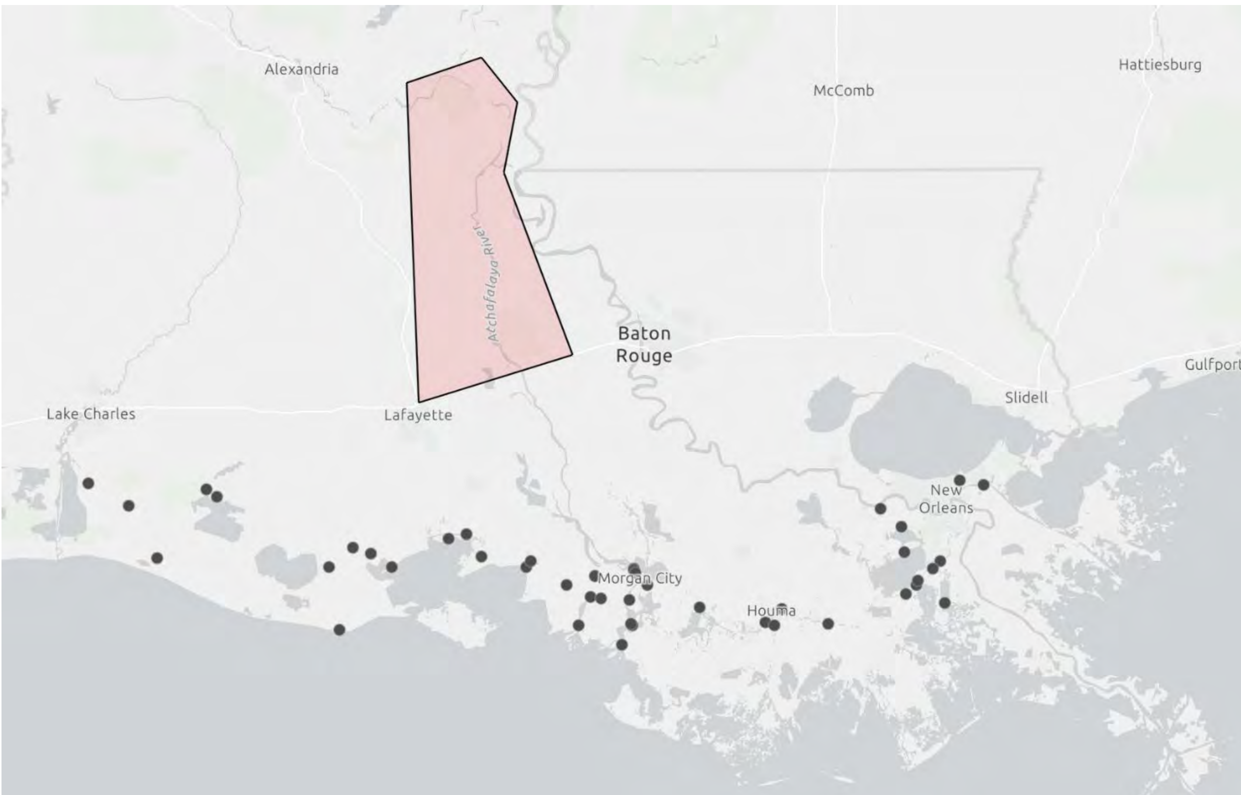
Five acoustic receivers will be deployed by LSU in the Atchafalaya River system north of the intercoastal waterway in the winter/spring of 2023 to monitor movements of invasive carp (Figure 1, orange polygon). We will also continue to maintain the existing array of 40 acoustic receivers deployed (with FY20 and FY22 funds) throughout the intercoastal waterway and waterbodies to the south (Figure 1, blue dots). Thus, our total array will consist of 55-60 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 12-16 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 United States Fish and Wildlife Service (USFWS), United States Army Corp of Engineers (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.

LDWF will provide project oversight, field assistance 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 all technical and progress reports to the USFWS.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Purchase Equipment	January 2024
Graduate Student and Technician Start	January 2024
Deployment of Additional Receivers	February 2024
Receiver Maintenance	Quarterly (every 12 weeks) throughout the study period
Acoustic Tagging (Multiple locations)	Winter/Spring 2024
Additional Acoustic Tagging (Multiple locations), as needed	Summer/Fall 2024
Data Analysis	Ongoing as data is received, final analyses Winter 2024
Manuscript Prep and Submission	Winter 2024
Annual Report	March 2025 (covering calendar year)

Agency: Missouri Department of Conservation (MDC)

Activities and Methods:
In support of Objective 1, MDC will continue to maintain an extensive acoustic telemetry network from Cairo, IL downstream to the southern extent of Missouri. Data from the Lower Mississippi River telemetry efforts will help fill in information gaps (i.e., residency time, and transition rates between basins), inform removal efforts, and describe movements of invasive carp in response to contract removal throughout the system. These data will also be available for use to inform complex temporal-spatial models (i.e., SEICarP) that could be developed for the LMR by modifying models developed in other basins. Additional receivers or acoustic tags may be added to the system if deemed necessary.

MDC will coordinate with the LMR Partnership to ensure data is shared and updates are provided.

Map of Project Area:

Estimated Timetable for Activities:

Project Activity	Season	Year
Sample invasive carp using electrofishing	Spring/Summer	2023
Complete fish ID from preserved specimens	Fall	2023
Download Receiver Data	Every 4-6 weeks	2023
Annual Report	March	2024

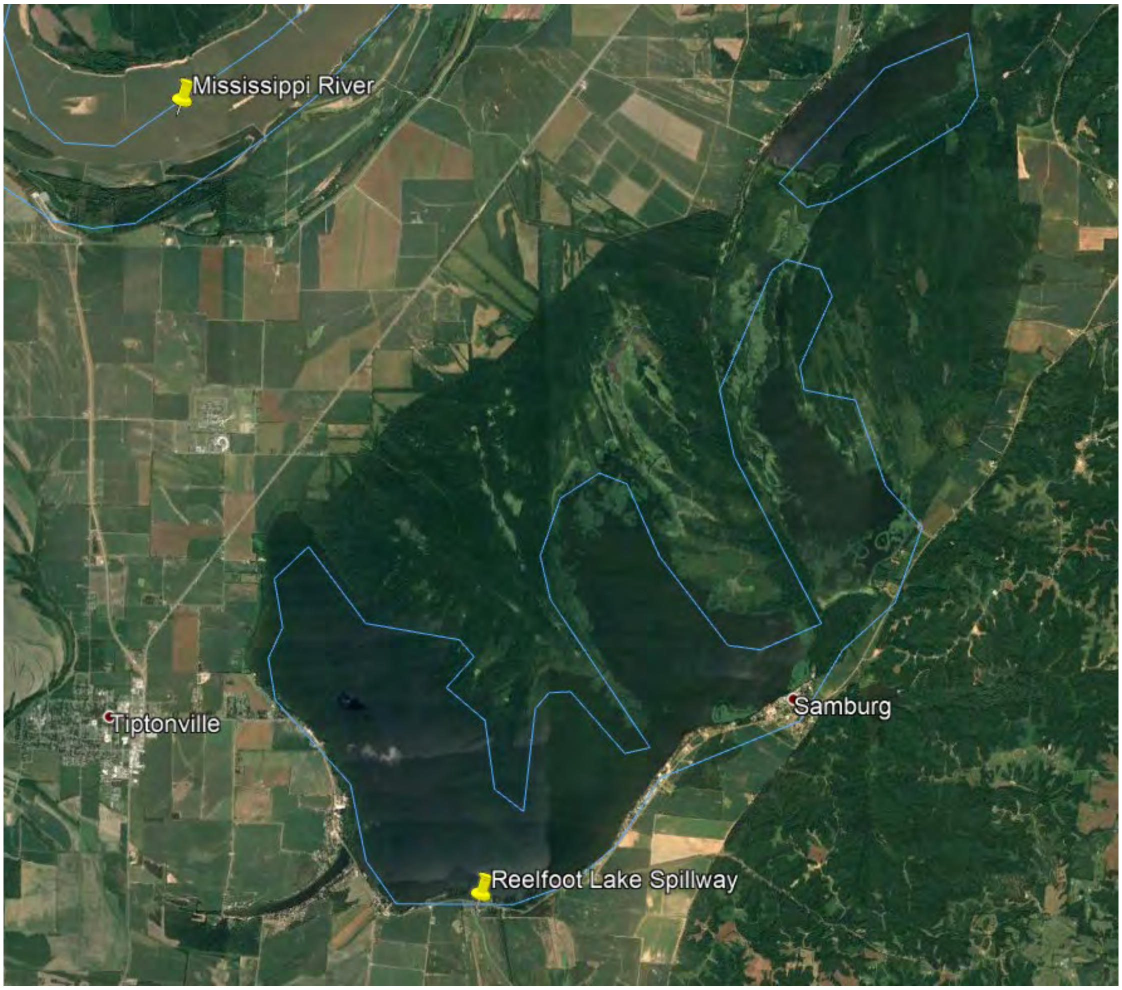
Agency: Tennessee Wildlife Resources Agency (TWRA)

Activities and Methods: In support of Objective 1, 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 continue implementation of 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. If sufficient numbers cannot be collected for tagging from within Reelfoot Lake, some individuals may be targeted and tagged below Reelfoot Lake Spillway. 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). The receiver array may be expanded as more is learned about fish behavior in the study area. 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.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Compiling data/information from partners	Ongoing
Maintain/expand acoustic receiver array	Ongoing
Tagging invasive carp	Spring 2024; Fall 2024
Receiver downloading	Ongoing (approx. every 3 months)
Data analysis and Final Report	Spring 2025

Diets and Detectability of Invasive Carp: Expanding Coverage

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 (SLU)

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 invasive carp in their catch. A better understanding of invasive carp diets is needed to determine impacts to native fish. Sampling methods such as eDNA are more efficient than the time consuming and labor-intensive sampling of both adult invasive carp and ichthyoplankton to help determine carp distributions. This project builds previous projects during FY 2021 and FY 2022 examining diets in coastal Louisiana and the lower Red River and Atchafalaya River sub basins of the Mississippi River. 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:

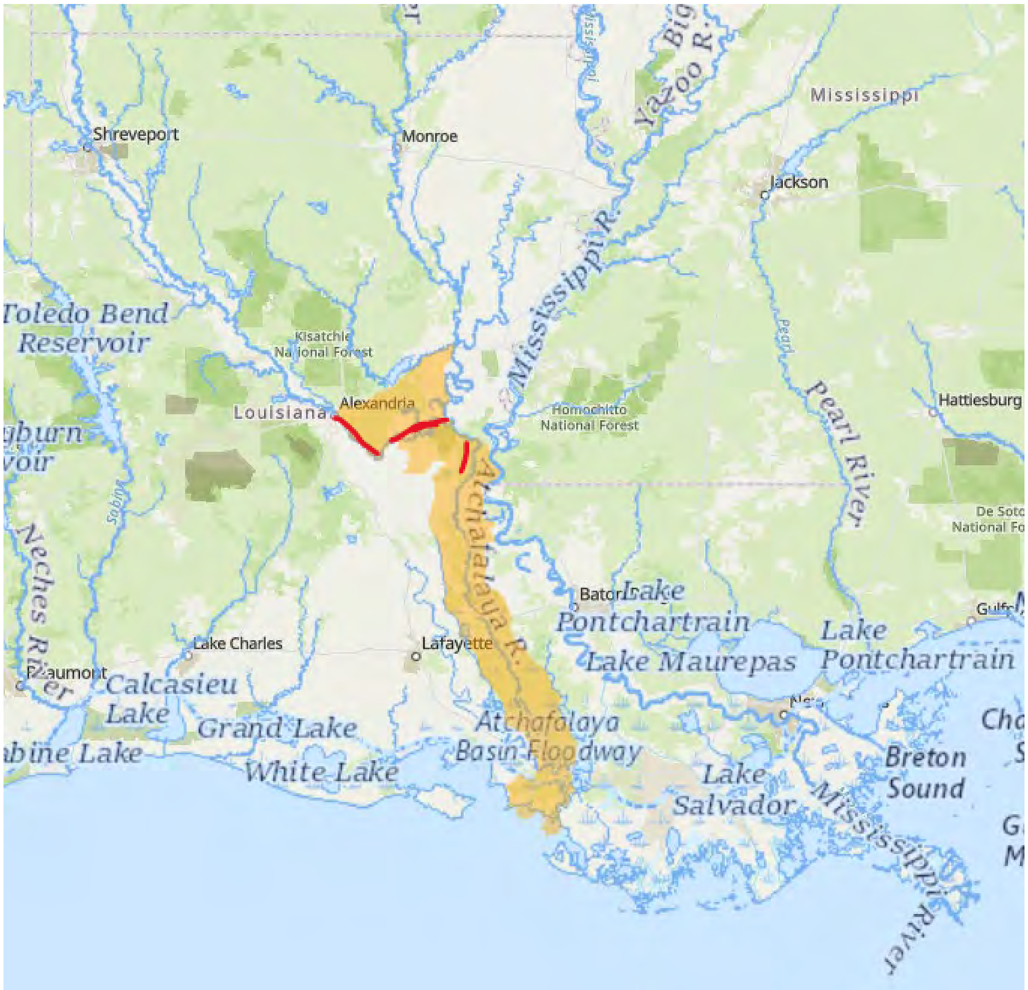
1. Assess methods of describing diets by DNA metabarcoding and stable isotopes on invasive carp and native fish condition and eDNA-based detectability of invasive carps, such as Black Carp and Silver Carp, in the Lower Red River and Atchafalaya River.

Agency: Louisiana State University Agricultural Center (LSU AgCenter), Louisiana State University, Southeastern Louisiana University (SLU)

Activities and Methods: This objective will focus on multiple methods of characterizing diets of invasive carp (Silver Carp *Hypophthalmichthys molitrix*, Bighead Carp *H. nobilis*, Grass Carp *Ctenopharyngodon Idella*, and Black Carp *Mylopharyngodon piceus*) 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 management (e.g., fertilizer for coastal restoration, 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, 30 basal food resource samples, and 30 centrarchids (total tissue/sample collection ~ 90 samples). Previous diet 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 (Miller et al, 2015). 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. Gut contents will be analyzed through DNA metabarcoding to describe diets using stable isotope based mixing models parametrized using priors obtained from gut content DNA metabarcoding. Each spatially independent river reach will have invasive carp density 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 using eDNA metabarcoding, an approach currently used in other projects. Additionally, physicochemical measurements will be taken to describe habitat variation among the sampled locations. Results from this year of sampling will be compared with eDNA and diet results of FY 22 lower Mississippi River sampling and diet sampling coastal freshwater systems (FY 21) to better determine the spatial distribution of invasive carps and their impacts.

Agency: Louisiana Department of Wildlife and Fisheries (LDWF)
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 all technical and progress reports to the USFWS.

Map of Project Area: Sampling reaches for fishery-independent sampling are in red. Collections for eDNA will include these reaches and other locations within the orange shaded region.



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Project Initiation	January 2024
Fish Sampling and Tissue Collection	February 2024-October 2024
eDNA Sampling	February 2024-October 2024
Stable Isotope Tissue Processing	February 2024-October 2024
Stable Isotope Tissue Analysis	October 2024-November 2024
eDNA Analysis	February 2024-November 2024
Data Analysis and Final Report Draft	December 2024

Using live imaging sonar (LIS) to find and identify invasive carp and to observe reactions to removal gear.

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

Statement of Need: Many fisheries agencies throughout the U.S are beginning to utilize live imaging sonar (LIS) technology to conduct various fisheries research projects in an effort to better understand fish behavior and perform population assessments. This relatively new technology allows the user to view fish in real time, similar to as would be depicted on video or more costly adaptive resolution imaging sonar (ARIS) technology. Fish can often be identified to species and lengths can also be estimated. This technology may help fill in knowledge gaps regarding the location, densities, and behavior of invasive carps.

At this time, there are no LIS units within LDWF dedicated to research on invasive carps. LIS should prove to be a valuable tool in learning more about the invasive carp populations in LA, which will aid in determining appropriate geographic focus and techniques of future management activities. Invasive carps have been identified in many waterbodies throughout northeast LA, though abundance and specific habitat preferences within the state are not well known. They have also been reported in certain waterbodies that have not yet been confirmed by LDWF. LIS should serve as an invaluable tool to gather much needed information about the status and impact of invasive carps in LA.

Many potential uses for LIS have already been determined, though many more will likely be discovered with increased knowledge and proficiency of these units. Knowledge of the behavior of invasive carp in response to various stimuli, as provided by LIS, can aid in capture and removal techniques. With a better understanding of not only where fish tend to congregate, but how they behave in response to removal efforts, we should be able to pursue these tasks more efficiently in the future.

Objectives:

1. To identify and confirm invasive carp presence in Lake Bruin, select waterbodies in northeastern Louisiana, the Atchafalaya Basin, and select waterbodies in south Louisiana.
    1. Capture and confirm identities of fish viewed on LIS.
    2. Inform if barriers are needed in Lake Bruin.
2. Observe behavior of carp and note reactions to various stimuli and gill nets.
    1. Alter capture techniques based on findings.
3. Develop protocols to observe invasive carp using LIS and guide monitoring or removal efforts.

Activities and Methods: A mobile LIS unit will be constructed and shared amongst LDWF Inland Fisheries districts to be used on a variety of boats to detect invasive carp. The first task will be to test the unit in an area known to be inhabited by carp. We will use a combination of LIS with electrofishing and/or gill nets to confirm the identity of the fish on the LIS. Video recordings of carp and other notable species will be kept as references.

The community around Lake Bruin has requested carp barriers, and we lack confirmation of invasive carp presence or densities. After initial testing of the unit and confirmed carp detections elsewhere, Lake Bruin will be surveyed by mounting the LIS on an electrofishing boat, dividing the lake into four sections, and surveying a 15-minute transect per section. Transects will be performed in a zigzag pattern from bank to bank to cover a variety of habitats. Upon suspected carp detection, the electrofishing unit will be activated for 300 seconds to attempt to confirm carp presence. If no carp are sighted in the initial four LIS transects, biologists will use LIS to survey an additional 15-minute transect at a site of their choice, and one more transect at another favorable site if none are detected there. Numbers and locations of carp will be recorded and reported for all detections.

If electrofishing is ineffective in areas of suspected carp presence, gill nets will be set in zigzag patterns or in parallel sets, and fish will be herded into them using similar methods used in the marking portion of telemetry studies in south Louisiana. The netting methods will be adaptive based on habitat characteristics of the waters being sampled.

Following the sampling events at Lake Bruin, LDWF will be able to advise the Lake Commission if carp were detected in the lake, if barriers are a feasible method of control, and, if so, what type of barriers would be preferable.

For the second objective of the project, the LIS unit will be taken to the Atchafalaya Basin to sites that are being sampled as part of another invasive carp project. Inland Fisheries staff will set gill nets and herd carp into those sites using boat electrofishing, while a boat mounted with LIS will be positioned at the nets to observe how carp behave approaching the nets using methods similar to Lawson et al.'s (2021) work with ARIS. Reactions of carp to electrofishing will be recorded as well as their behavior when they "wear out" and stop jumping in an area due to continued harassment. Observations will be described in the report.

For the final objective of the project, a protocol will be written for detection of carp using LIS. The protocol will include identification techniques, LIS usage techniques, and recommendations for use.

Map of Project Area:

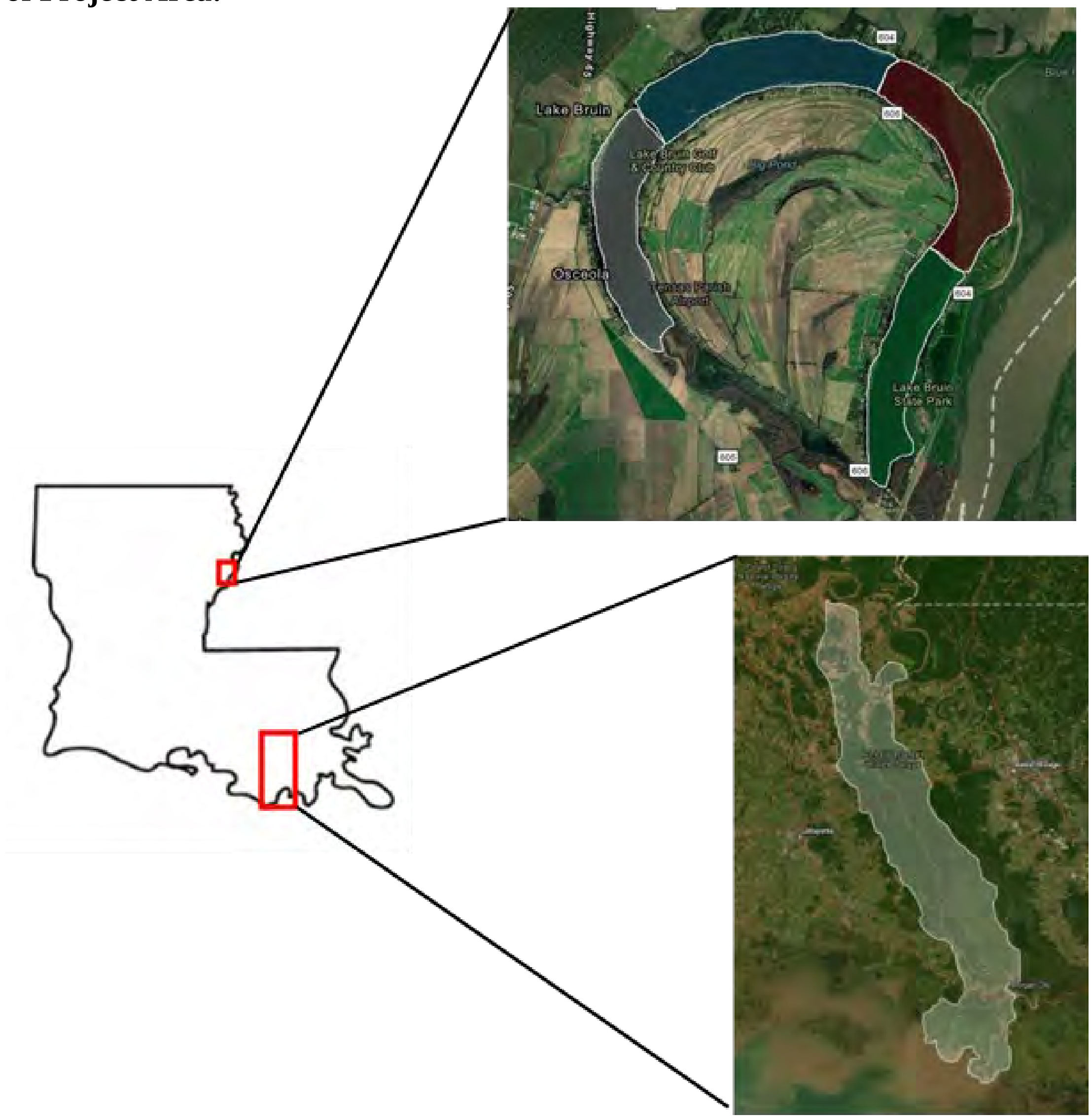


Figure 1. Lake Bruin divided into four zones (top), and the Atchafalaya Basin (bottom).

Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Purchase and construct LIS unit	Winter 2023/2024
Test unit and confirm carp identification	Spring 2024
Survey Lake Bruin	Spring/Summer 2024
Observe carp behavior in Atchafalaya Basin	Summer/Fall 2024
Develop LIS carp detection protocols	Fall 2024
Write final report	Winter 2024/Spring 2025

Literature Cited:

Ridgway, J.L., Lawson, K.M., Shier, S.A., Calfee, R.D. and Chapman, D.C. (2023), An Assessment of Fish Herding Techniques: Management Implications for Mass Removal and Control of Silver Carp. North Am J Fish Manage, 43: 176-188. https://doi.org/10.1002/nafm.10685.

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), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), and Tennessee Wildlife Resources Agency (TWRA)

Statement of Need: Populations of invasive carp (silver carp, bighead carp, black carp, and grass carp) have rapidly expanded throughout the Mississippi River basin. Management and control of invasive carp is necessary to reduce their impact on native species, the ecosystem, and the economy. In response to these threats, many states throughout the Mississippi and Great Lakes basins have been working to find effective strategies to manage existing populations and to control the expansion of invasive carp into adjacent aquatic systems. Appropriations for the Department of Interior indicate that 'while the Committees (House Subcommittee on Interior, environment, and Related Agencies and the Senate Subcommittee on Interior, Environment, and Related Agencies) recognize the importance of studying and understanding invasive carp patterns, the Service is encouraged to take action on a strategy that increases the focus on biomass removal and restricts carp progression by coordinating with other Federal partners on constructing invasive carp barriers'. This project addresses the need for biomass removal and provides the opportunity to collect data on invasive carp populations and native fish communities that may inform future removal efforts.

Objectives:

1. Reduce overall invasive carp population numbers and alleviate propagule pressure in areas with low population density by implementing carp 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.
4. Target and remove invasive carp from the LMR and tributaries in support of a large-scale, multi-agency effort in the LMR and Middle Mississippi River to suppress populations and reduce propagule pressure throughout waters of the MRB.

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: MDC will implement 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 periodic 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:

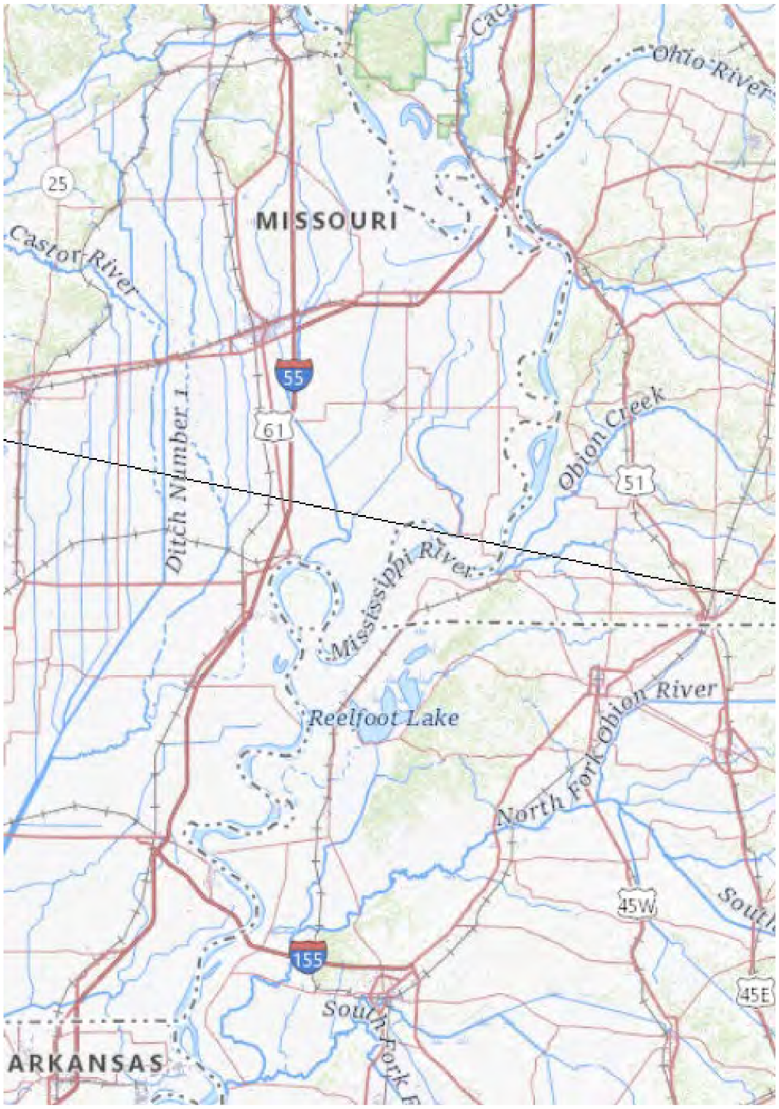


Figure 1. *Lower Mississippi River adjacent to the state of Missouri (RM 828-953).*

Estimated Timetable for Activities:

Activity	Time Period
Fish Assemblage Monitoring	Summer 2023
Invasive Carp Removal	Fall and Winter 2023
Ride-Alongs/Data Collection	Fall and Winter 2023
Data Summary/Analysis	Winter 2023/2024
Technical Report	Spring 2024

Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods:
AGFC will continue to use an in-house Invasive Carp Removal Program. Invasive carp funding will be used to staff one full-time Invasive Carp Biologist that will oversee the program, cover salaries of at least two part-time employees to catch and remove carp, and purchase supplies needed to implement removal activities. This project compliments an identical removal project being conducted by the AGFC Invasive Carp Removal Program in the Arkansas-Red-White Sub-basin and allows for removal in the full range of Silver Carp within the Arkansas and White River systems.

Invasive carp will be targeted and removed from the Arkansas River (river mile 63 downstream to the confluence with the Mississippi River) and White River (river mile 176 downstream to the confluence with the Mississippi River), and includes backwaters, oxbows and tributaries of these rivers (Figure 1). Two boat crews will be used to conduct removal efforts. Gear used to catch and remove carp will primarily consists of gill nets, but boat electro-fishing will be used if warranted. The Invasive Carp Biologist will coordinate with other federal and state agencies to test new methods and equipment for improving control efforts, if available. Prior removal efforts using gill nets has shown, based on the average size of Silver Carp in the Arkansas and White Rivers, gill nets constructed with 4 ¼ or 4 ½ inch square mesh, 7 or 8 ply multi-strand monofilament produced higher catch rates than other gill net designs (i.e., 3-inch, 4-inch and 5-inch square mesh). Also, the majority of past removal efforts occurred in water depths less than 10 feet. Therefore, gill nets used will be 12 feet deep hobbled to 10 feet, with 4 ¼ or 4 ½ inch square mesh, 7 or 8 ply multi-strand monofilament, with foam core float lines and lead core lead lines.

Removal locations will be determined from catch data recorded during prior removal efforts, the AGFC ANS Report Database, information obtained from commercial fishers and other agency staff, and river gauge readings. Areas with highest carp densities will be prioritized for removal. Boat crews will identify carp using side-scan sonar and visual observations. Nets will be fished in an active manner and will be monitored at all times. All species caught during removal efforts will be documented. Native species will be released immediately. Invasive carp will be removed from the gear and euthanized. Unless other disposal options become available, all Silver and Grass Carp will be disposed of in the main channel or deepest portion of the water body being fished. All invasive carp removed from National Wildlife Refuge (NWR) waters will be disposed in the main river channel outside of the NWR. Length and weight will be recorded from a subsample of Silver Carp at each location fished, and for all Bighead, Black Carp, and Grass Carp. Data collected for each net set includes: GPS location, invasive carp species caught, by-catch species caught and mortality, date, time in, time out, river gauge reading, water clarity, water temperature, and cloud cover. Data will be collected on paper data sheets in the field and entered into the Invasive Carp Removal Program Database on a weekly basis.

Total number, weight, and size structure of invasive carp species removed, as well as any notable information on by-catch mortality, harvested fish use, gear modifications, or changes in capture techniques will be provided in subsequent interim and technical reports related to this project.

Map of Project Area:

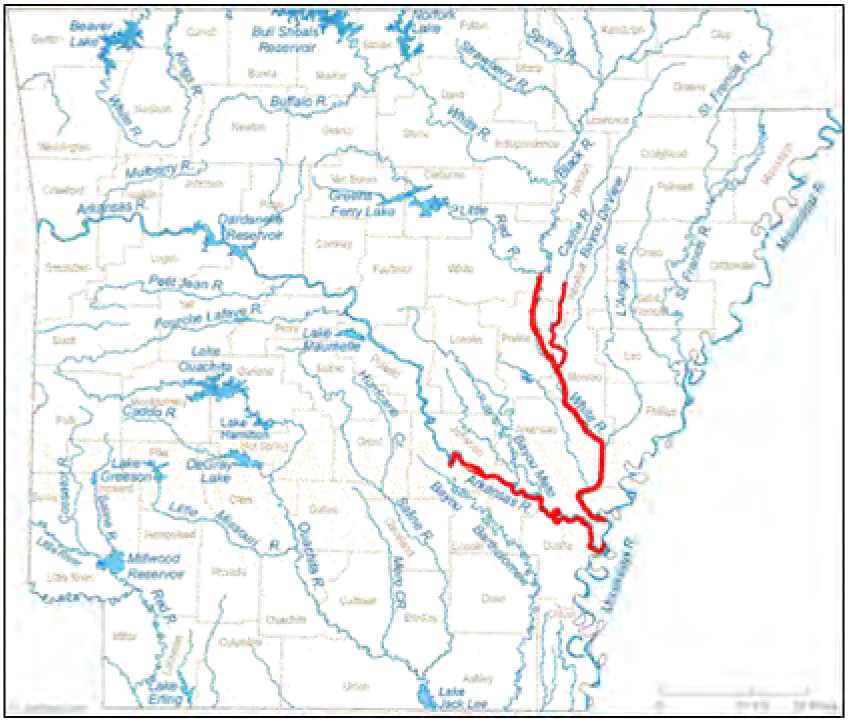


Figure 2. *Map illustrating reaches of the Arkansas and White Rivers, within the LMR Sub-basin, where targeted removal of invasive carp will be conducted by the AGFC Invasive Carp Removal Program from October 1, 2023 to September 30, 2024. Focus area is represented by red lines.*

Estimated Timetable for Activities:

Activity	Time Period
Arkansas River Removal	Annually (Oct. 1, 2023 – Sept. 30, 2024)
White River Removal	When river gauge is below 24 feet at Augusta (Oct. 1, 2023 – Sept. 30, 2024)

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

Activities and Methods: MDWFP plans to continue offering invasive carp processors an incentive of 18 cents per pound if they pay fishermen at least 25 cents per pound for invasive carp harvested from the Mississippi River where it borders the State of Mississippi and from waters in the Yazoo River Basin. MDWFP also plans to hire, equip and train two temporary agency employees at $16.00/hr. to harvest invasive carp using gillnets and record some biological data as per that collected by the AGFC. MDWFP plans to have their employees travel to Arkansas to learn harvesting techniques and methods from AGFC personnel. Harvested fish will either be disposed of in a sanitary manner on agency property or taken to a rendering plant if this can be arranged.

Map of Project Area:

Figure 3. *Mississippi River and Yazoo River Basin.*

Estimated Timetable for Activities:

Activity	Time Period
Reimburse Processors	October 2023 - September 2024
Staff Removal Efforts	October 2023 - September 2024
Data Summary/Analysis	October 2023 - September 2024
Technical Report	September - December 2024

Agency: 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 and pectoral spines 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 will contract with licensed wholesale fish dealers to remove invasive carp from waters of the LMR and tributaries, including Reelfoot Lake, as 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 Tennessee Carp Harvest Incentive Program (TCHIP) purchases and quantify harvest. 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:

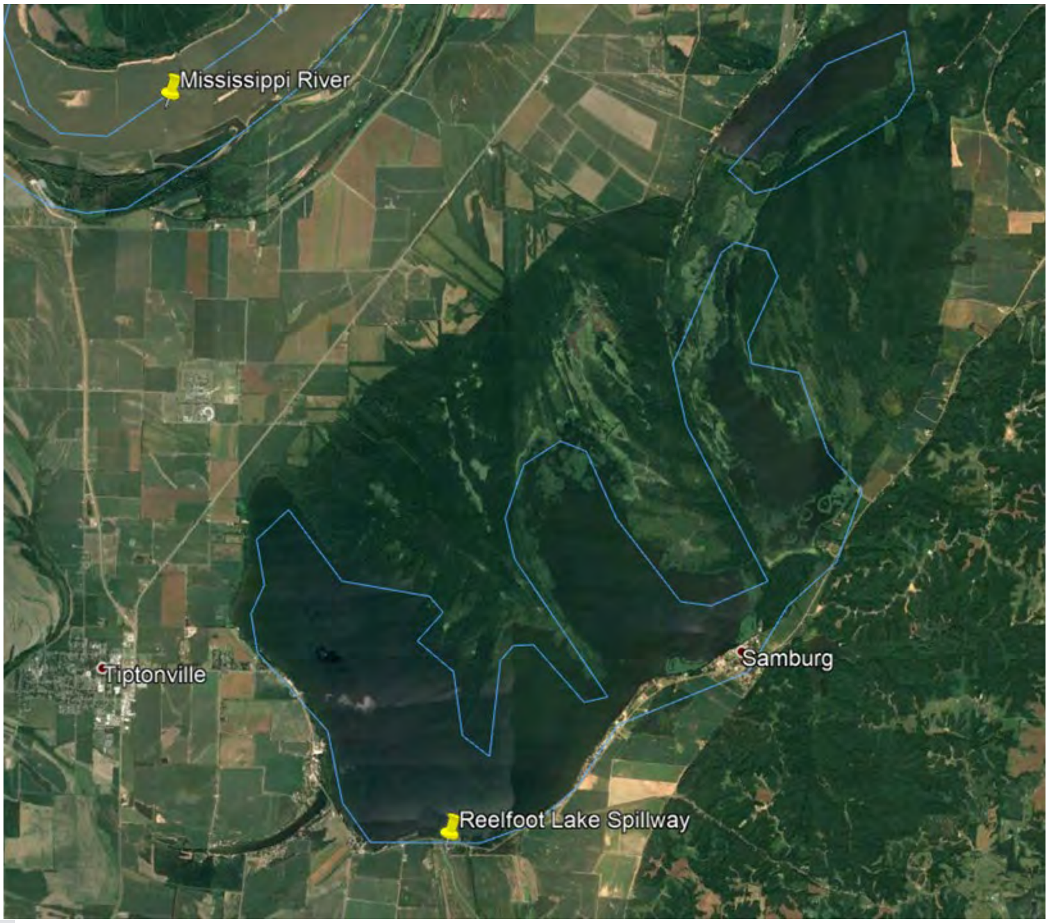


Figure 4. *Primary agency sampling activities will occur in Reelfoot Lake. Invasive carp harvest activities associated with implementation of TWRA's TCHIP will occur in the LMR and tributaries along Tennessee's western border.*

Estimated Timetable for Activities:

Activity	**Time Period**
TCHIP Commercial/Contract Removal	January 2024 – June 2025
Electrofishing	Spring-Fall 2024
Gillnetting	Summer-Winter 2024
Bowfishing Tournament	TBD
Annual Report	Spring 2025

Literature Cited:

Ratcliff, E. N., E. J. Gittinger, T. M. O'Hara, and B. S. Ickes. 2014. Long Term Resource Monitoring Program Procedures: Fish Monitoring, 2nd edition. A Program Report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program. June 2014. Program Report LTRMP 2014-P001. 88 pp. including Appendixes A–G.

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.

Examining deterrence potential of existing water infrastructure for limiting invasive carps movements while promoting population connectivity of native fishes

Lead Agency and Author: U.S. Geological Survey (USGS), Alabama Cooperative Fish and Wildlife Research Unit (ALCRU) and Auburn University, Shannon Brewer (skb0064@auburn.edu; sbrewer@usgs.gov)

Cooperating Agencies: U.S. Geological Survey (USGS), Mississippi Cooperative Fish and Wildlife Research Unit (MSCRU) and Mississippi State University (MSU), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), U.S. Geological Survey (USGS), Mississippi Cooperative Fish and Wildlife Research Unit (MSCRU) and Mississippi State University (MSU), U.S. Geological Survey (USGS), Columbia Environmental Research Center (CERC), U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center, Environmental Laboratory (ERDC)

Statement of Need: There is an inherent tradeoff between limiting movements of carps with deterrents (barriers) and minimizing impacts to native fishes unless barriers are operated to allow passage of native fishes. Mismatches in the timing of large-scale movements between native fishes and carps might provide such opportunities to operate deterrents in a manner that limits carps while minimally interfering with population connectivity needed to sustain native fish populations. However, it is not clear whether the timing of large-scale movements by invasive carps and native planktivores coincide.

Constructing barriers or modifying operations of existing water infrastructure is a leading strategy for limiting the spread of invasive carps (Cupp et al. 2021). Invasive carps require multiple habitat types to complete their life cycle. For example, Silver Carp typically forage in slow-moving pools and off-channel habitats but require long stretches of moving water for egg development. Thus, the Department of Interior and partnering agencies have invested heavily into understanding the timing and extent of large-scale carp movements to optimize harvest strategies (Erickson et al. 2021) and identify where deterrents could be deployed strategically to limit carps (Post van der Burg et al. 2021).

The potential is high in the Lower Mississippi Alluvial Valley (LMAV) to operationalize existing water infrastructure to limit carp invasions given there are at least 500 barriers (water-control structures, weirs) that manage water levels in this highly engineered riverscape (SARP 2020). Nearly all invasive carp deterrent studies investigate passage rates through lock-and-dam structures designed to pass shipping traffic. These studies often report small percentages of acoustically tagged bigheaded carps (6–9%) pass through lock-and-dams, and passage events often are related to water levels and lock operations (Tripp et al. 2014; Lubejko et al. 2017; Fritts et al. 2021). However, none of these studies investigate passage rates of invasive carps through water-control structures. Tripp et al. (2016) noted 34% of tagged fish among 13 species (not including invasive carps) passed through a water-control structure in St. Johns Bayou (MO), indicating passage rates might be higher than observed at lock-and-dams structures.

Over the last several decades conservation practitioners have sought to restore hydrologic and ecological connectivity among mainstem rivers, tributaries, and off-channel waterbodies in the LMAV (LMRCC 2015). Further, several goal within USFWS' carps management strategies aim to limit impacts of invasive carps on native fishes (Conover et al. 2007; Rogers 2019), especially native planktivores such as Paddlefish and Bigmouth Buffalo (Pendleton et al. 2017; Kinlock et al. 2020). The few studies reporting passage rates of native planktivores typically report similarly low passage rates through lock-and-dam structures (Paddlefish, 2–6%, Tripp et al. 2014, Fritts et al. 2021; buffalofishes, 16%, Fritts et al. 2021). Interestingly, Fritts et al. (2021) noted that passage pressure (time within vicinity of barrier) and passage events by native fishes and Silver Carps varied seasonally. For example, Silver Carp mainly encountered navigation locks in fall, whereas Paddlefish and Bigmouth Buffalo mainly encountered navigation locks in early spring and summer, respectively. Accordingly, native planktivores might exhibit long-range movements earlier than bigheaded carps in unobstructed rivers, but obstructions could force long-range movements by native planktivores and invasive carps to coincide, thereby exacerbating potential competition for space between invasive and native fishes (Figure 1).

If the timing of long-range movements varies between native planktivores and bigheaded carps, then it would be possible to fine-tune operations of water-control structures to allow passage of native planktivores while deterring movements of Silver Carp, which would help minimize collateral damage to native fishes while managing carp invasions.

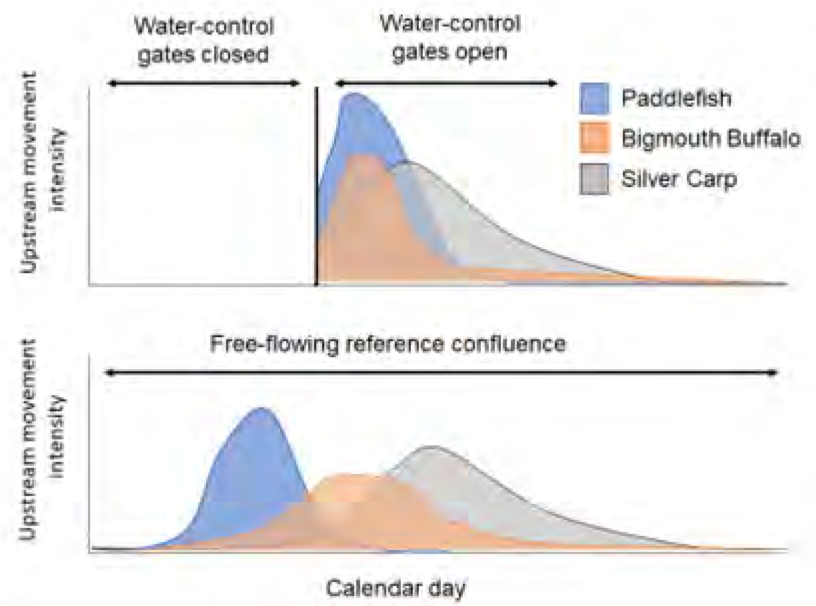


Figure 1: Predicted influence of a water-control structure on upstream movements of Silver Carp, Paddlefish, and Bigmouth Buffalo. When closed, water-control structures synchronize the timing of large-scale movements by allowing passage only when the water-control structure is opened. In an unobstructed confluence, seasonal upstream movements for spawning by native planktivores and Silver Carp coincide lightly.

Objectives:

1. Assess timing and duration (passage pressure) of invasive carps and native fishes near Steele Bayou water-control structure.
2. Quantify passage rates of invasive carps and native fishes through Steele Bayou water-control structure.
3. Contrast movements of invasive carps and native fishes at Steele Bayou to those observed at an unobstructed reference confluence in the Yazoo River system to assess impacts of water-control structures on fish movements.

Agency: U.S. Geological Survey (USGS), Mississippi State University (MSU), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP)

Activities and Methods: We propose expanding the existing telemetry array in the Yazoo River basin into the upper Yazoo River to quantify movement and passage rates of native fishes while continuing to monitor passage rates of Silver Carp through water-control structures on Steele Bayou and Muddy Bayou (Figure 2). Yazoo River basin is an ideal setting for examining the efficacy of deterrents. Yazoo River is a 7th-order river comparable in size to other LMAV rivers including Black (LA, AR), White (AR), St Francis (MO), and Obion rivers (TN) and provides >200 kms of free-flowing river for migrations of large-river fishes. Due to leveeing, large tributaries of the Yazoo River are the main access ways to spawning shoals and off-channel oxbows.

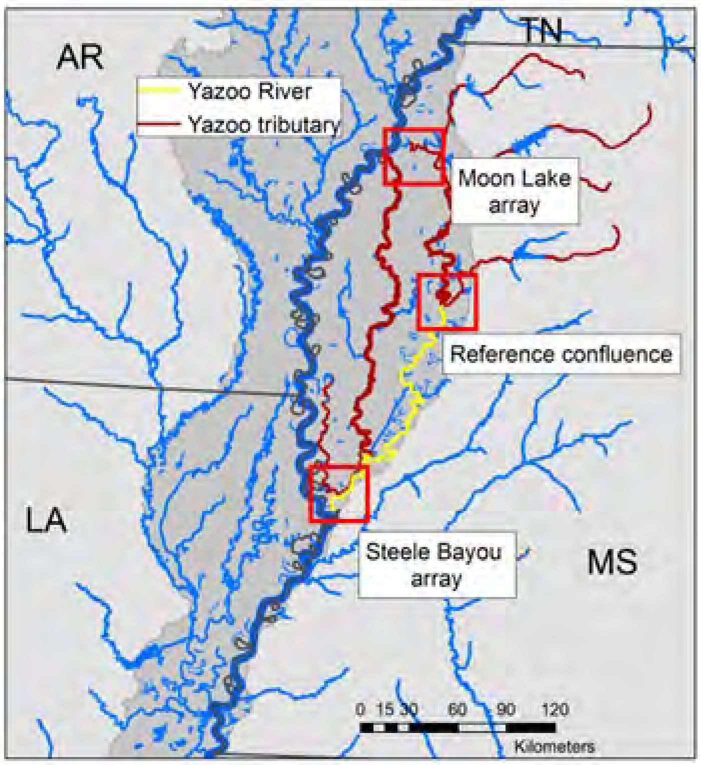


Figure 2: Locations of existing telemetry array (Steele Bayou, Moon Lake) and the proposed array (reference confluence) in the Yazoo River basin centrally located in the Lower Mississippi River Region.

Our telemetry array in Eagle Lake-Steele Bayou-lower Yazoo River is part of a broader framework (3 active projects) to manage bigheaded carps in LMAV oxbow lakes. Preliminary results from these projects indicate 1) Silver Carp movement rates into oxbows without deterrents are high (frequent movements into Moon Lake from Coldwater River by 80 tagged Silver Carp); 2) water-control structures prevent movements of Silver Carp when intentionally operated to limit passage of invasive fishes (0 passage events by 60 tagged carp at Muddy Bayou water-control structure on Eagle Lake), and 3) Silver Carp can pass through water-control structures when the structure is opened (5 passage events among 60 [8%] acoustically tagged Silver Carp at Steele Bayou water control structure). In addition to recording Silver Carp, our acoustic array in lower Yazoo River has recorded 34 unknown fish and 1 Paddlefish (from TN) implanted with acoustic tags. These preliminary results indicate other tagged fish originating throughout the Lower Mississippi Region use the Yazoo River and attempt to pass through Steele Bayou water-control structure. For example, most of the Mississippi Delta is drained by Big Sunflower River, which passes through Steele Bayou water control structure near its confluence with the Yazoo River (Figure 3). Big Sunflower River historically supported a large spring run of Paddlefish from Yazoo River, but long-term monitoring by Engineer Research and Development Center (ERDC) indicates Paddlefish numbers declined following the construction of Steele Bayou water-control structure.

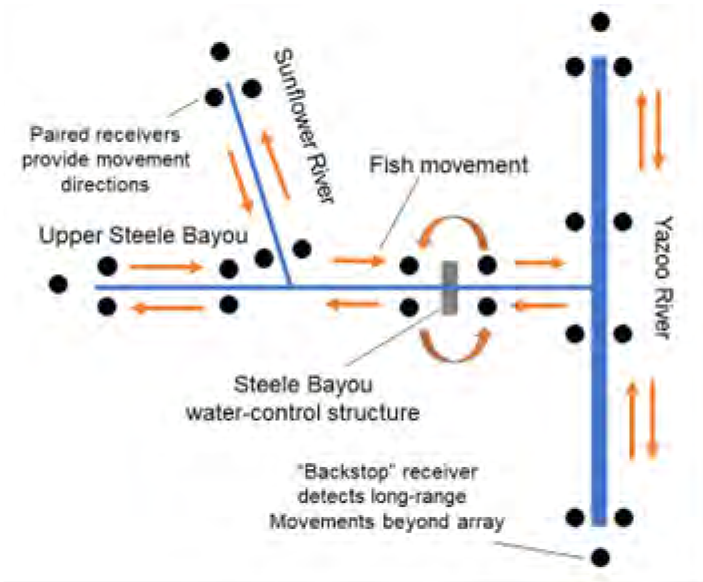


Figure 3. Existing acoustic array spanning Steele Bayou water-control structure in the lower Yazoo River basin. The array monitors movements upstream Yazoo River into Steele Bayou/Sunflower River and through the water-control structure. Backstop receivers will be placed upstream and downstream of the array to monitor long-range movements throughout the Yazoo River system.

Our preliminary data indicate 8% of acoustically tagged Silver Carp have passed through Steele Bayou water-control structure. However, we do not have a reference for normal exchange rates of fishes between mainstem rivers and tributaries to evaluate the effectiveness of Steele Bayou water-control structure nor do we have a reference for the typical timing of spawning runs for Silver Carp and native planktivores.

We will maintain the current acoustic array consisting of 24 VR2W-69 kHz receivers spanning 10 km of lower Yazoo River, confluence of Steele Bayou/Sunflower River with Yazoo River, and the water-control structure on Steele Bayou (Figure 3). This array tracks fish either moving up the Yazoo River past the mouth of Steele Bayou or into Steele Bayou/Sunflower River. Receivers track fish that approach within 500 m of either side of Steele Bayou water-control structure, which also records movements through the water-control structure. Additional "backstop" receivers record movements farther upstream in the Mississippi Delta into Eagle Lake, Steele Bayou, and Big Sunflower River.
We will also maintain the array on Muddy Bayou to quantify any additional movements between Steele Bayou and Eagle Lake (5 receivers), thereby providing additional information on the optimal management of water-control structures on outlets of oxbow lakes.
We will add a similar array consisting of 12–16 receivers to a confluence in the upper Yazoo River drainage to track the timing of seasonal movements of Silver Carp and native planktivores

within an unobstructed river as a reference. Candidate reference confluences include Tallahatchie-Yalobusha-Yazoo river confluence or Tallahatchie-Coldwater confluence (Figure 4). ERDC biologists recently witnessed spawning aggregations of Silver Carp in these reaches (Kilgore and George 2021), suggesting these receivers could provide additional insights into Silver Carp spawning habitat and behavior.

Each receiver will be outfitted with temperature loggers and water-pressure loggers to record water depth. We will use loggers to establish relationships between local water-level height and gages operated by USACE. We will deploy receivers and loggers in fall of 2023.

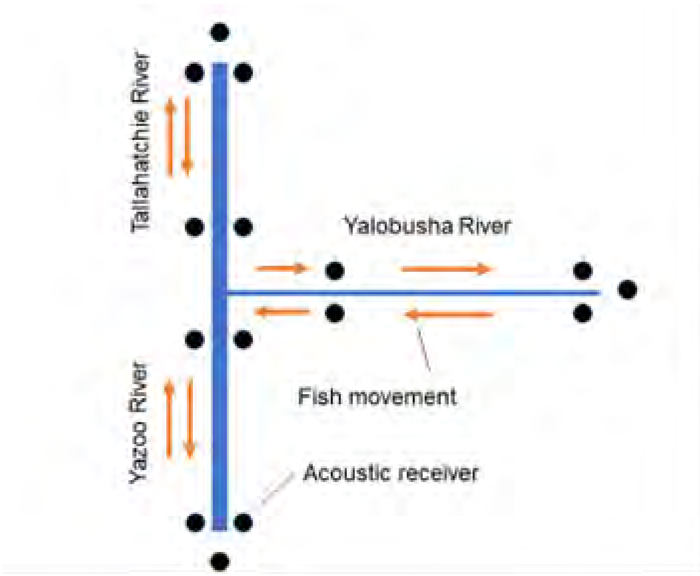


Figure 4. Proposed acoustic array in upper Yazoo River of unobstructed reference confluence to monitoring normal timing and transition probabilities of Silver Carp, Paddlefish, and Bigmouth Buffalo.

We will aim to capture and tag (V16-x acoustic tags) Silver Carp, Bigmouth Buffalo, and Paddlefish using boat electrofishing, gill nets, and hoop nets from rivers and adjacent oxbows in fall-winter 2023. Our aim is to tag and release at least 50 fish per species at each confluence (Steele Bayou-Yazoo River, upper Yazoo River confluence) in December 2023. Fish will be manually tracked monthly with a hydrophone while maintaining the array. Manual tracking allows deceased or emigrated fish and tag losses to be omitted from analyses.
Note numbers of tagged fish, study species, and receivers can be adjusted to align the project more closely with priorities of other Lower Mississippi River basin partners.

Objective 1: Assess timing and duration (passage pressure) of invasive carps and native fishes near Steele Bayou water-control structure

- Receivers positioned on either side of Steele Bayou water-control structure record when tagged fish approach the water-control structure. We will model the daily probability of a tagged fish occurring within 500 m of the water-control structure as a function of calendar day (timing) while treating fish length, sex, and absolute and change-in water temperature and stage as covariates. We will assess among-species differences in timing with a species x calendar day interaction.

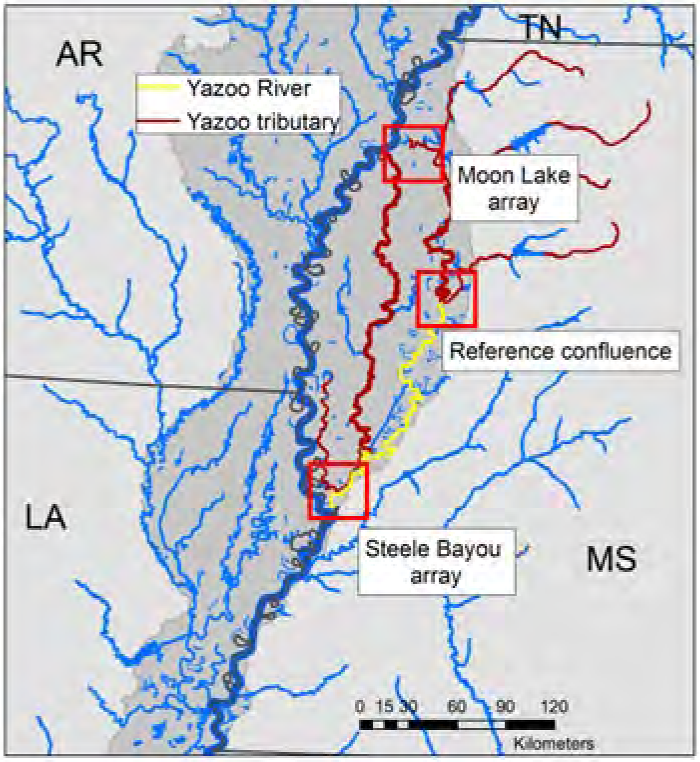
Objective 2: Quantify passage rates of invasive carps and native fishes through Steele Bayou water-control structure

- We will model the daily probability of a tagged fish passing through Steele Bayou water-control structure with a multi-state model that accounts for imperfect fish detection (Figure 3). We will use the same model to model the probability of fish moving from Yazoo River into Steele Bayou/Sunflower River. On the upstream side of Steele Bayou, the multi-state model will model the probability of tagged fish transitioning into upper Steele Bayou or Sunflower River to determine which tributary system species are using. Transition probabilities will be modeled as a function of calendar day, water temperature, stage height, change in stage height, species, fish sex and length. Transition probabilities through the water-control structure will be set to zero when Steele Bayou water-control structure is closed. We will use USACE's published operations of Steele Bayou water-control structure to determine these transition probabilities, which will be corroborated with water-level loggers on either side of Steele Bayou water-control structure.

Objective 3: Contrast movements of invasive carps and native fishes at Steele Bayou to a reference confluence in the Yazoo River system

- Findings from Objective 2 will be compared to transition probabilities of a reference confluence in the upper Yazoo River basin. Without an unobstructed reference confluence, it is unclear whether high water velocities through release gates of Steele Bayou attract fish into Steele Bayou from Yazoo River or whether Steele-Bayou water-control structure deters upstream movements of fish. Therefore, we will model the daily transition probabilities of Silver Carp, Paddlefish, and Bigmouth Buffalo from the mainstem Yazoo River into principal tributaries rivers (e.g., Tallahatchie, Yalobusha). Transition probabilities will be modeled as a function of calendar day, water temperature, stage height, change in stage height, species, and fish sex and weight. Findings from the reference system will be used to contrast the timing of large-scale movements to those observed in the lower Yazoo River and through the Steele Bayou water-control structure.

Map of Project Area:



Locations of existing telemetry array (Steele Bayou, Moon Lake) and the proposed array (reference confluence) in the Yazoo River basin centrally located in the Lower Mississippi River Region.

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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 (Dam 1) 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 throughout the Arkansas and White Rivers. Black Carp have been documented in the White River up to the Devall's Bluff area and the Arkansas River up to Pool 9. These range expansions suggest population numbers for these species are increasing and will likely continue to increase into the future. Public sightings and subsequent reports are increasing in the Arkansas and White Rivers and their oxbows and tributaries. Increasing invasive carp abundance could impact recreation and commercial actives and is likely impacting the ecological stability of these fisheries. While complete elimination of invasive carp is not currently feasible, management and control of these species is necessary to reduce their impact on native species, the ecosystem, and the economy.

The AGFC will continue to implement an in-house Invasive Carp Removal Program to reduce invasive carp populations in the Arkansas and White River systems, within the Arkansas-Red-White Sub-basin. Removal efforts will help minimize ecological and economic impacts and the likelihood for upstream range expansion. Data collected from fish removed will increase our knowledge of invasive carp distribution, abundance, and size structure and further inform future control efforts.

This work plan supports the following goals and strategies from the Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States. Goal 3: Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass, and silver carps in the United States. Strategy 3.3.4. Physical removal by natural resources management agencies. Strategy 3.3.4.1. Biologists should physically remove Asian carps collected as a result of management actions or research. This work plan addresses the following items from the Lower Mississippi River Basin Asian Carp Control Strategy Framework. Goal 2: Monitoring and Population Status; Strategy 2.4: Implement contract surveillance or targeted Asian carp sampling to monitor the distribution and abundance of Asian carps. Goal 3: Population Control and Agency Response; Strategy 3.2: Utilize commercial harvest and implement contract fishing of Asian carps to decrease densities. Strategy 3.3: State natural resources agencies will work within their authorities to increase opportunities for commercial harvest of Asian carps. Strategy 3.5: Utilize knowledge of Asian carp habitat requirements and preferences to target control efforts.

Objectives:

1. Reduce invasive carp population numbers by utilizing dedicated agency personnel to implement invasive carp removal in the Arkansas and White River systems.

Activities and Methods: The Arkansas Game and Fish Commission (AGFC) will continue to use an in-house Invasive Carp Removal Program. Invasive carp funding will be used to staff one full-time Invasive Carp Biologist that will oversee the program, cover salaries of at least two part-time employees to catch and remove carp, and purchase supplies needed to implement removal activities. This project compliments an identical removal project being conducted by the AGFC Invasive Carp Removal Program in the Lower Mississippi River Sub-basin and allows for removal in the full range of Silver Carp within the Arkansas and White River systems.

Invasive carp will be targeted and removed from the Arkansas River (Pools 4, 5, 6, 7, 8, and 9) and White River (from Batesville (Dam 1) downstream to the confluence of the Little Red River) and includes backwaters, oxbows, and tributaries of these rivers (Figure 1). Two boat crews will be used to conduct removal efforts. Gear used to catch and remove carp will primarily consists of gill nets, but boat electro-fishing will be used if warranted. The Invasive Carp Biologist will coordinate with other federal and state agencies to test new methods and equipment for improving control efforts, if available. Prior removal efforts using gill nets has shown, based on the average size of Silver Carp in the Arkansas and White Rivers, gill nets constructed with 4 ¼ or 4 ½ inch square mesh, 7 or 8 ply multi-strand monofilament produced higher catch rates than other gill net designs (i.e., 3-inch, 4-inch, and 5-inch square mesh). Also, the majority of past removal efforts occurred in water depths less than 10 feet. Therefore, gill nets used will be 12 feet deep hobbled to 10 feet, with 4 ¼ or 4 ½ inch square mesh, 7 or 8 ply multi-strand monofilament, with foam core float lines and lead core lead lines.

Removal locations will be determined from catch data recorded during prior removal efforts, the AGFC ANS Report Database, information obtained from commercial fishers and other agency staff, and river gauge readings. Areas with highest carp densities will be prioritized for removal. Boat crews will identify carp using side-scan sonar and visual observations. Nets will be fished in an active manner and will be monitored at all times. All species caught during removal efforts will be documented. Native species will be released immediately. Invasive carp will be removed from the gear and euthanized. Unless other disposal options become available, all Silver and Grass Carp will be disposed of in the main channel or deepest portion of the water body being fished. Length and weight will be recorded from a subsample of Silver Carp at each location fished, and for all Bighead, Black Carp, and Grass Carp. Data collected for each net set includes GPS location, Invasive Carp species caught, by-catch species caught and mortality, date, time in, time out, river gauge reading, water clarity, water temperature, and cloud cover. Data will be collected on paper data sheets in the field and entered into the Invasive Carp Removal Program Database on a weekly basis.

Total number, weight, and size structure of invasive carp species removed, as well as any notable information on by-catch mortality, harvested fish use, gear modifications, or changes in capture techniques will be provided in subsequent interim and technical reports related to this project.

Map of Project Area:

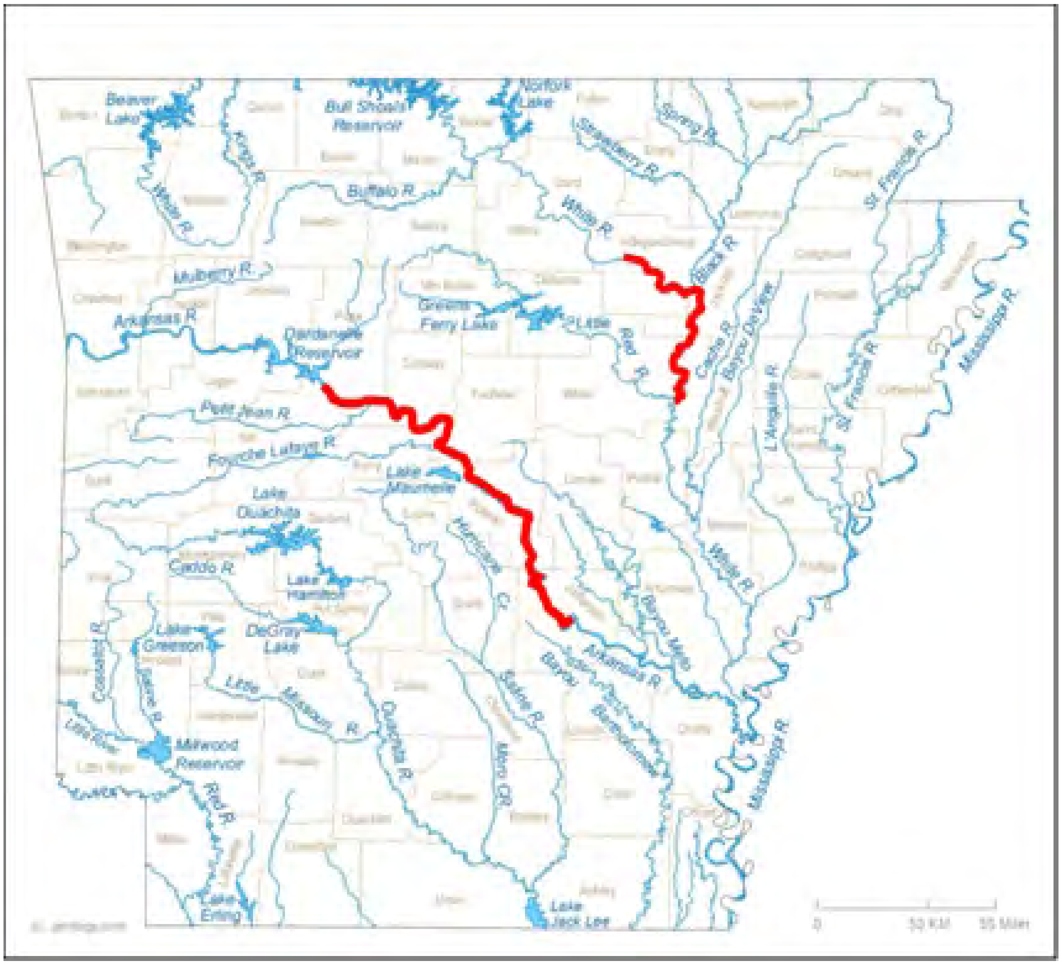

Figure 1. Map illustrating reaches of the Arkansas and White Rivers, within the ARW Sub-basin, where targeted removal of invasive carp will be conducted by the AGFC Invasive Carp Removal Program from October 1, 2023 to September 30, 2024. Focus area is represented by red lines.

Estimated Timetable for Activities:

Activity	Time Period
Arkansas River Removal	Annually (Oct. 1, 2023 – Sept. 30, 2024)
White River Removal	When river gauge is below 24 feet at Augusta (Oct. 1, 2023 – Sept. 30, 2024)

Equipment Maintenance for Evaluating 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), Auburn Cooperative Fish and Wildlife Research Unit (ACFWRU), USFWS Oklahoma Fish and Wildlife Conservation Office (OKFWCO)

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. In 2023, the use of acoustic telemetry was begun to evaluate movements and obtain additional information about the bigheaded carp population dynamics to enhance sampling and provide insights of relevance related to spawning and for future potential control efforts. This work plan supports and continues the telemetry component to replace any damaged or lost equipment for this ongoing project to ensure continued project success.

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 telemetry project addresses the general lack of knowledge of invasive carp population dynamics in this sub-basin and builds on the previous population assessment for the lower Red River basin. The intentions of this effort are to aid in evaluation of population dynamics and potential spawning and guide potential future control 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. Provide support for continuation of efforts to determine movement patterns of invasive carp in the Red River using telemetry.

Agency: Texas Parks and Wildlife Department (TPWD)

Activities and Methods: TPWD will coordinate with other agencies and ACFWRU to coordinate the project in the Red River and major tributaries in Texas, Arkansas, and Oklahoma. We will obtain and manage the USFWS grant to support this project as well as initiate and manage a research contract with ACFWRU to accomplish project objectives. We may assist with sampling as time and staffing permit. TPWD will lead development of project reports in collaboration with ODWC, AGFC, OKFWCO, and ACFWRU.

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 sections. Timetable for report preparation will follow grant guidelines.

Agency: Oklahoma Department of Wildlife Conservation (ODWC)

Activities and Methods: The ODWC will coordinate with other agencies and ACFWRU to coordinate work in Oklahoma waters. The ODWC may assist with sampling as time and staffing permit. The ODWC will collaborate on development of project reports with TPWD, AGFC, OKFWCO, and ACFWRU.

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.

Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods: The AGFC will coordinate with other agencies and ACFWRU to coordinate work in Arkansas waters. The AGFC may assist with sampling as time and staffing permit. The AGFC will collaborate on development of project reports with TPWD, ODWC, OKFWCO, and ACFWRU.

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.

Agency: Auburn Cooperative Fish and Wildlife Research Unit (ACFWRU)

Activities and Methods: Objective 1: 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; the specific objective of this work plan is to replace lost or damaged submersible ultrasonic receivers to support completion of this objective, with receivers being replaced at the beginning of the year and/or as needed. We primarily focus our telemetry 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 are used in this study with the passive receivers used primarily to determine if and when tagged fish move into the tributaries. We will continue tracking up to 50 fish tagged during late autumn/winter 2022 and 2023 and may tag additional fish if there are any tags remaining. Captured fish are sedated using an electrofishing sedation table as it prevents use of chemical sedation and allows for rapid recovery. We make an incision on the ventral side of the fish, posterior to the left pelvic fin and anterior to the anal vent. The incision is 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.) is inserted into the abdominal cavity and interrupted absorbable sutures are used to close the incision (2-0 PDO, 3/8 reverse cutting needle; Unify, AD Surgical,

Sunnyvale, CA, USA). The tag burden is < 2% of body weight. Fish with implanted transmitters are also fin clipped for visual identification if captured and Passive Integrated Transponder tags are inserted.
We determine the sex of each fish based on macroscopic observation of the gonads (if possible). Following surgery and morphometric measurements, fish are released in a slow-moving environment. Because others have expressed concern related to "fallback" (Frank et al. 2009; Vallazza et al. 2021), we exclude all fish detections for 14 days following surgery.

Active Tracking

We actively track tagged fish seasonally (spring, summer, winter) beginning late February 2023 through May 2024. All tracking is conducted during the day (~0700-1900 hours) and three river sections are tracked every 1-2 weeks from approximately Feb-July, and December-January. We conduct tracking by boat. We move in a downstream direction covering each study reach. Because spawning movements are of primary interest, active tracking effort is greater 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. As part of this year's work plan, SURs lost or damaged during the previous year will be replaced.
During active tracking, we 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 record a GPS location and the date. We also record several habitat characteristics at each fish location.

Passive Tracking

Four receiver stations (2 receivers near each station) with fixed-position antennas are being used to help monitor tagged fish in the study area. Each receiver station (4 stations with two receivers at each) were 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 anchored two passive submersible ultrasonic receivers (SUR) (VR2Tx InnovaSea) in four locations as agreed upon with the state agencies. Paired passive receivers were 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. Data collected by the passive receivers is 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. Any SURs damaged, lost, or stolen during the first year of the project will be replaced under this work plan (up to 10 total SURs).

Geographic location

We will continue to 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 are focusing on three active tracking reaches that were determined based on agency consultation, access, and safe river conditions.
Passive receivers will have been 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 seemed prudent. Location of SURs to be replaced under this work plan will be dependent upon equipment loss and replacement needs experienced during the first year of the telemetry project.

Map of Project Area:

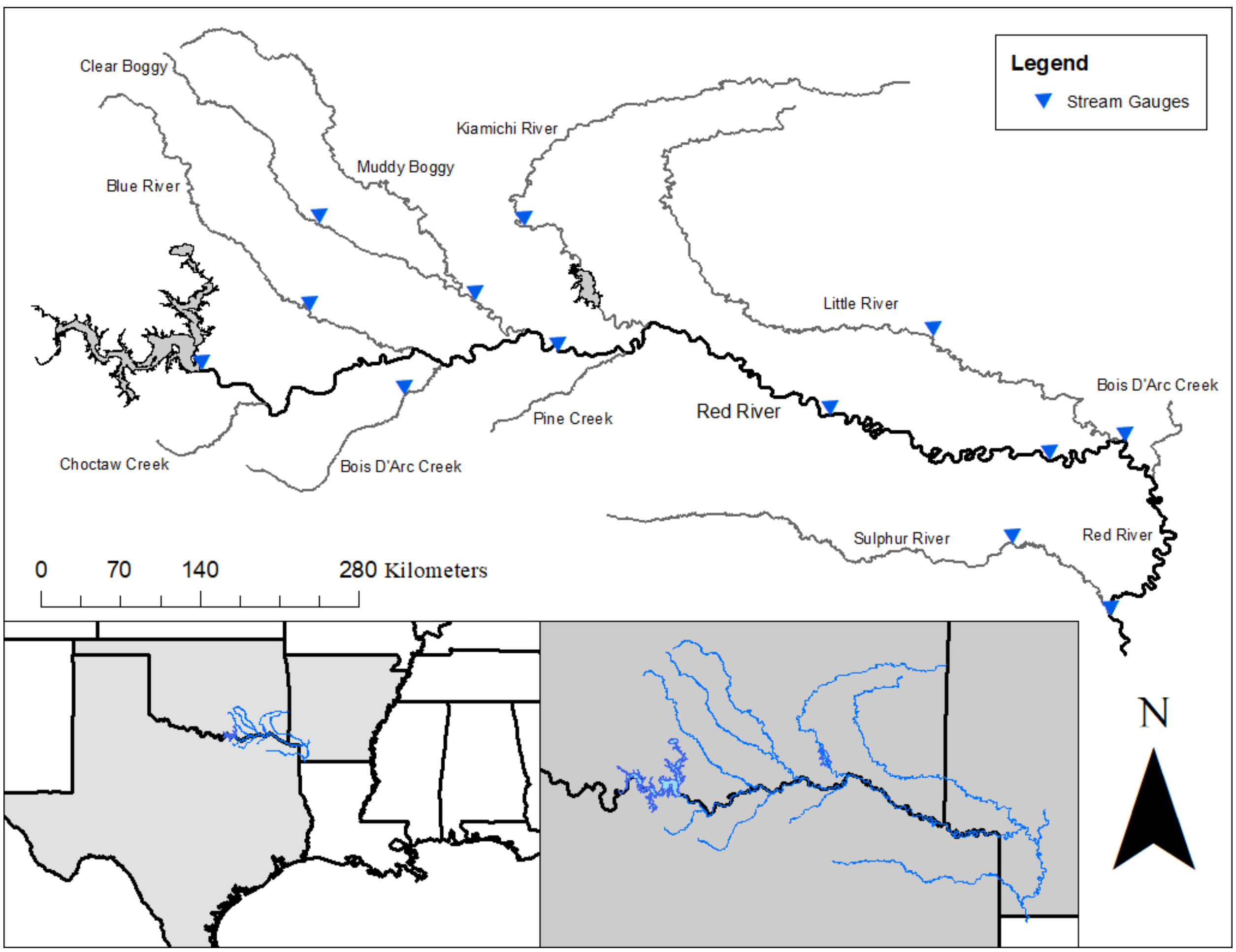

Figure 1. Study area of the Red River basin and major tributaries where carp occupancy, demographics, and movements will be determined.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Bigheaded Carp Telemetry & SUR Replacement – Red River and tributaries in OK, TX & AR	Fall 2023*, Winter 2023-2024 (limited)*, Spring 2024, Summer 2024
Project Final Technical Report Preparation	Winter 2024-2025**

*Anticipated timeline for SUR replacement

**March 1, 2025 technical report submission date; will be prepared earlier if next project phase not funded

Agency: USFWS Oklahoma Fish and Wildlife Conservation Office (OKFWCO)

Activities and Methods: The OKFWCO will continue to implement a small-scale telemetry project and share fish tag/telemetry information with TPWD, ODWC, AGFC, and ACFWRU for augmenting project data. The OKFWCO will also collaborate on development of project reports in collaboration with TPWD, ODWC, AGFC, and ACFWRU.

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 sections. Timetable for report preparation will follow grant guidelines.

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Seasonal Movement and Habitat Use of Invasive Carp in the Neosho River-Grand Lake System to Inform Removal

Lead Agency and Authors: Kansas Department of Wildlife and Parks (KDWP), Chris Steffen (chris.steffen@ks.gov) and Liam Odell (liam.odell@ks.gov)

Cooperating Agencies: Missouri State University (MSU), Oklahoma Department of Wildlife and Conservation (ODWC)

Statement of Need: In North America, invasive carp (i.e., Bighead Carp Hypophthalmichthys nobilis, Silver Carp H. moltrix, Grass Carp Ctenopharygodon idella, Black Carp Mylopharygodon piceus) have successfully invaded many inland aquatic systems. Invasive carp exhibit the characteristics of a successful invader (e.g., rapid growth, efficient dispersal capabilities, high-reproductive potential, lack of natural predators, and wide environmental tolerance). Studies have demonstrated negative effects on native and game fish abundance and condition, particularly native planktivores (e.g., Paddlefish Polyodon spathula, Gizzard Shad Dorosoma cepedianum, and Bigmouth Buffalo Ictiobus cyprinellus). Invasive carp impacts need to be evaluated. Additionally, native fishes during all life stages (i.e., larvae, juvenile, adult) are likely deleteriously influenced by increasing numbers of invasive carp. As such, there is a need to evaluate seasonal movement and habitat use of invasive carp telemetry study to inform removal and develop control/eradication methods.

Understanding fish movement and habitat use is a critical component of large-river ecology, especially the overlap between nonindigenous fishes and native fauna (Yallaly et al. 2014; Phelps et al. 2015; Phelps et al. 2017). Non-native invasive carp can pose deleterious effects in large river ecosystems. Despite the apparent relevance, invasive carp impacts on native biota have received little attention. This is especially true for systems where invasive carp have recently invaded (Kolar et al. 2005; Chapman et al. 2016). Invasive carp have been extensively introduced beyond their range and were brought to the United States for biological control in the 1970’s (Jennings 1988). After escaping ponds, the invasive carp spread throughout the Mississippi River, Missouri River, and Ohio River basins and now inhabit a majority of the United States’ open waters (Kolar et al. 2005). Since that time, invasive carp biomass has increased substantially and are likely posing negative effects on aquatic systems. Specifically, Invasive carp may compete with and or consume native biota (fishes, mollusks, invertebrates, etc.) or disrupt trophic interactions through direct reductions in primary and secondary productivity (i.e., phytoplankton and zooplankton; Sampson et al. 2009; Phelps et al 2017). Specifically, Schrank et al. (2003) suggested bigheaded carps (i.e., silver and bighead carp) had deleterious effects on Paddlefish under experimental conditions. Furthermore, D. Chapman (Personal Communication) suggested Invasive carp are posing deleterious effects on native fishes in the Missouri River. Irons et al. (2007) and Phelps et al. (2017) used data from the Long-Term Resource Monitoring (LTRM) element in the Illinois River and suggested negative interactions between native fishes (i.e., Gizzard Shad and Bigmouth Buffalo) and Invasive Carp. Correspondingly and relative to the upper Mississippi River, Phelps et al. (2017) also suggested negative interactions between native and non-native planktivores. Specifically, Phelps et al. (2017) documented that the relative abundance and condition of many of the native fishes in the Mississippi River basin are declining as bigheaded carp relative abundance has increased.

Currently, invasive carp are well documented and studied in areas of hyperabundance (e.g., Solomon et al. 2015; Phelps et al. 2017), however, knowledge gaps remain (Chapman et al. 2016). Specifically, minimal Invasive carp information exists in the Neosho River Grand Lake System, despite invasive carp presence as far upstream as John Redmond Reservoir and below Baxter Springs Dam on the Spring River (Rasset unpublished data). This is especially troubling given Invasive carp adults have the propensity to move long distances in relatively short time intervals (Tripp and Phelps 2018, N. Jackson, Personal Communication). However, uncertainty exists as to the spatial extent or intensity of invasive carp in the upper portion of the Neosho River Grand Lake System (i.e., adult abundance [presence], reproduction, movement/passage) and the relative influence on native fishes. Biological information is needed for proper invasive species management and control (Simberloff 2003). Acquiring this information is particularly important given the collaborative efforts (among state and federal agencies) that are currently occurring throughout various river basins to evaluate the Invasive carp population. Given that minimal information exists in the Neosho River Grand Lake System, a telemetry study is needed and will be complementary to many various state and federal agencies evaluating movement patterns of invasive carp.

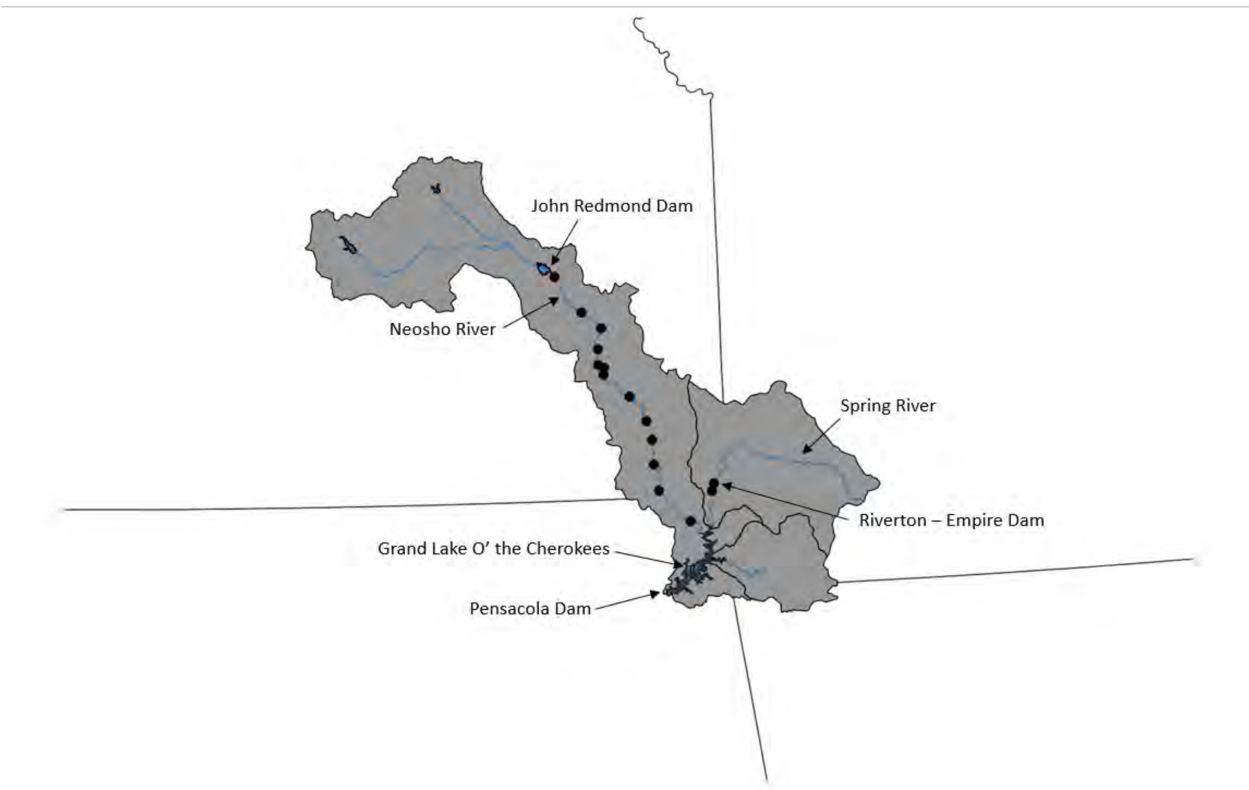
Objective:

1. Determine seasonal movement and habitat use of invasive carp in the Neosho River-Grand Lake System to inform removal.

Activities and Methods: KDWP will contract with Missouri State University to conduct a telemetry study to meet project objective. KDWP and ODWC will serve in advisory roles and assist as needed and available. Invasive carp will be sampled throughout the Neosho River Grand Lake system. Targeted collection efforts will be conducted around areas where invasive carp have been successfully captured (E. Rasset, unpublished data). Invasive carp will be targeted during colder periods (e.g., fall and winter) using a compliment of gears (e.g., electrofishing and trammel nets) that will sample the broadest size and age distribution to garner a representative sample of the fishes. Invasive carp captured will be weighed and measured. All invasive carp will be implanted with ultrasonic transmitters (Vemco V16-5H; 69kHz) using methods described in Tripp et al. (2013). Invasive carps will be anesthetized and once equilibrium is lost or swimming ability ceases, surgeries will commence. Fish will be placed onto a clean V-shaped surgery board, and water will be circulated over the gills. In all surgeries the incision area will disinfected. All surgeries will be made by experienced surgeons ventral to the lateral line and anterior to the anal opening. A scalpel and curved hemostats will be used to lift tissues while cutting to avoid damage to internal organs, and three or four Ethicon 3-0 monofilament sutures will be evenly placed to close the incision site. Sutures will be closed with a simple interrupted technique, deemed the strongest and most suitable for closing the skin of fish (Summerfelt and Smith 1990). Once fishes are fitted with transmitters movement and passage will be documented throughout the life of the transmitters (up to 5 years). Given the low abundance of invasive carps, approximately 40 transmitters are needed for fishes sampled.

A monitoring array will be utilized that is a combination of stationary receivers and manual tracking. The entire stationary receiver array will extend throughout Grand Lake, Neosho River, and Spring River. Major tributaries (e.g., Elk River) and other strategic locations (i.e., above and below dams and other pinch points throughout the system) will encompass passive tracking efforts. Transmitter detections from the stationary receivers will be summarized to describe invasive carp and movement throughout the Neosho River Grand Lake system and downloaded at regular intervals (e.g., monthly). Manual tracking (Vemco VR100) will be conducted at regular intervals and concentrated during seasons with high movement (e.g., spawning movement) throughout the study to garner more fine scale habitat information (e.g., spawning locations) and “hot spots” (e.g., areas of high Asian carp concentration). Approximately 45 receivers will provide enough spatial coverage to detect longitudinal movement throughout the system. Receivers place above and below low head dams can inform passage across these structures. Coverage will extend from Grand Lake, below twin bridges, to Riverton on the Spring River and below John Redmond Dam on the Neosho River. Additional receivers will be placed between low-head dams to ensure maximum spatial coverage. Additionally, extra receivers have been proposed to replace loss and wear.

Map of Project Area (unlabeled dots indicate low head dam locations):



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Fish Collection and transmitter implantation	October 2023 until complete
Receiver Placement	October 2023 until complete
Receiver monitoring	October 2023 – September 2025
Data analysis and submission of annual Technical Report	March 2025
Data analysis and submission of annual Technical Report	March 2026

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Distribution and Suppression of Bighead Carp in the Neosho River/Grand Lake System

Lead Agency and Author: Oklahoma Department of Wildlife Conservation, Elaine Gainer (elaine.gainer@odwc.ok.gov)

Cooperating Agencies: N/A

Statement of Need: There is a need for the Oklahoma Department of Wildlife Conservation (ODWC) to conduct fisheries research, monitoring, management and education on the Grand Lake O' the Cherokees Bighead Carp (*Hypophthalmichthyes nobilis*) population. The ODWC Aquatic Nuisance Species (ANS) Program is responsible for all aquatic invasive species throughout the state of Oklahoma. Bigheaded carp (i.e., Silver and Bighead) have aggressively invaded the midwestern portion of the United States and are continuing to cross political borders, furthering their invasion. Oklahoma, along with several other states, is the western-most extent of bigheaded carp range thus far.

Bighead Carp were first documented in the Grand River system in 1992. Oklahoma anglers continue to periodically report Bighead Carp catches. Anecdotal evidence is showing that Bighead Carp are increasing in population size within the Grand Lake system. Population assessments in the Grand Lake system are being studied by Missouri State University. Missouri State's efforts coupled with increasing angler reports on the Grand Lake system suggest a need for further research, monitoring and eventually management or suppression of the Bighead Carp populations.

Grand Lake consists of over 41,000 surface acres with three rivers feeding into it (Neosho, Spring and Elk Rivers), creating plenty of escape opportunities. Historically, Bighead Carp have been captured as bycatch in the ODWC winter paddlefish netting or unintentionally snagged by paddlefish anglers. Reports have been minimal but, have been increasing in the last couple of years. Notorious for their shy, fleeing behavior, successful Bighead Carp capture within the Grand Lake system is going to require a suite of gears (e.g., boat electrofishing, gill nets) and approaches (e.g., herding techniques, Garmin Live Scope identification).

There is a need for the ODWC to work collaboratively with both public and private entities in order to best manage and conserve the fisheries resources and to meet the needs and expectations of anglers. Information regarding impacts from invasive species on the environment, economy, and society can be beneficial for future management and suppression efforts.

Objectives:

1. Collect baseline Bighead Carp population demographic information including relative abundance, age and growth, size structure, along with any other possible pertinent information for a population assessment.

2. Identify locations within the Grand Lake system for removal, and/or eradication efforts.

3. Use collected information from project to make future management, monitoring, research, education and/or eradication decisions.

Activities and Methods: ODWC will use standard sampling methods (e.g., gillnets and/or boat electrofishing) to assess Bighead Carp demographics throughout the Neosho River/Grand Lake system. Other approaches may include using Garmin Live Scope and working with fishing guides to help locate Bighead Carp. Demographics will be used to estimate the level of harvest needed to reduce the size of the Bighead Carp population within the Neosho River/Grand Lake system, if adequate numbers are successfully sampled.

Use detections of Bighead Carp within the Neosho River/Grand Lake System to guide targeted removal efforts. Broadscale Bighead Carp movement and location may be monitored using telemetry methods. After location is identified, ODWC will target Bighead Carp for removal from the system using standard sampling methods (e.g., gillnets and/or boat electrofishing), and or non-traditional such as Live Scope and targeted snagging. Captured fish will be tested for ploidy.

The ODWC ANS Program will base future efforts and decisions based on the information gathered from this project. Efforts may be in the form of possible regulation changes, educational outreach campaigns, further monitoring efforts or eradication attempts depending on our findings.

Map of Project Area:
This grant will involve primarily coordination and implementation of the invasive carp National Plan Goals and Strategies in the Grand Lake O' the Cherokees system (Neosho, Spring, and Elk Rivers) in Craig, Ottawa, Delaware, Mayes, Cherokee, Wagoner, and Muskogee counties within the Central Irregular Plains, Ozark Highlands and Boston Mountain ecoregions of Oklahoma. Sampling may occur but is not limited to backwater habitats, coves, tributaries and any other possible location where bighead carp may be present within the system. Sampling location and success may be dependent on but not limited to access, water level, weather and any other possible factors that may influence sample feasibility.

Estimated Timetable for Activities:

Activity	**Time Period (Season, month/year)**
Boat electrofishing in conjunction with gill net and/or trap net sets.	Seasonally for grant duration *October 2023-September 2025*
Possibly tagging for telemetry efforts depending on number of fish captured.	Collection dependent *October 2023-September 2025*
Ploidy testing depending on number of fish captured.	Collection dependent *October 2023-September 2025*

Literature Cited:

Chapman, D.C., Chen, D., Hoover, J.J., Du, H., Phelps, Q.E., Shen, L., Wang, C., Wei, Q., and Zhang, H., 2016, Bigheaded carps of the Yangtze and Mississippi Rivers—Biology, status, and management, in Chen, Y., Chapman, D.C., Jackson, J.R., Chen, D., Li, Z., Killgore, K.J., Phelps, Q., and Eggleston, M.A., eds., Fishery Resources, Environment, and Conservation in the Mississippi and Yangtze (Changjiang) River Basins: American Fisheries Society (Bethesda, Maryland), p. 113–126

Invasive Carp Detection in the Arkansas River, Oklahoma, Using eDNA and Physical Herding Techniques

Lead Agency and Author: Oklahoma Department of Wildlife Conservation, Elaine Gainer (elaine.gainer@odwc.ok.gov)

Cooperating Agencies: N/A

Statement of Need: There is a need for the Oklahoma Department of Wildlife Conservation (ODWC) to conduct fisheries research, monitoring and management on the status of Bighead Carp (*Hypophthalmichthyes nobilis*) and Silver Carp (*Hypophthalmichthyes molitrix*) populations within the Arkansas River. The ODWC Aquatic Nuisance Species (ANS) Program is responsible for all aquatic invasive species throughout the state of Oklahoma. Invasive carp (i.e., Bighead and Silver) have aggressively invaded the midwestern portion of the United States and are continuing to cross political borders, furthering their invasion. Oklahoma, along with several other states, is the western-most extent of their range thus far.

The Arkansas River provides a corridor for ANS transfer between Arkansas and Oklahoma. Currently, invasive carp have not been reported in the Oklahoma portion of the Arkansas River but have been collected in the Arkansas portion of the river from Lake Dardanelle to the confluence with the Mississippi River. Bighead carp have been documented in the Grand River system since 1992, which is part of the Arkansas River drainage. Grand Lake consists of over 41,000 surface acres with three rivers feeding into it (Neosho, Spring and Elk Rivers), creating plenty of escape opportunities. Historically, Bighead Carp have been captured as bycatch in the ODWC winter paddlefish netting or snagged by paddlefish anglers. Those anglers are not as prevalent on the Arkansas River, therefore invasive carp could be in the area. The use of environmental DNA (eDNA) for invasive carp in the system can help in early detection of these species and help suppress further invasions into Oklahoma.

There is a need for the ODWC to work collaboratively with both public and private entities in order to best manage and conserve the fisheries resources and to meet the needs and expectations of anglers. Information regarding impacts from invasive species on the environment, economy, and society can be beneficial for future management and suppression efforts.

Objectives:

1. Environmental DNA throughout Arkansas River system from the Robert S. Kerr Reservoir lock and dam 15 to the Oklahoma-Arkansas border for presence/absence of invasive carp (bighead and silver) in Oklahoma in conjunction with physical samples to confirm that invasive carp are physically present.

2. Use collected information from project to make future management, monitoring, research, education and/or eradication decisions.

Activities and Methods: ODWC will collect water samples for invasive carp eDNA detections along the river gradient seasonally for two years. In conjunction with eDNA water samples, ODWC may perform herding techniques in confined areas near eDNA water collection areas with the goal of triggering invasive carp leaping behavior. This will allow for physical detection opportunities. Physical detection in the system will allow for eDNA ground-truthing.

The ODWC ANS Program will base future efforts and decisions based on the information gathered from this project. Efforts may be in the form of possible regulation changes, educational outreach campaigns, further monitoring efforts or eradication attempts depending on our findings.

Map of Project Area: This project will involve environmental DNA sampling on the Arkansas River between the Robert S. Kerr Lock and Dam 15 and the Arkansas border in Le Flore and Sequoyah counties in Oklahoma, in the Arkansas Valley ecoregion. Sampling may occur but is not limited to backwater habitats, coves, tributaries and any other possible location where bighead carp may be present within the system. Sampling location and success may be dependent on but not limited to access, water level, weather and any other possible factors that may influence sample feasibility.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Collect water samples seasonally within the Arkansas River in Oklahoma below the Robert S. Kerr Lock and Dam to the Arkansas Border.	Seasonally for grant duration *October 2023-September 2025*
Collect water samples in temporarily unconnected waters along the Arkansas River, if accessible.	Seasonally for grant duration *October 2023-September 2025*
Ploidy testing depending on number of fish captured.	Collection dependent *October 2023-September 2025*
Physical collection attempts depending on eDNA results.	Pending eDNA results *October 2023-September 2025*

Literature Cited:

Rees, H.C., B.C. Maddison, D.J. Middleditch, J.R.M. Patmore, and K.C. Gough. (2014). REVIEW: The detection of aquatic animal species using environmental DNA – a review of eDNA as a survey tool in ecology. J Appl Ecol, 51: 1450-1459. https://doi.org/10.1111/1365-2664.12306

Support of Invasive Carp Monitoring and Control Project in Oklahoma Waters

Lead Agency and author: Oklahoma Department of Wildlife Conservation, Elaine Gainer (elaine.gainer@odwc.ok.gov)

Cooperating Agencies: N/A

Statement of Need: The Aquatic Nuisance Species (ANS) Program of ODWC consists of two full time employees, a biologist and a technician. Since the introduction of invasive carps, ODWC's ANS Program has an increased workload yet has been unable to increase its number of personnel or purchase the necessary equipment to research, monitoring, and control invasive carps. ODWC is requesting funding from FY23 plus-up to increase personnel and equipment capacity of its ANS Program to effectively and safely conduct activities related to invasive carps. ODWC is seeking to add two additional full-time employees to assist current staff with ongoing and proposed invasive carp project efforts (see project list below) related to invasive carp research, monitoring, and control. The ODWC ANS Program will benefit greatly from this addition and will more effectively meet the goals and objectives outlined in the two submitted proposals to the Arkansas-Red-White Basin.

Ongoing projects include 1) Distribution and Population Demographics of Bighead Carp in the Neosho River-Grand Lake System to Inform Removal, 2) Abundance and distribution of early life stages of Asian carp in Red River Basin in Louisiana and Oklahoma, and 3) Distribution and Population Demographics of Asian Carp in the Lower Red River Basin

Proposed FY23 projects include 1) Distribution and Population Demographics of Bighead Carp in the Neosho River-Grand Lake System to Inform Removal, 2) Distribution and Population Demographics of Asian Carp in the Lower Red River Basin, 3) Distribution and Suppression of Bighead Carp in the Neosho River/Grand Lake System, and 4) Support of Invasive Carp Monitoring and Control Project in Oklahoma Waters.

Objectives:

1. Support the Arkansas–Red–White and Lower Mississippi River Invasive Carp Partnerships and ODWC projects by providing equipment, supplies, and personnel to ODWC.

Activities and Methods: Assist with ongoing and upcoming invasive carp projects within the Arkansas-Red-White and Lower Mississippi River Partnerships through additional personnel, equipment and supplies. Manage and administer grants and prepare reports. Conduct surveys and analyses in support of invasive carp projects of the ODWC ANS Program.

Map of Project Area: This project will involve primarily coordination and implementation of the invasive carp National Plan Goals and Strategies in the Grand Lake O' the Cherokees system (Neosho, Spring, and Elk Rivers) in Craig, Ottawa, Delaware, Mayes, Cherokee, Wagoner, and Muskogee counties within the Central Irregular Plains, Ozark Highlands and Boston Mountain ecoregions of Oklahoma. Additionally, this grant will also involve environmental DNA sampling on the Arkansas River between the Robert S. Kerr Lock and Dam 15 and the Arkansas border in

Le Flore and Sequoyah counties in Oklahoma, in the Arkansas Valley ecoregion. Sampling may occur but is not limited to backwater habitats, coves, tributaries and any other possible location where bighead carp may be present within the system. Sampling location and success may be dependent on but not limited to access, water level, weather and any other possible factors that may influence sample feasibility.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Boat electrofishing in conjunction with gill net and/or trap net sets.	Seasonally for grant duration *October 2023-September 2025*
Possibly tagging for telemetry efforts depending on number of fish captured.	Collection dependent *October 2023-September 2025*
Ploidy testing depending on number of fish captured.	Collection dependent *October 2023-September 2025*
Collect water samples seasonally within the Arkansas River in Oklahoma below the Robert S. Kerr Lock and Dam to the Arkansas Border.	Seasonally for grant duration *October 2023-September 2025*
Collect water samples in temporarily unconnected waters along the Arkansas River, if accessible.	Seasonally for grant duration *October 2023-September 2025*
Ploidy testing depending on number of fish captured.	Collection dependent *October 2023-September 2025*
Physical collection attempts depending on eDNA results.	Pending eDNA results *October 2023-September 2025*

Literature Cited:

Chapman, D.C., Chen, D., Hoover, J.J., Du, H., Phelps, Q.E., Shen, L., Wang, C., Wei, Q., and Zhang, H., 2016, Bigheaded carps of the Yangtze and Mississippi Rivers—Biology, status, and management, in Chen, Y., Chapman, D.C., Jackson, J.R., Chen, D., Li, Z., Killgore, K.J., Phelps, Q., and Eggleston, M.A., eds., Fishery Resources, Environment, and Conservation in the Mississippi and Yangtze (Changjiang) River Basins: American Fisheries Society (Bethesda, Maryland), p. 113–126

Rees, H.C., B.C. Maddison, D.J. Middleditch, J.R.M. Patmore, and K.C. Gough. (2014). REVIEW: The detection of aquatic animal species using environmental DNA – a review of eDNA as a survey tool in ecology. J Appl Ecol, 51: 1450-1459. https://doi.org/10.1111/1365-2664.12306

Arkansas Invasive Carp Market Stimulation Project

Lead Agency and Author: Arkansas Game and Fish Commission (AGFC), Matt Horton; (Matthew.Horton@agfc.ar.gov)

Cooperating Agencies: Arkansas Economic Development Commission (AEDC)

Statement of Need: Populations of invasive carp (silver, bighead, black, and grass carp) have rapidly expanded throughout the Mississippi River Basin, and continue to increase their distribution in Arkansas waters. Management and control of invasive carp is necessary to reduce their impact on native species, the ecosystem, and the economy. In response to these threats, many states within the Mississippi River Basin have been working to find effective strategies to manage existing populations and control range expansion into adjacent aquatic systems. Recognizing commercial harvest was the most efficient and effective means to remove invasive carp, the Arkansas Game and Fish Commission (AGFC) attempted to implement a contract fishing program in 2020, utilizing federal invasive carp grant funds. The goal was to hire up to four commercial fishermen to remove 800,000 pounds of invasive carp from the Arkansas and White River systems, within the Lower Mississippi River (LMR) and Arkansas-Red-White River (ARW) Sub-basins. At the time, Arkansas did not have a fish processor or other buyers that would accept invasive carp from our commercial fishermen, nor was there an established market for invasive carp in Arkansas. Contractors would be paid 20 to 30 cents per pound, which increased as poundage goals were met, to remove invasive carp. Free gear tags were offered to incentivize removal. Contract stipulations were restrictive, and included only allowing harvest of invasive carp, other commercial gear could not be fished within 15 miles of the access point, and all commercial tackle had to be provided by the commercial fisherman. In October 2020, letters were sent to all current commercial fishing permit holders (approximately 1,350), advising them of the contract availability. Nineteen commercial fishers communicated interest and were sent an RFQ. No commercial fishermen submitted proposals by the deadline date. Subsequently, the AGFC amended the 2020 grants to implement an in-house removal program (AGFC Invasive Carp Removal Program). Removal efforts started in fall of 2021 and has continued to date. The program has removed over 138,000 pound of invasive carp and contributed valuable information such as range distribution, density, and size structure of invasive carp in the Arkansas and White River systems. However, there is still a need improve effectiveness of removal efforts and significantly increase biomass removal from Arkansas waters.

Over the past three years, the states of Tennessee, Kentucky, and Illinois have successfully utilized harvest incentive programs to increase commercial harvest and processing capacity, which has resulted in millions of pounds of invasive carp being removed. Those states created a subsidy for invasive carp but use somewhat different ways to inject it into the market through existing commercial fishers and processors. In Arkansas, we have commercial fishers but no processors or developed market uses for invasive carp. This limits the commercial value of invasive carp, motivation for fishers to harvest invasive carp, and opportunities for fishers to sell large quantities of invasive carp harvested in Arkansas. To increase effectiveness of removal efforts, the AGFC desires to create an incentive program which provides subsidies to commercial fishers for harvesting and selling invasive carp, and encourages collaboration between fishers and wholesale fish dealers, processors, or other buyers to develop markets which increase demand and processes to receive carp caught in Arkansas. In addition, AGFC will partner with the Arkansas Economic Development Commission (AEDC) to help interested businesses expand processing capacity and market development into Arkansas. This project differs from past AGFC projects by allowing any licensed commercial fisher to receive subsidies for harvesting and selling invasive carp; all Arkansas waters, within the ARW Sub-basin, open to commercial fishing can be utilized; fish can be sold to any buyer for any price; fishers receiving incentives may also harvest and sell native commercial fish species; and a limited supply of start-up fishing supplies and equipment will be provided on a first-come-first-served basis to help incentivize harvest and aid fishers with providing quality fish for market product use. The AGFC has proposed an identical project in the Arkansas portion of the LMR Sub-basin this fiscal year, to cover all waters in Arkansas harboring invasive carp.

The activities outlined in this work plan address the following goal and objectives of the National Plan: Goal 3: Extirpate, or reduce to levels of insignificant effect, feral populations of bighead, black, grass and silver carps in the United States; Strategy 3.3.2. Increase the commercial harvest of Asian carps; Strategy 3.3.2.2. Increase the number of commercial fishers; Strategy 3.3.2.3. Examine commercial fishing regulations and consider changes to increase harvest; Strategy 3.3.2.4. Provide financial incentives to commercial fishers to increase harvest of Asian carps; Strategy 3.3.2.5. Develop new markets for Asian Carps. It also addresses the following goals and objectives of the Lower Mississippi River Basin Asian Carp Control Strategy Framework: Goal 3. Population Control and Agency Response: Reduce Asian carp densities with the ultimate goal of extirpation of Asian carps; Strategy 3.2. Utilize commercial harvest and implement contract fishing of Asian carps to decrease densities; Strategy 3.3. State natural resource agencies will work within their authorities to increase opportunities for commercial harvest of Asian carps. States will work with commercial fishers, industry, and local communities to alleviate limiting factors (e.g., regulatory hurdles, low price, and proximity of processing plants) that might encourage more commercial fishers to target Asian carps; Strategy 3.4. States can assist, where appropriate, in the development of new markets for Asian carps. Markets should be expanded both within the United States and abroad.

AGFC is working to phase out the in-house removal program (agency removals) and shift removal efforts to commercial harvest. AGFC will outline conversion of agency removal efforts to re-direct existing staff, equipment, and future federal funding requests to support monitoring of commercial harvest to directly inform commercial fishing effectiveness and optimize control strategies. This project is needed to build capacity of commercial harvest as a primary means of biomass removal in Arkansas waters ahead of this planned transition.

Objectives:

1. Stimulate the commercial market for invasive carp in Arkansas through incentivizing subsidies to help control invasive carp populations.
    1. Implement a subsidy for invasive carp sales to attract commercial operators such as processors and wholesale fish distributors to Arkansas.
    2. Incentivize commercial fishers to target and harvest invasive carp.
2. Provide start-up supplies and access to equipment for licensed commercial fishers, wholesale fish distributors, or processors.
    1. Provide start-up fishing supplies such as gill nets, rope, and anchors to licensed commercial fishers.

    2. Provide licensed commercial fishers, access and use of equipment such as ice machines to help ensure wholesale fish distributors, processors, or other buyers receive quality fish for market product uses.
3. Create and administer subsidy program within the AGFC Fisheries Division.
    1. Provide salary for one staff to track invasive carp sales and other reporting mechanisms and submit forms for payments to commercial fishers. This staff addition will also work to administer requests for equipment start-ups.
4. Scope standards for monitoring invasive carp populations in Arkansas to evaluate the effectiveness of commercial fishing.
    1. Outline conversion of the Arkansas invasive carp control program to include monitoring which would:
        1. Develop an invasive carp population standard monitoring protocol.
        2. Revise invasive carp control program staff roles, as appropriate, to collect data which directly informs commercial fishing effectiveness and optimal control strategies.
        3. By 2026, phase out AGFC Fisheries Division invasive carp control program (agency removals) once invasive carp commercial fishing is established and invasive carp population monitoring protocol can be implemented by existing Fisheries Division programs.

Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods: To increase effectiveness of invasive carp removal efforts in Arkansas, the AGFC will create and administer an invasive carp harvest incentive program which provides a per-pound subsidy to qualified commercial fishers, start-up fishing supplies to commercial anglers, and access to equipment that helps fishers and buyers provide and receive quality fish for desired market product uses.

Locations where fishers can harvest invasive carp and receive subsidies through this program include all waterbodies of Arkansas, within the Arkansas-Red-White River Sub-basin, which are open to commercial fishing. These waters include the Arkansas River (Pools 4, 5, 6, 7, 8, 9, 10, 11, 12, & 13 to the Oklahoma state line), White River (from the confluence of the Little Red River to the confluence of the Black River), Black River, Red River, Sulfur River, and Little River; their tributaries, backwaters, and oxbow lakes (Figure 1).

The AGFC will mail a letter to all people who obtained an Arkansas Resident Commercial Fishing Permit in 2022 and 2023, to solicit participation in receiving subsidies for invasive carp (Bighead, Black, Bighead and Silver Carp) sold to any buyer, residing within or outside of Arkansas. Qualified applicants must have a valid Arkansas Resident Commercial Fishing Permit, Resident Fisheries Conservation License, provide a W-9 From to the State of Arkansas, and sign an affidavit agreeing to comply with the terms of the program, including: eligibility for harvest subsidies and start-up fishing supplies, access to program equipment, reporting requirements, and any other program eligibility requirement. The AGFC will provide at least 30 days for individuals interested in the program to register before distributing any subsidies or start-up fishing supplies.

A per-pound subsidy of 18 cents per pound will be paid to qualified fishers who provide required reporting documents for invasive carp caught by them, and sold to any buyer, for any price. Fishing supplies (nets, anchors and rope) will be purchased by AGFC and provided to program applicants on a first-come-first-served basis and will be distributed in a manner which allows opportunity to multiple applicants. Equipment, such as ice machines, will be purchased by AGFC, and placed in strategic locations which allow access to participating fishers. Equipment will be installed and maintained by AGFC. Cooperative agreements will be made between AGFC and other government agencies or private entities, as needed, to ensure equipment is in convenient, accessible, and safe locations.

Subsidy payments for invasive carp sold by fishers will be contingent on fishers submitting a bill of sale (sales receipt) and cover sheet. The bill of sale must include the fisher's name, AGFC customer identification (CID) number, catch location (waterbody), date, buyers name and address, receipt number, species, total weight by species, and price paid per pound. The cover sheet will include the fishers name, address, CID number, fishing gear used (gear type and mesh size), catch location (waterbody), date of harvest, species, total weight by species, fisher's signature, buyers' signature, and date.

A part-time employee will be hired by the AGFC Fisheries Division to track invasive carp sales, verify receipts submitted by fishers, submit payment forms, and administer requests for start-up fishing supplies and access to equipment. This person will be housed at the AGFC Headquarters in Little Rock. This person will be directly supervised by the AGFC Fisheries Division Bookkeeper.

AGFC Fisheries Division staff will use data collected by the in-house removal program, mandatory commercial fishing reports, and bills of sale submitted for this harvest incentive program to identify and prioritize waterbodies for population assessment. AGFC Fisheries Division staff will develop a population assessment protocol for Arkansas, which directly informs effectiveness of commercial harvest and optimal control strategies for invasive carps after MICRA's ICAC Population Assessment Workgroup provides guidelines. AGFC Invasive Carp Removal Program staff and equipment, in addition to any other resource needs will be identified and considered for future federal invasive carp funding opportunities to support program monitoring needs.

Agency: Arkansas Economic Development Commission (AEDC)

Activities and Methods: The Arkansas Economic Development Commission (AEDC) has agreed to cooperate with AGFC, by providing support to businesses interested in expanding processing capacity and market use of invasive carp in Arkansas. AEDC will assist prospects in the site location process, workforce pipeline development, and collection of helpful information regarding invasive carp populations in Arkansas. They will help make connections with key stakeholders and service providers such as local governments, utility providers, and financial and legal support, and facilitate connections with stakeholders that might be able to help with increasing efficiency and effectiveness of fish acquisition. In addition, AEDC will help identify appropriate incentives and in-state grant opportunities to fill business needs.

Map of Project Area:

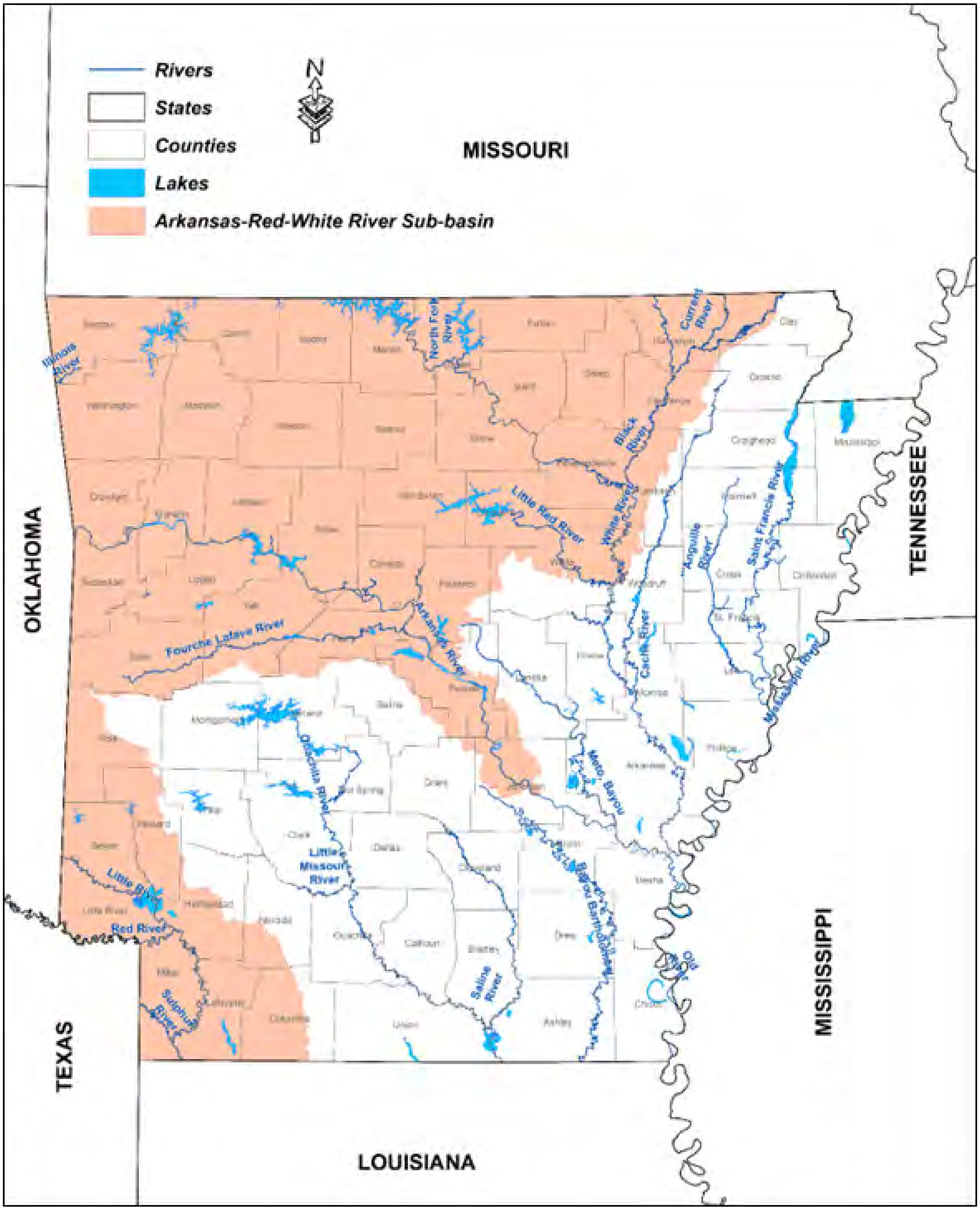


Figure 1. *Arkansas-Red-White River Sub-basin in Arkansas (highlighted in orange), which delineates the area where participating commercial fishermen can harvest invasive carp for subsidies provided through the Arkansas Game and Fish Commission's Invasive Carp Market Stimulation Project.*

Estimated Timetable for Activities:

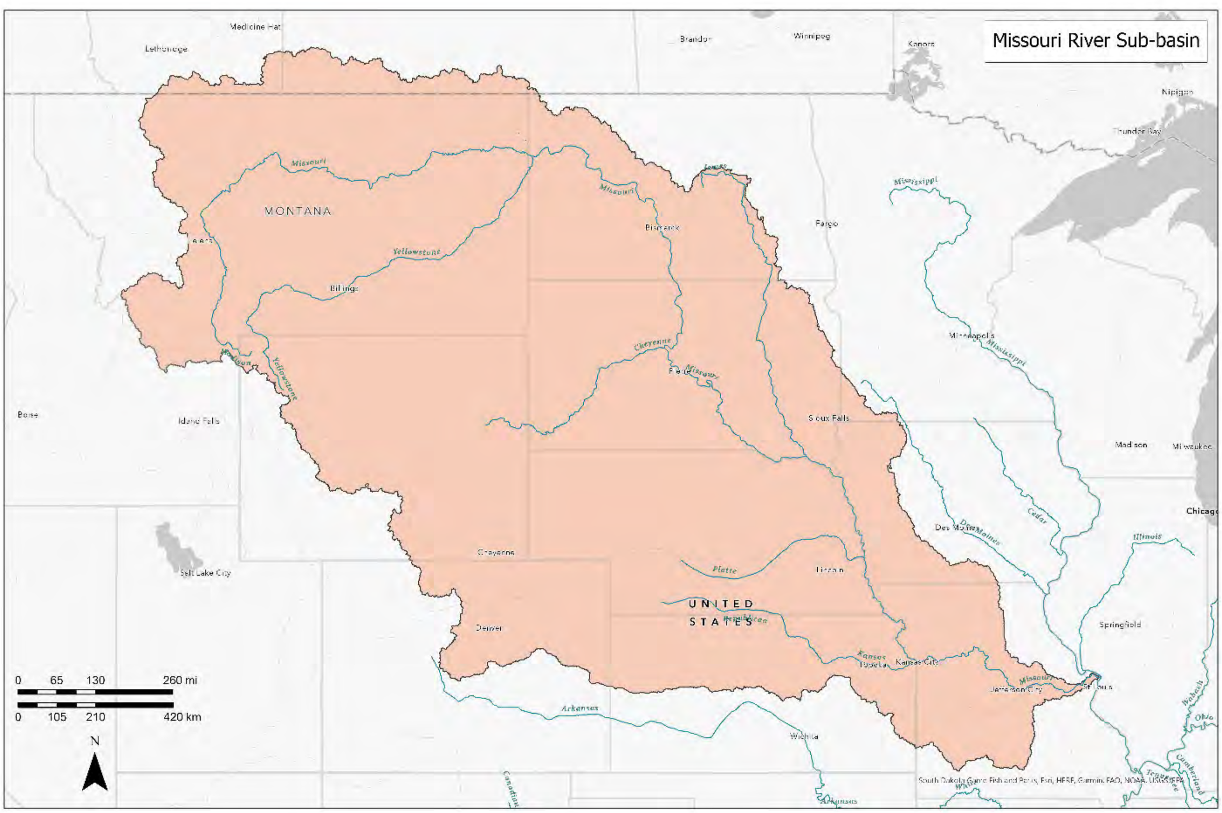
Activity	Time Period
Send sign-up letter to commercial fishers	As soon as the grant is approved
Purchase start-up fishing supplies and equipment	As soon as the grant is approved
Hire part-time employee to administer the subsidy program	As soon as the grant is approved
Implement invasive carp harvest subsidy program	July 15, 2023 – June 30, 2024
AEDC aids with building invasive carp processing capacity and market development in Arkansas	July 15, 2023 – June 30, 2024

Literature Cited: N/A

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 2023 was the fourth 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 $1,507,861 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 (ESU), Missouri Department of Conservation (MDC), Nebraska Game and Parks Commission (NGPC); University of Nebraska-Lincoln (UNL), South Dakota Department of Game, Fish and Parks (SDGFP); South Dakota State University (SDSU), 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, Gavins Point National Fish Hatchery

Statement of Need: In collaboration with multiple stakeholders, the USFWS and the Aquatic Nuisance Species Task Force 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 a 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, economic, 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.

To 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), and calcium (Ca) along with oxygen (^{16}O, ^{18}O) 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 the 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:

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: USFWS).
   - Sub-Objective 1: Participate in the US Fish and Wildlife Service Invasive Carp eDNA Community of Practice to increase understanding of environmental DNA (eDNA) as a tool for the detection and measurement of invasive carp populations. This workgroup hosts informational webinars/workshops to provide education and learning opportunities.

   - Sub-Objective 2: Implement a strategy for information sharing on the methods needed to successfully analyze eDNA samples for invasive carp primers, and coordinate efforts with Genetic Labs to integrate methods with partners already using eDNA for the detection of invasive carp.

   - Sub-Objective 3: Continue to assess 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: Continue to assess the presence/absence of Bighead and Silver Carp in the Missouri River and its tributaries concentrating above and below fish movement barriers to better understand invasive carp distributions.

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, recruitment) while developing standard operating procedures that are specific for the lower Missouri River Basin to prescribe and assess population control measures (Agencies involved: ISU, MDC, NGPC, SDGFP, SDSU, 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 eDNA sampling sites to validate eDNA results.

   - Sub-Objective 4: Evaluate the natal origin and movement of Silver Carp collected in the Missouri River and its tributaries using microchemistry analysis.

3. Characterize the historic and current fish community in 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: KDWP, MDC).
   - Sub-Objective 1: Deploy fish community assessment gears to characterize the fish community and select native fish species.
   - Sub-Objective 2: Determine the size distribution, relative abundance, and other population characteristics of select fish.
   - Sub-Objective 3: Empirically examine direct and indirect effects of invasive carps on native species and food webs through the 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 4: Compare Kansas River isotope results with similar studies in other river systems (Wabash and Illinois Rivers; Meta-analysis).
   - Sub-Objective 5: Run hydrological models to determine the amount of primary productivity under different flow regimes: is there a way to increase the prey base when native fish species are feeding, by supplementing low flows in the Kansas River from upstream reservoirs, thereby increasing primary productivity and subsequently zooplankton?

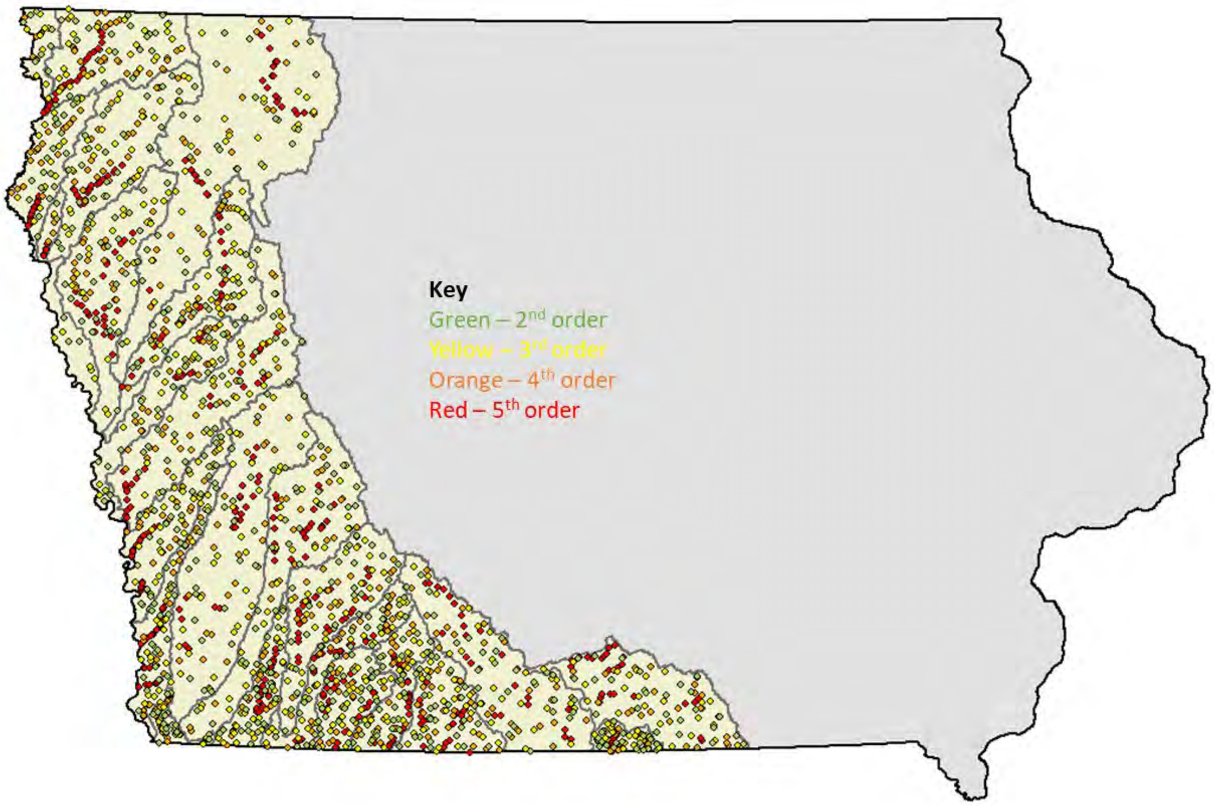
Project title: Reproduction and recruitment of invasive carp in Missouri River tributaries

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, and 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

Project Title: Kansas River invasive carp food web study

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, and 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 the 10 native species and invasive carp. 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 the collection and analysis 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
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

Project Title: Define the population demographics of invasive carp populations and the associated fish community in the Missouri River Basin

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: Objective 2: MDC: Conduct targeted invasive carp sampling in 3 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 3 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 3 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: Platte River (MO) from the confluence with the Missouri River (rkm 0.0) to 20 rkm upstream. Grand River from the confluence with the Missouri River (rkm 0.0) to 20 rkm upstream. Lamine River from the confluence with the Missouri River (rkm 0.0) to 20 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

Project title: Sampling efficiency assessment for Silver Carp and Bighead Carp in Nebraska mid-order streams and rivers.

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

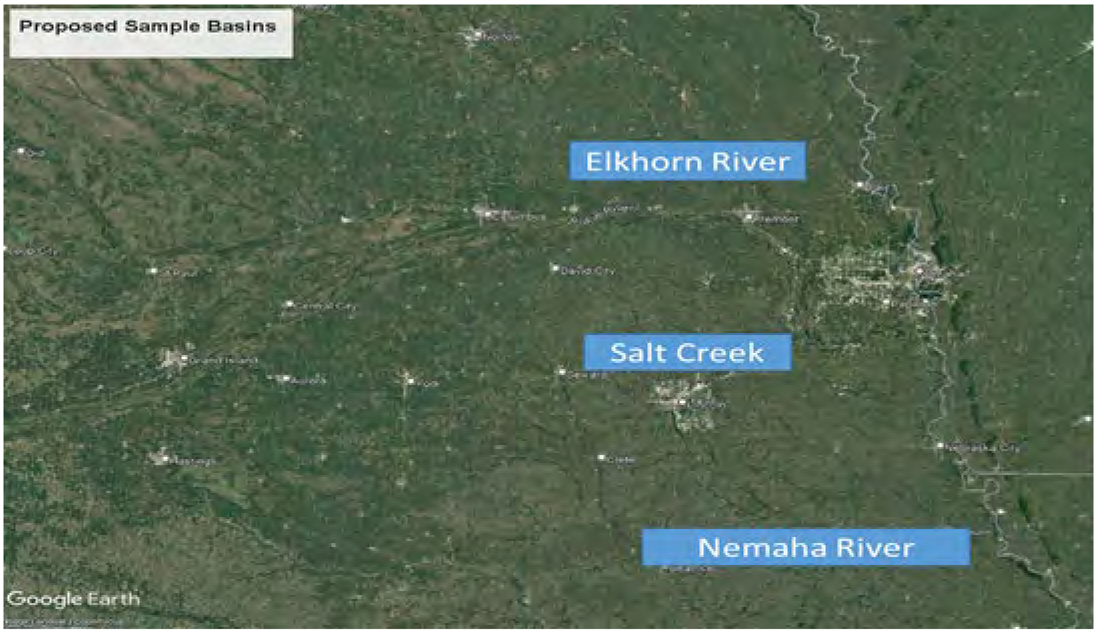
Activities and Methods: Objective 1: NGPC in conjunction with UNL will use data gathered from fish sampling efforts (see Objective 2 below) for field verification of eDNA results collected during UNL's Nebraska Environmental Trust (NET) project 'Improving Water Quality and Surveying Fish populations 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 the spring, summer, and fall of 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 in 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 on 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 the 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.

Map of Project Area:



Proposed general sample areas in mid-sized prairie rivers and streams. Locations along the Little Nemaha River, Big Nemaha River, Salt Creek, and Elkhorn River will be sampled dependent on access and land-owner permission. Additional creeks that empty into the mainstem Missouri River (e.g., Papillion Creek) may also be considered.

Estimated Timetable for Activities:

Activity	Time Period
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

Project title: Assessment of Silver Carp and Bighead Carp in the Platte River, Nebraska: Emphasis on population distribution, population demographics, and reproduction.

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

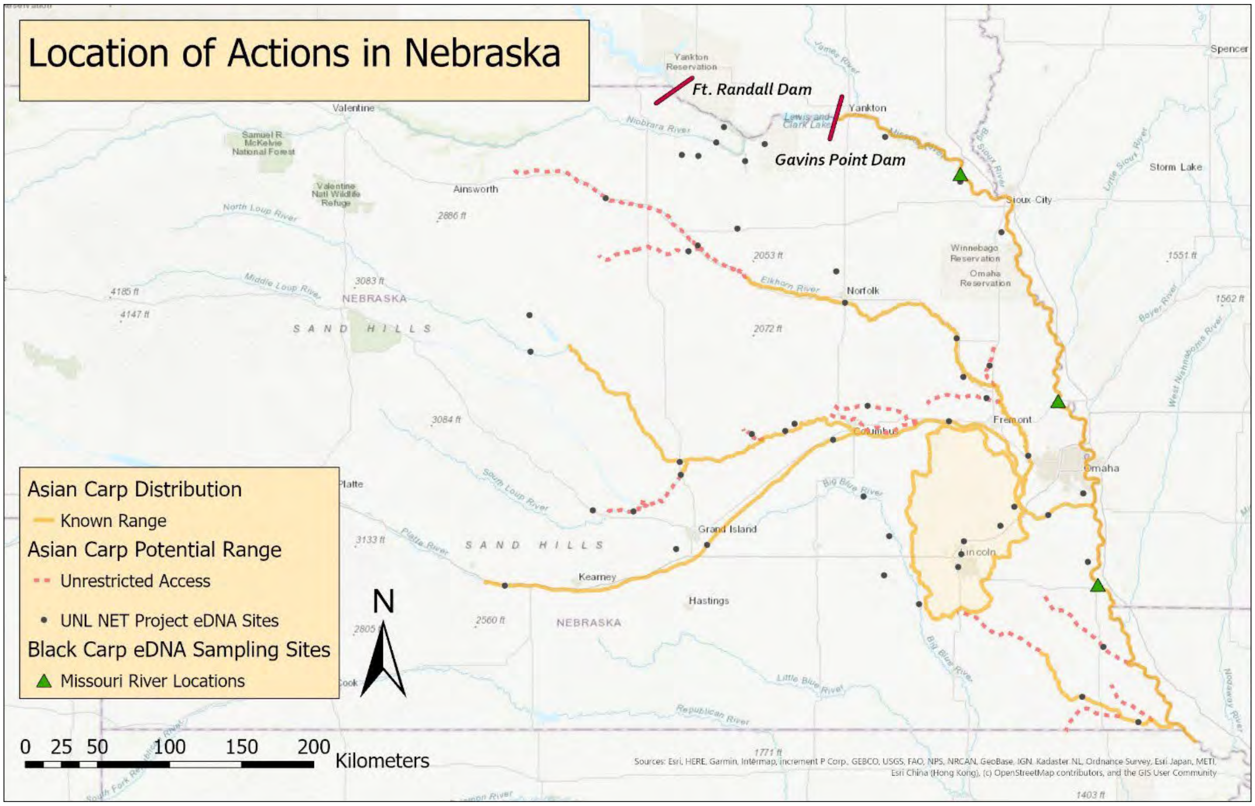
Activities and Methods: Objective 2: In the Platte River and lower reaches of major tributaries of the Platte River, netting (i.e., mini-fyke nets) will focus on the occurrence and habitat uses of young-of-year for both Silver and Bighead carp. Sampling for young-of-year will occur in late summer and 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 the 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.

Map of Project Area: Missouri River tributaries and periphery streams within eastern and central Nebraska. Potential rivers and watersheds include Platte, Elkhorn, and Loup.

Nebraska Tributaries: 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.



Estimated Timetable for Activities:

Activity	Time Period
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), South Dakota State University (SDSU)

Identify: Using otolith microchemistry to identify the natal origin and movement of invasive carp in the Missouri River Basin

Activities and Methods: Objective 2 (Sub-objective 4): SDGFP in conjunction with SDSU will work to determine invasive carp recruitment sources throughout the Missouri River Basin. This work will build upon a prior study by Southern Illinois University that identified differences in water chemistry throughout the Missouri River Basin (stable oxygen isotope ratio and strontium, barium, and calcium concentrations). Since otoliths are chemically inert, the chemical composition of the environment is collected in otoliths as fish grow and move among locations with different water chemistry. We can then analyze the chemical composition from the core of an adult's otolith to identify the location where it was spawned. This allows us to determine whether adults collected from a location were produced in that area or if they were spawned in another location and subsequently moved later in life. This knowledge can identify potential locations from which adult Missouri River Basin invasive carp are recruiting while informing source-sink dynamics and decisions regarding the location of management actions (e.g., placement of movement deterrents or removal effort).

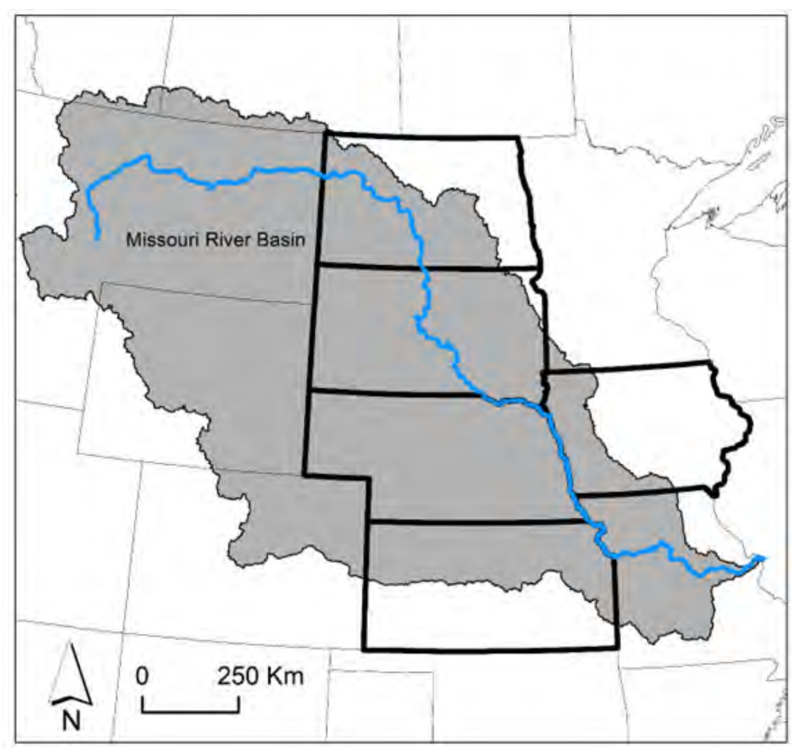
Otolith microchemistry can provide an important tool for determining the natal origin of freshwater fishes from environments with distinct water chemistries (Campana et al 2000; Gibson-Reinemer et al. 2009; Zitek et al. 2010). Water samples were previously collected and analyzed from the Missouri River main channel and tributaries (Listed in Table 1 of Whitledge 2022). This prior study indicated that many tributaries and main channel reaches have distinct chemical signatures that can be used to identify the natal origins of invasive carp (Whitledge 2022). To account for possible changes in water chemical signatures between this study and prior data reported by Whitledge (2022), 46 additional water samples will be collected and analyzed for trace elements (barium, Ba; strontium, Sr; and calcium, Ca) and oxygen isotope ratios ($\delta^{18}O$). These water samples will be collected using 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. Trace elements of Ba, Sr, and Ca will be analyzed using inductively-coupled mass spectrometry (ICP-MS) at Southern Illinois University. Water samples will be sent to the University of Arizona for stable oxygen isotope ratio ($\delta^{18}O$) analysis.

In 2024, a maximum of 75 adult Silver Carp and Bighead Carp will be collected from up to 23 locations (tributaries and main channel reaches) throughout the Missouri River Basin in collaboration with state partners (maximum 1,725 otoliths). Lapilli otoliths will be removed from these individuals and processed for trace element analysis. Otoliths will be mounted in epoxy, and transversely sectioned to create a thin section exposing the nucleus, and thin sections will be mounted to a glass slide. With one otolith, laser-ablation ICP-MS will be used 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. Microchemistry will be analyzed for strontium, barium, and calcium concentrations. If needed to differentiate the origin, a core sample will be extracted from the second otolith using micro-milling and sent to the University of Arizona for $\delta^{18}O$ analysis.

Chemical composition data will ultimately determine the proportion of adults present at a location that was spawned in that location versus the proportion of adults spawned in other specific tributaries or main channel reaches. These results will also allow us to quantify the amount of movement occurring among tributaries and main channel reaches a temporal scale that complements ongoing telemetry work and spawning assessments in the basin.

The natal origin of Silver Carp will be evaluated by comparing trace-elemental markers and their ratios (Sr:Ca, Ba:Ca) measured from otoliths to chemical signatures from water samples. To screen for potential markers allowing the separation of chemical signatures from different rivers, we will use correlation analysis to evaluate relationships between element concentrations in water samples and otoliths. Trace elements and $\delta^{18}O$ 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 origin to carp, we will use a cross-validation approach. Age-0 Silver Carp may be targeted from tributaries across the basin to validate results from otolith microchemistry. Microchemical signatures from the otoliths of these age-0 individuals from known locations may be used as a training dataset for discriminant function analysis alongside the available water data (Hegg and Kennedy 2021).

Map of Project Area: Sampling will be opportunistic and associated with sampling by cooperating agencies/groups throughout the basin.



Collection of otoliths for microchemistry will occur in up to 23 locations including tributaries to the Missouri River and at least three reaches in the Missouri River main channel. Sampling will span the states highlighted in black (North Dakota, South Dakota, Nebraska, Iowa, Kansas) and sampling may also occur in Missouri.

Estimated Timetable for Activities:

Activity	Time Period
Hire graduate student	January 2024
Otolith collection from collaborating agencies/groups	March 2024 – October 2024
Water sample collection	March 2024 – October 2024
Otolith preparation	August 2024 – March 2025
Otolith microchemistry processing	March 2025 – September 2025
Annual Report	Fall 2024
Final Report	Fall 2025

Project Title: eDNA monitoring.

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

Activities and Methods: Objective 1. Conduct surveillance and early detection monitoring for invasive carp eDNA at the extent of their geographical range in the Missouri River, its major tributaries (i.e., James, Big Sioux, and Vermillion rivers), and smaller tributaries of the major tributaries near Gavins Point Dam, SD/NE.

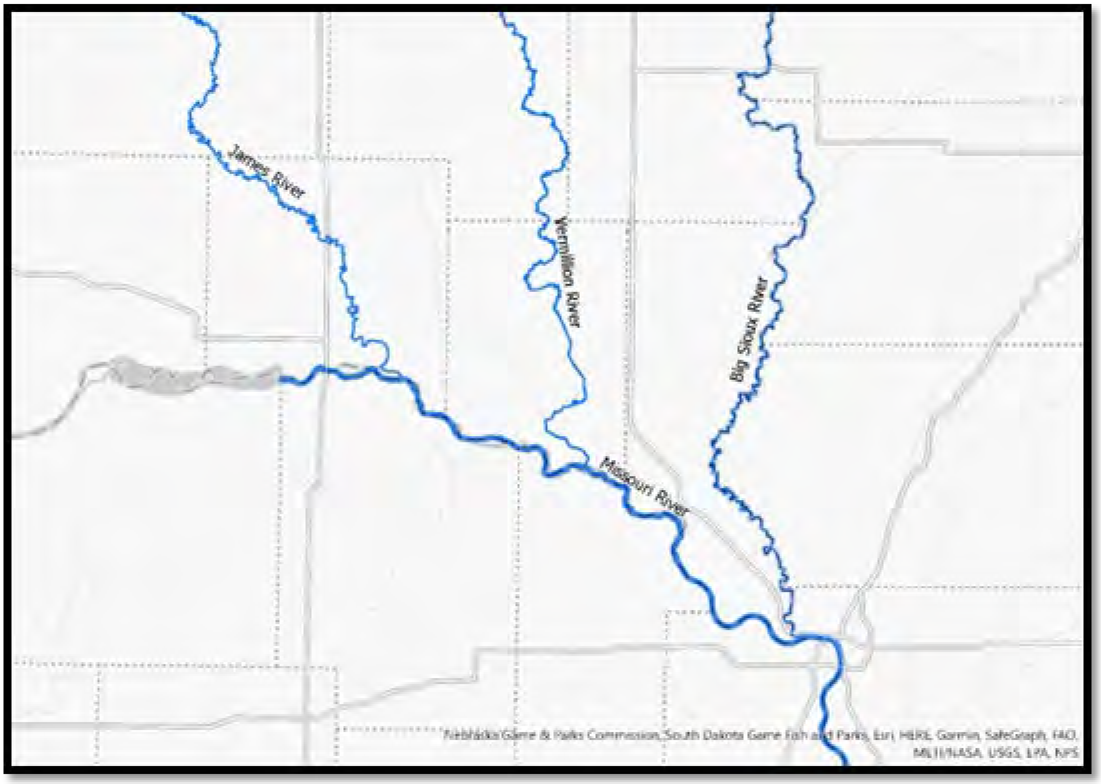
Water samples will be placed on ice immediately after collection with control samples at each site. In the field and laboratory, procedures detailed in the Quality Assurance Project Plan eDNA Monitoring of Bighead and Silver Carps (QAPP; USFWS 2019) will be followed. Samples will be stored at -80°C until DNA extraction occurs. Lab processing will be completed by the USFWS Bozeman Fish Health Lab.

A water field sample processing lab will be developed and established in a clean room on the grounds of Gavins Point NFH. The lab will contain a refrigerated centrifuge and associated tools and supplies to properly process raw water samples and preserve eDNA with ethanol. Preserved samples will then be transported to the Bozeman Fish Health Lab for eDNA extraction and analyses.

Map of Project Area: The Missouri River and its major and minor tributaries near Gavins Point Dam, SD/NE.

Major Tributaries: Lower James River from the confluence with the Missouri River (rkm 0.0) to Huron, South Dakota (rkm 358.0). Vermillion River from the confluence with the Missouri River (rkm 0.0) to a major barrier at East Vermillion Lake spillway (rkm 192.0). 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).



Estimated Timetable for Activities:

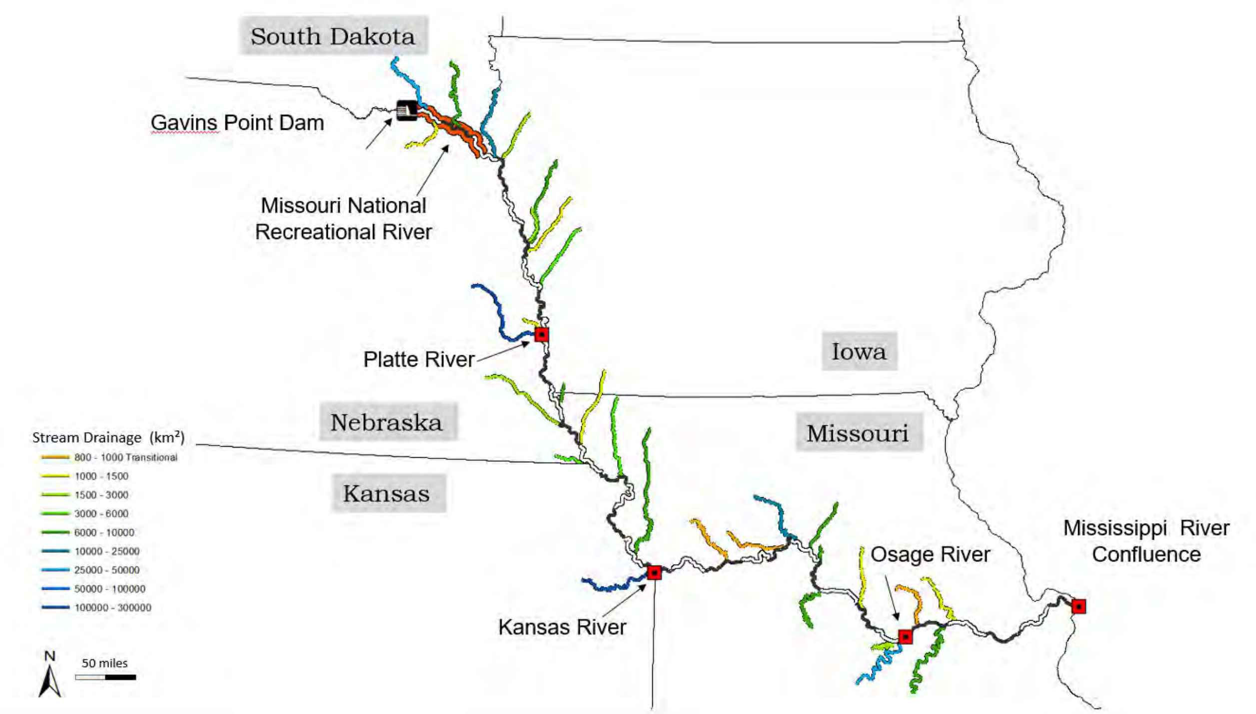
Activity	Time Period
Collect and process eDNA field samples	Summer-Fall 2023
Lab processing and analyses	Fall/Winter 2023-2024
Final Report	Winter 2024

Project Title: Missouri River tributary invasive carp population assessment

Agency: U.S. Fish and Wildlife Service (USFWS) Columbia Fish and Wildlife Conservation Office and Great Plains 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) and prior year data (for frequency and site selection based on in-depth data analysis). Hydroacoustics sampling to estimate Bighead and Silver carp abundance will be implemented in select tributaries as informed by prior year testing and hydrological conditions. 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 variability, 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:

Activity	Time Period
Project development and sample site selection	February – July 2023
Field collections	September – October 2023
Partner update	November 2023
Lab analysis	September 2023 – February 2024
Data analysis	November 2023 – March 2024
Final report	April 2024

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Building consensus on invasive carp management in the Missouri River Basin

Lead Agency and Author: Kansas Department of Wildlife and Parks, Chris Steffen (chris.steffen@ks.gov)

Cooperating Agencies: Colorado Parks and Wildlife, Iowa Department of Natural Resources, Minnesota Department of Natural Resources, Missouri Department of Conservation, Montana Fish, Wildlife and Parks, Nebraska Game and Parks Commission, North Dakota Game and Fish Department, South Dakota Game, Fish, and Parks, Wyoming Game and Fish Department, U.S. Fish and Wildlife Service Columbia Fish and Wildlife Conservation Office.

Statement of Need: The Missouri River Basin comprises one-sixth of the continental United States, including all or parts of 10 states, two Canadian provinces, and 25 Native American tribal reservations or lands. The economic resources that rely on the Missouri River Basin include municipal needs, agricultural practices, hydropower, recreation, flood control, navigation, and fish and wildlife. Recreation alone generates millions of dollars into the basin's economy. However, recreational use of the Missouri River basin is threatened by the establishment of invasive carp. Currently, bighead and silver carp are increasing in abundance and expanding their range in the Missouri River Basin.

To help address these issues, the Asian Carp Technical Committee of the Missouri River Natural Resources Committee Missouri River completed the *Missouri River Basin Asian Carp Control Strategy Framework*, which provides goals and strategies for invasive carp management in the basin. However, as funding for invasive carp projects in the basin is limited, it is imperative that partners responsible for invasive carp management in the Missouri River Basin work collaboratively to prioritize and conduct projects. Consensus of basin-wide invasive carp management priorities - and a summary of challenges to meeting those priorities - is urgently needed to improve basin-wide invasive carp management.

A model of how to do this exists in the "Building Consensus in the West Workgroup" of the Western Regional Panel on ANS. The effort was successful in bringing together the 19 western states to collaborate and agree upon standard protocols and procedures that have been very effective in preventing the spread of zebra and quagga mussels in the western United States (see https://westernregionalpanel.org/wp-content/uploads/2019/11/WRP-BC-Activity-Report-FINAL.pdf). The workgroup achieved this by providing a forum for facilitated dialogue between state and federal jurisdictions conducting watercraft inspection and decontamination programs. The facilitated dialogue resulted in the creation of science-based standards for preventing and containing the spread of mussels overland by recreational watercraft and early detection sampling and monitoring, in addition to the development of a model legal framework for state watercraft inspection and decontamination.

This "Building consensus on invasive carp management in the Missouri River Basin" project is meant to borrow from and emulate the success of the "Building Consensus in the West Workgroup".

Objectives:

1. Hold facilitated discussions among Missouri River Basin states to build consensus on invasive carp management actions and locations within the basin and identify challenges and potential solutions for implementation.

Activities and Methods: Funds would be used to contract an impartial entity to facilitate discussion, consensus building, and prioritization of invasive carp management priorities and locations among Missouri River basin partners. The contractor will gather input and facilitate discussion among agency employees such as Missouri River Basin Invasive Carp Partnership voting members, fish chiefs, AIS/ANS coordinators, invasive carp biologists, river biologists, and other members of state agencies whose duties include invasive carp management.

We anticipate at least one in-person meeting will be held in addition to supplemental virtual meetings (large group and individual as needed). The contractor will be responsible for ensuring productive, collaborative dialogue takes place and producing a report summarizing activities, areas of consensus for invasive carp management, and challenges and potential solutions to implementation of invasive carp management in the Missouri River Basin.

The contractor will produce a report that will be used to guide invasive carp management in the Missouri River Basin. The report will summarize activities, areas of consensus for invasive carp management, and challenges and potential solutions to implementation of invasive carp management in the Missouri River Basin. This document with basin-wide invasive carp management priorities and challenges summarized will be instrumental to begin addressing those challenges and seeking solutions to improve basin-wide invasive carp management.

The report will include:

- List of priority management actions and locations
- Descriptions of challenges to implementation of management actions
- Potential solutions to these challenges

Map of Project Area:

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
KDWP conducts RFP process to locate and contract with facilitator	October 2023 – January 2024
Contractor initiates conversations and virtual meetings with lead and cooperating agencies	January 2024 – July 2024
Contractor schedules and organizes in-person meeting	March - July 2024
Contractor hosts in-person meeting	July - August 2024
Contractor conducts follow-up discussions and zoom meetings as needed; either with individual cooperating agencies or jointly	August – December 2024
Contractor drafts report that to summarize activities, areas of consensus for invasive carp management, and challenges and potential solutions to implementation of invasive carp management in the Missouri River Basin	January 2024 – January 2025
Contractor submits draft report to lead and cooperating agencies to review	January 2025
KDWP and cooperating agencies provide review and comments on draft report	February 2025
Contractor incorporates reviews and comments and submits final report	April 2025

Literature Cited:

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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), Missouri Department of Conservation (MDC), USFWS Columbia Fish and Wildlife Conservation Office (USFWS - Columbia)

Statement of Need: Populations of invasive carp (silver carp, bighead carp, black carp, and grass carp) have rapidly expanded throughout the Mississippi River basin. Management and control of invasive carp is necessary to reduce their impact on native species, the ecosystem, and the economy. In response to these threats, many states throughout the Mississippi and Great Lakes basins have been working to find effective strategies to manage existing populations and to control the expansion of invasive carp into adjacent aquatic systems. Appropriations for the Department of Interior indicate that 'while the Committees (House Subcommittee on Interior, environment, and Related Agencies and the Senate Subcommittee on Interior, Environment, and Related Agencies) recognize the importance of studying and understanding invasive carp patterns, the Service is encouraged to take action on a strategy that increases the focus on biomass removal and restricts carp progression by coordinating with other Federal partners on constructing invasive carp barriers'. This project addresses the need for biomass removal and provides the opportunity to collect data on invasive carp populations and native fish communities that may inform future removal efforts.

Objectives:

1. Remove invasive carp downstream of Bowersock Dam to provide a buffer against upstream range expansion should the dam be inundated during a high flow event.

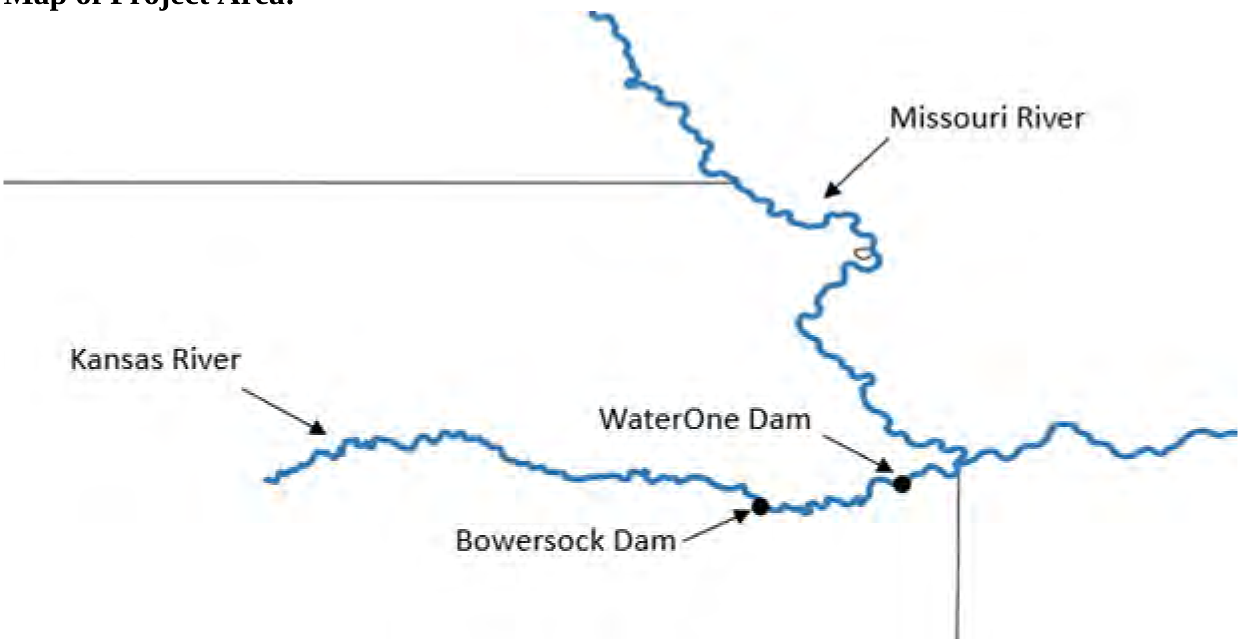
2. Implement most effective removal techniques based on previous projects on adult and juvenile bighead and silver carp in the Lower Missouri River Basin.

Agency: Kansas Department of Wildlife and Parks (KDWP)

Activities and Methods: 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. Standard electrofishing and electrified push trawling will also be used in addition to traditional gear types. Electrofishing and acoustic equipment may also be used to herd invasive carp into static gears.

KDWP intends to meet the objective of population reduction by utilizing existing staff hired for invasive carp projects. KDWP will collect data on number 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 of invasive carp removal effectiveness. At the conclusion of removal efforts, KDWP will prepare a final report.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
KDWP remove invasive carp and maintain/acquire gear	October 2023 – September 2024
Submit annual technical report - evaluation of removal totals, gear effectiveness, and demographics	March 2024
Submit annual technical report - evaluation of removal totals, gear effectiveness, and demographics	March 2025

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: MDC, in cooperation with USFWS – Columbia, will evaluate multiple bighead carp and silver carp removal methods in Missouri River tributaries. This project is a multi-year assessment and efforts conducted during FY24 will examine removal efforts and the amount of effort needed to reach targeted exploitation rates in addition to utilizing hydroacoustic surveys to quantify changes in silver carp densities.

MDC: Implement and evaluate best removal methods for different size classes of bighead carp and silver carp in the mainstem Missouri River, mid-sized tributaries, and floodplain waterbodies. MDC will also estimate the amount of fishing effort required to achieve targeted exploitation rates among techniques.

USFWS - Columbia: In cooperation with MDC, USFWS-CFWCO will utilize electrified trawls as a removal tool and measure relative contribution in mid-sized tributaries and floodplain waterbodies. The electrified trawls along with other physical capture gears (either independently or in combination) will be utilized to remove invasive carp from identified areas. Invasive carp number and size structure as well as non-target fish data will be collected. Effort (as measured in time) will also be recorded for the various techniques and approaches. Remote sensing paired with physical capture will be utilized in pre- and post-removal assessment protocols to provide size structure and relative abundance estimates. This data will be shared with MDC for collaborative reporting.

Based on findings from the 2022 Grand River Invasive Carp Removal, further testing of removal efforts will be conducted on the Grand River in 2023. 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, hoop nets) as well as gears being used by state and federal agencies (e.g., dozer trawl, paupier and boat electrofishing). Hydroacoustic surveys conducted by USFWS pre and post removal will be used to quantify change in silver carp densities. 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 and guide future removal efforts and management actions.

Map of Project Area:

Figure 1. *Missouri River and Grand River near Brunswick, MO.*

Estimated Timetable for Activities:

Activity	Time Period
Removal efforts and post removal evaluation	September 2024 – March 2025
Data entry, analysis and report writing	December 2024 – March 2025
Technical Report	March 2025

Literature Cited:

Asian Carp Regional Coordinating Committee (ACRCC). 2019. 2019 Asian carp action Plan. Asiancarp.us

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

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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.
    1. Determine if Silver Carp and Bighead Carp have extended presence in tributaries and directional movement into and out of Missouri River tributaries.
    2. Evaluate environmental factors (e.g., season, temperature, discharge) for Silver Carp and Bighead Carp movements in select Missouri River tributaries.
    3. 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.
    4. Evaluate seasonal congregations of Silver Carp and Bighead Carp in Missouri River tributaries, particularly as they relate to fish barriers.

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

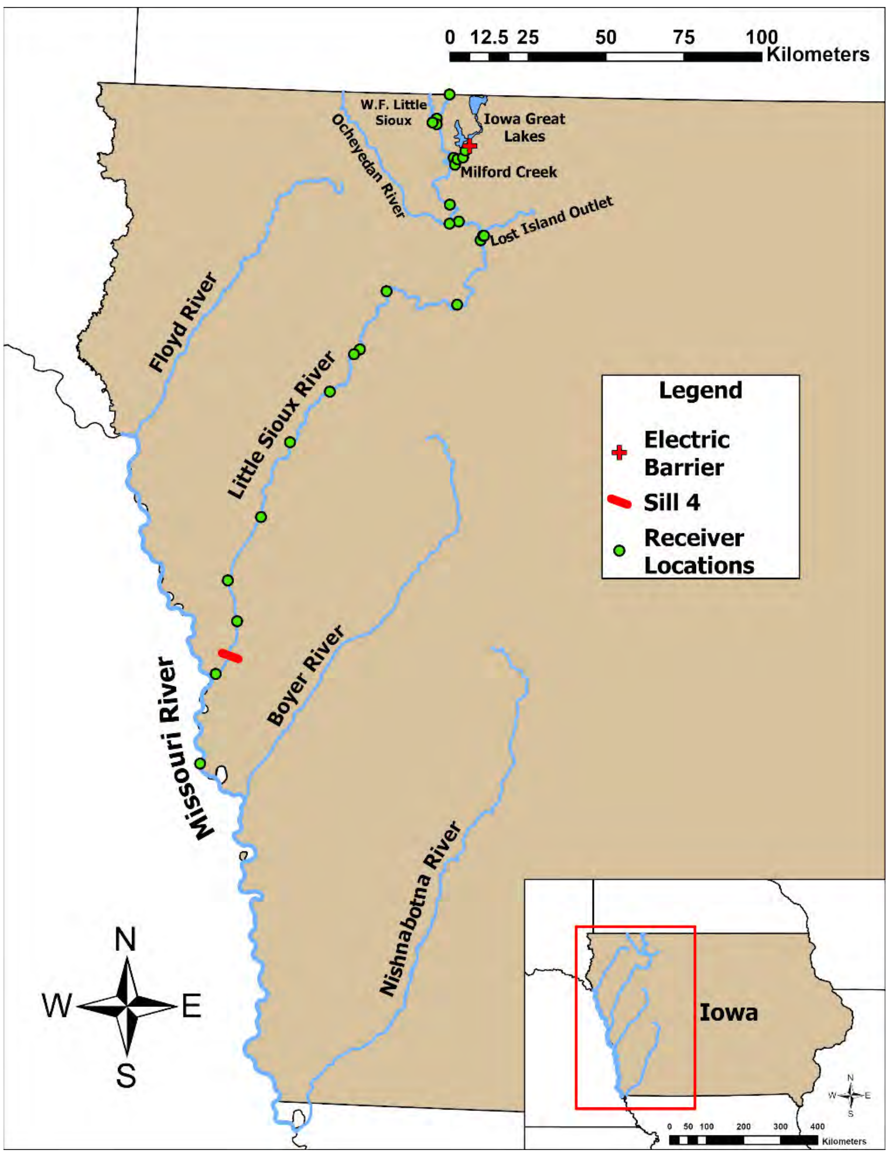
Activities and Methods: First, we will maintain acoustic receivers throughout the Little Sioux River from the confluence with the Missouri River upstream to Minnesota through September 2025 to evaluate seasonal movements within the Little Sioux River, congregations of fish near the electric barrier below Lower Gar Lake, and movements of fish upstream into Minnesota as well as downstream out of the Little Sioux and into the Missouri River. We will implant additional acoustic tags in Silver and Bighead Carp below the electric barrier, other tributaries in NW Iowa, and near Correctionville, IA to assess movements within the Little Sioux River and into the Missouri River.

Second, we will install acoustic receivers above and below Sill #4 on the Little Sioux River and acoustically tag invasive carp and native fishes below Still #4 to assess use of this area and conditions associated with upstream movements past this barrier for two years through September 2025. Results from this project will help guide decisions on whether or not to install a deterrent or barrier at this site to limit or stop invasive carp movements into the Little Sioux River as well as potential barrier type and design.

Third, we will tag invasive carp between Sioux City and Nebraska City and deploy an additional six acoustic receivers in tributaries (Floyd, Boyer, and Nishnabotna rivers; two receivers per tributary) of the Missouri River to assess movement throughout the Missouri River through September 2025. We will also assess what portion of the mainstem population uses various tributaries throughout the basin, population mixing, and broad scale habitat use of these systems to assess source-sink dynamics throughout the basin.

Map of Project Area: This project will occur in three overlapping areas. First, we will assess broad movements of invasive carp in the Missouri River from rkm 1,183 upstream of Sioux City to rkm 885 downstream of Nebraska City. Major tributaries of the Missouri River in Iowa where invasive carp movements will be assessed include the Little Sioux, Floyd, Boyer, and Nishnabotna rivers.

Second, the Little Sioux River joins the Missouri River at approximately rkm 1,077 and extends from Iowa into Minnesota. Milford Creek connects the Little Sioux River to the Iowa Great Lakes, which are comprised of seven different waterbodies that are extremely important recreationally and economically. Following flooding in 2012 that allowed invasive carps to invade the Iowa Great Lakes, the Iowa DNR, Minnesota DNR, and local partners installed an electric barrier at the outlet of Lower Gar Lake on Milford Creek.
Third, we will assess movements at Sill #4, a US Army Corps of Engineer structure located approximately 9 km upstream of the mouth of the Little Sioux River.



Nineteen sites on the Little Sioux River, Iowa where acoustic receiver housing were installed summer 2021 and receivers were installed spring 2022 (green dots). Receiver 19 was placed in the Missouri River downstream of the Little Sioux to obtain directional information for fish that leave the Little Sioux. Still #4 (red line) is a US Army Corps of Engineers structure on the Little Sioux River where we will assess fish passage. We will also expand our work into the Nishnabotna, Boyer, and Floyd rivers.

Estimated Timetable for Activities:

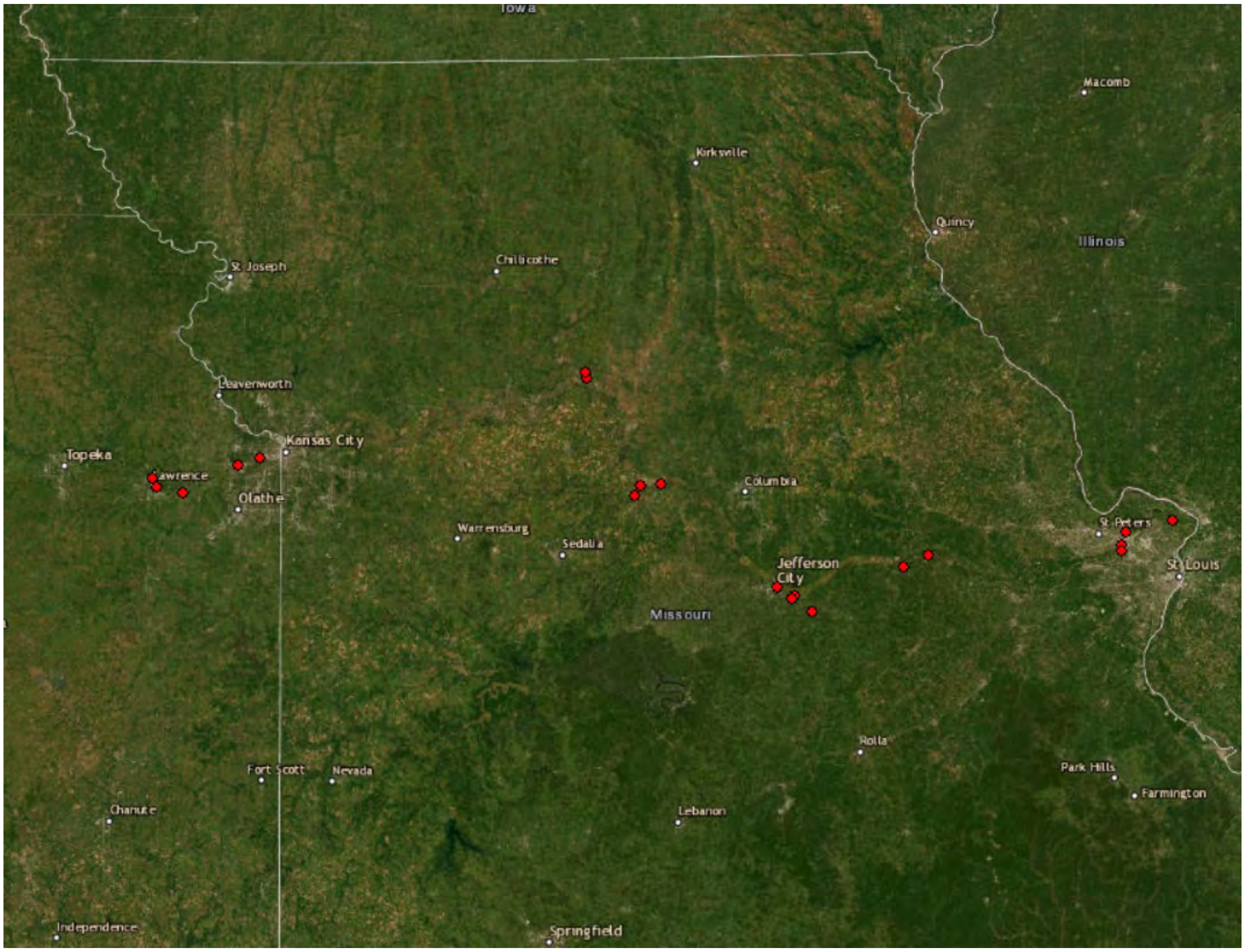
Activity	**Time Period (Season, month/year)**
Download acoustic receivers, deploy additional receivers in tributaries, tag fish	October-November 2023
Telemetry data QA/QC, evaluate preliminary carp movement patterns	December 2023 – March 2024
Tag fish, download acoustic receivers, change receiver batteries, deploy additional receivers	April – August 2024
Telemetry data QA/QC, evaluate preliminary carp movements, write annual report	September-October 2024
Submit annual report	March 2025

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: In support of Objective 1, MDC will continue to maintain an extensive acoustic telemetry network from the confluence of the Kansas River downstream to the Mississippi River confluence. Data from the Missouri River telemetry efforts will help fill in information gaps (i.e., residency time, and transition rates between basins), inform removal efforts, and describe movements of invasive carp in response to contract removal throughout the system. These data will also be available for use to inform complex temporal-spatial models (i.e., SEICarP) that could be developed for the MOR by modifying models developed in other basins. Additional receivers or acoustic tags may be added to the system if deemed necessary.

MDC will coordinate with the MOR Partnership to ensure data is shared and updates are provided.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Maintain Acoustic Array	1 October 2023 – 30 September 2024 As Needed
Download Receiver Data	1 October 2023 – 30 September 2024 Every 4-6 weeks
Annual Technical Report	March 2025

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

Activities and Methods: SDGFP 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.

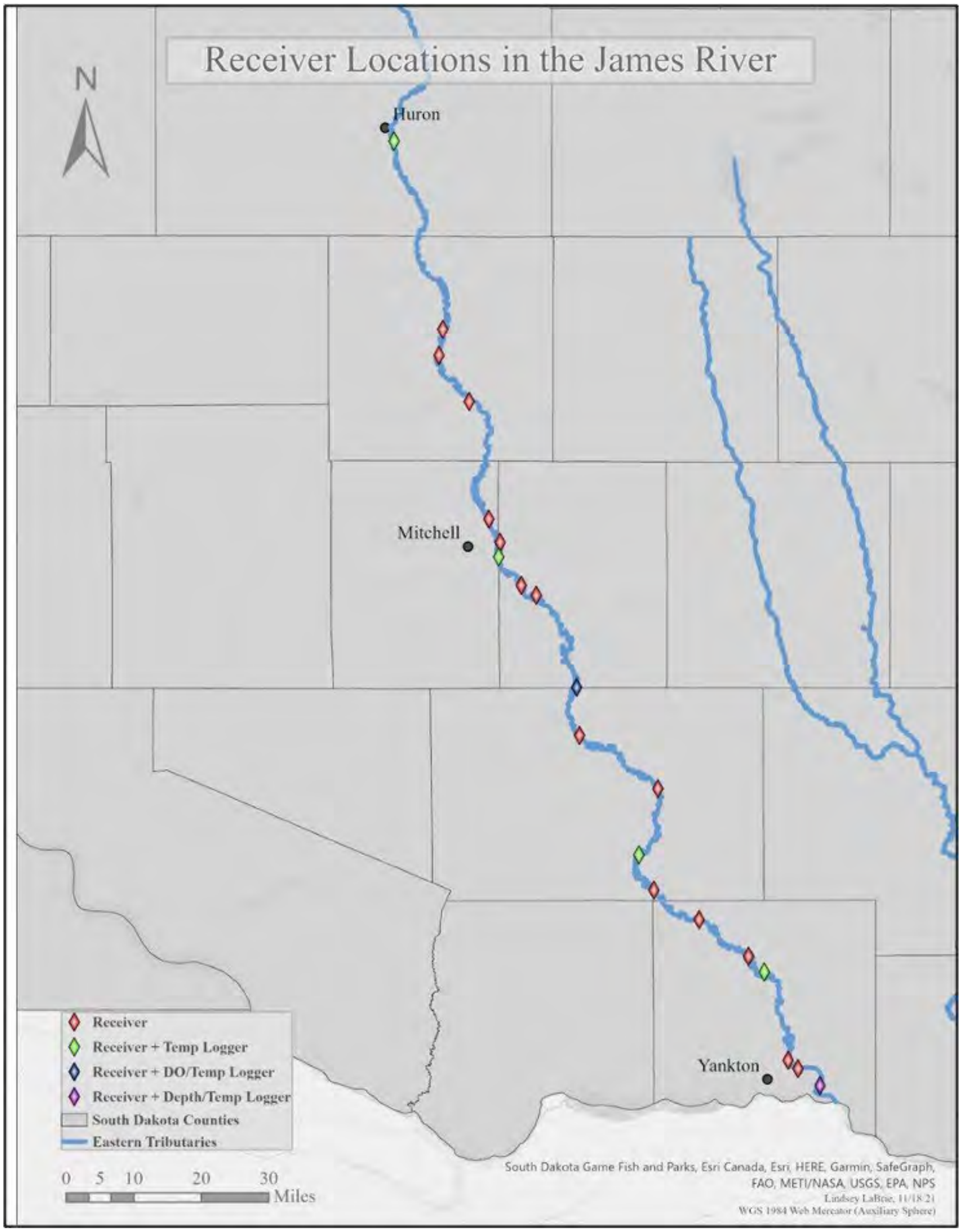
A receiver array consisting of at least 21 total acoustic receivers (16 Vemco VR2W, 5 VR2Tx) was deployed in the James River upstream of the confluence with the Missouri River (rkm 0) between the Highway 50 bridge near Yankton, South Dakota (rkm 1) and Huron, South Dakota (rkm 358). Most receivers were attached to the downstream side of bridge pilings and secured inside 4” PVC tubing, but a subset of VR2Tx receivers were 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 annually in the spring and fall, at a minimum. 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.

The SDGFP will receive 50 acoustic tags in either in October 2023 or April 2024 and will deploy them as soon as they are received. Surgeries will be conducted in at locations in the lower portions of the James River. Most tags deployed prior to this study will be placed in areas >40 river km upstream of the James River confluence, so these tags will fill a gap in the range of tag deployments. Limited water levels in the James River in 2021 limited inference about fish movements, and fluctuating water levels in 2022 provided some preliminary data for early inference. Ultimately, these tags will be used in conjunction with other tags deployed in the James River to .

Silver Carp will be collected using boat electrofishing 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 the Shramm boat access (rkm 41), 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)
Tag 50 Silver Carp	Fall 2023/Spring 2024
Retrieve data from acoustic receivers and environmental loggers	Spring 2024
Retrieve data from acoustic receivers and environmental loggers	Fall 2024
Final Report	March 2025

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.

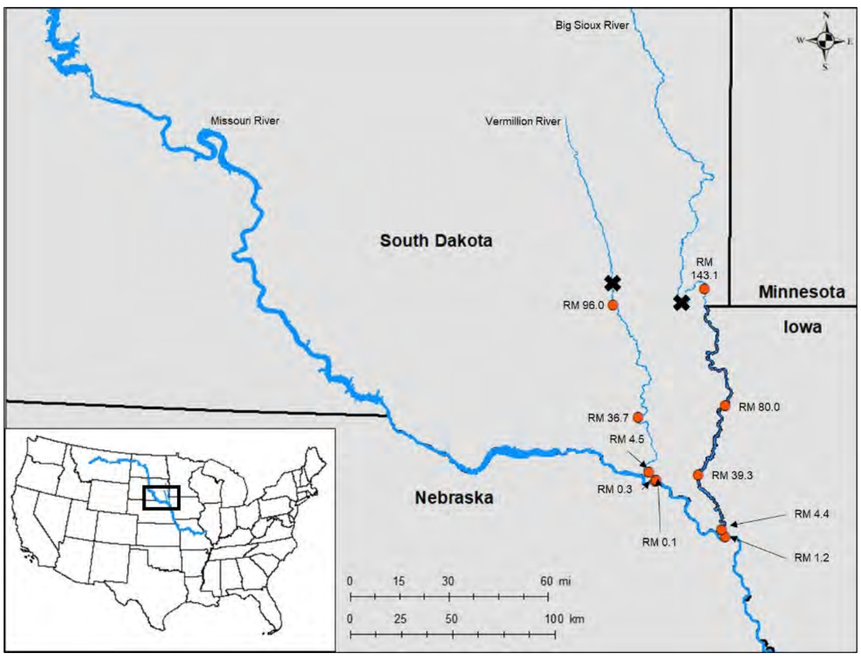
Acoustic Transmitter Tagging
In addition to tracking 127 tagged silver carp from 2021 (80 fish) and 2022 (27 fish), 80 new silver carp will be implanted with transmitters. Fish will be caught using electrofishing methods beginning at the confluence of the Vermillion and Big Sioux rivers, continuing upstream until 80 fish total (i.e., 40 in the Vermillion River and 40 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	August/September 2023
Deployment of VR2W receivers and HOBO temperature loggers	May 2023
Data entry and analysis, annual report	October- December 2023
Data offload of receivers and HOBO loggers	Monthly 2022
Annual report	January 2024

Literature Cited:

Coulter, A. A., E. J. Bailey, D. Keller, and R. R. Goforth. 2016. Invasive Silver Carp movement patterns in the predominantly free-flowing Wabash River (Indiana, USA). Biological Invasions 18:471-485.

DeGrandchamp, K. L., J. E. Garvey, and R. E. Colombo. 2008. Movement and habitat selection by invasive Asian carps in a large river. Transactions of the American Fisheries Society 137:45-56.

Summerfelt, R. C., and L. S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213–272 in C. B. Shreck and P. B. Moyle, editors. Methods for fishery biology. American Fisheries Society, Bethesda, Maryland.

Understanding invasion risk to more effectively allocate monitoring and management.

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

Cooperating Agencies: Nebraska Game and Parks Commission (NGPC), University of Nebraska – Lincoln, Civil and Environmental Engineering, University of Nebraska – Lincoln, School of Natural Resources, U.S. Geological Survey—Nebraska Cooperative Fisheries and Wildlife Research Unit, School of Natural Resources, University of Nebraska-Lincoln, South Dakota Game, Fish & Parks (SDGFP), South Dakota State University (SDSU), USGS South Dakota Water Sciences Center.

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.

Control and mitigation of invasive carp species has largely focused on efforts to remove or divert them in an attempt to minimize short- and long-term changes in ecosystems where they are already established. Much of this work has focused on larger sub-adult and adult sized fish in an attempt to decrease populations in larger river systems. However, emerging data from otolith microchemistry analyses show that many individual carp collected in the Missouri River basin have natal origins from tributaries rather than the mainstem portion of the basin. This information suggests an unaccounted-for source-sink dynamic that could sustain carp populations even in the presence of large-scale removal efforts if successful recruitment is occurring in these tributaries on a regular basis.
We have a basic understanding of the requirements these carps need to successfully reproduce and thus survive through their early life stages (e.g., free-floating eggs to larval drift stages). For

example, the FluEgg model has been used to simulate drift requirements for invasive carps in rivers characterized as a single channel (e.g., Illinois River Waterway). However, many tributaries in the Missouri River and especially those flowing through the Great Plains are characteristically shallow, braided systems (e.g., Platte River) that incorporate additional complexity that has yet to be evaluated. Therefore, understanding the dynamics of early life-stage outcomes in braided river systems may shed light on the ability of these systems to support the spawning and development of eggs and larvae as well as on new avenues to affect control measures. Better knowledge of how eggs and larvae drift in the water column in these braided systems could prove beneficial for informing prevention and innovation in population control. Specifically, being able to determine how eggs and larvae move throughout a system could identify potential habitat types and locations where young invasive carps become concentrated due to flow dynamics. These concentration habitats could then be targeted for monitoring in areas not yet invaded by invasive carp or intensive carp management practices to remove individuals in a more effective manner. Our goal is to better understand how flow and habitat dynamics in the Platte River Basin influence egg and free-floating life-stages of invasive carp.

The primary goal of this project is to limit the spread of invasive carp in the Missouri River basin. Further, we will increase our understanding of their drift dynamics to identify areas to target larval and/or age-0 removal. 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. Model and evaluate drift dynamics of Invasive Carp eggs and larvae in the Platte River to assess the successful spawning potential of invasive carps under varying flow conditions and identify habitat types or locations conducive for carp population management.

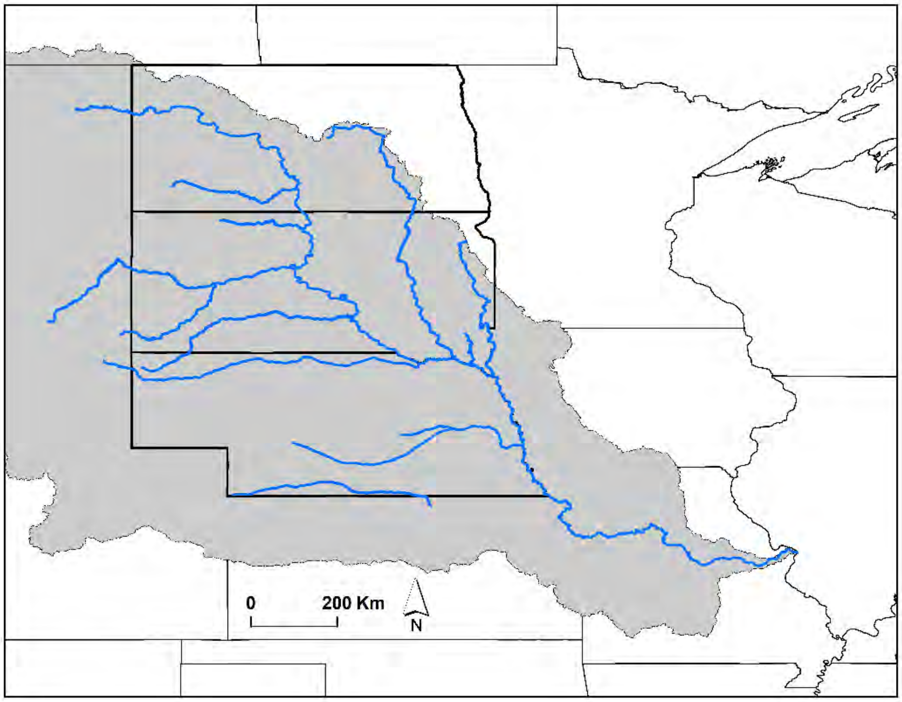
Agency: South Dakota

Activities and Methods: Objective 1. This project will be a collaborative effort between SDGFP, SDSU, 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. Areas identified as at-risk of potential connectivity will be evaluated in-person to assess elevations, culverts, and other features affecting possible hydrologic connectivity. 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. Led by SDSU and SDGFP in collaboration with other states in the basin, 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 using reach-specific observations of water temperature, velocity, and plankton density. This study will initially target mid-order tributaries (e.g., 3rd to 5th 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 reduces 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)
Complete habitat suitability modeling for MO River tributaries	Summer 2025
Create final products: GIS layers and database of site invasion risk metrics	Summer 2025
Annual report	January – February 2025
Final report	Fall 2025

Agency: Nebraska

Activities and Methods: Objective 3: This project will be a collaborative effort between the University of Nebraska-Lincoln – School of Natural Resource, the Civil and Environmental Engineering department, and the Nebraska Game and Parks Commission. To meet the stated objective, our plan is to develop an effective hydrodynamic model for predicting flow behavior and resulting egg-drift in sand bed sections of the Platte River Basin, including the Platte River and tributaries with similar characteristics. Existing software, *FluEgg*, is appropriate for Lagrangian tracking of fertilized eggs in typical rivers and can be used to predict and record the path of a fertilized egg over a specific time period (e.g., 7 to 8 days) in a single channel flow. By repeating release points, such a model can provide a statistically based estimate of egg transport paths and termini. This approach, while robust, is largely one-dimensional. However, the sand bed rivers in the Platte Basin are often braided with multiple flow paths and regions of retarded flow (see figure below). The multiple flow paths and backwater areas create a significantly more complex pattern of lateral advection and dispersion, one that requires more sophisticated hydrodynamic modeling. Two options include three-dimensional computational fluid dynamics (3D-CFD) and two-dimensional hydrodynamic modeling with assumptions about the vertical velocity distribution (2-D). Either of these models can be used to predict flow fields within a reach of interest, and the results can be coupled with a Lagrangian particle release approach to get a statistical estimate of how eggs track through the reach.

We propose a 2-D hydrodynamic approach for the following reasons: (1) while 3D-CFD is the most rigorous option, an accurate 3D model of a reasonably-sized study reach is likely beyond available computational capabilities, (2) the reaches of interest are shallow and dominated by two-dimensional flow behavior, and (3) it will be easy for us to build upon a widely used platform like HEC-RAS 2D for the hydrodynamic model. We can then implement an advection-dispersion-diffusion model that utilizes 2-D velocity field outputs to predict egg tracks; variations of individual egg tracks will result from randomness of the diffusion. This two-part model founded on HEC-RAS will be easily accessible to others.

Loup River upstream of Columbus showing multiple channels (multiple flow paths).

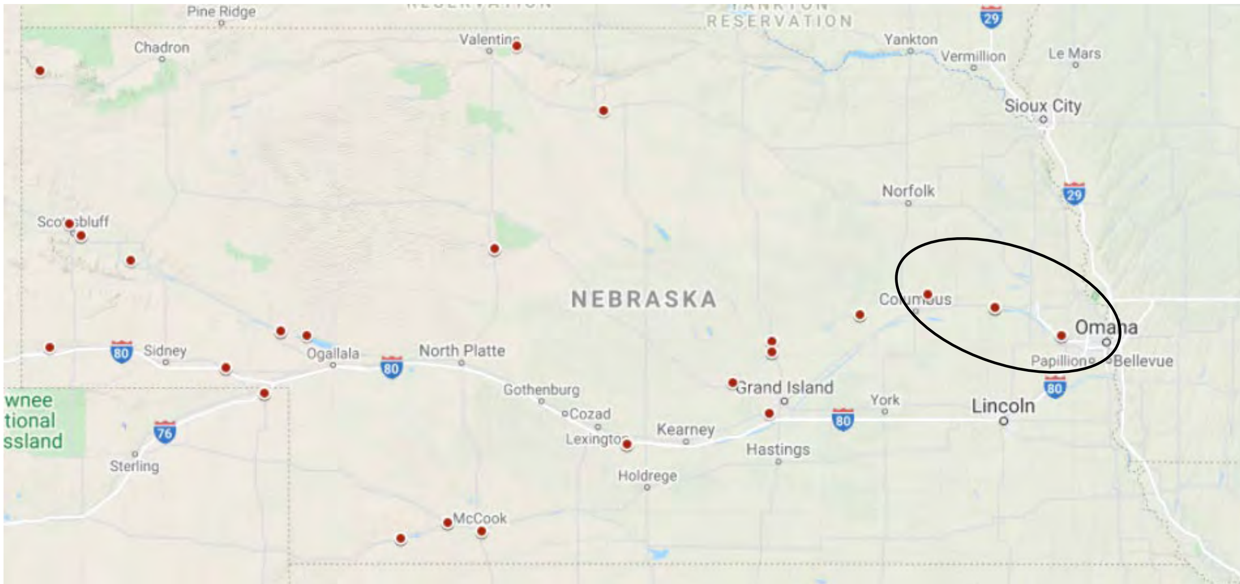
Model Validation: During model development, it is important to thoroughly test model performance. There are two aspects of model performance that require testing: (1) the hydrodynamic performance of the model, and (2) the ability of model results to predict egg tracks from artificially created egg-like particles with similar characteristics to the invasive carp eggs (i.e., similar size, buoyancy, etc.). These are two somewhat separate components because the first requires adequate understanding of flow and roughness characteristics in these complex reaches, whereas the second requires knowledge of local turbulent diffusion and dispersion characteristics.

To capture this information in the field we propose a rigorous field approach that allows us to collect both hydrodynamic and tracking information. The hydrodynamic information will

require velocity and bathymetry measurements in selected project reaches. The most efficient way to collect water velocity and bathymetry information is with an Acoustic Doppler Current Profiler (ADCP). Transects of project reaches at the upstream and downstream ends and information about bedforms and bed roughness throughout the project reaches will be collected using ADCP and depth sounder equipment. This information will be used to (1) verify the 2-D hydrodynamic model, and (2) develop predictions of advection and dispersion behavior.
A second field data set will be simultaneously collected to validate egg-drift track predictions. A large number of floating trackers will be released at semi-random times and positions within study reaches. We intend to use trackers with GPS sensors that map their locations to within 2.5 meters as a function of time. Long range wireless transmitters installed in the trackers will be used to report their positions in real time. Although the floating trackers will not mimic fertilized egg behavior identically because they are larger and likely more buoyant, they will provide detailed information about surface advection, dispersion, and diffusion of the river that is useful for validating model predictions. The trackers will be particularly useful for verifying two-dimensional advection paths and lateral dispersion. If preferential surface flow paths are observed, tracker release locations will be adjusted to obtain a more complete data set. The trackers will be collected for reuse after each release. While dye releases are another possible validation option for dispersion and diffusion, effectively processing dye cloud information in these complex systems might be very difficult.

The proposed project will use a combination of computational flow modeling and field work to develop a framework for predicting fertilized egg dispersal in shallow, braided sand bed rivers. The modeling effort will combine two-dimensional hydrodynamic modeling using a standard platform (HEC-RAS 2D) with an advection-dispersion-diffusion model to identify the most likely paths of released carp eggs. A two-pronged field investigation that includes both Eulerian (ADCP/Depth sounder) and Lagrangian (Surface Flow Trackers) elements will be used to thoroughly validate the hydrodynamic and advection-dispersion-diffusion components of the model. The result will be a solid methodology for predicting egg drift. The methodology may also be viable for predicting drift of recently hatched larvae.

Map of Project Area:



Study area: Map of the state of Nebraska. Red dots indicate potential locations of invasive carps. Black circle highlights the lower Platte River where this project will be conducted, but results will be applicable to entirety of the Platte River given similar channel geomorphology throughout the system.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Recruit Graduate Student	October – December 2023
Purchase Equipment	January – March 2024
Field work	April-October2024
Model development and validation	September 2024 – August 2025
Preliminary Report	November 2024
Final Report	March 2025
Publications	October - December 2025

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.

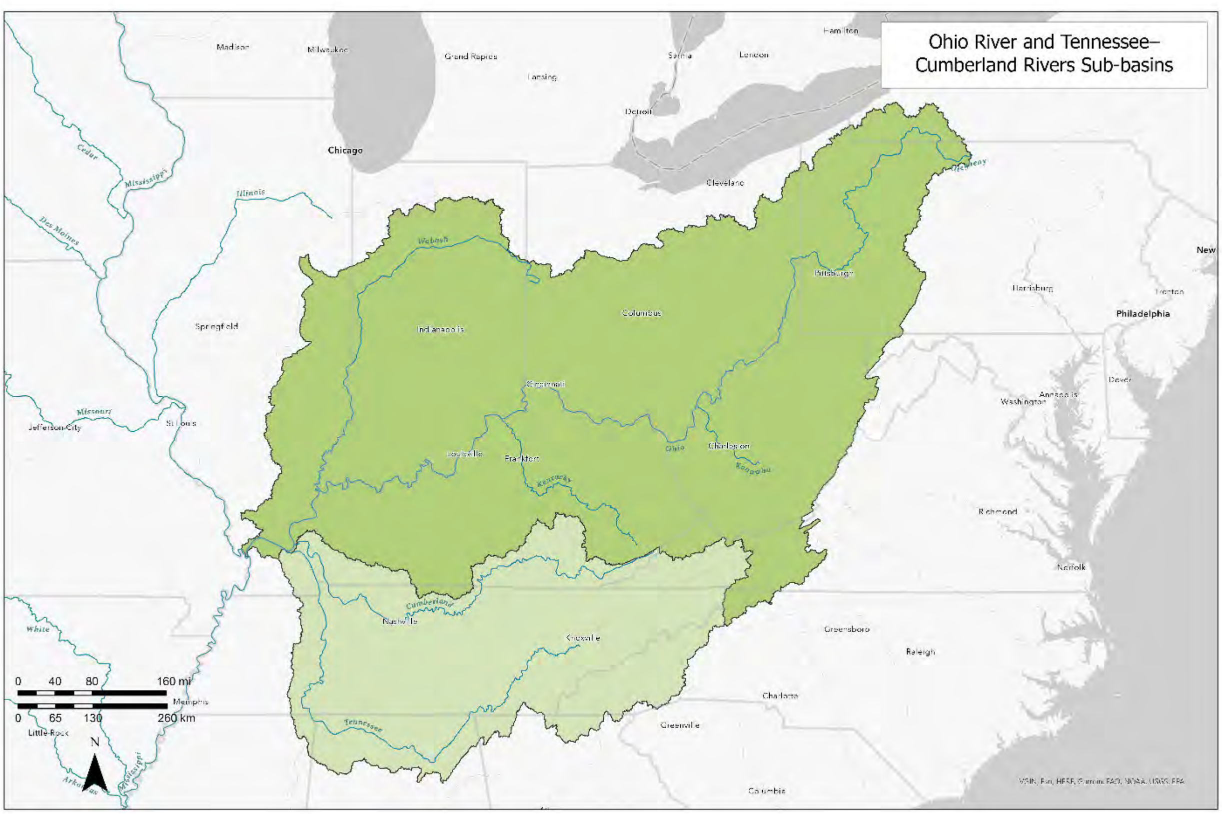
Irons, K. S., Sass, G. G., McClelland, M. A., & Stafford, J. D. (2007). Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River, USA Is this evidence for competition and reduced fitness? *Journal of Fish Biology*, *71*, 258-273.

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.

The Ohio River and Tennessee Cumberland Sub-basins have four and five projects respectively in 2023. The Ohio River received $4,887,681 in support of four projects going to five different states. The Tennessee Cumberland sub-basin received $5,379,718 in support of five projects going to four different states.



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 Geological Survey (USGS), Eastern Illinois University (EIU).

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 primarily referring to Silver Carp and Bighead Carp (*Hypophthalmichthys* species), also known as bigheaded carp, however, some work specifically on Black Carp is occurring in the lower Ohio River basin.

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 were captured in Cannelton Pool (RM 691.5) and in 2022, they were captured even further upstream a RM 508.6 in Markland Pool. 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.

To support the Ohio River Fish Management Team (ORFMT) Basin Framework objectives (ORFMT 2014), this project was initiated in 2016 to improve our ability to detect both early stages of invasion and spawning populations of invasive carp (Strategy 2.8) and also monitor upstream range expansion and changes in distribution and abundance (Strategy 2.3). The results of this project will help managers make informed decisions during future planning efforts regarding resource allocation for invasive carp deterrent and control strategies.

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 basin in which spawning occurs.

3. Determine the extent, biological characteristics, and environmental requirements of invasive carp reproductions and recruitment locations in the Ohio River basin.

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

5. Determine genetic structure and relatedness of invasive carps in the Wabash and Ohio River basins to identify sources of propagule pressure and inform contract harvest at large scales.

Agency: Indiana Department of Natural Resources

Activities and Methods: Objective 2 - Identify locations of the Ohio River basin 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 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, 2024. 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).

Indiana DNR will subcontract with USGS to complete FluEgg model simulations to determine where spawning may be occurring in the Ohio River basin. The USGS will use an existing

HEC-RAS model maintained jointly by the U.S. Weather Service and the U.S. Army Corps of Engineers to provide input flows for the model. The FluEgg model will simulate:

- The 2020 conditions (water temperature, discharge, dam gate settings) to simulate egg dispersion from the observed spawning at McAlpine L&D
- Likely 2020 spawning conditions to simulate where Hovey Lake larvae were spawned
- Likely 2021 spawning event conditions to forecast egg and larval dispersion from spawning at McAlpine L&D
- Based on results of the simulations above, strategically design and simulate up to 20 other scenarios

Objective 3 - Determine the extent, biological characteristics, and environmental requirements of invasive carp reproductions and recruitment locations in the Ohio River basin.

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 2022, YOY were captured at multiple sites 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).

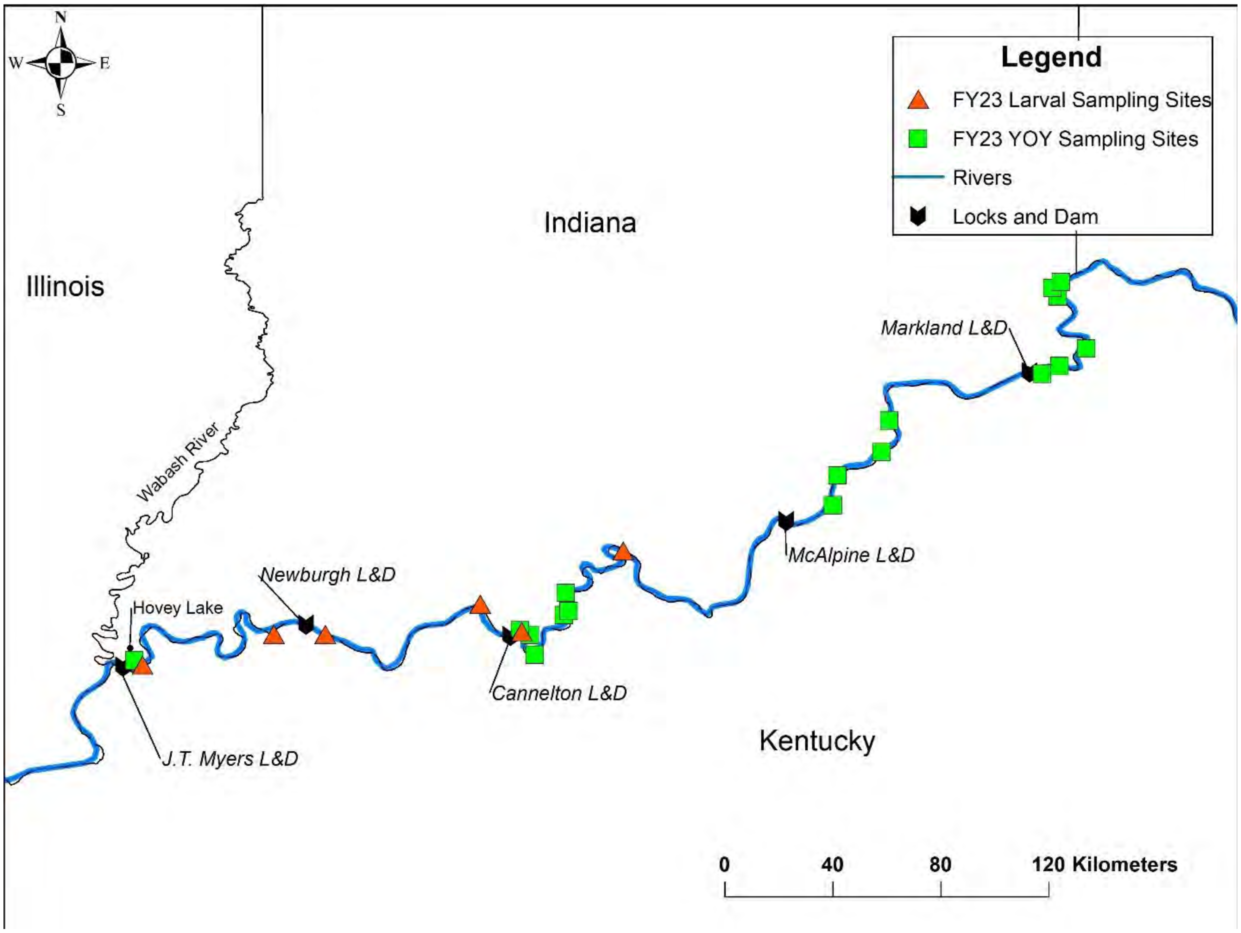
Indiana DNR will collect a suite of habitat measurements at each sample site during targeted juvenile efforts to describe both the morphology characteristics (average depth, maximum depth, tributary width, presence/absence of woody debris and aquatic vegetation) of the tributary as well as water quality 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.

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 if a new instance is reported, will gather data and site location information if possible. Indiana DNR will work on creating an online citizen-based reporting tool for the general public to share invasive carp sightings. These data will be compiled by the project lead and will be used to inform future planning efforts.

Objective 4 - Evaluate the feasibility of drain structure modifications to limit invasive carp recruitment from Hovey Lake.

Indiana DNR will conduct intensive sampling during the spring (mid-May through June, 2024) near the Hovey Lake drain control structure to determine what environmental conditions allow for larval or YOY invasive carp to enter into Hovey Lake. Previous years of sampling indicate that invasive carp are most likely entering Hovey Lake through the water control structure, because that was the only connection point between the river and the lake during the spring and summer of 2021 and 2022. Sampling will take place during four days and two nights per week. Daytime sampling will consist of conducting ichthyoplankton tows and surface trawls (exact net specifications described above) on both the lake side and river side of the control structure. Overnight sampling will consist of deploying larval light traps on both the lake side and river side of the control structure. USGS will be collecting real-time velocity and flow direction data which will be paired with fish sampling data to determine exact conditions at the control structure when invasive carp fish passage occurs. These data will offer insight into how short-term operational changes at the control structure could limit large amounts of YOY carp passage into the lake.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Executive technical report for 2023 data	Spring, March/2024
Larval IC Sampling	Spring, May-June/2024
Hovey Lake drain sampling	Spring, May-June/2024
Juvenile IC Sampling	Summer, July-Aug/2024
Nursery Habitat Assessment	Summer, July-Aug/2024
Process larval samples	Summer, July-Aug/2024
Submit genetic samples to WGL	Fall, September/2024

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 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.

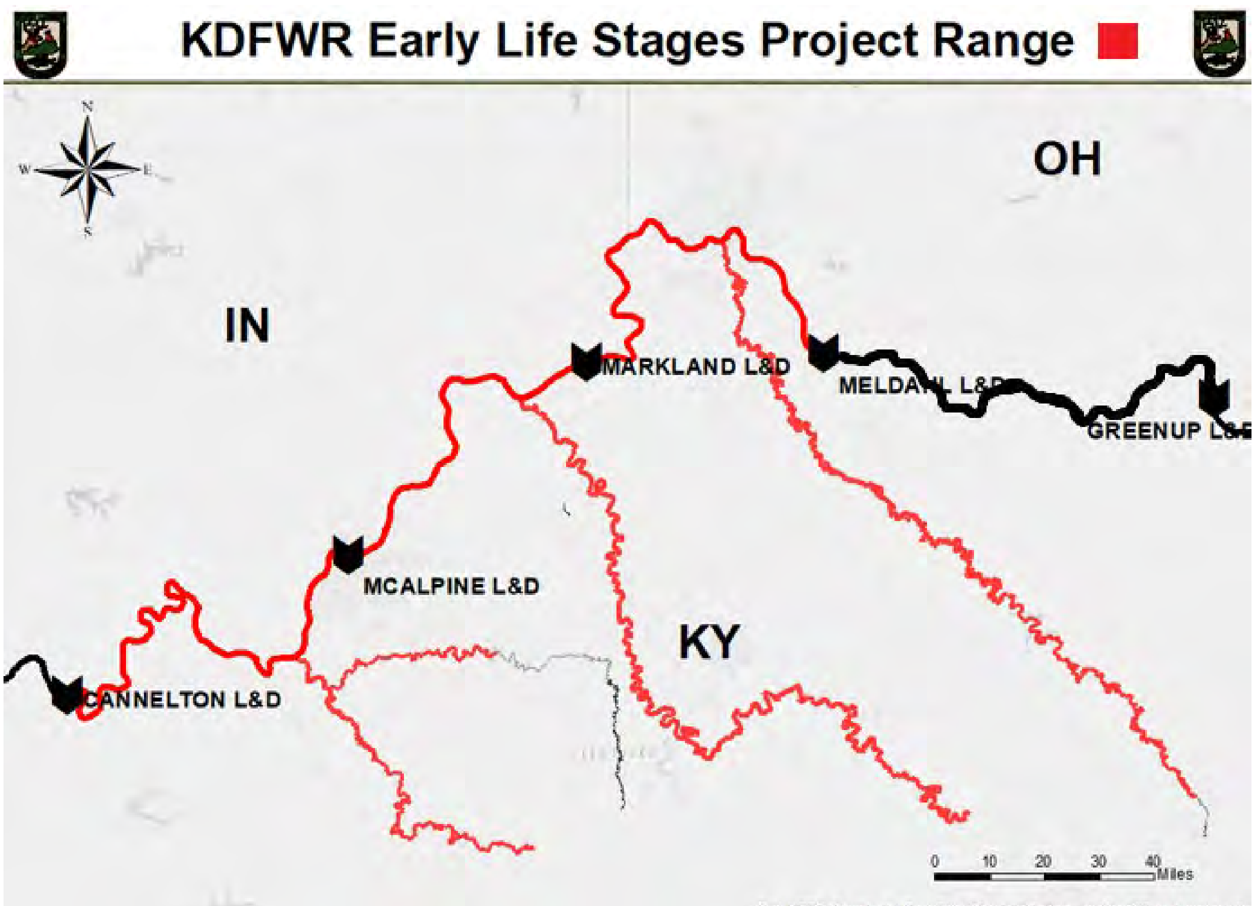
KDFWR will help survey the Cannelton, McAlpine, and Markland pools for young-of-year (YOY) invasive carp. Because typical nursery habitat (shallow backwater areas) is less prominent in the Ohio River, flooded creek mouths, embayments, and tributaries likely serve as a substitute. Previous sampling efforts have regularly captured YOY in JT Myers Pool with occasional captures in Newburgh Pool. Captures of YOY in Cannelton Pool were seen in 2021 and 2022, and 2022 marked the first year YOY invasive carp were caught in Markland 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 the lower Smithland pool. Sampling locations will be chosen based on the hydrologic similarity to the location where YOY Black carp were collected previously in Kentucky or locations that are accessible depending on water elevations. Areas will be sampled with beach seine, mini fykes and backpack electrofishing, depending on available habitat. 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 2024 – July/2024
Survey for YOY Invasive Carp	Summer, August/2024 – September/2024
Process larval samples	Summer, July/2024
Data and suspect samples Sent to INDNR/USFWS for molecular verification	Fall, September/2024
Black Carp YOY sampling lower Ohio River	Fall 2023/2024
WRRDA Report to Congress	Fall, October/2024
KDFWR Contribution to Annual Technical Report	Spring, March/2025

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 invasive carp spawning activity in the Ohio River above Markland Dam. WVU will conduct approximately biweekly ichthyoplankton tows from mid-May through July 2024 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 be 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).

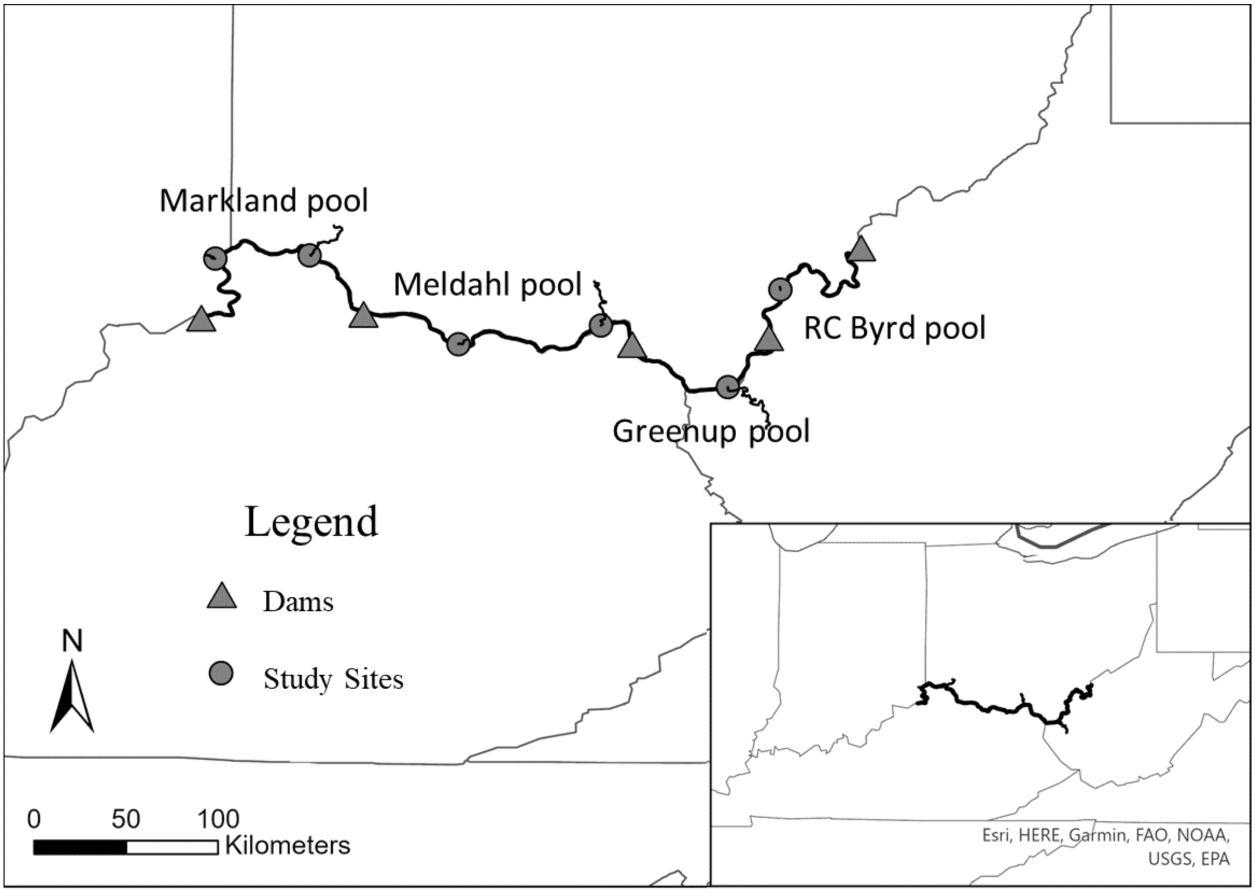
WVU will also identify and enumerate all larval fish collected and subsample larval lengths to assess phenology and growth rates of larval fish by species. This will be compared across pools relative to environmental drivers, e.g. flow, water temperature, day length, and lunar period and density of invasive 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 front. 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 as INDNR. 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 Egg and Larval Sampling	May-July 2024
WVU Juvenile Sampling	July-Sept 2024
WVU Process larval and Juvenile Samples	July 2024 – March 2025
WVU Send carp genetic samples and data to INDNR	Nov 2024
Project Report Technical Document	April 2025

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.

As needed, 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.

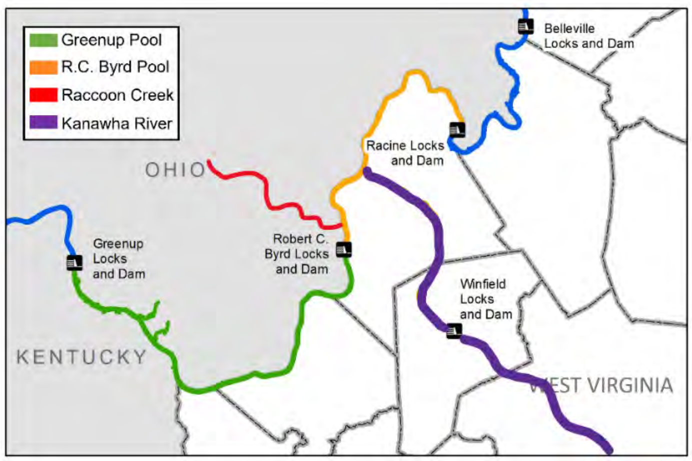
Objective 2 - Identify locations of the Ohio River in which spawning occurs.

WVDNR will collect ichthyoplankton in Raccoon Creek, OH 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 (moderate to high flows; water temperatures 64 - 80°F). 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. 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/Summer, May 2024 – Jul 2024
Eggs, Embryos, Larval Fish Isolated from Samples and Potential Carp Identified	Summer, July 2024
Data and Suspect Samples Sent to INDNR/USFWS for Molecular Verification	Summer, August 2024
WRRDA Report to Congress	Fall, October 2024
WVDNR Contribution to Annual Technical Report	Spring, March 2024

Agency: Eastern Illinois University (EIU)

Activities and Methods: Objective 2 - Identify locations of the Ohio River Basin in which spawning occurs. EIU will estimate the density of invasive carp eggs and larvae throughout the Wabash River basin and over time, using previously developed protocols that are comparable to existing OHR early life stages sampling techniques. Past research by EIU has shown invasive carp reproduction occurs in greater magnitude in the Wabash compared to surrounding basins on average, and we hope to estimate the level of potential propagule pressure of this system (Roth et al. 2020, Schaick et al. 2021). EIU will also focus on developing a standardized invasive carp ichthyoplankton sampling protocol for the Ohio River and Wabash River Basins. This will allow better comparison of reproductive rates as gear efficiency limitations are controlled for, allowing us to identify spatial and biological factors involved in invasive carp reproduction at large scales. EIU has an existing protocol based on previous gear evaluations that can be adapted to fit basin objectives (Roth et al. 2020).

EIU will sample four tributaries of the Wabash River (Vermilion, Embarras, White, and Little Wabash rivers) to collect invasive carp (Hypopthalmichthys spp.) larvae and eggs. Tributary mouths are located near Cayuga, IN, Vincennes, IN, Mount Carmel, IL, and New Haven, IL (see map below). We will sample within, above, and below the mouth of each tributary on a bi-weekly schedule from May-July. Additionally, EIU will employ targeted sampling during favorable conditions for invasive carp spawning. EIU will also sample the mainstem Wabash River both above and below the confluence of each tributary during each sampling event at four sites. We will collect three pushes from each site during each sampling event at the left bank, center channel, and right bank. Pushes may be grouped closer together in the event of low water or obstruction within the preferred sampling area. Larval fish and egg relative densities will be measured using a bow-mounted 500-micron, nylon mesh, conical ichthyoplankton net pushed in an upstream direction. The mouth of the net is constructed of an aluminum frame and will be deployed directly below the surface of the water and pushed for five minutes in an upstream direction. To determine sample volume and water filtered, a flow meter (General Oceanics 1030) will be mounted using a monofilament line in the mouth of the net. Larval fish samples will be fixed in 90% ethanol for later separation and identification. EIU will process each sample by separating fish from other organic matter and sediment. Prepared specimens will then be identified to the family level using morphological characteristics such as body shape, pigmentation, meristic count, and trait measurements.

EIU will fulfill all deliverables required by the Ohio River Basin Partnership including annual reports, species distribution maps, and sharing of larval data. Within the annual report EIU will include full results and conclusions for each objective.
Objective 3 - Determine the extent, biological characteristics, and environmental requirements of invasive carp reproduction and recruitment locations in the Ohio River basin.

EIU will identify locations supporting consistent invasive larval carp production over time and make recommendations for harvest program through the above objective 2. When these locations have been identified, EIU will conduct additional targeted continuous (i.e., 1 sample/hour x 24 hours) sampling at known spawning locations near EIU. Additionally, EIU will collect the following abiotic factors during each sampling event: dissolved oxygen (mg/L), temperature (degrees Celsius), conductivity (µs), pH, flow (m/s), Secchi depth (cm), river stage (feet), total phosphorus (mg/L), chlorophyll-a (µg/L), and river discharge (m3/s) (USGS gauges). This will allow us to measure changes in biological and environmental conditions throughout the course of a spawn to identify factors that promote spawning and gain a better understanding of how detection probability varies as density of larvae and abiotic factors change in real-time. Lastly, EIU will incorporate all of our data into a multi-variate model that can help predict when and where carp may spawn by incorporating more detailed hydrological and environmental information. This will allow agencies who are interested in mass-removal events to monitor these factors and take action in areas where fish are likely spawning in large concentrations.

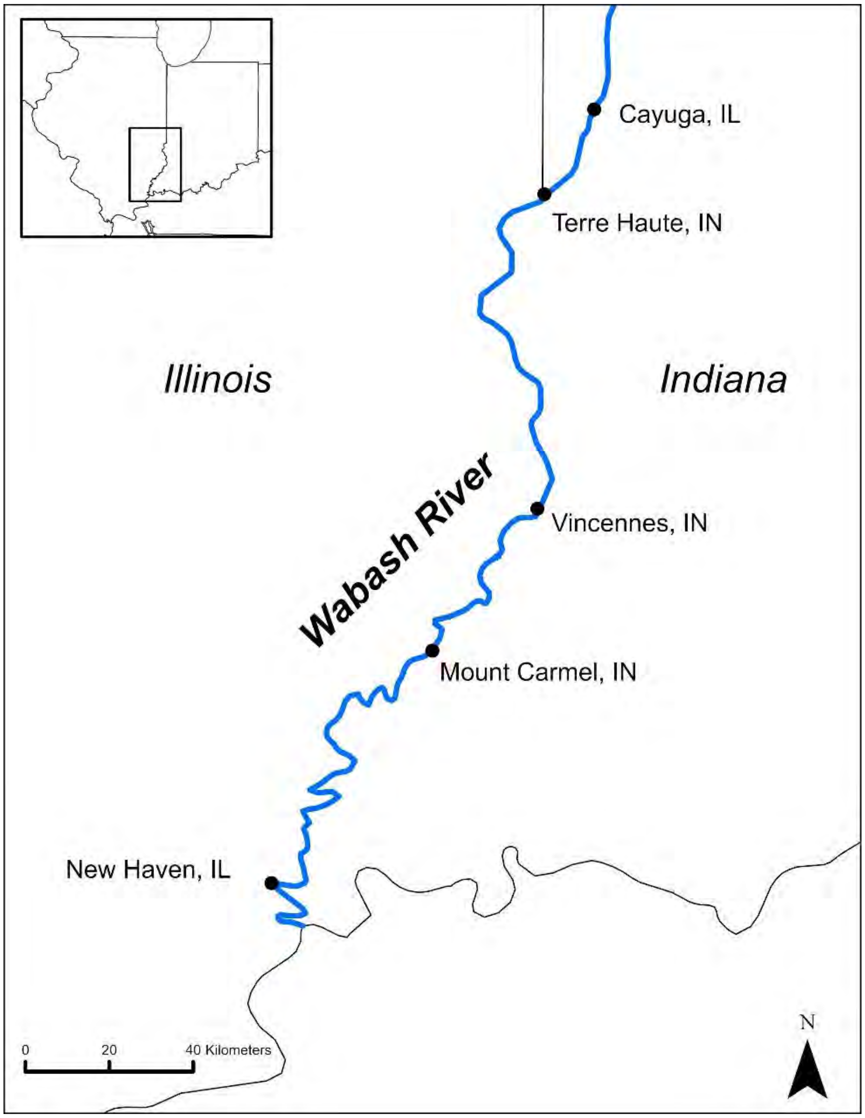
This component will be conducted using equivalent methods described in EIU's portion of objective 2. Sampling sites (N = 1-3) for this objective will be located on the Embarrass River near Charleston, Illinois where invasive carp populations exist both seasonally and year-round. EIU will attempt to monitor the plume of eggs and larvae produced on a near continuous basis (12-24 samples per day), until the spawning is complete. Laboratory methods will be equivalent to EIU's portion of objective 2.

Objective 5 - Determine genetic structure and relatedness of invasive carps in the Wabash and Ohio River Basins to identify sources of propagule pressure and inform contract harvest at large-scales.

Objective five focuses on identifying the genetic relatedness of invasive carps and their early life stages across basins. Previous genetic research has found high rates of hybridization and genetic mixing among populations of invasives carps in the Mississippi River, further evidence these invasive fishes need to be controlled at a basin-level scale or greater. EIU will preserve a subsample of larvae and eggs collected in the Wabash and Ohio River Basins for use in our genetic analyses. Preliminary genetic analysis on samples collected in the Little Wabash and Embarrass Rivers found significant genetic differences among tributaries in 2016-2017. Ultimately EIU hopes to determine the feasibility of identifying invasive carp source populations through genetic sequencing.

Potential genetic methodology conducted by EIU may include: A subsample of invasive carp larvae and adult (predominantly Silver Carp) DNA will be extracted and genotyped using previously developed microsatellite loci and amplified using a multiplex polymerase chain reaction (PCR). Additionally, recent breakthroughs in next generation DNA sequencing (high-throughput sequencing of all genes at once) have increased the speed of species identification. No additional computing infrastructure is required and can be used in a variety of field settings. Using this technology, EIU researchers were able to produce high quality data from freshwater benthic diatoms and effortlessly identify the species and their abundance. This new technology may offer a rapid detection technique for invasive carp in real time in a field setting. Development of these novel early detection methods for these invasive species will likely be invaluable for implementing control strategies across the gradient of invasion, basin wide.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Prepare field gear for 2024 field season.	Spring, March - April 2024
Larval field sampling (biweekly & targeted).	Spring, May - July 2024
Process samples, process genetic subsample.	Fall/Winter, July- Dec 2024
Prepare and analyze data, prepare technical reports and other deliverables.	Winter/Spring, January - March 2025

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.

ORFMT (Ohio River Fisheries Management Team). 2014. Ohio River Basin Asian carp control strategy framework.

Roth, D. R. Pesik, J. J., Effert-Fanta, E. L., Wahl, D. H., & Colombo, R. E. 2020. Comparison of Active and Passive Larval Sampling Gears in Monitoring Reproduction of Invasive Bigheaded Carps in Large-River Tributaries. *North American Journal of Fisheries Management.* https://doi.org/10.1002/nafm.10548.

Schaick, S. J., Moody-Carpenter, C. J., Effert-Fanta, E. L., Hanser. K. N., Roth, D. R., & Colombo, R.E. 2020. Bigheaded carp spatial reproductive dynamics in Illinois and Wabash River tributaries. *North American Journal of Fisheries Management*. doi:10.1002/nafm.10573.

Control and Containment of invasive carp in the Ohio River Basin

Lead Author and Agency: Illinois Department of Natural Resources, Brian Schoenung (Brian.schoenung@illinois.gov)

Cooperating Agencies: West Virginia Division of Natural Resources (WVDNR), Kentucky Department of Fish and Wildlife Resources (KDFWR), 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)

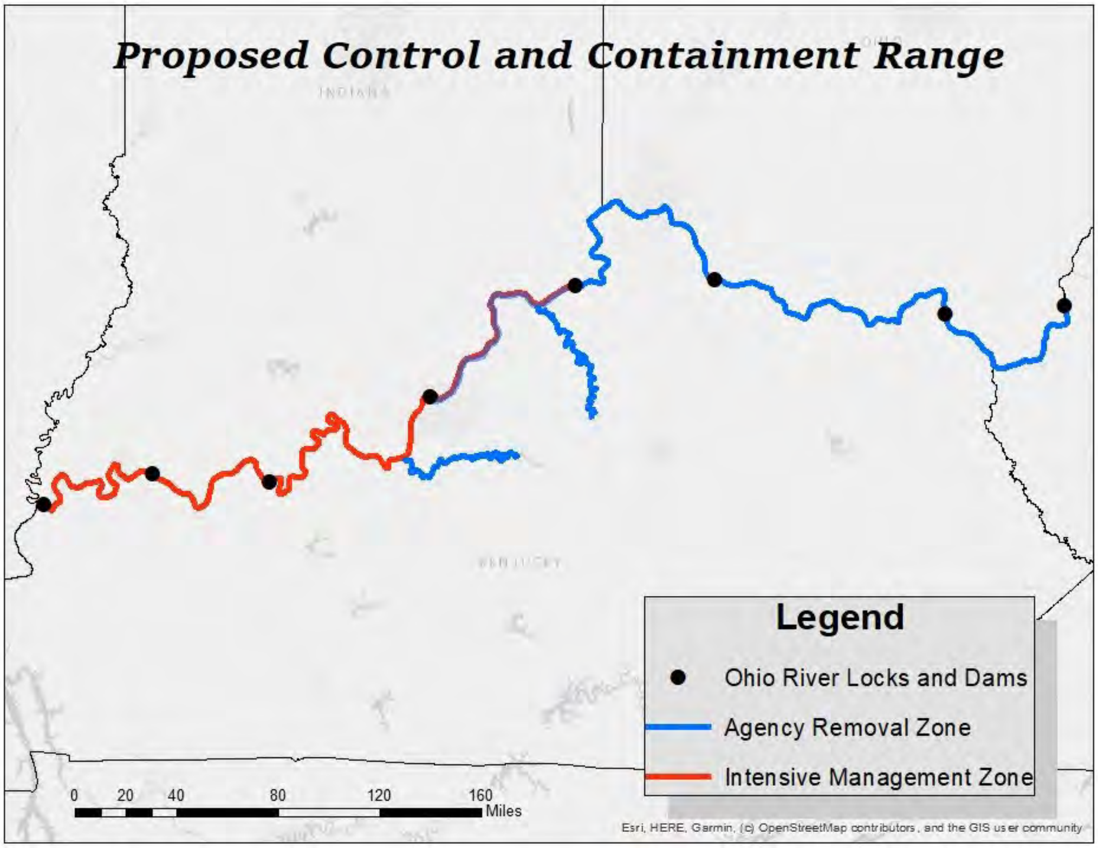
Activities and Methods: Objective 1 - Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.

Agency crews will remove invasive carps from the Ohio River and large inland tributaries and embayments, 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. 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 1:152 and Emergency Rule 312 LSA # 22-4), were given access to otherwise net-restricted waters 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 500 contract fishing days and reach a minimum benchmark of 500,000 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)	Winter, Spring, January/2024 – May/2024
Agency Removal in McAlpine and above the IMZ	Spring, Summer, Fall, and Winter, May/2024 – December/2024
Agency Removal in Inland Waters including Salt River and Kentucky River	Spring, Summer, Fall, and Winter, May/2024 – December/2024
Contract removal within the intensive management zone (IMZ)	Fall and Winter, October/2024 – December/2024
WRRDA Report to Congress	Fall, October/2024
Project Report Technical Document	Spring, March/2025

Agency: Indiana Department of Natural Resources (INDNR)

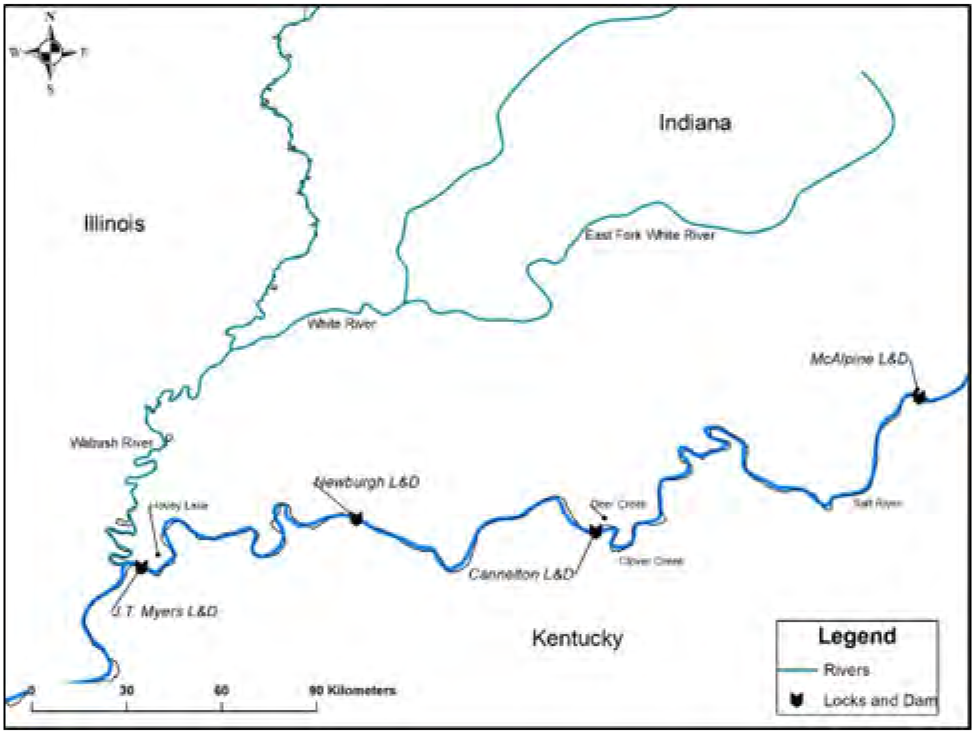
Activities and Methods: Objective 1 - Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.

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 2024. 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 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 and/or permitted 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 and will provide observers as needed 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 are being developed 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/2023 (Continue through 2024)
Create/modify regulations to promote more invasive carp harvest	Started, continue through 2024
Project Report Technical Document	Spring, March/2024
Removal and ride-alongs in the Wabash River	Start Spring, March/2024
Agency based removal efforts in White, Wabash, and Ohio Rivers	Start Spring, March/2024

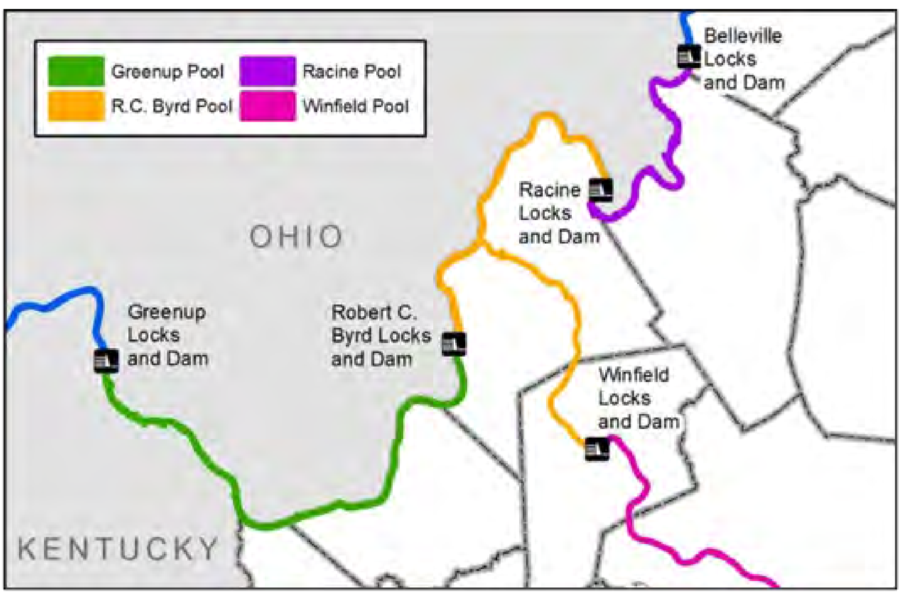
Agency: West Virginia Division of Natural Resources (WVDNR)

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.). WVDNR will purchase an additional work boat, trailer and motor as well as a vehicle for hauling. Two seasonal employees will be hired to add an additional crew for invasive carp removal in West Virginia. This crew will focus on known areas

of occurrence of invasive carps as well as identify additional locations where carp congregate to increase removal efforts. Additionally, WVDNR will build a storage garage to house boats and gear used for invasive carp research.
Removal efforts will focus on known areas of occurrence, discovered by previous years' sampling. Angler and public reports of sightings will also be taken into account to locate potential locations for removal. 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	Aug 2023-July 2024
Agency Removal in Greenup Pool	Aug 2023-July 2024
WRRDA Report to Congress	Fall, October/2023
Project Report Technical Document	Spring, March/2024

Agency: Illinois Department of Natural Resources (IDNR)

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 take place in late 2023 and early 2024 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 current program for ORB, initiated in early 2022, offers contracts to licensed commercial fishers for compensation of $0.10 per pound for invasive carp removed from designated commercial waters and sold to a fish processor(s) or other buyer(s) for at least $0.07 per pound. The program for this proposal maintains these same terms but expands the designated waters from which fishers may remove invasive carp. New water bodies include (1) the Mississippi River from Pool 26 north of St. Louis, Missouri to the confluence of the Mississippi and Ohio rivers, and (2) the Kaskaskia River from the river's headwaters west of Champaign, Illinois, to the Mississippi River. A complete listing of designated waters is depicted in maps below and includes the commercial waters of the following: (1) the portion of the Wabash River from the Ohio River to the southernmost city limits of the city of Lafayette, Indiana, (2) Skillet Fork River, (3) Little Wabash River, (4) Embarras River, except from Route 130 in Coles County upstream to the Harrison Street Bridge, (5) Lake Charleston, (6) Ohio River from McAlpine Dam to its confluence with the Mississippi River, including the tailwaters of Kentucky and Barkley Lakes, (7) Green River from the highway 259 bridge at Brownsville, Kentucky, downstream to the confluence with the Ohio River, (8) Mississippi River from Pool 26 north of St. Louis, Missouri to the confluence of the Mississippi and Ohio rivers, (9) the Kaskaskia River from the river's headwaters west of Champaign, Illinois, to the Mississippi River.

Enhanced fishing contracts will be entered into for the water bodies referenced above and made available to any licensed commercial fishers who wish to participate in the program. Contracts will have a maximum of $99,999.00 in payments to be made for invasive carp caught in the designated waters and sold to processors or other buyers for the minimum price per pound. Prior to reimbursement, fishermen will be required to present to the program a cover sheet and receipt for each catch. Cover sheets will include fisher name, address, commercial fishing license, equipment used, catch location (by pool), affidavit, signature, and date. Receipts must contain name, address, license number, catch location, and date as well as buyer name and address, invoice number, listing of each species, each species weight, and price per pound. Prior to each fishing day, fisherman will be required to notify the program of their intended fishing location and boat ramp they expect to use.

Data collected through this program will include fish weight by species, catch locations, dates, and equipment used. These data will be provided to Southern Illinois University for measurement against hydroacoustic and other fish population analyses to determine population changes and effects of removal on population characteristics.

This program facilitates practicable mechanisms for use of the harvested fish by private industry for a variety of purposes, including human consumption. Through a cooperative relationship of agency and fisher along with end users/markets, technical assistance and support will be provided, as necessary, to further inform fishers on the delivery of quality and quantity of fish to the end user/markets through this interaction. This program allows for personnel services, and contracts for fishing as well as any necessary contracts for staff monitoring personnel.

<u>Contracted Facilitation</u> The Contracted Facilitation program also was initiated in early 2022 and offers contracts to fish processors and other buyers purchasing invasive carp from commercial fishers. Purchases must be made from either a facility or pick locations within 10 miles of designated waters. Compensation is $0.05 per pound for invasive carp removed from designated commercial waters and purchased for at least $0.07 per pound. The program in this proposal maintains similar terms and makes the following changes to the designated waters. The designated waters from which fishers may remove invasive carp and where processors may pick up are expanded. New water bodies include LaGrange Pool on the Illinois River; Mississippi River from Pool 26 north of St. Louis, Missouri to the confluence of the Mississippi and Ohio rivers; and the Kaskaskia River from the river’s headwaters west of Champaign, Illinois, to the Mississippi River. One designated area is removed - the portions of Kentucky and Barkley Lakes in Kentucky.

<u>Designated Waters</u> - A complete listing of designated waters is depicted in maps below and includes the commercial waters of the following:(1) Peoria and LaGrange Pools of the Illinois River, (2) the portion of the Wabash River from the Ohio River to the southernmost city limits of the city of Lafayette, Indiana, (3) Ohio River from McAlpine Dam to its confluence with the Mississippi River, (4) the tailwaters of Kentucky and Barkley Lakes, (5) Green River from the highway 259 bridge at Brownsville, Kentucky, downstream to the confluence with the Ohio River, (7) Mississippi River from Pool 26 north of St. Louis, Missouri to the confluence of the Mississippi and Ohio rivers, (8) the Kaskaskia River from the river’s headwaters west of Champaign, Illinois to the Mississippi River.

<u>Additional Fishing Area</u> - Invasive carp caught in the following waters may also be picked up at one of the above designated water pick up locations: (1) Little Wabash River; (2) Skillet Fork River; (3) Embarras River, except from Route 130 in Coles County upstream to the Harrison Street Bridge; and (4) Lake Charleston.

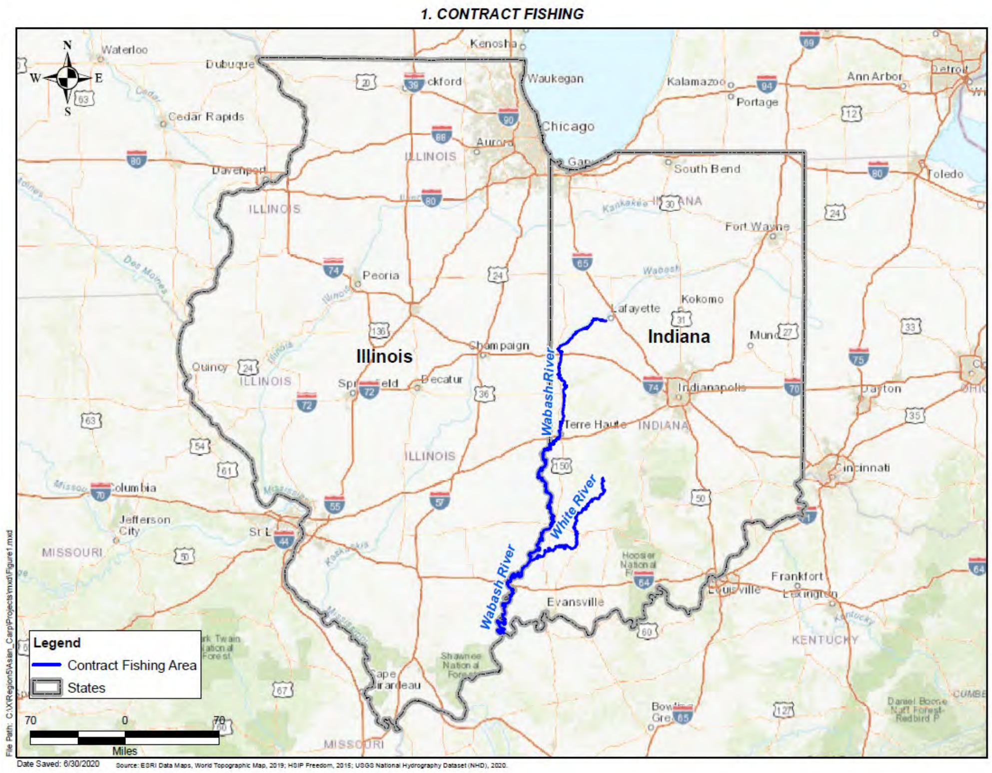
A similar contract to the Enhanced Contract Fishing Program is made available to any licensed buyer, if applicable, authorized to operate in Illinois, Indiana, Missouri, and Kentucky. These buyers must also have a facility and/or buy invasive carp within 10 miles of one or more of the regional river system areas noted in the Designated Waters list section above. Invasive carp must be caught in one or more of the areas noted in the Designated Waters and Additional Fishing Area lists above. Contracts will provide payment of $0.05 per pound up to $99,999.00 for invasive carp offloaded from commercial fishers at processors' facilities that are located within 10 miles of water edge of any of the designated waters listed above, or that are providing pick up waterside and/or at buying station(s) within 10 miles of the designated waters above. Invasive carp must be caught in one or more of the Designated Waters and/or Additional Fishing Area listed above and sold for at least $.07 per pound.

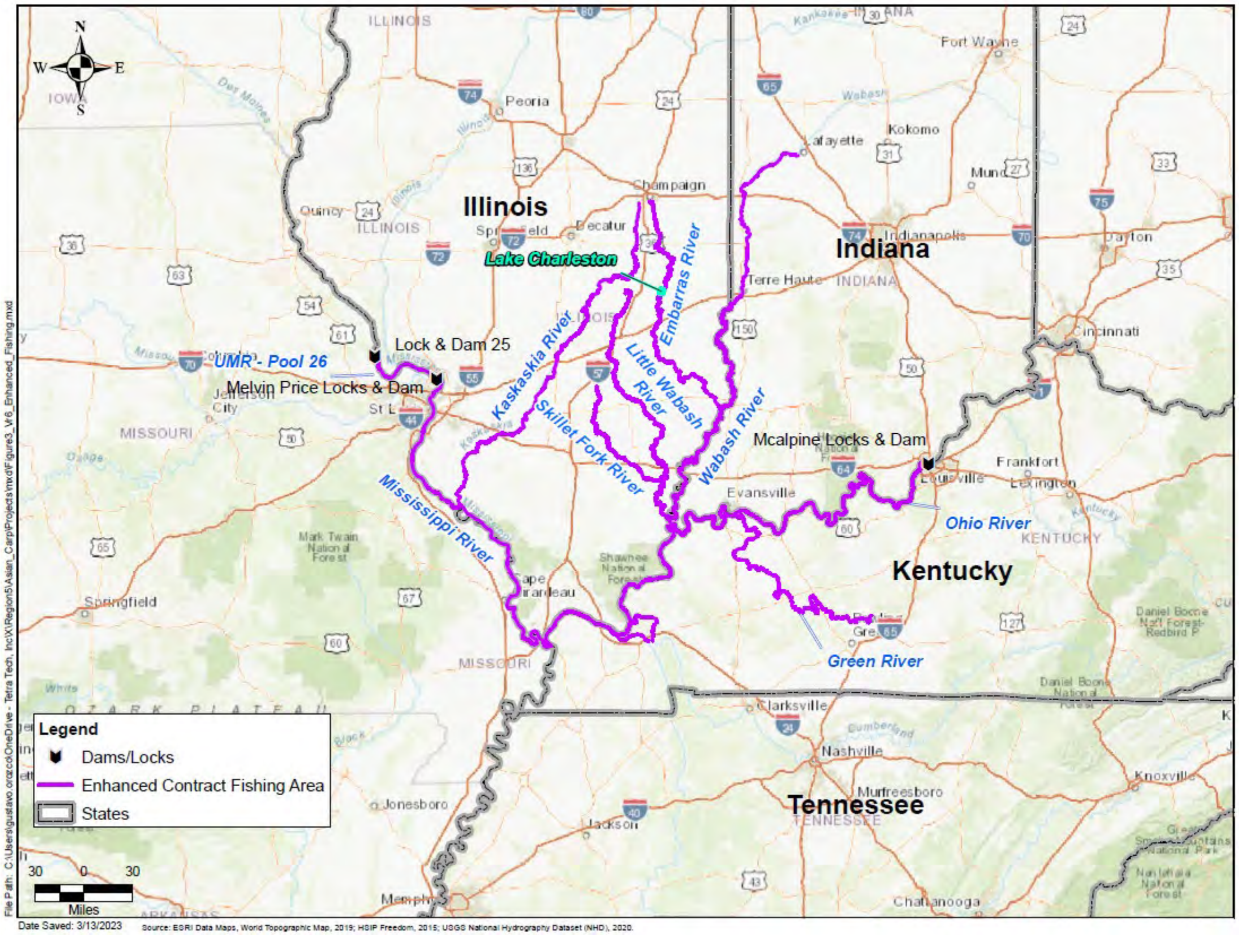
Facilities, buying stations, and other pick-up locations are required to be pre-approved by the program prior to use. Locations may be established at public boat launches, up to 10 miles from the shoreline. Considerations for pickup locations may be further defined and coordinated with state and local managers and customized based on need, site location, and other relevant factors. Buyers will be required to present copies of receipts for invasive carp purchased at designated locations. These receipts must contain the same information as for the Enhanced Contract Fishing Program and will be required to be accompanied by a similar cover sheet. Prior to pick up, the buyer will be required to notify the program of the intended pick-up location and (if applicable) license plate of the truck to be used.

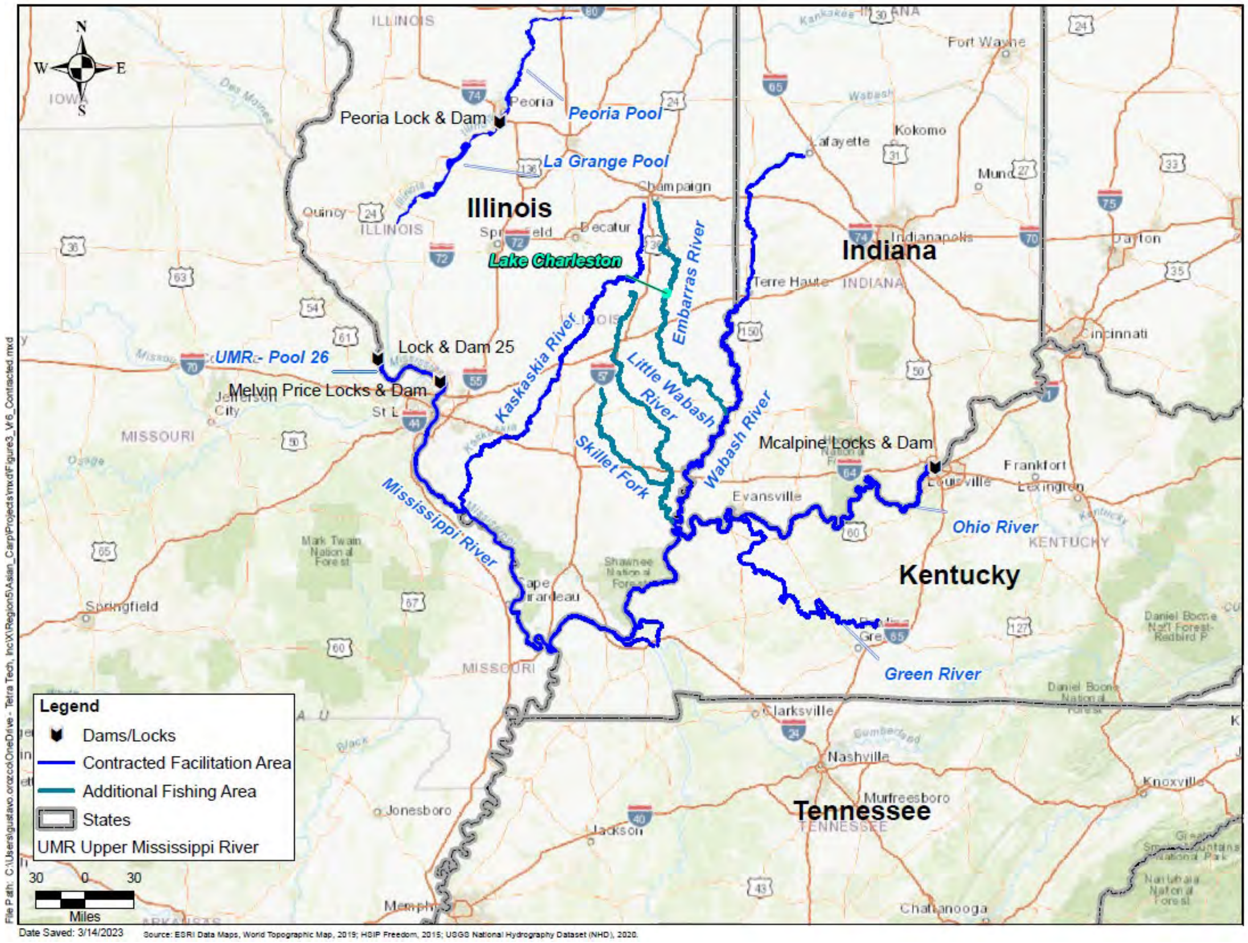
Facilitation efforts under this program are complementary and additive (but not redundant) to contract fishing efforts identified in the ICRCC Action Plan as well as ongoing state invasive carp removal programs, including the Tennessee Wildlife Resources Agency (TWRA) Invasive Carp Harvest Incentive Program and the Kentucky Department of Fish and Wildlife Resources (KDFWR) Invasive Carp Harvest Program.

This program will support efforts to evaluate contracted facilitation as a method of increasing invasive carp harvest to increase ability to manage/reduce the invasive species while informing future investments in these basins and others. 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.

Maps of Project Areas:




Illinois
Indiana
Kentucky
Tennessee
Lake Charleston
Lock & Dam 25
UMR - Pool 26
Melvin Price Locks & Dam
Mcalpine Locks & Dam
Kaskaskia River
Embarras River
Little Wabash River
Skillet Fork River
Wabash River
Mississippi River
Ohio River
Green River
Legend
Dams/Locks
Enhanced Contract Fishing Area
States
Miles
Date Saved: 3/13/2023
Source: ESRI Data Maps, World Topographic Map, 2019; HSIP Freedom, 2015; USGS National Hydrography Dataset (NHD), 2020.



Estimated Timetable for Activities

Activity	Time Period (Season, month/year) *
Contract Removal	Start October 2023 (Continue through March 2024)
Enhanced Contract Removal	2023 through 2024
Contracted Facilitation	2023 through 2024

* Timelines subject to funding availability and participation in contracts.

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

Lead Agency and Author: West Virginia Division of Natural Resources, Katherine Zipfel (katherine.j.zipfel@wv.gov)

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

As control strategies are implemented to manage invasive carp within the Ohio River basin, managers must establish benchmarks and track the progress of population control efforts. This project is intended to evaluate management efforts and guide future actions. The tasks outlined in this document would add a seventh 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, incorporation of unique data such as hydroacoustics and incorporation of unique data analysis of sampling results such as community size spectra. 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:

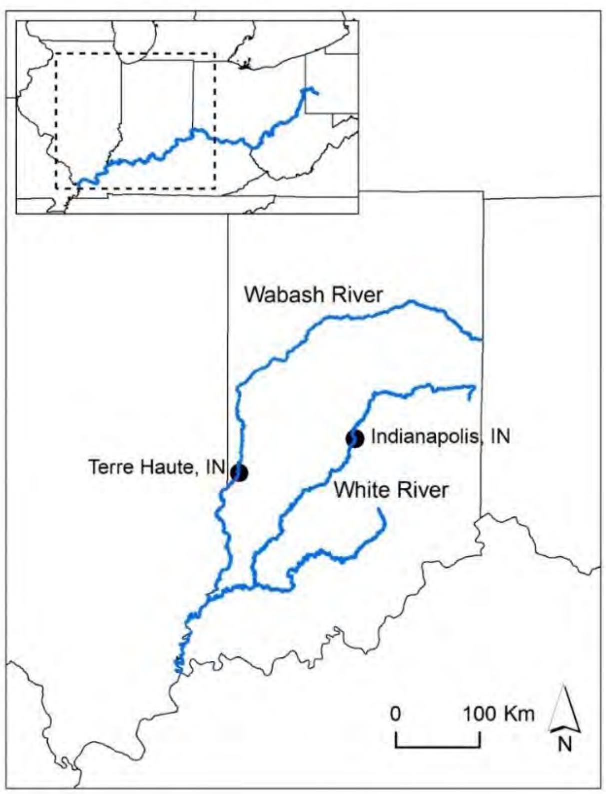
1. Evaluate management actions using changes in relative abundance, population characteristics, and distribution of carps within intensive management zones.
2. Monitor long-term trends in native fish communities as indicators of change due to invasive carp presence.
3. Survey invasive carp presence in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

The following documents outline the plans by agency for this project:

Agency: Illinois Department of Natural Resources, 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 summer of 2024. 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 sampling of the fish community will also occur at this time. Species-specific proportional abundances will be calculated by size class from this capture data, which 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:



Time Table of Activities:

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

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.

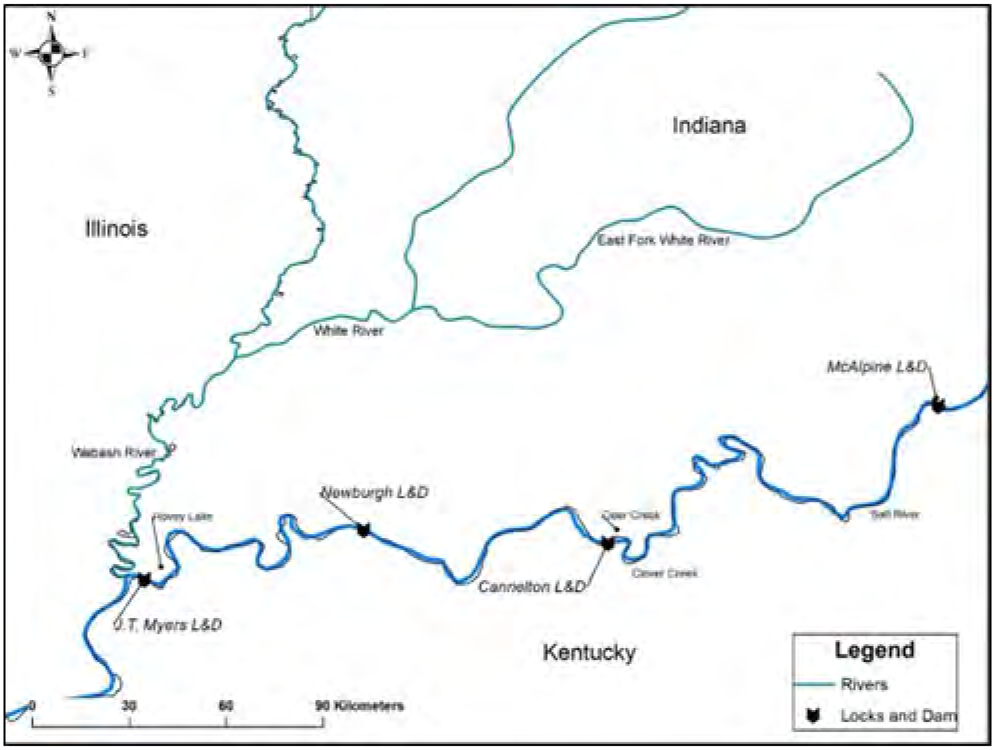
INDNR will utilize pulsed-DC boat electrofishing to target bigheaded carps within Cannelton Pool of the Ohio River. Effort will include sampling at least 24 sites on two separate occasions totaling approximately eight crew-days of effort. Electrofishing will be conducted during the day (0800 to 2100 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 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. All fish captured using either gear will be identified to the lowest possible taxonomic level and total length (mm) and weight (kg) will be recorded for all species. Invasive carp will be euthanized.

Objective 5 - Utilize hydroacoustics surveys to determine 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 to determine carp density estimates using hydroacoustic analyses.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Targeted Sampling Field Work	Spring, April/2024
Wabash River Fish Community Work	Spring, April and May/2024
Occupancy Modeling Sampling	Summer, June/2024
Population Demographic Sampling	Summer, Aug and Sept/2024
Hydroacoustics Community Surveys	Fall, October/2024
Process and Age Otoliths	Fall, Nov and Dec/2024
Executive Technical Report	Spring, March/2025

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

Activities and Methods: Federal funding for this project for FY23 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 FY23, KDFWR will continue to place additional effort into designing and implementing a protocol to determine occupancy of invasive carps within the intensive management zone of the Ohio River. Efforts will also be put towards 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. 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), with a minimum goal of 3,000 Watts transferred from water to fish. 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 continue implementing occupancy modeling programs within the intensive management zone of the Ohio River (120 sampling events), as well as occupancy sampling events within inland waters that have limited data on the extent of invasive carp invasion progression. Tributaries of interest include the Salt, Licking, Kentucky, Green, Tradewater, and Clark's rivers. 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. 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.

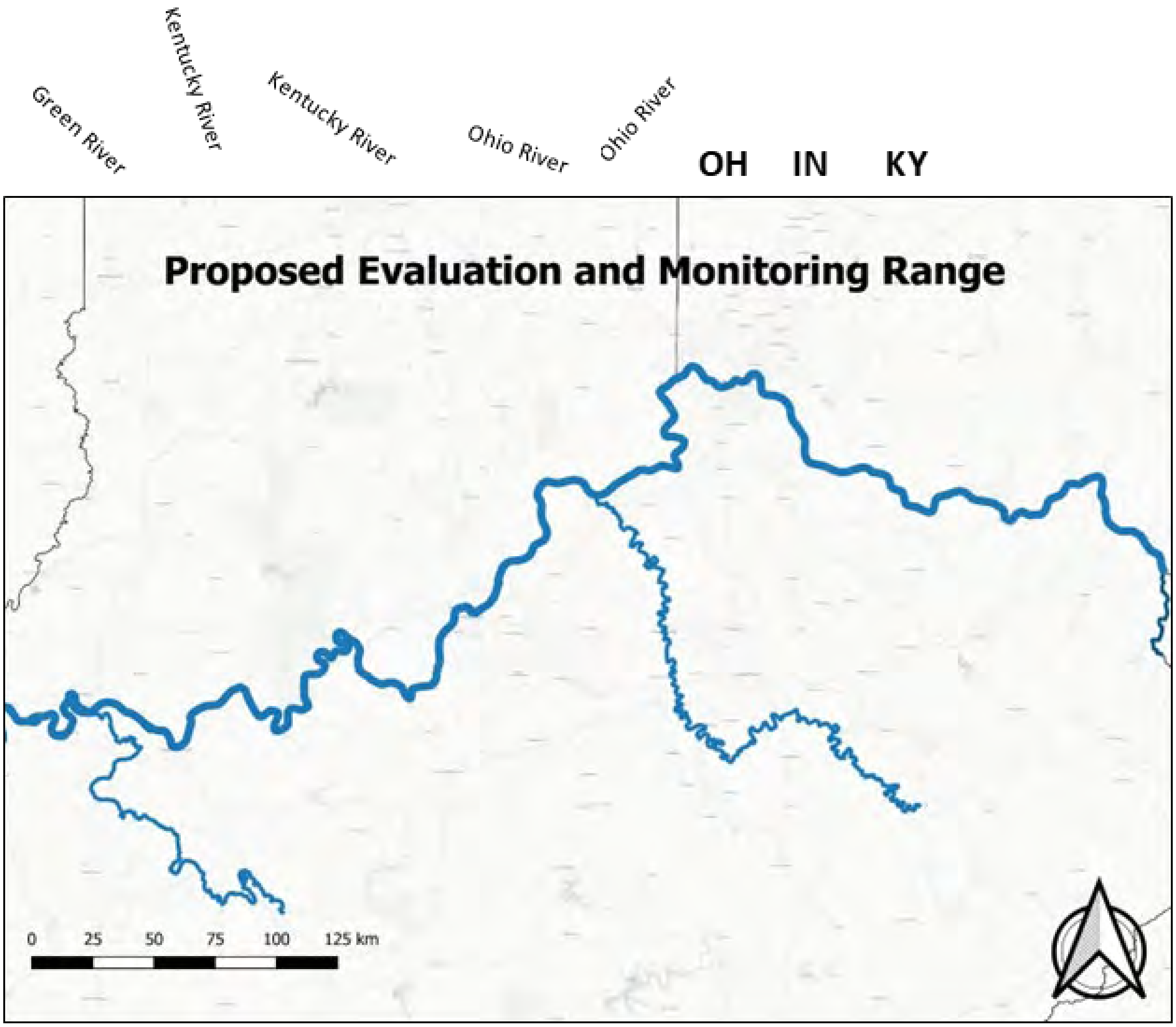
Data collected outside of this project during activities focused around invasive carp in the ORB will also be compiled and used to inform field sampling and analyses on bigheaded carp distributions. ORSANCO's annual sampling data and the USGS Nonindigenous Aquatic

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 hydroacoustic surveys to determine biomass densities and verify patterns of relative abundance for invasive carp species within strategic management zones.

The KDFWR will also provide efforts towards fish community sampling on the Ohio River. The data from this analysis will be used by USFWS for analysis of hydroacoustic data. Boat electrofishing will be utilized to aid in determining community composition. 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 to May/2024
Occupancy Modeling on Ohio River	Summer, June/2024
Population Demographics Sampling	Summer, August to September/2024
Hydroacoustic Survey Sampling	Fall, September to October/2024
Inland River Surveys	Fall, September to October/2024
WRRDA Report to Congress	Fall, October/2024
Process and Age Otoliths	Winter, January to March/2025
Annual Technical Report	Spring, March/2025

Agency: Pennsylvania Fish and Boat Commission (PFBC)

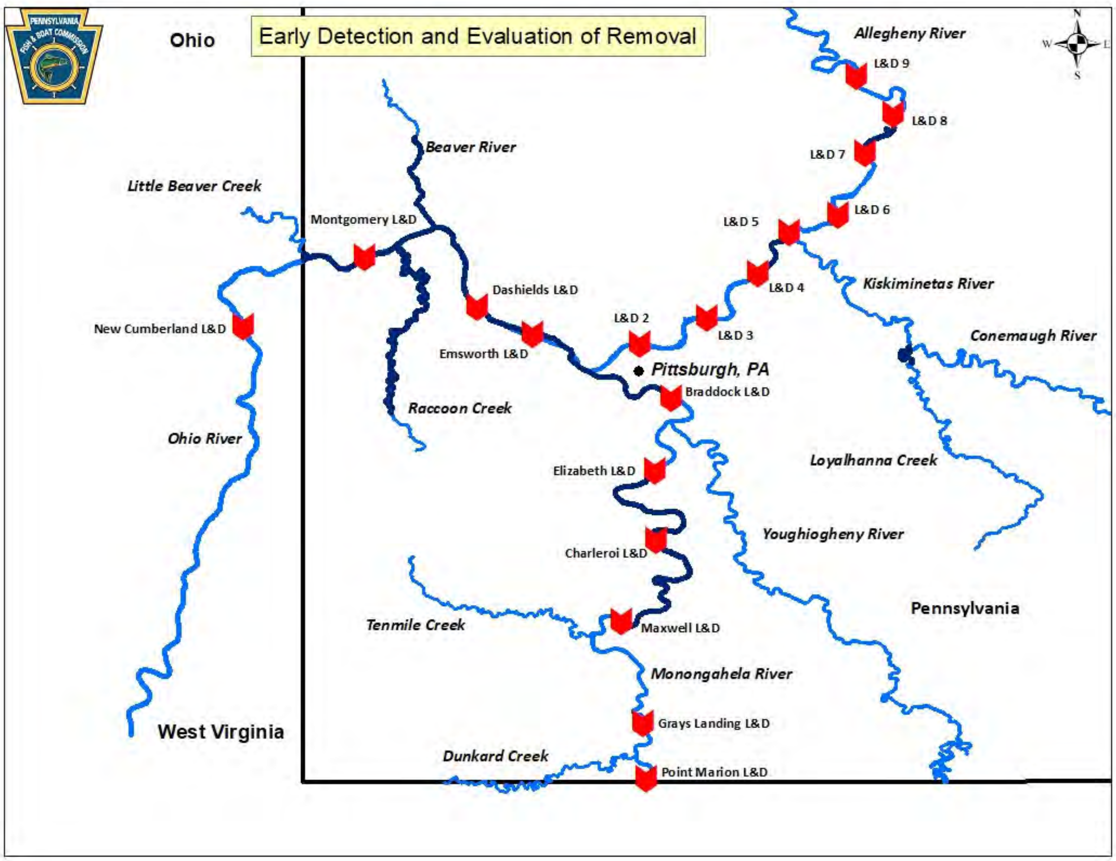
Activities and Methods: The PFBC may assist the USFWS in conducting eDNA sampling on the Ohio River in the fall of 2023 and 2024. Locations of positive eDNA hits for Bighead and Silver Carp, including locations with positives from previous years, will be used to guide targeted gill net sampling. Additional 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 2023 and 2024. 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.

The PFBC will also conduct targeted sampling for Grass Carp in August/September 2024 in Loyalhanna Creek below the outflow of Loyalhanna Dam. Gear types used for this survey will include backpack and tow barge electrofishing. The PFBC has documented diploid Grass Carp in Loyalhanna Lake in previous surveys and recent angler reports indicate there may be Grass Carp present in the outflow of Loyalhanna Dam. All fish species captured in this sampling event will be enumerated and any Invasive Carp species will be euthanized.

The PFBC will conduct fish community surveys in August 2024 and September/October 2024. Monitoring in August in the Montgomery Pool will be conducted using seines (20 m length, 6 mm mesh) at six historic sites. 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 (New Cumberland and Dashields) of the Ohio River. Gear types used in this fall community sampling event will include both gill nets (76, 102, and 127 mm mesh) and boat electrofishing. 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. A subset of fish over 125 mm (10 per 25 mm size class) for each species will also be weighed for use in WVU’s Community Size Spectrum (CSS) analysis.

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.

Map of Project Area:



Dark blue areas represent pools to be surveyed in FY23.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Targeted Sampling Field Work	Fall, November/2023
Targeted Sampling Field Work (Grass Carp)	Summer, August-September/2024
Community Surveys Field Work	Summer, August/2024
Community Surveys Field Work	Fall, September-October/2024
Assist eDNA sampling	Fall, September-October/2024
Targeted Sampling Field Work	Fall, November/2024
Laboratory Fish Identification	Fall/Winter, November-March/2025
Executive Technical Report	Spring, March/2025

Agency: U.S. Fish and Wildlife Service – Lower Great Lakes and Carterville FWCOs

Activities and Methods: The Carterville FWCO will implement the Region 3 hydroacoustic standard operating procedure (SOP) in conjunction with community sampling to estimate pool-wide densities (# • $1000m^{-3}$) of Silver Carp in two Ohio River pools during fall (September and October) 2023. During fall 2023 Newburgh and Cannelton pools will be sampled using 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. This approach is designed to collect a representative sample of the pelagic fish community inhabiting each pool. The number of 1-mile transects in Cannelton and Newburgh pools will be approximately 35% of the available main channel sites (# sites = 2 • length of pool; one site on each bank). Within each pool, up to five tributaries will also be sampled using hydroacoustics and physical capture gears to estimate Silver Carp densities in these areas. The sampling design implemented for hydroacoustic data collection will differ between main channel and tributary habitats. Main channel sampling will include both shore- and- thalweg-facing transects whereas tributary sampling will include only shore facing transects. 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 13.0 following the Region 3 hydroacoustic SOP. Silver Carp densities will be reported within each habitat type and pool (e.g., Cannelton main channel, Cannelton tributary), within each pool.

Community sampling (i.e., boat electrofishing and dozer trawling) will be conducted by state agencies (KDFWR, INDNR) and the CAR FWCO, respectively. Boat electrofishing will follow standard protocols. Briefly, pulsed DC electrofishing (40% duty-cycle and 80 pulses per second) will consist of 15 minute transects in a general downstream direction with one dip netter. 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, 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 excellent gear for informing the apportionment of hydroacoustic targets and, therefore, understanding the density and distribution of Silver Carp in the Ohio River basin.

The Lower Great Lakes and Carterville Fish and Wildlife Conservation Offices (FWCOs) will conduct environmental DNA (eDNA) sampling in six tributaries of the upper Ohio River (Raccoon Creek, Little Beaver Creek, Muskingum River, Sandy Creek, Mills Creek, and Tombleson Run). Because eDNA sampling allows managers and researchers to detect the presence of a species without physical captures, 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), Sandy Creek, Mills Creek, and Tombleson Run (Racine Pool) during spring 2023. The Carterville FWCO will also collect 352 water samples from the Muskingum River (Belleville Pool) during fall 2023. 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:

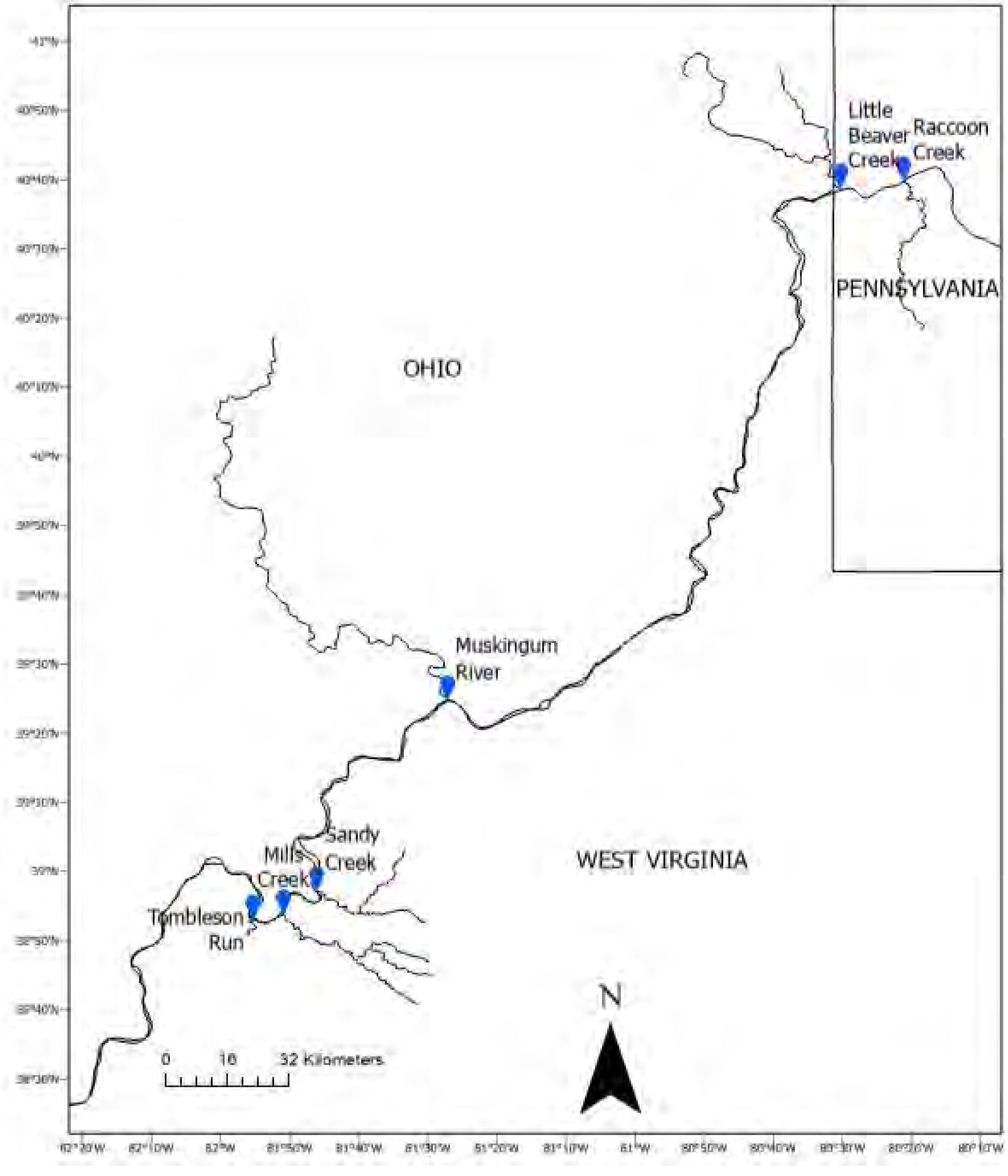


Figure 1: Blue dots show location of tributaries to be sampled for invasive carp eDNA.

Estimated Timetable for activities:

Activity	Time Period (Season, month/year)
Hydroacoustics Surveys	September/October 2023
Hydroacoustic Data Processing and Analysis	Winter 2023
Hydroacoustic results and Reporting	Spring 2024

Agency: West Virginia Division of Natural Resources (WVDNR)

Federal funding for this project for FY2023 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. 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 of Invasive Carp. Also, the continued learning process of adapting sampling techniques to catch invasive carps in low density areas will improve efficiency for the future.

Activities and Methods: Objective 2 - Monitor long-term trends in native fish communities as indicators of change due to invasive carp presence.
To track long-term trends in native fish communities, WVDNR will conduct community surveys in the Greenup, R.C. Byrd and Racine pools 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) with be taken to evaluate condition on select species. 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.

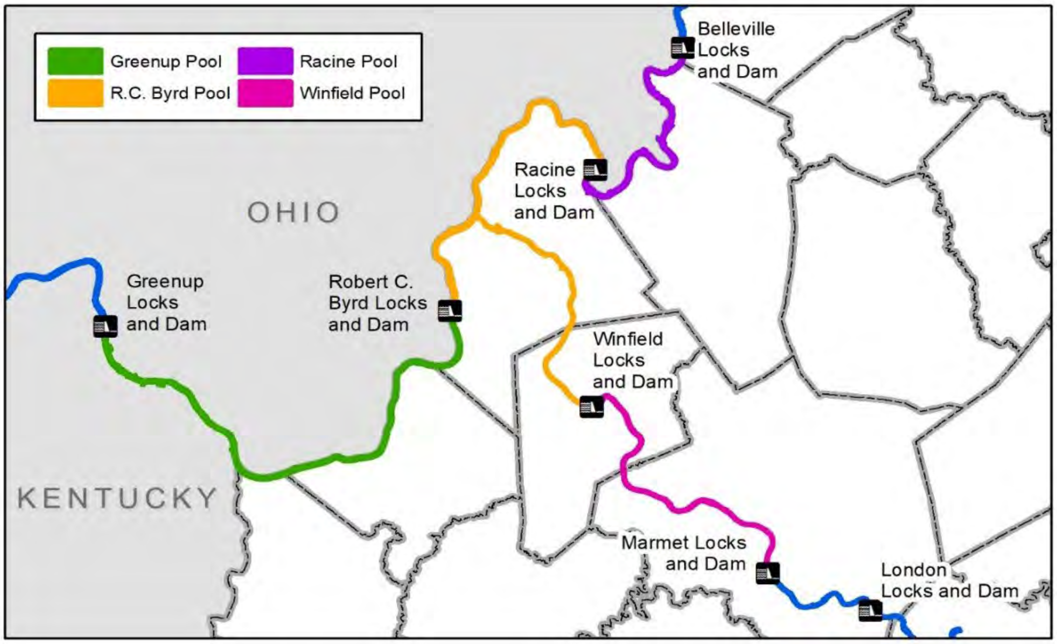
WVDNR will track relative abundance and population characteristics of invasive carp independently and in coordination with other state agencies by conducting targeted sampling for invasive carp along several pools, upriver of the Cannelton Locks and Dam complex. WVDNR, specifically, will conduct targeted 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 main stem river 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' projects. Electrofishing surveys will consist of timed 15-minute shoreline transects in a downstream direction during the daytime at fixed sites throughout each pool. 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 age and growth analysis.

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 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 elevated. 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 for age and growth analysis. All by-catch will be recorded and any non-target fish will be released immediately after capture.

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 and Kanawha rivers. 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.

As conditions and staff allow, WVDNR staff will assist project partners with collection and aging of a subset of invasive carp otoliths collected from pools of interest. Otoliths will be processed and aged based on established protocols and data will be shared with project partners.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Community Fish Surveys in Racine Pool	Fall, October 2023
WRRDA Report to Congress	Fall, October/2023
Annual Technical Report	Spring, March/2024
Targeted Invasive Carp Sampling	Spring, April 2024
eDNA Sampling	Spring, May/June 2024

Agency: West Virginia University

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 FY2023 will enable WVU to work with state partners (KDFWR, WVDNR, PFBC, and USFWS) to collate existing boat electroshocking fish community data for community size spectra (CSS) analyses. CSS will be used to compare community size structure (1) pre- and post-invasion in impacted pools to unimpacted (invaded vs not-invaded pools) and (2) along the invasion gradient. The original analyses (being completed now, Novak master thesis) included Cannelton, McAlpine, Markland, Meldahl, Greenup, and R.C. Byrd pools 2015 and 2020. This year we will expand this work in collaboration with USFWS and PFBC to include the upstream uninvaded areas to develop an assessment of existing baseline conditions (e.g. mean CSS parameter values and degree of natural inter-annual and inter-pool variation). 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. Analyses will address three management themes demonstrating the utility of the CSS slope as (1) a food web-based indicator of invasive carp impacts, i.e. a trigger indicating a threshold has been passed in new invasion areas, (2) as a restoration target (pre-carp condition) for heavily impacted areas to produce ecological impacts, and (3) the potential to develop removal targets, e.g. pounds of carp, to reduce ecological impacts and reach restoration goals.

WVU will use these analyses of 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. We will continue conversations with the hydroacoustic team and as possible collaborate on a pilot application of CSS using the hydroacoustic data. Product goals for FY23 will be to publish 1-2 peer-reviewed papers and at least 1 AFS presentation demonstrating the application of CSS to Ohio River carp management, this may include a long-term assessment of the Illinois River as a test case in a more heavily impacted area.

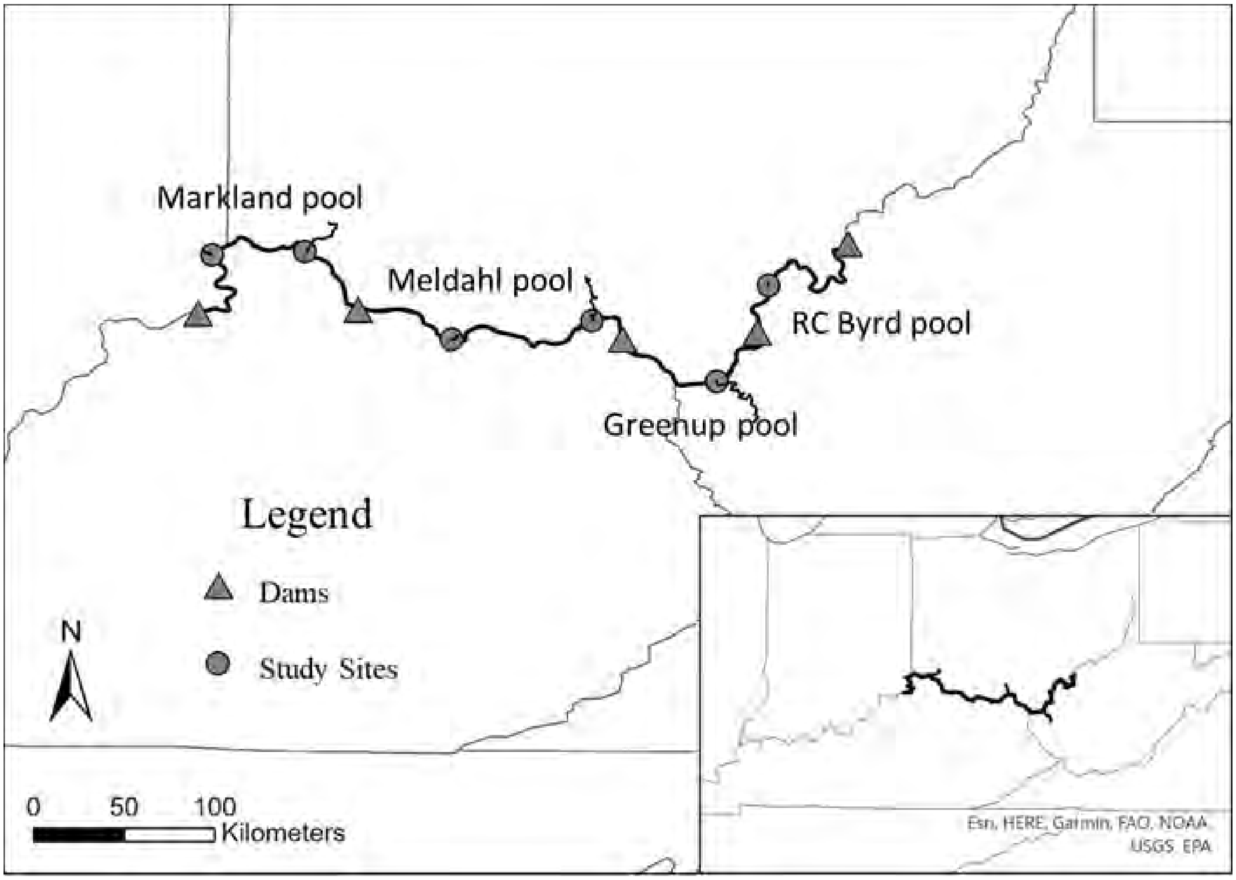
Objective 3 - Survey invasive carp presence in upstream areas where they are rarely detected to inform response and containment efforts.

WVU will hire a post-doctoral fellow to evaluate sampling and modeling strategies for early detection of invasive carp along the invasion front. The post-doctoral fellow will collate data from partners sampling invasive carp along the Ohio River. These data will be collected along a gradient of pools with established populations to pools where invasive carp have yet to be detected. We will attempt to collect all data relating to invasive carp sampling, including observations/collections of early life history (eggs and larvae), juvenile, and adult invasive carp as well as available eDNA data.

Once data are collected, the post-doctoral fellow will use occupancy models to evaluate the probability of invasive carp presence and detection probability within pools. The post-doctoral fellow will explore two primary methods of assessing invasive carp occupancy: multi-scale occupancy models and occupancy models with abundance-induced heterogeneity in detection probability. Multi-scale occupancy models permit estimation of occupancy at both the pool-level and the sampling-level within the pool, and are well suited to the structure of the Ohio River. Occupancy models with abundance-induced heterogeneity in detection probability would allow detection probability to decrease as abundance of invasive carp decreased and is also well-suited to track a potential invasion gradient. While fitting models, the post-doctoral fellow will work with partners to identify environmental variables that may influence both occupancy and detection probabilities.

Once the post-doctoral fellow has fit occupancy models to data collated from partners, they will work to identify optimal sampling strategies along the invasion front. Recommendations will include suggesting where to sample, how often to sample, and the amount of sampling effort required to detect carp that are present with a pre-determined confidence level. The post-doctoral fellow will present to collaborators software tools for identifying optimal sampling strategies that consider both time and budgetary constraints.

Map of Project Area:



Timetable of Activities:

Activity	Time Period (Season, month/year)
Data analyses	Summer, May/2023 – Spring, April 2024
Collating data	Fall, August 2023
Fitting occupancy models	Winter, November 2023
Developing optimal sampling strategies	Winter, February 2024
Final technical report	Spring, April 2024

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

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Cooperating 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 Lawrenceburg, IN, near Cincinatti, OH. 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 Olmsted 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 density and for an adaptive management framework to be developed and implemented in response to changes in invasive carp populations.

The approach outlined here will support the National Goals and Strategies while meeting the management plans and strategies outlined for the Ohio River basin. 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 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: Between October 2023 and September 2024, the Kentucky Department of Fish & Wildlife Resources (KDFWR) will continue working with other agencies to maintain a 675+ mile stationary receiver array that is a critical component of the project's first three objectives. During this study period, most of KDFWR's efforts will focus on a specific area of the stationary receiver array that begins in the middle Markland Pool and continues downstream to where the Salt River empties into the Cannelton Pool (Figure 1). This 140-mile section of the array contains 25+ receiver stations that are distributed among three primary site types, which include the main channel of the Ohio River, lock and dam projects and lower end of tributaries near their confluence with the Ohio River (Table 1). KDFWR will also start making regular visits to a second group of newly established receiver stations (n = 12) located within upstream sections of the Kentucky and Salt rivers that are not under the direct influence of the mainstem Ohio River. Beginning in October 2023, agency staff will visit each site in both groups at least

once every two months to offload new telemetry data and complete all other maintenance tasks as needed (e.g., replace batteries and/or cables, update firmware). A special effort will be made to visit all sites in December 2023 to conduct year-end offloads, reset receivers for the upcoming year and complete other activities (i.e., retrieve receivers from mainstem sites) that are required for specific habitat types. Upon the return of favorable river conditions in early spring 2024, agency crews will visit each receiver station again to offload any new tag detections and conduct other site-specific activities. After the initial spring efforts are completed, KDFWR will return to visiting each site at least once every two months through the end of September 2024.
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 Objective 1, KDFWR staff will visit each tributary site in their section of the array according to the aforementioned schedule beginning in fall 2023 and continuing through the end of September 2024. A lower risk of seasonal losses allows the receivers to remain at these sites for the entire year, but this also requires that agency staff complete additional maintenance at each location. During their December 2023 site visits, KDFWR staff will offload all tag detections, replace the batteries, and then reset each receiver for the next project year. And finally, if any upper tributary sites still have working temp loggers from 2017, crews will offload the new water temperature data and replace the battery.
Over the past several years, KDFWR occasionally conducted active tracking of tagged carp within the upper reaches of the Kentucky River and other nearby tributaries. These efforts were primarily focused on identifying possible emigration of tagged fish from the mainstem Ohio River, and they were specifically designed to complement the data recorded by receivers located near the mouth of each tributary. However, KDFWR does not plan to continue these active tracking efforts during fall 2023 or spring 2024. This decision was partly due to persistent shortage in available field staff, but also because of KDFWR’s ongoing efforts to establish year-round receiver sites in the upper Kentucky and Salt rivers, which would mean that future tracking efforts in either of these tributaries would eventually become unnecessary.

By October 2023, KDFWR expects to have completed their ongoing efforts to establish at least six new stationary receiver sites within the upper reaches of both the Kentucky (RM 545) and the Salt (RM 630) rivers. According to telemetry data obtained during last several years, above-average densities of tagged carp regularly occupy both of these tributaries and they have demonstrated a real potential to serve as a route that invasive carp could use to emigrate from the Ohio River. However, despite any real potential, there has been very little information regarding the movements of tagged carp in these tributaries, especially when they have traveled a mile or so beyond the mainstem river. Although each waterbody will contain some tagged carp prior to fall 2023, recent efforts have demonstrated that both tributaries are likely to contain far fewer invasive carp than originally anticipated. Hence, if needed, KDFWR will continue their efforts to implant transmitters into at least 20 invasive carp from the upper areas of both tributaries. If this target cannot be reached even after ramping up tagging efforts through the end of 2023, agency staff will discuss other options for bolstering the number of tagged carp in these waterbodies.

Objective 2 - Delineate the upstream population distribution of invasive carps. As was the case in previous years, KDFWR’s telemetry efforts in 2023 – 2024 will take place primarily within the lower half of the project’s receiver array. This will effectively limit the amount of effort that can be committed towards the project’s 2nd objective. Despite these limitations, agency staff will continue to maintain a small group (n = 5) of stationary receivers located upstream of Markland

Lock & Dam, which represents the most downstream border of the low-density carp population that occupies the upper Ohio River. As previously mentioned, between October 2023 and September 2024, crews will visit these receiver stations at least once every two months to offload new detections and conduct site maintenance as needed. Other than the regular visit to these locations, KDFWR will also be responsible for managing/analyzing any new telemetry data that project partners offload from stationary receivers deployed throughout the upper Ohio River.

Objective 3 - Quantify passage of invasive carps through Ohio River locks and dams. The only remaining receivers within KDFWR's section of the array are those deployed to sites in in the mainstem Ohio River and two separate Lock & Dam (L&D) projects. In fall 2023, site visits and receiver offloads will be completed as part of the ongoing efforts related to the project's 3rd objective. Field staff will return to Markland and McAlpine L&D sites in December 2023 to offload new tag detections and finish year-end maintenance tasks that are similar to those conducted at receiver sites located in nearby tributaries. Mainstem sites will also be visited again prior to the end of 2023, but unlike others, the purpose of these efforts is to retrieve any VR2W's that need to be stored off-river for the rest of the winter season. When favorable river conditions return in early spring 2024, these receivers will be redeployed to their mainstem sites. From the initial spring visits through end of September 2024, KDFWR field staff will return to each L&D and mainstem receiver site at least once every two months to offload any new detection data and complete other maintenance tasks as needed.

KDFWR also intends to conduct occasional active tracking in very specific areas of the Ohio River. Agency staff will continue to their previous tracking efforts in a section of the mainstem river that is located directly upstream of Markland L&D. This stretch of the telemetry array has proven to be difficult when trying to maintain adequate receiver coverage, but it has become an increasingly important area when trying to determine if/when tagged carp are successfully transferring between pools. Hence, active tracking within this specific area is expected to resume in fall 2023 and again in spring/summer of 2024 if needed. These efforts will help with the ongoing search for evidence of whether tagged carp are transferring pools without be detected by the stationary receivers located within the lock chambers. Previous data suggests that Markland L&D is a formidable barrier to the upstream movements of invasive carp, and the goal of the ongoing active tracking efforts is to determine whether or not these conclusions are representative of what's actually happening in the river.

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 consisting of various environmental parameters that were recorded at sites within the project's telemetry array. The environmental database is an important component to ongoing efforts to identify any environmental factors that may be influencing the behavior of invasive carp populations within the Ohio River Basin.

TABLE 1. Receiver counts (by site type) for KDFWR's section of the 2023 telemetry array.

Pool	River mile		Receivers		
	US	DS	Mainstem	Tributary	L&D
Cannelton (upper)	605.0	630.0	2	8	-
McAlpine	531.7	605.0	3	13	2
Markland (lower)	491.0	531.7	-	5	3

Map of Project Area:

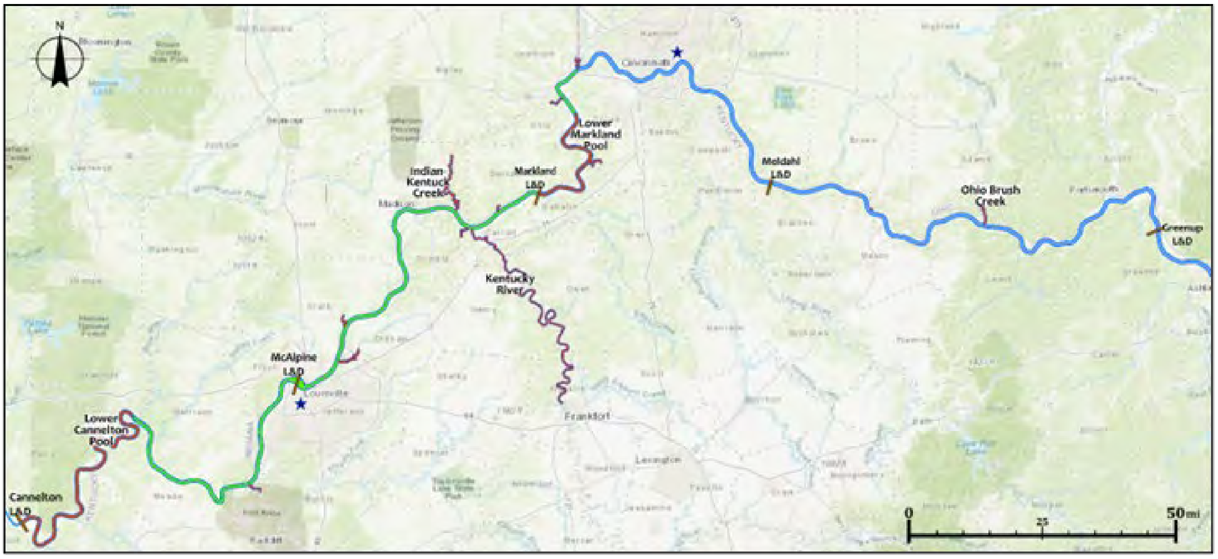


FIGURE 1. During this study period, KDFWR will maintain all receivers in a 140-mile section of the telemetry array that starts in the middle Markland Pool and continues downstream to where the Salt River empties into the upper Cannelton Pool (Green). KDFWR staff will also maintain new receiver sites in the upper reaches of the Salt and Kentucky rivers (Dark Blue). And finally, active tracking will occasionally be conducted in mainstem areas around lock and dam sites to determine if tagged carp are transferring pools without being detected (Red).

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 2023
Conduct active tracking in the mainstem river near Markland L&D.	Fall, Oct-Nov 2023
Resume tagging efforts as needed in upstream sections of the Kentucky & Salt rivers	Fall, Oct-Nov 2023

Complete year-end offloads and reset tributary receivers; Retrieve any mainstem VR2's for overwinter storage.	Winter, Dec 2023
If needed, resume tagging efforts in the upper Kentucky & Salt rivers; Assist USFWS with mainstem tagging efforts.	Spring, Mar-Jun 2024
Redeploy VR2's to mainstem sites in the Cannelton & McAlpine Pools; Resume monthly offloads of all receivers.	Spring-Summer, Apr-Sep 2024

Agency: Indiana Department of Natural Resources (INDNR)

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) from RM 848 (Wabash River confluence) to RM 709 (lower Cannelton Pool). 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 2024 will focus primarily on maintaining the expanded array in the lower pools and offloading tributary receivers every other month. 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. In addition, INDNR will coordinate with project partners to deploy additional receivers in mainstem areas as needed to provide comprehensive coverage throughout the pools, including providing additional coverage in Cannelton Pool to evaluate contract fishing pressure impacts to invasive carp movements.

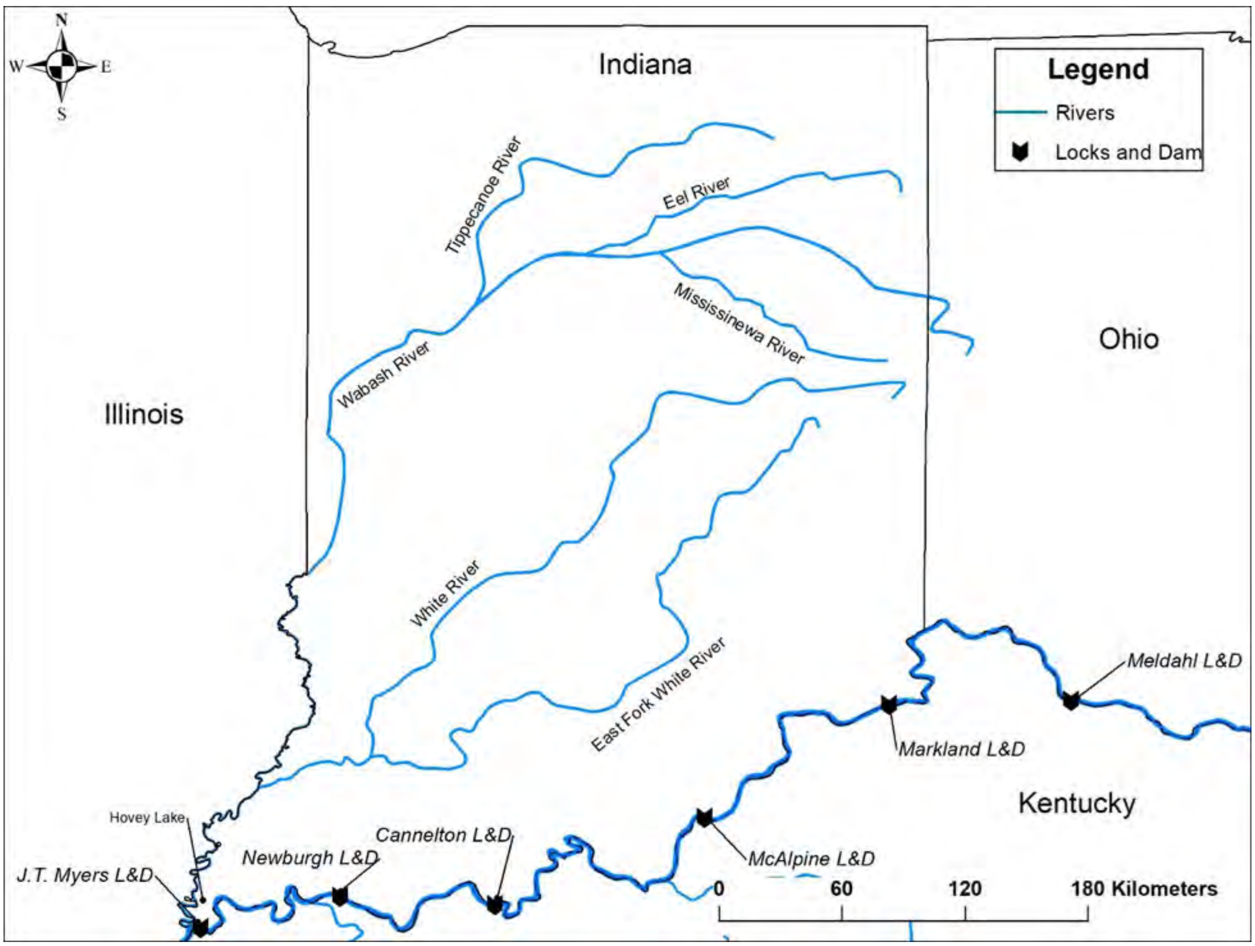
Objective 3 - Quantify passage of invasive carps through Ohio River locks and dams
To quantify passage of invasive carp through Ohio River locks and dams, INDNR will maintain and offload four receivers at each J.T. Myers, Newburgh, and Cannelton pools. The J.T. Myers and Newburgh locks and dams differ 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 offload lock and dam receivers quarterly and send data to KDFWR for compilation with existing data. INDNR will also assist project partners with tagging events as necessary to maintain an appropriate number of tagged fish per pool.

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.

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.
Objective 5 - Inform invasive carp removal efforts by quantifying fine-scale habitat use and how this changes through time in the Wabash and White rivers
INDNR will coordinate with SIU and EIU on Wabash and White rivers tracking efforts and will provide assistance as needed under the guidance of the universities. INDNR will use the fine-scale habitat data collected by SIU and EIU to inform removal efforts by invasive carp harvest permit holders, once a permit is in place to allow the use of gill nets and seines to selectively target and remove invasive carp.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time period (season, month/year)
Ecosystems Connections Institute download receiver data monthly	Start December 2023 (continue through 2024)
Maintain and download receivers	Monthly, Jan-Dec/2024
Assist SIU with receiver offloads	Summer, June-Aug/2024
Assist SIU with active tracking in Wabash, and White rivers	Summer, June-Aug/2024
Pull receivers from all mainstem sites for overwinter storage	Winter, December/2024

Agency: West Virginia Division of Natural Resources (WVDNR)

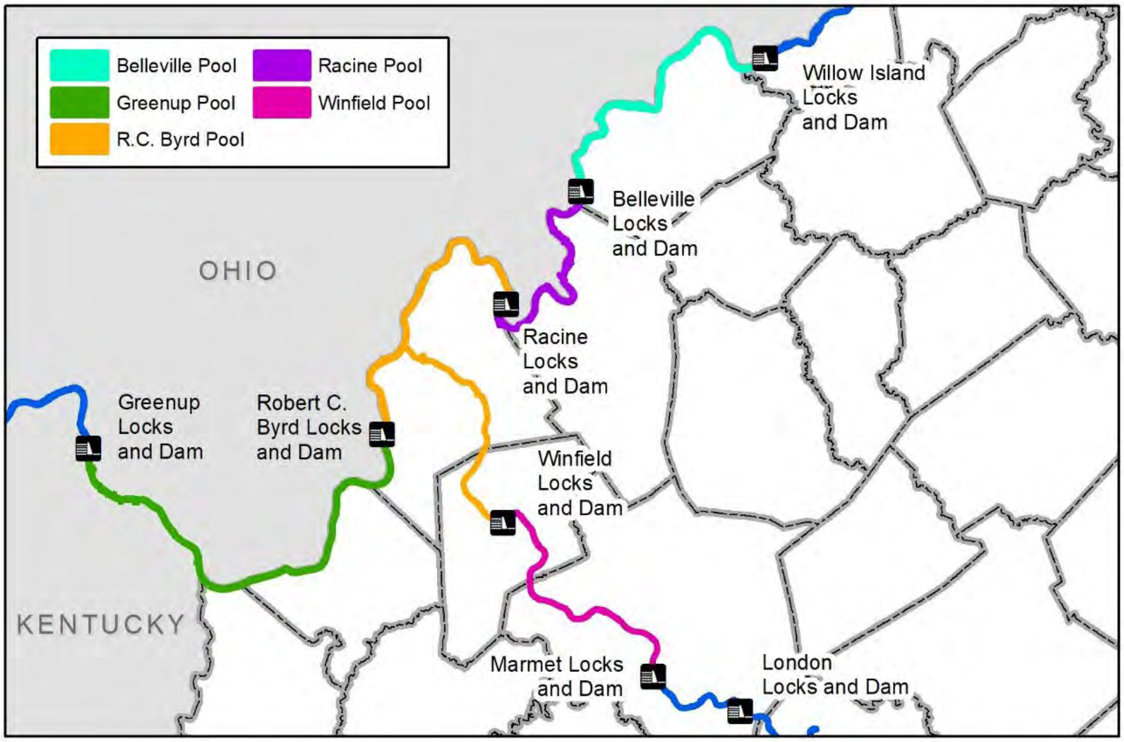
Activities and Methods: Objective 2 - Delineate the upstream population distribution of invasive carps. To delineate the upstream population distribution of invasive carps, WVDNR will maintain an array of mainstem receivers located in R.C. Byrd Pool including the portion of which is in the Kanawha River. WVDNR will coordinate with USFWS on transferring responsibility of the rest of the mainstem and tributary receivers in the Belleville and Racine pools. 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 WVDNR will coordinate with USFWS on transferring responsibility of maintaining the stationary receivers located within the lock and dam complexes at Willow Island, Belleville, Racine and R.C. Byrd dams.

Estimated Time Table of Activities:

Project activity	Pool	Dates	Year
Mainstem receiver deployment	R.C. Byrd – Willow Island	March-April	2024
Invasive carp tagging	McAlpine, Markland & Meldahl	October, April	2023-24
Lock and dam receiver download	R.C. Byrd – Willow Island	August-July	2023-24
Mainstem receiver retrieval	R.C. Byrd – Willow Island	August-July	2023

Map of Telemetry Project Area:



Station/Location name	Pool	OH river mile	Latitude	Longitude
Willow Island L&D upstream approach	Willow Island	161.7	39.36187	-81.31759
Willow Island L&D OH side lock	Belleville	161.8	39.36002	-81.32210
Willow Island L&D WV side lock	Belleville	161.8	39.35988	-81.32222
Willow Island L&D Downstream Approach	Belleville	161.9	39.35774	-81.32553
Hocking River upper	Belleville	199.3	39.20276	-81.77608
Hocking River lower	Belleville	199.3	39.19401	-81.75847
Mustapha Island-Red	Belleville			
Belleville L&D upstream approach	Belleville	203.9	39.12125	-81.74275
Belleville L&D OH side lock	Racine	203.9	39.11674	-81.74282
Belleville L&D WV side lock	Racine	203.9	39.11642	-81.74271
Belleville L&D downstream approach	Racine	203.9	39.11402	-81.74208
Ravenswood Bridge-Green	Racine	221.5	38.93519	-81.75764
Mill Creek upper	Racine	231.2	38.88852	-81.84469
Mill Creek lower	Racine	231.2	38.88693	-81.85531
Racine L&D WV upstream approach	Racine	237.5	38.91608	-81.91302
Racine L&D WV side lock	R.C. Byrd	237.5	38.91762	-81.91207
Racine L&D OH side lock	R.C. Byrd	237.5	38.91805	-81.91150
Racine L&D downstream approach	R.C. Byrd	237.5	38.91983	-81.90909
Mason (Rt.33) Bridge	R.C. Byrd	251.1	39.01215	-82.04139
Point Pleasant RR Bridge	R.C. Byrd	265.1	38.84568	-82.14064
Kanawha R.-Winfield Upstream	R.C. Byrd	KRM 32	38.53399	-81.89921
Kanawha R.-Winfield TW-red	R.C. Byrd	KRM 29.7	38.53104	-81.93609
Kanawha R. Winfield TW-green	R.C. Byrd	KRM 29	38.53832	-81.94702
Raccoon Creek upper	R.C. Byrd	276.0	38.72102	-82.19310
Raccoon Creek lower	R.C. Byrd	276.0	38.71778	-82.20813
R.C. Byrd L&D upper approach	R.C. Byrd	279.2	38.67716	-82.18561
R.C. Byrd L&D lower approach WV side	Greenup	279.2	38.68079	-82.18433
R.C. Byrd L&D lower approach OH side	Greenup	279.2	38.68057	-82.18456
R.C. Byrd L&D old lock wall point	Greenup	279.2	38.67930	-82.18785

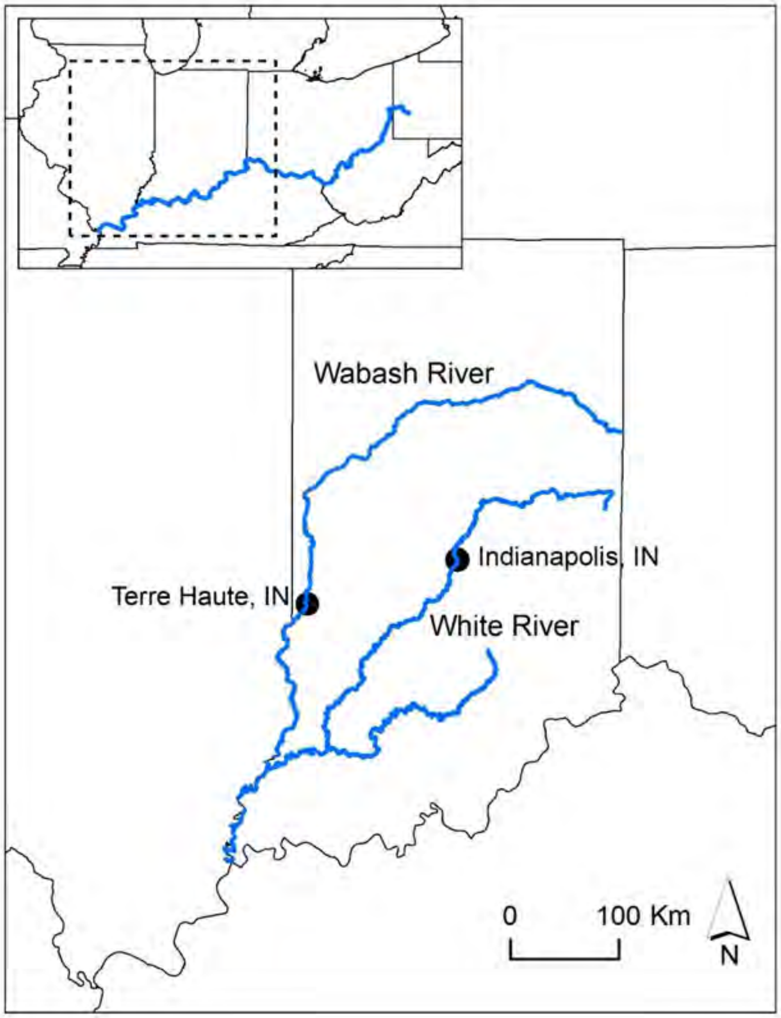
Agency: Illinois Department of Natural Resources (ILDNR), Southern Illinois University (SIU)

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 lower White River. Invasive carp (n=125) will be collected from the Wabash River 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 maintain 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.

Data from stationary receivers will be downloaded during spring and fall of 2024. 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)
Acoustic Tagging of Invasive Carps	Spring, 2024
Interim Progress Report and Executive Technical Report	Spring, 2024
Stationary Receiver Downloads	Spring & Fall 2024

Agency: Illinois Department of Natural Resources (ILDNR), Eastern Illinois University (EIU)

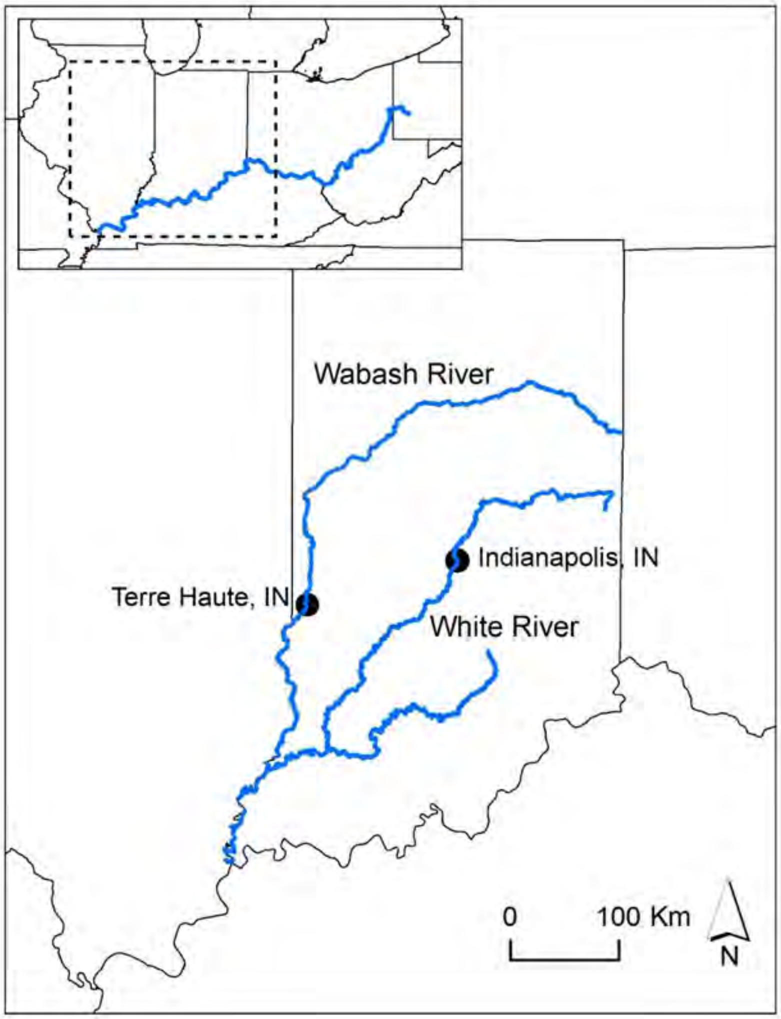
Activities and methods: EIU will be contracted by ILDNR to complete work on the acoustic telemetry of invasive carps in the Wabash and White rivers (Objective 4). EIU will assist with acoustic tagging of invasive carps (described in SIU section) and will collect active tracking and habitat use data from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

Monthly, EIU personnel will actively track the lower Wabash River (termed, ‘reach tracking’). Beginning at the Terre Haute boat ramp and continuing 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 2024
Interim Progress Report and Executive Technical Report	Spring 2024
Active Tracking	April – September 2024 (monthly)

Agency: U.S. Fish and Wildlife Service Lower Great Lakes (LGL) Fish and Wildlife Conservation Office - Ohio River Substation

Activities and Methods: From April through mid-November the Lower Great Lakes (LGL) FWCO – Ohio River substation will activity monitor invasive carp populations in the following pools of the Ohio and Kanawha Rivers: R.C. Byrd, Racine, Belleville, Willow Island, Open water (Kanawha River), and Winfield (Kanawha River). We will work closely with our WVDNR partners to ensure all shared objectives are met. Monitoring efforts will use primarily electrofishing and gillnetting, but new sampling efforts could be explored in 2023. The majority of the sampling efforts in 2023 will be within R.C. Byrd as this pool has been classified as the presence front of invasive carp in the Ohio River. Additionally, surveys will be conducted in new locations to grow our base knowledge of the population status within this portion of the Ohio River. There will also be a large emphasis on collaborative/supportive work with several partners to ensure active population monitoring is achieved. Most notably, assisting the Carterville FWCO with tagging and removal in Markland pool, community size spectra analysis with WVU, and targeted carp removal in R.C. Byrd pool with WVDNR.

To effectively monitor invasive carp movement and passage through lock and dam facilities, this substation will oversee an assortment of telemetry receivers located in our study area (R.C. Byrd pool to Willow Island pool). Throughout the year, crews will visit actively deployed receivers to retrieve stored data on each unit. These visits will occur roughly every two months to closely monitor for invasive carp detections. Currently, there are four receivers deployed at each Ohio River mainstem lock and dam facility in our study area (R.C. Byrd, Racine, Belleville, and Willow Island). In addition to these lock and dam receivers, there are other deployed units scattered throughout our study area. Those additional receivers are located within backwaters, side channels, and large tributaries. All data collected on invasive carp will be shared with project partners. WVDNR has additional receivers located in the R.C. Byrd pool for other fish movement projects. If detections for these additional projects are discovered, USFWS staff will contact WVDNR immediately to report said detections. Data from this project will be used to indicate movement and frequent areas of use by invasive carps in our study area. Future objective goals would include expanding our array of receivers to include the Kanawha River at both lock and dam facilities and non-lock and dam facilities locations.

Agency: U.S. Fish and Wildlife Service Carterville Fish and Wildlife Conservation Office

Activities and Methods: Carterville FWCO will lead tagging efforts within the mainstem Ohio River to replace expiring tags in Cannelton, McAlpine, Markland and Meldahl 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 number to identify individuals with internal telemetry tags to facilitate tag returns from harvested fish. Innovasea (Vemco) Model V16-6x acoustic transmitters (69 kHz 16mm diameter, 95 mm length, 34g), programmed to transmit on a random delay from 20 to 60 seconds with a battery life of 1,460 days (4 years) 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, Newburgh, Cannelton, and McAlpine pools, 100 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, INDNR, and WVDNR sections of this document for information regarding the existing array. Additional information about the potential 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). A report of July 1, 2022, through June 30, 2023, summarizing telemetry activity and analyses including the most recent data collected for this project (between July 1, 2022, and June 30, 2023) will be available March 2024.

Table 1. Number of acoustic tags expiring and needing deployment to reach minimum active tag goal by pool at the end of 2023.

	Pool					
Tags	JT Myers	Newburgh	Cannelton	McAlpine	Markland	Meldahl
Expiring	0	0	0	31	21	11
To deploy	0	0	0	4	50	50

Estimated Timetable for Activities:

Activity	Time period (season, month/year)
Assist with offloading data and maintenance of all receivers	Fall, October – November 2023 Spring, April – May 2024
Invasive carp tagging	Fall, October – November 2023 Spring, March – May 2024
Assist with retrieval of receivers from the mainstem Ohio River. Assist with final data offload from tributary and L&D receivers	Winter, December 2023
Assist with receiver deployment into mainstem Ohio River and replacement of batteries in tributary and L&D receivers	Spring, April – May 2023
Report	Spring, March 2024

2023 Mainstem Ohio River Download Schedule:

Pool	April	May	June	July	August	September	October	November
Willow Island	USFWS							
Belleville	USFWS							
Racine	USFWS							
R. C. Byrd	USFWS							
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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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: 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 established presence. 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 into and beyond the presence front 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 has remained a dominant cohort of fish captured during sampling efforts since 2016. The larval and juvenile sampling in this plan is 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 presence front, 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 presence 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). 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 carp's colonization of 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 presence front. 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 establishment 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 of and beyond the current presence front.
3. Determine invasive carp relative densities and assess sampling needs in the Tennessee-Tombigbee Waterway.

Agency: Tennessee Wildlife Resources Agency (TWRA)

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 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 surveys will be conducted during the daytime from approximately June through October. 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. Catch will be examined for presence of juvenile invasive carp, and catch rates calculated if juvenile invasive carp are encountered.

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

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 leading edge. Additional sampling, including dozer trawls, gill nets, and eDNA collection, will depend upon staff and partner (TTU) availability.

Map of Project Area:

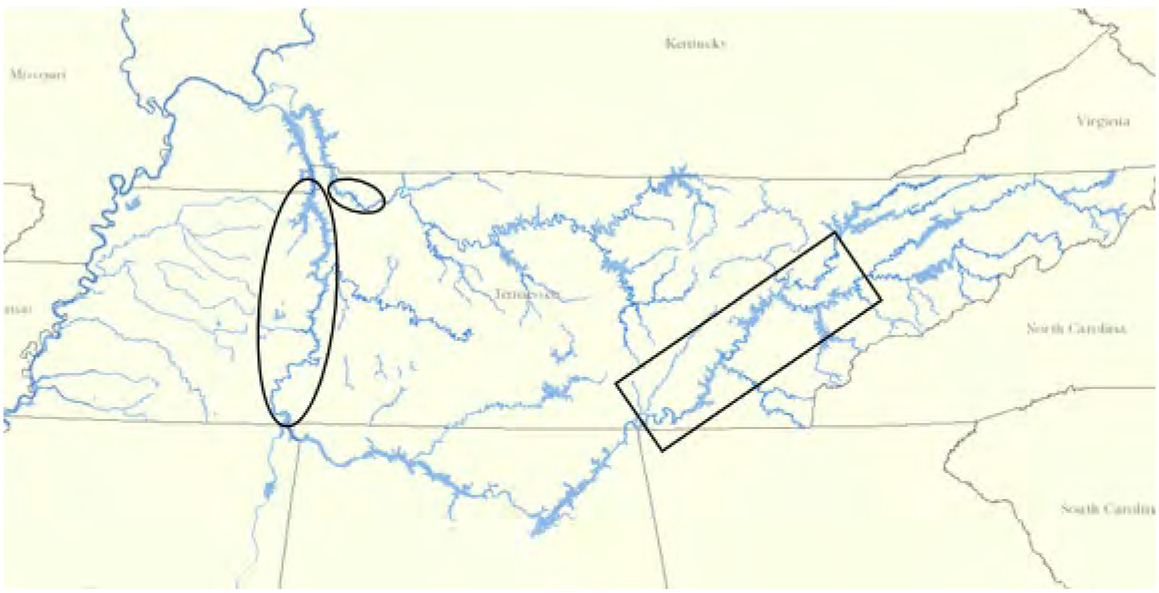


Figure 1: Map depicting Tennessee waters. The large oval (Kentucky Lake; Tennessee River) and small oval (Lake Barkley; Cumberland River) have existing populations of invasive carp and will be the focus of efforts to monitor for successful carp reproduction. The rectangle encompasses waters of the Tennessee River above the current leading edge 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, 2024
Larval light traps	Kentucky and Barkley reservoirs	May-August, 2024
Mini fyke nets	Kentucky and Barkley reservoirs	August, 2024
Dozer trawls	Kentucky and Barkley reservoirs	June-December, 2024
Electrofishing	Nickajack, Chickamauga, Watts Bar, Ft. Loudoun, and Melton Hill dams	April-September, 2024
eDNA collection	Guntersville, Nickajack, Chickamauga, Watts Bar, and Ft. Loudoun reservoirs	TBD, 2024

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 leading edge.*

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 known invasion front). The red circle denotes Wilson tailwater at the head of the invasion front in Pickwick Reservoir.

Estimated Timetable for Activities:

Activity	Location	Time Period (Season, month/year)
Electrofishing	Wheeler and Guntersville dams	April-September, 2024

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. If YOY invasive carp are collected, then length and weights will be recorded, and specimens will be kept for further analysis as needed. 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.

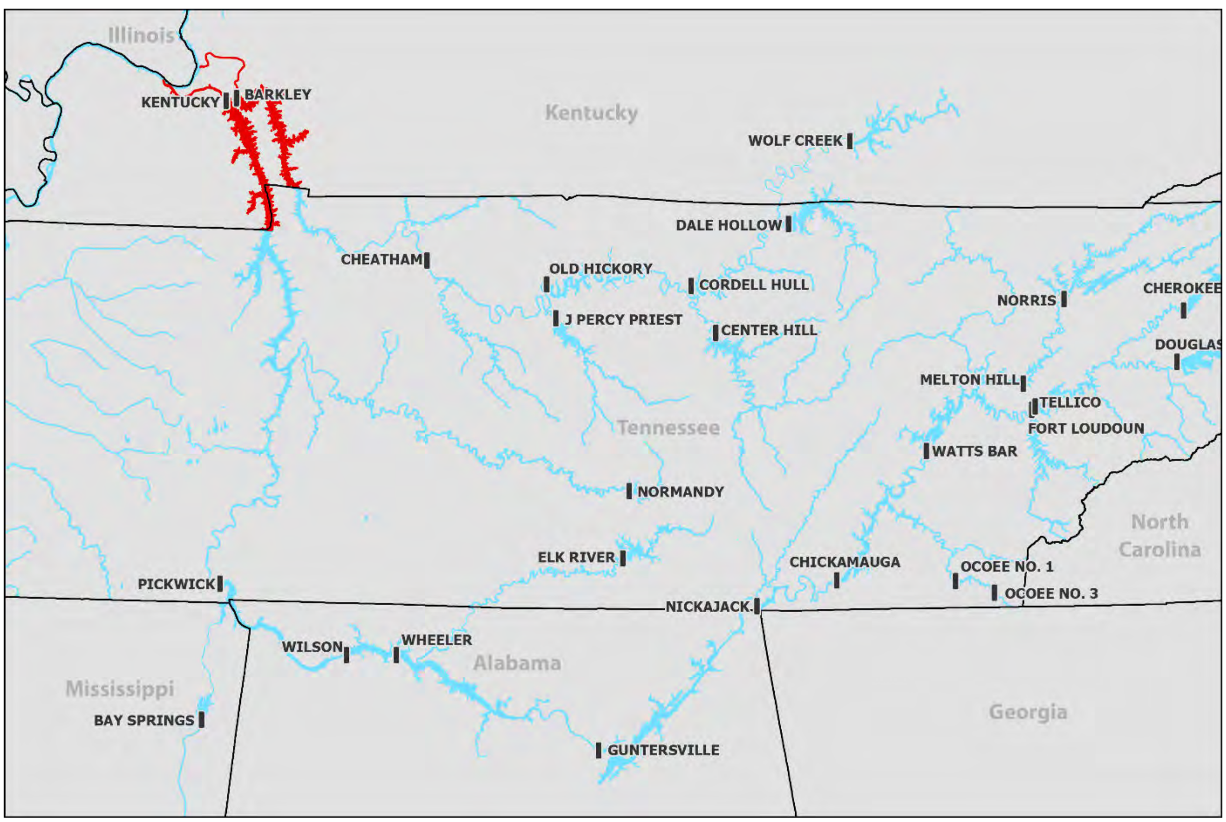
KDFWR will sample with pulsed DC boat electrofishing in Barkley and Kentucky reservoirs for one week in each reservoir. Electrofishing runs will not exceed 15 minutes of peddle time and will run parallel to shore in ½-2 meters of water. Sampling will start at sunset and will conclude after 6 transects in each embayment. Four embayments on each reservoir have been chosen based on shoreline length, depth, and proximity to boat ramp. Electrofishing box will be set at 120 hertz, 25% duty cycle, and 500 volts. This sampling will be in conjunction with native baitfish sampling that monitors impacts of invasive carp.

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.

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

While no funds were requested by KDFWR under this objective it is worth including this effort since it will be an extension of and complementary to the work being conducted for black carp within the FY23 OHR Early Life Stages workplan. KDFWR will sample the lower Cumberland and lower Tennessee Rivers in the summer of 2023 in search of YOY black carp. Sampling will be with boat electrofishing, backpack electrofishing and small seins. Crews will search for backwater areas along the shores of the Cumberland and Tennessee Rivers and their tributaries. Species collected will be identified and vouchered as needed. At each sampling location, habitat characteristics, water temperature, water depth, and GPS coordinates will be collected.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Location	Time Period (Season, month/year)
Electrofishing	Barkley and Kentucky reservoirs	Fall 2023 & 2024
Mini fyke nets	Barkley and Kentucky reservoirs	Fall 2023 & 2024
Monitoring for YOY black carp	Lower Tennessee and lower Cumberland Rivers	Fall 2023 & 2024

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

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

***The work described below is ongoing from FY22 and required no additional funding request in FY23.

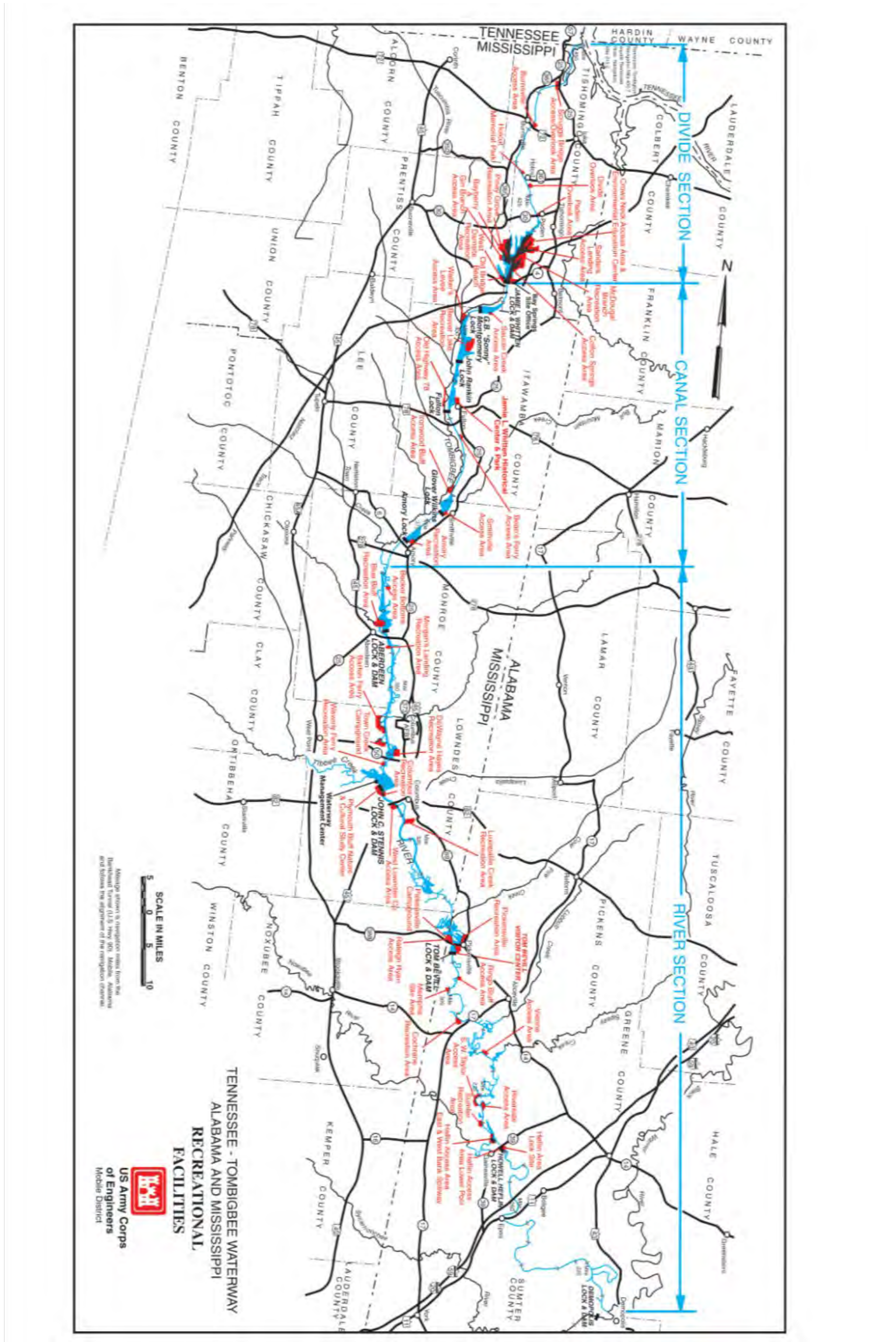
Sampling for invasive bigheaded carp will occur in the fall/winter seasons in pools below Bay Springs Lake. A "two-pool" rule will be implemented into the early detection sampling design of this project. The two-pool rule establishes that monitoring for invasive bigheaded carps should be conducted in 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 in 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 cataloged 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/2024
Annual Report	March 1, 2024

Literature Cited:

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Deterrent Strategy Planning for Invasive Carp in the Ohio River Basin

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Cooperating Agencies: 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 understand pool-to-pool movement probabilities and paired with information about the hydrological conditions at specific dam locations can be used to inform future deterrence projects. 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 Rivers have been increasingly supported in the last few years and federal funding could further enhance control and management capabilities. Cooperative efforts by partners have resulted in extensive numbers of invasive 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.
2. Specific to the Tennessee and Cumberland Rivers and the Tennessee-Tombigbee Waterway.
3. Specific to the Ohio River
4. Collect baseline movement information for native species and invasive carps among reservoirs and water bodies to inform deterrent efficacy and lock and dam passage.
5. Provide support to research activities associated with deterrent development and testing.

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

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 annual 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 of invasive carp 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 determined.

1.2: Specific to the Ohio River
KDFWR will further investigate the need for and priority locations that may warrant an invasive carp deterrent structure. Structured Decision-Making (SDM) protocols will be evaluated and determination for the best approach of engaging the partnership will be addressed.

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.

Tennessee and Cumberland Rivers
KDFWR will continue partnering with Murray State University to conduct tracking of tagged invasive carp within Barkley and Kentucky reservoirs, 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.

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 Barkley Lock chamber (Map 2). The Barkley BAFF project will be concluding in the fall of 2023, but KDFWR will work with partners to transition the equipment over to an agency for full time operation and lend support to the process where needed. All VEMCO telemetry receivers will be maintained, and data collected monthly. Analysis of data collected in Kentucky's portions of the Tennessee and Cumberland rivers will continue to be a joint effort with Murray State University and the USGS. Receiver locations, acoustic tag numbers, and data collected will be 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.

Estimated Timetable of Activities:

Project Activity	Location	Month	Year
Receiver Deployment	Tennessee River	as needed	2023-2024
Receiver Deployment	Cumberland River	as needed	2023-2024
Downloading of Receivers	Barkley & Kentucky reservoirs	Bi-Monthly	2023-2024
Downloading of Receivers	Kentucky Lock & Dam, Barkley Lock & Dam, Tailwaters	Monthly	2023-2024
Project Technical Report	N/A	February	2025

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

Map 1. Stationary receiver locations in Tennessee and Cumberland rivers that are maintained by KDFWR to monitor invasive carp reservoir usage and dynamics.

Map 2. Location of Bio-Acoustic Fish Fence (BAFF) deterrent system being tested at Barkley Lock and Dam on the Cumberland River.

Agency: Tennessee Wildlife Resources Agency (TWRA)

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 annual 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 determined.

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 [TWRA map]) 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.

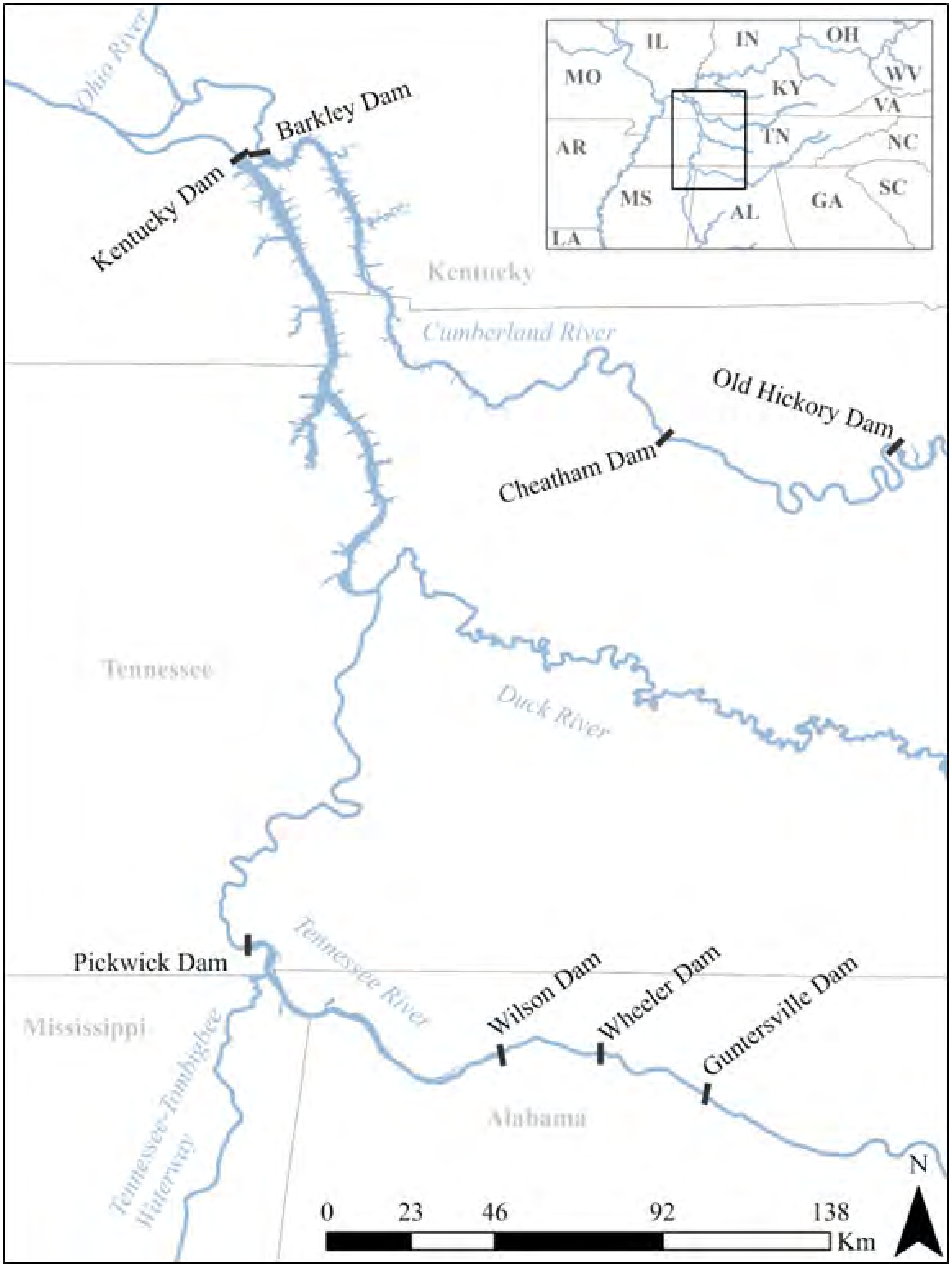
Acoustic telemetry receivers are currently deployed at the three most downstream dams on the Cumberland River and at the five most downstream dams on the Tennessee River (TWRA map). Receivers at these locations will continue to be maintained and monitored. Additionally, more receivers will be deployed 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.

Estimated Timetable of Activities:

Project Activity	Reservoir	Month	Year
Acoustic Tag implantation	Kentucky, Barkley, Pickwick, and Cheatham reservoirs	water temperature dependent	fall 2023 and spring and fall 2024 (until all tags are at-large)
Acoustic Receiver deployment and maintenance	Kentucky, Pickwick, Wilson, Wheeler, Cheatham, Old Hickory	Seasonally (target of 4X annually) and as needed for maintenance	2023 and 2024
Data summarization/reporting	TNCR	Quarterly updates in congruence with data downloads	2023 and 2024

Map of Project Area:

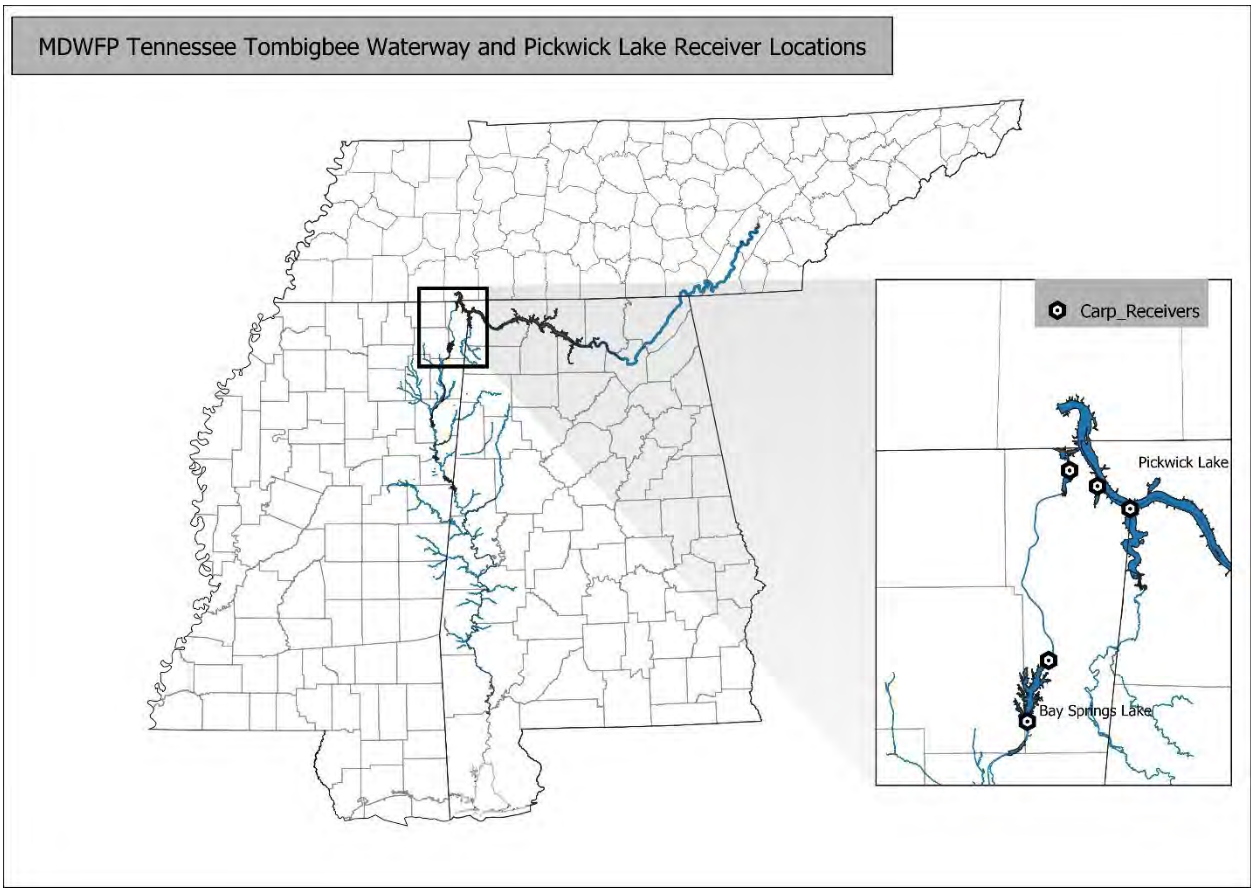


TWRA map. Map of the project area including dams on the Tennessee and Cumberland rivers, which are monitored for invasive carp passage using acoustic telemetry indicated by ▮.

Agency: 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 of Activities:

Activity	Location	Month	Year
Data Downloads	Pickwick Lake, Bay Springs Reservoir, TTW	Monthly	2023-2024
Receiver Replacement and Maintenance	Pickwick Lake, Bay Springs Reservoir, TTW	As needed	2023-2024
Annual Report	N/A	March	2024

Agency: U.S. Geological Survey

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

1.1 Tennessee and Cumberland Rivers

(USGS) Expansion of invasive carp range and density in the Ohio River basin has resulted in a large state and federal effort to limit movement of invasive carp throughout river basins. In 2021, the Tennessee Valley Authority (TVA) completed a programmatic Environmental Assessment (EA) of the installation of carp deterrents at nine lock structures throughout the Tennessee River. Priorities described in the EA were a direct outcome from an 8-week structured decision-making (SDM) process. The SDM process was coordinated by the USGS with participation from all key state and federal stakeholders to develop a consensus decision on what type of barriers and locations could impede the upstream movement of invasive carps. Due to property ownership and authorities, this SDM process only considered locations that were within TVA jurisdiction. However, stakeholders also identified several other locations where deterrents are needed, and those locations were tabled for future consideration.

The purpose of this project is to conduct follow-up SDM workshops to expand the analysis above to include locations on the Cumberland River and Tennessee Tombigbee Waterway. The primary focus of this follow-up will be to examine optimal deterrent and removal strategies to slow the spread of invasive carps into those areas. Each river system has unique economic, ecological, and social benefits that could be compromised by the establishment of invasive carps. Our previous decision analysis work with the TVA has laid much of the basic SDM framework for how to prioritize barriers on the Tennessee River. However, with this work, we envision expanding the group to include more stakeholders and decision makers to represent a much larger geographic scope. Thus, we anticipate needing to revisit aspects of the SDM framework and revising products to better reflect the expansion of geographic scope and decision-maker values. We plan to do this over the course of 8-12 weeks beginning in FY23. We plan to hold virtual meetings every other week to discuss components of the SDM process, followed by written input on draft products in the intervening weeks.

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 evaluate movement patterns and transition probabilities of three groups of silver carp: 1) individuals captured and tagged in the upstream reservoir, 2) translocated individuals captured from upstream reservoirs then tagged and released the in the tailwaters, and 3) tailwater origin individuals. 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 lock passage 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 Corps of Engineers Lock Performance Management System on a quarterly basis for all locks on the Tennessee and Cumberland rivers.

Estimated Timetable of Activities:

Project Activity	Location	Month	Year
Receiver Maintenance	Kentucky, Pickwick, Cheatham Dams	As needed	2023-2024
Gate Sensors and HOBO Depth Logger Maintenance	Kentucky, Pickwick, Cheatham Dams	As needed	2023-2024
Implantation of Transmitters	Kentucky, Pickwick, Cheatham Dams	March, April, October, November	2023-2024
Data management and analysis	N/A	As needed	2023-2024

Figure 4. VEMCO telemetry array deployed at Kentucky Lock and Dam.

Figure 5. VEMCO telemetry array deployed at Pickwick Lock and Dam.

Figure 6. VEMCO telemetry array deployed at Cheatham Lock and Dam.

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

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

Cooperating Agencies: TWRA; Kentucky Department of Fish and Wildlife Resources (KDFWR); Alabama Division of Wildlife and Freshwater Fisheries (ALWFF); Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); 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 Asian Carp (Conover et al. 2007). 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 control strategy framework. 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 allow TN, KY, and AL to implement sampling programs. Ultimately, while Mississippi Department of Wildlife, Fisheries, and Parks is not requesting funding for this project for FY23, 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 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. Implement exploitation study of invasive carp in Kentucky and Barkley reservoirs.

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 monitor commercial harvest to evaluate relative changes in invasive carp abundance in Barkley and Kentucky reservoirs. KDFWR will collect silver and bighead carp in the fall to use for aging structures and to evaluate population demographics.

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). Data collected during ride-alongs with commercial fishers allows KDFWR to quantify the catch per unit effort during the harvest effort and to estimate average weights of silver carp harvested. This information will be an additional metric in the assessment of invasive carp population demographics. During the ride-alongs, a random subsample of at least 20 total lengths(mm) and weights(g) from silver carp will be collected.

During fall sampling, pectoral fin rays and otoliths will be extracted from approximately 100 silver carp from each reservoir for aging. 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.

KDFWR will collaborate with partners and provide data as requested to support an exploitation study of silver carp in the TNCR. Partners within the TNCR will work with statisticians at US Geological Survey implement a Length-Based Bayesian Model (LBB) to determine how the mass commercial removal has affected the reservoirs. Ultimately, the information collected whether fisheries dependent or independent will be used to develop more reliable and uniform population trend models and aid in establishing sound removal and management objectives.

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. Data collected on movements of tagged invasive carp will be correlated with several variables to determine what factors may be affecting movements and habitat usage. KDFWR will assist with coordinating a communication effort to relay information gained to commercial fishers.

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 evaluate the removal program. 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.

KDFWR randomly provides observers to record harvests with an annual goal of 75 trips per year (ride-alongs). 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 Barkley and Kentucky reservoirs 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 Barkley and Kentucky reservoirs and their tailwaters. Additionally, KDFWR will develop a program to facilitate contract fishing through a processor subsidy program for entities operating in Kentucky. Finally, KDFWR will continue to maintain 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.

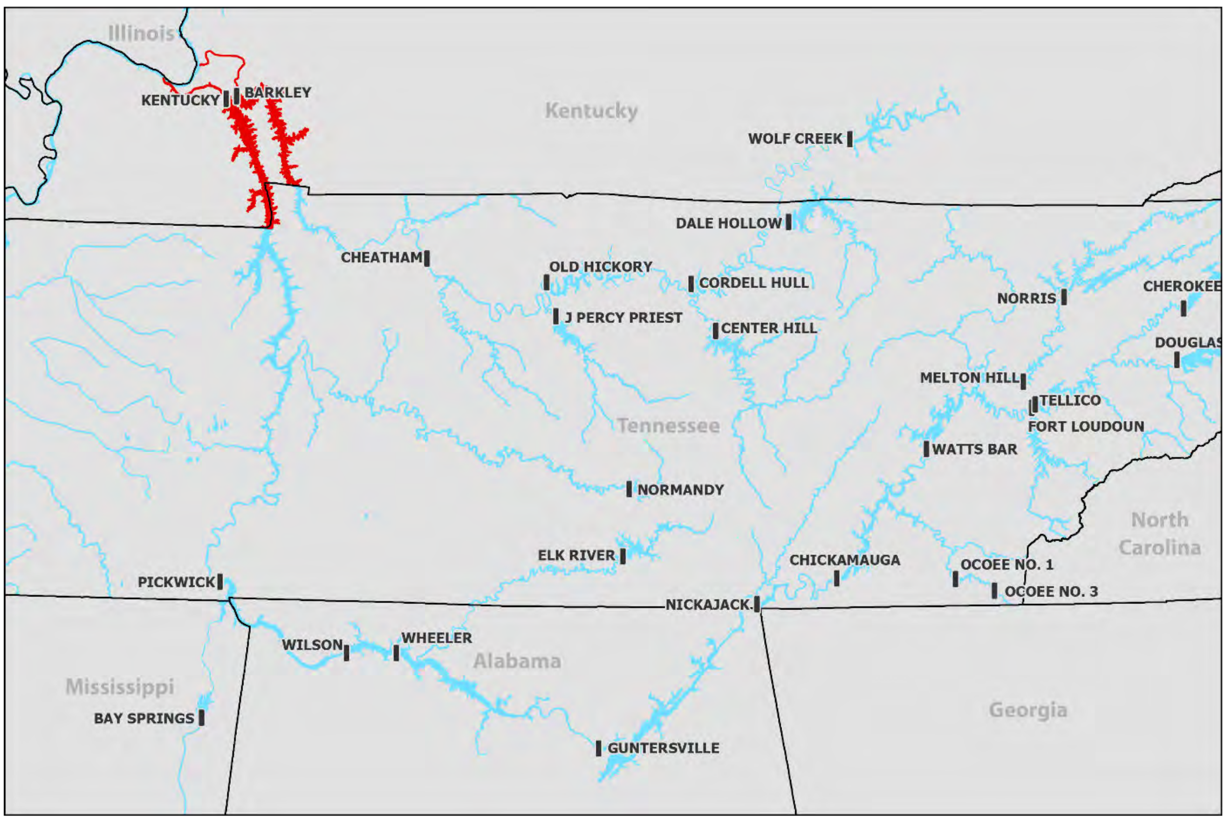
Objective 4: Evaluate new and/or experimental methods and gears for targeting invasive carp for harvest.

KDFWR will offer a new two-tiered permit program under which entities may test methods of invasive carp harvest that are not currently legal in Kentucky. Only 3 tier 1 permits will be awarded at a given time, because the program requires KDFWR staff to be present when vendors will be operating under this permit. Vendors will be required to hold a commercial fishing license and will be eligible to sell any invasive carp harvested during testing efforts. After vetting the gears and methods with KDFWR oversight, vendors may be eligible to apply for a tier 2 permit which would allow them to utilize their methods or gear with less rigorous 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: Implement exploitation study of invasive carp in Kentucky and Barkley reservoirs

KDFWR will support and collaborate with TWRA to facilitate a proposed exploitation study of invasive carp in Barkley and Kentucky reservoirs.

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



Estimated Timetable of Activities:

Project Activity	Pool	Month	Year
Collection of Invasive Carp Demographics Information	Kentucky / Barkley	All Seasons	2023 - 2024
Ride Alongs with Commercial Fishermen	Kentucky / Barkley	All Seasons	2023 - 2024
Ride Alongs with Commercial Fishermen	Lower Tennessee / Cumberland Rivers	All Seasons	2023 - 2024
Testing of Experimental Harvest Gears	Kentucky / Barkley	All Seasons	2023 - 2024
Contract with Commercial Fishers and Processors Harvesting Invasive Carp	Kentucky / Barkley	All Seasons	2023 - 2024
Maintenance of Industrial Ice Machine	Kentucky / Barkley	All Seasons	2023 – 2024
Collection of Aging Structures	Kentucky / Barkley	Fall	2023 - 2024

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>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 from approximately June through October. 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.

Hoop Nets – TWRA staff will experiment with use of hoop nets to sample invasive carp in Kentucky, Barkley, Pickwick, and Cheatham reservoirs. Hoop nets will be 4 ft diameter at the front hoop, consist of 2.5-inch webbing, and utilize 100 ft wings. We plan to work with commercial fishers to determine the optimal method for deployment of hoop nets and anticipate this experimental effort taking place during cooler months of the year (i.e., October to March). Catch of invasive carp and bycatch will be quantified.

Other Sampling – In addition to the sampling above, TWRA staff may utilize a variety of gears to sample invasive carp throughout the year, including standard electrofishing and gill nets. Samples will be collected to evaluate size and age structure.

Fish Collected During Surveys – All carp species that are not tagged in association with other projects/objectives 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). 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 as feasible given staff capacity limitations. We will record capture location and examine a subsample of carp to determine species, length (mm), and weight (g).

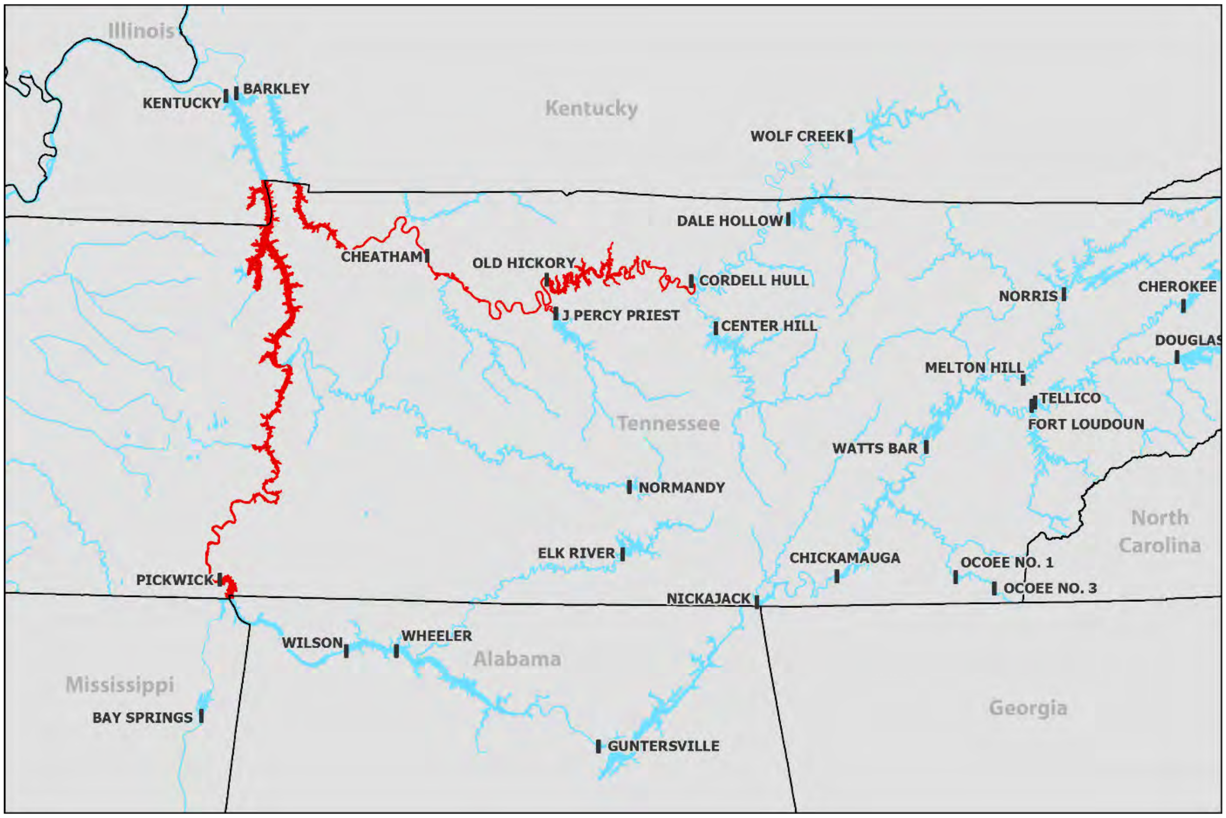
Objective 3: Target and remove invasive carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

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. TWRA will consider incentivizing secondary processors that create substantially altered products using invasive carp, on a per pound basis, to stimulate commercial markets.

Objective 5: Implement exploitation study of invasive carp in Kentucky and Barkley reservoirs.

TWRA has worked with partners to gather information and expert advice regarding project scale, tagging options, capacity needs, technological aspects, funding requirements, and analytical support of an exploitation study on Kentucky and Barkley reservoirs. Though the specifics of this project are still in development, the project will likely consist of a high-reward tagging component and span approximately 4 years. As details of this project are further developed, TWRA and partners assisting in development will keep the TNCR partnership aware of key project components and expectations.

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



Estimated Timetable:

Project Activity	Pool	Month	Year
Dozer Trawl	Kentucky, Pickwick, Barkley, Cheatham, and Old Hickory lakes	July-Sept and Nov-Jan	2024
Hoop Nets	Kentucky, Pickwick, Barkley, and Cheatham lakes	July-Sept and Nov-Jan	2024
Commercial Surveys	Sample carp harvested within TCHIP program (Agency specified lakes)	Year-round	2024
Targeted removal (TCHIP)	Agency specified lakes	Ongoing; year-round	2024-2025
Scope Exploitation Project	Kentucky and Barkley lakes	Year-round	2023-2028

Agency: Alabama Department of Conservation and Natural Resources (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 areas), Wilson Reservoir (3 areas), and Wheeler Reservoir (5 areas). The overall sampling strategy will follow methodology similar to Sullivan et al. (2018), using a robust

occupancy approach. At each area, three gill net sites will be set and fished during daylight hours. Each area will be sampled repetitively during four consecutive days (repetitions) a minimum of twice per year; once during the spring 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 50- or 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. Habitats sampled include embayments and overbank areas in depths ≥ 13-ft (deep nets described above) or ≥ 8-ft depths (short nets 5-ft high panels). Catch of all invasive carp species will be recorded by mesh size.

<u>Dozer Trawl Electrofishing</u> – ALWFF staff will conduct Dozer trawl electrofishing when practical as a standard method of sampling. The overall sampling strategy will follow methodology similar to Sullivan et al. (2018), using a robust occupancy approach. Dozer trawl electrofishing transects (5-min runs at 3.0 mph) will be paired with gillnet sets (one repetition of each gear per site) at Pickwick Reservoir (3 areas), Wilson Reservoir (3 areas), and Wheeler Reservoir (5 areas). At each area, three transect sites will be sampled repetitively during four consecutive days (repetitions), a minimum of twice per year; once during the spring and fall. Multiple factors, such as logistics, feasibility, scientific and statistical robustness were used in determining number and location of sampling sites. Specifications of the dozer trawl are similar to those currently operated by TTU and USFWS’s Columbia Field Office. Electrofishing surveys will be performed simultaneously with gill netting and conducted during the day. Sampling transects may include a variety of habitat types (i.e., overbank and embayments). 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.

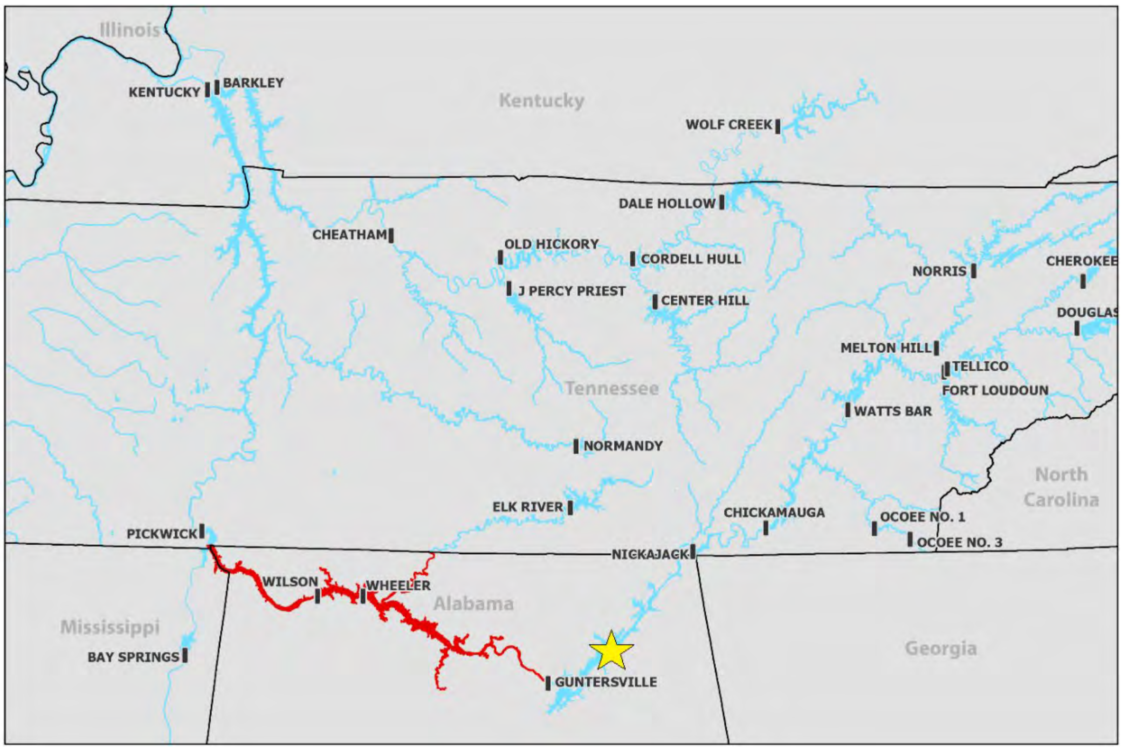
<u>Boat Electrofishing</u>– ALWFF staff will conduct boat electrofishing as a standard method of sampling when a dozer trawl is not appropriate or for other non-standard sampling approaches. Multiple factors, such as logistics, feasibility, and scientific and statistical robustness will be used in determining number and location of sampling sites. 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 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 or longer as needed. Invasive carp species will be counted, and catch rates will be calculated as fish/5-min.

<u>Fish Collected During Surveys</u> – 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 areas sampled 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	Spring, Fall
Dozer Trawl Electrofishing	Spring Fall
Boat Electrofishing without Dozer trawl	Spring Summer, Fall, late winter

Literature Cited:

Sullivan CJ, Weber MJ, Pierce CL, Camacho CA. 2018. Influence of river discharge on grass carp occupancy dynamics in south-eastern Iowa rivers. *River Res Applic*. 2018;1–8. https://doi.org/10.1002/rra.3385

Bracing for the long term: a conceptual framework to facilitate coexistence with invasive carps.

Lead Agency and Author: USGS Mississippi Cooperative Fish and Wildlife Research Unit, Steve Miranda (smiranda@usgs.gov)

Cooperating Agencies: Mississippi Department of Wildlife, Fisheries and Parks (MDWFP), Kentucky Department of Fish and Wildlife Resources (KDFWR), Tennessee Wildlife Resources Agency (TWRA), Alabama Wildlife and Freshwater Fisheries Division (AWFFD), Tennessee Cooperative Fishery Research Unit (TCFRU)

Statement of Need: To structure invasive carp management in the TNCR, we propose to develop a conceptual framework of how proliferation of invasive carps may affect TNCR aquatic environments, fish assemblages, and recreational use of these impounded rivers. The conceptual framework will be a network of interlinked concepts that together provide a comprehensive understanding of the effects of carp. It is intended to be a tool for charting the context of this complex conservation problem, including the problem itself, processes, threats, impacts, strategies, and opportunities (Margoluis et al. 2009). The conceptual framework will succinctly represent the presumed causal relationships among various factors that are believed to be impacted by expansion of bigheaded carps. The framework is expected to be a useful planning tool to help guide what actions may best influence the situation at a given site, what factors should be monitored to determine if those factors are changing with project implementation, what is not worth measuring, and which factors we need to focus on for future research (Sanderson et al. 2002). The model will explicitly link conservation strategy to the main threats, and to any indirect threats influencing direct threats. This conceptual framework can provide managers with the basis for monitoring, management, research, and evaluation of interventions. The framework will be accompanied by an extensive literature review.

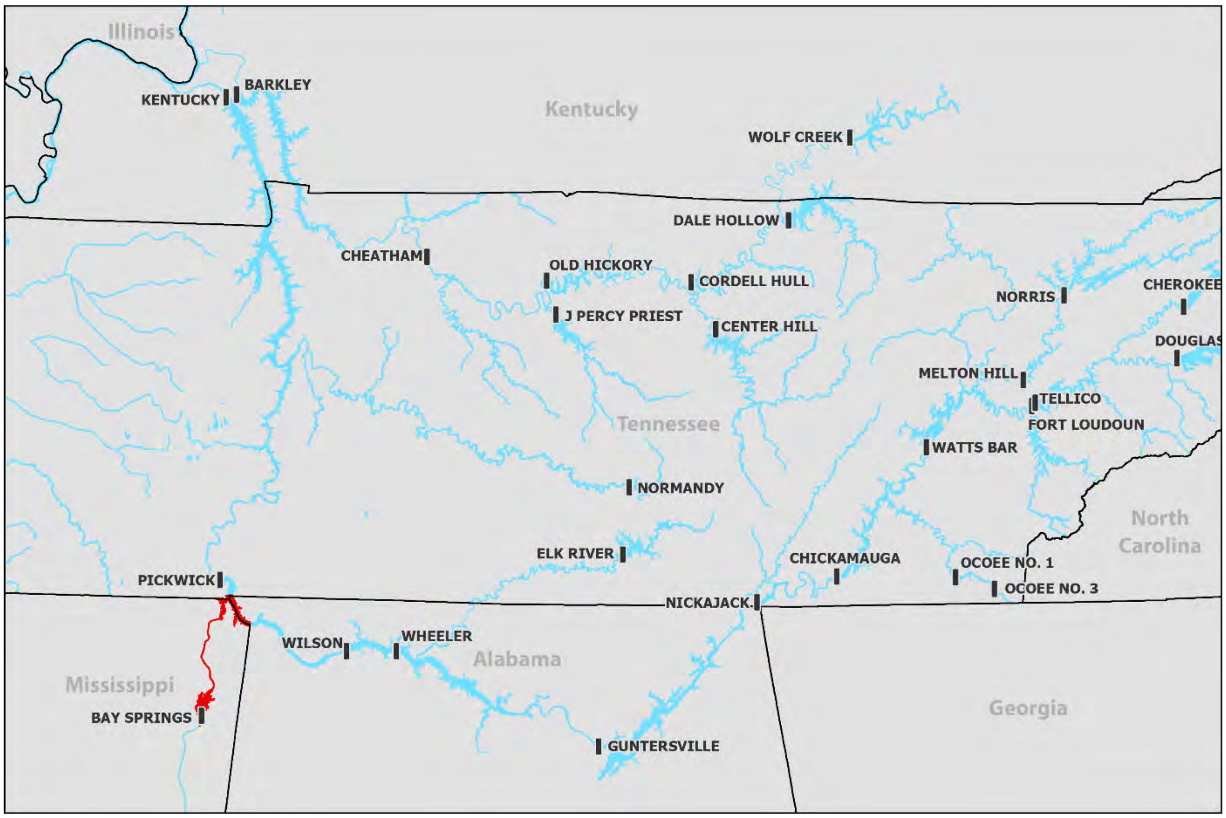
Objectives:

1. To develop a conceptual framework that defines how invasive carps may impact aquatic environments and their biota in the Tennessee and Cumberland rivers, and to identify management actions for addressing the impacts.

Agency: USGS Mississippi Cooperative Fish and Wildlife Research Unit

Activities and Methods: We will create the proposed framework in five separate stages. In stage 1, we will map the spectrum of multidisciplinary literature regarding the phenomenon of invasions by a primary consumer such as bigheaded carp, but not limited to fish literature. This process will include identifying literature and empirical data and is estimated to be one of the lengthiest stages of this project. However, this step will be facilitated by (1) an existing database of invasive carp literature compiled by D. Chapman, and (2) a python-based crawler able to find relevant literature online (Wang et al. 2020). In stage 2, we will review and catalogue the materials gathered in stage 1. The goal in stage 2 is to process, in part with artificial intelligence, the selected literature and data to arrive at concepts relevant to managing the impacts of the carp invasion. For this, we will apply machine-learning tools available for conducting reviews and syntheses of published articles and other documents (e.g., COLANDR software; Wang et al. 2020). In stage 3, we will deconstruct each concept identified in stage 2. The goal here is to identify main attributes, characteristics, assumptions, and effects within the framework. The results of stage 3 may be a table that includes at a minimum four columns including concept name, concept description, concept mechanisms, and references. In stage 4, we will integrate and group concepts that are similar and possibly reduce the number of concepts to facilitate a less complex conceptual framework. Lastly, in stage 5 we will validate the resulting conceptual framework. We will attempt to verify if the proposed framework and its concepts make sense to others in our discipline and in sister disciplines. This step may be accomplished by presenting the evolving framework at seminars, workshops, scientific meetings, or by submissions to peer reviewed journals. Existing datasets can support this stage by allowing empirical testing of selected sections of the framework. The work will be conducted by a post-doctoral student with the majority of the cost going towards paying salary and benefits.

Map of Project Area:



Estimated Timetable of Activities:

Project Activity	**Time Period (Season, Quarter, month/year)**
Postdoc recruitment	Jun-Aug 2023
Postdoc onboarding	Aug-Sep 2023
Conduct extensive literature review	Oct 2023 – Mar 2024
Process information obtained by the literature review and develop relevant concepts	Apr-Nov 2024
Clearly delineate concepts and relevance to carp invasions and management	Jul-Feb 2024
Simplify initial versions of framework	Jan-Apr 2024
Validate framework	Apr-Aug 2024
Final report to funding agency	Sep 2025

Literature Cited:

Margoluis, R., Stem, C., Salafsky, N. and Brown, M., 2009. Using conceptual models as a planning and evaluation tool in conservation. Evaluation and Program Planning 32:138-147.

Sanderson, E.W., Redford, K.H., Vedder, A., Coppolillo, P.B. and Ward, S.E., 2002. A conceptual model for conservation planning based on landscape species requirements. Landscape and Urban Planning 58:41-56.

Wang, J., Su, G., Wan, C., Huang, X. and Sun, L., 2020. A keyword-based literature review data generating algorithm—analyzing a field from scientific publications. Symmetry 12(6), p.903.

Monitoring Invasive Carp Impacts on Native Fish Communities

Lead Agency and Author: Kentucky Department of Fish and Wildlife Resources (KDFWR), Joshua Tompkins (Joshua.tompkins@ky.gov)

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 TNCR. In this 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 impacts on native species that compete for food resources with invasive carp.
    1. Monitor bycatch of native species collected through invasive carp harvest program.
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.

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

Activities and Methods: *Objective 1: Assess impacts on native species that compete for food resources with invasive carp*

During field work if bigmouth buffalo and paddlefish are collected, total length and weight data will be collected. 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 conduct 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 and will run parallel to shore in ½-2 meters of water. Length and weight will be taken from individuals collected. Sampling will start at sunset and will conclude after 6 transects in each embayment. Four embayments on each reservoir have been chosen based on shoreline length, depth, and proximity to boat ramp. Total length(mm) and weight(g) will be collected for all species greater than 180 mm. If less than 180 mm, only total length will be taken. After 25 specimens per transect have been measured from each species, the rest will be counted. Species targeted are gizzard shad, threadfin shad, skipjack herring, and emerald shiner. Midwest Lake Electrofishing box will be set at 120 hertz, 25% duty cycle, and 500 volts. Gizzard shad relative weights will be compared to historical data to assess impacts of invasive carp.

Objective 1.1: Monitor bycatch of native fish species collected through invasive carp harvest programs

KDFWR continues to administer the Asian Carp Harvest Program (ACHP) and content to develop and expand the Experimental Gears and Methods 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.

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

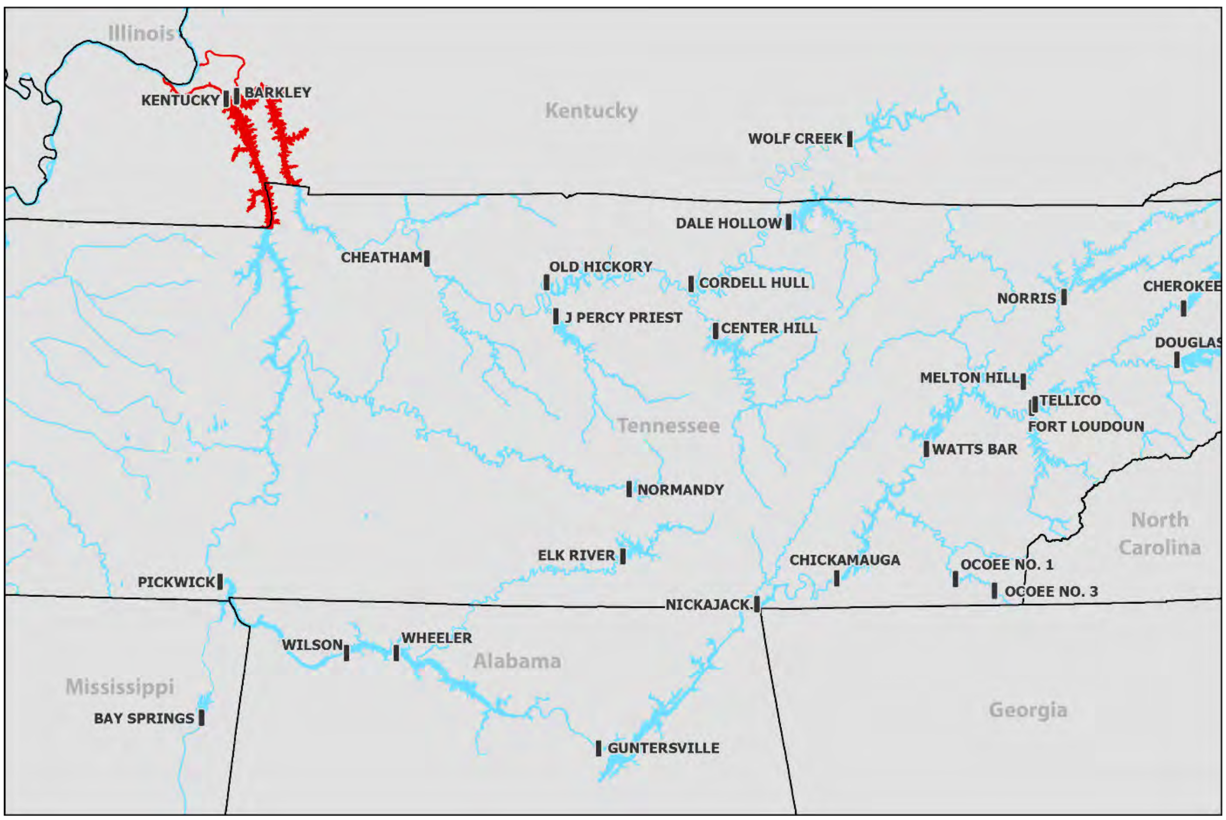
Barkley and Kentucky reservoir tailwater's will continue to be sampled with pulsed DC electrofishing in the fall to assess species composition, relative abundance, and condition of represented fish species. Sampling below Kentucky reservoir (Tennessee River) will consist of three 15-minute transects, moving downstream along each bank of the river. Sampling below Barkley reservoir (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. Field crews will consist of one driver and two netters, to conduct a non-bias sampling of species present. Data collected 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 Western Fisheries District personnel to assess changes in fish community over time. Additionally KDFWR staff will continue to collaborate with partners to investigate better analysis approach to understand community interactions in these areas.

Objective 3: Determine impacts of invasive carp on sport fisheries

Invasive carp harvest continues to increase from Barkley and Kentucky reservoirs, 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 sportfish species to identify trends that may be associated with the increased removal. Information on sportfish has been gathered routinely throughout the past few decades by KDFWR's Western Fisheries District (WFD). A robust data set on black bass, crappie, and catfish are annually collected from the two reservoirs. This information will be used to compare sportfish conditions (*W*r) with harvest rates of invasive carps to test for correlations.
Starting in January of 2024, KDFWR will perform a random, non-uniform probability, roving creel survey on Kentucky's portion of Barkley reservoir (45,600 acres). The reservoir is divided into eight 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 Little River and Eddy Creek areas from March through May, and October and November, than are assigned to the other six areas. Equal probabilities are assigned to all areas from June through September. An angler attitude questionnaire concerning fishing on Kentucky reservoir (satisfaction with the fishery, proposed regulation changes and invasive carp specific information) will be 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 Barkley reservoir, will be reviewed thoroughly. 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.

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



Estimated Timetable of Activities:

Project Activity	Pool	Month	Year
Electrofishing for Gizzard Shad	Barkley and Kentucky Reservoirs	Fall	2023/2024
Electrofishing Community Survey	Kentucky & Barkley Tailwaters	September, October, November	2023/2024
Creel Survey	Kentucky Reservoir Barkley Reservoir	All Seasons All Seasons	2023 2024
Ride Alongs	Kentucky Reservoir, Barkley Reservoir, Ohio River, Mississippi River	All Seasons	2023/2024

Literature Cited:

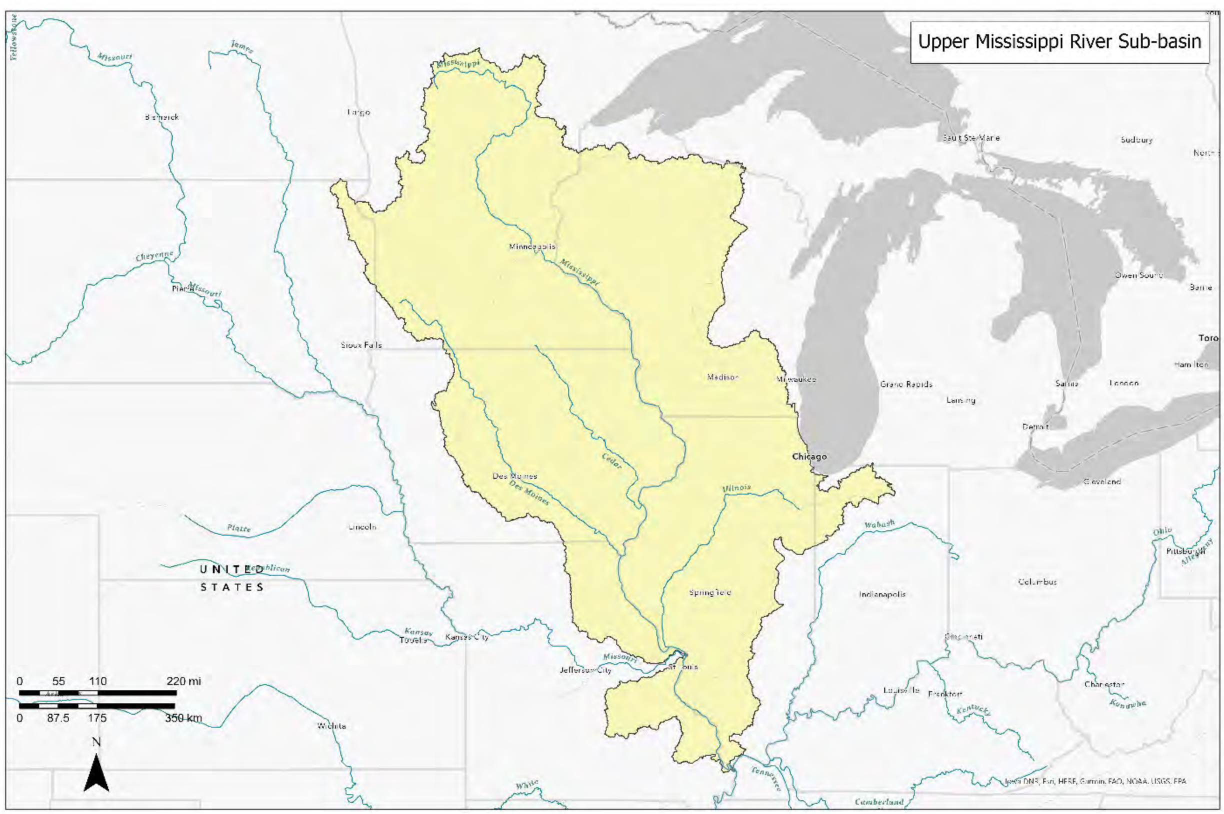
Collins,S.F.,andD.H.Wahl.2017.Invasiveplanktivoresas mediators of organic matter exchanges within and across ecosystems. Oecologia 184: 521–530.

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.

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.

The Upper Mississippi River sub-basin has nine projects in 2023. The UMR received $2,754,264 going to four different states.



Contract Fishing for invasive Carp Detection and Removal

Lead Agency and Author: Illinois Department of Natural Resources (ILDNR), Illinois Natural History Survey (INHS), James Lamer (lamer@illinois.edu)

Cooperating Agencies: Missouri Department of Conservation (MDC)

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). 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 downstream of Lock and Dam 19 in the UMR. 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 and help reduce populations as a whole, 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 through enhanced commercial fishing and contract facilitation program, down to the confluence of the Ohio River, including the Kaskaskia River will not only reduce the likelihood of upstream expansion and but also reduce the overall abundance of Invasive carp.

Objectives:

1. To fish and remove invasive carp populations (guided by fishermen knowledge and telemetry efforts) in Pools 14-19 of the Upper Mississippi River using contracted commercial fishers to reduce invasive carp populations in the management zone while reducing reproductive potential and density pressure on upstream pinch points (Lock and Dams 15,14) throughout the year.
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
3. To collect and offload telemetry receivers, assist with implanting fish, manual track telemetered fish and provide frequent feedback to help direct contracted fishing efforts.
4. Collect demographic data to help support spatially explicit modelling to enhance contract fishing efforts. This includes metrics such as age, GSI, body condition
5. To promote additional commercial fishermen harvest for bighead carp and silver carp in Pools 19 and 18 by paying fishermen an extra $0.10/lb up to $10K for fishermen enrolled in the program.
6. Targeted removal of invasive carp species in UMR from Cairo, IL, Pool 26, Pool 22, Pool 21, and Pool 20 using agency staff and or contracted fishers to reduce invasive carp density below Lock and Dam 19 and potentially decrease the number of invasive carp attempting to pass upstream into the Intensive Management Zone.
7. Synthesize harvest and telemetry data needed to help better inform rapid, adaptive invasive carp harvest management and efficiency in the UMR.

Agency: Illinois Department of Natural Resources (ILDNR), Illinois Natural History Survey (INHS)

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.

<u>*Objective 1*</u>. *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 100,000-200,000 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) where all fish will be iced down in large totes and used as fertilizer or as cut bait.

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, 2024

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. To collect and offload telemetry receivers, assist with implanting fish, manual track telemetered fish and provide frequent feedback to help direct contracted fishing efforts.

During the course of contracted harvest and as applicable, INHS biologists will assist with acoustic receiver downloads in coordination with USGS and USFWS collaborators to help evaluate invasive carp habitat use to increase harvest efficiency. This also includes assisting with tag implantation, manual tracking carp to better inform fishing efforts for the week. Number of fish tagged can vary, but will include at minimum the tagging of 250 invasive carp that will provide additional data points for real-time receiver harvest guidance. Manually tracking will occur primarily on Mondays to guide harvest for the remaining days of the week.

<u>Objective 4.</u> 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.

<u>Objective 5.</u> To promote additional commercial fishermen harvest for bighead carp and silver carp in Pools 19 and 18 by paying fishermen an extra $0.10/lb up to $10K for fishermen enrolled in the program.

Enhanced commercial fishing in Pools 19 and 18 will be explored in 2023-2024 by funding fishermen an additional $0.10 per lb for harvested bighead carp and silver carp up to a total of $10,000 (100,000 lbs). Fishermen that enroll in the program will be required to fish in Pools 19 and 18 only and must adhere to a strict reporting regiment. Tetratech, Inc. will assist with project coordination with fish processors and fishermen ($5,000).

<u>Objective 6.</u> Targeted removal of invasive carp species in UMR from Cairo, IL to Pool 26, and Pool 22-Pool 20 using agency staff and or contracted fishers to reduce invasive carp density below Lock and Dam 19 and potentially decrease the number of invasive carp attempting to pass upstream into the Intensive Management Zone.

ILDNR will implement an invasive carp removal program utilizing contract fishing and enhanced contract fishing in addition to facilitation contracts. The current program that is used for the ORB, initiated in early 2022, will be expanded into the UMR. It offers contracts to licensed commercial fishers for compensation of $0.10 per pound for invasive carp removed from designated commercial waters and sold to a fish processor(s) or other buyer(s) for at least $0.07 per pound. The program for this proposal maintains these same terms but expands the designated waters from which fishers may remove invasive carp. New water bodies include (1) the Mississippi River from Pool 26 north of St. Louis, Missouri to confluence of the Mississippi and Ohio rivers, and (2) the Kaskaskia River from the river’s headwaters west of Champaign, Illinois, to the Mississippi River.

Enhanced fishing contracts will be entered into for the water bodies referenced above and made available to any licensed commercial fishers who wish to participate in the program. Contracts will have a maximum of $99,999.00 in payments to be made for invasive carp caught in the designated waters and sold to processors or other buyers for the minimum price per pound. Prior to reimbursement, fishermen will be required to present to the program a cover sheet and receipt for each catch. Cover sheets will include fisher name, address, commercial fishing license, equipment used, catch location (by pool), affidavit, signature, and date. Receipts must contain name, address, license number, catch location, and date as well as buyer name and address, invoice number, listing of each species, each species weight, and price per pound. Prior to each fishing day, fisherman will be required to notify the program of their intended fishing location and boat ramp they expect to use.

Data collected through this program will include fish weight by species, catch locations, dates, and equipment used. These data will be provided to Southern Illinois University for measurement against hydroacoustic and other fish population analyses to determine population changes and effects of removal on population characteristics in select reaches.

This program facilitates practicable mechanisms for use of the harvested fish by private industry for a variety of purposes, including human consumption. Through a cooperative relationship of agency and fisher along with end users/markets, technical assistance and support will be provided, as necessary, to further inform fishers on the delivery of quality and quantity of fish to the end user/markets through this interaction. This program allows for personnel services, and contracts for fishing as well as any necessary contracts for staff monitoring personnel.

This program also contributes to providing critical information on population densities of invasive carp over time in the Mississippi River basin to guide agency management efforts. Additionally, to synthesize and adaptively evaluate and improve harvest and telemetry efforts to inform harvest, funds are being requested for 1, 2 year post-doc position to synthesize harvest and telemetry data and assist with building predictive models to better understand and predict invasive carp use of upper Mississippi River habitats. Collectively, including benefits and indirect costs, this position would require funding of $189,741 for the duration of 2 years. This position will be responsible for synthesizing telemetry data and answering questions related to harvest to better understand tributary and backwater use, evaluating harvest success through removal of tagged fish in targeted, closed backwaters, and looking at telemetered fish response to harvest in certain areas. These are some of the primary questions that need to be answered to help us move the science forward to more effectively target and remove fish from the system.

Contracted Facilitation

The Contracted Facilitation program was initiated offers contracts to fish processors and other buyers purchasing invasive carp from commercial fishers. Purchases must be made from either a facility or pick locations within 10 miles of designated waters. Compensation is $0.05 per pound for invasive carp removed from designated commercial waters and purchased for at least $0.07 per pound. The program in this proposal maintains these same terms but expands the designated waters from which fishers may remove invasive carp and where processors may pick up. New water bodies include the Mississippi River from Pool 26 north of St. Louis, Missouri, to confluence of the Mississippi and Ohio Rivers; and the Kaskaskia River from the river's headwaters west of Champaign, Illinois, to the Mississippi River.

A similar contract to the Enhanced Contract Fishing Program is made available to any licensed buyer, if applicable, authorized to operate in Illinois and Missouri. These buyers must also have a facility and/or buy invasive carp within 10 miles of one or more of the regional river system areas noted in the Designated Waters list section above. Invasive carp must be caught in one or more of the areas noted in the Designated Waters. Contracts will provide payment of $0.05 per pound up to $99,999.00 for invasive carp offloaded from commercial fishers at processors' facilities that are located within 10 miles of water edge of any of the designated waters listed above, or that are providing pick up waterside and/or at buying station(s) within 10 miles of the designated waters above. Invasive carp must be caught in one or more of the Designated Waters and/or Additional Fishing Area listed above and sold for at least $.07 per pound.

Facilities, buying stations, and other pick-up locations are required to be pre-approved by the program prior to use. Locations may be established at public boat launches, up to 10 miles from the shoreline. Considerations for pickup locations may be further defined and coordinated with state and local managers and customized based on need, site location, and other relevant factors. Buyers will be required to pay the same minimum $0.07 per pound price established for the Enhanced Contract Fishing Program and will be required to present copies of receipts for invasive carp purchased at designated locations. These receipts must contain the same information as for the Enhanced Contract Fishing Program and will be required to be accompanied by a similar cover sheet. Prior to pick up, the buyer will be required to notify the program of the intended pick-up location and (if applicable) license plate of the truck to be used.

This program will support efforts to evaluate contracted facilitation as a method of increasing invasive carp harvest to increase ability to manage/reduce the invasive species while informing future investments in these basins and others. 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.

Illinois will work with state partners to optimize facilitation to meet removal objectives. Harvest facilitation, paired with commercial or contract fishing in the UMR, will reduce propagule pressure at intensive management zones. Partners will contract several commercial fishers to target invasive carps throughout the year when weather and river conditions are satisfactory for fishing. ILDNR and MDOC (or their designees) are providing oversite and/or observers as appropriate in coordination with state management agencies to keep records of fishing effort, locations, harvest, gear types, and bycatch.

Objective 7. *Synthesize harvest and telemetry data needed to help better inform rapid, adaptive invasive carp harvest management and efficiency in the UMR.*

This funding will support a 2-year quantitative biologist position capable of synthesizing harvest and telemetry data to inform predictive harvest models and use harvest data to adaptively monitor the carp population. This INHS employee will work closely with ILDNR, USGS, USFWS, and other state collaborators to synthesize and apply harvest data and associated environmental data to not only help build predictive models to better inform harvest in the IMZ (Pools 16-19), but also predict areas to harvest invasive carp in low-density carp areas (upstream of IMZ) where fish can be very exceedingly difficult to target.

Estimated Timetable of Activities:

Project Activity	Pool	Month	Year
Harvest	14-19	October-September	2023-2024
Intensive harvest	16-19	April	2024
Demographics	14-19	Yearly	2023-2024
Enhanced harvest	OHR, PL26, PL 22-PL20, Kaskaskia River, PL19,PL18	October-September	2023-2024

Map of Project Area:

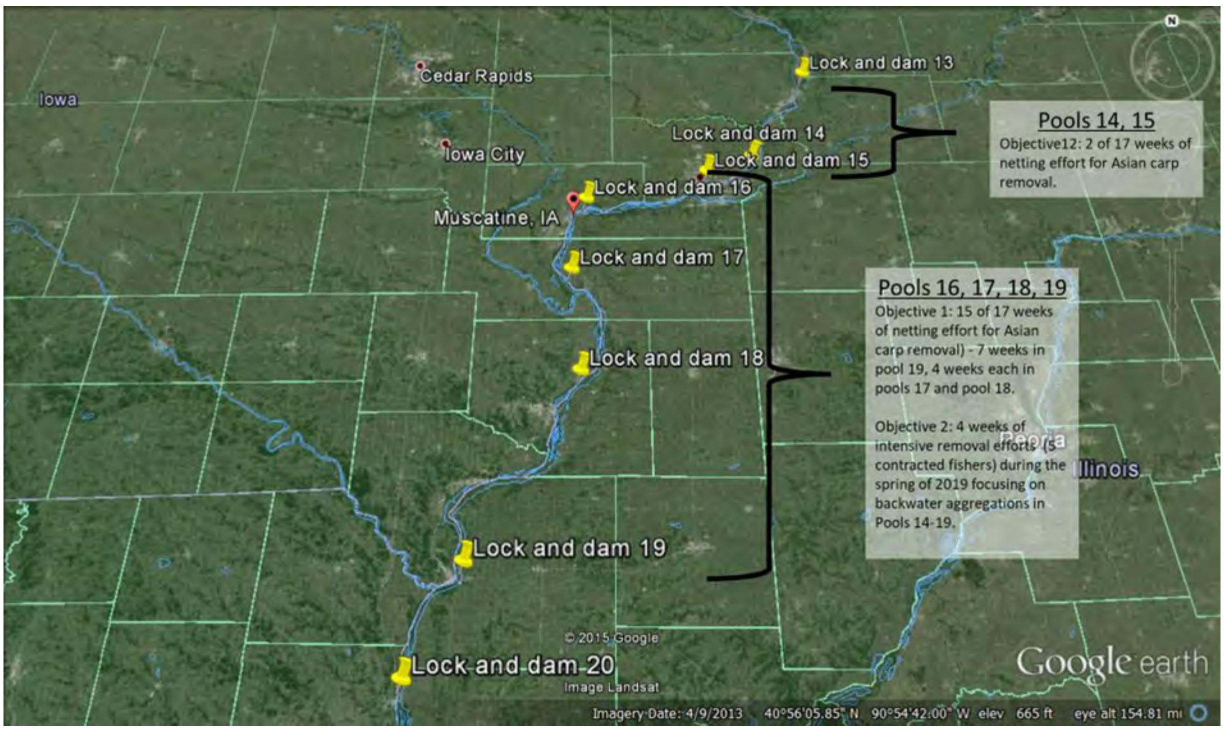


Figure 1. Map of study area for contracted removal

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: Dense, reproducing populations of bighead, grass, and silver carps exist in the lower pools of the Upper Mississippi River (20-26). Limited fish passage at Lock and dam 19 (LD19) has slowed their progression and establishment in UMR reaches above Keokuk, IA. To combat population expansion and decrease invasive carp densities, we propose removal efforts in pools downstream of Lock and Dam 19. While this effort may not directly affect the reduction in reproduction and recruitment in the Intensive Management Zone, it will reduce the overall density of invasive carp in the pools in the secondary management zone (Pools 20-22). This reduction in density downstream of 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.

MDC will continue an invasive carp harvest program that will employ a tiered approach with the potential to use agency staff, contract fishing and/or enhanced fishing to support Objective 6. Missouri removal efforts will occur in Pools 20, 21, and 22 to minimize movements of carp into the Intensive Management Zone above Lock and Dam 19. Removal efforts will take place in the fall and winter of 2023 as river conditions permit and contracts are in place.

In support of Objective 4, the other portion of funding will be used to support a biologist that will be coordinating removal efforts, pick up for harvested invasive carp by processors (coordinating with IL and KY for pick up if a certain number of pounds are harvested).

Map of Project Area:

Estimated Timetable for Activities:

Activity	Pool	Time Period (Season, month/year)
Invasive Carp Removal	20,21,22	Fall and Winter 2023
Ride Alongs/Data Collection	20,21,22	Fall and Winter 2023
Data Summary/Analysis	20,21,22	Winter 2023/2024
Annual Report	20,21,22	March 2024

Literature Cited:

2020 Invasive Carp Action Plan. http://www.invasivecarp.us/PlansReports.html

Evaluation of controls on density and behaviors of invasive carp in the lower UMR

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Cooperating agencies: Illinois Natural History Survey (INHS), Illinois Department of Natural Resources (ILDNR), Missouri Department of Conservation (MDC), Iowa State University (ISU), Iowa Department of Natural Resources (IADNR), US Geological Survey (USGS), Minnesota Department of Natural Resources (MNDNR).

Statement of need: In the Upper Mississippi River (UMR), Lock and Dam 19 (LD 19) in Keokuk, IA (rkm 2122), prevents upstream fish movement except for movement through the navigation lock chamber (Wilcox et al. 2004). Contracted commercial fishing and research funded through the UMR invasive carp partnership show high densities of invasive carps below LD 19 while populations above the dam exhibit drastically lower densities with limited reproduction (WIU & ILDNR 2018; MDC 2017). The Upper Mississippi River 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 began in FY21, and various levels of independent commercial fishing for invasive carp also occur, primarily below LD 19. A robust stock assessment program is needed to more directly evaluate how populations of invasive carps may be affected by current contract removals and control efforts, and to forecast their future response to alternative control strategies. A robust stock assessment program that incorporates information from telemetry, hydroacoustics, and multiple fishery-independent and dependent sources to provide the least-biased composite estimate of carp abundance, biomass, demographic distributions, and migratory tendencies is needed. 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.

Objectives:

1. Establish a sampling protocol for hydroacoustic surveys in the UMR to estimate Silver and Bighead Carp relative abundance, size distribution, spatial distribution and biomass at the pool-scale, to inform and evaluate management actions in the UMR.

2. Use hydroacoustic surveys to assess contracted removal operations, providing abundance estimates pre- and post-removal operations in areas within the intensive management zone (IMZ; Pools 15-19) and investigating relationships between hydroacoustic estimates and removal CPUE.

3. Conduct fishery-independent monitoring to quantify relative abundance, sex ratio, body condition, recruitment, growth, and mortality of invasive carp, support hydroacoustics

surveys, and inform and evaluate management actions in the UMR.

4. 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-26

5. Use light traps to establish an annual index of spawning activity by Silver and Bighead Carps in Pool 19.

6. Investigate the feasibility of a large-scale mark-recapture project for estimating Silver and Bighead Carp mortality in the UMR.

Agency: U.S. Fish and Wildlife Service La Crosse Fish and Wildlife Conservation Office (USFWS)

Activities and Methods:
Hydroacoustics Surveys in Pools 18-20

In support of Objective 1, the USFWS will continue working to establish a hydroacoustics sampling protocol for invasive carp in the lower UMR. 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 and may also expand to neighboring pools if time permits. Surveys will focus on the relative abundance, size distribution, spatial distribution, and biomass of invasive carp. Hydroacoustic data will be collected similar to that described in MacNamara et al. (2016) and Coulter et al. (2018). 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 Demer et al. (2015). Surveys will be conducted in September and October at selected areas of the main channel, side channels, bays and backwaters of Pools 18-20. Transects will be 0.5 nautical miles (nmi) in length, transect locations in these pools will be selected using a stratified random survey design. Transect length and level of sampling effort needed for each pool was determined through a re-sampling analysis of comprehensive pool survey data that was collected in FY21 and FY22.

Hydroacoustic data will be processed 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/habitat-specific fish community data that will be collected using several fisheries gears including fishery-independent data collected by the USFWS (see below), data from established state partner monitoring programs such as the Illinois Natural History Surveys long term electrofishing program (LTEF) and from fishery-dependent sources such as contract removals.

Pool/habitat-specific proportions of fish will be determined for each 1 cm length group for Silver Carp, Bighead Carp, and other fish species. Length-specific proportions will then be used to categorize acoustically detected fish. Length-weight regressions will then be used to estimate length-specific biomass for each species of interest, and relative density (numeric and mass) will be estimated.

In support of Objective 2, in addition to pool-wide population surveys, additional pre- and post-harvest surveys will also be conducted in FY23 at removal areas in the IMZ. Using similar data collection methods as the pool-wide surveys, these surveys will be conducted before and after contracted harvest events to evaluate harvest efficacy and establish the relationship between hydroacoustic density estimates, and harvest CPUE.

Fishery-Independent Sampling

In support of Objective 3, 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 ratios, tissue samples for genetic and physiologic studies, etc.) and enable estimates of recruitment, growth, and mortality. Furthermore, hydroacoustics gear requires physical sampling to separate the overall fish community size distribution into species-specific distributions. Fishery-independent sampling, using sampling gears like electrofishing and electrified dozer trawls, is less size selective than fisheries-dependent data collected through commercial netting captures, 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 FY23, the USFWS will use an electrified dozer trawl (Hammen et al. 2019) to conduct sampling from Pools 18-26, in portions of the open river reach extending downstream to the confluence with the Ohio River, and in locations associated with previous or new contracted removal efforts. Sample locations were identified as individual pools of the UMR (i.e., pools 18-26), and 10 kilometer stretches of river centered around major tributary confluences in the open river reach of the UMR (i.e., Missouri, Meramec, Kaskaskia, Big Muddy, Headwaters Diversion Channel, and Ohio Rivers). Habitat complexes within each study location or pool will be stratified into four categories: Main Channel Border, Side Channel, Backwater, and Tributary. A minimum of 20 sites will be sampled in each pool or tributary confluence location, with greater effort applied upstream of LD 19 in areas with low invasive carp density. Sample sites will be randomly selected and apportioned by habitat availability and accessibility.

Sampling will be conducted from August - September, usually with water temperatures around 20ºC ± 5ºC, during daytime. Fall sampling allows for more stable water levels, reduces the impact of reproduction on length-weight relationships, and coincides 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). This time period will also align with hydroacoustic surveys.

A standard electrified dozer trawl sample will consist of a five-minute transect with a boat speed of 4.8 kph (3.0 mph) conducted along the contour of the shoreline, as close to shore as possible without obstruction and where the net is completely submerged (net frame is 0.91 m high). Transects will be conducted in an upstream fashion when nearshore currents are less than 0.5 m/s to be most efficient with catches (Guy et al. 2009). In backwaters with an absence of flow, discretion will be left to the operator as to which direction along the shoreline to conduct the sample. For crew safety, sampling should not occur when nearshore currents are greater than 0.5 m/s. If current, depth, or other factors limit the ability to conduct a sample in the projected location, a list of alternate sites will be available from which to find a suitable replacement.

Total length (mm), weight (g), and sex will be recorded for all invasive carp captured. Sex will be determined for stock-sized and larger Silver Carp based on the presence of pronounced ridges on the dorsal surface of pectoral fins, which indicates the fish is male, or the absence of which indicates the fish is female (Wolf et al. 2018). Stock size for Silver Carp is 250 mm (Phelps and Willis 2013). Sex of Silver Carp below stock-length, and for Bighead Carp, will be determined through visual examination of the gonad. Maturity will be determined for all invasive carp between 300mm and 600mm TL. All fish under 300mm will be presumed immature and all above 600mm will be presumed mature. All bycatch will be identified to species, and enumerated. By-catch longer than 254 mm (10 inches) will be measured to the nearest millimeter total length, (eye to fork length for paddlefish), and weighed to the nearest gram.

For each study location, lapilli otoliths will be extracted from the first 100 Silver Carp and 100 Bighead Carp captured, with a maximum of 20 each per transect. After the initial 100, lapilli otoliths will be removed from five males and five females of each species for each 50 mm length bin for fish greater than 400mm total length that were not represented in the first 100 fish captured. Lapilli otoliths will also be extracted from the first 10 fish for each 100mm length bin below 400mm total length if not represented in the first 100 fish. Extracted otoliths will be stored in coin envelopes to allow otoliths to dry.

<u>Lab processing</u>

Otoliths collected from this sampling effort will be deposited in one of the USFWS Region 3 aging labs (Columbia, MO Fish and Wildlife Conservation Office, La Crosse, WI Fish and Wildlife Conservation Office). All otoliths will be prepared by mounting in epoxy and sectioning each lapilli otolith on a transverse plane at the nucleus using a low speed isomet saw with two 2-5" Isomet 20 LC blades with a .3mm spacer and polished with lapping film. Prepared otoliths will then be mounted on a slide, submerged in glycerol and analyzed using a Nikon SMZ25 dissecting scope with a camera using NIS Elements software or similar dissecting scope with similar software to capture and analyze pictures. If the first otolith is unreadable, the second otolith will be prepared and analyzed in the same manner. Three readers will analyze each otolith independently, then a final age will be recorded using a 2/3 or consensus mutual agreement (Maceina and Sammons 2006; Seibert and Phelps 2013). If no agreement can be reached, the otolith will not be used for analyses.

<u>Data analysis</u>

Relative abundance will be calculated as CPUE in fish/hour. Relative standard error (RSE) of invasive carp CPUE will be calculated for each pool and study reach to estimate precision of catches. A target CPUE RSE of ≤ 25 (Dumont and Schlechte 2004) represents reduced variability and is recommended when quantifying relative abundance of a fish population.

For each study location, relative abundance, sex ratio, body condition, recruitment, growth, and mortality will be calculated for Silver Carp and Bighead Carp. Sex ratio will be calculated as a ratio on a scale of one. Body condition will be calculated using standard weight equations published in Lamer (2015). An updated Pauly (1980) mortality estimator will be used to estimate mortality (Then et al. 2015). Age Frequency histograms will be used to provide evidence of recruitment trends. Finally, a von Bertalanffy (1938) growth model will be used to estimate growth parameters. Additional analyses will be utilized as appropriate to meet study objectives.

USFWS staff will be following an adaptive monitoring approach while implementing this sampling program as an intertwined component of the larger comprehensive stock assessment. Sampling protocols may be re-evaluated in the future to include additional gears or techniques, 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

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. In support of Objective 4, the USFWS will continue to maintain an extensive acoustic telemetry network in Pools 5a-20. Real-time receivers will be seasonally 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. This specialized technology allows INHS personnel to accurately direct the timing and location of fishing efforts to maximize harvest rates.

USFWS will partner with INHS, IA DNR, Iowa State University and USGS to capture and tag invasive carp in Pools 12-14 during FY23. We will also be partnering with WI DNR to attempt to capture and tag up to 30 invasive carp in the Wisconsin River and downstream Pools 10-12. Lastly, we will collaborate with MN DNR to attempt to capture and tag up to 24 invasive carp in Pools 5A-8. Some FY23 funds will be used to fund 1/3 of a FTE at INHS to assist with the telemetry project, including tagging, tracking, and downloading receivers. We will also provide in-kind support to IA DNR and Iowa State University projects to monitor invasive carp movements into Iowa tributaries.

The USFWS will coordinate efforts with MDC, who maintain receivers in the UMR below Pool 20 downstream into the Lower Mississippi River to monitor longitudinal movements of Silver and Bighead Carps (see MDC section below); Iowa State University who operates receivers in Mississippi River tributaries (see IA State University section below); MN DNR, who maintain receivers in the UMR above Pool 5a; INHS, who assist in deployment and 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 from these large-scale telemetry efforts will help document movement patterns (i.e., residency time, and transition rates between pools and basins), inform removal efforts, and describe movements of Silver and Bighead Carp in response to contract removal. These data will also be available for use to inform complex temporal-spatial models (i.e., SEICarP) that could be developed for the UMR by modifying models developed in other basins.

Map of Project Area:

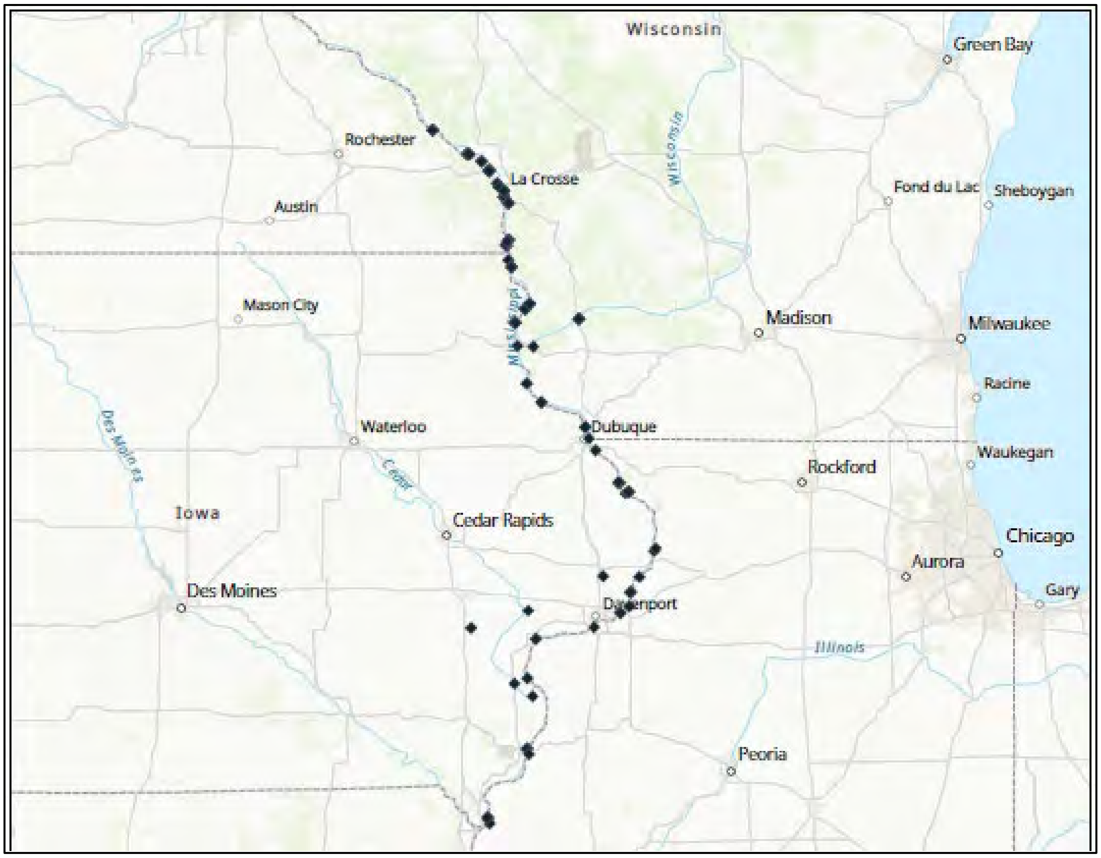


Figure 1: Locations of stationary receivers deployed by USFWS and INHS (diamonds) in the Mississippi River basin during 2023.

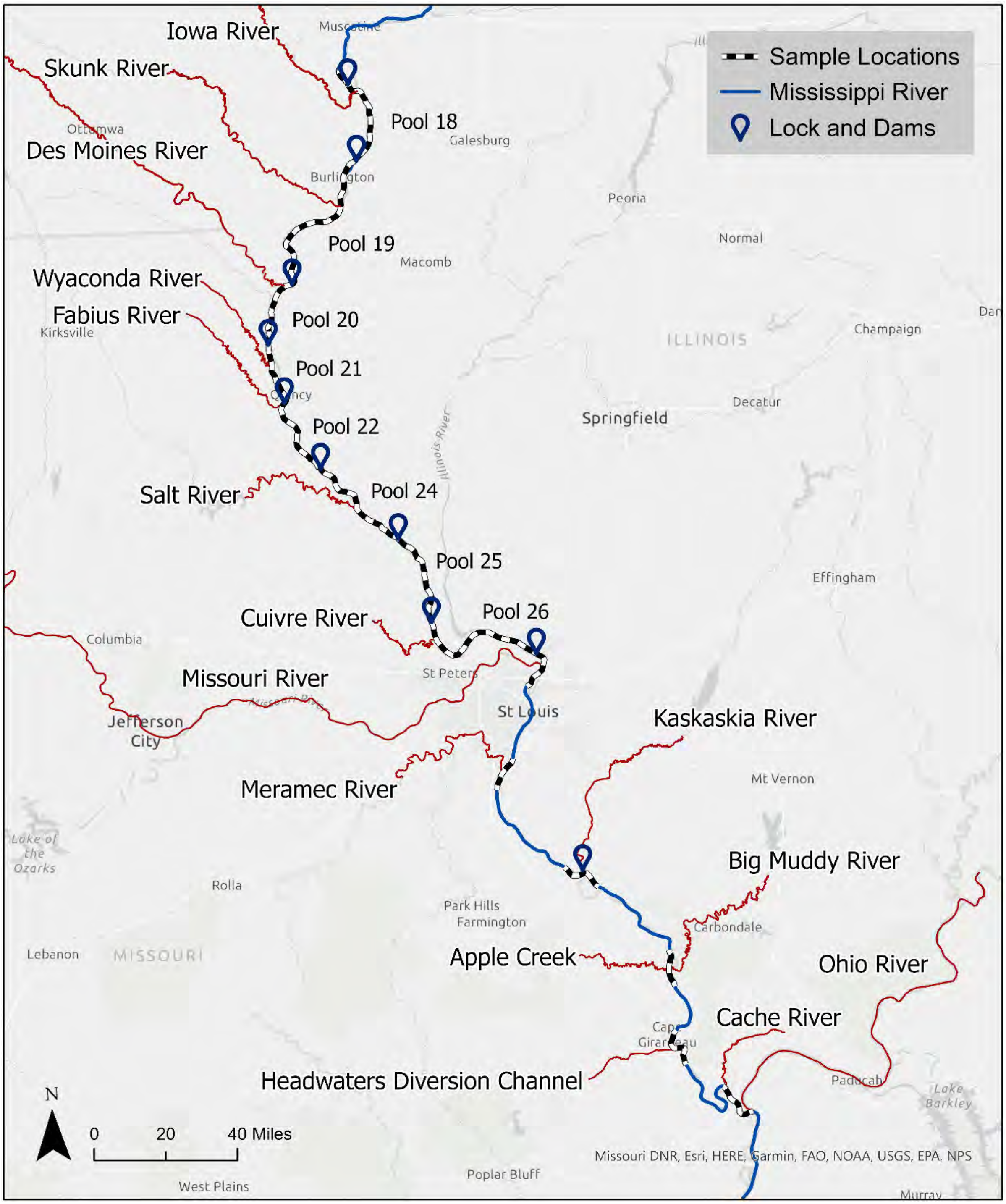


Figure 2: Locations of fishery-independent sampling conducted by the USFWS in the Mississippi River basin, 2023.

Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Hydroacoustic evaluation concurrent with removals	16-19	Spring	2023
Hydroacoustic Pool Surveys	18-20	Fall	2023
Fishery-Independent Data Collection	18-26, open river	Aug/Oct	2023
Deploy Acoustic Array	5A-20	Spring	2023
Capture and Tag Additional Invasive Carp	8-19	Spring	2023
Download Data from Stationary Receivers	5A-20	Every 4-6 weeks	2023
Annual Report	5A-20	March	2024

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

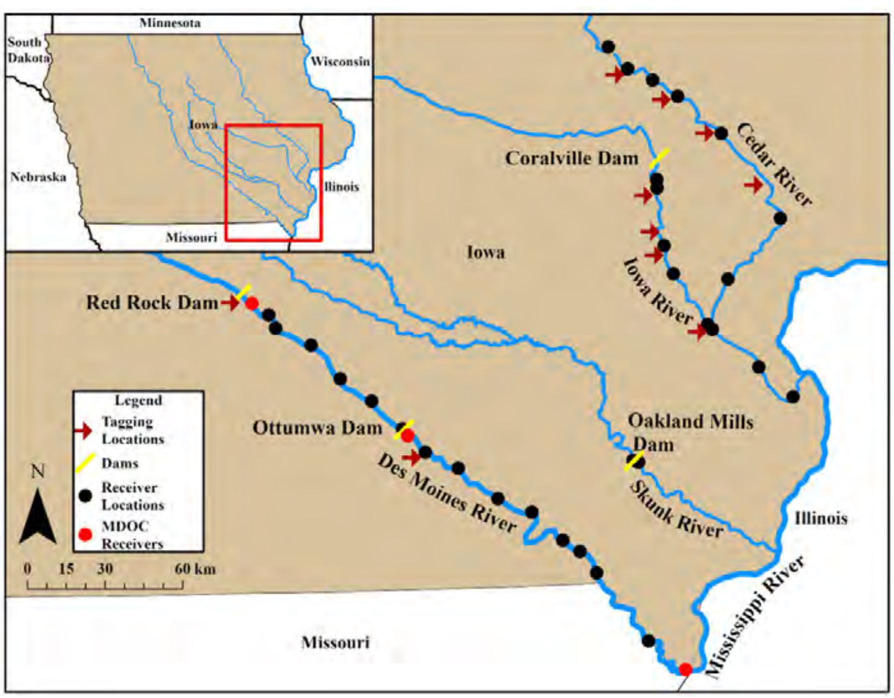
Activities and methods:

In support of Objective 4, ISU and IADNR have enhanced longitudinal telemetry arrays in Upper Mississippi River (UMR) tributaries, operating receivers in the Des Moines River (n=17), Skunk (n=2), Iowa (n=8), and Cedar (n=7) rivers to determine residency and migratory patterns of Silver and Bighead Carp in those tributaries. Movement dynamics have important implications for understanding population connectivity, spread, and whether separate populations occur at local scales or a large metapopulation exists over broad regions, with implications for local versus regional management and control efforts.

Silver and Bighead Carp tagged in the UMR have been documented to make frequent movements into the Des Moines and Iowa rivers during spring for spawning. However, large numbers of Silver and Bighead Carps have been observed in the Des Moines River throughout the year even during low water conditions, suggesting that at least part of the population may be residents that do not leave the system, particularly downstream of Red Rock and Ottumwa dams. No downstream barriers prevent Silver and Bighead Carp below Ottumwa Dam from returning to the Mississippi River, but a portion of these individuals may also choose to remain within the Des Moines River throughout the year. How fine scale movement of these fish varies compared to Silver and Bighead Carp in the Mississippi River is unknown, but would provide insight for local control efforts that may be able to target resident populations if they exist. Similar questions exist for the Iowa River at the leading edge of the invasion in the UMR where upstream movement is blocked by Coralville Dam but where Silver and Bighead Carp may choose to remain in the Iowa and Cedar rivers throughout the year. Additionally, the US Army Corps of Engineers is conducting experimental flow releases from Red Rock Dam to benefit native fishes. Altered reservoir water releases are likely to also alter the behavior and habitat use of Silver and Bighead Carp, but how these fishes respond to these new flow regimes is unknown.

Sampling and acoustic tagging occurs during fall and early spring when individuals from the Mississippi River would not be migrating up tributaries for spawning. Crews tagged 77 Silver and Bighead Carp in the Des Moines River during fall 2021, 38 between Red Rock and Ottumwa and 39 below Ottumwa. Despite substantial sampling effort, only 9 Silver Carp were captured and tagged in the Cedar River and no fish were captured in the Iowa River during fall 2021. Therefore, crews returned to the Cedar and Iowa rivers during spring 2022 prior to when individuals from the UMR were expected to move upstream and deployed the remaining transmitters (n = 24 in Cedar River, n =32 in Iowa River). Crews supplementary tagged an additional 30 Silver Carp in the Des Moines River (15 between Red Rock and Ottumwa and 15 below Ottumwa), 15 Silver Carp in the Iowa River, and 15 Silver Carp in the Cedar River during fall 2022. Additional tagging at all of these locations will occur during fall 2023. 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: Upper Mississippi River and four of its tributaries (Des Moines, Skunk, Iowa, and Cedar Rivers) in southeastern Iowa. Red arrows indicate Silver Carp tagging locations, black dots represent new receiver locations, and red dots represent locations of preexisting Missouri Department of Conservation receivers. Yellow lines denote location of dams.



Estimated Timetable for Activities:

Project Activity	**Pool**	**Season**	**Year**
Tag invasive carp with acoustic tags	18, 20	Fall	2022
Download acoustic receivers in tributaries	18, 20	Spring	2023
Download acoustic receivers and assess movements	18, 20	Summer	2023
Interim Summary Report	18, 20	March	2024

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 Pool 26. Data from the lower pool telemetry efforts will help fill in information gaps (i.e., residency time, and transition rates between pools and basins), inform removal efforts, and describe movements of invasive carp in response to contract removal throughout the system. These data will also be available for use to inform complex temporal-spatial models (i.e., SEICarP) that could be developed for the UMR by modifying models developed in other basins. Additional receivers or acoustic tags may be added to the system if deemed necessary.

MDC will coordinate with the UMR Partnership to ensure data is shared and updates are provided.

Map of Project Area: Locations of stationary receivers deployed by MDC in the Mississippi River basin during 2022.

Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Download Data from Stationary Receivers	20-26	Every 4-6 weeks	2023
Annual Report	20-26	March	2024

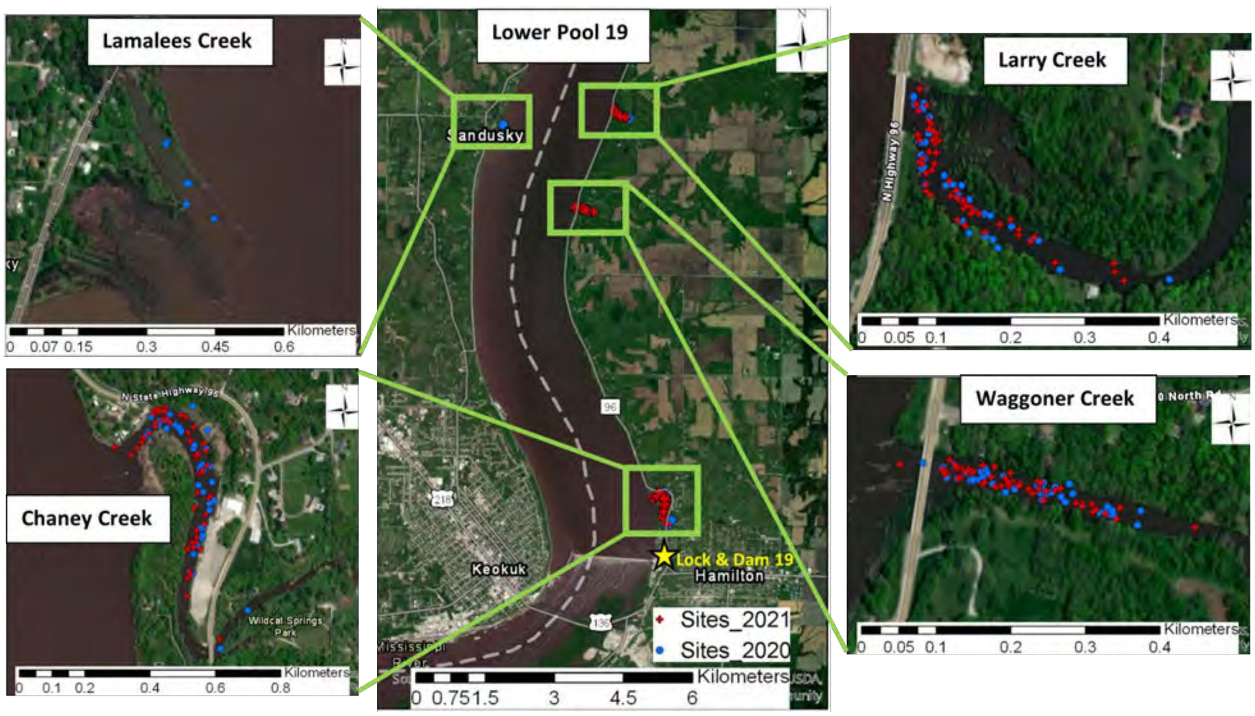
Agency: Illinois Natural History Survey (INHS)

Activities and Methods:

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. In support of Objective 5, 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: Larval light trapping locations in Pool 19 of the Upper Mississippi River.



Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Larval Light Trapping	19	Spring-Fall	2023
Process samples	19	Fall/Winter	2023/2024
Annual Report	19	March	2024

Agency: U.S. Geological Survey (USGS)

Activities and Methods:

Mortality Estimation Feasibility Study

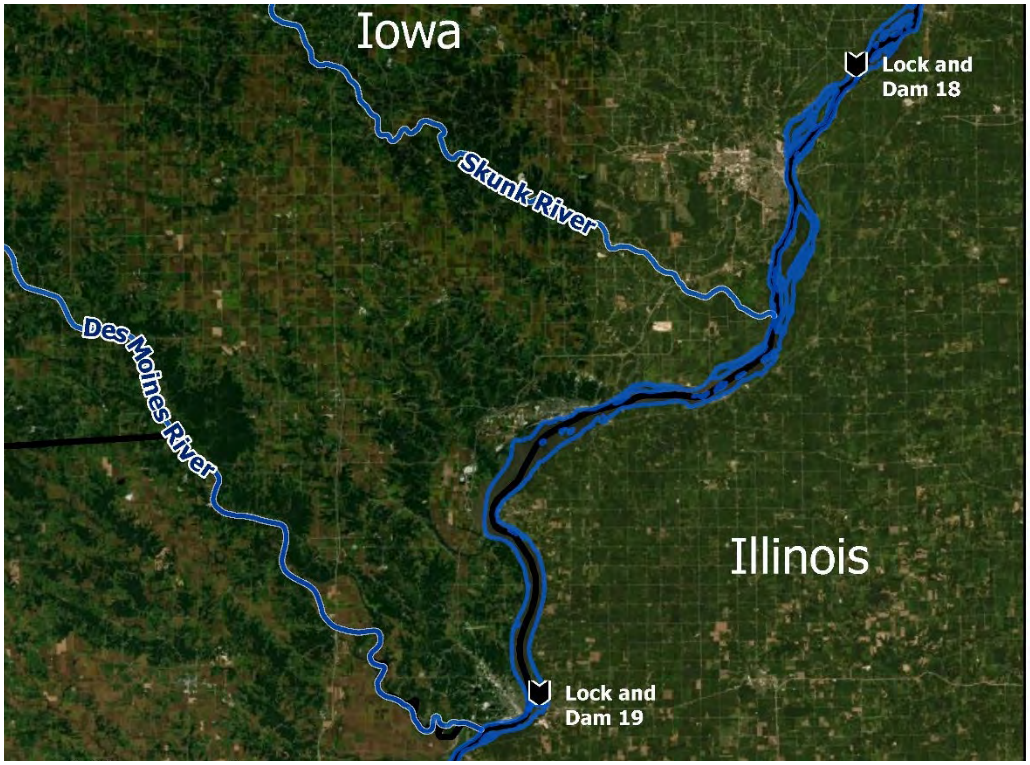
Understanding the effects of harvest of fish populations is critical to determining their status and appropriate management measures. Although there are several ways to estimate harvest mortality (e.g., stock assessment modeling and mark-recapture methods), these methods are often data-intensive, and it can take several years to collect the necessary information to develop reasonable estimates of harvest mortality. In addition, there is little guidance available to help natural resource management agencies develop sampling plans to effectively estimate harvest mortality. In support of Objective 6, this study seeks to develop guidance for mark-recapture studies to estimate the proportion of a population that is harvested. Initial simulation modeling began in FY22 using existing partner data from Pool 19. We used a series of simulations to examine the effects of different aspects of study design and assumptions on our ability to estimate fishing mortality in stochastic and information-limited environments. These simulations were designed following a Brownie model (Brownie et al. 1978) and assume that fish are affixed with an externally visible tag or marker that enables them to be identifiable minimally to the annual cohort of tagged fish.

In these simulations, we generated simulated tag-recovery datasets where a predetermined number of fish are marked with externally visible tags and some proportion of the tags are returned through annual harvest. We generated these datasets under a set of "known" parameters with added stochasticity to explore parameters that represent a range of management decisions and environmental scenarios. We then fit the simulated datasets to a Bayesian mark-recovery model and measured the magnitude of error between the fitted model parameters and the "known" parameters used to generate the dataset. In the simulations, we altered the study duration and the number of fish marked each year as well as assumptions about tag reporting and retention rates. For these simulations, we tested models using a range of "known" total annual harvest rates (as a proportion of the total population) that were held constant from year to year and ranged from 0.05 to 0.65. We selected a range of annual tagging effort to provide guidance to those considering tag-recovery studies that ranged from relatively small (50 tags per year) to large (4,000 tags per year). In our simulations, a short duration study included datasets with three years of fish tagging and four years of tag recovery, whereas a long-duration study included nine years of tagging and ten years of tag recovery.

In general, we found that it is possible to get reasonably accurate estimates of fishing mortality, even with relatively small studies (<200 tags/year, short duration study). If fishing mortality is low (5% of the population per year), however, a longer study duration and/or greater tagging effort (tags per year) may be needed. These simulations also indicated that it is important to have reasonable estimates of both the tag reporting and tag retention rates as these parameters were not directly estimable in the FY22 study design. Specifically, the tag reporting rate can have a large effect on the precision of the harvest mortality estimate and if it is over or under-estimated could result in misleading information regarding the number of tags or duration of the study necessary to obtain a precise estimate of harvest mortality.

The FY22 study assumed that harvest rate and natural mortality were constant throughout the duration of the study. These assumptions are likely unrealistic in practice. Addressing these assumptions are, therefore, the focus of the next steps in this modelling effort for FY23.

Map of Project Area: Data used for the initial simulations were collected from Pool 19 of the Upper Mississippi River.



Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Simulation modeling	19	Winter/Spring	2023
Report on modeling results for FY24 planning	19	Summer	2023
Final report	19	March	2024

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Evaluation of fish passage for assessment of invasive carp deterrents at locks in the upper Mississippi River

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Cooperating agencies: Missouri Department of Conservation (MDC), Illinois Natural History Survey (INHS), US Fish and Wildlife Service (USFWS) La Crosse Fish and Wildlife Conservation Office, US Army Corps 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 (U.S. Geological Survey, 2021). The physical and operational characteristics of Lock and Dam (LD) 19 restrict upstream movement of fishes because the only upstream fish passage route is through the lock chamber. This restriction might be hindering consistent reproduction and recruitment of silver carp *Hypophthalmichthys molitrix* and bighead carp *H. nobilis* enough to reduce their abundance upstream of LD 19. Locks and Dams 14 and 15 are infrequently in open-river condition (defined as the time when the adjustable spillway gates of the dam are raised out of the water, passing unobstructed water through the gates) and may also be limiting the continued upstream spread of invasive carp populations. 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 to deter fish movement through restricted passage points, and those systems show promise in deterring invasive carps (Murchy et al., 2017; Nissen et al., 2019; Putland & Mensinger, 2019). To date, small-scale acoustic deterrents have been tested on many native fishes and invasive carps in labs, outdoor ponds, and small rivers . In addition, there is a need to test these deterrents on a larger scale such as at lock structures in large rivers where invasive carps are abundant (Vetter et al., 2015; Murchy et al., 2017; Vetter, Casper & Mensinger, 2017). Federal, state, and local partners have agreed to move forward with testing an experimental underwater Acoustic Deterrent System (uADS) at LD 19 on the Mississippi River. The experimental uADS was installed during January 2021-March 2021. Testing of an experimental uADS at a pinch-point dam, such as LD 19, will help managers understand the impact of a deployment of a uADS at this site and other large river locations (Cupp et al., 2021; Fritts et al., 2021). There is a need to evaluate the effectiveness of the experimental uADS at preventing upstream passage of invasive carps into the lock chamber of LD 19 under varying environmental conditions and to assess the possible impacts to passage of native fish species. Our project proposes continued collection of movement data using VEMCO (Innovasea) receiver arrays and acoustically tagged fish in the upper Mississippi River (UMR) as part of the experimental uADS evaluation. Fiscal Year 2023 (FY23) funding will be used to tag and track native fish species, silver carp, and bighead carp. Lock and Dam 19 is an advantageous location to test an experimental uADS because upstream migrating fish can only move upstream through the lock chamber and because this location has five years of historical fish passage data that have been collected by the UMR Invasive Carp Team. The partnership has successfully evaluated 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 LD 19. Invasive carps that were originally tagged upstream of LD 19 and moved downstream on their own volition were much more likely to complete upstream passage through LD 19 than invasive carps tagged downstream of LD 19 in Pool 20 (Fritts et al., 2021). This observation prompted an experimental translocation effort in 2019. In addition, the partnership has gained insights into behavior of invasive carps and native species tagged with depth-sensitive transmitters. Data from these tags provided information about the position of a fish within the water column at LD 19 and how fishes interact and respond to river vessel presence in the downstream lock approach and lock chamber hydraulics. During spring 2021 and 2022, four native species (i.e., bigmouth buffalo *Ictiobus cyprinellus*, lake sturgeon *Acipenser fulvescens*, paddlefish *Polyodon spathula*, flathead catfish *Pylodictis olivaris*) were tagged with depth-sensitive transmitters to improve understanding of how native species react to the experimental uADS and river vessels at LD 19.

Passage data for invasive carps and native species (i.e., paddlefish, bigmouth buffalo) have also been studied at LD 15 over the past four years (Turney et al. 2022). 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 deployment of deterrents at these sites (Upper Mississippi River Asian Carp Partnership, 2018).

State and federal partners have identified evaluating the effects of a 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, 15, and 14 (Fig. 1-4). Many of the previously tagged fish will continue to be tracked in addition to newly tagged fishes by the passive receiver arrays. In the interest of maintaining sufficient numbers of active VEMCO tags in the area during the third year of the experimental uADS evaluation, we propose using FY23 funds to purchase 200 VEMCO tags that can be used to supplement existing native species of interest, tag additional native species of interest that are currently listed in the experimental uADS study plan (e.g., blue sucker *Cycleptus elongatus*, skipjack herring *Alosa chrysochloris*, American eel *Anguilla rostrata*, white bass *Morone chrysops*, freshwater drum *Aplodinotus grunniens*, walleye *Sander vitreus*, sauger *Sander canadensis*), and potentially supplement silver carp or bighead carp numbers in Pools 14, 15, 16, and 20 to maintain target numbers of active tags in proximity to LD 14, 15, and 19. Fiscal Year 2023 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, tracking, downloading receivers).

Information gathered from these receiver arrays are providing insight on how these fishes are passing through these locks and dams (i.e., LD 14, 15, and 19), and how passages relate to lock operation, environmental variables, and operation of the experimental uADS. Existing and future data will be used to evaluate the performance of the experimental uADS and the effects on invasive and native fish species. Information on fish behavior at LD 14 and 15 will be used to inform discussions on possible deployment of deterrents at these locations (Upper Mississippi River Asian Carp Partnership, 2018).

This project directly addresses multiple aspects of the UMR sub-basin framework (Jackson & Runstrom, 2018), including providing information on evaluating and implementing deterrent measures at strategic pinch points to prevent dispersal of invasive carps 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 assessing and potentially minimizing impacts to native species movement.

Objective:

1. Assessment of fish behavior and passage at lock and dam structures on the upper Mississippi River to evaluate passage rates, movement probabilities, and behavior in and around locks to inform and evaluate deterrent testing.

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 and 2022, depth-sensitive transmitters were implanted into paddlefish, bigmouth buffalo, flathead catfish, and lake sturgeon in Pool 20. U.S. Geological Survey and partners translocated invasive carps and bigmouth buffalo from locations upstream of LD 19 to Pool 20 during spring of 2021 and 2022 for the experimental uADS evaluation. These fish will be monitored to evaluate the response of invasive carps and native species to the experimental uADS installed at LD 19.

Fiscal Year 2023 funds will be used by INHS 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 LDs 14 and 15 (cost per transmitter = $350; cost for 200 transmitters = $70,000). Native fish species that may be tagged at LD 19 include bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye. Fish tagging will occur during fall 2023 and/or spring 2024 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. Fiscal Year 2023 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 2023, Spring 2024
Receiver downloads	Quarterly during 2023, 2024

Agency: US Fish and Wildlife Service (USFWS) La Crosse Fish and Wildlife Conservation Office

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 2023 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2023 and/or spring 2024 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 by the receiver arrays 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 2023, 2024
Tagging	Fall 2023, Spring 2024
Receiver downloads	Quarterly during 2023, 2024

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-20 in the spring of 2023 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2023 and/or spring 2024 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 by the receiver arrays 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 2023, 2024
Tagging	Fall 2023, Spring 2024
Receiver downloads	Quarterly during 2023, 2024

Agency: U.S. Geological Survey (USGS)-Upper Midwest Environmental Sciences Center

Activities and Methods: Fine-scale arrays have been deployed at LD 19 (Fig. 2), LD 15 (Fig. 3), and LD 14 (Fig. 4). These arrays will be maintained during 2023-2024. The USGS and the USACE-Engineer Research and Development Center will operate and maintain the experimental uADS at LD 19 through winter 2023/2024. In collaboration with partners, USGS will analyze telemetry data from the VEMCO arrays and the HTI (Innovasea) telemetry system deployed at LD 19. These telemetry data will be used to evaluate how environmental conditions (e.g., flow, water temperature, season, diel period), LD 19 lock operations, and operation of the LD 19 uADS affect native species and invasive carp movement and behavior (including passages). USGS will analyze VEMCO depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD 19 and how fishes respond to the experimental 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 *Ctenopharyngodon idella*) from Pool 19 to Pool 20 with HTI tags during spring 2023 to evaluate the performance of the experimental uADS (USGS Study Plan AEH-20-LD19ADS-01). 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 2023, 2024
Tagging	Fall 2023, Spring 2024
Analyze fish behavior, passages, and depth data	Winter 2023, Summer 2024

Agency: US Army Corps 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 carps while minimizing effects to native species. The USACE will provide Lock Queue Reports for LD 19, 15, and 14 on a quarterly basis to evaluate fish movements in relation to lock operation.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Provide Lock Queue Reports for LDs 19,15,14	Quarterly during 2023, 2024

Map of Project Area:

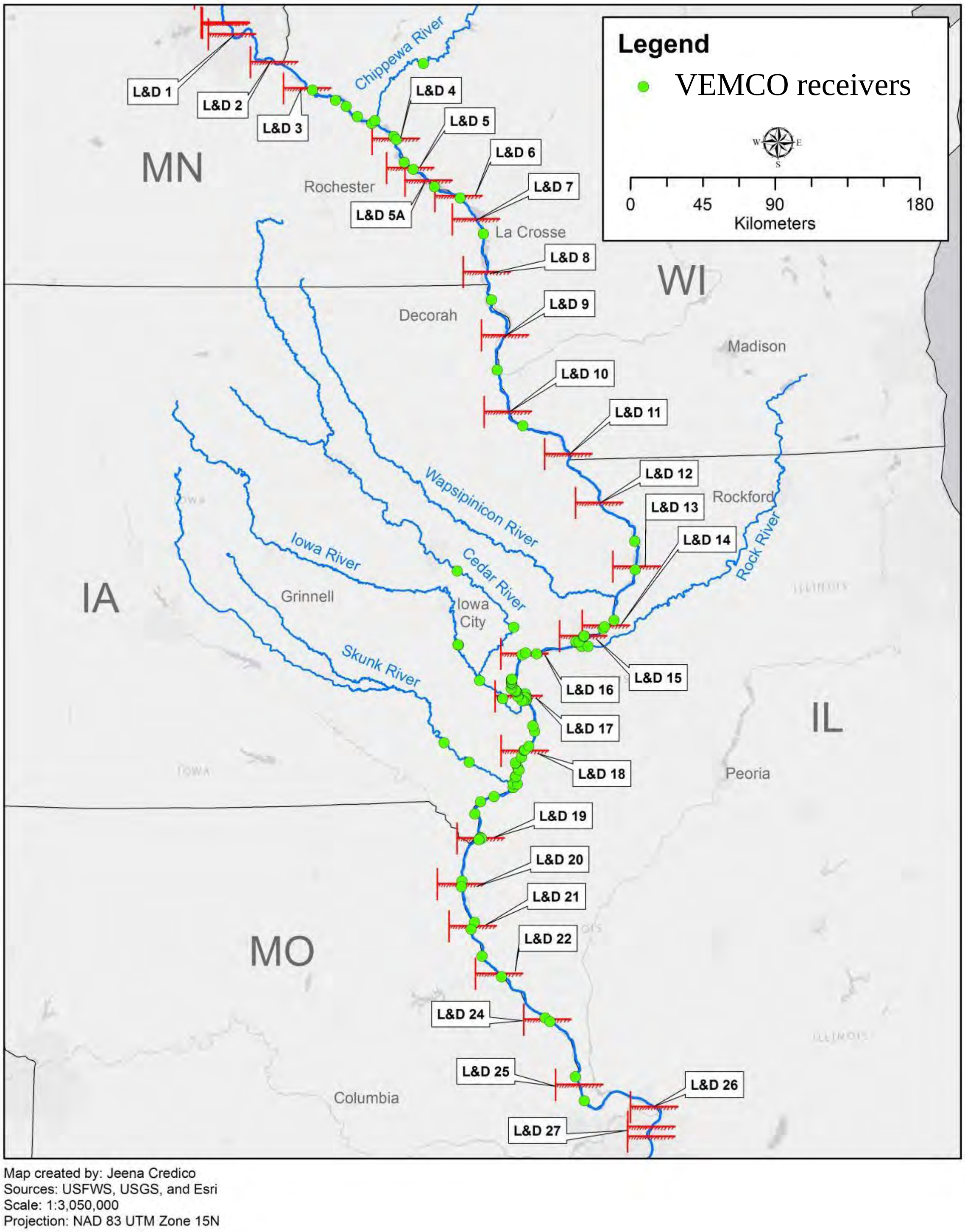

Figure 1. Locations of stationary VEMCO receivers in the longitudinal array deployed in the Mississippi River basin. Receivers are maintained by U.S. Fish and Wildlife Service (USFWS, above Lock and Dam 19), Missouri Department of Conservation (below Lock and Dam 19), and U.S. Geological Survey (USGS, fine-scale arrays at Locks and Dams 14, 15, and 19).

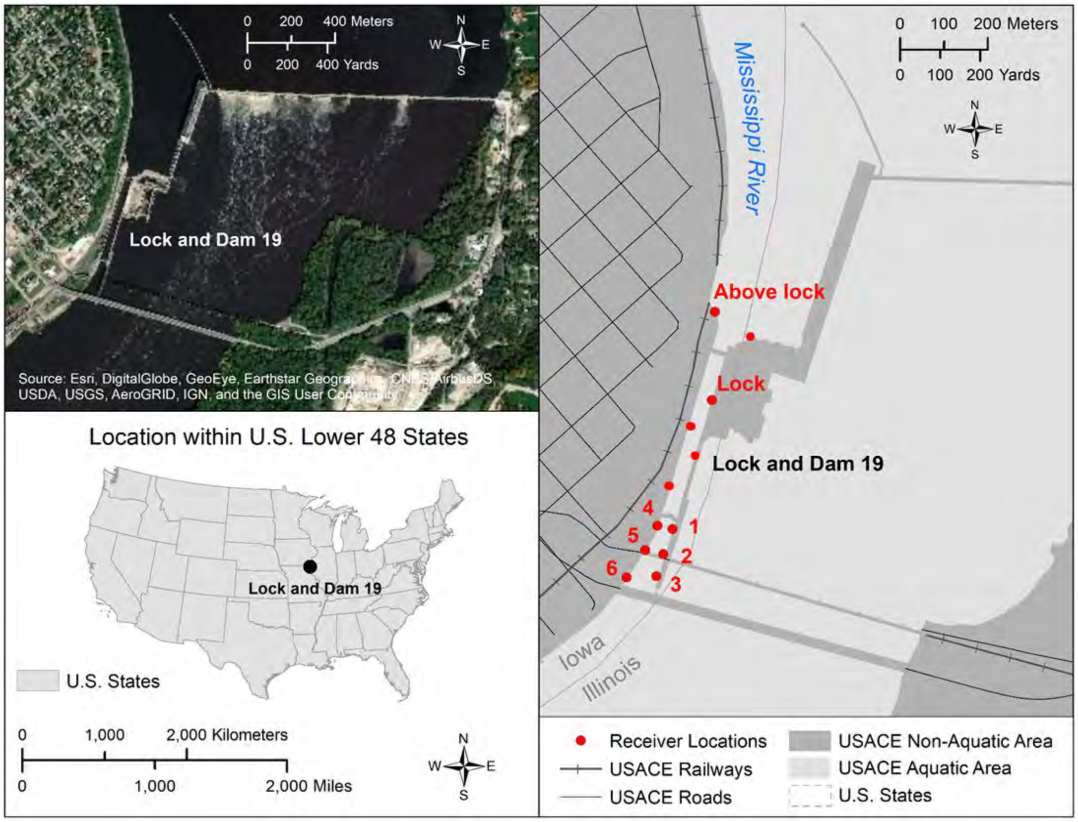

Figure 2. Location of telemetry receivers (red dots) in the fine-scale array at Lock and Dam 19. Array maintained by U.S. Geological Survey and Missouri Department of Conservation (USACE = US Army Corps of Engineers).

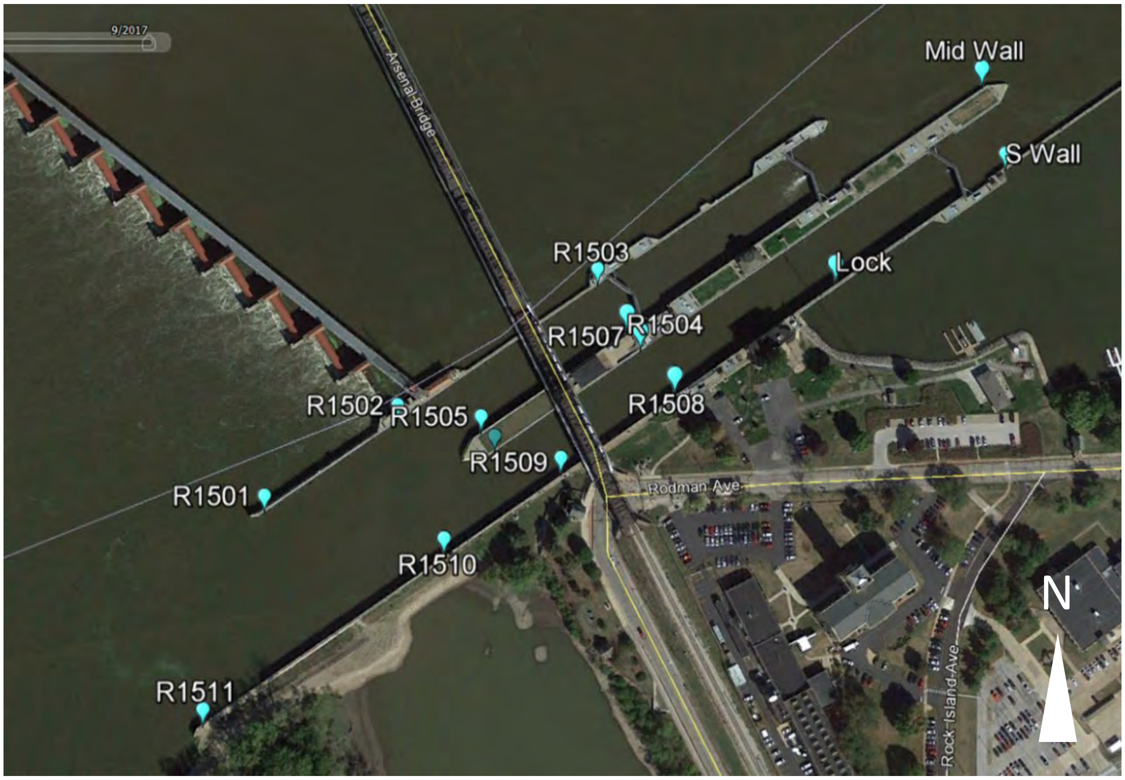

Figure 3. Location of receivers (blue dots) completing the VEMCO receiver array in the lock and lock approaches at Lock and Dam 15. Array maintained by U.S. Geological Survey and Illinois Natural History Survey.

Figure 4. Location of VEMCO receivers (blue dots) in the fine-scale telemetry array at Lock and Dam 14. Array maintained by U.S. Geological Survey and Illinois Natural History Survey.

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FluEgg Modeling of Silver Carp in Upper Mississippi River Pools 1-9

Lead Agency and Author: Minnesota Department of Natural Resources, Grace Loppnow (grace.loppnow@state.mn.us)

Cooperating Agencies: US Geological Survey

Statement of Need: Invasive carp captures have increased in Minnesota waters of the Upper Mississippi River following a high-water event in 2019. Necropsies showed that most of the silver carp captured in Minnesota in 2021 and 2022 were mature (Minnesota DNR 2022). In spring 2022, there were also credible reports of silver carp jumping below Lock and Dam 5 (Wisconsin DNR, personal communication) and a telemetered silver carp was observed moving upstream to this location (Minnesota DNR 2022). While no evidence of invasive carp reproduction has been found in pools 1-9 of the Mississippi River, the increased number of captures and sightings in this reach has raised concerns about the potential for reproduction to occur.

Minnesota DNR conducts ichthyoplankton trawl and light trap sampling weekly from May-August at select locations to monitor for evidence of invasive carp reproduction during potential spawning events. Additionally, we use a variety of fisheries gears and contracted commercial fishing to target adult invasive carp for removal. Deterrents on the Upper Mississippi River have been suggested as another possible management option. These monitoring and response actions are sited based on the best available information on invasive carp behavior, captures, telemetry, sightings, and eDNA detections. However, it is currently unknown where invasive carp would be able to successfully recruit in the Upper Mississippi River if a spawning event were to occur. Several pools likely have insufficient flow, length, or nursery habitat to allow for invasive carp recruitment. Knowing which locations are most likely to support recruitment would allow us to target our ichthyoplankton sampling to the most appropriate locations, and target management actions to reduce abundance in areas most likely to support recruitment.

Objectives:

1. Determine which pools of the Upper Mississippi River in Minnesota could potentially support silver carp recruitment if a spawning event were to occur below the upstream dam. Use the results to inform larval monitoring and invasive carp management activities, with a goal of disrupting reproduction.
2. Write and publish an open access USGS report or journal article on the results of the study.
3. Train Minnesota DNR staff (and other UMR agency staff as interested) in the use of the FluEgg model, to allow staff to conduct additional simulations in the future.

Agency: US Geological Survey (USGS)

Activities and Methods: USGS developed the Fluvial Egg Drift Simulator (FluEgg; Garcia et al. 2013, Domanski et al. 2020) to simulate the transport and development of invasive carp eggs and larvae in a riverine system. According to Domanski et al. (2021):

> FluEgg integrates the biological development of invasive carp eggs and larvae with a particle transport model that simulates the advection and dispersion of the eggs and larvae based on user-supplied one-dimensional hydraulic conditions. FluEgg can be used to evaluate the hydrodynamic suitability of a river for invasive carp spawning, to inform sampling and monitoring efforts, and to identify the most likely spawning areas of captured eggs or larvae.

Therefore, for a given scenario of spawning location, water temperature, and flow conditions, FluEgg predicts the position, extent, and suspended proportion of a plume of fertilized eggs at the time of hatching. After hatching, FluEgg continues to simulate the drift of larvae until they reach the gas bladder inflation (GBI) stage, at which point the larvae no longer passively drift and can swim laterally to find nursery habitat (Chapman and George, 2011). FluEgg simulations can be used to evaluate the suitability of a reach or river for spawning and recruitment based on two key assumptions: (1) that drifting fertilized eggs must be suspended in the water column until hatching to ensure viability (Garcia et al. 2013; George and Chapman 2015; George et al. 2015; George, Garcia, and Chapman 2017), and (2) that larvae must reach the GBI stage near nursery habitat for the greatest chance of survival. The FluEgg model has been applied in the Lower St. Croix River (Kasprak et al. 2022) and the Illinois River (Murphy et al. 2016, Zhu et al. 2018), among other locations (e.g., Garcia et al. 2013, 2015; Embke et al. 2019; Smyth et al. 2023).

USGS will partner with Minnesota DNR to apply FluEgg at 9 hypothetical spawning sites, located at the upstream ends of Mississippi River Pools 1-9, for a range of flow and water temperature conditions that are favorable for spawning. The lock and dam structures at the upstream ends of Pools 1-9 are potentially suitable spawning habitat for invasive carp, which typically seek out fast, turbulent flows for spawning (Kolar et al. 2007, Hayer et al. 2021). For Pool 1, this location will be set at Upper St. Anthony Falls Dam, which was closed to navigation to prevent upstream movement of invasive carp. The hydraulic data needed to run FluEgg will be supplied by an existing unsteady hydraulic model (HEC-RAS model) of the study reach developed by the U.S. Army Corps of Engineers (USACE, 2020). USGS will evaluate the unsteady flood events that were modeled by USACE (2020) to determine which flow conditions will be used for each spawning location. The results of the FluEgg simulations will help determine which spawning locations and river conditions (flow and temperature) are most likely to result in recruitment, and which nursery areas are most likely to host invasive carp young of year.

The output results files from the FluEgg simulations will be published as a non-interpretive USGS Data Release through the USGS ScienceBase website. Interpretive results will be published in an USGS report or a peer-reviewed journal article. This report will be made available in an open-access format online. If funding does not allow for a published report, results will be communicated in the final report for this grant.

In order to facilitate further simulations beyond the scope of this project (for example, using a different hydraulic model or simulating other species of invasive carp), USGS will host a workshop to instruct Minnesota DNR staff (and other UMR partner agency staff as interested) in the operation of the FluEgg model. This will likely be a multi-day workshop, which could be online or in-person depending on which format will best facilitate instructors and attendees. The simulations, reporting, and workshop will be completed by December 2025.

Agency: Minnesota Department of Natural Resources (MNDNR)

Activities and Methods:

Minnesota DNR will provide project support to facilitate the analysis by USGS. MNDNR will administer the grant funds and manage the grant. MNDNR provided the scope and direction for this project. MNDNR will also provide local information on sites likely to elicit spawning activity, the likelihood of modeled nursery areas to support recruitment, and other interpretation of results. MNDNR will provide a location to host the FluEgg workshop as needed.

Map of Project Area:

Figure 1: Map of study area showing locations (yellow target) where spawning will be simulated.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
FluEgg Simulations Completed	Summer 2025
Reporting Completed	December 2025
Workshop Completed	December 2025

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Detection of and Response to Invasive Carp at the Presence and Invasion Fronts in the Upper Mississippi River Basin

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Cooperating Agencies: US Geological Survey (USGS), US Fish and Wildlife Service La Crosse Fish and Wildlife Conservation Office (USFWS), Wisconsin Department of Natural Resources (WIDNR), National Park Service (NPS), Wild Rivers Conservancy (WRC)

Statement of Need: This project is a continuation of the existing monitoring and response program at the presence and invasion fronts in the Upper Mississippi River Basin. Understanding the population status at the presence front is important for a variety of reasons. Invasive carp continue to spread upstream, and it is important for us to know their extent. Monitoring invasive carp abundance in the Upper Mississippi River Basin informs us on when and where to implement management strategies such as deterrents or removal efforts. These response efforts may help delay populations from reaching numbers that result in successful spawning events. This is particularly important as the 2016 cohort of silver carp (which comprises most recent Minnesota captures) reaches maturity. Lastly, having a strong data set helps managers measure the success of management efforts. The monitoring program in the UMR established zone has begun to build the dataset needed for evaluation of management actions, but additional data are needed. Continued monitoring for invasive carp abundance and reproduction is key to gauge the success of UMR strategies.

Tagging and tracking invasive carp has been an important strategy for maximizing the impact of management actions. Tagged bighead and silver carp have shown movement patterns that can be exploited for removal. Multiple past captures would not have been possible without data from nearby tagged carp. These factors have prompted partner agencies to request additional tagging from Minnesota DNR.

Preventing reproduction and establishment of invasive carp is the most cost effective method for managing the impacts of these invasive species. The capture of over 100 invasive carp to date in Pool 8 and the detection of gravid females have raised concerns that the silver carp population in or above Pool 8 will soon be able to spawn. Increased harvest through commercial fishing and other agency-led mass removal methods could help maintain the population below this threshold.

1. *Invasion Front Population Monitoring*
   The MN DNR will employ methodology developed in previous years to sample all life stages of carp in UMR Pools 2-8, the St. Croix River below Taylor's Falls Dam, and the Minnesota River. Seines, electrofishing, and gill nets are used to target adult and juvenile fish at standard and randomized sites. Larval tows and light traps will be used to sample for larval fish in locations where spawning is most likely to occur. Detections of invasive carp are still relatively rare in this portion of the UMR, and additional data are needed to assess the status of these populations. Funds would be used for field staff salary, travel, supplies, and equipment maintenance.

2. *Tracking Invasive Carp*
   MN DNR will continue its tagging and tracking project in UMR Pools 2-9, the St. Croix River below Taylor's Falls Dam, and the Minnesota River. MN DNR will use both a two person active tracking crew and the stationary receiver system. USFWS has provided technical support on tagging and tracking. MN DNR will use tagged fish to identify movement patterns in order to more effectively deploy gears to capture and remove invasive carp. Funds would be used for field staff salary, travel, acoustic receiver and tagging equipment.
3. *Continued commercial harvest where carp numbers are increasing*
   Forty silver carp and 10 grass carp were caught in Pool 8 near La Crosse, WI on the weekend of March 7, 2020. Since then, dozens of invasive carp have been removed from Pool 8 using MUM events and commercial fishing. This is the largest conglomeration of carp seen in the MN/WI border waters of the Mississippi River. Gravid female silver carp have been detected in Pool 8, as the abundant 2016 cohort reaches maturity. In 2022, a tagged silver carp moved upstream to Pool 5A during high water, and silver carp were observed jumping below Lock and Dam 5. Due to these findings, commercial fishing effort needs to be continued in order to reduce invasive carp abundance below reproductive thresholds. Funds would be used to place a commercial fisher under contract for full-year removal of invasive carp, primarily in Pools 2-8, but also potentially in the St. Croix River. In addition to reducing risk of reproduction, having a commercial fisher under a full-year contract also improves MN DNR's ability for rapid response and collaboration with partner agencies during removal events.
4. *Cooperative strategies for enhanced capture ability*
   Agency-led cooperative strategies (often used in concert with commercial fishing) are also necessary to maximize invasive carp capture for tagging or removal. In locations where invasive carp are not yet at high densities, specialized expertise and equipment can be crucial for capturing invasive carp. Events such as the Modified-Unified Method (MUM), which have removed dozens of invasive carp at once from Pool 8, are proof of this concept. MN DNR is partnering with USGS, USFWS, Wisconsin DNR, NPS, and Wild Rivers Conservancy to implement MUM events. These partners have provided in-kind support of staff time in both 2021 and 2022. USGS continues to provide science support as we seek to make this technique more effective, efficient, and agile in pursuit of a rapid response tool for relatively low-density locations. These MUM events and other strategies such as the use of attractants to increase catch will enhance our ability to reduce invasive carp below reproductive thresholds. Funding would be used to implement 1-2 MUM events in FY23, and potentially for other mass capture strategies as available.

Objectives:

1. Monitor for all life stages of invasive carp in Pools 2-8, the lower St. Croix River, and the lower Minnesota River, including larval sampling at potential spawning sites.
2. Tag and track invasive carp movement to inform sampling methodology in low abundance areas.

3. Deploy contracted commercial fishing in Pools 2-8 to maintain invasive carp populations below reproductive thresholds.
4. Respond to increased captures through cooperative capture methods such as Modified-Unified Method (MUM) events.

Activities and Methods:

Sampling Sites

Sampling occurs in Pools 2-9 of the Mississippi River, the St. Croix River, and the Minnesota River. In the Mississippi River, sampling will occur all along the 276 km span of Pools 2-8 and the section of Pool 9 in Minnesota. In the St. Croix River, effort will be focused over an 83 km long span from the dam near Taylors Falls, MN to the confluence with the Mississippi River near Prescott, WI. In the Minnesota River, effort will be focused over an 80 km long span from River Mile 50 at Belle Plaine, MN to the confluence with Pool 2 of the Mississippi River near St. Paul, MN. If scheduling allows or a report is made, sampling will extend further than the areas previously listed. In addition, contracted commercial fishermen will be utilized throughout these systems to monitor for invasive carp and as rapid response actions if invasive carp are found or are presumed to be present.

Methods: Monitoring for all life stages of invasive carp

Gears, methods, and habitats for sampling were derived from a collection of personal communications with biologists who have been sampling invasive carps (V. Santucci, Illinois Department of Natural Resources, personal communication; J. Lamer, Western Illinois University, personal communication) and conducting research on the most efficient gears to sample invasive carp (M. Diana, Illinois Natural History Survey, personal communication), along with a variety of literature that included sampling techniques and habitat preferences (Lohmeyer and Garvey 2009; Williamson and Garvey 2005; Dettmers et al. 2001; DeGrandchamp et al. 2007; Kolar et al. 2007; DeGrandchamp et al. 2008; Wanner and Klumb 2009; ACRCC 2012). All captured fish will be identified, weighed, and measured, and 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 site. Fish caught commercial fishing will be counted or marked present/absent. If a tagged fish is captured, measurements will be taken if feasible.

Purse Seine

A large purse seine will be used to sample deep water habitats on the St. Croix River for adult invasive carp throughout the year. A purse seine will be invaluable 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 2000 ft. long and 40 ft. deep with 5 inch stretched mesh (2 ½” square mesh). The seine is constructed in panels connected with ½” braided poly rope and snap links to allow for reconfiguration allowing 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 contracted 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.

Larval Trawl

Larval trawling will be conducted weekly at standardized sampling sites from mid-May through mid-July on the Mississippi River to target the early life stages of invasive carps (Figure 3). 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 (N. Bloomfield, U.S. Fish and Wildlife Service, personal communication). Sites will be chosen based on tag data from a tagged silver carp, data from partners and hydrograph data. Sites could vary week to week between different pools on the Mississippi River. 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. A total of three locations will be sampled in each standardized system with four, five-minute pushes being conducted at each location. Sampling locations are located in the following macro habitats: main channel, side channel, and backwater locations in each system (Figure 3; Appendix C). Sample contents will be placed in containers labeled with sample location, name of water body, and date, and will be preserved in 90% ethanol for 24-48 hours, will be drained, and preserved in 90% ethanol. Samples will be processed by either genetic testing or visual identification. Genetic testing will be done by Whitney Genetics Lab in CREC. If done by visual identification all fishes will be identified to the lowest feasible taxonomic category and enumerated

Larval Light Traps

Starting in 2022, larval light traps have been used in backwaters in Pools 5A and 8. Quadrafoil Light Traps are deployed 5 traps per set, 5 feet apart. Sets are deployed in low to no current backwaters and side channels. Traps are deployed overnight with a green flashing light in the middle of the trap. When collected the sample is preserved in 90% ethanol for 24-48 hrs, drained and preserved in 90% ethanol. Samples are then either sent for genetic testing at Whitney genetics lab or fish are identified by visual identification. In 2023 additional sets will be deployed in tributaries along Pools 5A-8 when conditions allow.

Electrofishing

Minnesota DNR is in the process of obtaining a designated electrofishing boat for invasive carp work. 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 consist of eight standardized sampling locations in Pool 2 of the Mississippi River (Figure 1, Appendix A, Appendix C), the St. Croix River (Figure 2, Appendix A, Appendix C), and the Minnesota River (Figure 3, Appendix B, Appendix D), and all other sampling events will occur at non-standardized locations in the aforementioned habitats at the discretion of the sampler. Standardized sampling locations were selected based on habitats invasive carps are likely to occupy and will be 500 m in length. The goal will be to sample with electrofishing for at least eight hours per month. Sampling at each of the standardized sampling locations will occur at a minimum of two times annually. At these set sampling locations, all observed fish will be collected, identified, measured, and weights and ageing structures will be taken from fish included in age and growth analyses.

Electrofishing will also be used in conjunction with underwater speakers to drive invasive carp into a seine zone.

Beach Seine
A small, 35-foot seine will be used to sample shallow water habitats for young fish from June through September on the St. Croix River (Table 1). This sampling will be done on other water bodies if there is a need (evidence or potential of spawning event or small carp moving upstream). The seine measures 35 ft. long and 6 ft. deep with 3 ft. square bag (3 ft. x 3 ft. x 3 ft.) located at the center of the net, consisting of "Ace"-type nylon netting 1/8 in. mesh, with a mudline. Haul length, water depth, and benthic condition will be recorded. If possible, all fish will be identified and enumerated in the field. If positive identification is not possible, voucher specimens will be kept, labeled and preserved in 90% ethanol for later identification. In 2022, we partnered with NPS St. Croix National Scenic Riverway and Wild River Conservancy to start expanding beach seine sampling over the next 5 years. This information will be used to continue to expand our base-line knowledge of native species in areas that are difficult to sample by other means. There has been no indication of juvenile invasive carp. Small native species along the St. Croix River have limited sampling from Taylor's Falls to the Arcola High Bridge in previous years of this program.

Gill and Trammel Netting
Gill netting and trammel netting will occur from March through November as time allows. 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 trammel nets with outside wall square mesh sizes of 12 to 14 in. and inner square mesh sizes of 2 to 4 in. will also 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. may be used to target juvenile invasive carps if there is potential for their presence. Nets may be set either short term or overnight, with short-term sets favored when water temperatures are greater than 60º F.

Outreach
Several invasive carp have been reported to Minnesota DNR by the public. Recently, sightings of fish jumping that may be invasive carp have also been reported. These data can be a valuable addition to our program and to assessing the state of invasive carp in Minnesota waters. However, outreach by the MN DNR Invasive Carp Program has been limited to date. Work is underway to produce signage and handouts to promote reporting by the public, and to reach communities who may not speak English as their first language. An outreach component may be built into this grant to promote further reporting by the public, if funding allows.

Methods: Tagging and tracking

Acoustic Tagging

Pursuant to Minnesota Statute 84D.05, invasive carp collected in Minnesota waters can be tagged and released by Minnesota Department of Natural Resources staff. Subdivision 1 was amended in 2017 to read "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." MN DNR partners with USFWS on tagging surgeries. 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 removal efforts.

In 2022, up to two invasive carp were permitted to be tagged per pool (pools 2-7) with 10 permitted in Pool 8 on the Mississippi River as well as up to two permitted for each the Minnesota and St. Croix rivers. It is recommended that this number remain the same for all of the Pools expect for an increase to 10 for Pool 5A. Tracking of these fish will be done using both passive telemetry (using an elaborate receiver array already in place), active tracking (using finer scale tracking techniques) and remote tracking (using real-time receivers that detect tagged fish in an area and alert staff to the detection remotely) to determine preferred habitats, movement patterns, and ultimately to re-capture tagged fish and remove other invasive carp caught. It will ultimately be the discretion of the permittee if a given invasive carp should be tagged and released based on variables including location of capture, time of year, river flows, ability to successfully track the fish at staff levels available, as well as other contingencies dictated by the circumstances present and the in-depth knowledge of these species' biology and trends in movements and behaviors.

Both silver carp and bighead carp form tight schools, so if a tagged fish schools with other individuals, we will potentially be able to track the individual and other individuals of the same or similar species using what is most commonly referred to as the Traitor Fish Method. With this information, tagged fish can be tracked and effectively netted to aid in the removal of other invasive carp found in the school. Other states have already begun work of this nature in riverine environments and have shown significant results and the ability to remove additional fish with this tagging method. By tagging invasive carp, we are likely to see an increase in the number of additional invasive carp caught and ultimately increase the state's effectiveness at removing these species from our waterways.

The impacts of releasing wild-caught invasive carp back into the wild have been considered and are believed to be minimal when compared to the potential information gained from this project. While potentially sexually mature, there have not been any signs of reproduction occurring in Minnesota waters despite extensive fisheries sampling, including larval and juvenile fish sampling. Additionally, the concern for silver carp to jump and injure recreationists is low to non-existent at this time due to low population abundances. Silver carp, when population levels are high, are known to jump when disturbed and to date this has not been observed in Minnesota. The DNR will take all reasonable measures to ensure all tagged fish are tracked and their locations known through active tracking and an extensive passive tracking network. Comprehensive removal efforts will be employed to remove tagged and un-tagged fish from Minnesota waters.

Tracking

FishTracks is an online database administered by USGS to manage and coordinate the sharing of fish tracking information. This program allows for data to be shared between agencies and streamline coordination of downloading receivers. This program will provide an opportunity to better track tagged invasive carp and will be key in monitoring the upstream movement of invasive carp in future years. The DNR plans to integrate current and past data into the FishTracks program Spring of 2023.

In 2023, a real-time receiver will 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. Real-time receivers will also be deployed on the Mississippi River to aid in the tracking of tagged fish in those pools. Two real-time receivers will be built for the field season in addition to the existing 2 real-time receivers with the possible addition of more in the future from partnering agencies.

The described activities require a special permit issued by DNR Division of Ecological and Water Resources (EWR). 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 Invasive Carp Sampling Report (Minnesota Department of Natural Resources 2018) and for the most up-to-date movement and temperature and depth information see the 2022 Invasive carp Sampling Report (Minnesota Department of Natural Resources 2022).

Methods: Contracted Commercial Fishing for Invasive Carp Removal

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. Native fish captured in commercial gear may also be used for age and growth analysis or tagging if additional projects exist. Number of fish caught by species and/or the presence of species will be recorded during gill netting and seining operations and total weight harvested will be requested from the commercial fisherman for both gill netting and seining operations. In addition, 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 Euthanization

If an invasive carp is collected and the fish is not being tagged, it will be placed in a secure location to prevent escapement and will be transported to a partnering agency/office or Region 3 Headquarters in St. Paul. Invasive carp will then be processed. For black carp, eyes are removed, prepared, and sent to the U.S. Fish and Wildlife Service's Whitney Genetics Lab for ploidy analysis. Bighead, silver and grass carps will be measured, sexed and age structure samples will be taken based on an individual basis.

Methods: Cooperative Capture Strategies

Adapting the Modified-Unified Method for the UMR

The Modified-Unified Method, or MUM, is a technique for capturing invasive carp that was developed by USGS from traditional Chinese fishing techniques. During the MUM, a sampling site is divided into cells using block nets. Invasive carp are herded out of the cells using sound and electricity, towards a seining site for capture. This technique has commonly been used at sites with little current and a high density of invasive carp.

Invasive carp density remains low near the invasion front in the Upper Mississippi River, but captures have increased in recent years. This has prompted Minnesota DNR to explore new approaches to capturing invasive carp, including adapting the MUM for our area. Minnesota DNR has partnered with USGS, Wisconsin DNR, USFWS, NPS, and Wild Rivers Conservancy to hold several MUM events in the Upper Mississippi River since 2021. We learn more about the method with each event, and continue to test new techniques, sites, and timing. Our goal is to develop an efficient capture method that can be easily deployed and that is effective for our low-density invasive carp population and variable environment.

Four MUM events have been held in the UMR to date. Three were held in Pool 8, and one in Pools 5A-8. Thirty-seven invasive carp have been removed by these events to date, all during spring, and all in Pool 8. The method continues to provide valuable information on locations to target commercial fishing, and which methods work and do not work.

Timing in relation to water levels and temperature appears to be particularly important to capturing invasive carp using the MUM technique. Effective herding and containment is also critical. To this end, MN DNR has been working with partners to assess how to plan sites according to the time of year, and USGS has been developing technology to help us better herd and contain fish. New developments include floating gill nets to entangle jumping silver carp, GPS-controlled sound kayaks, site selection based on time of year, and stimuli for flushing fish from deep holes.

For this project, one to two MUM events will be conducted in Pools 5A-8 of the UMR. Timing will depend on the best available information and methods. The MUM continues to be altered and streamlined, and future iterations could include approaches that require fewer personnel. One such possibility is using sound boats and kayaks to push fish into a block net that has a floating escape-prevention net attached. Silver carp would be induced to jump, and captured in the floating nets.

The MUM requires substantial staff time to plan and execute. In addition to planning sites and approach, sites must be cleared for seining, landowners contacted, permits acquired, communications planned, and staffing coordinated. Coordination among partners is essential to the success of this effort, and we thank USGS, USFWS, Wisconsin DNR, NPS, and Wild Rivers Conservancy for their assistance. Funds will be used for travel, supplies, staff time, and to support travel by USGS staff.

Attractant stations

MN DNR will collaborate with USGS in 2023 on testing attractant stations (bait stations) for invasive carp, pending permit approval. The stations are mounted on floating platforms and can automatically dispense algae pellets several times per day. The platforms can also support monitoring equipment such as sonar or telemetry receivers. Signage will accompany the platforms to inform the public and keep boaters safe.

Attractant stations could be used in conjunction with removal events such as the MUM. They may help concentrate invasive carp in one location, which would make them very useful in a low-density population where fish are widely scattered. Funds would be used for algae pellets and platform-building supplies.

Map of Project Area:

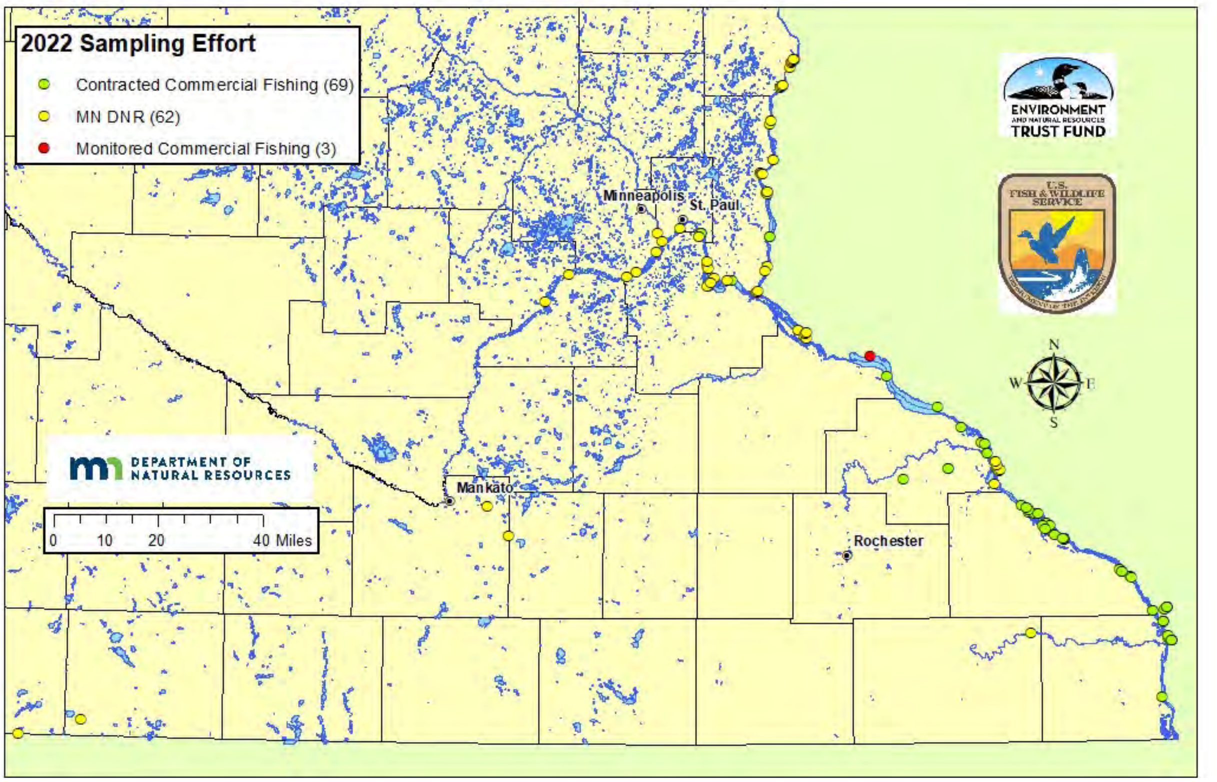

Figure 1: 2022 Sampling Locations. Locations in 2023 will be similar.

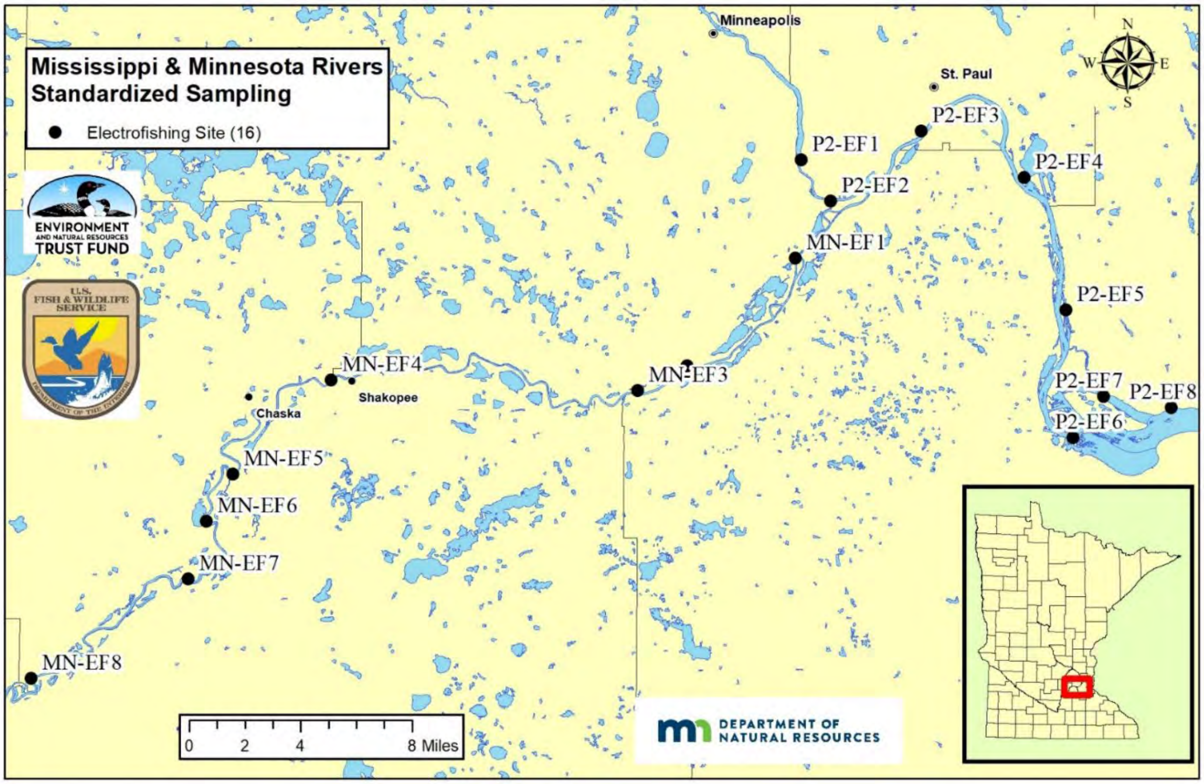

Figure 2: Standardized electrofishing locations on the Minnesota and Mississippi Rivers.

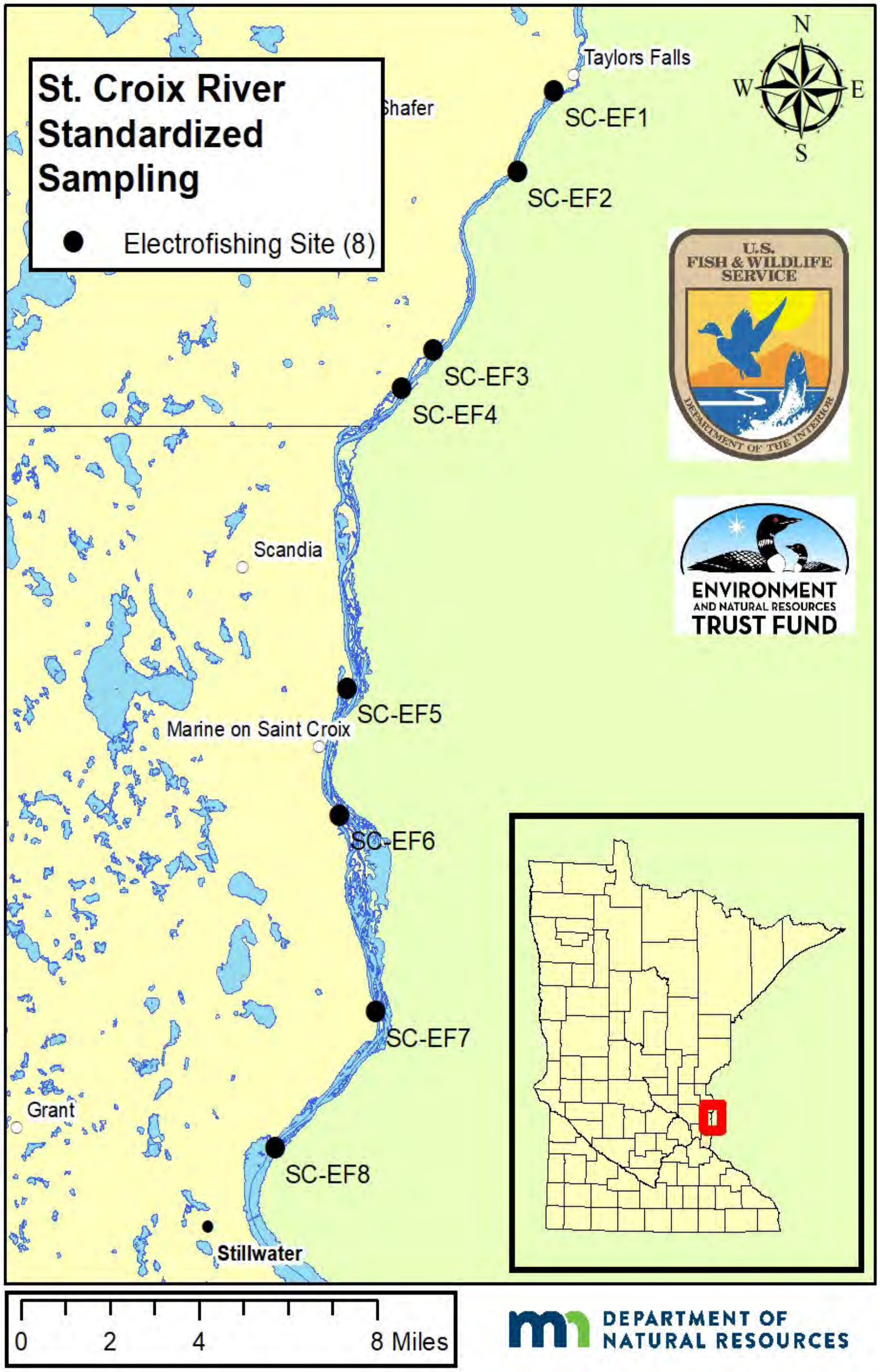

Figure 3: Standardized electrofishing sites on the St. Croix River.

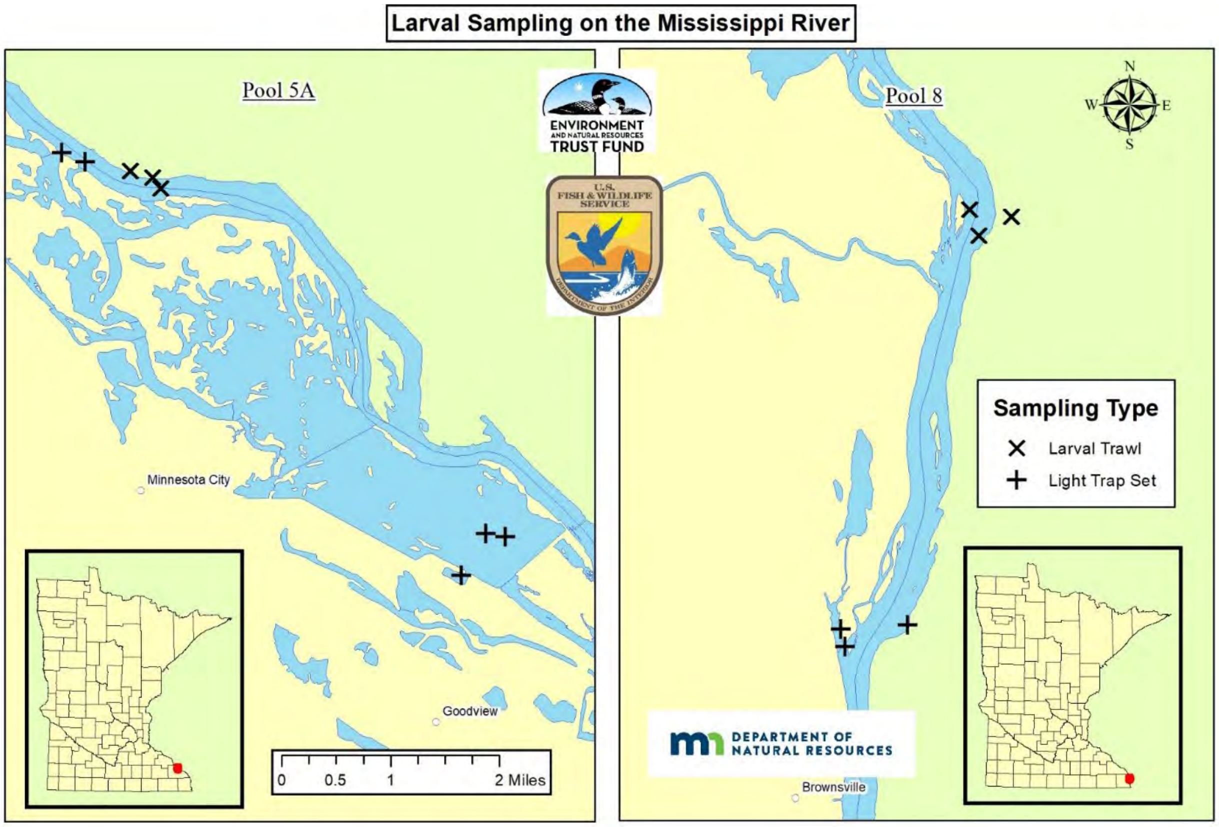

Figure 4: Standardized larval trawling and light trap locations on the Mississippi River.

Estimated Timetable for Activities:

Gear	***Time Period***
Gill/Trammel Netting	March - November
Electrofishing	May - September
Seine	June - September
Larval Trawling	May - August
Larval Light Trap	May - August
Commercial Seining	Year round
Commercial Gill Netting	Year round

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Examining drivers of temporal variation in hybridization outcomes in bigheaded carp in the UMR.

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Cooperating Agencies: U.S. Geological Survey Iowa Cooperative Fish and Wildlife Research Unit, Iowa State University, Iowa State University (ISU).

Statement of Need: Bigheaded carp continue to increase in abundance and distribution in the Mississippi River Basin (MRB). Hybridization between Silver Carp and Bighead Carp in the in the MRB was first identified from distinctive hybrid gill raker morphology in 2005 and confirmed shortly after using molecular markers in 2006 (reviewed in Lu et al. 2020). Still, the genetic and ecological mechanisms underlying the extensive hybridization between bigheaded carp only seen outside of their native range remain elusive (Lamer et al. 2010, Lamer et al. 2014, Lamer et al. 2019). The production of new genetic combinations through hybrid backcrossing, characteristic of a hybrid swarm, also hinders our ability to assess patterns in introgressive hybridization in the UMR solely relying on the presence or absence of an intermediate feeding morphology (Figure 2, see Lu et al. 2020 for an illustration of the gill raker morphology observed in early hybrids, Marian et al. 1986). Yet, the extent of hybridization (i.e. as the proportion of individuals of the parental species, first generation hybrids, back-crosses, or later generation hybrids) varies across environmental contexts (Lamer et al. 2014, Mandeville et al. 2015, Mandeville et al. 2019) and the question whether the extent of bigheaded carp hybridization remains unchanged over time warrants further attention (Lamer et al. 2019).

Hybridization is expected to dampen population growth of closely related species that co-occur in the same habitat and are ecologically distinct, if hybrid individuals contribute fewer offspring to the next generation relative to the individuals of the parental species (i.e., lower hybrid fitness scenario, Irwin and Schluter 2022). Since population declines can be driven solely by lower hybrid performance relative to non-hybridized bigheaded carp individuals, we need to assess the extent to which introgressive hybridization varies across individuals in order to understand recent past and future population dynamics. Past hybridization events can come with associated costs in terms of fitness disadvantage (Lamer et al. 2019) or conversely, confer new genetic variation providing invasive species with greater potential for adaptation to new conditions (Barton 2001, Taylor and Larson 2019). Indeed, the invasion success of bigheaded carp could be partly explained by positively selected genomic features associated with environmental adaptation or invasion-related traits only seen in hybrids (Wang et al. 2016, Wang et al. 2020). In addition, Coulter et al. (2020) proposed that the adaptive potential of unique genetic combinations in hybrids may facilitate the establishment and range expansion of two invasive carp species through individual differences in movement patterns. Whether poorly tuned energetic trade-offs between body growth and reproduction only found in hybrids (Lamer et al. 2019) could offset the unique benefits gained by a greater adaptive potential (Wang et al. 2020, Coulter et al. 2020) is still unknown.

To overcome the issue of stealth hybrid backcrosses and later generation hybrids lacking diagnostic morphologies (Lamer et al. 2010), advances in genomic technologies and associated developments in computing power now offer the opportunity to measure the extent of introgressive hybridization at a population level with an unparalleled degree of genomic resolution. High throughput sequencing technologies provide large numbers of genetic loci to quantify the number of individuals of each of the parental species (over 90% parental species ancestry), and in those hybrids (less than 90% parental species ancestry) assess both the extent of introgression (as the proportion of Bighead Carp ancestry in hybrid Silver Carp or vice versa, i.e., q) and the proportion of loci in an individual's genome that are estimated to have ancestry from both parental species, thus allowing for the distinction of F1 hybrids from later generation hybrid crosses (i.e., interspecific ancestry Q, Gompert et al. 2014).

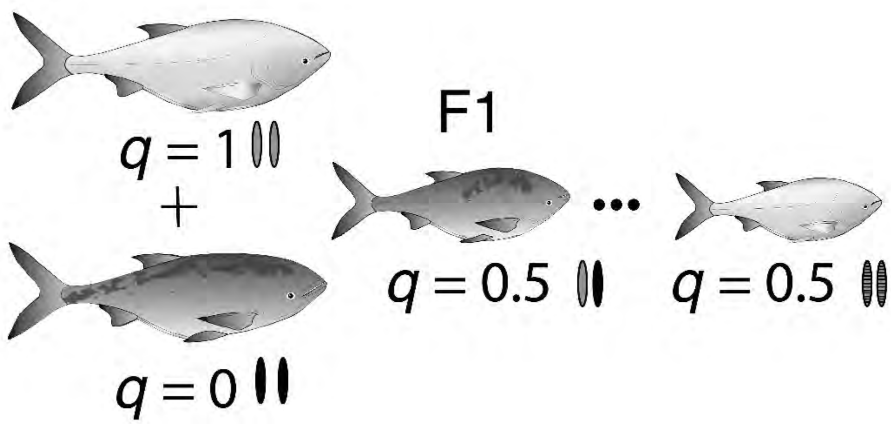

Figure 2: Illustration of the difficulties to identify hybrid individuals after generations of hybridization and introgression in a hybrid swarm. q is the proportion of Silver Carp ancestry, so parental species (Silver Carp and Bighead Carp) are represented with a q = 1 for Silver Carp (with homozygous biallelic loci) and q = 0 for Bighead Carp (with homozygous biallelic loci), respectively. Recent hybrids (F1) will present 50% Silver Carp ancestry (q = 0.5) and heterozygous biallelic loci. Note here how recombination in later generation hybrids could also result also in hybrid individuals with q = 0.5 with varying proportions of loci of hybrid origin, resulting in different genotypic and phenotypic outcomes.

For this project, we will take advantage of fin and tissue samples to examine the extent of introgressive hybridization across bigheaded carp harvested by commercial anglers and: **1)** assess the extent to which introgressive hybridization varies temporally in the UMR relative to other areas; and **2)** examine potential environmental drivers of temporal variation in hybridization outcomes. We will also rely on genomic data (restriction-site associated DNA or RAD sequencing data) collected by Lamer et al. (2014) which was used for the above-mentioned studies (e.g., Lamer et al. 2019, Coulter et al. 2020) and expand this existing data set with the 2022 samples that we collected by sequencing these using the same methodology to ensure data compatibility between the two studies (Lamer et al. 2014).

An updated estimate of hybridization will inform current demographic models guiding population control strategies across locations in the Mississippi River Basin and help clarify potential links between differential harvest of parental species across locations and hybridization dynamics over time. Quantification of hybridization along with recruitment dynamics will be relevant in explaining declines in the relative abundances of parental species across locations and to screen for potential genomic features found in hybrids that could in turn, facilitate invasion success. For instance, the different prevalence of potentially risky mobile individuals among hybrids, as documented by Coulter et al. (2020, 2022) should be considered in where individuals are harvested and in barrier design. Information on variable individual outcomes of hybridization can be then paired with knowledge on the species-specific responses to acoustic barriers to foresee potential changes in barrier permeability over time (Murchy et al. 2017, Wilson et al. 2021). Moreover, failure to consider potential differences in the ability to tolerate harmful toxins of hybrids relative to the parental species (Rach et al. 2008) could potentially prevent the success of management strategies involving chemical measures.

This research will help guide ongoing efforts to remove invasive carp populations and prevent them from further expanding their geographic range. This goal aligns well with the National Plan Goals: Goal 4 and Goal 6 associated to the generation of technical information in varied formats to reach the general public, commercial entities, and government agencies to improve effective management and control of bighead, black, grass, and silver carps in the United States. The results of this research will be made publicly available in different formats specifically designed to reach varied audiences.

This goal aligns with the sub basin goals and strategies Goal 3 on the elimination of invasive carps in the UMR. Evidence on how hybridization could influence population will inform our understanding on the population growth dynamics of Silver Carp. A clear understanding of all factors influencing population growth will be key to demonstrate the need for further harvest and population control of Silver carp in the UMR. Additionally, this study will update current understanding of hybrid prevalence and drivers of temporal variation in the extent of introgressive hybridization. This knowledge is key in explaining variability in the invasion success of bigheaded carp across locations in their invaded range.

Objectives:

1. Assess the extent to which introgressive hybridization varies temporally in the UMR and examine potential environmental drivers of temporal variation in hybridization outcomes.

Agency: Iowa Department of Natural Resources (IADNR) and USGS Iowa Cooperative Fish and Wildlife Research Unit and Iowa State University (ISU)

Activities and Methods: Between October and December of 2022, we measured total length, weight and gonad weight of 505 individuals Silver Carp, 16 individuals Bighead Carp and 5 hybrid individuals (identified by the presence of twisted gill rakers, presence of structural malformations) of individuals caught in pools directly upstream of LD 19 (Figure 1). We focused our sampling on individuals caught in pool 19, where both Silver Carp and Bighead Carp are most abundant in the Mississippi River Basin (Erickson et al. 2021). We will pool all individuals caught above LD19 regardless of their potential early life environment downstream of LD 19, since we want to focus on the temporal variation in the extent of hybridization and to avoid issued stemming from a lower sample size of individuals born upstream of LD 19. As a metric of hybrid fitness, we are using gonado-somatic index (gonad weight expressed as percent body weight) as in Lamer et al. (2019). We then collected fin clips, removed otoliths for natal origin and age estimation. We will extract DNA from fin clips using the Qiagen's DNeasy Blood and Tissue kit in a molecular-grade laboratory in the Department of Natural Resource Ecology and Management at Iowa State University. We will determine DNA quantity and quality metrics before sending 475 samples to FLORAGENEX laboratories for library preparation and ILLUMINA sequencing (RAD sequencing). After conducting standard data processing, we will align resulting DNA reads to the Grass carp (*Ctenopharyngodon idellus*) to detect the single nucleotide polymorphisms (SNPs) required for downstream hybrid genomic analyses (Gompert et al. 2014, Wu et al. 2022). Data analyses and final report draft will be completed through freely available software using available computational resources (High Performance Computing HPC) at Iowa State University.

Map of Project Area:

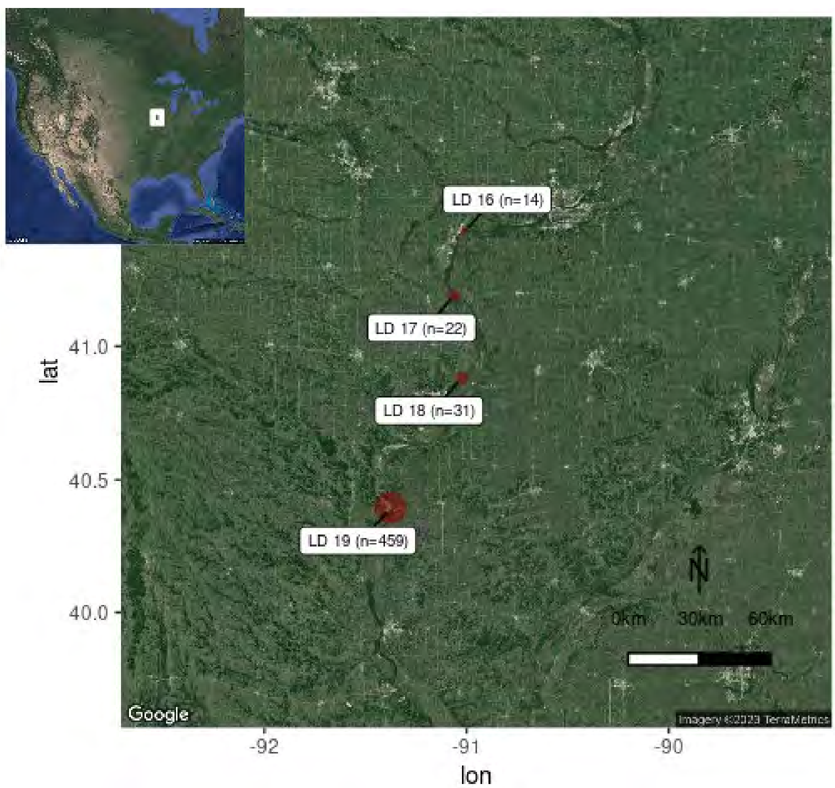

Figure 1: Map of sampling locations (October - December 2022) directly upstream of LD 16-19 in the UMR. Bigheaded carp catches by location are shown in parenthesis.

Estimated Timetable for Activities:

Activity	Time Period
DNA extractions, library preparation and sequencing	October - December 2023
Data analysis and final report draft	January 2024-September 2024

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Effects of invasive carp and impoundment on food web structure and fish condition in Upper Mississippi River tributaries.

Lead Agency and Author: Iowa Department of Natural Resources (IADNR), Kim Bogenschutz kim.bogenschutz@dnr.iowa.gov

Cooperating Agencies: U.S. Geological Survey Iowa Cooperative Fish and Wildlife Research Unit - Iowa State University.

Statement of Need: Invasive species and hydrologic alterations from navigation, flood control, and hydroelectric dams are among the most serious stressors present in the Upper Mississippi River basin. Both stressors can inflict ecosystem-level effects including the restructuring of food webs through increased competition, predation, habitat alteration, water quality degradation, and fragmentation. Bigheaded carp (*Hypophthalmichthys molitrix* and *Hypophthalmichthys nobilis*) are high-profile invasive species in North America that are continuing to expand upstream in the Mississippi River basin. In response, many state and federal agencies partner to reduce the undesirable effects of invasive carp through early detection, barrier management, and removal. Despite these programs, our understanding of the full consequences of bigheaded carp invasions is incomplete hampering our ability to enact scientifically led decision making to control their spread as well as understanding the ecosystem impacts they can have at different densities.

Previous research has focused mainly on trophic competition between bigheaded carp and three native planktivores: Bigmouth Buffalo (*Ictiobus cyprinellus*), Paddlefish (*Polyodon spathula*), and Gizzard Shad (*Dorosoma cepedianum*). These studies identified substantial dietary overlap between bigheaded carp and native planktivores (Harris et al., 2022), further implicating bigheaded carp in the declines in large crustacean zooplankton and native planktivores (Irons et al., 2007; Pyron et al., 2017; Sass et al., 2014; Tillotson et al., 2022). However, pilot data from the Des Moines and Iowa rivers suggest that trophodynamics of predatory fishes such as the Flathead Catfish (*Pylodictus olivaris*) may also be affected by carp abundances as well as impoundment (Weber, unpublished). Currently, bigheaded carp populations exist in all three stages of biological invasion, namely, arrival, establishment, and integration (Moyle & Light, 1996) across the upper Mississippi River basin pools and large tributaries. Gradients of bigheaded carp relative abundance exist, ranging from absent upstream of tributary dams to dominant in downstream reaches of southern tributaries such as the Lower Des Moines River. This establishes a spatially replicated natural gradient of relative carp abundance across the region and presents a unique and timely opportunity to acquire information about how serial disruptions to river continuity due to impoundment may interact with invasive species abundance to influence food webs dynamics for multiple native trophic guilds. This information is needed to adjust target density levels of bigheaded carp that can be attained through population suppression efforts. Therefore, we propose the following project.

This is a multi-year project, but in year one will be primarily focused on working with the master's student beginning in January 2024 to develop a research proposal and study design. The student will then scout field sites in the spring and subsequently use boat electrofishing and other sampling gears to capture fish for stable isotope analyses. Toward the end of the year in

September and October 2024, the student will begin to process tissue samples to be run for stable isotope analysis at labs on the Iowa State University campus.

Objectives:

1. Determine how fish condition and trophic position is related to individual and interactive effects of invasive species relative abundance and impoundment for multiple trophic guilds in tributaries to the Upper Mississippi River.

Agency: Iowa DNR and USGS Iowa Cooperative Fish and Wildlife Research Unit and Iowa State University

Activities and Methods: First, we will use a variety of sampling methods to collect nonnative Silver Carp and several native species across 10 sites in 5 tributaries as well as 2 mainstem Mississippi River sites. We will select native species that are representative of specific trophic groups and which are widespread across all or most of the sampling sites and will attempt to get a representative sample of the population with ~10 individuals per 25mm size interval (Figure 2). First, we will record physical measurements of individual fish such as length and weight in the field to analyze fish body condition using quantile regression. We will also harvest a subset of individuals in the sample in order to extract the livers to calculate hepatosomatic index as a secondary indicator of condition. These data will be analyzed using mixed models to investigate the main and interactive effects of relative carp density (i.e., low, medium, high) and degree of upstream impoundment (low, high) while accounting for nested effects of sites within tributaries on both condition metrics.

Secondly, subsets of each species sample will be collected for stable isotope analysis (SIA). Sample size goals for these analyses will be ~15 adult individuals per species with samples evenly distributed across adult size classes (Vinson & Budy, 2011) resulting in a total sample size of approximately 1,560 individuals at a cost of ~$20.00 per sample. Baseline data from freshwater mussels will also be collected to adjust SIA values from different rivers. Carbon 13 isotope values are typically used to infer the basal food resources in an individual's food chain (i.e., sources of primary production), while nitrogen 15 isotope values, which become enriched at higher trophic levels, can indicate an individual's trophic position. For large specimens a plug of tissue may be collected from the dorsal musculature using a biopsy punch so that the fish may be released alive whereas, smaller specimens will be retained whole. Samples will be stored frozen for later analysis in the lab. Tissue samples will be dried in a drying oven at 60°C for 24-48 hours, homogenized, and weighed in small tin or silver cups 0.5-3 mg. These samples will be analyzed at the Stable Isotope Lab at Iowa State (https://siperg.las.iastate.edu/stable-isotope-lab-sil/). We will compare the mean N15 and C13 values for species across sites using mixed models and analyze niche overlap among species across sites using multivariate methods such as PERMANOVA tests and Bayesian models (Swanson et al., 2015; Harris et al., 2022).

Iowa DNR staff will act in administration, advisory, and assistance roles during the project. They will attend meetings with the graduate student prior to them developing a proposal and proposal drafts will be sent to them for review and comment. Iowa DNR may also provide support by assisting with fish collection by providing gear and staff time to the sampling effort when possible.

Other expenses budgeted for completion of this work include access to computing supplies for students, miscellaneous lab and field supplies, boat fuel, boat maintenance, boat storage, travel, lodging, and per diem for fieldwork, wages for 2 summer field technicians to assist in collecting fish samples in the field, and one lab technician for 2 months in the first year, half graduate student tuition, and graduate student stipend. In the first year, there is no funds budgeted for travel to conferences or meetings to present results because we will still be early in the data collection phase.

Trophic Guild	**Candidate Species**
Non-native Planktivore	Silver Carp
Native Planktivore/Omnivore	Emerald Shiner, Bigmouth Buffalo, Bluegill, Sand Shiner
Detritivore/Herbivore/Planktivore	Gizzard Shad
Benthic Invertivore	Shorthead Redhorse, River Carpsucker, Quillback, Freshwater Drum, Blue Sucker, Smallmouth Buffalo, Suckermouth Minnow
Invertivore/Carnivore	Walleye, Channel Catfish, Flathead Catfish, Northern Pike, Smallmouth Bass

Figure 2. Candidate species for the study that are representative of trophic guilds and are widely distributed across most or all study sites.

Map of Project Area:

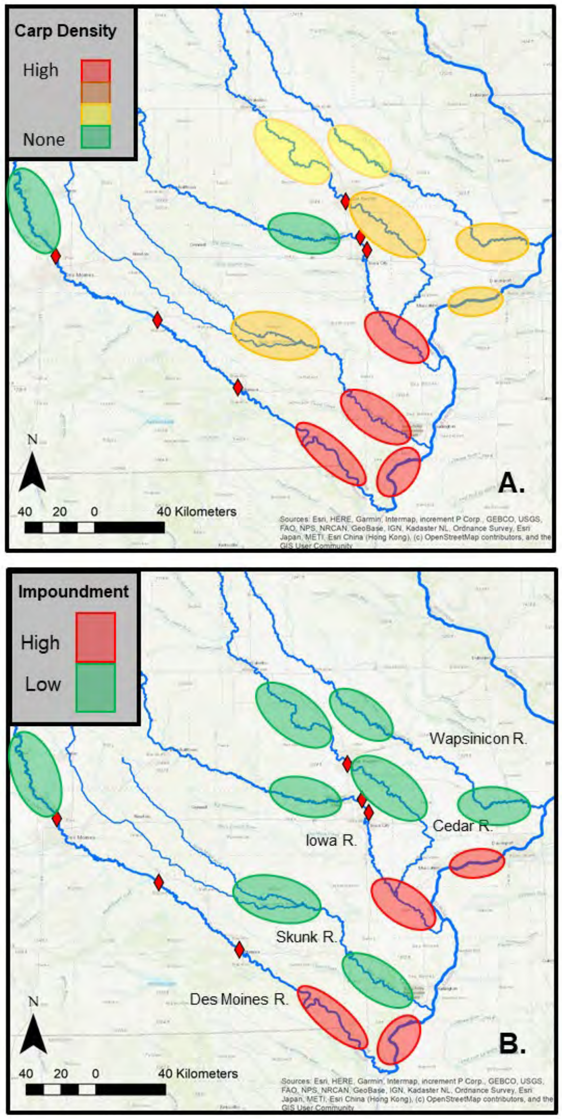

Figure 1: Map of study area with potential study reaches highlighted based on the: A. expected relative abundance of bigheaded carp present and B. the relative degree of upstream impoundment or hydrologic alteration. Focal rivers are labeled.

Estimated Timetable for Activities:

Activity	Time Period
Project initiation/advertise position/select student	Already completed. Justin Harms selected.
Bring on student	January 2024
Sampling approach development	December 2023-February 2024
Site reconnaissance	March 2024- May 2024
Fish sampling for condition and tissue collection	June 2024- October 2024, June 2025-October 2025
Isotope sample processing in lab	June 2024-October 2024, June 2025-September 2025
Isotope sample analysis	October 2024-April 2024; September 2025-January 2026

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eDNA Monitoring in the Upper Mississippi River

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Cooperating Agencies: N/A

Statement of Need: Environmental DNA is an important monitoring tool for invasive carp, particularly in areas of lower density such as above Pool 15 in the Mississippi River. Through regular eDNA monitoring across years in these pools, we can evaluate trends in Invasive carp DNA detection, which may serve as a first line of surveillance to give evidence to potentially increasing carp presence in sampled areas of the UMR.

In 2018, USFWS began sampling for Invasive carp eDNA in the pools upstream of the Intensive Management Zone for Silver and Bighead carp (IMZ; Pools 16-19) of the Upper Mississippi River (UMR). Within the IMZ, a diverse array of management actions and monitoring strategies are being implemented annually 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 scarcer, so eDNA sampling occurred annually from 2018-2022 to monitor for an increase in the rate of carp DNA detections. During this time fame, these two pools were not rigorously sampled by other USFWS Invasive carp monitoring efforts. Therefore, the goal of sampling Pool 13-14 was to assess trends in eDNA presence in backwaters over time, as a first line of surveillance, which may give evidence to changes in the Invasive carp population in those pools. These data may also be used to aid in directing removal and tagging efforts to areas of congregation outside of the IMZ. In 2021 and 2022, there was a noticeable increase in eDNA detection rates in Pools 13 and 14, which coincided with an increase in observations and captures in other pools above 15. Due to the assumed increase in carp presence in these two pools, which eDNA detections gave evidence to, efforts to capture and tag Invasive carp have now been allocated to these pools beginning in 2023. Although there is still no evidence of a reproducing population, eDNA data did point to a potential increase in the population present at targeted sampling locations. Because other carp monitoring efforts have now increase in these two pools, the eDNA samples will be reallocated to other upstream areas in 2023 and Pools 13 and 14 eDNA sampling will be discontinued.

Pool 8 of the Upper Mississippi River has seen an increase in commercial capture of Invasive carp, particularly Silver carp, in recent years and eDNA water sampling has also detected the genetic presence of carp in this time frame. Continued long-term sampling for eDNA in Pool 8, and other priority areas named by state partners, may help indicate early establishment of invasive carp populations in upstream pools and tributaries of the Upper Mississippi River that are not regularly monitored by other methods. The number of tagged Invasive carp present in Pool 8 and above is very low, therefore eDNA sampling can help direct fishing efforts to areas of potential carp congregation by highlighting backwaters with heightened or increasing positive DNA detection rates. eDNA sampling efforts from downstream, as discussed previously, have been reallocated to select areas of Pools 5 and 5a at the request of Minnesota due to an interest in monitoring for evidence of increasing Invasive carp presence above and below Lock and Dam 5.

Additionally, several tributaries of the Mississippi River have been named by Iowa, Wisconsin, and Minnesota partners as areas of interest to monitor for early Invasive carp establishment or spawning activity including the Turkey River (confluence in Pool 11), Wisconsin River (confluence in Pool 10), Upper Iowa River (confluence in Pool 9), St. Croix River (confluence in Pool 3), and Minnesota River (confluence in Pool 2).

The USFWS eDNA program seeks to continually refine eDNA technology and sampling strategy. Collecting samples and conducting research studies in 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.

Objectives:

1. Monitor for Invasive Carp eDNA, as part of a long-term monitoring strategy, in targeted backwaters and tributaries of the UMR, at the request of state managers
2. Inform managers of potential trends in Invasive carp presence and provide data to support the prioritization of backwaters and tributaries to target with traditional capture methods and tagging efforts
3. Conduct research studies to refine detection probability and optimal sampling design of eDNA sampling in the UMR
4. Provide eDNA monitoring support for MUM capture events in Pool 8 when appropriate

Activities and Methods: In 2023, to address objectives 1 and 2, eDNA samples will be collected from backwater habitats in pools 5, 5a, and 8 in the spring, as that is the season where Invasive carp tend to congregate in these habitats. In Pools 5 and 5a, sampling will target one backwater in each pool (Figure 1) and consist of 100 samples and 10 quality control field blanks. In Pool 8 the same areas as the previous year, consisting of 80 samples and 8 quality control field blanks will be collected in each of two backwater sites in Pool 13 and one backwater site in pool 14 (Figure 1-2).

Additionally, five backwater and off-channel areas in Pool 8 (Figure 2) will be targeted and sampled for Invasive carp DNA in the spring, following ice out, and again in the fall. In four backwaters, 100 samples and 10 quality control field blanks will be collected, and an additional 50 samples and 5 field blanks will be collected from an off-channel area near the French Island powerplant. These events will precede the spring Modified Unified Method sampling event, a mass removal effort coordinated by Minnesota Department of Natural Resources and the U.S. Geological Survey – Columbia Environmental Research Center.

In late spring, five tributaries of interest will be sampled for Invasive carp DNA in 2023 including the Turkey and Upper Iowa Rivers in Iowa, the Wisconsin River in Wisconsin, the Minnesota River in Minnesota, and the St. Croix River bordering Wisconsin and Minnesota will be sampled for invasive carp eDNA. In the Wisconsin (Figure 3), Turkey, Upper Iowa, and Minnesota (Figure 4) rivers, sampling will focus on the portion of each tributary downstream of the first barrier and be conducted in the spring when carp may be present during spawning activities. The St. Croix River will also be sampled in the spring, but sampling will focus on two backwater sites near Stillwater, MN (Figure 5). At each of these two sites, and in each of the other four tributaries, 100 samples plus 10 field blanks will be collected.

The Credit Island backwater in Pool 16 (Figure 6) will be sampled for Invasive carp DNA in fulfillment of objective 3. Sampling will occur once in the spring and once in the fall to allow an additional point of comparison with telemetry data. 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.

All sampling and preservation procedures will follow the USFWS Quality Assurance Project Plan (QAPP 2023). 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 Areas:

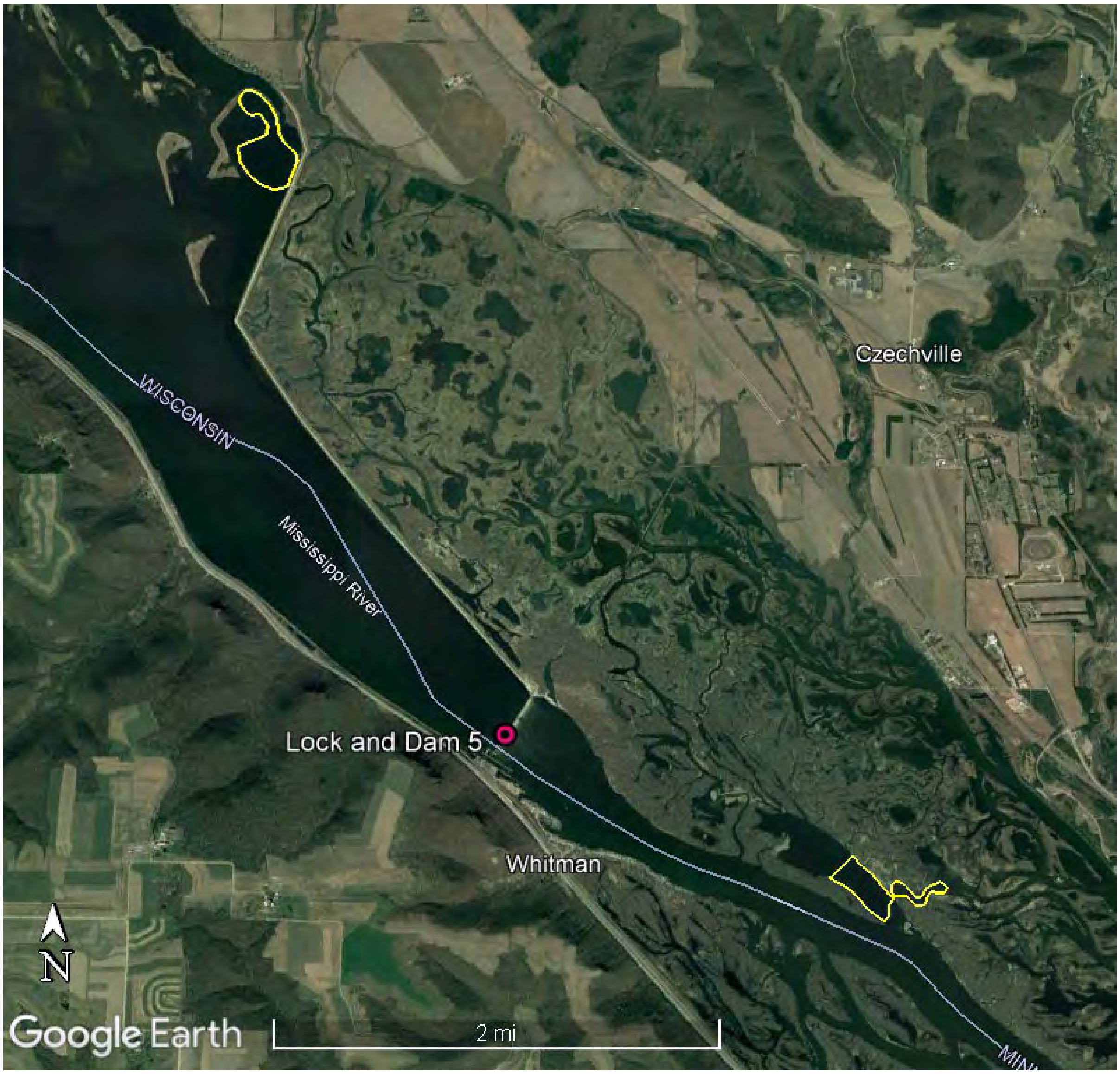

Figure 1. One backwater site in Pool 5 and one site in Pool 5a of the UMR to be targeted by USFWS for Bighead and Silver carp eDNA sample collection in 2023.

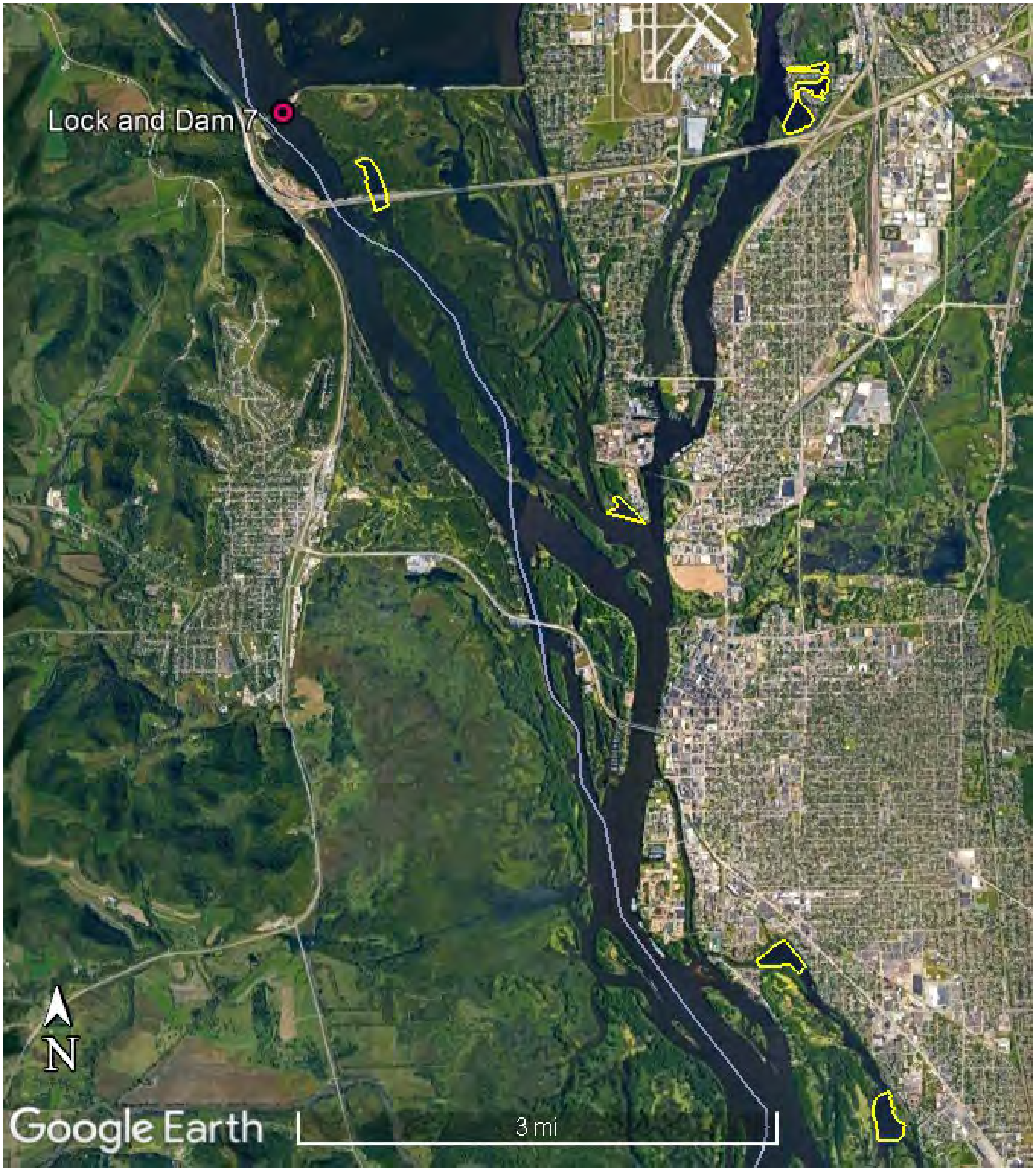

Figure 2. Five backwater and off-channel sites in Pool 8 of the UMR to be targeted by USFWS for Bighead and Silver carp eDNA sample collection in 2023.

Figure 3. Area of the Wisconsin River below Prairie Du Sac Dam to be targeted by USFWS for Bighead and Silver carp eDNA sample collection in 2023.

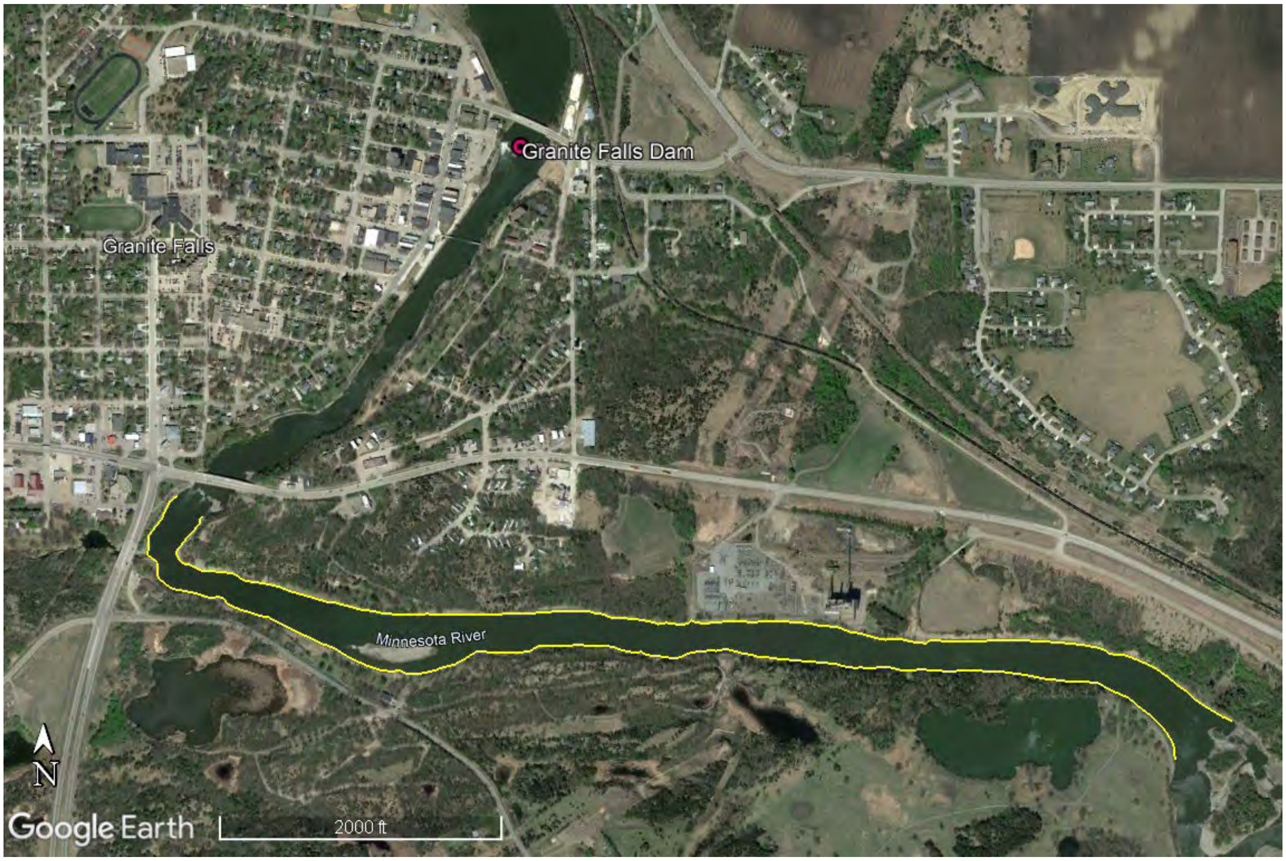

Figure 4. Area of the Minnesota River below the Granite Falls Dam to be targeted by USFWS for Bighead and Silver carp eDNA sample collection in 2023.

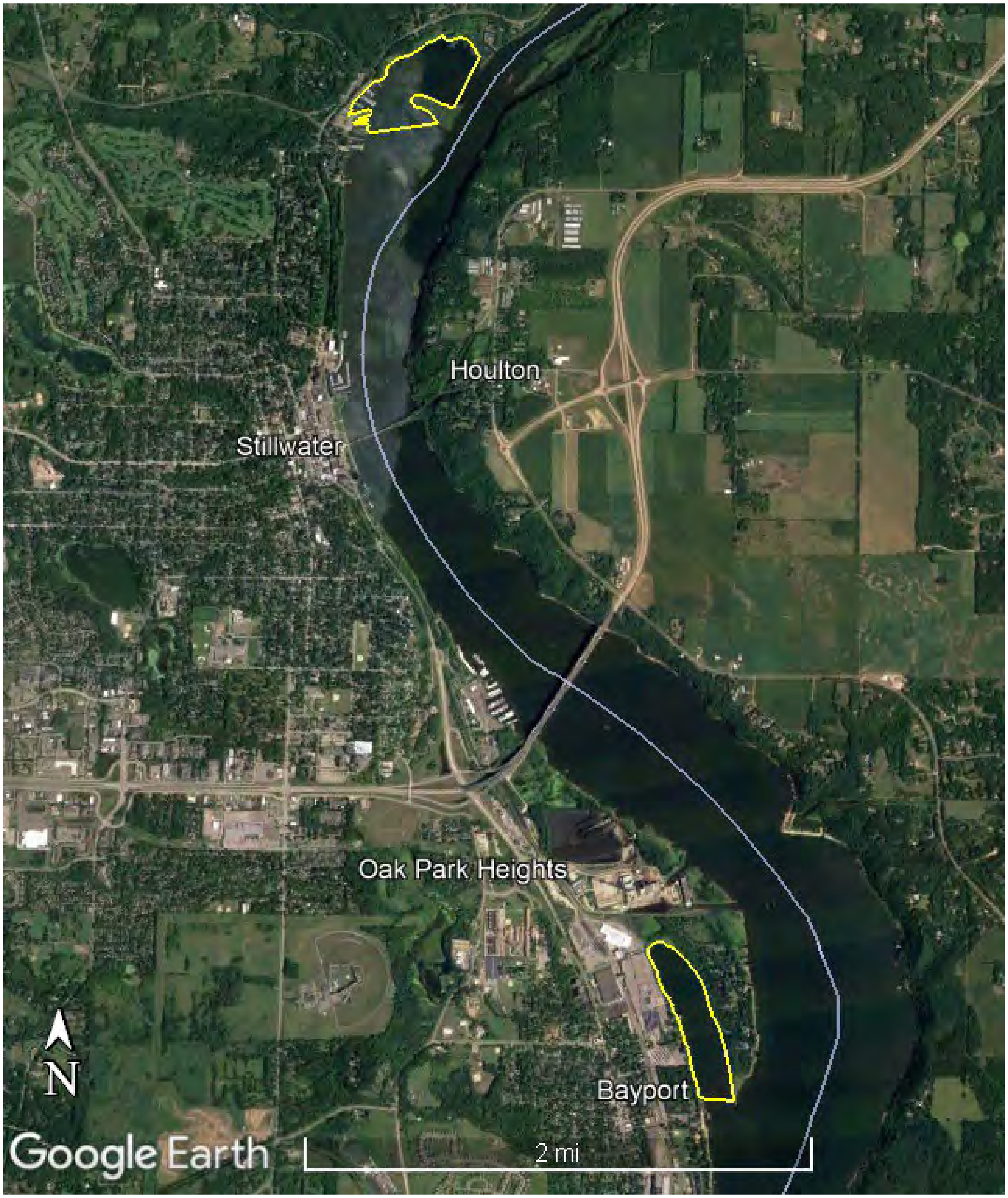

Figure 5. Two backwater sites in the St. Croix River to be targeted by USFWS for Bighead and Silver carp eDNA sample collection in 2023.

Figure 6. Credit Island backwater, in Pool 16, where Bighead and Silver carp eDNA samples will be collected in 2023 by USFWS.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Pool 5, 5a, 8	April
Pool 16	April
Turkey River, Upper Iowa River (IA)	May
Wisconsin River (WI)	May
Minnesota River, St. Croix River (MN)	May
Pool 8	October
Pool 16	October

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December 2023