2021

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

Presented by the Mississippi Interstate Cooperative Resource Association Invasive Carp Advisory Committee

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Suggested citation for this document:

Aldridge, C., N. Jackson, R. Neeley, E. Pherigo, and G. Conover, editors. 2022. 2021 Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin. Invasive Carp Advisory Committee. Mississippi Interstate Cooperative Resource Association, Carbondale, IL, 271 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 continues to be used when referencing titles of specific historic documents, e.g., Ohio River Basin Asian Carp Control Strategy Framework. Additionally, some agencies that participate in the sub-basin partnerships continue to use the term 'Asian carp' when referring to these species. Therefore, the terms 'invasive carp' and 'Asian carp' are used interchangeably in this document.

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, and includes numerous large tributary systems including the Arkansas, Illinois, Missouri, Ohio, Tennessee, Cumberland, Red, and White rivers. Recreational boating and fishing in the Mississippi River and tributaries support many local economies throughout the Mississippi River Basin. In 2015, the U.S. Fish and Wildlife Service (USFWS) estimated the economic output from recreational fishing in the Mississippi River Basin at more than $19 billion (USFWS, unpublished data).

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 (Figures 2 and 3).

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. The MICRA member agencies and their federal partners formed four sub-basin invasive carp partnerships (Figure 4) to develop and implement Frameworks in the Lower Mississippi River Sub-Basin, Missouri River Sub-Basin, Ohio River Sub-Basin (ORB), and the Upper Mississippi River Sub-Basin (UMRB). The Lower Mississippi River Sub-Basin Framework is inclusive of the Arkansas-Red-White Rivers Sub-Basin, and the ORB Framework is inclusive of the Tennessee-Cumberland Rivers Sub-Basin. The four sub-basin invasive carp partnerships provide coordinated implementation of regional Frameworks throughout the Mississippi River Basin (Figure 4).

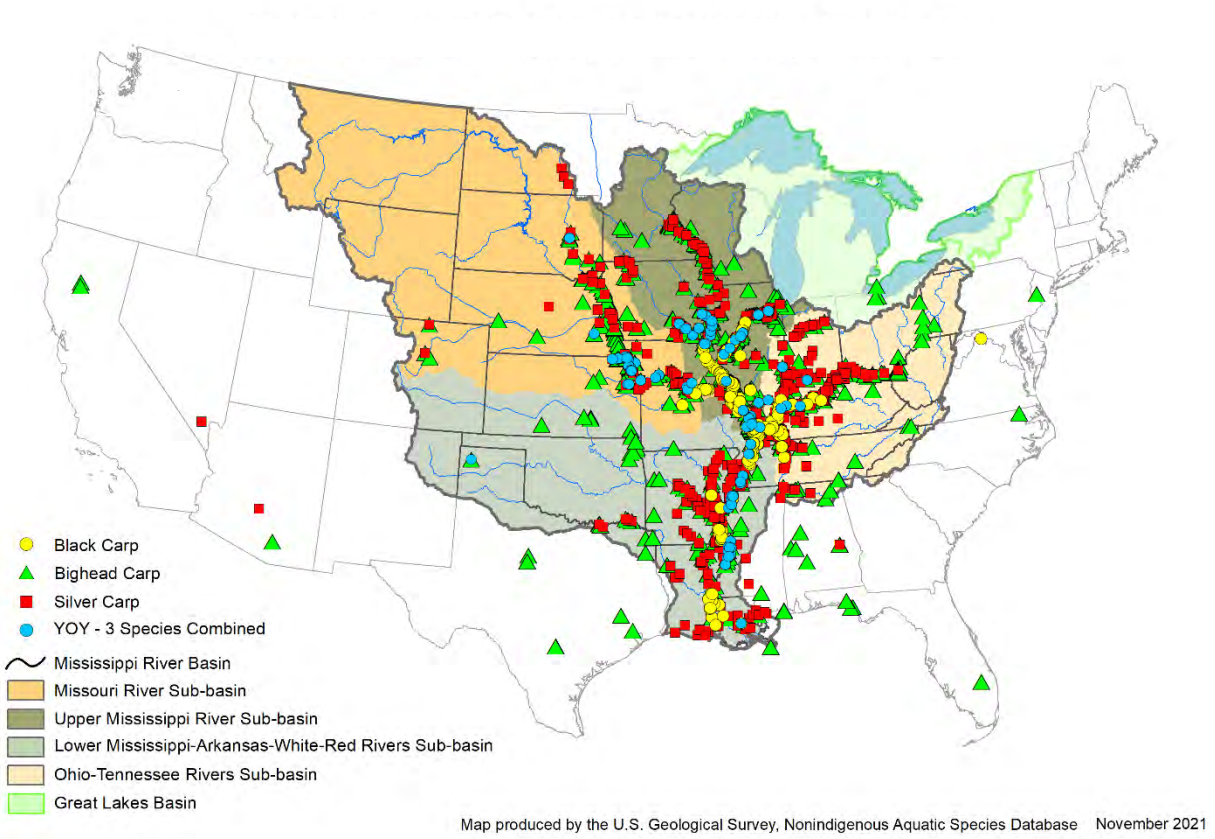


Figure 2. Distribution of Bighead Carp, Silver Carp, and Black Carp in the lower 48 states of the United States as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of November 2021. Shading indicates the sub-basin invasive carp partnerships within the Mississippi River Basin (Missouri River, Upper Mississippi River, Lower Mississippi including the Arkansas-White-Red Rivers, and the Ohio River Basin including the Tennessee and Cumberland Rivers) and the Great Lakes Basin. Asian carp Control Strategy Frameworks guide collaborative invasive carp efforts within each sub-basin.

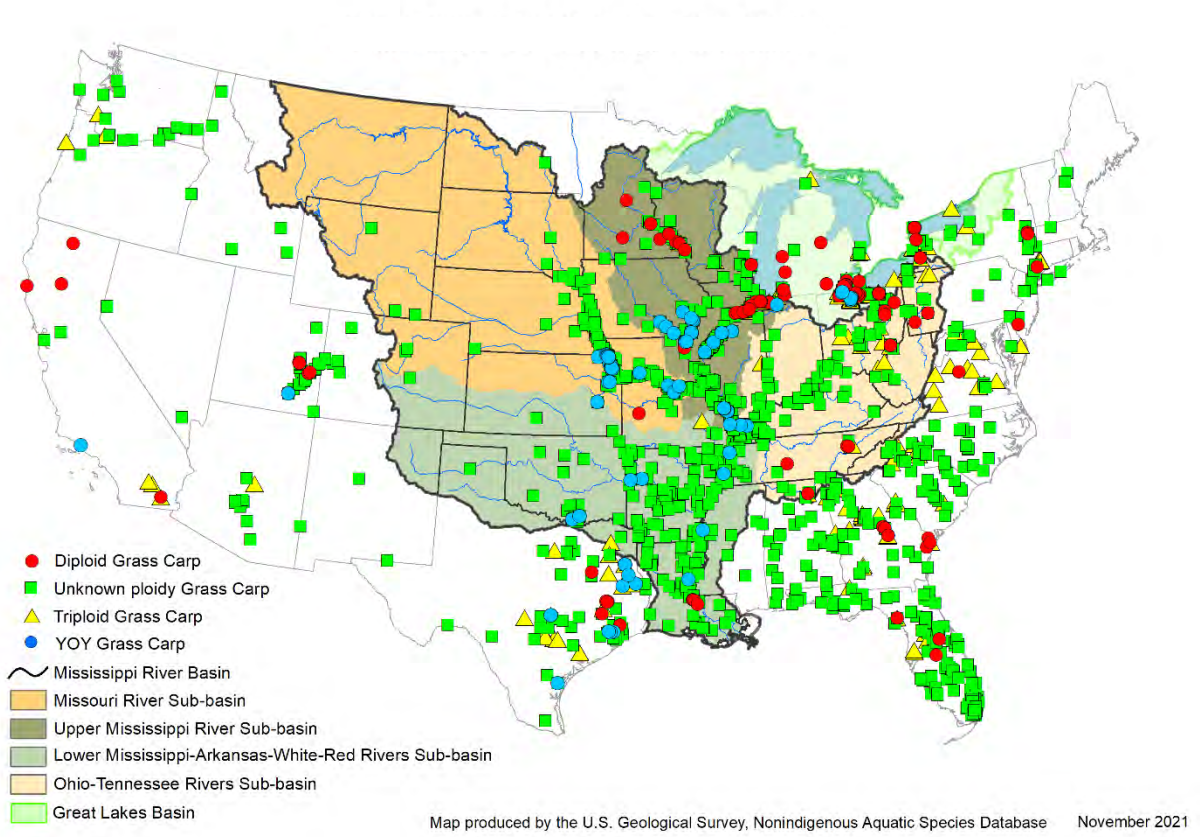


Figure 3. Distribution of Grass Carp in the lower 48 states of the United States as reported to the USGS Nonindigenous Aquatic Species (NAS) Database as of November 2021. Shading indicates the sub-basin invasive carp partnerships within the Mississippi River Basin (Missouri River, Upper Mississippi River, Lower Mississippi including the Arkansas-White-Red Rivers, and the Ohio River including the Tennessee Rivers) and the Great Lakes Basin. Asian Carp Control Strategy Frameworks guide collaborative invasive carp efforts within each sub-basin.

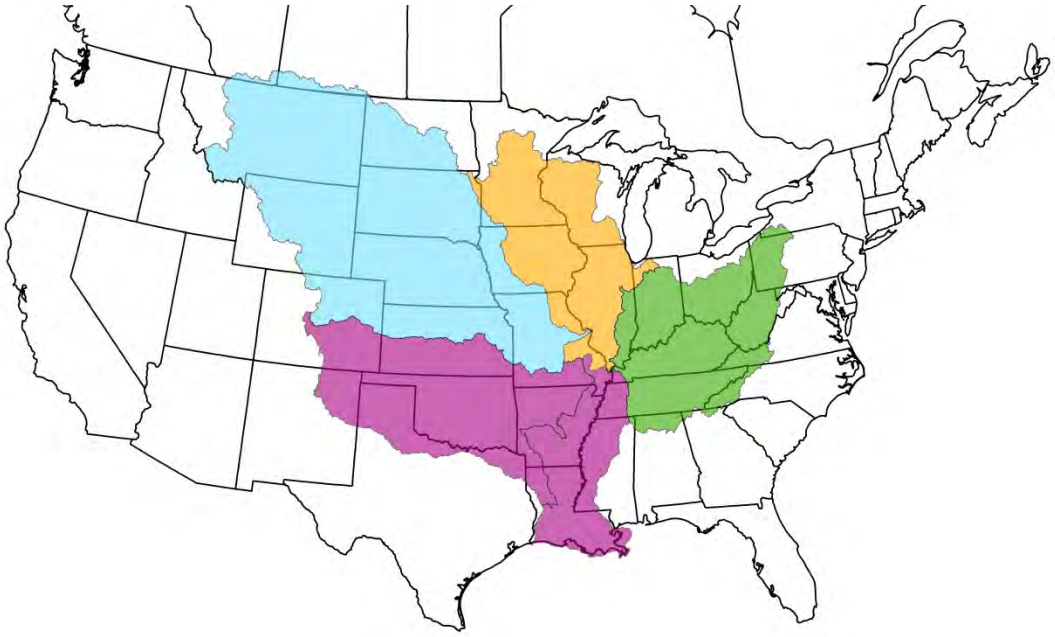


Figure 4. Development and implementation of Asian Carp Frameworks in the Mississippi River Basin is broken down into four sub-basins including the Ohio River Sub-Basin (green; includes the Tennessee-Cumberland Rivers Sub-Basin), Upper Mississippi River Sub-Basin (yellow), Missouri River Sub-Basin (blue)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

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

Mississippi River Basin Invasive Carp Federal Authorization and Appropriations Overview

On June 10, 2014, the United States Congress, in Section 1039 (b) of the Water Resources Reform and Development Act of 2014 (WRRDA), charged the USFWS, to work in coordination with the Secretary of the Army, the Director of the National Park Service (NPS), and the Director of the U.S. Geological Survey (USGS) to lead a multiagency effort to slow, and eventually eliminate, the spread of invasive carp in the ORB and UMRB. Congress appropriated $2.4 million in the USFWS's FY2015 base budget for invasive carp prevention and control in the ORB and UMRB[1], providing the first substantial funding to address invasive carp populations in the Mississippi River Basin beyond the upper Illinois River and the CAWS (Table 1). USFWS

[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".

funding for invasive carp work in the ORB and UMRB increased to $2.6 million in FY2016. USFWS funding for invasive carp work in the ORB and UMRB totaled $3.1 million in 2017 with the addition of $500,000 by Congress specifically for the development and implementation of deterrence technologies in the field that are transferrable to other basins and potentially useful for other aquatic nuisance species. USFWS funding in FY2018 increased to $4.8 million and includes the addition of $1.7 million to "expand and perfect the combined use of contract fishing and deterrents" in the ORB and UMRB. FY2019 appropriations included an additional $600,000 specifically for implementation of the ORB Framework within the Tennessee and Cumberland Rivers portion of the ORB.

Table 1. Total annual appropriations to USFWS for invasive carp prevention and control work outside of the Great Lakes (beyond the upper Illinois River and the CAWS) from 2015-2021, and the amount of agency funding provided by USFWS to the MICRA sub-basin invasive carp partnerships to support implementation of priority Framework actions in the Mississippi River Basin.

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

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." Similar to FY20, in FY21, the USFWS worked closely with MICRA and the four 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 FY21 funds using targets identified by the USFWS (Table 2).

Table 2. USFWS target allocation of FY21 base funding for invasive carp prevention and control work in the six Mississippi River sub-basins.

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

Mississippi River Basin Invasive Carp Project Coordination

To provide for state and federal agency executive level coordination on invasive carp prevention and control in the Mississippi River Basin, MICRA formed an Invasive Carp Advisory Committee (ICAC) in 2016 (Figure 5). The ICAC consists of the MICRA Executive Board (i.e., one state agency representative from each of the six MICRA sub-basin groups, two federal entity members, MICRA Chairman, MICRA Chairman-elect, and MICRA Coordinator) and a single agency representative from key federal partners not on the MICRA Executive Board (i.e., National Park Service, U.S. Army Corps of Engineers, and Tennessee Valley Authority). The ICAC provides a mechanism for coordination, communication, and collaboration across the regional sub-basin efforts to provide for the most effective implementation of a Mississippi River basin-wide invasive carp prevention and control program.

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

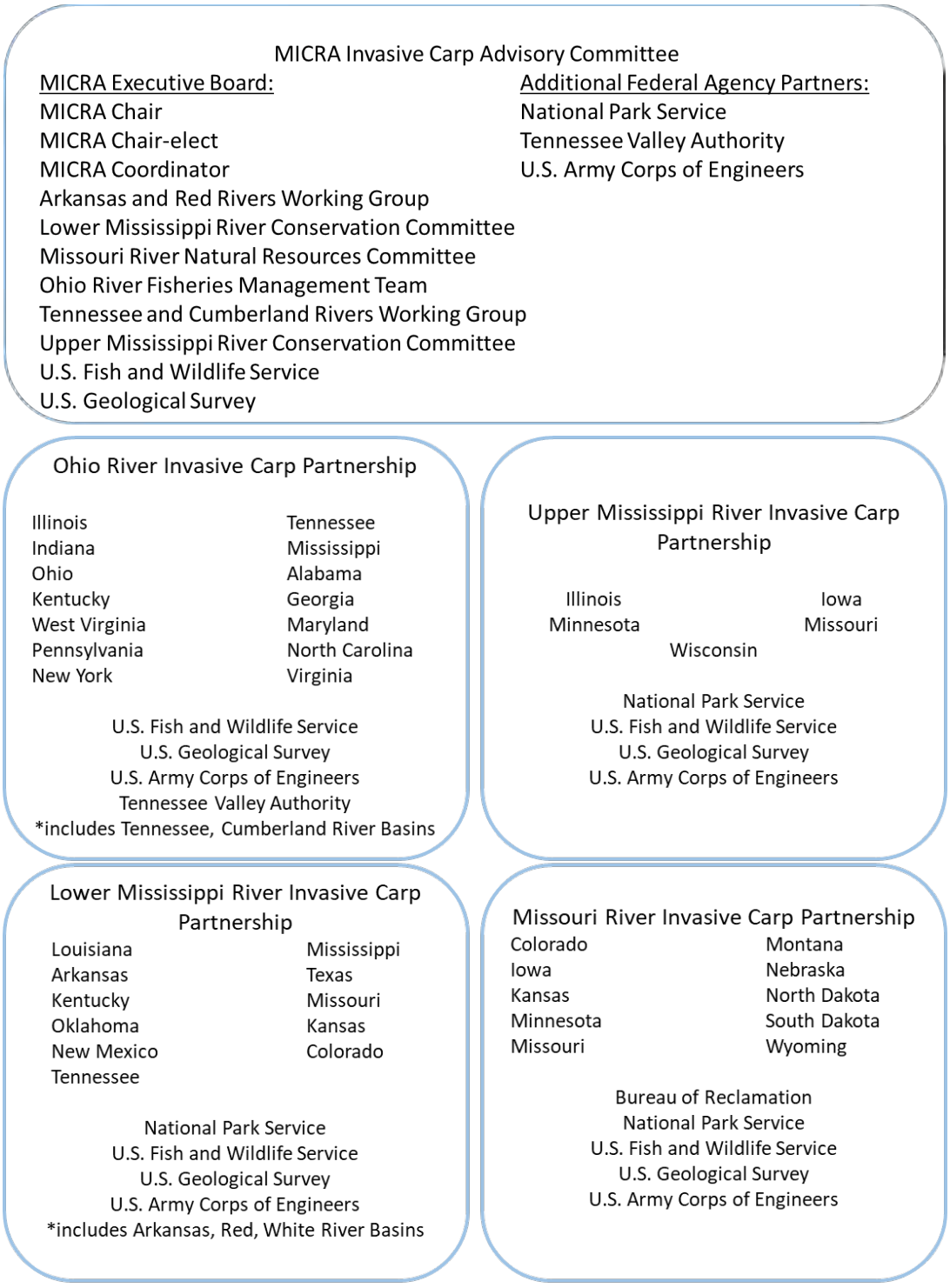


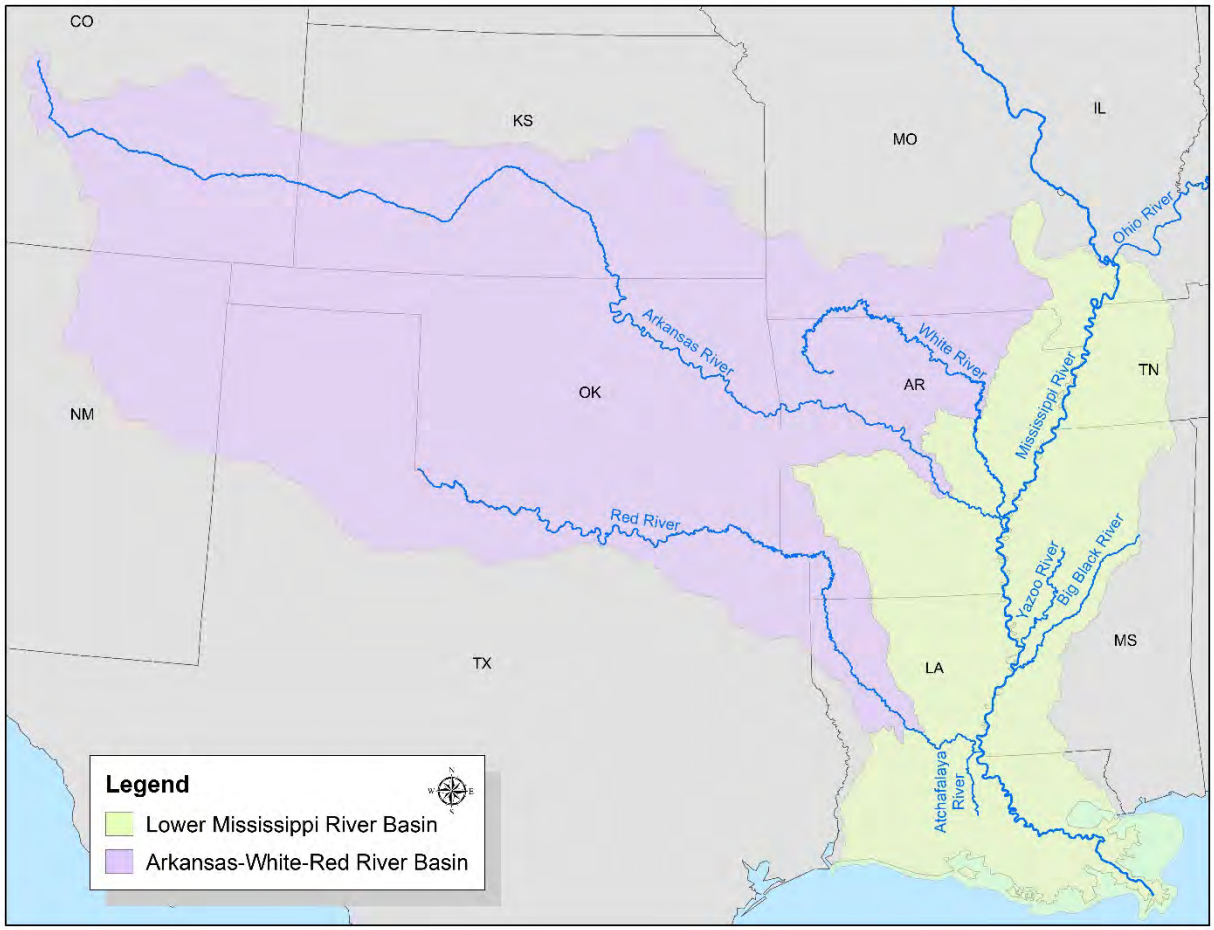
Figure 6. Structure for inter-agency coordination and implementation of Asian Carp Control Strategy Frameworks in the Mississippi River Basin. Basin-wide coordination occurs through the MICRA Invasive Carp Advisory Committee and regional coordination occurs through four sub-basin invasive carp partnerships: Ohio River (inclusive of the Tennessee-Cumberland Sub-Basin), Lower Mississippi River (inclusive of the Arkansas-Red-White Sub-Basin), Missouri River, and the Upper Mississippi River.

2021 Monitoring and Response Plan for Invasive Carp in the Mississippi River Basin

The 2021 MRP includes project work plans for 25 projects collaboratively developed by state and federal agency partners throughout the Mississippi River Basin working together through four sub-basin invasive carp partnerships. In FY21, USFWS funding support was provided for 8 projects in the Lower Mississippi River Sub-Basin, including the Arkansas-Red-White Rivers Sub-Basin (2); 4 projects in the Missouri River Basin; 9 projects in the ORB, including the Tennessee-Cumberland Rivers Sub-Basin (5); and 5 projects in the UMRB. An overview of each sub-basin partnership and the full project work plans supported in FY21 are provided in subsequent chapters for each sub-basin partnership.

Lower Mississippi River Sub-Basin Invasive Carp Partnership

The Lower Mississippi River Sub-Basin Invasive Carp Partnership includes 11 states from the Lower Mississippi River Sub-Basin and the Arkansas-Red-White Rivers Sub-Basin. These states convened a partnership to develop an Asian Carp Control Strategy Framework, which steps down the National Plan to a local level, allowing the partnership to collaboratively develop priority management and control projects. For project planning, the partnership often splits into two groups based on geography but overlap exists. Partners in this sub-basin are at varying levels of knowledge about invasive carp status within their respective jurisdictions. Initial projects are investigating unknown areas for basic population demographic data, but also include control efforts in locations where practicable, movement projects to better understand passage through locks and dams and between tributaries, and other high priority actions identified by the partnership.



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

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

Objective:

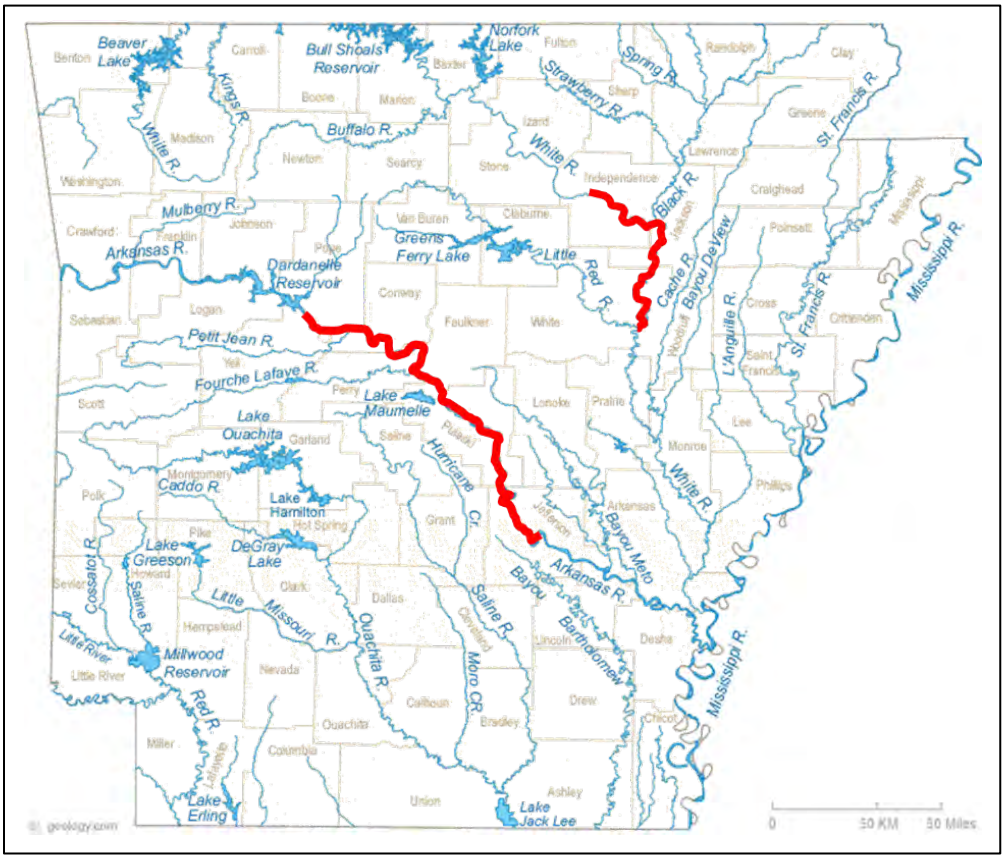
1. Remove Bighead, Silver, Grass and Black Carp from the Arkansas and White Rivers.

Agency: The Arkansas Game and Fish Commission (AGFC)

Activities and Methods: The Arkansas Game and Fish Commission will use the Asian Carp funding to hire two temporary employees and provide sampling gear as needed for the removal of Asian Carp from the Arkansas River pools 5, 6, 7, 8, 9, and the White River from RM 176 to the low water dam at Batesville. All by-catch will be released immediately. The crew will record date, capture location, number of each Asian Carp species captured, and tackle type used. Data on by-catch will also be collected. Netting locations will be determined from the AGFC ANS database and from information obtained from commercial fishers. All data collected should increase our knowledge of Asian Carp and improve management and collection options in the future.

Funding will also be used to hire a full-time Asian Carp Biologist to coordinate removal efforts, removal locations, and removal successes.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Arkansas River Pool 5	October 2021 – September 2022
Arkansas River Pool 6	October 2021 – September 2022
Arkansas River Pool 7	October 2021 – September 2022
Arkansas River Pool 8	October 2021 – September 2022
Arkansas River Pool 9	October 2021 – September 2022
White River RM 289	October 2021 – September 2022
White River RM 287.5	October 2021 – September 2022
White River RM 278	October 2021 – September 2022
White River RM 260	October 2021 – September 2022
White River RM 256.5	October 2021 – September 2022
White River RM 249.3	October 2021 – September 2022
White River RM 207.4	October 2021 – September 2022
White River 202	October 2021 – September 2022
White River 178.6	October 2021 – September 2022

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

Lead Agency and Author: Auburn University, Shannon K. Brewer (skb0064@auburn.edu) and Dennis Devries (devridr@auburn.edu)

Cooperating Agencies: Oklahoma Department of Wildlife Conservation (ODWC), Arkansas Game and Fish Commission (AGFC), USFWS Oklahoma Fish and Wildlife Conservation Office (OKFWCO)

Statement of Need: Asian carp pose significant ecological and economic threats to freshwaters around the globe, including in the Mississippi River Basin. Asian 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 Asian 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). However, there is a general lack of information regarding the population dynamics of Asian carps and their effects on native fish communities of the lower Mississippi River basin. Understanding occupancy by bigheaded carps in the basin, both spatially and temporally, is vital for directing the management actions. Furthermore, there 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.

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. This project will initiate a surveillance effort for Asian carp at a broad geographic scale across the Lower Red River Basin as well as establish baseline data for native fish assemblages potentially impacted by Asian carp needed for future evaluations of deleterious impacts. This project will address the general lack of knowledge of Asian carp population dynamics and native fish assemblages in this Sub-Basin. The intentions of this effort are to aid in early detection, assess population distribution and status, and facilitate future evaluations of deleterious impacts to native fishes. Data on Asian carp populations would also inform potential removal efforts. Collaborative efforts of multiple partners and agencies (state, federal, and university) will be implemented to accomplish the project goals and objectives. This project will provide an ongoing, coordinated effort to evaluate Asian carp distribution and status in the Lower Red River Basin that will contribute to a better understanding of the status of this species in the Mississippi River Basin as a whole.

Objectives:

1. Determine the spatial and temporal distribution and adult population demographics of Asian carp (Silver Carp and Bighead Carp)
2. Establish baseline native and non-native fish assemblage and habitat association data

Agency: Auburn University

Activities and Methods:

Red River and Tributaries

Portions of the Red River and major tributaries of Oklahoma (Kiamichi River, Muddy and Clear Boggy rivers, Blue River) will be sampled. Access on extensive portions of the Red River below Texoma can be challenging; thus, we will choose sample locations to both well represent the study extent at locations accessible by boat or raft.

Spatial and Temporal Extent of Bigheaded Carp (Hypopthalmichthys spp.)

We will sample using a wide variety of gears during spring, summer, and fall/winter. Sampling during winter will be limited because sample efficiency is so low due to water temperatures. Our catch rates from our first year of sampling will be used to help us determine which gear is most effective during the second year. We will use a combination of boat electrofishing, experimental gill nets, and fyke nets to sample different locations on the rivers. Several authors have noted that combining gears and 'chasing' fish into nets often produced the best results (Thompson 2013; Bouska et al. 2017; Butler et al. 2019). One reason to combine gears is that electrofishing may be more effective on Silver Carp (Williamson and Garvey 2005), whereas use of trammel/gill nets has been one of the best approaches for sampling Bighead Carp (Garvey et al. 2012). Nets will be placed at narrow locations within the river channel to increase the likelihood of capture while electrofishing. We know that bigheaded carp occupy the Red River, OK as our previous sampling efforts captured them downriver of Lake Hugo on the Kiamichi River and at the confluence of the Muddy Boggy-Red River (Brewer, Unpublished data). This project, in conjunction with existing projects, will add to information on occupancy by carp in the Red River basin. Collectively, our goal is to document the spatial and temporal extent of bigheaded carp in the Red River basin of Oklahoma, Arkansas, and tributaries in Texas (itemized as three proposals with similar objectives). Investigators across the basin will work together to ensure consistency in both sampling and ageing approaches.

Captured fish will be sacrificed and information obtained from several structures. We will measure the total length and weight of all captured fish and determine the sex where possible (Wolf et al. 2018). Gonads of fish will be removed to later determine fecundity (i.e., total gonad weight, and egg counts). We will also remove fin rays and otoliths for later ageing and to determine recruitment patterns and estimate length at age. A subset of otoliths from adult bigheaded carps will be retained for the possibility of additional future work in outyears (<u>not the current proposal</u>) to examine microchemistry analysis to determine origins and coarse-scale movement patterns.

Population Demographics of Bigheaded Carps

An understanding of population demographic parameters is needed to assess the current status of bigheaded carps in the Red River basin. Baseline demographic data can also be used to assess future population responses to management actions (e.g., reduction efforts) and assess bigheaded carps' responses to environmental changes (e.g., flow regime patterns) over time. We will summarize population demographics of bigheaded carps using data collected during Objective 1. We will estimate catch-per-unit effort for each gear type to assess relative abundances of

bigheaded carps across the Red River and tributaries. The catch per-unit-effort data will provide a baseline estimate of abundance to assess future changes in native fish communities with increases or decreases in bigheaded carps' abundance. We will use individual length data to summarize size structure as a means to assess potential differences in recruitment patterns or growth patterns among drainages. We will also make use of bigheaded carp hard-part structures to facilitate age determination. A subset of 10 individuals from each 10 mm TL size group will have sagittal otoliths and pectoral fins removed (Coggins et al. 2013). We will process and age otoliths (including a second read) and pectoral fins using light microscopes and digital photographs. The subset of aged individuals along with their respective lengths will be used to create an age-length key to predict ages from lengths of unaged individuals. Age structure data will be summarized by location along the Red River and tributaries and used in catch curve regression to estimate instantaneous (Z) and annual (A) mortality rates among locations, if possible (i.e., depends on catch). Additionally, individual carp will be assigned to a year class and indices of recruitment will be assessed among locations. Gonads from both male and female carp will be taken during Objective 1 to assess timing of sexual maturity both in terms of individual fish age and seasonal timing of reproduction.

Habitat Associations of Bigheaded Carps and Native Fishes

Because relatively little sampling has occurred in the Red River basin and tributaries, we will determine habitat associations and large river assemblage structure during sampling for Objective 1. Habitat will be related to channel unit structure (i.e, pool, backwater, main channel, side channel, run) and be tributary specific in both Oklahoma and Texas. All bigheaded carps and native fishes sampled will be identified and native fishes released unless identification needs to be confirmed in the laboratory. All threatened and endangered fishes will be identified and released during the sampling event.

Because bigheaded carps are highly fecund and planktivorous, they are hypothesized to compete with most all native post-larvae and fry stages of fishes (Kolar et al. 2007; Cudmore et al. 2011). Bigheaded carps may also compete for food with native adult planktivores (e.g., Paddlefish *Polyodon spathula*, Bigmouth Buffalo *Ictiobus cyprinellus*, and Gizzard Shad *Dorosoma cepedianum*, Schrank et al. 2003; Irons et al. 2007; Sampson et al. 2009). Moreover, established populations can use physical space typically occupied by native fishes and may result in species displacement leading to reductions in growth and survival.

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

management actions (e.g., targeted removal efforts of non-native fishes while minimizing harm to native fishes).

We will sample low-velocity habitats associated with the mainstem and larger tributaries of the Red River. Sampling for native and non-native juvenile fishes will begin in July and continue through September. Larger bigheaded carp typically spawn before smaller individuals (Hintz et al. 2017); thus, sampling as early as July will allow us the opportunity to capture very small juveniles that may be hatched early in the spring. We will sample areas around sandbars, backwater habitat, pool margins, and edges using a combination of seines, push nets, and electrofishing. Because the habitat is both complex and diverse within the Red River and tributaries, we will use a combination of habitat classification used in sand bed and gravel-bed streams (e.g., riffles, runs, pools, chutes, slackwater, ripples, dunes, sand bar heads and tails, backwater, etc). Our classifications will be collapsed into groups of similar mesohabitat character (e.g., ripples and riffles are similar in slope and water depth but differ via dominant substrate); however, differences in mesohabitats will be captured through quantification of specific microhabitat elements (e.g., substrates). Habitat conditions at sampling locations with be quantified at mesohabitat and microhabitat scales. Most captured native fish will be identified and released at the sampling location except a subset to be used as voucher specimens; all threatened and endangered fishes will be identified and released during the sampling event. All bigheaded carp juveniles captured will be removed from the system and otoliths retained.

We will remove lapilli otoliths from up to 20 juvenile bigheaded carp per species from each occupied site on each sampling date for aging. Otoliths will be mounted in thermoplastic cement, placed on microscope slides and sanded using 1,000 grit sandpaper and (or) diamond filament paper. Ring counts on otoliths will be performed by two independent readers using a compound microscope at 100× magnification. If otolith ring counts differ by more than 10% between readers, they will be discarded. We will estimate birth dates of juvenile Asian carp and examine conditions (discharge and temperature conditions) leading to successful recruitment. Otolith samples will be archived for potential future microchemistry analysis to assess origins and coarse-scale movements.

Map of Project Area:

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Targeted Bigheaded Carp and Native Fish Sampling – Red River and tributaries in OK	Fall 2021, Winter 2021 (limited), Spring/Summer 2022
Project Executive Summary	October 2022
Final Project Technical Report	February 2023

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

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

Cooperating Agencies: N/A

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

Previous observations in the LMR have suggested that Asian Carp occupy deep (>75 feet) holes behind dikes or associated with point bar scour holes during winter. Preliminary data indicates that carp form tight schools, or aggregations, during overwintering making them particularly susceptible to harvesting. The LMR is replete with deep holes where Asian Carp may aggregate but detailed analysis of these overwintering habitats have not been conducted. A pilot study is proposed to survey the river around Vicksburg, MS and locate deep holes and the presence of carp aggregations. Based on these observations, overwintering habitat in the LMR can be mapped and targeted for mass removal of Asian Carp to reduce recruitment in other watersheds.

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

entities can be established to effectively plan, implement, and evaluate management and control efforts by exploiting these vulnerable populations while overwintering in large schools.

Objectives:

1. A pilot study is proposed to evaluate the feasibility of locating large schools of Silver and Bighead Carp overwintering in deep holes on the Lower Mississippi River. Project duration is one year, and if the pilot study is successful, a more detailed proposal will be submitted for FY22-23 to expand the geographic extent of the study, optimize collecting techniques, and develop population models to evaluate harvesting requirements to reduce population densities in the LMR. Objectives for the pilot study are:

    a. Locate large schools of Silver and Bighead Carp overwintering in the LMR
    b. Measure and characterize the hydrogeomorphic and water quality environment of each overwintering habitat
    c. Evaluate different collecting gears to harvest carp in large numbers at overwintering locations

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

Activities and Methods: A pilot study is proposed to survey the river around Vicksburg, MS, locate deep holes, and determine the presence of carp aggregations. ERDC will survey the Vicksburg reach during several weeks in January and February 2022 (see Map below). We will use electronic fish finders to locate large schools of Asian Carp during winter conditions. A suite of variables will be measured at each site, including those with and without carp aggregations, to determine the hydraulic (depth, velocity), spatial extent, substrate types, and water quality characteristics. Depth, velocity, and different measures of turbulence (e.g., Reynolds stress) will be mapped along transects using an Acoustic Doppler Profiler and maps will be created. The areal extent of each deep hole will be calculated based on GPS coordinates. Substrate type will be measured with a benthic sled (Harrison et al. 2018). Water quality will be measured with YSI sondes along vertical transects and will include water temperature, pH, conductivity, dissolved oxygen, and turbidity. Habitat variables will be compared between deep holes with and without carp aggregations using ANOVA's and Principal Component Analysis to determine potential characteristics that serve to attract carp to overwintering habitat.

Fish collections will be conducted during an additional week after deep holes have been located. Crews will use different gear types to determine maximum efficiency of collecting carp focusing on gillnets 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 deep holes as overwintering habitat.

A report will be prepared that identifies number of schools and their size range located in the study reach, summarizes hydrogeomorphic and water quality characteristics of overwintering locations, analyzes gear efficiency, and provides recommendations on further studies.

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	January 2022
Sample Asian Carp at representative deep holes	February 2022
Prepare Report	March – April 2022

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Identifying Asian carp markets to increase harvest

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

Cooperating Agencies: Louisiana Universities Marine Consortium (LUMCON), Nicholls State University (NSU).

Statement of Need: Commercial harvest remains the most cost effective control method of Asian carp and may potentially benefit local economies. However, low prices have resulted in limited harvest in Louisiana (LA). In the past, LDWF partnered with Silverfin Group Inc. in an attempt to promote consumption of Asian carp through both recreational and commercial harvest. Success was limited; the demand has not significantly increased the harvest or dockside price. Increased nonhuman consumption of Asian carp as bait, animal feed, or fertilizer may be needed to increase the demand, which may in turn increase the dockside price.

The aquaculture industry relies heavily on fishmeal and fish oil (sourced primarily from marine fish species such as menhaden and anchovies) as key ingredients in aquaculture feeds. Under the current rates of industry growth, availability cannot match projected demand, with the industry requiring an additional 37.4 million tons of aquafeed by the year 2025 (Hua et al., 2019). Industry participants are examining a variety of alternative feed ingredients such as algae, soy, single celled proteins, and insects as cost effective and environmentally sustainable substitutes. However, these alternatives present their own complications when compared to traditional fishmeal-based feeds, often resulting in reduced growth and overall production performance. Companies across the United States are exploring the development of alternative aquafeed ingredients; one such company, Nobilis Aqua LLC (Fort Collins, CO), is currently in the process of developing a cost-competitive feed which incorporates Asian carp fishmeal and fish oil into trout diets**.** Protein and lipid sourced from Asian carp may offer an exceptional nutritional advantage compared to plant-based protein alternatives as these ingredients are highly palatable to a variety of aquaculture target species and likely offer a comparable nutritional profile (e.g. amino acid and fatty acid profile) to traditional marine fish-derived products.

Including Asian carp fishmeal and fish oil in aquaculture feeds will diversify market demand, thereby promoting targeted fishing efforts and minimizing environmental impact, as well as, enhancing sustainability in the aquaculture sector. Previous research regarding the use of Asian carp fishmeal in aquafeeds provided evidence that these ingredients are highly digestible and cost effective in a variety of carnivorous fish species, such as trout (Bowzer et al. 2015; Bowzer and Trushenski, 2015). Additionally, Nobilis Aqua recently completed a commercial-scale feeding trial with trout (using a preliminary feed formulation incorporating Asian carp fishmeal) in cooperation with Frontier Trout Ranch (Saguache, Colorado) and found competitive growth and production performance (FCR of 1.3) in this species. However, the commercial potential of integrating Asian carp ingredients into aquafeeds has yet to be fully explored with limited information regarding production performance in alternative key aquaculture species in the United States (such as Channel Catfish, an omnivore) or product quality across region and season.

Coastal restoration and wetland improvement are critical issues in Louisiana. A key component to coastal restoration is the establishment of vegetation. This often involves two components, nurseries or farms to prepare plants, and the planting effort at the restoration site. We are investigating using invasive Asian carp in a farm setting to measure differences in growth rates between control plants with no added nutrients and plots planted with whole carp. Findings from this study could spur use of Asian carp as a practical source of fertilizer in both nursery/farm settings and, ultimately, restoration sites.

Increased commercial harvest of Asian carp is the most efficient and sustainable way to control the populations and limit their impacts on native fisheries. However, the low demand for Asian Carp has caused the prices to decline to a level where subsidies have been suggested in order to promote a commercial harvest. There are issues surrounding the supplementation of commercial fish markets; subsidies can be abused, and contract fishing may not be a solution to remove Asian carp over a long period of time (Conover et al. 2007). Both require continual inputs of money and oversight from either state or federal partners. A survey of commercial fisherman will provide information on how best to strengthen and expand the Asian carp market from a harvester's and processor's perspective.

The overall objective of this project is to increase the demand for Asian carp by creating additional markets that utilize carp, and to identify obstacles commercial fisherman face that inhibit their ability or motivation to harvest Asian carp. Future projects will attempt to address these obstacles in an effort to increase commercial harvest of these invasive carp.

Objectives:

1. Assess if Asian carp can be used as catfish feed.
2. Study the effectiveness of Asian carp as fertilizer for native plants grown for coastal restoration.
3. Survey active commercial fisherman who have landed Asian carp recently to evaluate limitations and determine what can be done to increase harvest.

Agency: Louisiana Department of Wildlife and Fisheries (LDWF)

Activities and Methods:

Objective 1

LDWF will partner with LUMCON to produce feed for Channel Catfish using Asian carp as an ingredient. Growth performance of catfish consuming this feed will be investigated and analyzed to determine nutritional value and potential presence of any potential contaminates. Objective 1 is broken down into two main activities that will help determine the feasibility of Asian carp as a viable feed ingredient for commercial catfish production. Data collected on product feasibility and fish performance will be used to validate commercial marketability and shared with stakeholders including fish farmers, feed producers, and potential investors. Information will be widely disseminated to these relevant stakeholder groups through presentations at scientific conferences and publications through aquafeed extension networks (F3 Feed Innovation Network), periodicals (aquafeed.com, Global Aquaculture Advocate), association/society platforms (Southern Regional Aquaculture Center, National Aquaculture Alliance, U.S.

Aquaculture Society), and peer-reviewed scientific journals (Aquaculture, Aquaculture Nutrition).

Activity 1: Examine Asian carp fishmeal and fish oil as aquafeed ingredients for farmed catfish. Two feeding trials will be conducted to identify the maximum inclusion capacity of Asian carp fishmeal and fish oil in Channel Catfish (*Ictalurus punctatus*; omnivorous finfish primarily farmed in Mississippi and Alabama) feeds. This will allow us to determine the quantity of dietary protein and fat that can be replaced by Asian carp products in a balanced catfish diet while maintaining production performance (e.g. growth rate, feed efficiency, feed intake) and product quality (e.g. fillet yield, fillet quality). Special attention will be paid to the substitution capacity of Asian carp fish oil for menhaden fish oil as menhaden fish oil is generally viewed as an important palatant in catfish feeds (Nguyen and Davis, 2016). This study will compliment similar research currently being conducted with trout (*Oncorhynchus mykiss*; carnivorous finfish primarily farmed in Idaho) and provide the first study to examine Asian carp ingredients for use with Channel Catfish thereby targeting commercialization of these sustainable feed alternatives for use across the two largest finfish sectors in the U.S. aquaculture industry.

Two 12-week growth trials will be conducted to test the performance of Asian carp fishmeal and fish oil at graded inclusion levels in a practical catfish diet (Table 1; Nguyen and Davis, 2016). Two levels of Asian carp fishmeal (Trial 1) and two levels of Asian carp fish oil (Trial 2) will be assessed against a standard control diet formulated with traditional sources of protein and fat (Table 2). These data will be used to identify potential limitations on inclusion capacity of Asian carp products in catfish aquafeeds. Then, a balanced feed formulation for catfish grow-out will be generated and distributed with the maximum allowable substitution of fishmeal and fish oil sourced from Asian carp.

Example of a standard formulation for a practical catfish diet

Ingredient	g 100 g^{-1} as-is
Soybean meal	25.28
DDGS	20.00
Menhaden fish oil	4.82
Whole wheat	24.00
Corn starch	10.12
Trace mineral premix	0.50
Vitamin premix	0.80
Choline chloride	0.20
Stay C	0.10
CP dibasic	1.00
Lecethin	0.50
CPC	12.00
Methionine-DL	0.08
Glutamic acid	0.60

Treatment Diets: Diets will be formulated on a 28% crude protein, 6% lipid basis and balanced in accordance with the nutrient requirements for catfish with treatment diets as follows:

Asian carp fishmeal and fish oil treatment diets

	Trial 1: Asian carp fishmeal			Trial 2: Asian carp fish oil		
Ingredient source	Diet 1: control	Diet 2	Diet 3	Diet 1: control	Diet 2	Diet 3
Marine fish and plant protein	100	50	0	100	100	100
Asian carp fishmeal	0	50	100	0	0	0
Menhaden fish oil	100	100	100	100	50	0
Asian carp fish oil	0	0	0	0	50	100

Feeds will be manufactured at the Bozeman Fish Technology Center (Bozeman, MT). Dry ingredients will be weighed and mixed in a Marion paddle mixer and further co-ground in an air-swept pulverizer. Diets will then be processed through a twin-screw cooking extruder (DNDL-44, Buler AG, Uzwil, Switzerland) using an 18-s exposure to a six-extruder barrel section. A 3-mm die will be used to produce floating pellets that are dried in a pulse-bed drier (Buhler AG, Uzwil, Switzerland) for 15 minutes at 100°C until a moisture level below 7% is attained. Diets will be subsequently cooled on a forced air table. Fish oil will be topcoated and vacuum infused with a Phlauer™ vacuum infusion topcoater (AJ Mixing, Oklahoma City, OK). Feeds will be manufactured at 40 kg per diet and shipped to LUMCON. All feeds will be stored in a walk-in freezer before use.

Feeding trials: During each feeding trial, channel catfish (*Ictalurus punctatus*) with an initial mean mass of 40 g will be stocked into nine 47 gal. poly tanks at n=25 fish per tank and tank biomass corrected to overall mean ± 2%. Ten fish from the initial population will be euthanized with 250 ppm MS-222 and stored at -20 °C for later determination of proximate analysis. Tanks will be maintained in a recirculating aquaculture system at a temperature of 25 °C and a salinity of 5 ppt with biofiltration. Flow rates will be maintained at 12 L min^{-1} per tank and light held on a 12:12 h light:dark cycle. Treatment diets will be randomly assigned to triplicate tanks and tanks fed twice daily to apparent satiation 6 days per week for 12 weeks.

Growth analysis: Survival will be monitored daily and mortalities collected and weighed. Feed buckets will be weighed every four weeks to quantify feed consumption. Each tank of fish will be enumerated and bulk-weighed every four weeks to determine growth parameters as follows: specific growth rate, thermal growth coefficient, feed intake, and feed efficiency. At termination of the trial, five fish per tank will be euthanized with an overdose of MS-222 and frozen at -20 °C for compositional analysis. An additional five fish per tank will be similarly euthanized and length and weight recorded. Then, each fish will be sampled for liver, viscera, and fillet mass. These data will be used to calculate the following condition indices: condition factor, hepatosomatic index, viscerosomatic index, and muscle ratio. Proximate analysis of protein, lipid, and energy content will be determined for whole body and diet samples at Louisiana State University AgCenter, Department of Agricultural Chemistry Laboratory. These data will be used to calculate protein and energy retention efficiency.

Activity 2: Examine the influence of source region and season on Asian carp product quality. In, *The Future of Aquatic Protein: Implications for Protein Sources in Aquaculture Diets*, Hua et al. (2019) state that “the greatest challenges to alternative protein sources in aquafeeds include variable protein content and the feasibility of increasing production, which is a function of available processing technologies, cost, and scalability”. In this study, we will examine the influence of source location (Upper v Lower Mississippi River Basin) and season (spring, summer, fall, winter) on the nutritional quality of Asian carp products (fishmeal, fish oil) and byproducts (ingredients derived from Asian carp processing waste/offal). This will include an assessment of proximate composition (protein, lipid, energy, and moisture content), amino acid profile, fatty acid profile, and potential presence of major contaminants (lead, mercury, cadmium, and PCBs).

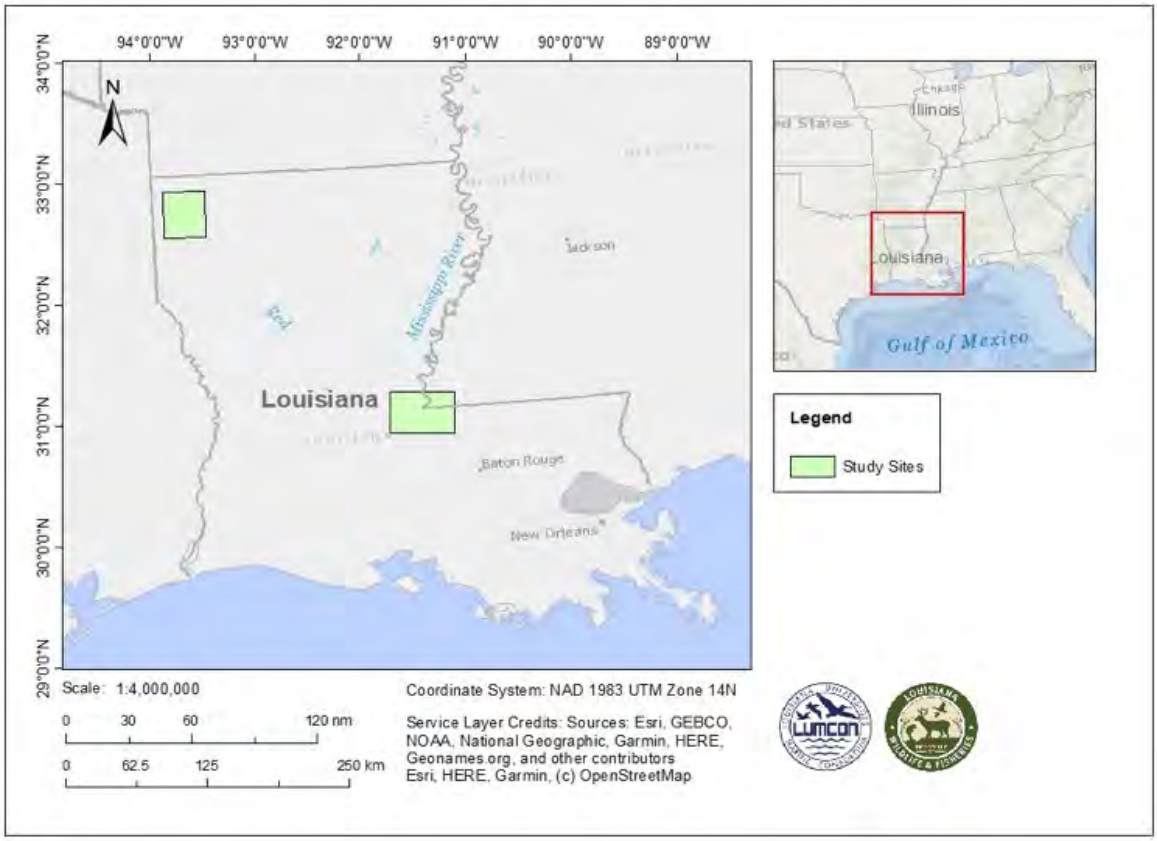
There is a commercial production plant in Beardstown, Illinois that produces Asian carp fishmeal and fish oil, with a processing capacity of forty tons of Asian carp daily. These products can be used for various animal feeds, fertilizers, and pharmaceuticals and are routinely incorporated into pet feeds. To our knowledge, this is the only source of commercially-available Asian carp fishmeal and fish oil in the United States. Therefore, we will compare Asian carp fish and feed ingredient samples from three sites: one in Illinois (Upper Mississippi River Basin; commercially producing Asian carp fishmeal and fish oil) and two in Louisiana (Lower Mississippi River Basin, proposed region of development in pre-production).

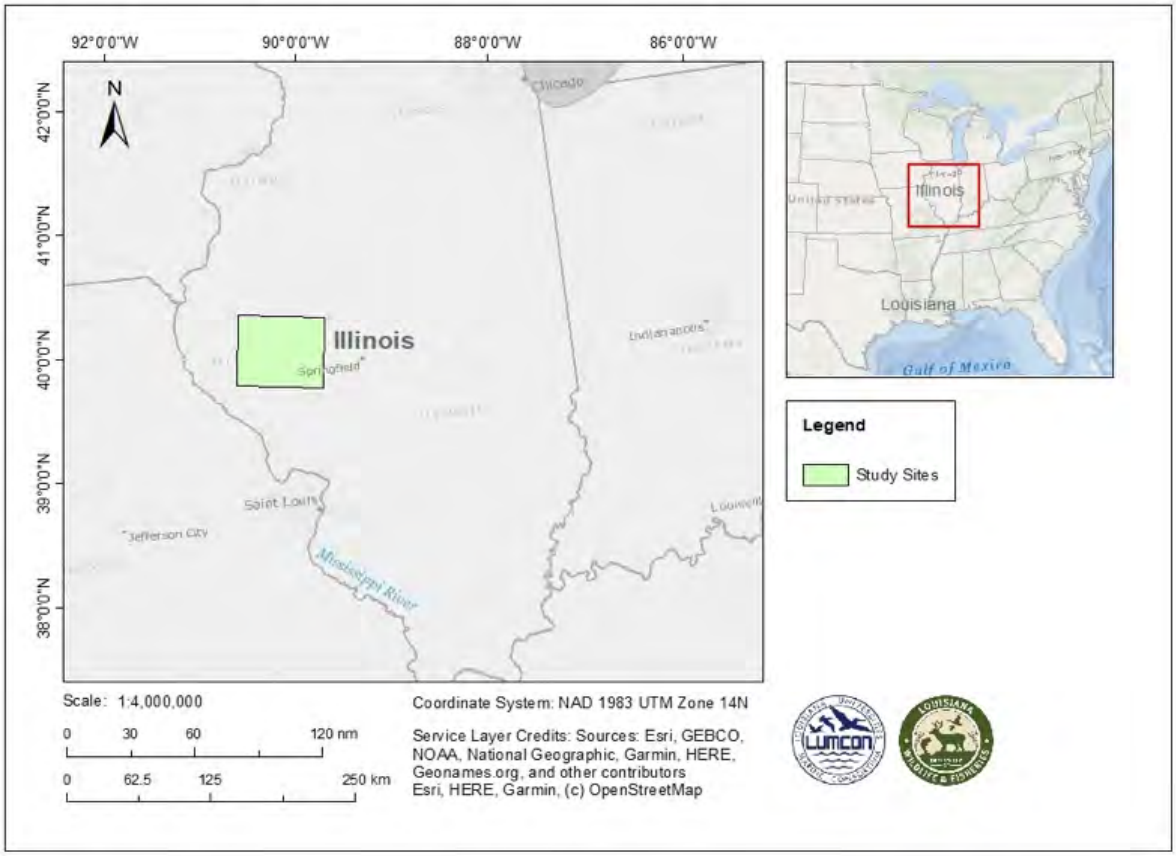
The study site in Illinois will be targeted in accordance with a heavily commercialized Asian carp fishing area, informed by the Asian carp processing plant, Nobilis Aqua, and Illinois Department of Natural Resources. Processed samples (fishmeal and fish oil) will also be procured from the Beardstown processing plant for quality analysis and use in the Activity 1 treatment diets. The Louisiana sampling sites will include a) the Three Rivers area of the main branch of the Mississippi River that supports a major fish house that currently buys most of the carp in the state and b) additional Louisiana study sites that will be determined based on reliable availability of fish and existing commercial Asian carp infrastructure.

Whole fish and select fish products/byproducts (fishmeal, fish oil, processing waste/offal) will be analyzed for each study site across four seasons (spring, summer, fall, winter) at n=8 replicates per study site per season. Samples will be collected, purchased, or processed in-house (e.g. in the case of proposed or future processing sites). Each sample will be analyzed to determine product quality through proximate composition (protein, lipid, energy, and moisture content), amino acid profile, fatty acid profile, and the potential presence of major contaminants (lead, mercury, cadmium, and PCBs). Analytical tests will be conducted by the Louisiana Agricultural Chemistry Laboratory (Baton Rouge, LA), Analytical Chemistry Laboratory at the University of New Orleans (New Orleans, LA), or the Agricultural Experiment Station Chemical Laboratories at the University of Missouri (Columbia, MO).

Results obtained from these activities will facilitate the use of Asian carp ingredients in aquafeeds by describing the performance of these ingredients in catfish diets, characterizing the overall nutritional value of a variety of Asian carp products and byproducts, informing sourcing guidelines, and identifying whether a potential confounding effect of contamination exists (which hinders the use of common carp products sourced from lakes in Utah).

Map of Project Area:





Estimated Timetable for Activities:

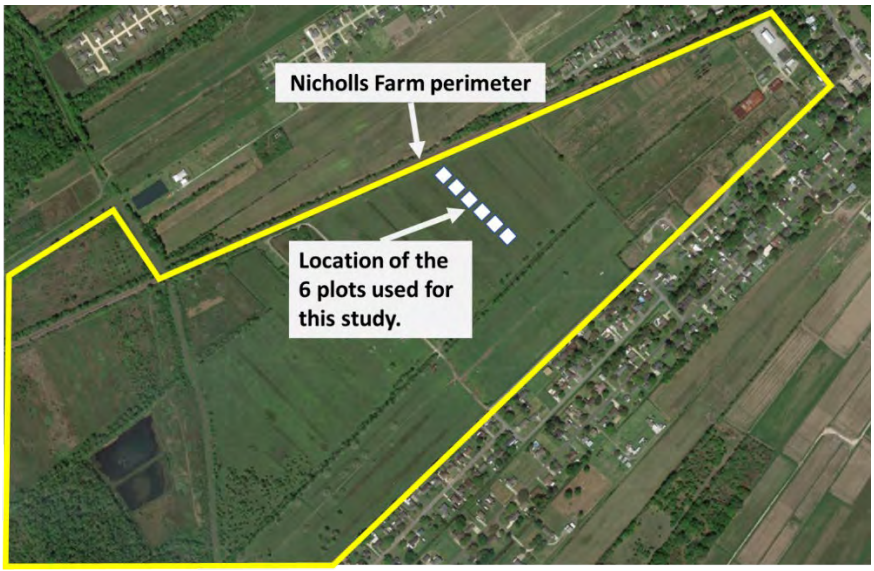
Activity	Time Period (Season, Month/Year)
Hire technician and project purchases	October
Feed manufacture	October - November
Catfish feeding trial #1	December - February
Catfish feeding trial #2	March-May
Samples collected	November, February, May, August
Laboratory and analytical tests	November - August
Data analysis	February - August
Reports and publications generated	July - September

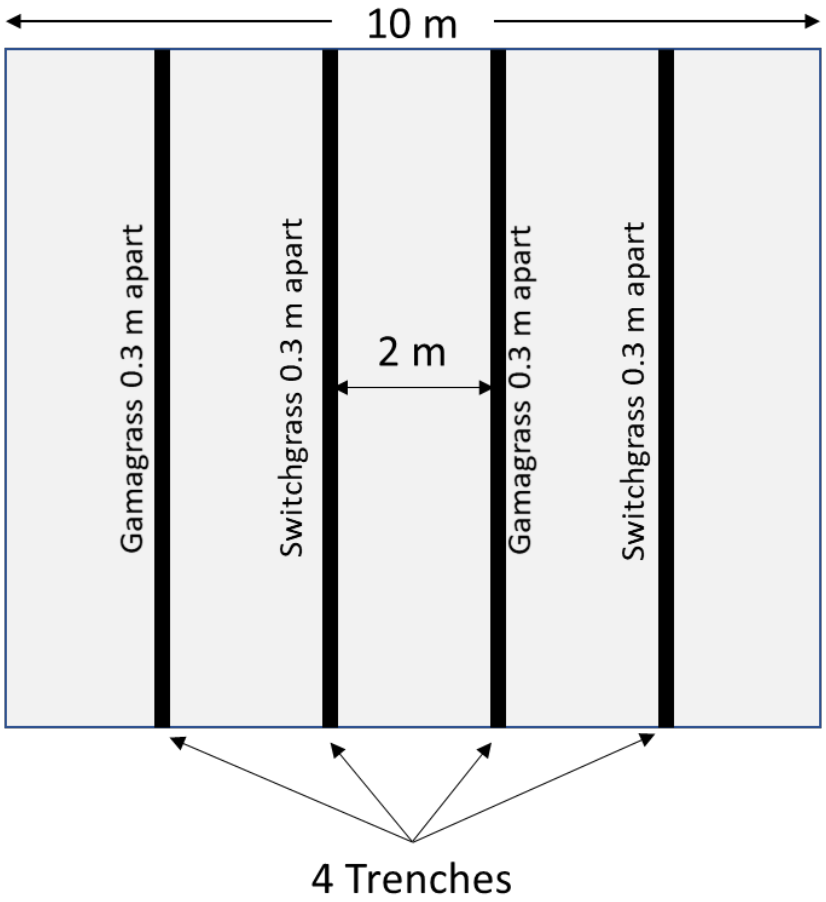
Objective 2: LDWF will partner with NSU to investigate the use of whole Asian carp as a suitable fertilizer for restoration plants. This project will occur at the NSU Farm. Six plots that measure 10 x 10 m will be staked out and tilled with a disc harrow and then a roto-tiller will be used to remove all existing vegetation. A pre-emergent herbicide will then be applied to prevent germination of undesirable seeds. Three plots will be treated with Asian carp and three plots will serve as a control.

A trencher will be used to create four trenches spaced 2 m apart and 0.7 m deep in all six plots, but only three plots will receive Asian carp. Asian carp will be placed in trenches head to tail so that the bottom of the trench is covered. The trenches will then be back-filled.

For each of the six plots, clones of Eastern Gamagrass *Tripsacum dactyloides* will be planted on two rows and clones of Switchgrass *Panicum virgatum* will be planted on two rows. Plants will be planted 0.3 m apart on top of the trench row. Weed growth will be controlled either with chemical or mechanical control throughout the summer. A subsample from each plot (n=10 plants) will be used to assess above ground biomass. Plant samples will be sent to a laboratory for nutritional analysis. Results of the plants grown in the presence of Asian carp will be compared to the results of plants grown in the absence of Asian carp to determine if Asian carp buried whole provide a nutritional benefit to plants.

Map of Project Area:





Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Create plots, apply pre-emergent herbicide	January 2022
Purchase Asian carp	March 2022
Dig trenches and add carp	March 2022
Plant vegetation	March 2022
Monitor plots and control weeds	March – October 2022
Harvest and quantify above ground biomass	October 2022
Send samples off for nutrient analysis	October 2022
Prepare final report	November 2022
Submit final report	December 2022

Objective 3: LDWF will conduct a phone survey to collect insight into the factors limiting Asian carp harvest. LDWF will also explore potential mechanisms that may be used to eliminate or decrease the complications associated with subsidies and contract fishing. The survey will target Asian carp fishermen and those wholesale dealers who have purchased Asian carp. LDWF Trip Ticket commercial landings data will be used to identify fisherman who have landed Asian carp in the last three years. The survey will be qualitative in nature in an effort to evoke conversation with participants.

LDWF will also utilize the data collected from the Asian carp fishermen to develop a list of commercial fishermen who have fished in similar waterbodies with similar gear, but have failed to record any harvest of Asian carp. This group will be surveyed to ascertain what obstacles have hindered their ability to land Asian carp or what actions could be taken to encourage their participation in the Asian carp fishery.

Wholesale dealers that purchased Asian carp will be contacted to determine if the market has the capacity to accommodate increased harvest of Asian carp. They will be asked for information regarding Asian carp buyers to better understand the final end use of Asian Carp landed in LA.

Survey participants will be asked if they are interested in participating in future projects designed to supplement the current market price to assist in removing more fish from LA waters. The survey will also be used to open lines of communication with Asian carp fishermen, which would be beneficial in future discussions with stakeholders. With this survey, we hope to ascertain what price thresholds will be needed to increase the harvest of Asian carp in Louisiana.

Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Compile survey participants	October 2021 to December 2021
Develop survey questions	October 2021 to December 2021
Survey fisherman	January 2022 to March 2022
Prepare final report	April 2022 to May 2022
Submit final report	June 2022

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Assessment of Dietary Overlap and Effects on Native Fish

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)

Statement of Need: Bigmouth Buffalo is the second most landed and second most valuable freshwater commercial finfish in Louisiana. It shares habitat with Silver Carp, both of which are planktivorous; therefore, dietary overlap between these two species is likely. Previous research has examined changes in fish communities and body condition of various species as a result of Silver Carp introductions in upper portions of the Mississippi River Basin (Bouska 2020). However, no such investigations have been undertaken in the Lower Mississippi River Basin. In Louisiana there is the potential that lower body condition in Bigmouth Buffalo may result due to competition with Silver Carp. We can infer similar impacts on other planktivores in the region (i.e. Paddlefish). Further, Silver Carp have the potential to impact recreationally important species higher up the trophic level, such as Largemouth Bass, through a trophic cascade resulting from a reduction of invertebrate biomass.

The information collected during this project will quantify the impacts of Silver Carp on two economically important fish species in the Lower Mississippi/Atchafalaya region.

Objectives:

1. The objective of this project is to determine the impacts of Silver Carp *Hypophthalmichthys molitrix* on commercially important Bigmouth Buffalo *Ictiobus cyprinellus* and recreationally important Largemouth Bass *Micropterus salmoides*.

Agency: Louisiana Department of Wildlife and Fisheries

Activities and Methods: LSU will collect fish using electrofishing, gill nets, or hoop nets, and lower trophic level detritus samples will be collected from southeastern Louisiana waterbodies across a suspected gradient of Silver Carp density. Specifically, Lake Fausse Pointe, East Grand Lake within the Atchafalaya River basin, Lakes Verrett/Palourde, Lac Des Allemands, and Lake Cataouatche/Salvador will be sampled a minimum of three times each in year one of the study. A minimum of 20 Silver Carp, 20 Bigmouth Buffalo, 10 basal food resource samples (detritus), and 20 Largemouth Bass will be collected from each location (total tissue/sample collection ~ 350 samples). Largemouth bass will be analyzed to test for trophic cascades and impacts to higher trophic levels. The Atchafalaya River basin was selected based on a long history of Silver Carp presence and previous stable isotope analyses (Nico and Jelks 2011; Nico et al. 2011). Other sampling locations were selected to reflect a gradient of Silver Carp densities. Based on observation and anecdotal reports, more Silver Carp are expected in Lake Fausse Pointe and fewer are expected in Lakes Verrett/Palourde, Lac Des Allemands, and Lake Cataouatche/Salvador.

Data collected from basal food resource samples will be used to describe the natural variation in trophic structures across these lakes. The tissue and basal resource material samples will be

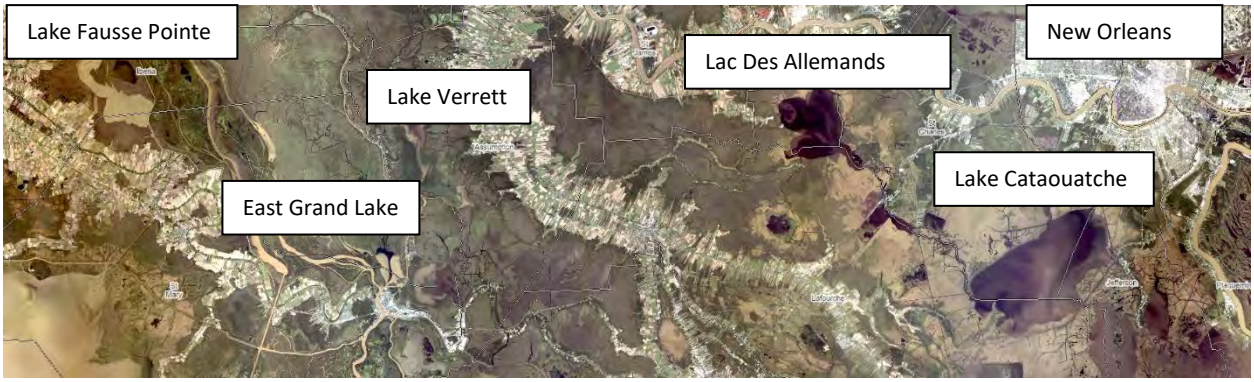
analyzed for isotopic ^{13}C and ^{15}N composition for statistical analyses of dietary overlap. Additionally, physicochemical measurements will be taken to describe habitat variation across the sampled lakes.

Silver Carp density per lake will be estimated by number of adults observed during multiple, low-speed transects using various disturbance methods. Bigmouth Buffalo condition will be compared with historic LDWF data, where available, to assess modern condition estimates against pre-Silver Carp condition estimates providing a second assessment of impacts to fish condition.

This analysis will produce fish condition and ^{13}C and ^{15}N data for Silver Carp, Bigmouth Buffalo, and Largemouth Bass in potentially impacted systems, as well as a quantified measurement of dietary overlap. Information regarding the relative abundances of these fish across systems will be used to provide a fishery-independent assessment of Bigmouth Buffalo and Silver Carp.

Specific to our objective, we will evaluate the following: 1) whether Silver Carp influence trophic position for Bigmouth Buffalo and Largemouth Bass by Bayesian trophic position estimation (Quezada-Romegialli et al. 2018) across estimates of Silver Carp relative abundance; 2) niche overlap, as described by isotopic metrics (isotopic niche size, isotopic similarity, and isotopic nestedness; Villéger et al. 2011; Cucherousset and Villéger 2015) between Bigmouth Buffalo with Silver Carp; and 3) differences in overall stable isotope mixtures (diet dissimilarity) by multivariate generalized linear model incorporating physicochemical covariates or by the linear model/residual permutation procedure described in Turner et al. (2010) and Daniel et al. (2015) to determine if physicochemical conditions modify the impacts of Silver Carp.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, Month/Year)
Project Initiation	October 2021
Scouting Sampling Locations and Sampling Method Refinement	November 2021-January 2022
Fish Sampling and Tissue Collection	February 2022-October 2022
Stable Isotope Tissue Processing	May 2022-November 2022
Stable Isotope Tissue Analysis	September 2022-February 2023
Data Analysis and Final Report Draft	February 2023-May 2023

Literature Cited:

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Nico, L. G. and H. L. Jelks. 2011. The black carp in America: An update. American Fisheries Society Symposium 74: 89-104.

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

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

Cooperating Agencies: Arkansas Game and Fish Commission (AGFC), University of Arkansas Pine Bluff (UAPB), Louisiana State University (LSU), Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Mississippi State University (MSU), Missouri Department of Conservation (MDC), Tennessee Wildlife Resources Agency (TWRA), U.S. Fish and Wildlife Service (USFWS)

Statement of Need: Successful containment and control of invasive species is reliant on an understanding of movements and life histories of populations in response to local conditions. Agencies involved in the LMR Asian 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 in a variety of habitat types. The proposed studies will be the first collaborative tracking efforts of this scale that will be conducted on Asian carp across the LMR. Proposed networks of receiver arrays will build upon existing networks of compatible Vemco technology maintained by cooperating and partner agencies, with data sharing being of high priority. A value-added benefit of the proposed projects is expanded capability to detect fish involved in other movement studies, which coincides with the expanded detection capabilities of Asian carp in existing networks maintained by partner agencies.

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

This is a continuation of a FY20 Work Plan. The only agencies requesting funding for FY21 are TWRA and MDWFP, detailed below. Other cooperating agencies will be continuing their work from the FY20 Work Plan into FY21.

Objectives:

1. Determine intrabasin and interbasin movement to inform placement of potential deterrent technologies and removal efforts.
2. Determine feasibility of deterrent technologies by evaluating migration pathways into a natural lake.
3. Determine distribution and estimate population demographics of Asian carp in the lower Arkansas and lower White rivers to inform control measures including removal efforts.

4. Assess the contribution of Asian carp produced in the Mississippi River to populations in the lower Arkansas and lower White rivers to inform control measures including removal efforts.

Agency: Louisiana Department of Wildlife and Fisheries (LDWF)

Activities and Methods: In support of Objective 1, LDWF will coordinate with Louisiana State University and other partner agencies to track the movements of Asian carp in South Louisiana. Commercial fishers will be contracted to capture Asian carp at several key locations along the Intracoastal Waterway (ICWW) near intersections with major rivers and/or estuaries of the lower Mississippi River Basin. The majority of tagging effort will be focused between the Mississippi and Atchafalaya Rivers, with additional tagging effort between the Calcasieu River and Vermilion Bay, as well as east of the Mississippi River near Lake Borgne and Lake Pontchartrain, depending on availability of specimens. While commercial netting will be the primary method of capture, additional techniques (electro fishing, gill nets) may be used as needed by researchers to supplement tagging numbers. Acoustic transmitters (Vemco V-16-4H, 69kHz) will be surgically implanted in 200 adult Asian carp in southern Louisiana water bodies over the two-year study period. Each uniquely coded transmitter will be programmed with a nominal delay of 60 seconds (30-90 seconds) and will have an expected battery life of 5-6 years. In addition, individuals will be tagged with a jaw tag and/or external floy tag to reduce harvest of tagged fish and encourage reporting of recaptured individuals. Fish will be measured, weighed, and sexed when possible, and 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 fishers to disseminate information about the project and to encourage release of tagged fish captured in local fisheries that are in good condition.

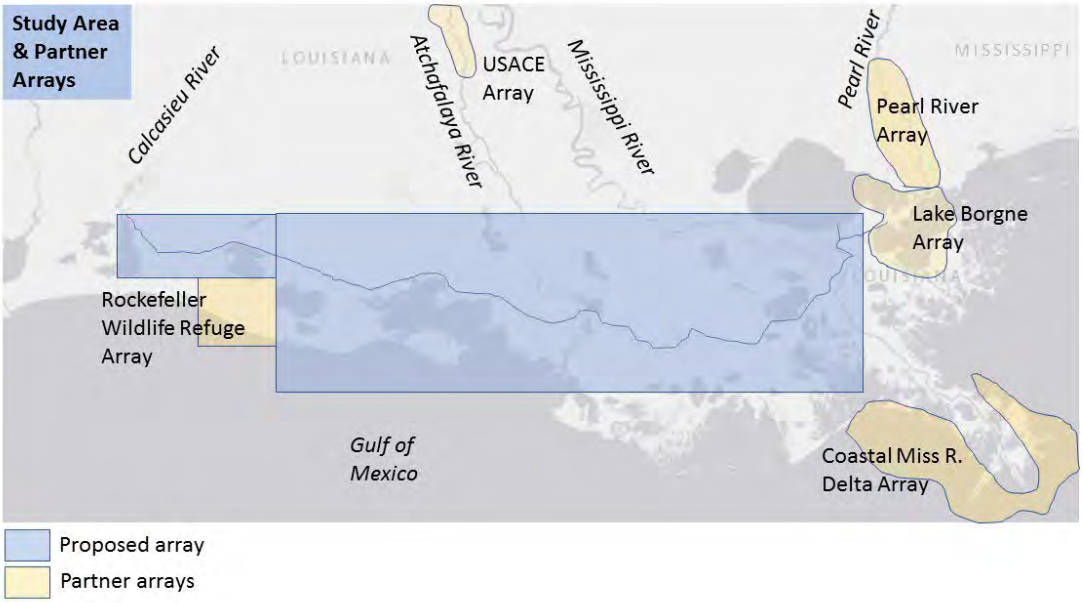
An array of 40 acoustic receivers will be deployed by LSU throughout the study area in the spring of 2021 to monitor movements of Asian Carp in coastal areas of the lower Mississippi River Basin. The array will consist of Vemco VRTx receivers, which will record temperature and ambient noise in addition to tag 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). The array will consist of receivers distributed west to east along the ICWW between the Calcasieu River and Lake Borgne. Areas of special interest (and a higher concentration of receivers) include major river confluences such as the Mississippi River, Atchafalaya River, Mermentau River, and Calcasieu River, as well as connections to major estuaries of interest such as Vermilion Basin, Barataria Basin, and Terrebonne Basin. Receivers will be attached to existing structures (pilings, channel markers), or anchored to the bottom and tethered to the shoreline. Salinity data loggers will be co-located with receivers deployed in the upper reaches of coastal estuaries to improve our understanding of salinity tolerance and responses of these species and the capacity for movement and additional expansion using coastal water bodies in Louisiana. Receivers and salinity loggers will be serviced by LSU every 8-12 weeks to retrieve and download data, monitor receiver condition, clean receivers, and replace batteries (as needed). We will also leverage existing and soon-to-be deployed arrays operated and maintained by partners including USFWS, USACE, and LSU to provide additional receiver coverage beyond the proposed array. These areas include Lake Borgne, Pearl River, Lake Pontchartrain and the Bonnet Carre Spillway, Rockefeller Wildlife Refuge, Atchafalaya River, and the Mississippi River Delta. We will also work closely with state agency partners throughout the Mississippi

River Basin to monitor inter-state movements of Asian carp both from and into 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 variables to spatiotemporal 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 recommendations for the placement of passage barriers or deterrents in the ICWW or other points of ingress/egress in south Louisiana. Recommendations for population reduction efforts based on movements will also be made.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Purchase Equipment	January 2021
Graduate student and technician start	January 2021
Deployment of Acoustic Array	February - March 2021
Receiver Maintenance	Ongoing throughout 2-year period, every 8-12 weeks
Acoustic Tagging (Multiple locations)	Spring 2021
Additional Acoustic Tagging (Multiple locations), as needed	Fall 2021
Annual Report	March 2022, March 2023 (covering calendar year)
Data Analysis	Ongoing as data is received, final analyses Spring 2023

Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods: AGFC will coordinate with UAPB to use a combination of radio telemetry and acoustic telemetry to assess Silver Carp movement and Bighead Carp movement to meet the goal of Objective 1. We will use both passive and active tracking of individual adult Silver Carp and Bighead Carp to assess movement through lock-and-dam complexes along the lower Arkansas River. We will attach acoustic receivers at lock-and-dam complexes so that individuals can be detected. We will make use of existing acoustic receivers from AGFC and purchase new receivers that can be strategically deployed in these two systems at bridges to monitor movement patterns. Receivers will be placed on the following lock-and-dam complexes: Montgomery Point lock-and-dam, Norrell lock-and-dam 1, Joe Hardin lock-and-dam 3, Charles Maynard lock-and-dam 5, and Murray lock-and-dam 7. We will also place acoustic receivers at bridged spanning the lower White River including Hwy 1 at St. Charles, Hwy 79 at Clarendon, and Hwy 38 at Des Arc (see map). During active tracking using radio telemetry, we will assess habitat use of individual Silver Carp and Bighead Carp in the mainstems of the lower Arkansas and White rivers. We will locate individuals each season and assess depth, substrate, and meso-habitat characteristics. Meso-habitats will include geomorphic characteristics including side-channel, backwater, main-channel, dyke-field complex.

In support to Objective 3, we will focus sampling efforts in the lower Arkansas river from Pool-4 to Pool-2. We will sample the Post Canal connecting the Arkansas River to the White River. We will stratify each pool along the Arkansas River by river kilometer. We will use a combination of

boat electrofishing and gill nets to sample randomly selected river kilometers in Spring and Summer 2021 and 2022. Additional gear types, including drifting experimental trammel nets, may be considered and tested depending on catch with electrofishing and gill nets.

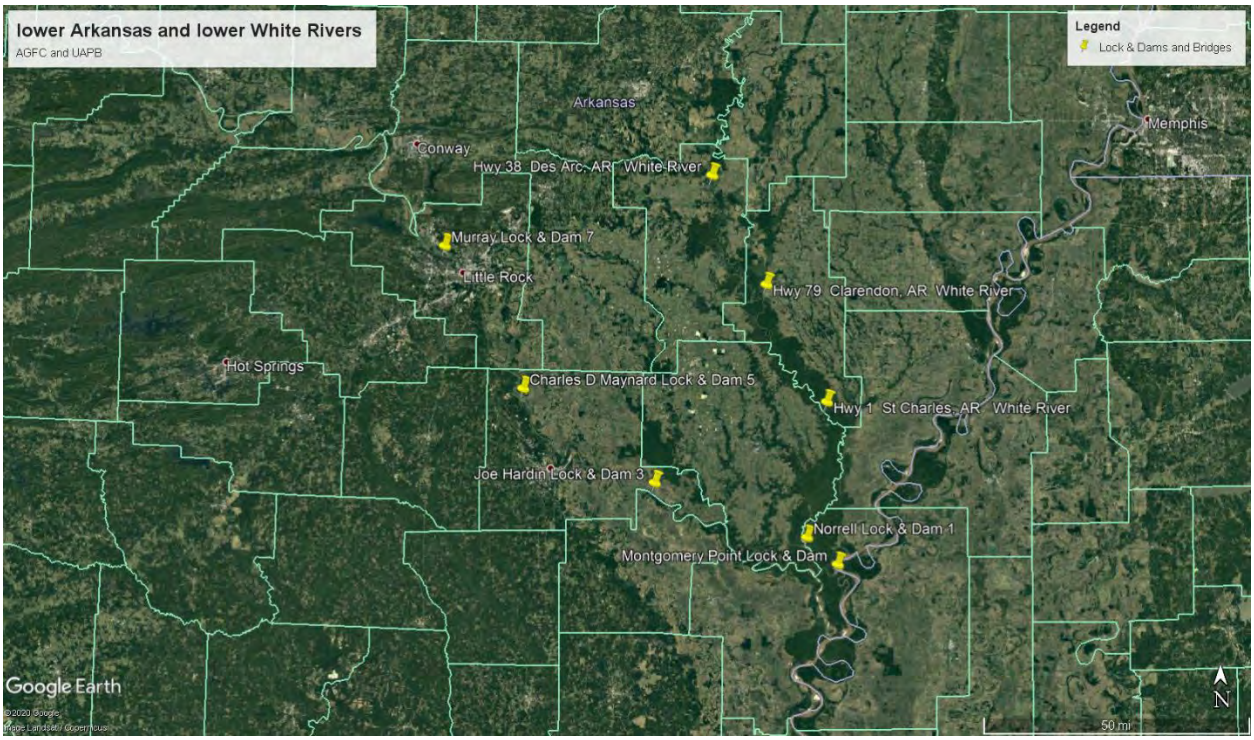
We will focus sampling efforts in the lower White River from Des Arc, AR, to the confluence with the Mississippi River. We will stratify the lower White River by river kilometer. We will use a combination of boat electrofishing and gill nets to sample randomly selected river kilometers in the Spring and Summer 2021 and 2022. Additional gear types, including drifting experimental trammel nets, may be considered and tested depending on catch with electrofishing and gill nets.

We will measure length (TL, mm) and weight (g) for each individual fish captured. We will determine sex for each individual. We will take otoliths and the right leading pectoral fin ray from up to 10 individuals per cm length group from each river kilometer sampled.

In support of Objective 4, we will use otolith microchemistry to assess the contribution of individuals produced in the Mississippi River to populations in the lower Arkansas and lower White rivers. Otoliths collected from individuals in Objective 3 will be sent to Southern Illinois University (SIU) for analysis of Sr, Ba, and Ca composition. Otolith microchemical signatures will be related to water microchemical signatures from the Mississippi River, lower Arkansas River, and lower White River. A discriminant rule will be developed to predict location of origin for individuals.

*Note: Bighead Carp are thought to be less abundant than Silver Carp in both the lower Arkansas River and the lower White River. We will deploy gears to sample both species, but may not capture sufficient numbers of Bighead Carp to conduct all analyses.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Year, Month[s])
Objective 1	
Bi-monthly data retrieval from stationary receivers	Spring/Summer/Fall 2021 Winter/Spring/Summer 2022
Bi-monthly mobile tracking	Summer/Fall 2021 Winter/Spring 2022
Data analysis and interpretation	Summer 2022
Manuscript preparation and submission	Fall 2022
Objective 3	
Collect fish, aging structures, ovaries	Spring/Summer/Fall 2021
Prepare aging structures and age fish	Winter/Spring 2022
Data analysis and interpretation	Summer 2022
Manuscript preparation and submission	Fall 2022
Objective 4	
Microchemistry analysis at SIU	Spring 2022
Data analysis and interpretation	Spring/Summer 2022
Manuscript preparation and submission	Fall 2022

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

Activities and Methods: In support of Objective 1, MDWFP will partner with MSU to monitor Asian carp in Moon Lake and connected waterbodies. Silver carp (N = 60) will be collected in Moon Lake and Yazoo Pass with the assistance of commercial fishers contracted through MSU. Captured silver carp will be measured for total length (nearest 1 mm) and weighed (nearest 1 g). Silver carp across the range of sizes will be surgically implanted with VEMCO V16 transmitters and tagged externally with a Floy loop tag. Carp not selected for telemetry tagging will have hard structures removed (e.g., vertebrae, lapillus otoliths, pectoral spines, postcleithra) for age estimation. Tags will be distributed evenly, if possible, between Yazoo Pass and Moon Lake to capture potential movement in and out of the lake through this major connection.

Seasonal spatial and temporal distribution of silver carp within the oxbow lake will be examined with mobile telemetry. A VEMCO VR100 hydrophone and receiver will be used to determine the location of telemetry tagged carp in the oxbow lake and associated macrohabitat variables and location specific variables (e.g., depth, temperature, dissolved oxygen). Location-specific and macrohabitat-specific covariates will be used to evaluate habitat use and if possible, habitat selection. Tracking intensity will likely differ seasonally and among locations.

To log the dates and times of individual fish movements into or out of Moon Lake, VEMCO VR2 stationary receivers (N=10-12) will be deployed at key spatial unit boundaries delineated within the lake, the discharge stream, and the Coldwater River. Additionally, receivers will be placed in major neighboring streams to identify alternative entry or exit routes. A receiver will also be secured 25-50 miles downstream from the confluence of Yazoo Pass and Coldwater River to detect fish that might have left the area. Receivers will be monitored monthly to download fish detections at each receiver location.

Seasonal and temporal movements of silver carp into and out of the oxbow lake will be examined with a combination of fixed telemetry and mobile telemetry. Mobile tracking within Moon Lake and Yazoo Pass associated with Objective 2, and as needed, depending on major hydrological events, will be used to confirm the presence of fish within the study area. All fish locations will be assigned to a spatial unit (e.g., Moon Lake, Yazoo Pass). To identify variables that potentially influenced silver carp movements into different spatial units, we will use capture-recapture analysis to estimate the probability of movement among the spatial units. The capture-recapture analysis can explicitly evaluate variables like air temperature, precipitation, lake and river stage, seasonality, and time of day on the probability that tagged fish will move into a different spatial unit. Air temperature and precipitation data will be obtained from the NOAA for the nearest weather station. Water temperature and lake water level will be monitored with HOBO temperature and HOBO water level data loggers (HOBO Pendant; Onset Computer Corp., Bourne, Massachusetts). We will work with USGS water resources to install a temporary station to obtain water discharge information. Data will be offloaded for the sensors deployed during 2021 to monitor water connectivity (trail cameras), water level and temperature using

HOBO water level data loggers (HOBO Pendant; Onset Computer Corp., Bourne, Massachusetts).

The capture-recapture analysis will provide a predictive model to evaluate risk of movement into or out of the oxbow lake. The predicted probabilities of movements can be used to inform the potential operations of a barrier if installed. For example, if environmental covariates are associated with increased probability of movement into the oxbow lake then the barrier can be operated. Alternatively, if environmental covariates are associated with increased probability of movement out of the oxbow lake then the barrier can be turned off. Varying operational rule sets can be developed to minimize the risk of silver carp moving into the oxbow lake while potentially promoting movement out of the lake.

Manual tracking in Moon Lake will occur monthly and locations of acoustically tagged Asian carp will be located and assigned a spatial location. Potential aggregation of Asian carp will be evaluated over time using standard analyses. A thesis and final report will be drafted and developed that reports the results of monitoring and analyses of movement and aggregation.

In support of Objective 1, MDWFP will partner with MSU to monitor Asian carp in Eagle Lake and connected waterbodies. Silver carp (N = 85) will be collected in Eagle Lake with the assistance of commercial fishers contracted through MSU. Silver carp across a broad range of sizes will be surgically implanted with VEMCO V16 4x transmitters and tagged externally with a Floy loop tag. After tagging approximately 55 of the 85 tagged fish will be placed at predetermined locations outside Eagle Lake in various streams, and the rest of the fish will be released in Eagle Lake.

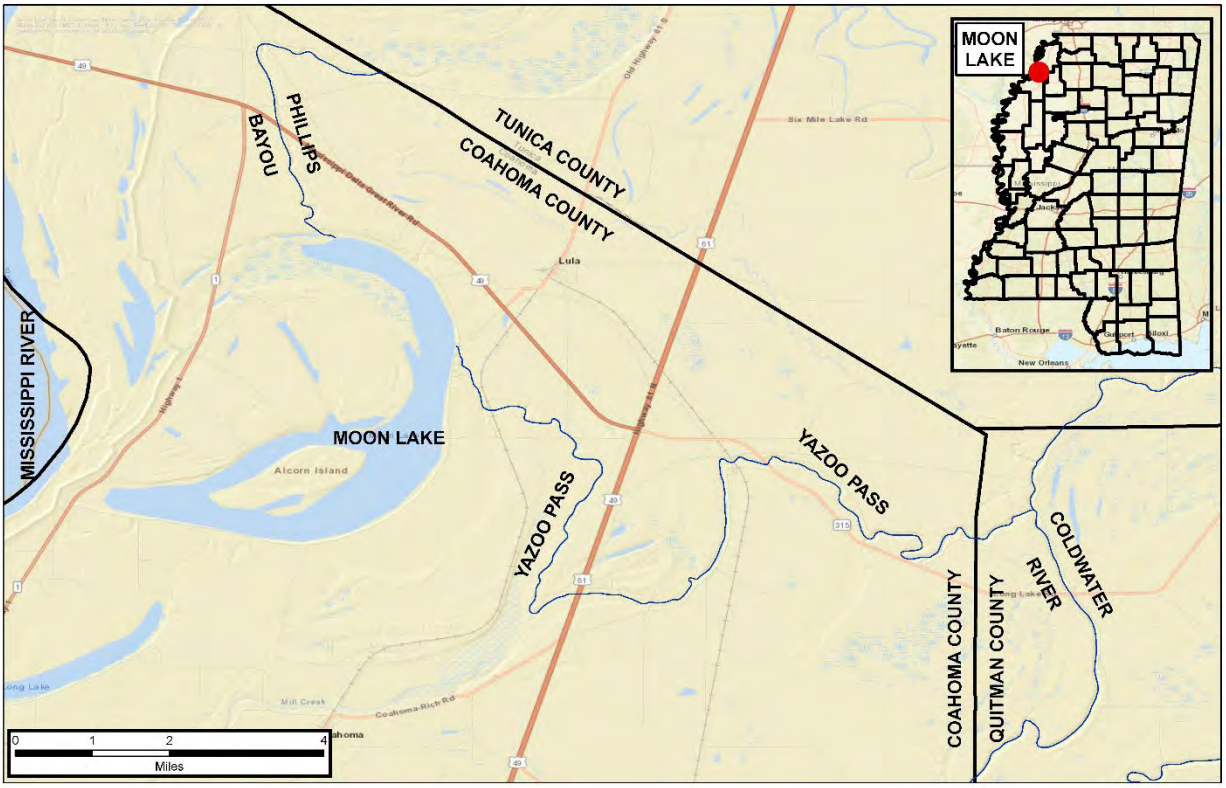
Seasonal spatial and temporal distribution of silver carp will be examined be examined with mobile and stationary telemetry. A VEMCO VR100 hydrophone and receiver will be used to determine the location of telemetry tagged carp in the oxbow lake and associated macrohabitat variables and location specific variables (e.g., depth, temperature, dissolved oxygen). Location-specific and macrohabitat-specific covariates will be used to evaluate habitat use and if possible, habitat selection. Tracking intensity will likely differ seasonally and among locations.
To log the dates and times of individual fish movements into or out of Eagle Lake, VEMCO VR2 stationary receivers (N=10-12) will be deployed at key spatial unit boundaries delineated within the lake, Muddy Bayou the discharge stream, Steele Bayou, and the Yazoo River. Additionally, receivers will be placed in major neighboring streams to identify alternative entry or exit routes. Receivers will be monitored monthly to download fish detections at each receiver location.

Fish movement depends on hydrologic connectivity. Therefore, observing spatial and temporal connections of water in and out of Eagle Lake is crucial to monitoring when and where tagged

fish may move. The control structure in Muddy Bayou has a gage in both sides (lake and bayou) and daily readings are available online (https://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm). We expect to be able to access current and historical data to develop a water elevation/discharge model. As a backup, and if needed, trail cameras (APEMAN, H55, China) and water temperature and pressure level loggers (HOBO Water Level Data Logger - U20L-02, ONSET, MA, USA) will be used to evaluate and monitor stream connectivity into Eagle Lake and if silver carp escapement or access is possible via ephemeral streams and creeks. Trail cameras will also be placed to capture visual connectivity and direction of water flow. Water temperature and pressure loggers will collect water pressure, yielding water height. While water height will be useful to add as a covariate to movement models, it can be imperfect if water level loggers are in a pool, and pools are disconnected. With trail cameras placed near water pressure level loggers, we can effectively determine if a stream is connected or not connected. Within the movement model, if pools were disconnected, then the associated spatial state would create a zero-probability chance of fish to move from state to state which is crucial to understanding the need for a barrier in space and time.

The capture-recapture analysis will provide a predictive model to evaluate risk of movement into or out of the oxbow lake. The predicted probabilities of movements can be used to inform the potential operations of a barrier if installed. For example, if environmental covariates are associated with increased probability of movement into the oxbow lake then the barrier can be operated. Alternatively, if environmental covariates are associated with increased probability of movement out of the oxbow lake then the barrier can be turned off. Varying operational rule sets can be developed to minimize the risk of silver carp moving into the oxbow lake while potentially promoting movement out of the lake.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Complete IACUC protocol, select MS student, conduct reconnaissance of study area	Aug 2021
Identify commercial fishers to assist with carp collections; obtain required permits from Mississippi and Louisiana download historical water level data from Muddy Bayou USACE gage	Sep-Nov 2021
Install receivers, implant tags in fish, begin mobile tracking	Nov 2021 – Jan 2022
Install trail cameras and HOBO water loggers as needed	Nov 2021 – Jan 2022
Continue mobile tracking, monitor receivers, monitor water level, and monitor discharge sensors	Jan 2022-Jul 2023
Prepare annual report	Jul-Aug 2022
Reassess receiver network and rearrange as needed	Aug-Sep 2022
Tag and release additional carp as needed	Nov 2022-Jan 2023
Download and review historic water levels at Muddy Bayou and Steele Bayou water control structures to develop and SDM model to effectively manage bidirectional flow	Sep-Dec 2022
Movement analyses	Oct 2022-Jun 2023
Aggregation analyses	Oct 2022-Jun 2023
Prepare final report	Jun-Aug 2023

Agency: Missouri Department of Conservation (MDC)

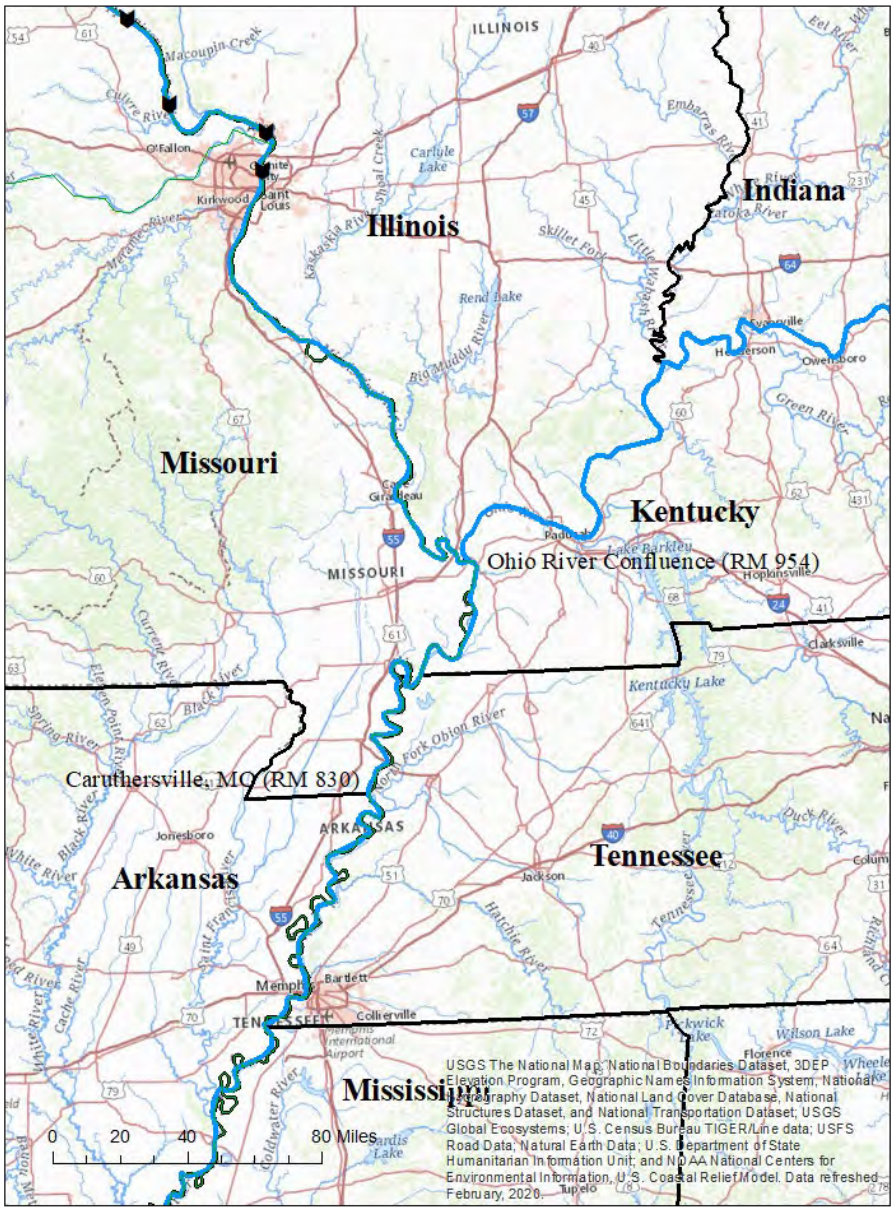
Activities and Methods: In support of Objective 1, MDC will expand and continue to maintain the existing stationary receiver array from Pool 20 downstream into the Lower Mississippi River, including associated major tributaries. Currently, there are Silver Carp and Bighead Carp with functional tags throughout the Upper Mississippi River, Illinois River, Ohio River, Kentucky Lake, and Barkley Lake, and Black Carp are tagged in the Middle Mississippi River, but the stationary receiver array between these basins is sparse. This year, Asian carp telemetry will

additionally occur in the Missouri and Lower Mississippi Rivers and their tributaries, adding to the level of information gained by expanding the stationary receiver array. Specifically, the equipment requested this fiscal year will allow MDC to increase coverage in the Lower Mississippi River from the confluence of the Ohio River at Cairo, IL, to the southern Missouri border near Caruthersville, MO. A pair of stationary receivers will be placed every 30 miles (exact location will depend on multiple variables) to track residency time and transition rates between states and basins. The addition of 100 transmitters implanted in Asian carp (50 Silver and 50 Bighead) will increase detection and provide information about movement among basins and tributary use.

Data from the Lower Mississippi River telemetry efforts will help fill in information gaps, since Missouri is centrally located between all the basins (OHR, MOR, UMR, LMR), providing information about mixing between basins. This project will also look at movement within the LMR and its tributaries and could inform removal efforts of Asian carp. These data will also be available for use to inform complex temporal-spatial models (i.e., SEACarP) that could be developed for the LMR by adapting models developed in other basins.

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
Deploy Acoustic Array	Summer/Fall	2020
Implant Acoustic Tags in Asian Carp	Fall	2020
Download Receiver Data	Every 4-6 weeks	2020/2021
Annual Report	March	2021

Agency: Tennessee Wildlife Resources Agency (TWRA)

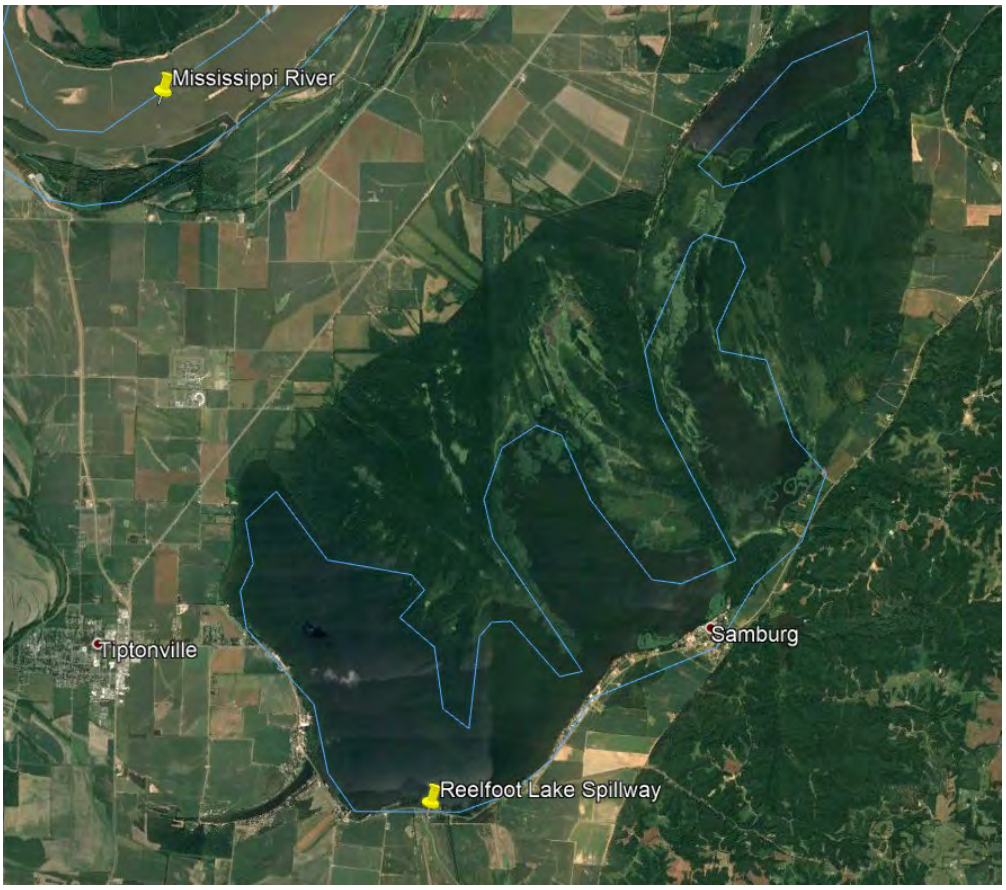
Methods and Activities: In support of Objective 2, TWRA will continue working with state and federal partners to gather information on currently available deterrent technology, and to evaluate the need for/feasibility of a deterrent system at Reelfoot Lake. Currently, Asian carp migrate into Reelfoot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

Invasive carp will be collected, primarily by means of electrofishing and short-set gillnets, and surgically implanted with Vemco acoustic tags. Fish will be tagged both above and below the spillway, with a target goal of 50+ carp tagged in total. In addition to acoustic tags, carp will also be fitted with external loop tags. Measurements (i.e., total length and weight) and sex determination will be recorded for all carp encountered during this effort.

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

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

Map of Project Area:



Estimated Timetable for Activities:

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

Control of Asian 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), Tennessee Wildlife Resources Agency (TWRA)

Statement of Need: Invasive species cause billions of dollars in ecologic and economic damage every year in the United States (Pimentel et al. 2005). While complete elimination of invasive species is nearly impossible, the management or control of these non-native species is necessary to reduce the impact on native species, the ecosystem, and the economy. The rapid expansion of Asian carp (Silver, Bighead, Black, and Grass Carp) throughout the Mississippi River and its tributaries has caused concern throughout the basin. The ability of this group of fishes (especially Silver and Bighead Carp) to rapidly expand and colonize river reaches in high densities, has led to changes in the food webs of the invaded aquatic ecosystems (Irons et al. 2007, Freedman et al. 2012; Sass et al., 2014; Solomon et al., 2016; Pendleton et al., 2017; DeBoer et al. 2018). Not only do Asian carp have ecological impacts, they also pose economic threats through reduction in recreational and commercial opportunities (e.g., reduced recreation, tourism). In response to these threats, many states throughout the Mississippi and Great Lakes basins have been working to find effective strategies to control the expansion of Asian carp into adjacent aquatic systems.

Currently, multiple types of technologies (i.e., Electrical Dispersal Barrier System, Bio-Acoustic Fish Fence, Acoustic Deterrent System, CO_2, etc.) are being used or field tested to both prevent more Asian carp from entering specific locations and prevent invasion of new areas, but these types of technology are not financially or physically possible in all locations. Because of the need for multiple options to prevent the expansion of and control Asian carp populations, many states are employing contracted commercial harvest. The Asian Carp Regional Coordinating Committee Contract stated that commercial harvest remains one of the most successful tools to reduce the threat of Asian carp moving toward the Great Lakes in the 2019 Asian Carp Action Plan (ACRCC 2019). In the 2019 plan, the coordinating committee also emphasized the importance of harvest in the lower pools as to reduce the overall relative abundance of Asian carp in the Illinois River, which could subsequently reduce propagule pressure in areas of lower density. This technique has not only been shown to be successful in the Illinois River, but also in the Ohio River and in Kentucky and Barkley Lakes.

All four Asian carp species are found in the Lower Mississippi River Basin; Grass Carp have been stocked in the past so they are not the focus of control and management efforts. Silver and Bighead Carp are found throughout the Lower Mississippi River (LMR) and Black Carp are being collected more regularly (Rodgers 2019). The states with the Lower Mississippi River Basin understand the magnitude of the Asian carp threat and the need for coordinated efforts to prevent their continued spread, explore strategies to reduce the abundance of established populations, and better understand the impacts of established populations (Rodgers 2019). The removal efforts within this work plan not only address the need for control and management, but also provide the opportunity to collect data on the Asian carp population and the native fish community which can also provide an assessment tool to help inform future efforts in the LMR.

One of the main priorities for the Lower Mississippi River Sub-Basin Working Group is population control through removal efforts to reduce the impact of Asian carp, while effectively relaying this information to the constituents (i.e., recreational and commercial fishers, recreational users, etc.) of the Mississippi River. Both objectives 1 and 2 of this project address this priority as well as the National Asian Carp Framework Goals 2, 3, and 5. This is a project continuing from FY20. Agencies requesting funding for FY21 are AGFC, MDC and TWRA.

Objectives:

1. Reduce overall Asian carp population numbers and alleviate propagule pressure in areas with low population density by implementing Asian carp removal programs utilizing commercial fishing in the Lower Mississippi River and tributaries.
2. Reduce the overall density and determine population characteristics of Asian carp in a large natural lake.

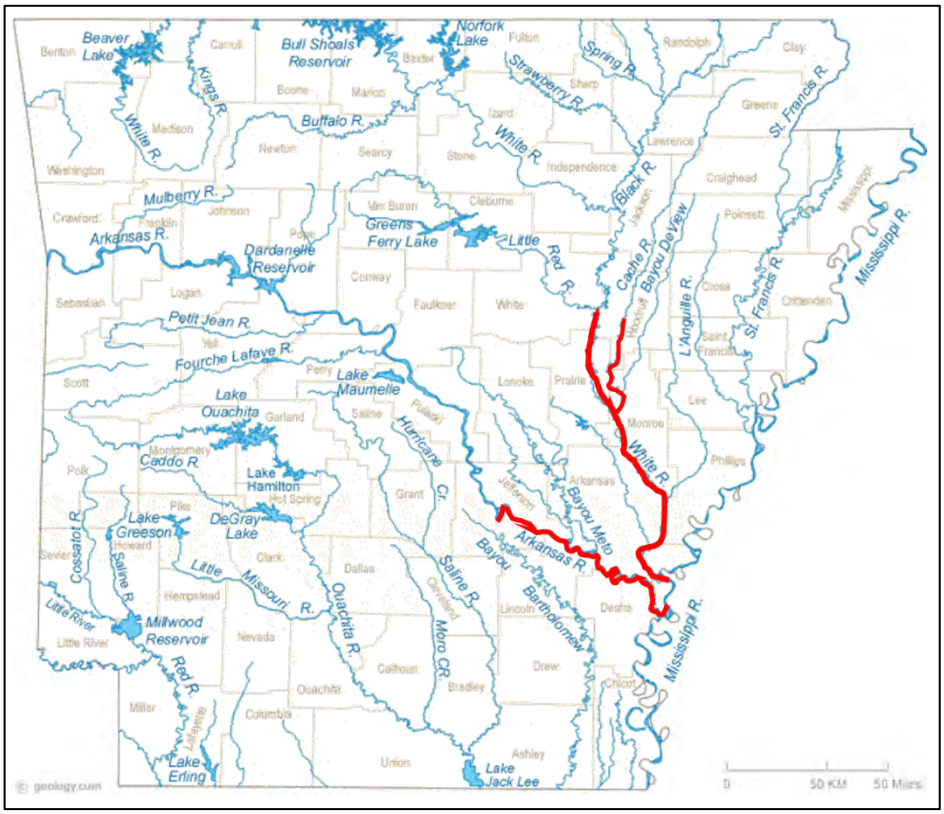
Agency: Arkansas Game and Fish Commission (AGFC)

Activities and Methods: AGFC will continue a removal program for Asian Carp utilizing two temporary employees focusing solely on catching and removing Grass, Silver, Bighead and Black Carp. All other species will be released. Gills nets of 100 yards length, 5” square mesh of 177 monofilament, 8 feet deep tied down to 6 feet with standard float line and lead line will be used. They will target areas that have known concentrations of Asian Carp as determined by previous monitoring. The removal crew will record demographic data of Asian Carp and by-catch numbers and condition of by-catch species upon release. The crew will be required to collect catch locations, tackle used and numbers of each species removed. The removed fish will be disposed by being made available for human consumption, pet food, fertilizer or an approved landfill. Harvest statistics will be used to inform future harvest efforts.

The goal of this project is the removal of 150,000 to 250,000 pounds of Asian Carps. The White/Cache River will be worked from RM176 downstream to the Mississippi River and the Cache River from Highway 38 to the confluence with the White River. The Arkansas River crew will work from RM63 downstream to the Mississippi River. The crew will work main stem and backwaters.

Funding will also be used to hire a full-time Asian Carp Biologist to coordinate the activities of the removal crew and the removal successes.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Removal	Fall 2021 through Summer 2022
Demographic Data Collection	Random throughout project
Annual Report	Winter 2022

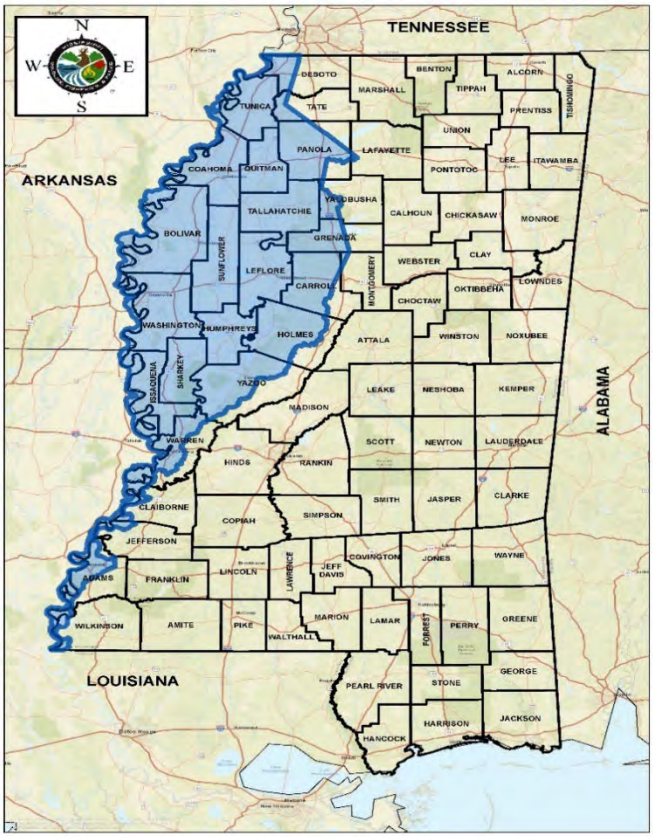
Agency: Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP)

Methods and Activities: During January – March 2021, the MDWFP prepared a contractual scope of work, a reimbursement invoice, and an Asian carp fish purchase ticket form for an Asian Carp processor fish reimbursement program. We distributed these documents to the Asian Carp processing firms in Mississippi and both firms signed contracts to participate. These contracts state that the MDWFP will reimburse these firms 18 cents/pound if they pay fisherman at least 25 cents/pound for Asian Carp harvested from the Mississippi River where it borders Mississippi and from the Yazoo River Basin.
Flooding conditions in the spring of 2020 in the Yazoo River Basin have limited fishing effort and the harvest of Asian Carp.

We plan to continue this Asian carp reimbursement program in 2021. The fish purchase tickets will provide information on numbers and pounds of the four Asian Carp species, along with harvest dates and locations. These data will be provided in annual project reports.

FY21 funds are not being requested for this project. FY20 funds will be expended until depleted.

Map of Project Area:



Estimated Timetable for Activities:

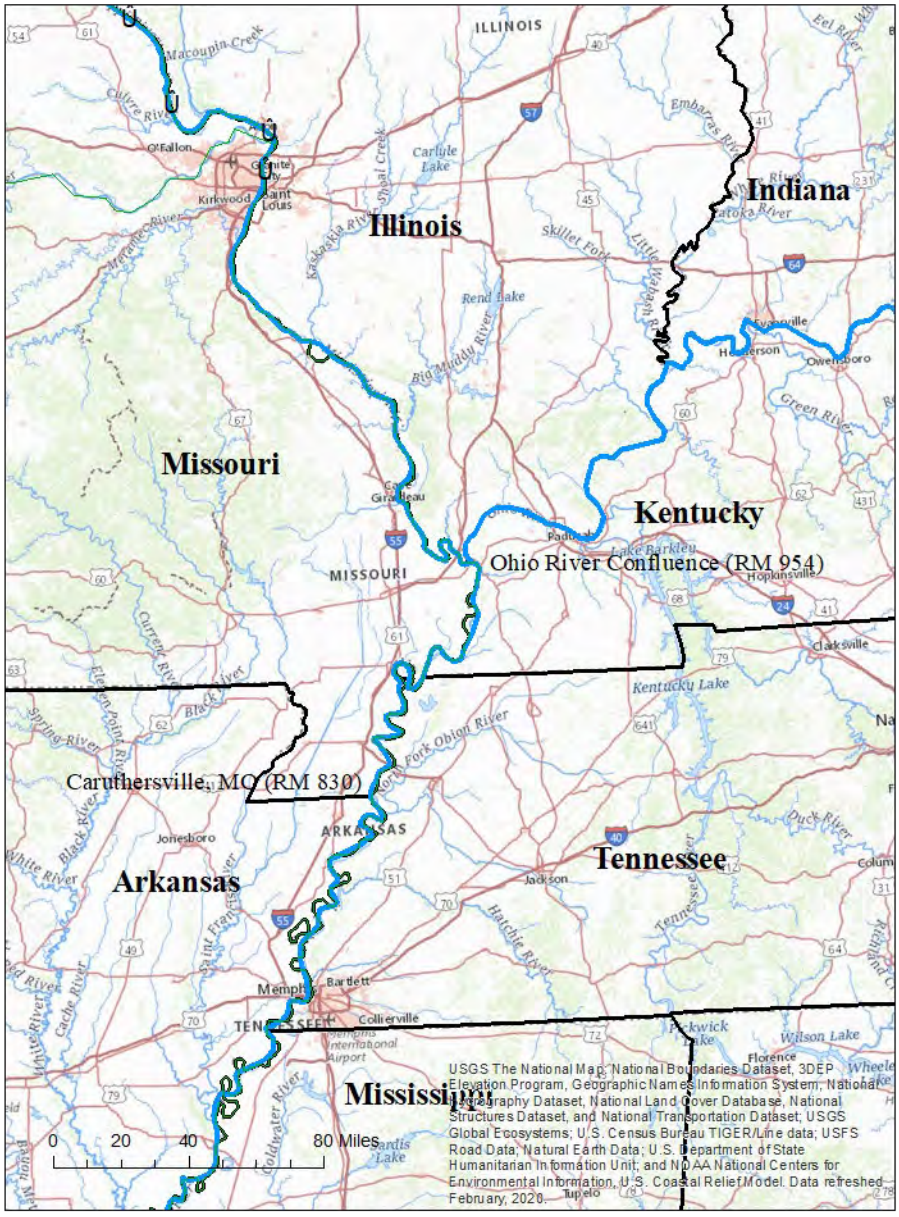
Activity	Time Period (Season, month/year)
Reimburse Asian carp processors for purchase of Asian Carp	March – December 2021 January – September 2022
Data Summary/Analysis	August- September 2021 August- September 2022
Grant Progress Report	September 2021 September 2022

Agency: Missouri Department of Conservation (MDC)

Methods and Activities: MDC will continue an Asian carp contract removal program to support Objective 1. Missouri removal efforts will occur in the LMR from the Ohio River Confluence (RM 954) to the southern border of Missouri near Caruthersville (RM 830). If conditions are unfavorable for mainstem sampling, there will be opportunities for removals in tributaries and old oxbows (only under special contract with an agency observer). Removal efforts will take place in the fall and winter of 2021 as river conditions permit and contracts are in place. Effort will be spread throughout the LMR reach.

Similar to what other agencies are doing, on a subsample of Asian carp, an MDC observer will record length and weight from Asian carp prior to being sacrificed and bycatch will be identified to species, enumerated, and disposition will be recorded (i.e. healthy, moribund, dead) prior to release.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Asian carp removal	Fall and Winter 2021
Demographic Data Collection	Fall and Winter 2021
Data Summary/Analysis	Winter 2021/2022
Annual Report	Spring 2022

Agency: Tennessee Wildlife Resources Agency (TWRA)

Methods and Activities: TWRA staff will identify sites (minimum of 4) on Reelfoot Lake to set clusters of gillnets. 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.

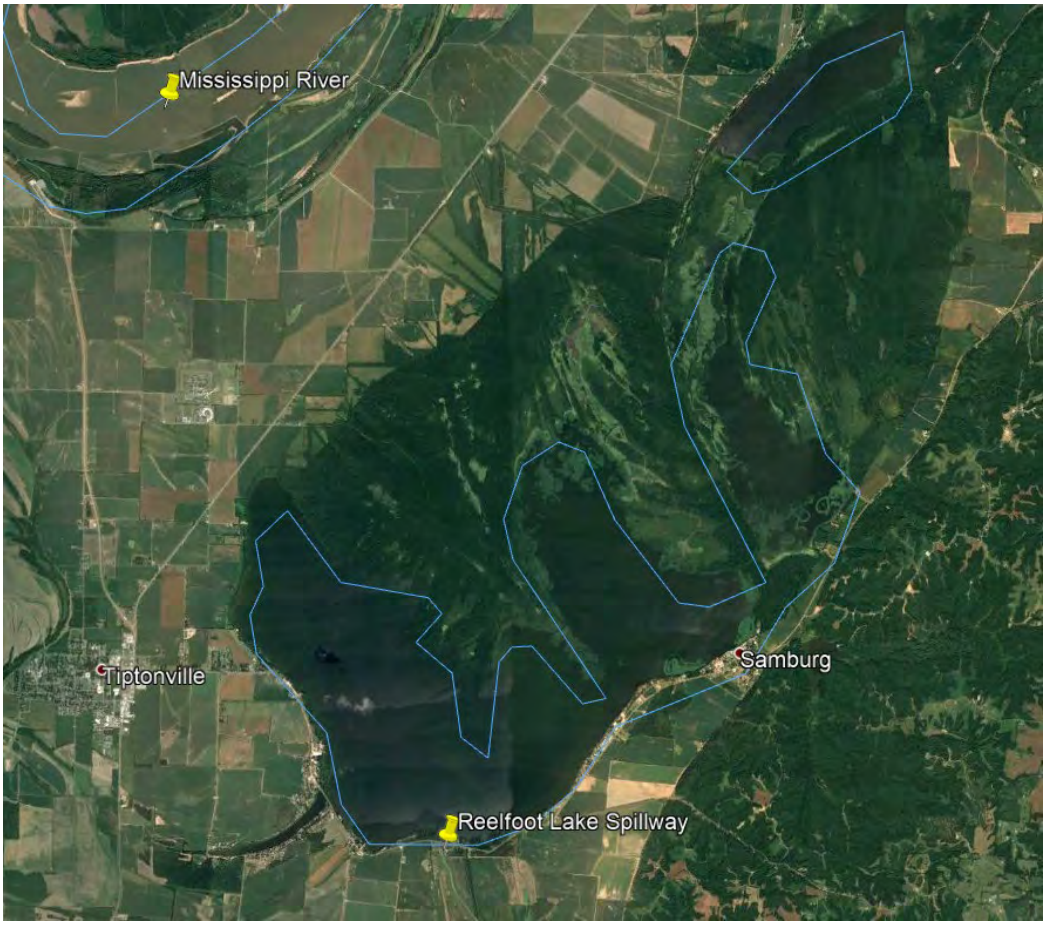
TWRA staff will establish 15 electrofishing sites on Reelfoot Lake. Sampling will occur at least twice per year (spring and fall). Electrofishing surveys will be conducted during the daytime using a high-frequency pulsed DC boat electrofishing. Voltage and amperage will be adjusted to achieve a 3,000-W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

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

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

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

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Commercial/contract removal	ASAP, 2021-2022
Electrofishing	Spring-Fall, 2022
Gillnetting	Summer-Winter, 2022
Bowfishing tournament	TBD
Final report	Spring, 2023

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Developing an adaptive framework based on connectivity for evaluating management actions that limit bigheaded carps access to floodplain lakes

Lead Agency and Author: Mississippi Department of Wildlife, Fisheries and Parks, Dennis Riecke (dennis.riecke@wfp.ms.gov)

Cooperating Agency: Mississippi State University (MSU)

Statement of Need: Bigheaded carps have become abundant in many floodplain lakes of the Lower Mississippi River Alluvial Valley. These fish access floodplain lakes through permanent or irregular connections created by hydrologic cycles. Because hydrologic connectivity is desirable to maintain ecologic diversity, natural resources management agencies must weigh tradeoffs between maintaining hydrologic connectivity to promote ecologic diversity, or restricting connectivity to limit invasion by exotic species. Given hydrologic connectivity can vary greatly among floodplain lakes, management actions must be tailored for specific lakes or types of lakes. For example, if hydrologic connectivity is infrequent, then managers could aim to preserve ecosystem services by suppressing bigheaded carps via commercial fishing. However, if hydrologic connectivity is frequent and complex, managers may need to formulate multiple strategies to restrict connectivity and limit undesired invasions at the expense of reduced ecologic diversity. Nevertheless, little is known about the various types of connectivity that occur in floodplain lakes of the Lower Mississippi River Alluvial Valley, and how management actions may be adapted to address each type.

Objectives:

1. Develop a typology of connectivity modes suitable for classifying the hundreds of floodplain lakes in the Lower Mississippi River Alluvial Valley into connectivity types to provide a framework for developing broad-scale strategy to adaptively manage bigheaded carps access to floodplain lakes.
2. Develop geospatial database to house information on hydrologic connectivity of floodplain lakes in the Lower Mississippi River Alluvial Valley

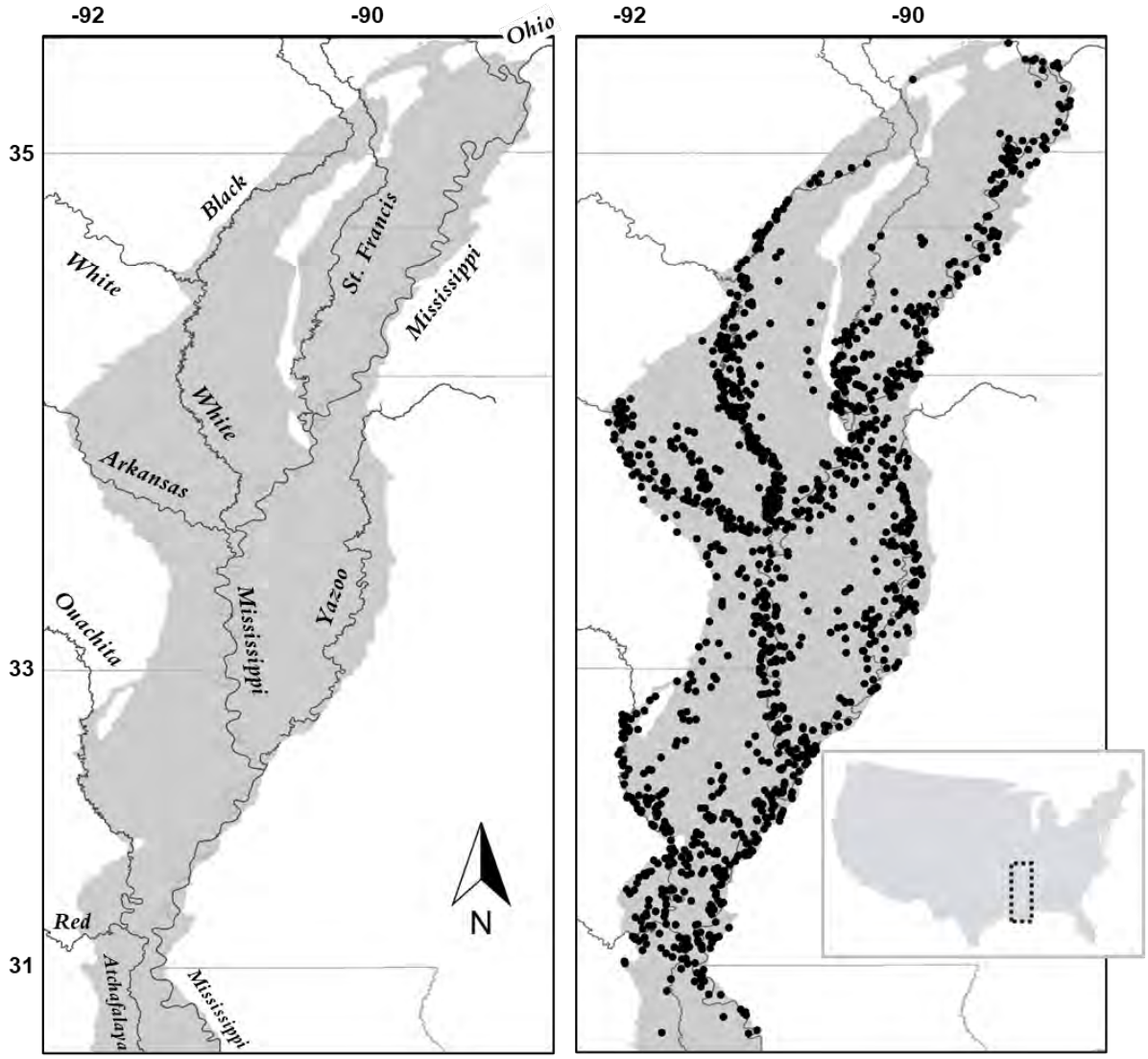
Activities and Methods: In support of Objective 1, MDWFP will partner with MSU to construct a typology of connectivity modes suitable for classifying the hundreds of floodplain lakes in the Lower Mississippi River Alluvial Valley into connectivity types that provide a framework for developing broad-scale strategy to adaptively manage bigheaded carps access to floodplain lakes. We will conduct a review of the hydrology literature to identify the many ways in which rivers can connect to adjacent waterbodies. Connectivity may take various general modes including flow through (regular river flow to and from the main channel); flood channel (flow only at high water stages reaches the lake); fill and spill (inflow from catchment drainage fill to a threshold level and then lake overflows); fill and drain (fills at high river discharge and returns to normal

levels); and disconnected (no flow except during exceptionally large floods). We expect a gradient of methods, but we will focus on the most common and relevant to movements of bigheaded carps. Our interest is on permanent lakes (i.e., those that retain water most years). Miranda et al. 2021 mapped over 1,300 permanent lakes (https://gcpolcc.databasin.org/maps/0d5517c361df4a178e48d6f1101f2e3b/active). Connectivity types will be assigned to these lakes based on the results of the literature review. Connectivity type may be assigned automatically if suitable GIS layers are found or may require a manual review of features to classify each lake by examining Landsat imagery and/or LiDAR imagery. Inundation frequency is another tool that may be applied to identify connectivity. These different data sets are assessed in relation to hydrologic and geomorphic data that relate to temporal and spatial connections to floodplain lakes.

In support of Objective 2, a concurrent literature review will be conducted to identify options for organizing a connectivity database. In addition to the connectivity types listed earlier, multiple variables such as distance to river, elevation difference between lake and river, flood magnitude, flood duration, flood frequency, water-level variability, connection channel bevel may influence these modes and may be included in the database. Additional relevant information will include confirmed presences of bigheaded carps from agency and public databases, presence of infrastructure that affects hydrologic connectivity (e.g., pumping systems, levees, drainage ditches, dams), and surrounding land uses affecting floodplain lake condition. Data will primarily be assembled through remote sensing and solicited from lake managers.

Map of Project Area:

The alluvial valley of the Mississippi River (shaded in gray) between latitudes 37.3° N and 30.4° N, about 770 km, north to south. At its widest the valley stretches almost 200 km, east to west.



The left panel shows the distribution of the major rivers that flow through the valley; the right panel shows the distribution of 1,329 lakes. The lakes shown range in area from 3 to 5,602 ha and consistently retain some wetted area. The extent and mode by which these lakes connect to neighboring rivers is mostly unknown.

Estimated Timetable for Activities:

Activity	**Time Period (Season, month/year)**
Recruit and select MS student	Aug 2021
Conduct literature review of hydrological connectivity modes and identify modes relevant to bigheaded carp management	Aug-Dec 2021
Review and obtain access to sources of remote sensing data needed for connectivity assessment	Sep-Dec 2021
Begin classifying lakes by connectivity mode, first automatically and next through manual review as needed	Jan-Jul 2022
Ground-truth connectivity modes through onsite visits as needed	May 2022-Jul 2023
Conduct literature review to identify options for organizing a connectivity database	Apr-May 2022
Begin populating the database and make accessible online	May 2022-Jul 2023
Prepare annual report	Aug 2022
Develop alternative classification systems of connectivity relevant to Asian carp intrusion control	Sep 2022-Jul 2023
Construct an online geospatial database with information on floodplain lake hydrologic connectivity	Nov 2022-Jul 2023
Survey agency staff to determine presence/absence/unknown status of Asian carp in lakes classified and develop framework for updating status in the online database	Jan 2023-Jul 2023
Develop management strategy suitable for controlling Asian carp intrusion into lakes of various connectivity modes	Jan 2023-Jul 2023
Prepare final report	Jul-Aug 2023

Missouri River Sub-Basin Invasive Carp Partnership

The Missouri River Sub-Basin (MORB) 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 (Figure 5) and two Canadian provinces. Recognizing the increasing threat of Invasive carp in the MORB, the Missouri River Natural Resources Committee (MRNRC) hosts an Asian Carp Technical Committee (Committee) made up of representatives from ten states in the basin and five federal agencies. The Committee finalized the *Missouri River Basin Asian Carp Control Strategy Framework* to minimize the social, ecological, and economic impacts of invasive carp to the MORB. The Framework applies the National Plan at the Missouri River sub-basin level.

Fiscal year 2021 was the second year of funding Invasive carp management and control in the Missouri River Basin as part of National Plan implementation. The Committee partnered with state and federal agencies and universities to develop four 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; and communication. The four projects resulted in $1.5M in grants allocated to five of the ten states in the Missouri River Basin.

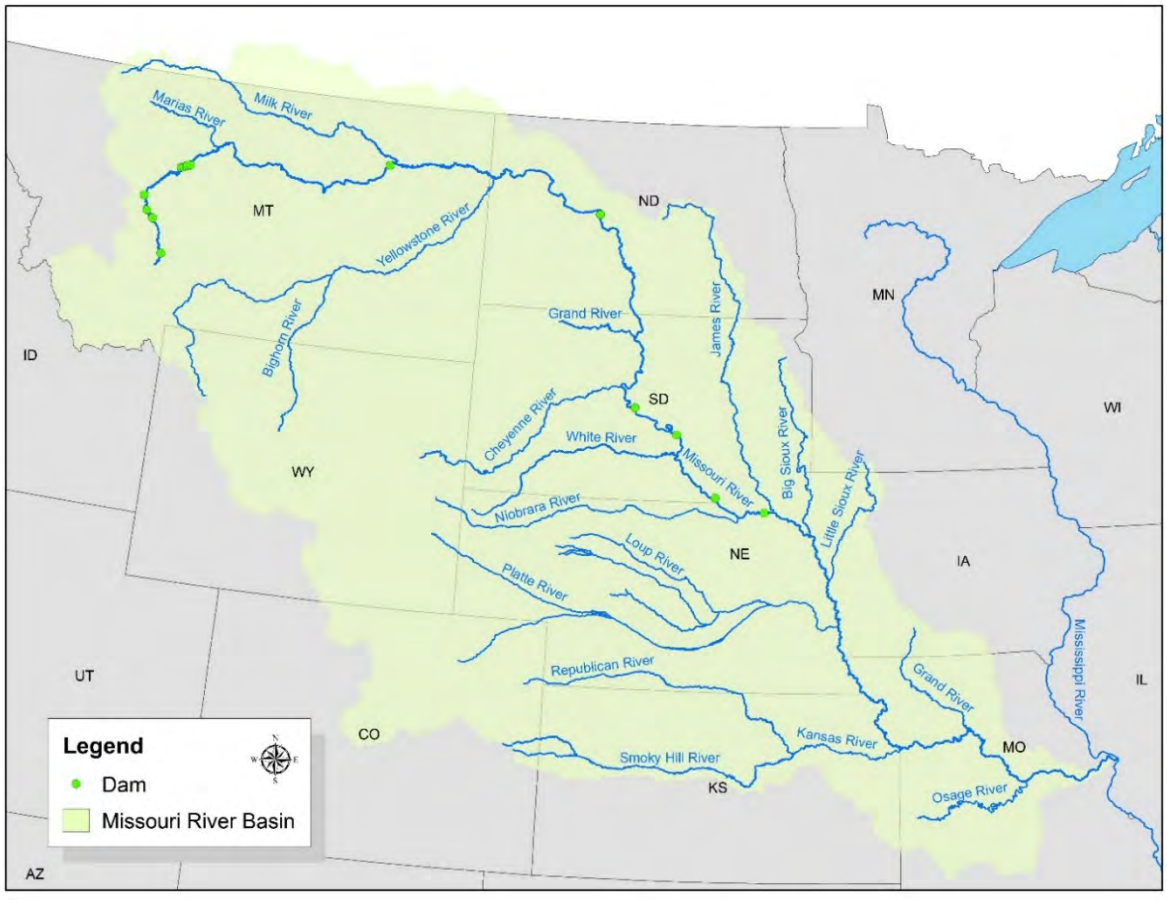


Figure 5. Map of the Missouri River Sub-Basin

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: Nebraska Game and Parks Commission (NGPC), Kirk Steffensen (kirk.steffensen@nebraska.gov)

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

Statement of Need: The USFWS and the Aquatic Nuisance Species Task Force, in collaboration with multiple stakeholders, released a national invasive carp management and control plan (National Plan; Conover et al. 2007) to limit ecological and economic problems posed by these species. Despite tremendous progress towards achieving National Plan goals, there remains great need to develop metrics to quantify the success of invasive carp management and inform containment and control efforts, especially in the Missouri River Basin where funding for invasive carp research has only recently been initiated. 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, age structure, maturity schedules, and fecundity of fish in a population are central to informed decision making.

Currently, more information on the abundance and distribution of Silver Carp *Hypophthalmichthys molitrix*, Bighead Carp *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 (Hayer et al. 2014). 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, mechanisms, and extent of spread. By detecting new populations early, actions can more effectively be implemented to control the population.

Missouri River Basin partners identified tributaries of the Missouri River as high priority areas as they provide access to state inland waters of high recreational, economical, and ecological value. The Platte River is a major tributary to the Missouri River and Nebraska's largest river system.

The Platte River contains multiple large tributaries and a network of diversion canals for an array of water usage. Furthermore, the Platte River does not contain large main-stem impoundments to block fish movement and may act as a source for both native and non-native fishes to the Missouri River. As such, understanding the population characteristics and recruitment of Silver Carp and Bighead Carp within the Platte River system is imperative to prevent further expansion and mitigate the risks to human interests and the native fish communities.

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

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) and otolith microchemistry are examples that are of interest to Missouri River Basin partners. The scope of this work and the depth of specialized knowledge will require a collaborative effort among partners to develop and implement effective protocols using these tools to answer high priority questions.

Otolith microchemistry is an important tool for determining the natal origin of fishes from environments with distinct water chemistries (Campana et al 2000; Gibson-Reinemer et al. 2009; Zitek et al. 2010). An important first step is determining the variation in water chemistry among water bodies of interest. Specifically, the trace elements of barium (Ba), strontium (Sr), calcium (Ca) along with oxygen (^{16}O, ^{18}O) and strontium (^{86}Sr, ^{87}Sr) isotopes are commonly used to differentiate between waterbodies. Once the unique water chemistries are determined, signatures within fish tissues such as otoliths can be assessed for the same trace elements and isotopes to

inform where a fish spent portions of their life history, including natal origins. This technique may be best applied over a large spatial scale where differences in water chemistry are evident and can retroactively determine where fish from multiple year classes captured in a single sampling season spent time, informing habitat use, movement, and, subsequently, future management actions.

The tasks outlined in this document are the initial 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: SDGFP, NGPC, USFWS).
    - Sub-Objective 1: Develop a Missouri River Basin Invasive Carp Genetics Team to increase understanding of environmental DNA (eDNA) as a tool for the detection and measurement of invasive carp populations, host informational webinars/workshops from experienced labs to provide education and learning opportunities for labs in the Missouri River Basin, and develop a standard framework for field collection, laboratory analysis, database development, and communication the results.
    - Sub-Objective 2: Implement a strategy for information sharing on the methods needed to successfully analyze eDNA samples for invasive carp primers, coordinate efforts with USFWS Bozeman Fish Health Lab in Bozeman, MT & Whitney Genetics Lab in La Crosse, WI, to integrate methods with partners already using eDNA for detection of invasive carp.
    - Sub-Objective 3: Determine the feasibility and efficacy of eDNA analysis in these aquatic systems to detect the presence of invasive carp in water and/or sediment samples across various sized drainage areas.
    - Sub-Objective 4: Determine the presence/absence of Bighead and Silver Carp and investigate the feasibility of using eDNA for detecting Black Carp in the Missouri River and its tributaries concentrating above and below fish movement barriers to better understand invasive carp distributions.
    - Sub-Objective 5: Utilize otolith microchemistry to inform natal origins and spatial use patterns of Silver Carp in Missouri River Basin.
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 and relative abundance) while developing standard operating procedures that are specific for the lower Missouri River Basin to prescribe and assess population control measures (Agencies involved: NGPC, MDC, USFWS).

- Sub-Objective 1: Evaluate a suite of gears and sampling logistics to determine an effective and efficient method to sample all sizes of Silver and Bighead Carp in a variety of aquatic systems.
- Sub-Objective 2: Determine the size distribution, relative abundance, and other population characteristics of the Silver and Bighead Carp populations in a variety of aquatic systems to help identify areas where population control measures can be implemented.
- Sub-Objective 3: Pair fishery sampling efforts with and eDNA sampling sites to validate eDNA results.

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

    - Sub-Objective 1: Deploy fish community assessment gears in the inter-reservoir reach and, in the lower Missouri River, use the data collected from Objective 2.1 to characterize the fish community and select native fish species.
    - Sub-Objective 2: Determine the size distribution, relative abundance, and other population characteristics of select fish species to help identify potential differences between areas with and without established invasive carp populations.
    - Sub-Objective 3: Utilize historic fisheries data (i.e., Pallid Sturgeon Population Assessment or Benthic Fishes) to determine changes in the associated fish community diversity, richness, size distribution, relative abundance, relative condition, and other population dynamics parameters.

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

Activities and Methods:

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

Additionally, surface ichthyoplankton drift nets will be deployed to document potential invasive carp presence and reproduction above Lewis and Clark Lake.

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

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

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

In the Platte River and lower reaches of major tributaries of the Platte River, netting (i.e., mini-fyke nets) will focus on the occurrence and habitat uses of young-of-year for both Silver and Bighead carps. Sampling for young-of-year will occur in late summer and early fall 2022 and 2023. All species collected will be identified and enumerated to provide base data on native and non-native fish assemblages. Boat and barge electrofishing will also be performed. Habitat measurements will be taken at each sample location to characterize habitat use of young Silver Carp and Bighead Carp.

Silver Carp and Bighead Carp gonads as well as ichthyoplankton tows collected will be used to assess spawning phenology. We will collect length, weight, hard-part structures (otolith and pectoral spines) used for aging and microchemistry, and gonads from each individual Silver Carp

and Bighead Carp. If we identify spawning aggregations, future contaminant and control efforts may be warranted.

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

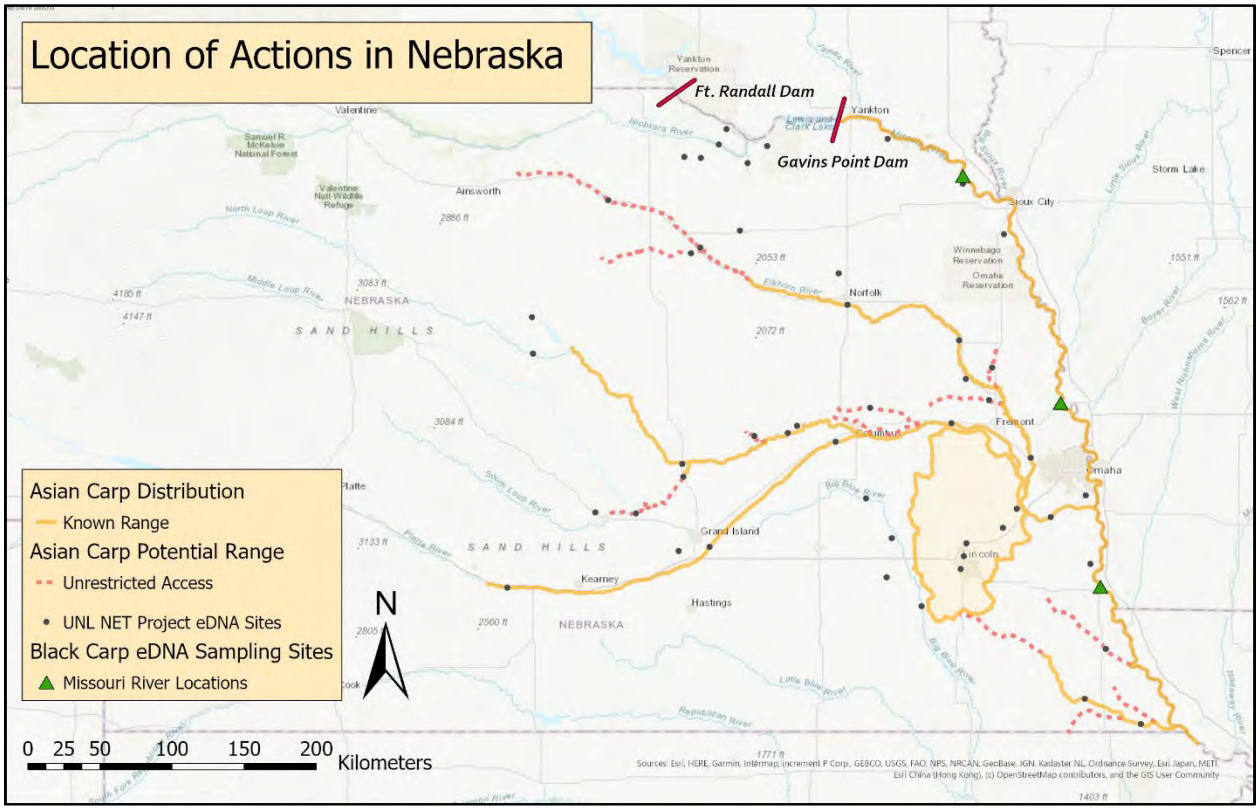
Objective 3: NGPC in conjunction with UNL will characterize fish communities and assess select fish species (e.g. Paddlefish, Buffalo spp.) in the Gavins Point Dam tailwaters, the most upstream infestation on the mainstem Missouri River, as well as Missouri River tributaries and periphery streams in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

Map of Project Area:

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

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

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


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

Estimated Timetable for Activities:

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

Agency: Missouri Department of Conservation (MDC)

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

Objective 3: MDC: Conduct fish community sampling in 4 tributaries of the Missouri River, associated Missouri River bends, and potentially 2 Missouri River oxbow lakes between river kilometers 0 and 885 to obtain baseline data for comparison after future management actions are implemented. Sampling units delineated for Objective 2 will also be used for fish community sampling. Tributary sampling gears and regime will be based on Dunn and Paukert 2020, while Missouri River bend sampling will be based on Welker and Drobish 2016. This will allow for comparison to other programs' fish community work to evaluate long-term trends in areas with invasive carp. Along with overall fish community sampling, selected species of interest will be sampled to monitor any impacts. Species of interest will be selected based on current literature, expert opinion, and agency priorities.

Map of Project Area:

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

Missouri Tributaries:

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

Estimated Timetable for Activities:

Activity	Time Period
Invasive Carp population demographic sampling	Summer/Fall 2022
Fish Community sampling	Summer/Fall 2022
Sample analysis, data entry, analysis, and report writing	October 2022 – March 2023
Submit Annual Report	March 2023

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

Activities and Methods:
Objective 1: SDGFP and USD staff will participate in environmental DNA (eDNA) training with USFWS staff from the Whitney Genetics Lab and the Bozeman Fish Health Center, along with staff from other basin partners, during the late Spring or early Summer of 2021. Training will occur in eastern South Dakota, and samples will be collected from a combination of the Big Sioux, Vermillion, and James Rivers, where Silver Carp and Bighead Carp (hereafter bigheaded carp) are known to persist. Topics to be covered during the training session include proper sampling protocols, collection, and pre-processing techniques, and broader discussions on efficacy, sample sizes, preservation, and processing techniques.

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

Sampling locations in the Big Sioux and Vermillion Rivers will correspond with locations above and below presumed barriers. On the Big Sioux River, samples will be collected in Sioux Falls below the natural waterfalls (rkm 243) and/or below the manmade diversion spillway (rkm 241), where bigheaded carp are known to persist. Samples will also be taken above the barrier at

locations to be determined where bigheaded carp have never been documented. One potential sample site above Sioux Falls is below Flandreau Dam (rkm 357), which acts as the next barrier to fish movement under normal water conditions on the Big Sioux River. Water samples will be collected on the Vermillion River will occur below the East Vermillion Lake spillway (rkm 192), where bigheaded carp are known to exist, and at a location to be determined above East Vermillion Lake.

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

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

Otolith microchemistry is an important tool for determining the natal origin of freshwater fishes from environments with distinct water chemistries (Campana et al 2000; Gibson-Reinemer et al. 2009; Zitek et al. 2010). To evaluate variation in water chemistry among eastern South Dakota rivers, water samples will be collected in spring and fall (2021-2023) from the James (n=2), Vermillion (n=2), Big Sioux (n=2), and Missouri Rivers (n=3). Water samples for trace element

and oxygen isotope analysis will be collected in 250-mL, acid-washed, polyethylene bottles that are pre-rinsed with river water, filtered through a Whatman Puradisc PP filter (0.45 µm), and stored in sealed, acid-washed polyethylene bottles. Water samples for strontium isotope analysis will be collected in 200-mL, acid-washed, polyethylene bottles and will be stored unfiltered in a refrigerator until processing. Trace elements of barium (Ba), strontium (Sr), calcium (Ca) along with oxygen (^{16}O, ^{18}O) and strontium (^{86}Sr, ^{87}Sr) isotopes will be analyzed using inductively-coupled mass spectrometry (ICP-MS). Water samples will be analyzed by the Kennedy LIFE laboratory at the University of Idaho (^{86}Sr, ^{87}Sr) or Southern Mississippi University (Ba, Ca, Sr, ^{16}O, ^{18}O).

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

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

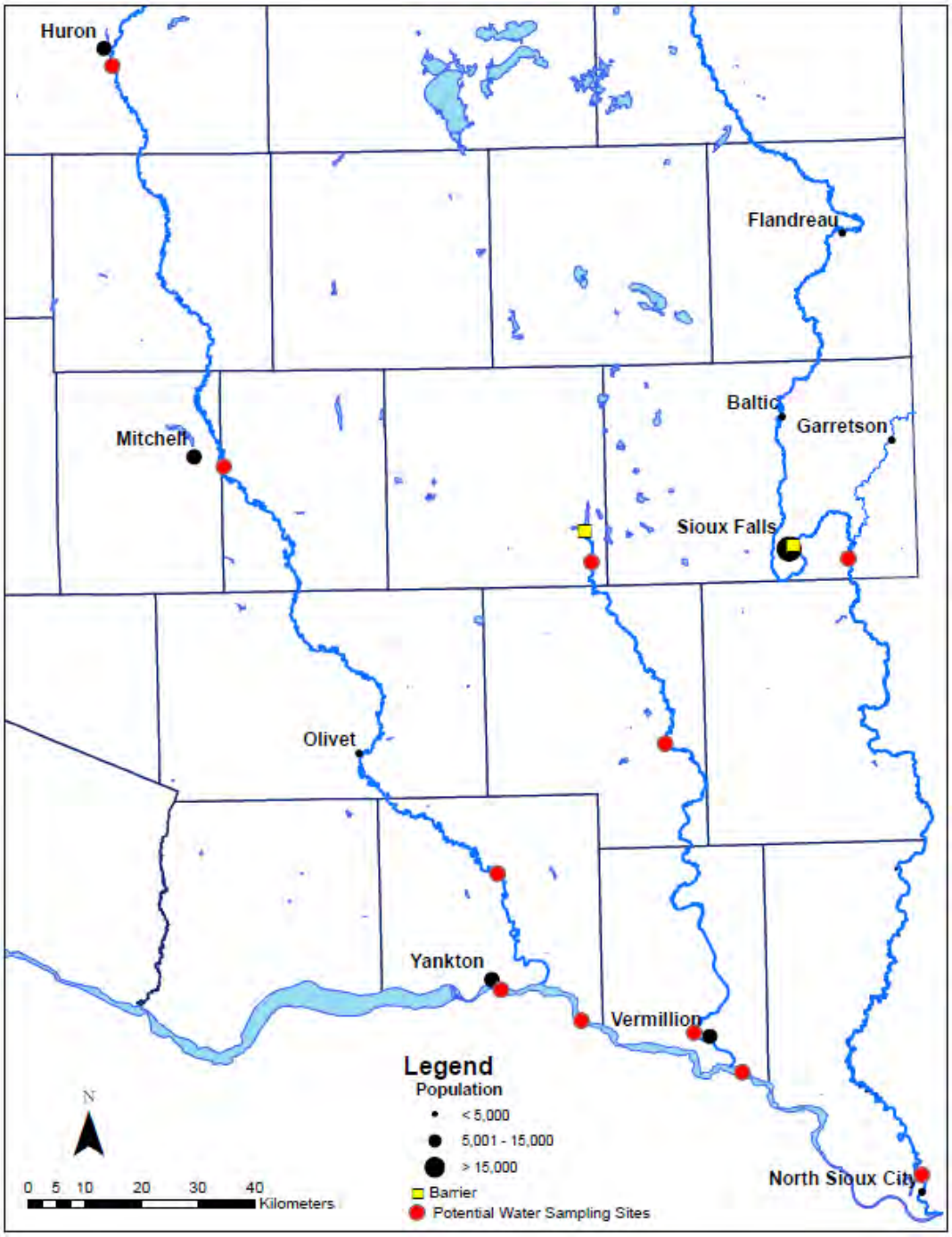
To validate results from otolith microchemistry, age-0 Silver Carp may be targeted from the eastern South Dakota rivers to provided known signature matches to each system. Several age-0 or age-1 fish were collected from the Missouri and Big Sioux rivers in 2020 and may be used to provide water chemistry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

Map of Project Area:

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

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

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period
Process eDNA samples	Summer-Fall 2021
Water samples collected	Fall 2021
Otoliths collected and prepped for analysis	Fall 2021
Water Samples Processed	Winter 2021
Preliminary otoliths sent for processing	Winter 2021
Data analysis and synthesis	Winter 2021-2022
Annual technical report	March 2022
Water Samples Collected	Spring 2022
Water Samples Processed	Summer/Fall 2022
Lab selected for otolith processing	Summer/Fall 2022
Otoliths sent for processing	Fall 2022
Interim report	Fall 2022
Annual technical report	March 2023
Water Samples Collected	Spring 2023
Water Samples Processed	Summer/Fall 2022
Final Reports Submitted	Fall 2023

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

Activities and Methods:

Objective 2: Ichthyoplankton sampling will be conducted throughout the Little Sioux River to evaluate when, where, and under what conditions invasive carp reproduction occurs. Larval fishes will be sampled at sites throughout the Little Sioux using ichthyoplankton tows. Ichthyoplankton tows (0.5 m diameter net) will be conducted and a General Oceanics flowmeter will be mounted in the mouth of the net 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 as the number of larvae/m^3. This information will be used to assess the timing of appearance and spatial variation in larval densities throughout the Little Sioux River and the environmental conditions under which reproduction occurs.

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, cast nets, cloverleaf traps, etc) to sample juvenile fishes during the summer and fall throughout Iowa tributaries of the Missouri River. We will also sample habitat 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 2023
Ichthyoplankton sampling in Little Sioux	May-June 2022
Sample processing in the laboratory	June - October 2022
Sample juvenile fishes in MO basin tribs	July-October 2022
Summarize and analyze data, write reports	October 2022-May 2023
Sample juvenile fishes in MO basin tribs	July -October 2023
Summarize and analyze data, write reports	October 2023-September 2024

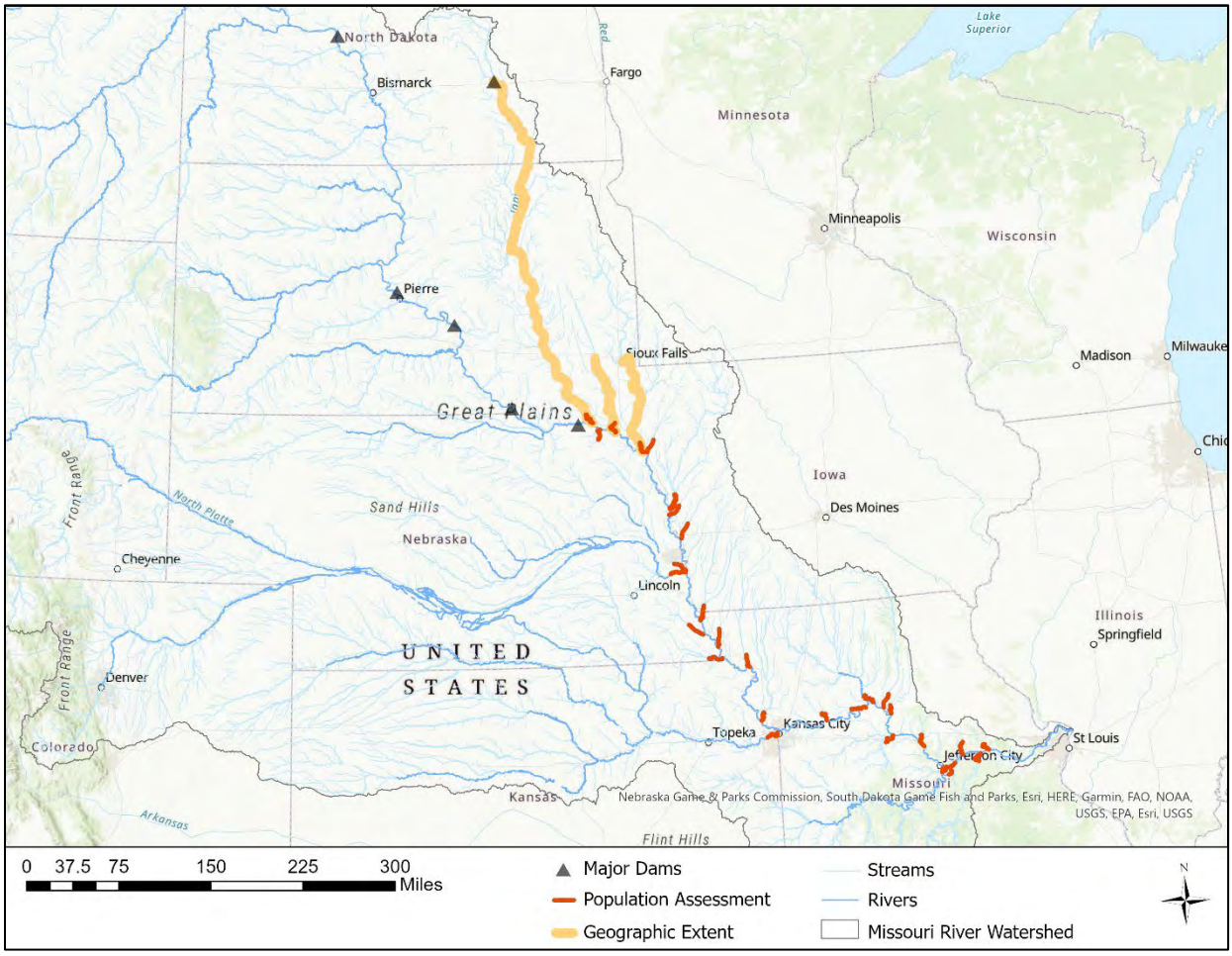
Agency: U.S. Fish and Wildlife Service (USFWS) including the Columbia Fish and Wildlife Conservation Office, Bozeman Fish Health Lab, Missouri River Fish, and Wildlife Conservation Office, and the Great Plain Fish and Wildlife Conservation Office

Activities and Methods:

Objective 1: USFWS Bozeman Fish Health Center (BFHC) is working with USFWS Whitney Genetics Lab (WGL) to increase and enhance existing eDNA laboratory capacity in the Missouri Basin at BFHC in Bozeman, MT. Missouri River FWCO staff will use their existing invasive carp mapping to develop an eDNA sampling site strategy for Vermillion, Big Sioux, and James Rivers following WGL protocols. Field sampling will be conducted in partnership with the LaCrosse, WI, FWCO genetics trailer team. BFHC in Bozeman, MT will determine the presence/absence of Bighead and Silver carp using eDNA methodologies.

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

Map of Project Area:



Estimated Timetable for activities:

Project Activity	Time Period
Field collections	September – October 2021
Lab analysis	Summer 2021 – February 2022
Data analysis	November 2021 – March 2022
Annual Technical Report	March 2022
State-specific fact sheets	May 2022

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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: United States Fish and Wildlife Service (USFWS), Emily Pherigo (emily_pherigo@fws.gov)

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

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

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

The electric barrier on the outlet of the Iowa Great Lakes is 49 m wide and 8 m long and consists of eight electrodes and seven pulsers that span the width of the outlet with a gradient of electrical

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

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

Objectives:

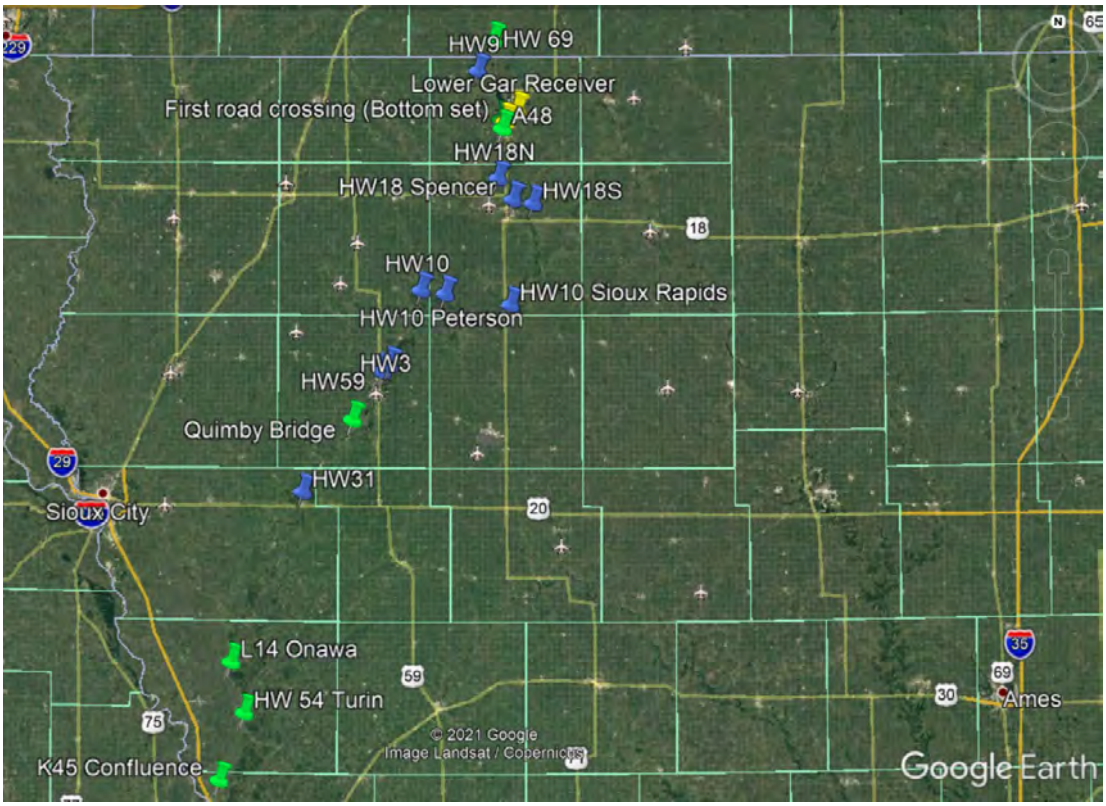
1. Determine Silver Carp and Bighead Carp residence time and movement in the Missouri River and its tributaries in association with season, environmental conditions, and barriers to inform containment and control management actions.
    a. Determine if Silver Carp and Bighead Carp have extended presence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

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

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

Map of Project Area:

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



Sites on the Little Sioux River, Iowa for potential acoustic receiver deployment.

Estimated Timetable for Activities:

Activity	**Time Period** **(Season, month/year)**
Site visits, scout potential receiver locations, range testing	October 2021 – March 2022
Purchase supplies	October 2021 – March 2022
Deploy receivers and tag fish	October 2021 – May 2022
Record fish locations	October 2021-September 2022
Download receivers	September-October 2022

Agency: Missouri Department of Conservation (MDC)

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

By the winter of 2021/2022 stationary receiver arrays and HOBO temperature/water level loggers will be deployed at each of the five tributaries in Missouri (Creve Coeur, Moreau, Lamine, Grand and Kansas rivers). Each tributary array will consist of seven stationary receivers and two HOBO loggers. Near the mouth of each tributary, two receivers will be deployed so that the direction of movement (entering or exiting) can be determined and the remaining five receivers will be placed further upstream depending on access and presence of Asian carp. Range tests will be completed at each receiver location to evaluate performance and adjustments will be made as needed. A HOBO logger will be placed on the receiver closest to the confluence of the Missouri and at the furthest upstream receiver. The HOBO loggers will provide the environmental data needed to determine if there are any patterns or environmental cues that can be linked to timing of movement and tributary use. A minimum of 50 Silver Carp or Bighead Carp will be surgically implanted with V16 (6H or 4H, depending on fish size) transmitters in each system. Up to 100 additional Silver and Bighead Carp will be added to the tributaries as needed to attempt to maintain the goal of 50 bigheaded carp per tributary. Receivers and HOBO loggers will be downloaded on a regular basis (every 4-6 weeks) and active tracking may be employed to inform removal efforts. Downloaded data will be shared with partnering agencies as appropriate and analyzed for Silver Carp tributary use and movement in relation to season and environmental conditions.

Data collected from the stationary receivers in the tributaries will be used to fulfill Objective 1 by providing the residence time and movement of Asian carp in tributaries, while the HOBO loggers will allow us to evaluate whether environmental factors effect movement and use of tributaries. All of this information combined will be used to inform future removal efforts and also inform decisions in locations where barriers occur (Bowersock Dam and Creve Coeur).

Map of Project Area:

Estimated Timetable for Activities:

Activity	**Time Period (Season, month/year)**
Deploy Acoustic Array	Fall/Winter 2021
Implant Acoustic Tags in Asian Carp	Fall/Winter 2021
Download Receiver Data	Every 4-6 weeks 2021/2022
Annual Report	March 2022

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

Activities and Methods: No additional funding is requested for this objective. SDGFP in coordination with USD graduate student will continue work started in 2021 to assess Silver Carp movement in the James River. Activities include setting, replacing, or removing receivers, downloading data from telemetry receivers as well as water level loggers and temperature loggers, and sharing significant findings. Additionally, the graduate student will map habitat characteristics in the lower James River to identify preferred habitats or spawning suitability.

A minimum of ten acoustic receivers (Vemco VR2W) will be deployed in the James River between Olivet, South Dakota (rkm 105) and Huron, South Dakota (rkm 358). An additional 1-2 VR2W receivers will be deployed either at locations in the Missouri River or the James River. Placement of these receivers will depend on deployment of Vemco acoustic receivers being used for studies of other species (i.e., Saugeye, Walleye, Blue Suckers, Pallid Sturgeon) in the Missouri River, Lake Lewis and Clark, and Missouri River tributaries. Potential receiver deployment locations in the mainstem Missouri River include the Yankton bridge (rkm 1,297) and the Vermillion-Newcastle bridge (rkm 1,252). A receiver array of VR2Ws will already exist downstream of Olivet, SD on the James River to the confluence of the Missouri River as part of an ongoing Blue Sucker telemetry project. Receivers will be attached to the downstream side of bridge pilings and secured inside 4” PVC tubing.

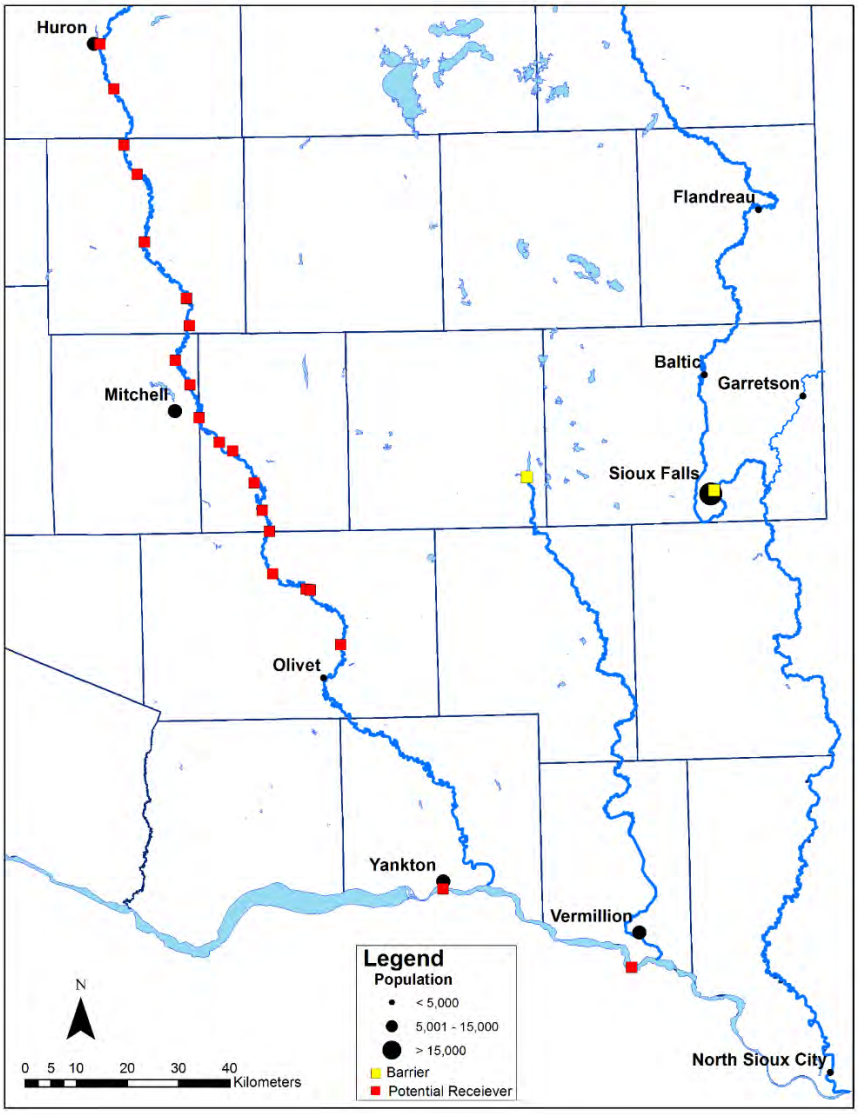
Silver Carp will be collected in summer 2021 and surgically implanted with Vemco V16 acoustic transmitters. Tags will only be implanted if the tag weight is <2% of the total mass of the individual fish. Tags will be implanted following similar procedures as described in DeGrandchamp et al. (2008) and 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. Fifty Silver Carp will be tagged with V16 tags, with tags distributed between tagging locations between the confluence of the James River with the Missouri River and Huron, SD. Likely tagging locations include the James River confluence, Olivet, Mitchell, and Huron, but tag distribution will likely be determined by Silver Carp availability.

Water temperature loggers will be deployed near the confluence and at several upstream locations and 1-2 water level loggers will be placed near the confluence of the James River to

monitor the impact of backflow from the Missouri River into the James River. Data will be downloaded from the acoustic receivers, temperature loggers, and water level loggers in fall 2021 and fall 2022, at a minimum. Available habitats will be mapped in the James River using side scan sonar. 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.

Map of Project Area:

Map of Big Sioux, Vermillion, and lower James River with barriers to fish movement indicated by yellow squares and potential acoustic receiver locations indicated with red squares.



Estimated Timetable for Activities:

Activity	**Time Period (Season, month/year)**
Retrieve data from acoustic receivers and environmental loggers	Fall 2021
Annual report to Sub-Basin partnership	December 2021-February 2022
Habitat mapping	Summer 2022
Retrieve data from acoustic receivers and environmental loggers	Fall 2022
Interim Progress Report	Fall 2022
Data analysis and synthesis	Spring 2023
Final Report	Fall 2023

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

Eighty Silver Carp (> 500 mm TL, and > 1200 g; n= 40 in Vermillion River, and n=40 in the Big Sioux River) will be caught with electrofishing and tagged with acoustic transmitters (Vemco, Model V16-4H; 69kHz, 16mm diameter, 68 mm length, 24g) in May 2021 to assess movement within the Missouri River and its tributaries. V16-4H coded transmitters have a 1,350 day battery life, which allows fish movements to be monitored until approximately February 2025. Fish will be held in a tank with a continuous flow of fresh river water, anesthetized with Aqui-S 20E, and tags implanted following surgical procedures outlined in Summerfelt and Smith (1990). Each fish will be weighed (g), measured for total length (mm), and sexed. 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 near the dorsal fin base of each fish. 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 the fish will be released near the point of capture.

Acoustic Receiver Array

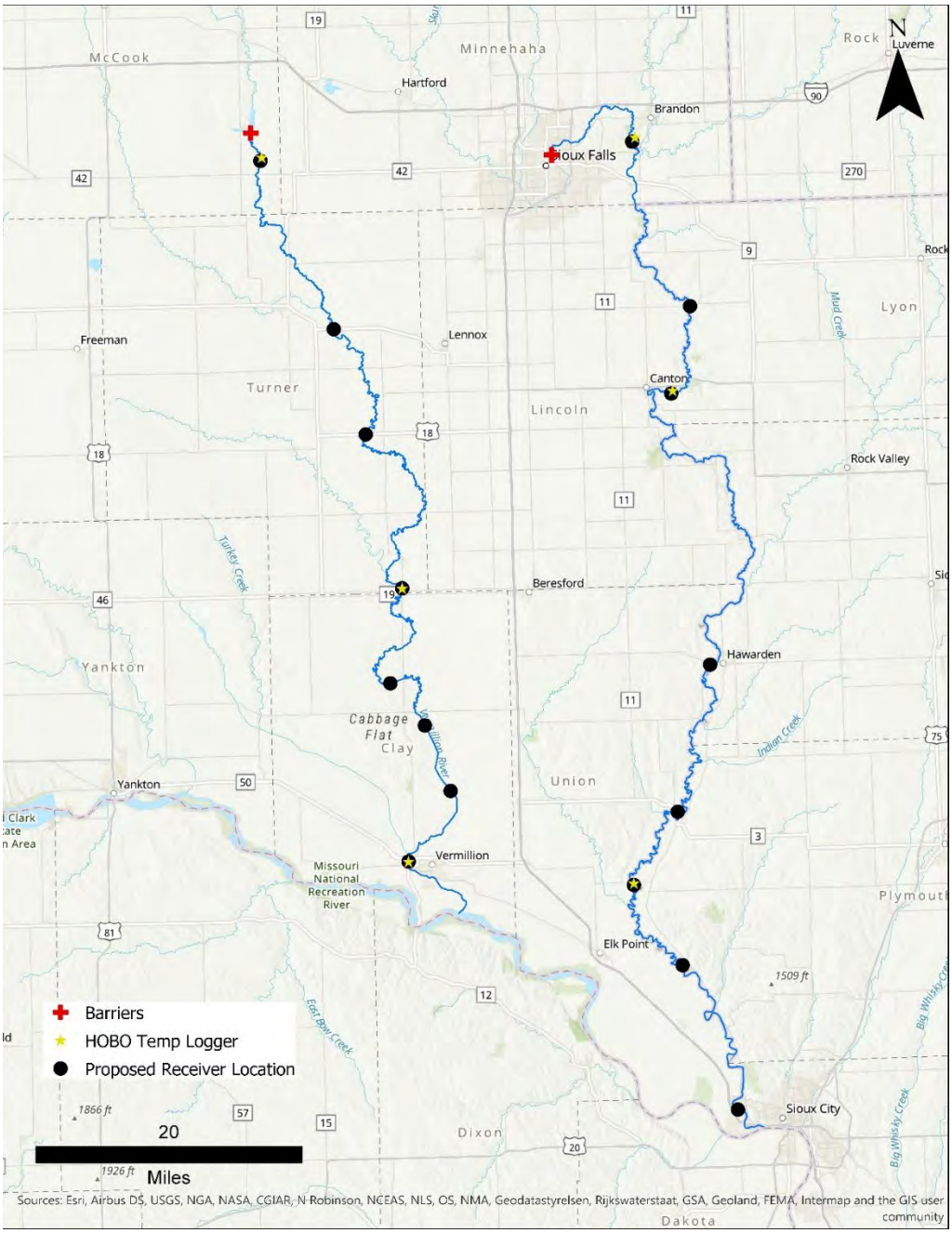
Silver Carp movement will be assessed by stationary receiver arrays consisting of 5 Vemco receivers (combination of VR2W and VR2Tx) and 3 HOBO water temperature loggers in each river. Receivers will monitor movements in and out of the tributaries. Data from stationary receivers and HOBO temperature loggers will be downloaded monthly (dependent on staff availability).

Active Tracking

Active tracking will be used to locate fish within the tributaries to determine fine scale movement patterns outside of stationary receiver coverage. Tracking will be attempted monthly from April to October (depending on river conditions, staff availability, and distance from boat ramp). Habitat data will be recorded once a reading of >75 db is achieved. Depth (m), water temperature (°C) and GPS location will be recorded at each fish location. Fish will be located with a Vemco VR100 receiver and a VH110 or VH165 hydrophone.

Map of Project Area:

- The Vermillion River joins the Missouri River at approximately rkm 1,242 and extends into South Dakota. 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 joins the Missouri River at approximately rkm 1,181 and extends into Iowa and South Dakota. 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).
- Potential locations of stationary VR2W receivers and HOBO water temperature loggers in the Vermillion and Big Sioux rivers. Low water levels during 2021 may require selection of alternate receiver and logger locations.


McCook
Minnehaha
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Luverne
Hartford
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Sioux Falls
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Lincoln
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Rock Valley
Beresford
Hawarden
Yankton
Cabbage Flat
Clay
Union
Vermillion
Missouri National Recreation River
Elk Point
Plymouth
Sioux City
Dixon
Dakota
Barriers
HOBO Temp Logger
Proposed Receiver Location
20
Miles
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Silver Carp tagging efforts	May 2021
Deployment of VR2W receivers and HOBO temperature loggers	May-July 2021
Data offload of receivers and HOBO loggers	Monthly 2021
Manual tracking (dependent on staff availability)	May-October 2021
Data entry and analysis, annual report	October- December 2022
Data offload of receivers and HOBO loggers	Monthly 2022
Manual tracking (dependent on staff availability)	May-October 2022
Data entry and analysis, annual report	October-December 2022
Data offload of receivers and HOBO loggers	Monthly 2023
Manual tracking (dependent on staff availability)	May-October 2023
Data entry and analysis	October-December 2023
Final report	December 2023 - February 2024

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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: The Kansas River drains approximately the north half of the state of Kansas and a portion of south-central Nebraska and flows east to its confluence with the Missouri River at Kansas City. The Bowersock Dam at Lawrence, Kansas serves as a barrier to the upstream movement of invasive carp except during periods of exceptionally high flow (approximately >120,000 cfs). Only six (6) bighead carp have been documented upstream of this barrier. These fish likely passed over the Bowersock Dam during extreme flooding in 1993. At that time, the invasive carp population in the Kansas River was very low and the number of fish that migrated upstream over the dam was insufficient to establish a breeding population in the upper portion of the river basin. Removing invasive carp downstream from the Bowersock Dam would reduce the number of fish that may attempt to pass over the dam during a high flow event, decreasing the potential for a breeding population to establish upstream of the dam. Long-term, we are exploring ways to install a deterrent at the Bowersock Dam that would minimize passage over the dam during high flow events. The fish removal described in this proposal is intended be a temporary project in order to prevent establishment of an upstream population of invasive carp while the dam deterrent options are explored. In addition to the upstream barrier (Bowersock Dam), there is a downstream semi-passable barrier (WaterOne Dam at Edwardsville, KS) that limits further upstream movement in the Kansas River from the Missouri River during normal flows. Data from a 2017-2018 study found that the demographic data for silver carp in the section of Kansas River proposed to be fished are different than those of silver carp in the lowest portion of the Kansas River. Therefore, we do not expect harvested fish to be quickly replaced by migrants. In addition, very few juvenile invasive carp were encountered in the section of river proposed to be fished; most fish will be of a size vulnerable to harvest. KDWP intends to meet the objective of population reduction by either contracting with a commercial fisher or hiring additional KDWP staff to remove invasive carp below Bowersock Dam. If a commercial fisher is used, we anticipate implementing an effort-based (rather than catch-based) payout to prevent a reduction in fishing effort in conjunction with an expected reduction in harvest.

MDC, in cooperation with USFWS – Columbia, will evaluate multiple bighead carp and silver carp removal methods and identify areas with a high probability of capture. During fiscal year 2020 focus was on pilot evaluations of removal methods, site identification, and gear procurement. Targeted sampling for the pilot evaluations were conducted in the Missouri River between RKM 0 and 885, including select tributaries and cutoff lakes, using a suite of gears.

This project is a multi-year assessment and efforts conducted during fiscal year 2021 will entail identifying discrete habitat types with high densities of bighead and silver carp in the Missouri River between, primary tributaries, and cutoff lakes. Age and size structure data would be collected from these selected sites, identified during fiscal year 2020 to estimate pre-removal

mortality. Then, multiple gears would be deployed at variable levels of effort targeting removal of bighead and silver carp. Size structure data would be collected in future years to estimate post-removal mortality.

Objectives:

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

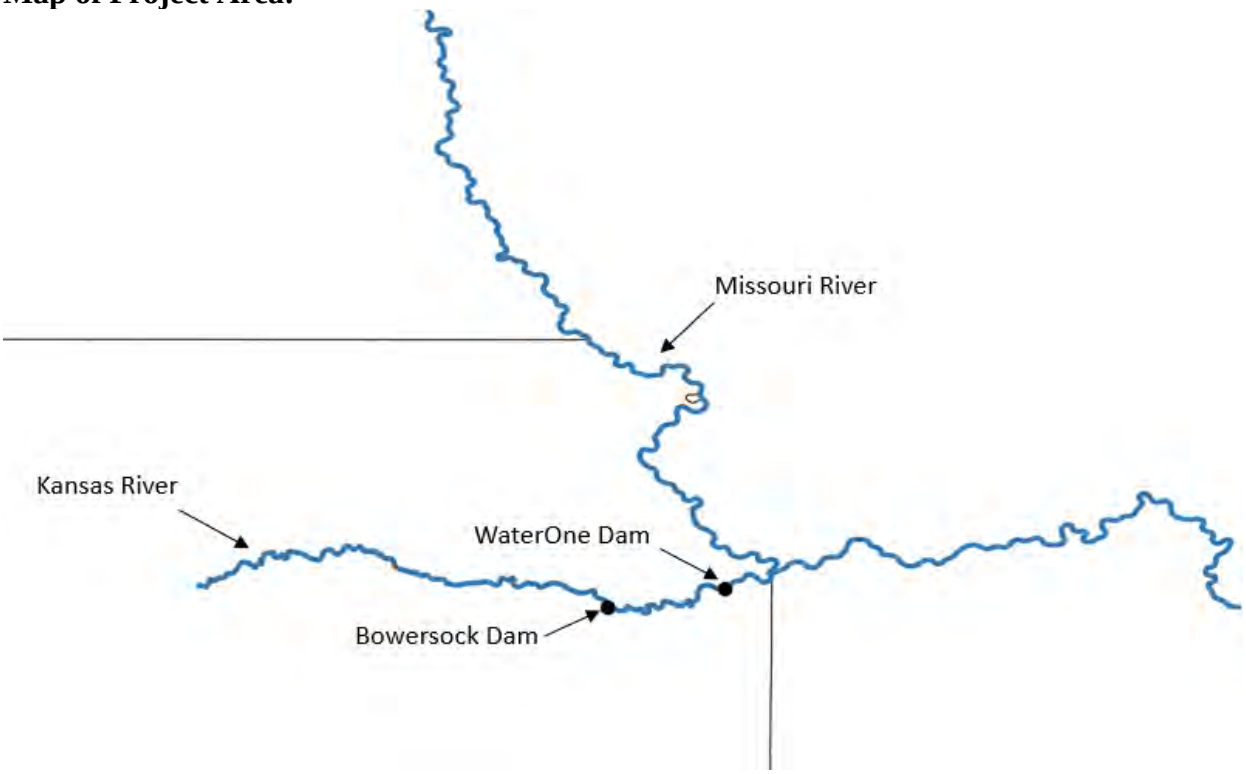
Agency: Kansas Department of Wildlife and Parks (KDWPT)

Activities and Methods:

Objective 1: Funds from this grant will be used to direct fishing efforts toward invasive carp removal in the Kansas River from immediately below the Bowersock Dam (Lawrence, KS, RKM 60) downstream to the WaterOne Dam (Edwardsville, KS, RKM 24).

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, experimentation with gear types, techniques, and deployment locations will be necessary. Traditional fishing gears such as gill-nets and hoop-nets in a suite of configurations and mesh sizes will be deployed. Electrofishing equipment may also be used to herd invasive carp into static gears. Funds will be used to compensate a commercial fisher for fishing effort or to employ additional staff by KDWP to remove invasive carp. If commercial fishing efforts are used, and since invasive carp abundance and catch rates in the Kansas River are unknown and may vary with hydrological conditions or decline as fishing effort is carried out, KDWP anticipates implementing an effort-based payout to sustain fishing effort. If commercial fishing efforts are used, KDWP employees will serve as observers during invasive carp removal efforts. KDWP staff will collect demographic information on captured invasive carp. Total invasive carp removed, gear types used, and effort information will be recorded. Notes on bycatch will be collected as well. At the conclusion of removal efforts, KDWP will prepare a final report. The final report will summarize observer data as well as pre-removal and post-removal invasive carp demographics.

Map of Project Area:



Estimated Timetable for Activities:

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

***Future work needed for complete evaluation.**

Agency: Missouri Department of Conservation (MDC)

Activities and Methods:

Objective 2: Based on findings from the Defining Asian Carp Populations study, locations for testing removal efforts will be selected. Age and size structure data from these selected sites will be used to estimate pre-removal mortality. At these locations MDC, in cooperation with USFWS – Columbia, will apply variable levels of effort using multiple bighead carp and silver carp gears, techniques, and removal methods. Gears will include commercially available nets (e.g., gill nets, trap nets) as well as gears being used by state and federal agencies (e.g., dozer trawl). Size structure data will be collected post removal to estimate post-removal mortality. Based on results of removal efforts on the population structure, estimates of the amount of effort needed to achieve published exploitation rates in Seibert et al. 2015, Tripp and Phelps 2018, and ACRCC 2019 using top-performing removal techniques will be calculated. This information will be used to determine the feasibility of a fishery-induced collapse of invasive carp at these locations. This project will be a multi-year assessment. Initial efforts have focused on pilot evaluations of removal methods, site identification, and gear procurement. First year removal efforts will take place in summer/fall 2021 and an annual report over current progress submitted by March 2022. Second year removal efforts will be in summer/fall of 2022 and 2023 to fully evaluate exploitation.

Map of Project Area:

Map of proposed actions by Missouri Department of Conservation for Objective 1 and 2 including sampling locations on the Missouri River between river kilometers 0.0 and 885 (green

circles), sampling stretches of the selected tributaries (lower 40km highlighted with blue) and potential oxbow lakes (identified in dark blue).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Year 1 removal efforts and post removal evaluation	September 2021 – March 2022
Data entry, analysis and report writing	February 2022 – March 2022
Submit Year 1 Annual Report	March 2022
Year 2 removal efforts and post removal evaluation	September 2022 – March 2023
Data entry, analysis and report writing	February 2023 – March 2023
Submit Year 2 Annual Report	March 2023
*Year 3 removal efforts and post removal evaluation	September 2023 – March 2024
*Data entry, analysis and report writing	February 2024 – March 2024
*Submit Final Report	March 2024

***Future work needed for complete evaluation.**

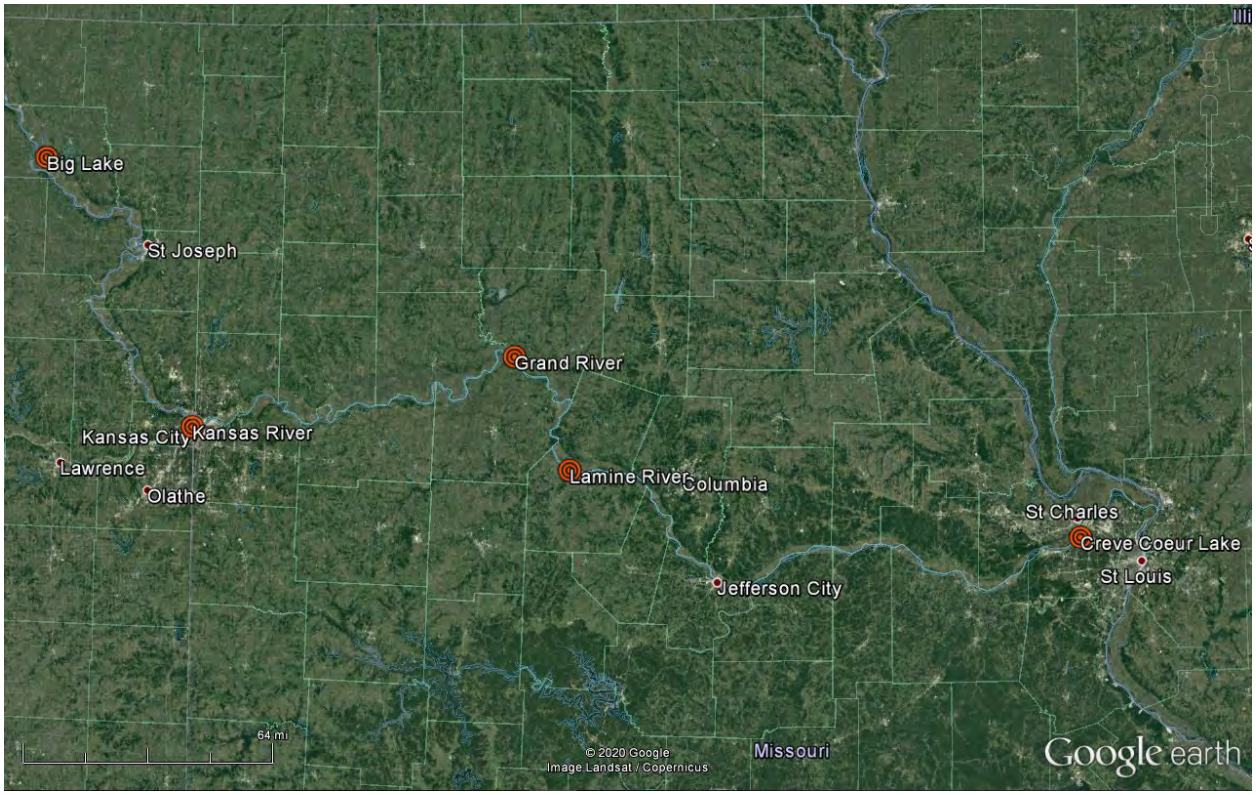
Agency: USFWS – Columbia

Activities and Methods:
Objective 2: We will test the feasibility of mass-harvest methods designed for removal of invasive carp within known high-population areas. Methods will include electrified trawls, trap/herding/weir systems and large surface twin trawls in conjunction with traditional entanglement netting. Pre-and post-harvest assessments, using remote sensing tools and fish capture assessments, will describe the availability of the population of fish (invasive carp and native fish species) and provide metrics for changes in the fish community and Silver Carp population .

In addition to using fisheries data for the evaluation of Invasive Carp removal techniques, technical aspects of gear deployment and retrieval including logistics, duration, labor hours, maintenance, ability to replicate, and habitat suitability will be considered. These aspects may be used to further inform exploitation models being develop by MDC.

Map of Project Area:

Kansas River, Lamine River, Grand River, Creve Coeur Lake, and Big Lake, Additional floodplain lakes (e.g., refuge backwater or waterfowl- management area lakes) and small tributaries of the Missouri River may be added.



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Develop assessment protocols and identify removal sites	September 2020-September 2021
Pilot removal efforts and gear procurement	September 2021 – March 2022
Removal efforts and post removal evaluation	April– December 2022
Data entry, analysis and report writing	December 2022 – March 2023
Submit Annual Report	March 2023

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Invasive carp communication and outreach in the Missouri River Basin

Lead Agency and author: Nebraska Game and Parks Commission, Kristopher Stahr (kristopher.stahr@nebraska.gov)

Cooperating Agencies: Iowa Department of Natural Resources (IDNR), Kansas Department of Wildlife and Parks (KDWP), Nebraska Game and Parks Commission (NGPC), U.S. Geological Survey—Nebraska Cooperative Fish and Wildlife Research Unit (NCFWRU), 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 – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia FWCO)

Statement of Need: Communication is paramount to managing any aquatic resource, but is particularly critical when managing aquatic invasive species. Asian carp are found throughout the Missouri River Basin and do not stop at state boundaries. Thus it is critical for a basin-wide approach to manage Asian carp, and communication among partners and agencies is a centerpiece of that approach. Moreover it is most important for managers on the ground to effectively communicate with each other to ensure that the most up-to-date science and techniques are being shared. As more research is conducted in the Missouri River Basin on Asian carp, the results and recommendations must be shared across partners in an effective, useable manner. Ultimately all efforts need to be made to prevent the spread of Asian carp and to manage these species in their current localities. This workplan provides a framework for the Missouri River Basin to effectively communicate with each other to achieve the best overall management of Asian carp possible.

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

One pathway for Asian carp expansion that has not been fully investigated is human-mediated movement. Asian carp (primarily as young-of-year) closely resemble common baitfishes, such as Gizzard Shad *Dorosoma cepedianum* and Alewife *Alosa psuedoharengus*, used by anglers and sold commercially. Several Missouri River Basin states allow anglers and bait dealers to collect their own bait, resulting in a high risk of human-mediated movement of Asian carp especially if improperly released. In addition even in localities with regulations restricting live bait collection, illegal collection and subsequent selling of live bait cannot be ruled out. Thus it is imperative to not only investigate all methods of human-mediated movement of Asian carp, but to develop pragmatic management solutions to prevent or reduce the risk from this pathway.

Objectives:

1. Support coordination and communication among partners regarding Asian carp outreach and management in the Missouri River Basin and beyond for the most efficient use of resources.
2. Evaluate recreational satisfaction and Asian carp knowledge in areas of the Missouri River Basin with Asian carp to inform management actions and increase the effectiveness of outreach messaging.
3. Assess human-mediated pathway risks for Asian carp movement to prevent the introduction and further spread of Asian carp into and within the Missouri River Basin.

Agency: Kansas Department of Wildlife and Parks (KDWP)

Activities and Methods:

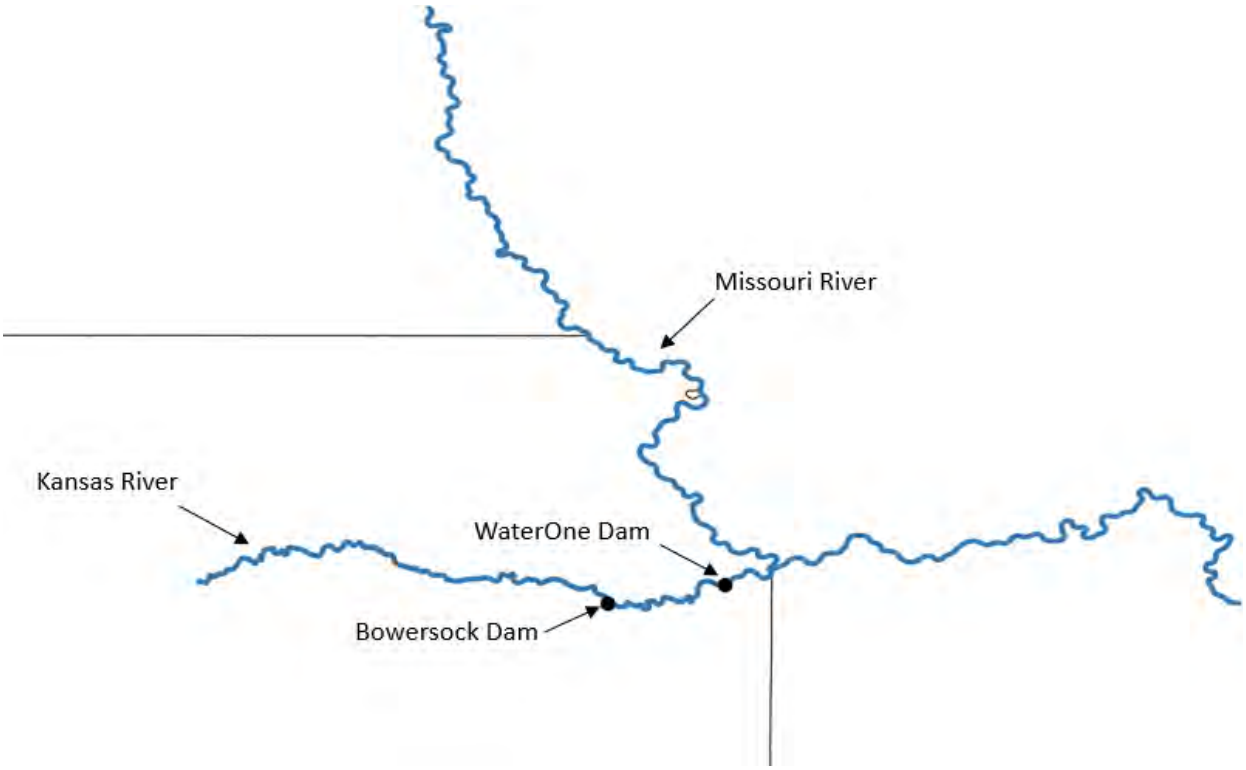
Objective 2: The Kansas River is one of only three rivers in the state of Kansas that is a publicly navigable river. The designation allows for public recreation such as kayaking/canoeing, fishing, hunting, wildlife viewing, etc. Additionally, the Kansas River was designated as a National Water Trail in 2012 by the National Park Service. This designation, as well as the recent nationwide surge of participation in kayaking, appears to have led to increasing use of the Kansas River by paddlers. A burgeoning trophy blue catfish population also appears to be increasing angler use of the Kansas River. The Kansas River is a unique and increasingly valuable destination for outdoor recreation in the State of Kansas.

Invasive carp are abundant in the Kansas River from the Missouri River confluence upstream to the Bowersock Dam at Lawrence, Kansas (RKM 83). The impacts of invasive carp to recreationalists are not well understood. KDWP occasionally receives reports of unfavorable interactions between recreationalists and invasive carp, but it is likely that most of these interactions are unreported. Additionally, there is concern that some blue catfish anglers may be tempted to transport invasive carp to other waterbodies based on their belief that the presence of invasive carp lead to the development of the trophy blue catfish fishery. The prevalence of this perception is unknown, and education and outreach are needed to address this issue.

KDWP is proposing to conduct in-person (i.e., on-river) surveys of recreationalists in the invasive carp infested portion of the Kansas River basin. The survey would collect information from recreationalists about specific impacts and challenges they have experienced in relation to invasive carp. Data would also be collected to determine if the presence of invasive carp changes type of use or frequency of use of the river by recreationalists. The survey would also ask about how recreationalists perceive invasive carp as well as desires they have for invasive carp management. Finally, conducting the survey will provide opportunities for direct education and outreach about invasive carp.

KDWP has a fisheries-focused human dimensions specialist on staff that will assist in survey design, data collection, and data analysis. Inclusion of this expertise will help improve the overall project and interpretation of results. Grant funding would be used to acquire equipment and hire seasonal staff. By understanding recreationalists and their experiences, perceptions, and desires, KDWP can better manage invasive carp and their impacts in the Kansas River system.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Acquire needed equipment (boat) and design survey	October 2021 – March 2022
Conduct recreationalist interviews and disseminate invasive carp information	March 2022 – October 2022
Data analysis and report writing	October 2022 – March 2023

Agency: Nebraska Game and Parks Commission (NGPC), U.S. Geological Survey—Nebraska Cooperative Fish and Wildlife Research Unit (NCFWRU), University of Nebraska-Lincoln (UNL)

Activities and Methods:

Objective 1: NISP: Compile compendium of existing Asian carp outreach and education materials and the NISP will make it available to AIS managers and partners to use for Asian carp outreach and education efforts.

Objective 2: NGPC: The Nebraska Game and Parks Commission in conjunction with the South Dakota Fish, Game, and Parks oversee two Paddlefish-fishing seasons annually in the mainstem Missouri River between Gavins Point Dam and the Big Sioux River (Figure 1). The Asian carp community has steadily increased in abundance in this reach during the past several decades,

anecdotally negatively affecting anglers' satisfaction. Currently, we rely on a postcard survey to monitor this fishery and judge anglers' satisfaction from the comment section of the returned postcards. We are proposing an in-person creel survey during our June-archery and October-snagging seasons of 2022 and 2023. These creel surveys would quantify catches (target and non-target) and efforts during paddlefish seasons mainly around Gavins Point Dam as anglers are highly concentrated in this area.

Satisfaction generally is as an attitude-like judgment following an event based on pre-event expectations. The confirmation or disconfirmation of expectations is the essential determinant of satisfaction. Thus, confirmed expectations lead to moderate satisfaction, positively disconfirmed (exceeded) expectations lead to high satisfaction, and negatively disconfirmed (underachieved) expectations lead to dissatisfaction. In many cases, experience-based norms derived from past personal experiences or information received from influential acquaintances determine the pre-event expectations. Thus, in addition to in-person creel surveys, we will send mail (or internet) surveys to previous year's license holders to quantify anglers' expectations as a basis for understanding stated satisfactions. Further, we will ask questions targeted at general knowledge about Asian carp and understanding of potential consequences of human-mediated spread; similar questions will also be asked of a random draw for the general public through the annual survey conducted by the Bureau of Sociological Research (housed at UNL). Finally, we will qualitatively assess the comment section of previously returned postcards to determine the nature of the long-term trend in anglers' satisfactions (i.e., gradual decline or sudden decline associated with appearance of Asian carp).

Map of Project Area:

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

Estimated Timetable for Activities:

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

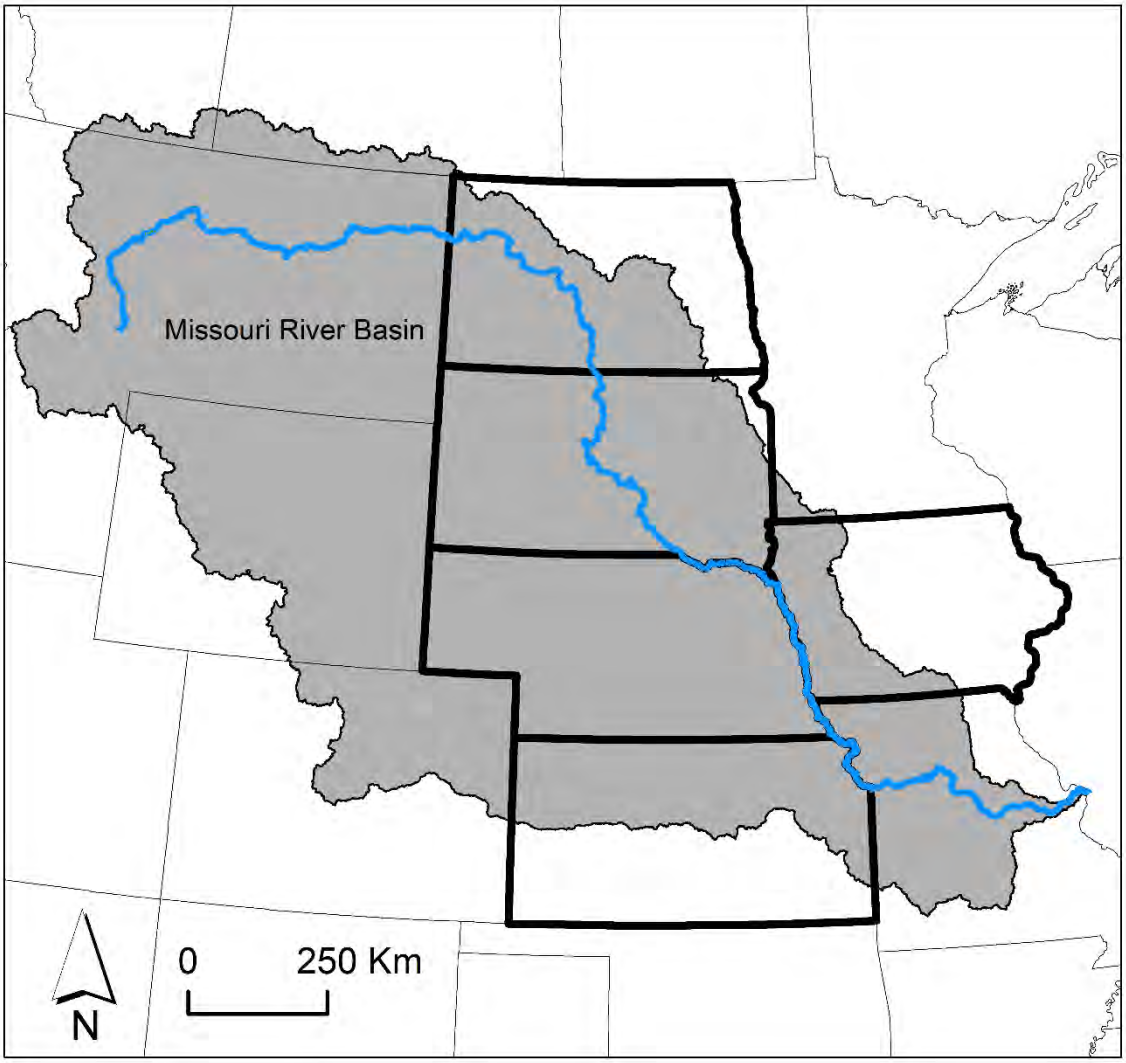
Agency: South Dakota Department of Game, Fish, and Parks (SDGFP), South Dakota State University (SDSU)

Activities and Methods:

Objective 3: Spread of aquatic invasive species (AIS) via dumping of live bait is a known vector for AIS spread. Targeted educational campaigns, in specific regions or at particular bait shops, could help reduce the risk of AIS spread by anglers using live bait. Additionally, understanding the relative risks posed by bait shops regionally and how the characteristics of each bait shop (e.g., proximity to AIS established population, regulations of particular states, sources of baitfish) influence risk will help increase effectiveness of educational programs by targeting interventions. In the Missouri River Basin, Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis*) are particular AIS of concern. They are established in the Missouri River mainstem upstream into South Dakota where Gavins Point Dam has limited their expansion further upstream. Additional dams on tributaries to the Missouri River (e.g., Big Sioux River Falls and East Vermillion Lake spillway in South Dakota, the Jamestown Reservoir spillway in North Dakota, Bowersock, and Clinton dams in Kansas) have likely also inhibited upstream expansion of these AIS. However, introduction of these species above dams that currently inhibit their spread via bait dumping is a serious concern. In the Great Lakes region, Silver Carp eDNA was previously documented in bait shops that were located outside of the current range of Silver Carp (Nathan et al. 2015) indicating that Silver Carp were currently present or may have passed through bait shop tanks.

We propose to assess the risk for Silver Carp and Bighead Carp to spread via live bait by assessing the presence of eDNA in bait shops in multiple states within the Missouri River Basin. Bait will be purchased from multiple bait shops across North Dakota, South Dakota, Nebraska, Kansas, and Iowa along a gradient of Asian carp abundances including areas they have not yet invaded. Bait will be identified to species and bait water will be evaluated for the presence of Silver Carp and Bighead Carp eDNA. Risk posed by particular bait shops will be evaluated by modeling the risk of Silver Carp of Bighead Carp eDNA presence in conjunction with possible risk factors (i.e., state regulations, proximity to established populations, sale volume, baitfish source, existence of a bait inspection program). FY 2022 will focus on sample collection and processing and data analysis will continue through FY 2023.

Map of Project Area:



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

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Selection of Bait Shops for Sampling	Fall 2021
Sampling of Bait Shops	December 2021 – April 2022
Samples sent to Bozeman	April or May 2022
Annual Report	Fall 2022
Final Report	August 2023

Agency: USFWS – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia FWCO), USFWS – Denver Regional Office, USFWS-Bozeman Fish Health Center, USFWS-Gavins Point National Fish Hatchery

Activities and Methods:
Objective 1: Provide guidance to Missouri River Basin Asian carp partnership on the planning, implementation, and reporting process to ensure coordination with other regional and national plan implementation structures. Assist with implementation of conference symposium to provide opportunities to exchange ideas among Missouri River Sub-Basin, regional and national partners conducting research, management, and control of Asian carp. Provide facilitator for basin team collective conversations at regional meeting. Coordinate with other aquatic research taking place in the Missouri River Basin that may have an impact on or be impacted by the management of Asian carp.

Professional quality photos of all Asian carp species will be taken in a specialized aquatics photo studio space. The studio is housed within the Aquarium building at Gavins Point National Fish Hatchery. Young fish will be photographed in aquatic light boxes resulting in lifelike swimming photos. Fish collected from field crews throughout the Missouri River Basin and from the USGS CERC lab will be photographed and held in refugia at the hatchery allowing continued photo sessions as the fish grow. Finished photos will be available open source through the USFWS Mountain-Prairie Flickr website for all Asian carp partners to use in future outreach and education efforts.

Objective 3: Bozeman Fish Health Center will provide support in analyzing baitfish study samples for Asian carp eDNA.

Literature Cited:

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

Ohio River Sub-Basin Invasive Carp Partnership

The Ohio River (OHR) flows through or along the border of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia; these six states collaboratively manage fisheries in the mainstem OHR through the Ohio River Fisheries Management Team (ORFMT). The ORFMT recognized the magnitude of the Asian carp threat and the need for coordinated efforts to limit the negative impacts of Asian 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 Asian carps, and improve communication and coordination in the basin. The Tennessee and Cumberland rivers (TNCR) are major tributaries to the mainstem OHR, and are therefore included as part of the ORB Framework. However, because independent funding was provided through legislation to the Tennessee and Cumberland River partners, two teams (ORFMT and TNCR) come together to implement the ORB Framework that was completed in October 2014.

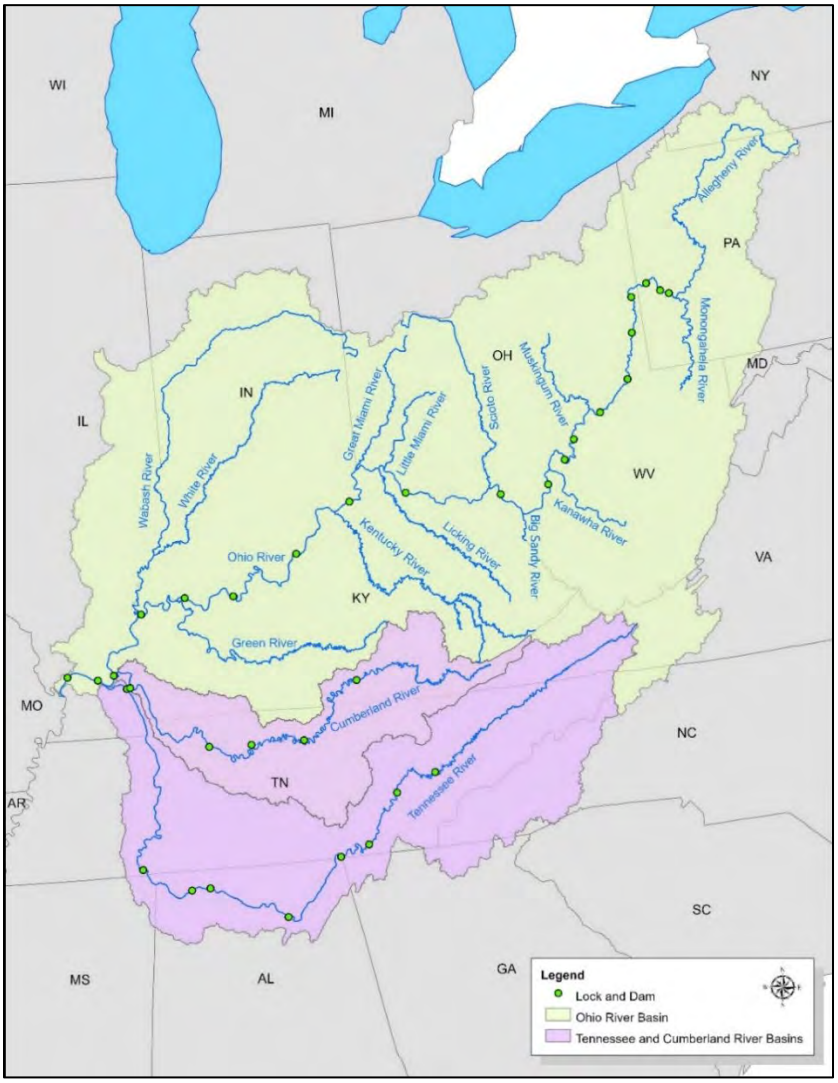


Figure 7. Map of the Ohio River Basin.

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

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

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

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

The tasks outlined in this document would add a sixth year of multi-agency and university surveillance and data collection focused on Asian carp early detection and removal primarily above Cannelton Dam. Collaborative efforts have included fish community sampling, targeted Asian carp sampling, and incorporation of unique data such as hydroacoustics. The primary goal of these projects is to provide an accurate population trend assessment of Asian 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 Asian carp management and suppression in the ORB.

Objectives:

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

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

Activities and Methods: Federal funding for this project for FY2021 will enable KDFWR to deploy additional crews for all sampling, effectively doubling previous years' efforts. Congress and the USFWS require justification for funding projects. Therefore, perhaps as important as removing Asian carp from the Ohio River study area is our ability to determine the effects of removal efforts have on relative Asian Carp densities above Cannelton Dam. 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 in relative abundances. Increased sampling will improve accuracy for describing relative density trends and other population demographics, especially for the more abundant Silver Carp.

KDFWR will track relative abundances and population characteristics independently and through coordination with other state agencies to conduct targeted sampling for Asian carp along several pools, upriver of the Cannelton Locks and Dam complex (See map). Pulsed-DC boat electrofishing and gill netting techniques will be utilized to target bigheaded carps along the Ohio main stem river to maintain consistency with efforts from previous years. Electrofishing will be conducted during the day (0800 to 2100 hours local time) with one driver and one staff in the bow of the boat dip-netting fish (dipper). Sampling is conducted in the spring of each year when water temperatures are 50°F – 65°F. Electrofishing is conducted in a general downstream direction for 900 seconds. Carp will be targeted with pulsed-DC electricity at 80 pulses per second (PPS) and a 40% duty-cycle (or comparable settings). A power goal allowing the minimum transfer of 3,000 Watts from water to fish will be targeted (Burkhardt and Gutreuter, 1995). Adjustment to the electrical output will be made as needed to increase effectiveness. Driving speed adjustments and pursuit of individual carp is allowed upon fish sightings. Non-target fish species should be ignored during sampling; however, all small, shad-like species should be dipped and examined thoroughly before being released to avoid misidentifying young Asian 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.

Gill netting will be conducted at fixed sites in the same timeframe as boat electrofishing (See map). Each site will include 300 ft of 4-in. bar webbing, 300 ft of 5-in. bar webbing, and 150 ft of 3 in. bar webbing for a total of 750 ft of net fished 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. Nets will soak for 2 hrs/set, and boat noise and herding techniques will be applied to drive fish into the gear. Records of bycatch will be kept for each mesh size including species, and a subsample of total lengths. All bycatch will be recorded and released immediately after capture

In addition to expanding efforts within the Ohio River pools above Cannelton Locks and Dam, Kentucky will use additional funds and new equipment to begin sampling programs in the Green, Salt, and Licking river systems in August and September. These large rivers are contiguous tributaries of the Ohio River and may be important to reducing carp numbers and controlling ORB populations. Currently there is no consistent data on the extent of Asian carp infestation or

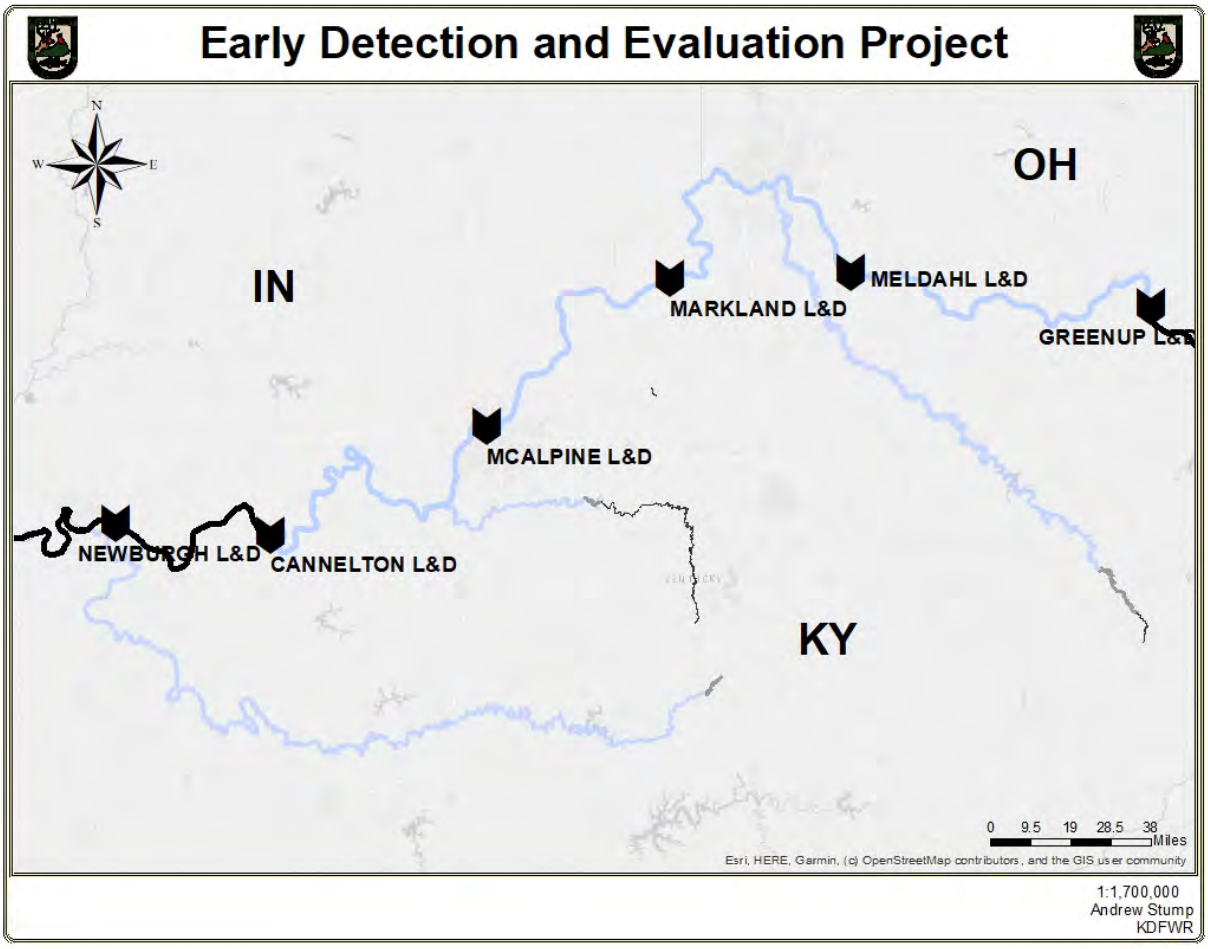
invasion progression within these rivers. These surveys will be used to determine control points and recommendations for further population control within these systems and monitoring reductions of populations through time. Surveys are planned to be conducted as presence-absence counts using defined plots during repeated 10 minute sampling periods. Sampling efficiency will be determined using detection probabilities estimated from plot depletions at locations where carp are present.

All information from targeted sampling 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 spanning late August to early September will be attempted. Bigheaded carps will be collected from Cannelton and McAlpine pools in an attempt to obtain more reliable aging structures and population demographics data. 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 Asian 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 Asian 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.

The KDFWR will also provide approximately 30 crew-days dedicated to community sampling for hydroacoustics analysis. Boat electrofishing and gill netting will be utilized to aid in determining community composition and data will be passed off to USFWS in order to determine carp biomass estimates using hydroacoustic analyses.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Inland River Surveys	Fall, September/2022
Community/Hydroacoustic Surveys	Fall, September/2022
WRDA Report to Congress	Fall, October/2022
Annual Technical Report	Spring, March/2023
Targeted Sampling on the Ohio River	Spring, April/2023
Population Demographics Sampling	Fall, August/2023

Agency: West Virginia Division of Natural Resources (WVDNR)

Activities and Methods: Federal funding for this project for FY2021 will enable WVDNR to continue monitoring Asian carp populations in the R.C. Byrd and Greenup pools of the Ohio River as well as assess the baseline fish community in some Ohio River pools ahead of the invasion. Congress and the USFWS require justification for funding projects. Continued evaluation of the Asian carp population in areas of low density is necessary to assess the rate at which the invasion is progressing as well as assessing the effectiveness of the removal efforts downstream on reducing upstream movement. Also, the continued learning process of adapting sampling techniques to catch Asian carps in low densities will improve efficiency for the future.

WVDNR will track relative abundance and population characteristics of Asian carp independently and in coordination with other state agencies by conducting targeted sampling for Asian carp along several pools, upriver of the Cannelton Locks and Dam complex. WVDNR will conduct targeted samples in the Greenup and R.C. Byrd pools. Both pulsed-DC boat electrofishing and gill netting techniques will be utilized to target bigheaded carps along the Ohio 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' sampling. 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 Asian carps. The straight-line distance attained during electrofishing should be approximately 400 m (~0.25 miles) of shoreline. All feral Asian carps captured during sampling will be removed from the system. Otoliths and fin rays will be removed as needed from Asian 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 excessive. Each net set will be actively monitored, and effort will be expended to run fish into the nets with boat noise and herding techniques. All feral Asian carps captured during sampling will be removed from the system. Otoliths and fin rays will be removed as needed from Asian carp for age and growth analysis. All by-catch will be recorded and any non-target fish will be released immediately after capture.

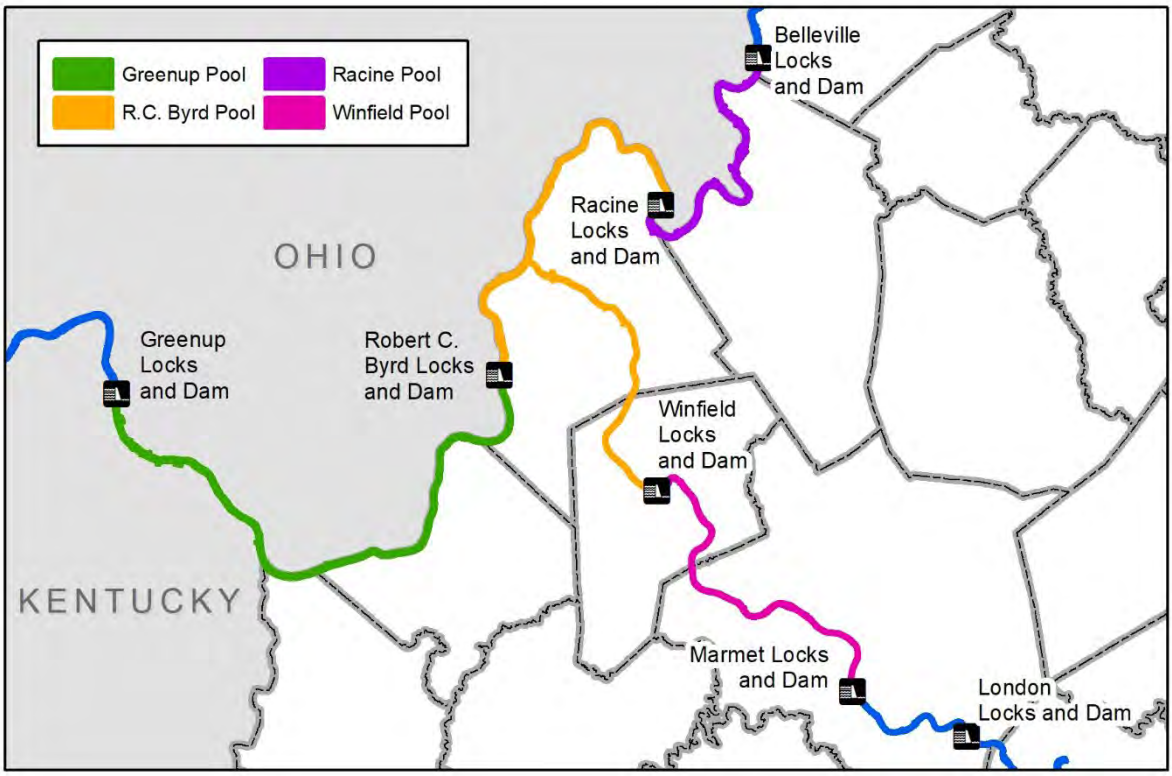
To track long-term trends in native fish communities, WVDNR will conduct community surveys in the Racine Pool of the Ohio. Pulsed-DC boat electrofishing and gill netting techniques will be utilized primarily. The pool will be divided into habitat types and 20-24 electrofishing and 8-10 gill net sites will be chosen at random across all habitat types. Sites will then be chosen for suitability and serve as the set of fixed sites for the assessment. 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 Asian 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.

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

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Community Fish Surveys in Racine Pool	Fall, October 2021
Community/Hydroacoustic Surveys	Fall, Sept-Oct 2021
WRRDA Report to Congress	Fall, October/2022
Annual Technical Report	Spring, March/2022
Targeted Asian carp Sampling	Spring, April 2022
eDNA Sampling	Spring, May/June 2022

Agency: Pennsylvania Fish and Boat Commission (PFBC)

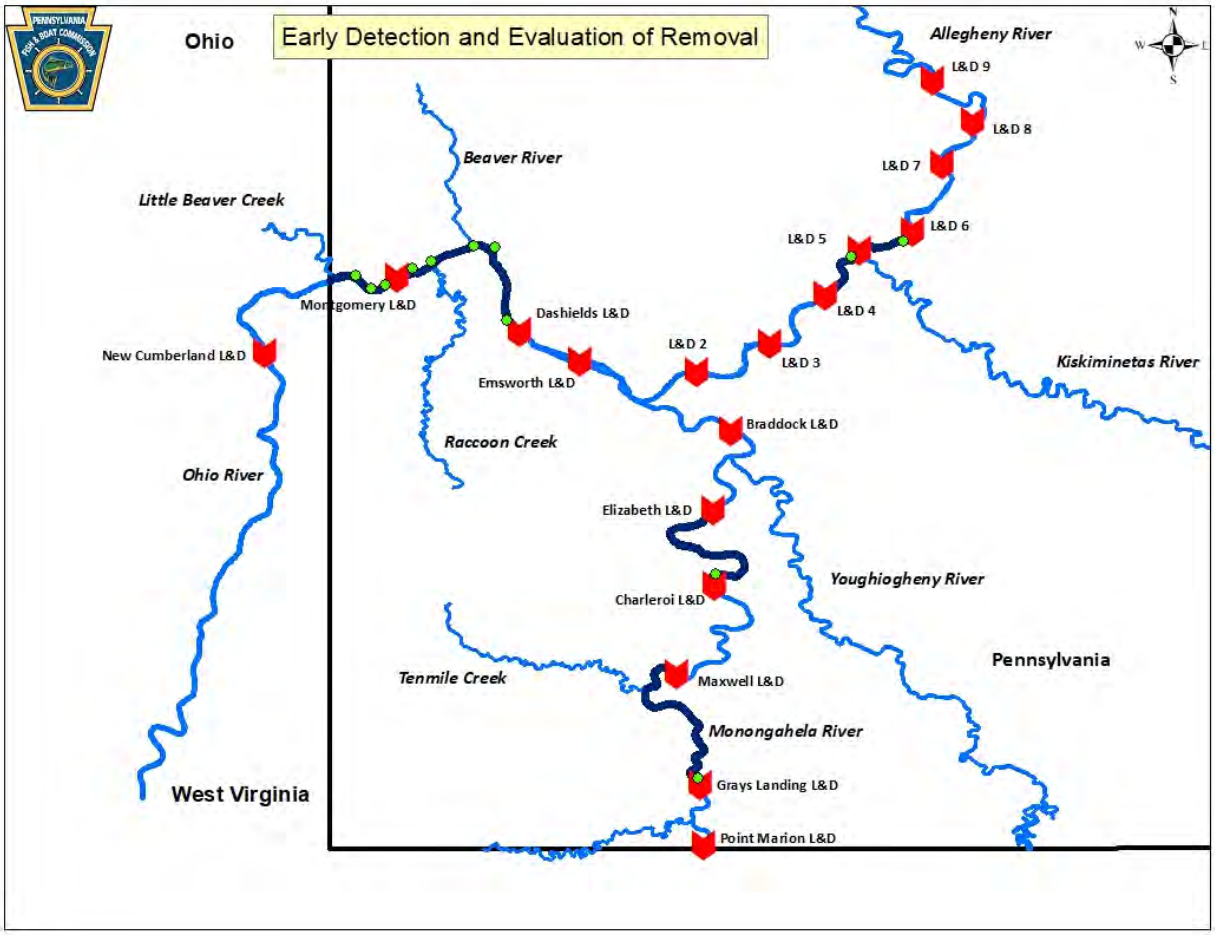
Activities and Methods: The PFBC will assist the USFWS in conducting eDNA sampling on the Ohio River in the fall of 2021 and 2022. Locations of positive eDNA hits for Bighead and Silver Carp, including locations with positives from previous years, will be used to guide targeted gill net sampling. Additional 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 2021 and 2022. 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 Asian Carp species will be euthanized.

Tailwater community fish surveys from 2008-2016 will be used to establish and refine future sampling locations. A second round of such surveys began in 2018 and will continue until 2023. Boat electrofishing (60 pps, 25% duty cycle, typically 200-500 volts) at each tailwater will consist of 10 minute transects across 17 fixed tailwater sites in total for the duration of the project. Ten transects will be sampled at each site with five transects conducted on each bank. Sampling will begin on the right descending bank as close as possible to the dam and will proceed downstream for five consecutive runs. The same procedure will then be conducted on the left descending bank. We will conduct fish community surveys in the spring of 2022 at a minimum of four tailwaters on the Ohio, Allegheny, and Monongahela Rivers. All fish will be netted and those large enough to identify in the field will be enumerated; small individuals will be retained for identification in the laboratory.

The PFBC will conduct additional fish community surveys in the Montgomery Pool in August 2022 and September/October 2022. Monitoring in August 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. Monitoring in September/October will include a randomized pool wide sampling event using protocols being developed by the USFWS. Gear types used in this fall community sampling event will likely include both gill nets and boat electrofishing.

The PFBC conducts additional targeted sampling for various gamefish throughout the Ohio, Allegheny, and Monongahela Rivers on an annual basis. Incidental Asian Carp captures will be recorded during these surveys.

Map of Project Area:



Dark blue areas represent pools to be surveyed in FY21 and green dots represent approximate locations

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Targeted Sampling Field Work	Fall, November/2021
Community Surveys Field Work	Spring, May/2022
Community Surveys Field Work	Summer, August/2022
Assist eDNA sampling	Fall, September/2022
Community Surveys Field Work	Fall, September-October/2022
Targeted Sampling Field Work	Fall, December 2022
Executive Technical Report	Spring, March/2023

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

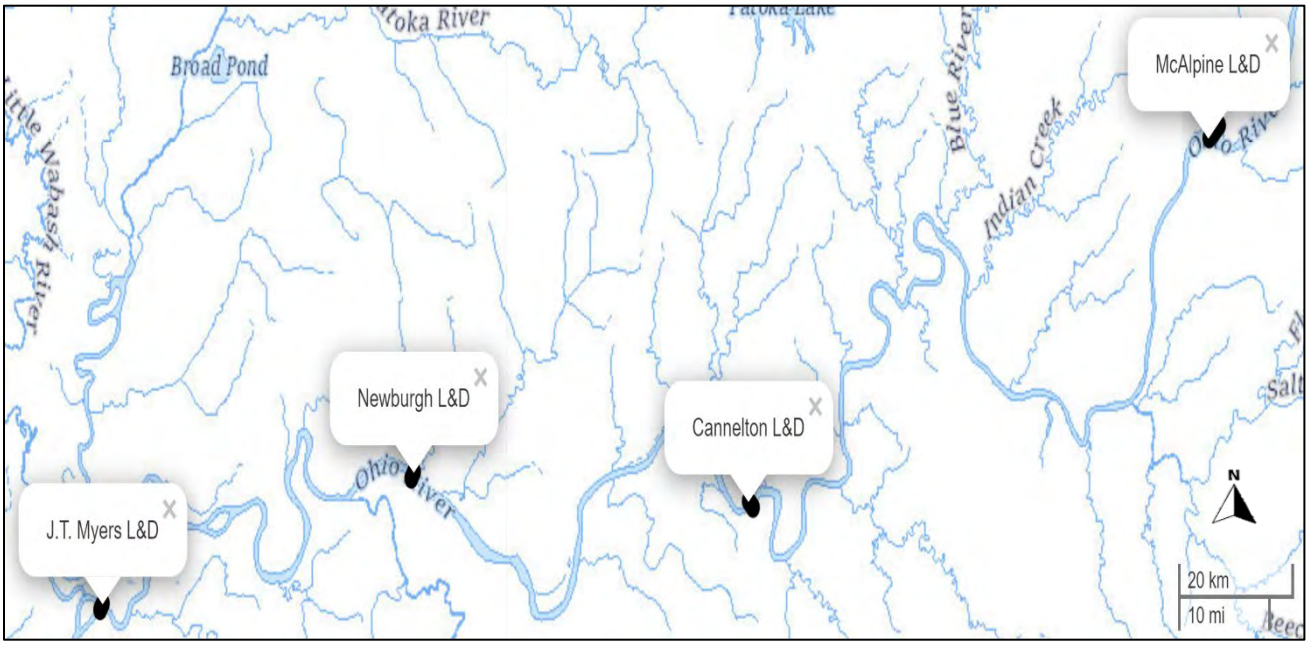
Activities and Methods: The Carterville FWCO will implement the new Region 3 hydroacoustic standard operating procedure (SOP) in conjunction with increased community sampling to estimate pool-wide density (# • $1000m^{-3}$) and biomass (kg • $1000m^{-3}$) of silver and bighead carp, known collectively as bigheaded carp, in three Ohio River pools during fall (September and October), 2021. Community sampling (i.e., gill nets and boat electrofishing) will be conducted by state agencies (KDFWR, INDNR). To facilitate the increased sampling, we have separated the Ohio River pools into two categories; intensive pools (J.T. Myers, Newbourgh, Cannelton, McAlpine) that have established bigheaded carp populations and extensive pools (Markland, Meldahl, Greenup, R.C. Byrd, Montgomery, and Emsworth) that do not have well-established populations. Three intensive pools will be sampled during fall, 2021 (J.T. Myers, Newburgh, and Cannelton pools). The new SOP uses a stratefied random sampling design to select sites (i.e., a 1-mile stretch of river) for community sampling and hydroacoustic transects with the goal of collecting a more representative sample of the pelagic fish community inhabiting each pool and its tributaries. The total length of hydroacoustic transects in two intensive pools (J.T. Myers and Newburgh) will be approximately 35% of the available main channel sites (# sites = 4 • length of pool; one shoreline and one mid-channel site on each bank). Hydroacoustic transects will be completed along the entire length of the third pool (Cannelton). Data gathered from the third pool will be used to determine the minimum number of sites needed to produce precise density and biomass density estimates for future sampling events. Within each pool, at least five tributaries will also be sampled using hydroacoustics (and physical capture gears) to monitor tributary use by bigheaded carps. Transect design will differ between main channel and tributary habitat. Although all transects run parallel to shore, main-channel transects use shore-facing transducers, whereas tributary transects use thalweg-facing transducers. Hydroacoustic survey equipment will be comprised of two BioSonics split-beam transducers. The transducers are calibrated at 200-kHz and are 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 analysis will be conducted in Echoview Version 10.0 following the Region 3 hydroacoustic SOP. Results will include species-specific density (# • $1000m^{-3}$) and biomass density (kg • $1000m^{-3}$) estimates for bighead and silver carp in each habitat type (e.g., main channel, tributary), within each pool.

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

hydroacoustic targets and, therefore, understanding the abundance and biomass of bigheaded carps in the Ohio River basin.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Hydroacoustics Surveys	September/October 2021
Data Processing and Analysis	Winter 2021
Results and Reporting	Spring 2022



Map showing dam locations for each pool that may be sampled with hydroacoustics in 2021.

Agency: Indiana Department of Natural Resources (INDNR)

Activities and Methods: To assess population structure, distribution, and relative abundance of Asian carp in the Ohio River for informing management actions, INDNR will utilize pulsed-DC boat electrofishing and gill netting techniques to target bigheaded carps within Cannelton Pool of the Ohio River. 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 Asian 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.

Gill netting will be conducted at fixed sites in the same timeframe as boat electrofishing. Each site will include 300 ft of 4-in. bar webbing and 300 ft of 5-in. bar webbing for a total of 600 ft of net fished 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. Nets will soak for 2 hrs/set, and boat noise and herding techniques will be applied to drive fish into the gear. Records of bycatch will be kept for each mesh size including species, and a subsample of total lengths. All bycatch will be recorded and released immediately after capture. Information from targeted sampling will be used to track changes in relative abundances of bigheaded carp. All invasive carps captured during sampling will be euthanized and a subsample of lengths, weights, and sex will be recorded.

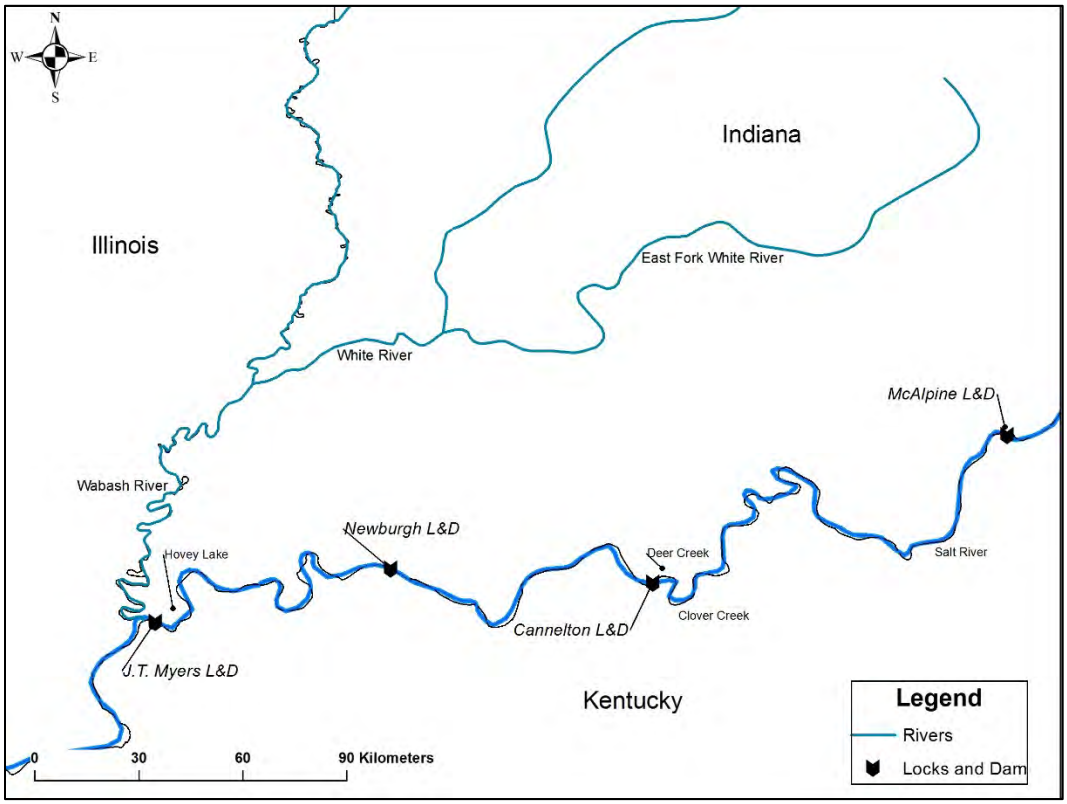
To determine spatial distributions and densities of Asian carps in the lower Wabash and White rivers, INDNR will conduct fish sampling at four locations throughout the lower Wabash River. SIU will conduct hydroacoustic sampling at eight to sixteen sites, and INDNR will collect fish community data at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

of net fished at each site equal to 600 ft. Gill netting protocol will follow the same methods as described above and records of catch will be kept for all species captured. All fish captured using either gear will be identified to the lowest possible taxonomic level and total length (mm) and weight (kg) with be recorded for all species. Asian carp will be euthanized.

To quantify changes in Asian carp density before and after select removal events, INDNR will coordinate with SIU and plan removal events accordingly. SIU will sample selected sites with hydroacoustics prior to and immediately following removal events. During removal events, INDNR will record all catch data and report those to SIU. SIU will process the data to determine any changes in Asian carp densities and size distributions as a result of the removal effort.

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 and gill netting (using similar methods as described above) will be utilized to aid in determining community composition and data will be forwarded to USFWS in order to determine carp biomass estimates using hydroacoustic analyses.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Executive Technical Report	Spring, March/2022
Targeted Sampling Field Work	Spring, April/2022
Wabash River Fish Community Work	Spring, April and May/2022
Removal Effort Evaluations	Summer, June – Aug/2022
Hydroacoustics Community Surveys	Fall, October/2022
Executive Technical Report	Spring, March/2023

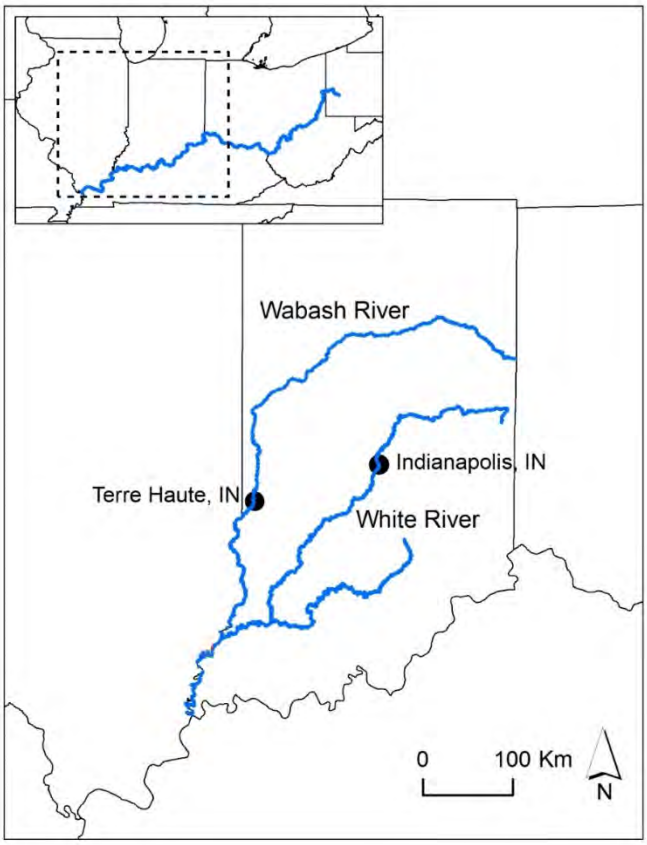
Agency: Southern Illinois University (SIU)

Activities and Methods: SIU will be contracted by the Illinois Department of Natural Resources (ILDNR) to complete hydroacoustic sampling in the Wabash and White rivers to quantify bigheaded carp spatial distributions and identify density hotspots to inform and assess harvest efforts (objectives 4 and 5). Densities will be assessed in the lower Wabash River between the confluence with the Ohio River and Terre Haute, IN in June of 2022. 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, 128 miles of survey transects will be sampled, with 16 sites sampled throughout the lower Wabash River. Physical capture data used in hydroacoustic data analysis will be collected by INDNR. Species-specific proportional abundance will be calculated by size class from capture data. These data will then be applied to the number of fish observed within the same size classes from hydroacoustic sampling, along with the volume of water ensonified, to estimate species-specific densities. Sampling and data analysis techniques follow established protocols for assessing Asian 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.

SIU will also conduct mobile hydroacoustic surveys in backwaters of the Wabash and White rivers to identify bigheaded carp spatial distributions for informing coordinated removal events and in assessing potential changes in density and size distributions due to harvest. SIU will partner with INDNR to identify specific backwaters for coordinated removal events. Within 48 hours prior to each removal event, SIU will conduct a mobile hydroacoustic survey throughout the backwater site to identify bigheaded carp spatial distributions prior to harvest. Sampling procedures and data analysis will be identical to those described for hydroacoustic sampling in the lower Wabash River channel. Heatmaps depicting bigheaded carp density hotspots will be generated from this sampling and shared with INDNR prior to harvest. SIU will also conduct mobile hydroacoustic surveys at each site within 48 hours after harvest. Bigheaded carp densities and size distributions will be compared between pre-harvest and post-harvest sampling at each site to evaluate potential changes in relative abundance and size distributions as a result of harvest. Capture data (species size and relative abundances) that are needed for analyzing hydroacoustic data will be collected by INDNR during the harvest events.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Executive Technical Report	Spring, March/2022
Conduct Wabash River Hydroacoustic Sampling	Summer, June/2022
Pre- and Post-Harvest Hydroacoustic Surveys at Targeted Removal Sites	Summer, June-Aug/2022
Executive Technical Report	Spring, March/2023

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

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

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

Statement of Need: Acquiring a full understanding of the early life history information is imperative for evaluating the population status (i.e., extent of invasion). As defined in the Upper Mississippi River basin (Brent Knights and Ann Runstrom, personal communication), the extent of Asian carp invasion has three predominate levels (presence front, invasion front, and established front) that will guide specific management actions. The “presence front” is the most upstream extent of Asian carp capture where densities are low and reproduction has not occurred. The “invasion front” is that location(s) where reproduction (i.e., eggs, embryos, or larvae) has been observed but recruitment has yet to be documented. The “established front” is that location(s) where reproduction and recruitment to the adult life stage are currently occurring. 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 Asian carp early life stages is needed. For the purposes of this plan, the term ‘Asian carp’ is referring to Silver Carp and Bighead Carp (*Hypophthalmichthys* species), also known as bigheaded carp.

In order to limit the negative impacts of Asian carp populations and their further spread, efforts have increased to understand the distribution and abundance of Asian carp in the waters they currently inhabit. Previous sampling efforts on the Ohio River have documented adult Asian carp presence as far upstream as Robert C. Byrd Dam near Gallipolis Ferry, West Virginia. Densities of adult Asian carp are highest downstream of McAlpine Lock and Dam (Louisville, KY) and substantially decline farther upstream. Despite the high abundance of adults in Cannelton Pool and additional targeted juvenile sampling there in 2019 and 2020, efforts have only captured young-of-year (YOY) Asian carp as far upstream as Newburgh Pool, with the majority of the YOY being consistently captured in J.T. Myers Pool since 2016.

Suspected reproduction of non-indigenous bigheaded carp, through the morphometric identification of Asian 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 Cannelton Pool during 2019 and 2020. Previous efforts have been successful in collecting Asian 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 Asian carp early life history among pools.

Objectives:

1. Determine the extent of bigheaded carp spawning activity in the Ohio River above Markland Dam.
2. Identify tributaries and areas of the Ohio River in which spawning of bigheaded carp occurs.
3. Determine the geographic extent and locations of bigheaded carp recruitment in the Ohio River.
4. Identify characteristics of potential bigheaded carp nursery areas when juvenile Asian carp are encountered.
5. Estimate Hovey Lake recruitment potential and evaluate the feasibility of drain structure modifications to limit bigheaded carp recruitment from Hovey Lake.
6. Determine the propagule source of Bigheaded carp in the Ohio River.

Agency: Indiana Department of Natural Resources (INDNR)

Activities and Methods: To identify tributaries and areas in which spawning occurs, Indiana DNR will conduct and coordinate sampling for Asian carp eggs, embryos, and larvae at high priority sites of Newburgh, Cannelton, and McAlpine pools. Locations will include suspected areas of spawning in tributaries based on current information, and locations in the mainstem river above and below Locks and Dams to determine if dams are providing ideal 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, 2022. Field staff will coordinate closely with KDFWR personnel to communicate when spawning patches begin to develop on female Asian 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 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).

To determine the geographic extent of Asian carp recruitment, Indiana DNR will conduct targeted sampling for juvenile Asian carp in J.T. Myers, Newburgh, and Cannelton 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, occasionally captured them in Newburgh Pool, and have not captured YOY Asian carp in Cannelton Pool despite the

high relative abundance of adults present and additional targeted sampling there in 2019 and 2020. Each site will be targeted with pulsed DC electrofishing during July and August, the time of year when juvenile Asian carp have been captured in the lower Ohio River in previous years. 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. In addition, a surface trawl will be used at suitable sites because it has proven effective for capturing young-of-year Asian 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. Juvenile Asian carp collected will be identified to species, geo-located and enumerated. When Asian carp are encountered, lengths and weights will be recorded and a subsample of aging structures will be collected; Otoliths will be taken from fish >200 mm, and fish <200 mm will be frozen whole and taken back to the lab for dissection of aging structures. Results will be used to estimate the extent of Asian carp recruitment in the Ohio River and thus will directly inform future management actions (e.g. targeted removal efforts and/or barrier placement considerations).

In addition to sampling, participating agencies will collaborate with other fisheries professionals to inform them to report back with any confirmed findings of juvenile Asian 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.

To identify characteristics of potential Asian carp nursery areas 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 Asian carp growth and development.

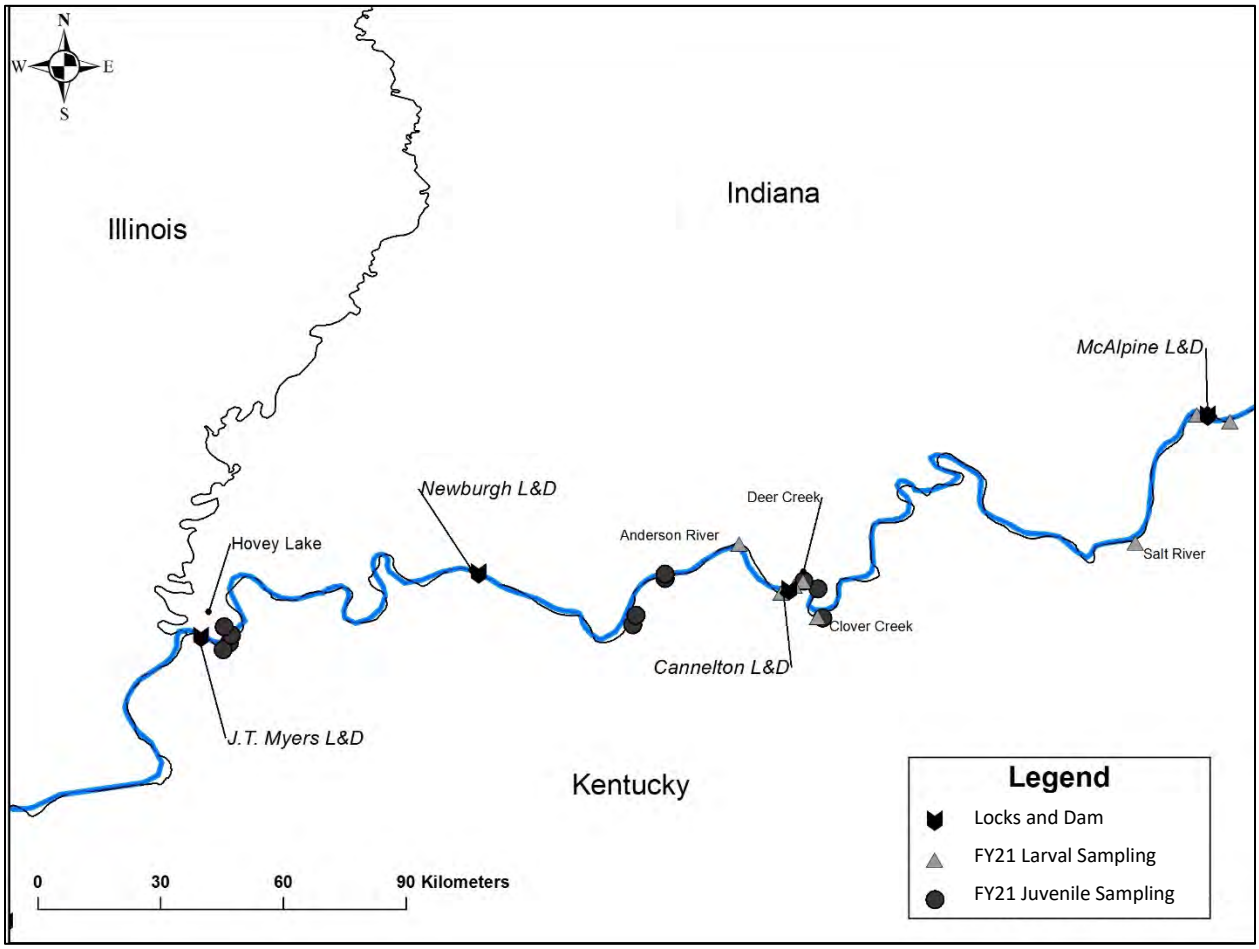
To estimate the recruitment potential of Hovey Lake, Indiana DNR will contract with Ball State University (BSU) to complete this work. Specific work will include quantifying the input of larval Asian carp from the Ohio River through the drain structure into Hovey Lake. The Hovey Lake drain consists of a 70 meter cement dam across the outlet of the lake. During normal flows, all water is constricted to flowing through three culvert pipes, each approximately 1 meter diameter. Flow can be impeded through these culvert pipes with the manual placement of boards, to block water from entering or leaving the lake. The current design allows for fish passage to be restricted solely through culvert pipes until the river stage reaches 30 ft at the J.T. Myers gage. Once the river tops 30 ft, water begins to flow over the cement dam freely into the lake, allowing more unrestricted fish passage. Using larval nets and/or fine mesh bait nets, the drain will be sampled across a variety of flows and conditions in May, June, and July to estimate YOY Asian carp passage into the lake. These data will be used to estimate a total number of YOY that have

passed into the lake. Throughout June, July, and August, surface trawls and electrofishing will be used within Hovey Lake to capture YOY Asian carp. All YOY captured will be euthanized and taken back to the lab where otoliths will be extracted. Daily growth rings will be counted on otoliths to develop daily survival estimates of YOY Asian carp. Survival data will then be paired with estimates of YOY Asian carp in the lake to determine Hovey Lake recruitment contribution to the Ohio River basin Asian carp population.

In addition, Ball State University will evaluate the feasibility of drain structure modifications to significantly reduce Asian carp recruitment from Hovey Lake. Using GIS, an analysis of floodplain connectivity at various river stages will be conducted. In addition, site visits to confirm connectivity will be necessary. These data will be used to quantify historic timeframes and durations of connectivity between the lake and river, and will help determine what modifications to the existing drain structure may be needed to reduce Asian carp recruitment.

To determine the propagule source of Asian carp in the Ohio River, Indiana DNR will contract with Southern Illinois University (SIU) to complete this work. Water samples will be collected during summer and fall months from rivers that are potential recruitment sources for Asian carps collected from the Wabash, White, and Ohio rivers. Water samples will be filtered in the field using a syringe filtration (0.45 μm pore size) technique and analyzed for Sr, Ba, and Ca concentrations using high-resolution, inductively coupled plasma mass spectrometry. Lapilli otoliths will be removed from bigheaded carps collected in the Wabash, White, and Ohio rivers and analyzed trace element:calcium ratios (Sr:Ca, Ba:Ca, Mg:Ca). One otolith from each fish will be embedded in epoxy and sectioned in the transverse plane (otoliths from age-1 and older fish) or affixed directly to a glass microscope slide with a drop of cyanoacrylate glue and gently sanded to expose the otolith core (otoliths from age-0 fish). Otolith samples will be analyzed for Sr:Ca, Ba:Ca, and Mg:Ca using laser ablation-ICPMS. The laser will be used to ablate a transect extending from one side of the otolith primordium to the edge of the opposite side of the otolith along the longest axis of the otolith cross-section; this will enable identification of natal environment and movement among chemically-distinct locations during the fish's lifetime. Water chemistry data and published relationships between water and otolith chemistry for bigheaded carps will be used to estimate expected, multivariate otolith chemical "signatures" for all potential natal rivers for bigheaded carps in the study area. Otolith core chemistry data for bigheaded carps will be compared with these expected chemical "signatures" to identify natal environment for each fish. At a minimum, this approach will enable us to distinguish fish spawned in the Ohio River from those that originated in Ohio River tributaries; we will also assess whether finer-scale resolution of locations in the Wabash River basin may be possible.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Executive technical report for 2021 data	Spring, March/2022
Larval AC Sampling	Spring, May-June/2022
BSU – Hovey Lake drain sampling	Spring, May-June/2022
BSU – Hovey Lake juvenile sampling and daily growth	Summer, June-Sept/2022
BSU – Hovey Drain feasibility	Summer, June-Sept/2022
SIU – Process otoliths	Summer, June-Sept/2022
SIU – Collect water samples	Summer and Fall, July-Oct/2022
Juvenile AC Sampling	Summer, July-Aug/2022
Nursery Habitat Assessment	Summer, July-Aug/2022
Process larval samples	Summer, July-Aug/2022
Otolith collections	Summer, August/2022

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

Activities and Methods: KDFWR will conduct sampling for Asian carp eggs, embryos, and larvae using conical tows during peak spawning periods in the Ohio River. The main stem Ohio River will be sampled above and below locks and dams to determine if Asian carp are using tailwater areas to spawn. Some tributaries believed to be important to spawning will also be investigated using similar sampling protocols.

Three-minute conical ichthyoplankton tows (0.76m, 500 µm mesh) will be conducted on at least two dates from May through July during ideal spawning conditions (water temperatures from 64° to 80°F with moderate to high flows). To determine optimal sampling periods, field staff will coordinate with INDNR personnel to identify when spawning patches begin to develop on female Asian 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).

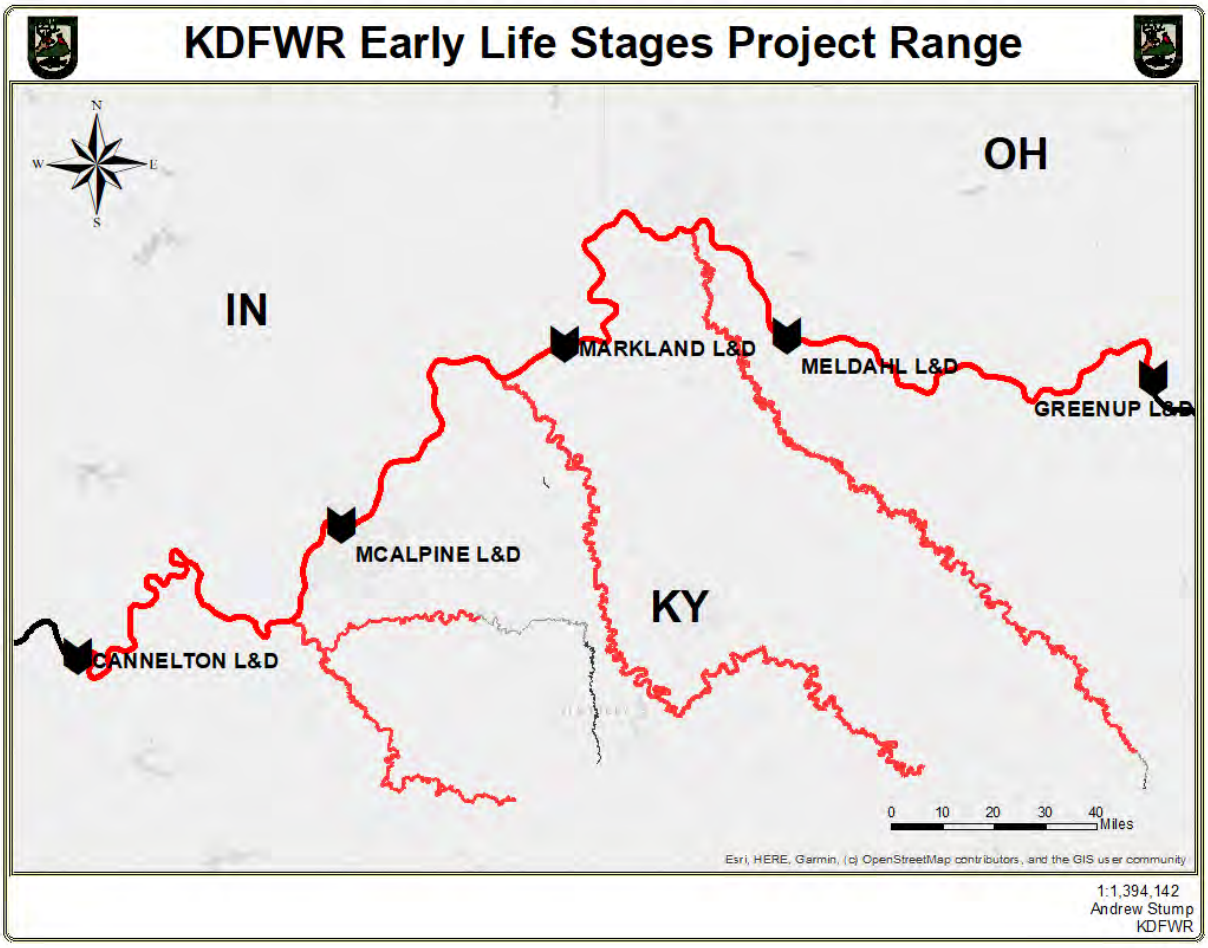
To determine the geographic extent of Asian carp recruitment in the Ohio River, KDFWR will survey the Cannelton and McAlpine pools for young-of-year (YOY) Asian carp. Because typical nursery habitat (shallow backwater areas) is less prominent in the Ohio River, flooded creek mouths, embayments, and tributaries likely serve as a substitute. Previous sampling efforts have regularly captured YOY in JT Myers Pool with occasional captures in Newburgh Pool. However, despite extensive upriver sampling effort, YOY Asian carp have not been observed in Cannelton Pool. Suspected locations believed to be important for recruitment will be targeted with pulsed DC electrofishing during July and August. Additional gears (trap nets, surface trawls, and seines) will be used in an effort to confirm juvenile carp presence or absence.

If juvenile Asian 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 Asian 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 Asian 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)
Survey for YOY Carp in Cannelton and McAlpine pools	Summer, August/2021 – September/2021
WRRDA Report to Congress	Fall, October/2021
KDFWR Contribution to Annual Technical Report	Spring, March/2022
Collection of Eggs, Embryos, and Larval Fish	Spring, May 2022 – July/2022
Eggs, Embryos, Larval Fish Isolated from Samples and Potential Carp Identified	Winter, December/2022
Data and Suspect Samples Sent to INDNR/USFWS for Molecular Verification	Winter, December/2022

Agency: West Virginia University (WVU)

Activities and Methods: West Virginia University's (WVU) primary role will be to determine the extent of bigheaded carp spawning activity in the Ohio River above Markland Dam. WVU will coordinate and conduct sampling for Asian carp eggs, embryos, and larvae in RC Byrd, Greenup, Meldahl, and Markland pools. Specifically, WVU will sample at 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).

To evaluate relative abundance of Asian carp eggs, embryos, and larvae, conical ichthyoplankton tows (0.76m, 500 µm mesh) will be conducted at each site once a week from early-May through late-July 2022 (water temperatures 64 - 80°F with moderate to high flows). The ichthyoplankton net will be deployed on the side of the boat facing upstream, with each tow lasting 3 minutes. A flow meter will be used to determine water volume sampled. All contents will be rinsed into a 500 µm sieve and preserved in 95% ethanol for identification in the lab. At each site on the main stem Ohio River we will sample at the right descending, center, and left descending portions of the river. A fourth sample will be taken at each site either at the intake structure (power plant sites) or within the tributary mouth as tributaries may serve as a refuge for newly hatched larvae to escape the main channel flow. If possible, velocity (m/s) will be measured using a flow meter and depth (m) and water temperature (^{0}C) will also recorded using a boat-mounted depth sounder at each sampling site.

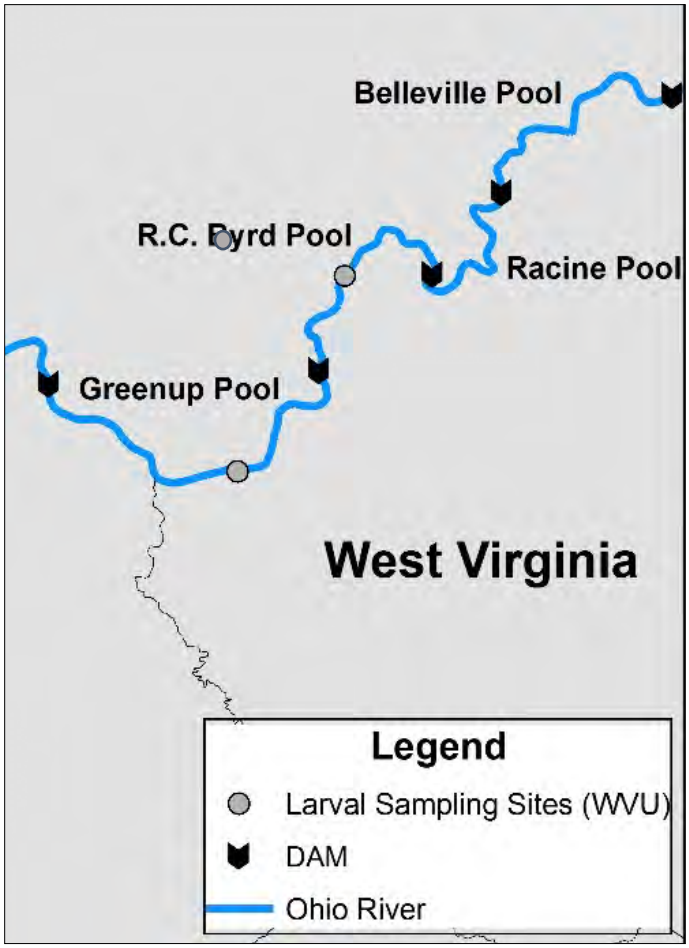
Approved morphometric characteristics will be used to identify suspected Asian carp eggs, embryos, and larvae. WVU will send a subsample of suspected Asian carp eggs, embryos, and/or larvae to Whitney Genetics Laboratory for confirmation of species. Results will be used to estimate the extent of spawning 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 Asian carp and zooplankton.

WVU will also collect plankton community data, as time allows, concurrently with larval fish collections. This will be a "test year" to evaluate methodologies and functionality of the results in informing management decisions. WVU will adopt standard tube sampling methodology presently being used by the Illinois Natural History Survey as components of their Asian carp monitoring and other inland waters surveys. As the opportunities arise WVU will visit lower river reaches where Asian carp are more abundant to collect samples to compare/contrast plankton communities across gradients of Asian 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 Asian carp density.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
WVU Larval AC Sampling	Spring, May-July/2022
WVU Process larval samples	Summer, July-Aug/2022
WVU Send compiled data to INDNR	Fall, Sept-Oct 2022
WVU Report to WVDNR	Fall, December 2022
Project Report Technical Document	Spring, March/2023

Literature Cited:

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

Control and Containment of Asian carp in the Ohio River Basin

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

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

Statement of Need: Invasive species are continually responsible for undesirable economic and environmental impacts across the nation. Asian carp rapidly colonize river reaches in high densities, affecting the native food webs important to ecosystem functions 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 Asian 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 Asian 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:

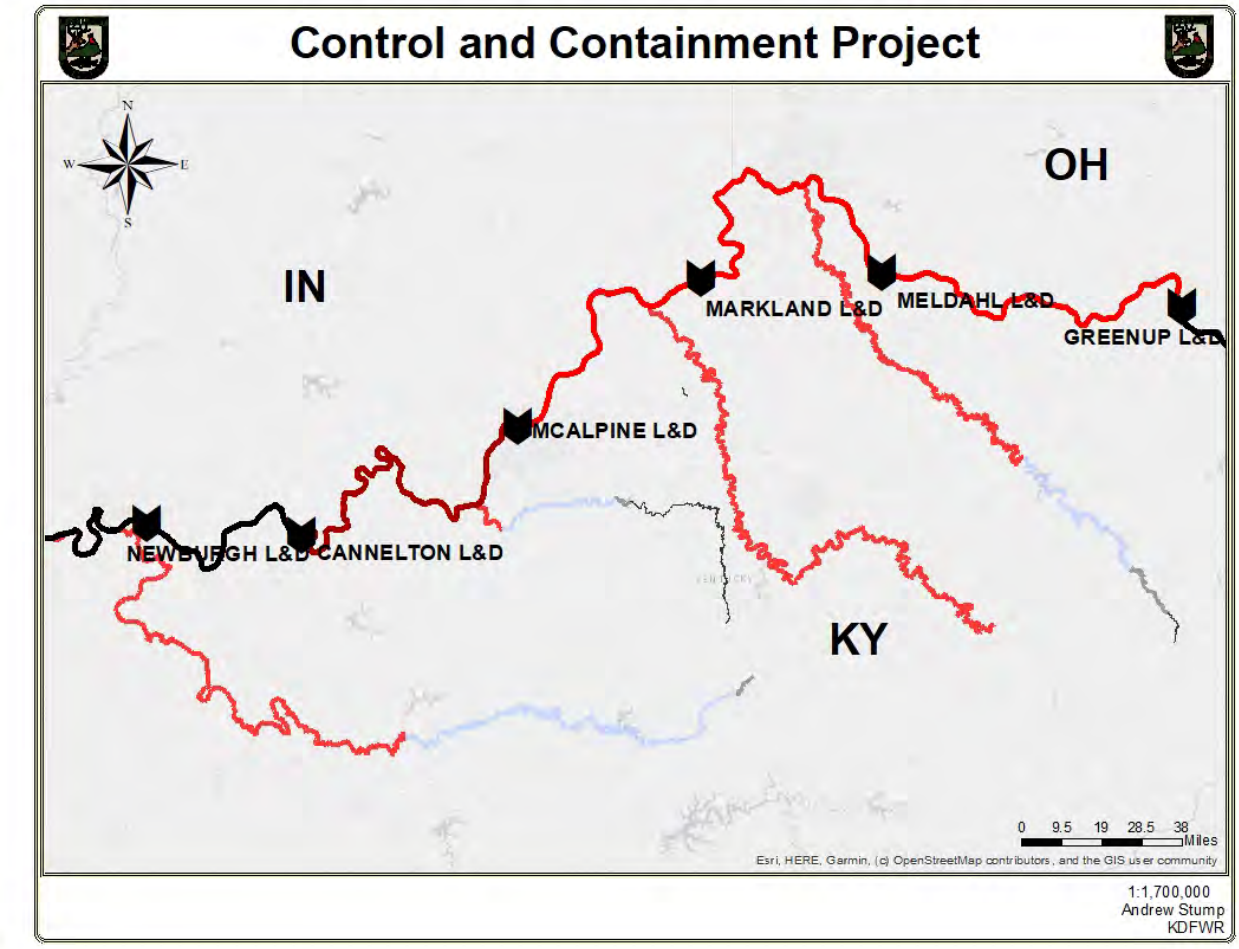
1. Target and remove Invasive carp to suppress populations and reduce propagule pressure in the Ohio River basin.
2. Implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin.

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

Activities and Methods: Agency crews will remove Asian carps from the Ohio River and large inland tributaries and embayments for approximately 125-150 fishing days, focusing on known or suspected areas where invasive carps congregate. Agency efforts will rely on pulsed-DC or AC 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 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.

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 were employed to conduct regularly scheduled removal, and using a suite of special Kentucky regulations (Asian Carp Harvest Program), were given access to otherwise net-restricted waters in order to target Asian 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. Asian 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 350 contract fishing days and reach a minimum benchmark of 250,000 lbs of carp harvested in the Cannelton Pool. 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 in Cannelton Pool (**Refer to Map**)	Summer, July/2022 – June/2023
Agency Removal OH River and Inland (**Refer to Map**)	Summer, July/2022 – June/2023
WRDA Report to Congress	Fall, October/2022
Project Report Technical Document	Spring, March/2023

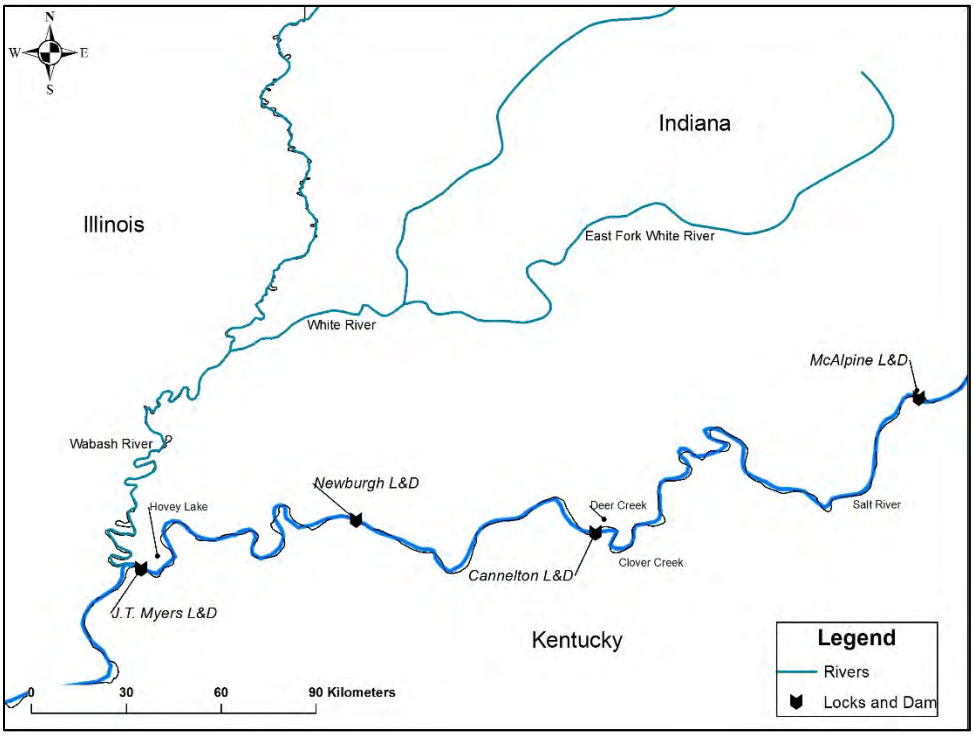
Agency: Indiana Department of Natural Resources (INDNR)

Activities and Methods: INDNR will use agency crews to target and remove Asian 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 Asian carp (portions of the White, Wabash, and Ohio rivers). INDNR will plan or assist at least 15 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.

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 2022. Contracted fishers will be employed to conduct regularly scheduled removal, and using a suite of special Kentucky regulations (Asian Carp Harvest Program), will be given access to otherwise net-restricted waters in order to target Asian carp species. INDNR will provide onboard observers for this program to collect daily location, harvest, bycatch, and effort data. INDNR will continue developing a program similar to the Kentucky Asian Carp Harvest Program to allow additional Asian carp harvest opportunities in Indiana waters. This program will allow INDNR to bring contracted fishers into otherwise closed waters for the purpose of additional Asian carp harvest. INDNR will work closely with ILDNR to increase contract removal effort on the Wabash River while providing observers to collect ride-along data.

INDNR will work with current contract and commercial fishers to the most suitable avenues for facilitating increased Asian carp harvest in the lower Wabash River area. Developing ice supplies and/or transportation programs for fishers to make harvest and selling of Asian carp more feasible will be a priority. INDNR will consult with active Asian carp commercial fishers to determine best locations, quantities, and logistic challenges to ensure resources are fully utilized.

Map of Project Area:



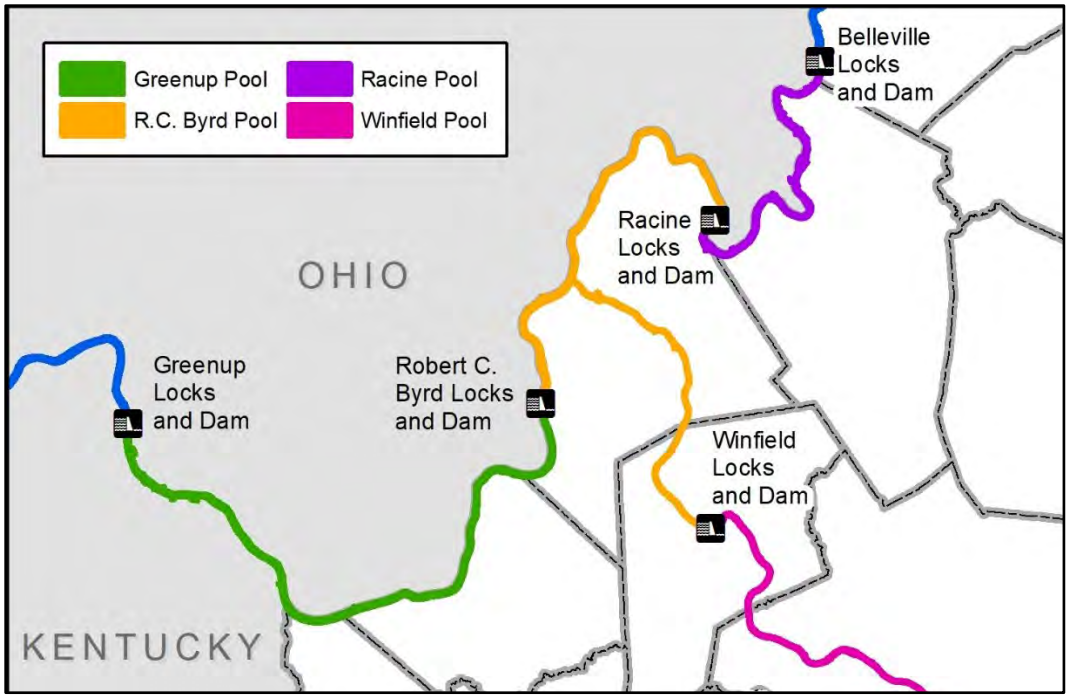
Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Staff observers for contract removal in Cannelton Pool	Start Fall, October/2021 (Continue through 2022)
Agency Removal and Aid to Contract Fishers	Start Fall, October/2021 (Continue through 2022)
Send observer data to KDFWR	Start Fall, October/2021 (Continue through 2022)
Develop ice supply and/or transportation programs to facilitate Asian carp harvest	Start Fall, October/2021 (Continue through 2022)
Project Report Technical Document	Spring, March/2022
Removal and ride-alongs in the Wabash River	Start Spring, March/2022
Agency based removal efforts in White, Wabash, and Ohio Rivers	Start Spring, March/2022

Agency: West Virginia Division of Natural Resources (WVDNR)

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

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Agency Removal in R.C. Byrd Pool	Summer, Aug 2021-July 2022
Agency Removal in Greenup Pool	Summer, Aug 2021-July 2022
WRRDA Report to Congress	Fall, October/2021
Project Report Technical Document	Spring, March/2022

Agency: Illinois Department of Natural Resources (ILDNR)

Activities and Methods: ILDNR continues operation of an Asian 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 Asian carp removal in key locations.

Contract Fishing, where fishers will be under contract to ILDNR directly will be undertaken in late 2021 and early 2022 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-Asian carps will be enumerated and released back into the water, while all Asian 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 Asian carp is desired, these efforts overall will inform managers of both Illinois and Indiana regarding future management goals and considerations.

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

Original enhanced fishing contracts are continuing to be executed with inclusion of the new water bodies referenced above and are being made available to any licensed Illinois and/or Indiana commercial fishers who wish to participate in the program. Contracts provide $.10 per pound payments for Asian carp caught in the authorized waters stated above and sold to processors or other buyers for a minimum price of $.07 per pound. Prior to reimbursement, fishermen are required to present to the program a summary cover sheet and receipt for each catch. Cover sheets include fisher name, address, commercial fishing license, equipment used,

catch location (by pool), affidavit, signature, and date. Receipts must contain name and address of both fisher and buyer, fisher's license number, catch location (by pool), invoice number, date, listing of each species, each species weight, and price per pound and buyer signature.

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

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

Contracted Facilitation will continue offloading of Asian carp catches from commercial vessels at designated locations within 10 miles of the shoreline to support increased removal where contract and enhanced contract harvest is ongoing. This effort encompasses regional river systems including: 1) Peoria Pool of the Illinois River, 2) Pools 20 - 22 of the Upper Mississippi River, 3) Wabash River, and 4) Kentucky and Barkley lakes in KY and TN. (See maps below.) A similar contract to the Enhanced Contract Fishing program is available to any licensed buyer authorized to operate in Illinois, Indiana, Missouri, Kentucky, and Tennessee for offloading in their respective states. Companies/buyers are required to enter into this contract to pick up fish within these watersheds to be eligible for facilitation funding. Considerations for pickup locations are coordinated with state and local managers. Companies/buyers are not restrained by where their facilities are located, just the locations/distance they are picking up fish from target waterbodies. The contract provides payment of $.05 per pound for Asian carp offloaded from commercial fishers in the designated areas, while funds are available and/or additional funds are refreshed.

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

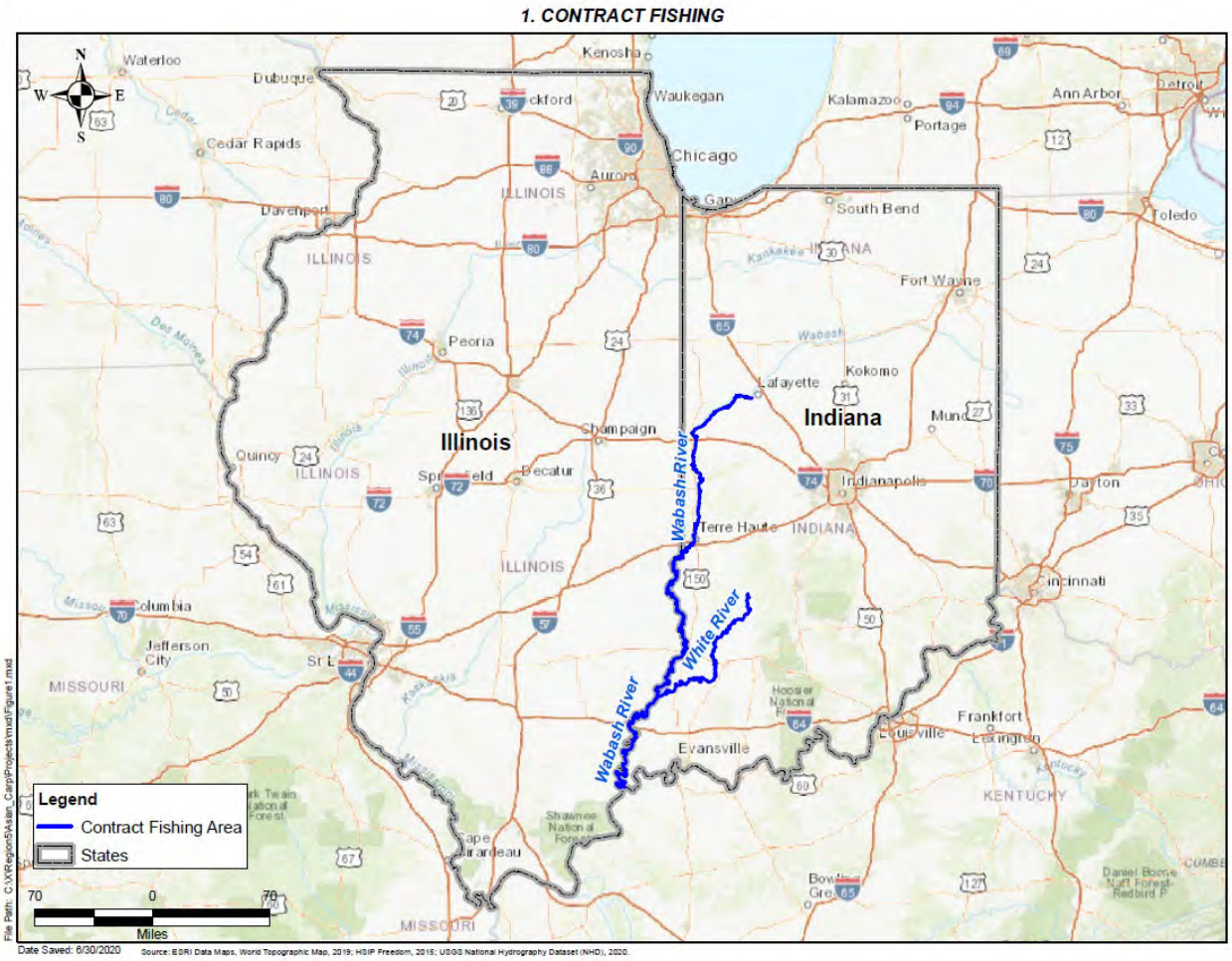
Prior to pick up, the buyer is required to notify the program of the intended pick-up location and (if applicable) license plate of the truck to be used. Program monitoring is performed of reported pick-up and fishing activity.

Facilitation efforts under this program are complementary and additive (but not redundant) to contract fishing efforts identified in the ACRCC Action Plan as well as ongoing state Asian carp removal programs including TWRA Asian Carp Harvest Incentive Program and KDFWR Asian

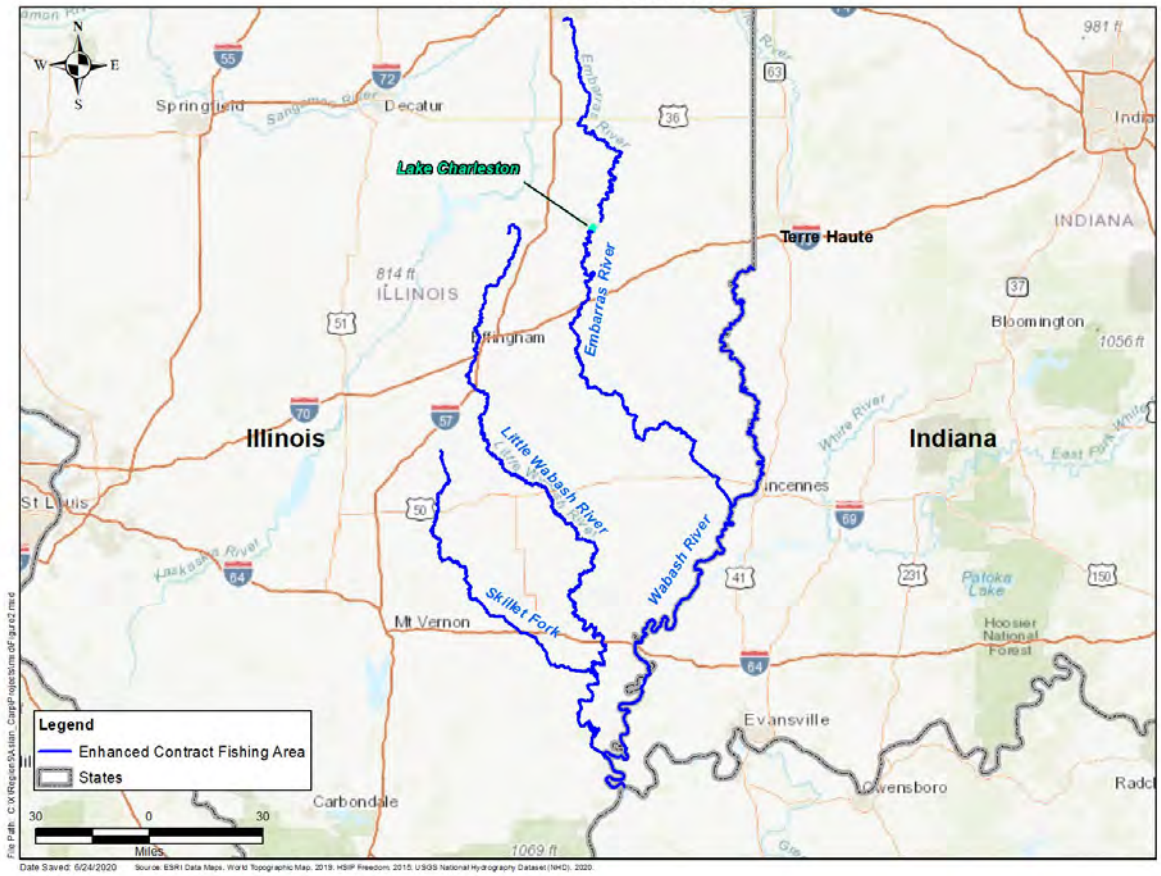
Carp Harvest Program. Removal goal for Contracted Facilitation for the period of performance is 6 million pounds of Asian carp.

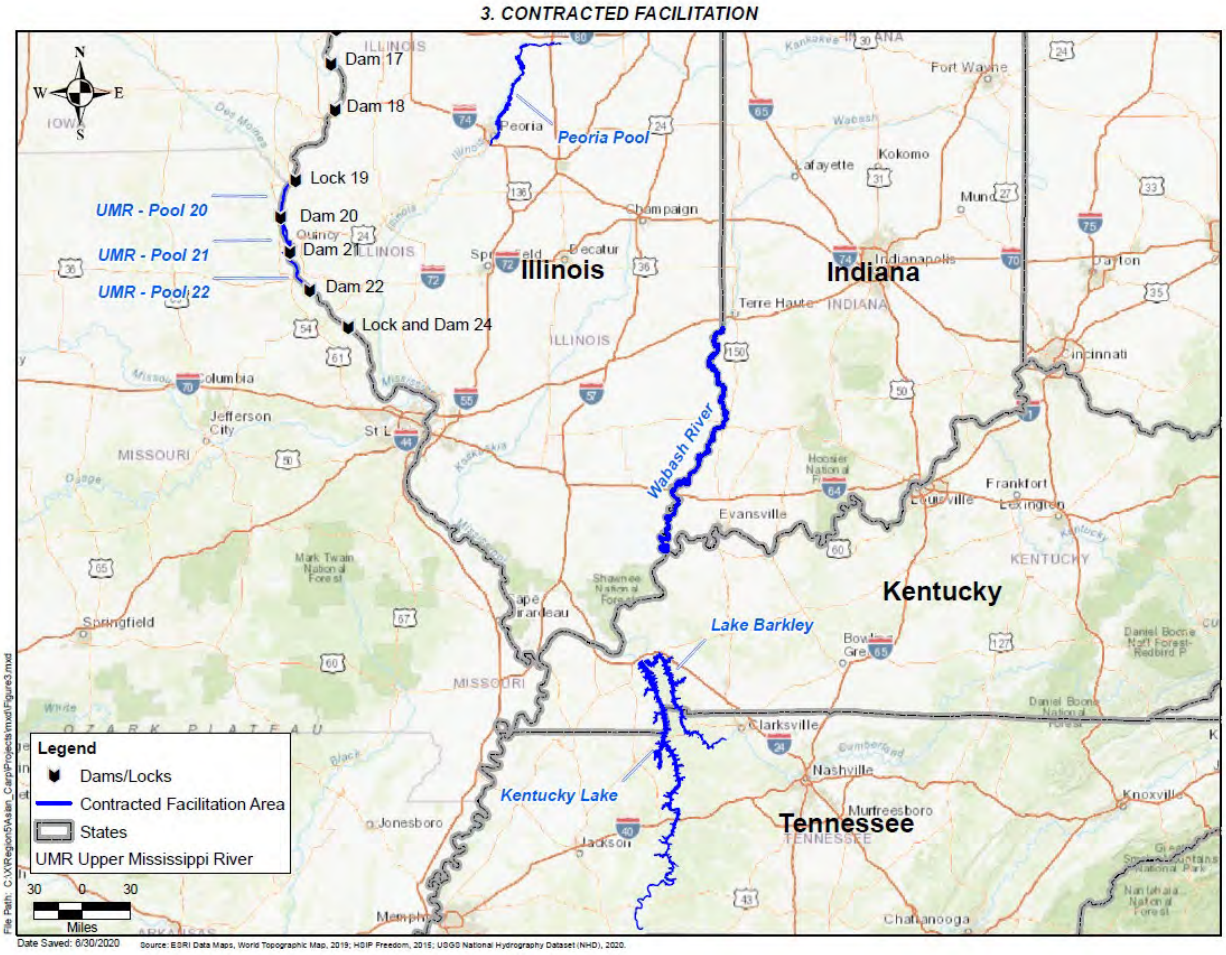
This project supports SIU's efforts to evaluate contracted facilitation as a method of increasing Asian carp harvest to increase ability to manage/reduce these invasive species while informing future investments in these and other basins. Data collected will not duplicate data collected in the Enhanced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

Maps of Project Areas:



2. ENHANCED CONTRACT FISHING





Estimated Timetable for Activities:

Activity	Time Period (Season, month/year) *
Contract Removal	Start October 2021 (Continue through March 2022)
Enhanced Contract Removal	2022 through 2023
Contracted Facilitation	2022 through 2023

* Timelines subject to funding availability and participation in contracts.

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

Lead Agency and Author: U.S. Fish and Wildlife Service **(**USFWS), Ben Marcek (Benjamin_marcek@fws.gov)

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

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

Invasive carp locations will be recorded using a stationary receiver array throughout the study area (i.e., mainstem Ohio River from Smithland to Willow Island pools and major tributaries such as the Wabash River). Observations from the stationary receiver array will be supplemented with active tracking at specified locations (e.g., Wabash and White rivers and the Markland and Cannelton pools). Broad-scale (among-pool) movement data will be used to evaluate the

dispersal and invasion dynamics of invasive carp, their ability to navigate the lock and dam systems, and the contribution of the Wabash River basin to Ohio River populations of invasive carps. Fine-scale (within pool) movement data will be used to identify areas in which invasive carps congregate in the Ohio River and its tributaries and to relate habitat use to environmental conditions such as temperature, flow, and light that are related to daily or seasonal transitions as well as stochastic events (e.g., rainfall). Understanding the relationships between environmental conditions and the habitat use and movement of invasive carps will improve the management of invasive carps by informing the locations for movement deterrents and mass-removal efforts that can slow range expansion and increase capture efficiency. Moreover, increased efficiency of removal efforts will allow for the assessment of changes in the movement and habitat use of invasive carps in response to decreased population 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 relies on inter-agency coordination to implement field work and provide results on an annual basis. This design allows for timely dissemination of data and analysis to further our understanding and guide management actions.

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 and Wildlife Resources (KDFWR)

Activities and Methods: The stationary receiver array on the mainstem Ohio River is all set to expand downstream in 2021 and 2022, and as such, it's becoming even more influential to the efforts that multiple agencies have made towards the completion of this project's first three objectives. This is especially true for the KDFWR as it continues to maintain all telemetry sites

in a ~140 mile stretch of the Ohio River, which includes the upper Cannelton, McAlpine and lower Markland pools. By the end of 2021, this section of the array is expected to contain ~30 receiver sites distributed among three primary habitat types (Table 1). Field crews will visit the sites at least once in Oct – Nov 2021 to offload receivers and complete other site-specific maintenance (i.e. replace batteries, cables, etc.). Each location will be visited again in Dec 2021 to complete year-end activities that are defined by the habitat type of each site. When river conditions are favorable during spring 2022, the crews will resume all site visits in KDFWR's section to once again conduct normal maintenance activities. Following the completion of initial spring efforts, KDFWR will continue to visit each site at least once every two months through the end of September 2022. Even though a site's habitat doesn't usually impact the timing of its receiver work, it does influence the field crew's actions once they get there. Furthermore, the habitat type and pool location can be used to accurately identify the objective(s) each site was established for.

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 to accomplish this first objective, the KDFWR will visit all tributary sites in their section of the array according to the previously described schedule that begins in fall 2021 and continues through the end of September 2022. An overall lower risk of seasonal losses allows the VR2W's at tributary sites to remain active all year, but this also requires the field crews to conduct certain tasks that are specific to these sites. KDFWR will conduct year-end maintenance during December 2021 that includes offloading all data, replacing batteries and resetting each VR2W for the next project year. In addition to these efforts, field crews will also offload the temperature data that was recorded by the HOBO temp loggers that were previously deployed to specific tributary sites.

Between fall 2021 and summer 2022, the KDFWR will continue to follow an active tracking protocol designed to complement the stationary receiver sites in many tributaries of the Ohio River. These efforts will be primarily focused in upstream areas of larger tributaries (e.g., Kentucky River, Indian-Kentuck Creek, etc) that are likely attract decent numbers of invasive carp by providing an abundance of suitable habitat. The volume of water expected to be surveyed during the active tracking efforts in 2021-2022 will be based on each tributary's overall size and is likely range from 5 to 50 miles upstream of the existing stationary receiver sites.

By late 2021, KDFWR also plans to extend their telemetry efforts in order to track movements of invasive carps that primarily reside in two important tributaries of the middle to lower Ohio River. Both the Green (RM 784) and Salt (RM 630) rivers play a role in the current telemetry project, which is limited to a couple of stationary receiver sites located near their confluences with the mainstem Ohio River. In order to expand telemetry efforts into upstream areas of both rivers, KDFWR will start to identify up to 8 potential receiver sites in each tributary during the the fall of 2021. These receivers are expected to complement those that are already located near the mouths of both rivers. Although some carp that were tagged in the mainstem Ohio River are expected utilize these waterbodies, it is not yet known how many are currently present, or how much of each tributary that they actually occupy. Hence, KDFWR plans to bolster the tagged

fish totals at these locations by expanding the tagging efforts into the upstream reaches of each waterbody. During fall 2021, field crews will attempt to collect ~20 invasive carp from the Green and Salt rivers and implant transmitters into each of them so that their movements can be monitored upon release. These efforts are specifically designed to better understand how invasive carp are utilizing the tributaries, which includes identifying areas that carp often inhabit and determining if the combination of habitat use and behavior could make them more vulnerable to ongoing removal efforts.

Depending on the availability of personnel (the previously mentioned active tracking efforts will take priority), KDFWR could begin 24-hr tracking of invasive carp during the summer of 2022. KDFWR biologists will select groups of tagged carp using telemetry results obtained through the end of 2021. This will be used to identify the more "Active" fish that frequently move between receiver sites so that they can used as the initial subjects of the 24-hr tracking efforts. In order to provide relevant information to ongoing removal efforts, preference will likely be given to tagged carp that are located in or near the pools being targeted by contract fishermen. Despite these plans for preliminary efforts, the KDFWR does not expect to fully begin 24-hour active tracking efforts until the latter half of 2022.

Objective 2 - Delineate the upstream population distribution of invasive carps

In 2021 – 2022, the overall location of KDFWR's section (~140 mi long) of the array will continue to effectively limit the effort that field crews can commit towards the project's 2nd objective, which focuses on upstream extent of the invasive carp population that inhabits the Ohio River. Regardless of this, in fall 2021, KDFWR will resume efforts to maintain a total of six stationary receivers that happen to be located upriver of Markland Lock & Dam, which serves as the downstream boundary for the lower density carp population that occupies the upper Ohio River. As with the previously discussed receiver work, field crews will continue to visit these sites once every two months until September 2022 in an effort to offload the detection data and conduct other maintenance as required. Aside from visiting these six sites, the only other work that KDFWR will specifically conduct for this objective is related to the management and analysis of all 2021 – 2022 tag detections that will be offloaded from VR2W's at sites located throughout the upper Ohio River.

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

The only other receivers located in KDFWR's section of the array are those that have been distributed between sites in the mainstem Ohio River and two different Lock & Dam locations. Site visits and receiver offloads will be conducted in late fall 2021 for the ongoing efforts to complete the telemetry project's 3rd objective. Field staff will then follow up by returning to each receiver site once more in December 2021 in order to conduct specific maintenance tasks that are determined by each site's habitat type. In accordance to this, all tag detections will be offloaded from receivers at Lock & Dam sites (McAlpine & Markland) before they undergo a maintenance routine that closely resembles the year-end activities that were previously described for tributary sites. Field crews will also visit mainstem sites once more before the end of 2021, but unlike others, these efforts will be done with the sole purpose of retrieving the VR2W from each site in order to store it off-river for the upcoming winter. When favorable conditions return

in spring 2022, KDFWR staff will return to mainstem sites in order to redeploy the VR2W's to each location. During this time period, crews will also revisit the L&D sites in order to offload any new tag detections and conduct various site-specific maintenance tasks. As was previously described for other efforts, field staff will continue their maintenance of mainstem and L&D receivers through the end of September 2022 by visiting all sites at least once every two months.

In addition to the ongoing efforts being conducted various tributaries, KDFWR staff are also planning to resume active tracking for tagged carp in specific areas of the mainstem Ohio River that could prove to be very important to the completion of the project's 3rd objective. Over the course of this study period, field crews will conduct active tracking efforts in an area of the Cannelton pool that's located directly below McAlpine L&D and a section of the Markland Pool that's situated immediately upstream of Markland L&D. These sections of river exhibit characteristics that have made it difficult to establish/maintain adequate receiver coverage, and yet both areas are important to ongoing efforts to verify potential pool transfers. Hence, KDFWR staff will conduct active tracking during late fall 2021 to search both areas for tagged carp that may have transferred pools without being detected by a stationary receiver. The results of these active tracking efforts should help inform the Ohio River Basin Partnership about the carp's ability to pass through McAlpine and/or Markland L&D. Current data suggests that invasive carp will readily pass through McAlpine L&D, but not Markland, which has only one verified upstream transfer since the project started in 2013. If conducted properly, the active tracking efforts should help identify possible sites for a barrier on the mainstem Ohio River.

In fall 2021 and spring 2022, KDFWR staff will collaborate with USFWS and INDNR to continue the project's annual efforts to maintain the overall sample of invasive carp in the Ohio River that have active transmitters. To accomplish this, field crews will use a combination of pulsed DC electrofishing and gill nets to collect either Silver or Bighead carps. Any carp of a large enough size will be surgically implanted with a ~100 mm long acoustic transmitter, marked with an external tag and then released back into the same pool it was collected in. During this study period, tagging efforts will commence in both the Cannelton and McAlpine pools, which contain large numbers of previously tagged carp with transmitters that are scheduled to reach the end of their 5-year battery life before the end of 2021. If time allows, KDFWR staff will also assist INDNR with their ongoing efforts to implant transmitters into invasive carp that are collected from pools that were recently added to this project (i.e., Newburgh & J.T. Myers).

Management & Analysis of data from objectives 1 – 3

KDFWR will continue to maintain the database that has served as the telemetry project's primary data repository since 2014. The year-end processing efforts for the 2021 data will involve the retrieval and archiving of files that KDFWR, WVDNR, ODOW and USFWS have offloaded from the receivers in their sections of the array and then shared with project partners via email or an online file service (i.e. ODOW's FTP site, Google Drive, etc). Each dataset will be error-checked and compiled prior to being imported into a database that contains all tag detections recorded since 2013. In addition to their ongoing efforts to process all data collected from the mainstem Ohio River telemetry array, KDFWR staff will also continue to record the accurate locations of all receiver sites, to compile all the data that is collected from carp that are implanted

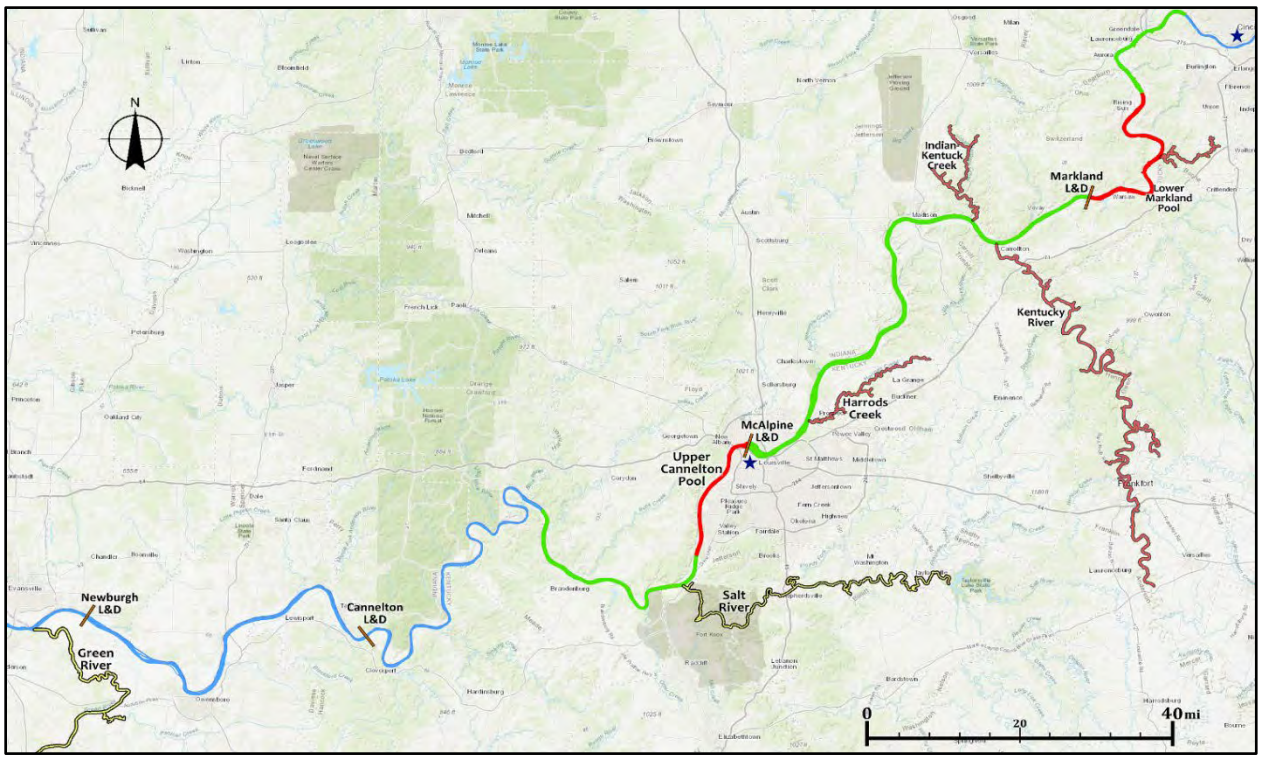
with transmitters, and maintain a separate database with the environmental data from a time period that matches up with this project.

This project has expanded a great deal over the past 5+ years, and as a result, the database has grown tremendously to the point where it now contains of >30 million detections of >700 tagged carp that were recorded by ~220 stationary receiver sites. Not surprisingly, databases of this size can be quite cumbersome. Hence, in addition to the routine data processing, KDFWR staff will also make efforts to improve accessibility to both the project's telemetry data and the results of any related analyses. To support this goal, KDFWR biologists will continue their efforts to summarize raw detection data into more user-friendly datasets that consist of either hourly or daily detections. Each reduced dataset will be regularly updated and then made available to the collaborating agencies via a several online file services (i.e. FTP site, Google Drive, OneDrive, etc). Despite its improved usability, a reduced dataset can still easily consist of over a million observations. To improve on this even further, KDFWR will continue their recent efforts to create an online data dashboard that will provide users with interactive data visualizations that are directly connected to the project's overall database. By design, these dashboards can be easily expanded to incorporate many other variables, such as additional information on tagged carp (e.g., size at tagging and location of tagging), receiver locations, and the environmental conditions at the time of detection. The goal of this type of effort would be to give all partners access to every bit of data that they've helped to collect, and then in turn, increase the likelihood that they will be able to complete all of the telemetry project's current objectives. The user-friendly interface will also allow partners to extract information relevant to them, and even perhaps, their local efforts to manage/reduce the invasive carp populations within their state.

Receiver counts (by site type) for the first 4 pools of the 2021 telemetry array.

Agency	Pool	US RM	DS RM	Mainstem Receivers	Tributary Receivers	L&D Receivers
KDFWR	Cannelton (upper)	605.0	630.0	3	2	--
KDFWR	McAlpine	531.7	605.0	5	10	3
KDFWR	Markland (lower)	491.0	531.7	--	6	3
ODOW	Markland (upper)	436.3	491.0	6	4	3
ODOW	Meldahl	341.5	436.0	12	8	4

Map of Project Area:



During 2021-2022, KDFWR will maintain stationary receivers in a ~140-mile section of the telemetry array from the upper Cannelton pool to the lower Markland pool (green). KDFWR will also conduct active tracking in the areas of the mainstem Ohio River directly above the Markland L&D and below the McAlpine L&D (red) and in a group of nearby tributaries (brown). Additionally, KDFWR personnel will extend the receiver array into the upstream areas of the Green and Salt rivers (yellow).

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 maintenance tasks.	Fall, Oct-Nov 2021
Cont. active tracking efforts in tributaries of the OHR & specific areas of the main stem river (Markland L&D & Cannelton Pool).	Fall, Oct-Nov 2021
Conduct active tracking in upstream areas of Green & Salt rivers to locate any tagged carp from the mainstem Ohio River; Start identifying locations for new stationary receiver sites.	Fall, Oct-Nov 2021
Assist tagging efforts in McAlpine, Cannelton & Newburgh pools; Initiate carp tagging efforts in the Green & Salt rivers.	Fall, Oct-Nov 2021
Complete year-end efforts to offload temp loggers & tributary receivers; Retrieve mainstem VR2's for overwinter storage.	Winter, Dec 2021
Assist the tagging efforts in downstream areas of the receiver array and continue tagging carp in upper Green & Salt Rivers.	Spring, Mar-Jun 2022
Redeploy VR2's to mainstem sites in the Cannelton, McAlpine & Markland pools; Deploy VR2's to new sites in upper Green & Salt River; Resume monthly offloads of receivers at all assigned Sites.	Spring-Summer, Apr-Sep 2022
Cont. efforts to actively track tagged carp in several tributaries & mainstem areas of the Ohio River; And, if applicable, start 24-hr tracking of the most active tagged carp.	Spring-Summer, May-Sep 2022

Agency: Indiana Department of Natural Resources (INDNR)

Activities and Methods: To understand the use of tributaries as potential sources for recruitment of invasive carps, INDNR will help deploy, maintain, and offload at least 12 receivers positioned in select tributaries of J.T. Myers, Newburgh, and Cannelton pools. A pair of receivers will be deployed in at least two key 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, the existing array was expanded to include lower pools. Work conducted by INDNR in 2022 will focus on maintaining the expanded array in the lower pools and further adding receivers to the array as needed with the goal of completing a comprehensive array throughout most of the Ohio River. INDNR will focus on the lower pools which have higher invasive carp

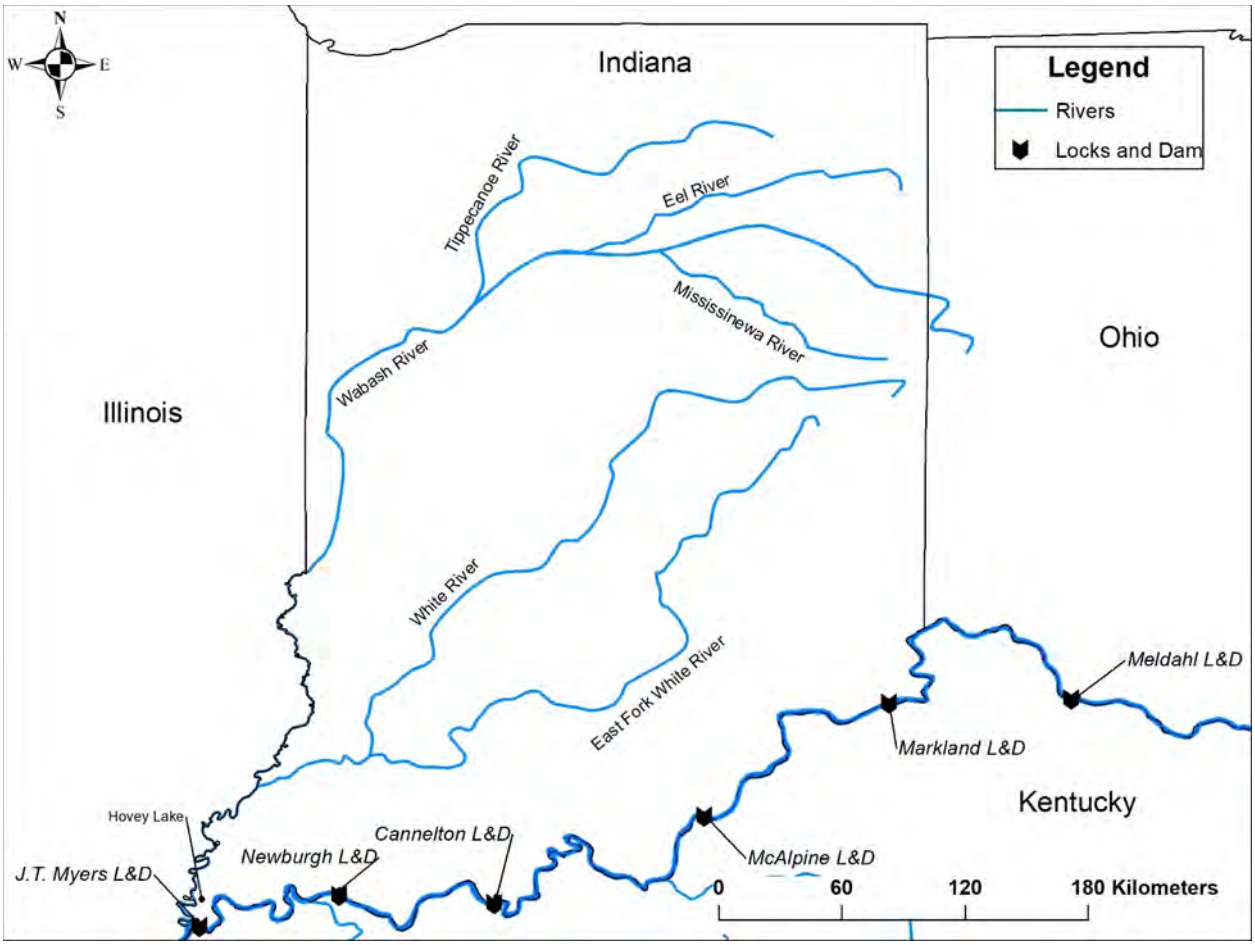
densities. The invasive carp populations in the lower pools are thought to act as sources for pools farther upstream. Understanding tributary use in these lower pools will help managers determine potential spawning locations and help determine productive areas for removal efforts. INDNR will use active tracking in select tributaries to obtain real-time usage information.

To quantify passage of invasive carp through Ohio River locks and dams, INDNR will deploy at least 18 receivers in Smithland (N = 2) J.T. Myers (N = 6), Newburgh (N = 6), and Cannelton (N = 4) pools. These additional receivers will expand the current array and allow managers to quantify invasive carp passage through dams in high-density 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. KDFWR currently has four receivers in the lock chambers of both J.T. Myers and Newburgh locks and dams, in addition to two receivers in the Green River. INDNR will coordinate with project partners to deploy receivers in areas to provide comprehensive coverage throughout the target pools. Receivers will be deployed in the Ohio River on navigation buoys or bridge piers from RM 848 (Wabash River confluence) to RM 709 (lower Cannelton Pool) to track inter-pool movement and help determine survival rates of tagged fish. INDNR will offload receivers monthly and send data to KDFWR for compilation with existing data. INDNR will also purchase 300 Vemco tags to be implanted in invasive carps within Smithland, J.T. Myers, and Newburgh pools. Tagging locations will be spread out among pools to ensure oversaturation of tags in an area does not occur. INDNR will coordinate with crews from USFWS and KDFWR to tag adult invasive carps. Fish will be tagged in the spring and fall when water temperatures are suitable for survival.

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

INDNR will contract Ecosystems Connections Institute to conduct a telemetry study on native fish passage pre and post dam removal on the Eel River (located in the upper Wabash River watershed). INDNR intends to partner with the researchers to expand this work to include invasive carp movements throughout the Eel River once low-head dams are removed, along with quantifying invasive carp movements/use of other nearby tributaries in the upper Wabash River (Mississinewa and Tippecanoe rivers). At least 8 receivers will be deployed in the mainstem Wabash River from river mile 320 to river mile 376, along with paired receivers in each the Tippecanoe, Eel, and Mississinewa rivers. At least 50 invasive carp will be tagged throughout the study reach with both acoustic and PIT tags. Eel River dam removal is currently slated to occur fall of 2021, therefore the ability to collect pre-removal data may be limited at this point, but attempts will be made as time, staff, and gear availability allows.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period Season, month/year
Tag invasive carps in upper Wabash River and nearby tributaries	October 2021
Deploy receivers in upper Wabash River and nearby tributaries	October 2021
Ecosystems Connections Institute download receiver data monthly	Start December 2021 (continue through 2022)
Tag invasive carps in Smithland, J.T. Myers, and Newburgh pools	Spring, March-May/2022
Deploy receivers in Smithland, J.T. Myers, Newburgh, and Cannelton pools	Spring, April-May/2022
Maintain and download receivers	Monthly, May-Nov/2022
Assist SIU with receiver offloads	Summer, June-Aug/2022
Conduct active tracking in Ohio, Wabash, and White rivers	Summer, June-Aug/2022
Tag additional invasive carps	Fall, October/2022
Pull receivers from all mainstem sites for overwinter storage	Winter, December/2022

Agency: West Virginia Division of Natural Resources (WVDNR)

Activities and Methods:

Objective 1: No federal funding is being requested for this objective. Therefore, there are no planned actions. WVDNR will assist and cooperate with partner agencies conducting activities associated with this objective where applicable. All activities will be funded through state resources.

Objective 2: WVDNR will continue to assist USFWS in all aspects of this objective including, but not limited to setting, replacing, or removing receivers, downloading data, sharing data, sharing significant findings, capturing and tagging invasive carps. WVDNR will continue maintaining and, downloading, and sharing data from receivers located in the R.C. Byrd Pool, including the portion within the Kanawha River. WVDNR also assumed the responsibility for maintaining the mainstem and tributary VR2 receivers located in the WV portion of the Ohio River in 2020 and will continue these efforts. This includes deployment of receivers during spring, offloading data, and retrieving receivers during late fall as well as replacing any lost receivers. All data collected on invasive carp will be shared with project partners.

As schedules allow, WVDNR will 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.

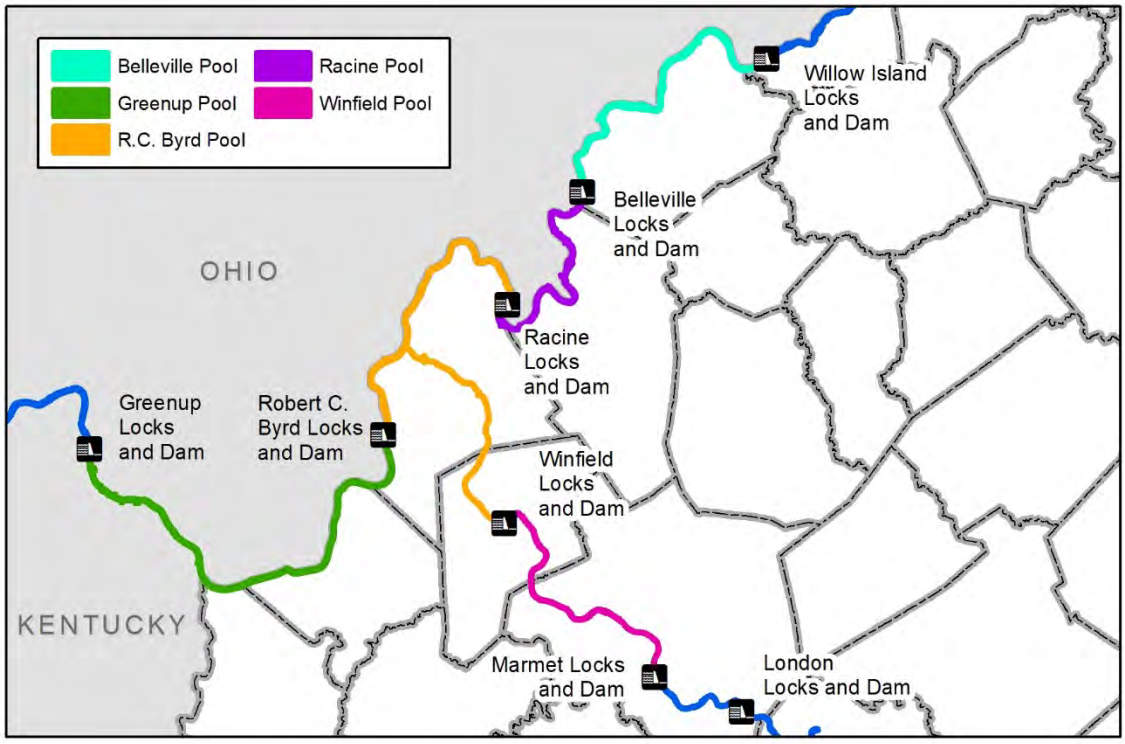
Objective 3: WVDNR will assist USFWS in downloading data from and maintaining stationary VR2 receivers located within the lock complexes at Willow Island, Belleville, Racine, and R.C.

Byrd on a bi-monthly schedule. All invasive carp movement data will be shared with project partners. No data analysis will be completed by WVDNR for this project.

Estimated Timetable for Activities:

Project Activity	Pool	Dates	Year
Mainstem receiver deployment	R.C. Byrd – Willow Island	March-April	2022
Invasive carp tagging	McAlpine, Markland and Meldahl	October, April	2021-22
Lock and dam receiver download	R.C. Byrd – Willow Island	Aug-July	2021-22
Mainstem receiver retrieval	R.C. Byrd – Willow Island	November/December	2021

Map of Telemetry Project Area:



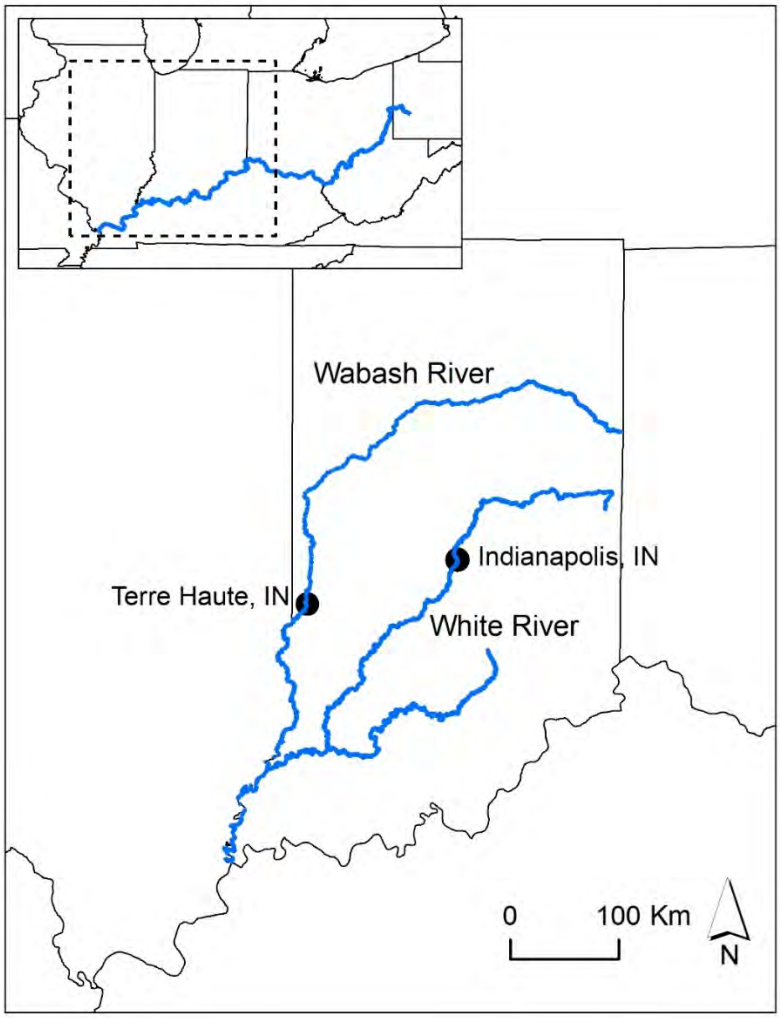
Agency: Illinois Department of Natural Resources, Southern Illinois University (SIU)

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, INDNR and EIU will collect and tag Silver and Bighead Carps from the Wabash River, from its confluence with the Ohio River to Terre Haute, IN, and within the White River from its confluence with the Wabash River to Indianapolis, IN. Fifty invasive carp (34 from the Wabash River and 16 from the White River) will be collected via boat electrofishing and implanted with Vemco V16 69kHz tags using surgical procedures as outlined in Lubejko et al. (2017). Fish total length and weight will be recorded, and each fish will receive an external tag with an SIU phone number to identify individuals with internal telemetry tags and to facilitate tag returns of harvested fish. Tags will be distributed in at least three locations along the White River and five locations along the Wabash River to avoid oversaturation of acoustic tags in one location. Information about tagged fish (length, weight, tag location, species) will be shared with other groups engaged in telemetry in the Ohio River Basin and with the FishTracks database.

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

Data from stationary receivers will be downloaded during spring and late summer 2022. Exact timing of downloads will depend on water levels. SIU will QA/QC data to identify and remove false detections from the dataset and then combine with other telemetry data from the Ohio River Basin (dependent on sufficient numbers of fish moving/not moving). Telemetry data will be used to quantify movement probabilities among the Ohio, Wabash, and White rivers following the same analysis procedure described in Coulter et al. (2018). Additionally, information on movement patterns, including distances and directions traveled and seasonal patterns (Coulter et al. 2016) within the White and Wabash rivers, will be quantified. This project will contribute to the existing acoustic telemetry network in the Ohio River Basin.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Time Period (Season, Month Year)
Deployment of Stationary Receivers	Spring, March 2022
Acoustic Tagging of Invasive Carps	Spring, March - April 2022
Interim Progress Report and Executive Technical Report	Spring, March 2022
Stationary Receiver Downloads	May 2022, September 2022
Final Report	Winter, November 2022

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

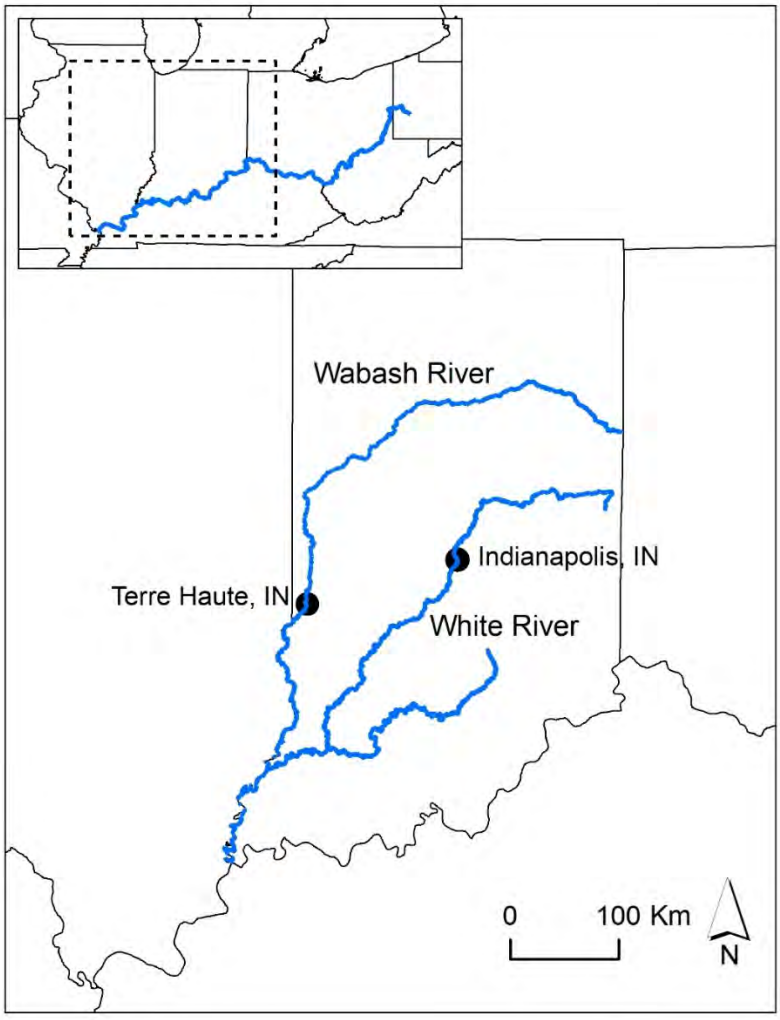
Activities and Methods: EIU will be contracted by ILDNR to complete work on the acoustic telemetry of invasive carps in the Wabash and White rivers (Objectives 4 and 5). EIU will assist with acoustic tagging of invasive carps (described in SIU section) and will collect active tracking and habitat use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

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

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

To determine if invasive carps are selective in their habitat use, we will calculate habitat selection ratios following Manly et al. (1993). To calculate the proportion of each habitat type, we will use ArcMap to measure the total area of each site (extent of site was dependent on range of fish locations) and the area of each habitat type (m^2). 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, March- April 2022
Interim Progress Report and Executive Technical Report	Spring, March 2022
Active Tracking	April – September 2022 (monthly)
Final Report	Winter, November 2022

Agency: US Fish and Wildlife Service (USFWS)

Activities and Methods: Carterville FWCO will lead tagging efforts within the mainstem Ohio River to replace expiring tags in Meldahl, Markland, McAlpine, and Cannelton pools. All tagging will take place during spring and fall when water temperatures are most conducive to fish survival. Fish will be collected using daytime electrofishing and short-term gill net sets. Total length (mm), weight (g), sex, and species will be recorded along with an external tag to identify individuals with internal telemetry tags and to facilitate tag returns from harvested fish. Vemco Model V16-6H acoustic transmitters (69 kHz 16mm diameter, 96 mm length, 34g), programmed to transmit on a random delay from 20 to 60 seconds with a battery life of 1,825 days will be used 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 as outlined in Table 1. These efforts are aimed at maintaining 200 active tags in Cannelton pool, 150 in McAlpine pool, 50 in Markland pool, and 50 in Meldahl pool. Tagging efforts will be allocated throughout each pool and its tributaries to prevent oversaturation of tagged fish in any given area.

Carterville FWCO will also assist with tagging adult invasive carps within J.T. Myers and Newburgh pools. Those efforts will be led by INDNR. Additional information regarding the effort to tag fish in these pools can be found in the INDNR section of this document.

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

All tagging and telemetry data will be sent to KDFWR for initial processing and uploaded to ODOW's FTP site for use by all partners. Carterville FWCO will analyze data from the mainstem telemetry array to estimate pool-to-pool transition probabilities, annual survival, and detection probabilities using RMark (Laake 2013), an R-based interface with Program MARK (G.C. White, Dept. of Fish, Wildlife, and Cons. Bio., Colorado State University, Fort Collins, CO). A report of calendar year 2021 activity and analysis will be available March 2022.

Number of expiring tags to be replaced by pool and species during project period

Cannelton		**McAlpine**		**Markland**		**Capt. A Meldahl**	
Silver	Bighead	Silver	Bighead	Silver	Bighead	Silver	Bighead
92	4	94	1	6	4	0	2

Estimated Timetable for Activities:

Activity	Time Period (Season, Month Year)
Assist with receiver deployment into mainstem Ohio River and replacement of batteries in tributary and L&D receivers	Spring, April – May 2021
Assist with offloading data and maintenance of all receivers	Spring – Fall, May – November 2021
Invasive carp tagging	Spring, April – May 2021 Fall, September – November 2021
Assist with retrieval of receivers from the mainstem Ohio River. Assist with final data offload from tributary and L&D receivers	Winter, December 2021
Report	Spring, March 2022

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

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

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

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

In 2017, TTU commenced standardized, systematic sampling on Kentucky, Barkley, Cheatham, and Pickwick reservoirs to evaluate relative densities of bigheaded carp using gill nets and electrofishing. This project will fund another year of systematic sampling conducted in spring, summer, and fall at those reservoirs.

This ongoing work also aims to increase samples (e.g., otolith, sex, length, and weight data) used to characterize populations (e.g., age, growth, mortality analysis). Tennessee Wildlife Resources Agency and KDFWR commenced inter-agency carp sampling in spring 2019. In 2020, TTU worked with those agencies to continue sampling to further support data collection on bigheaded carp populations in the Tennessee and Cumberland rivers so that data are comparable to past sampling efforts and useful to evaluating demographics. Sampling will continue in 2021 and is proposed for 2022 to continue efforts to supply spatiotemporally-comparable data that can be used to fulfill the objectives and goals of the Sub-Basin framework. The specific purpose of the project is to provide demographics data that can effectively inform managers and stakeholders about populations of bigheaded carp in reservoirs of the Tennessee and Cumberland rivers.

Objectives:

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

Agency: Tennessee Tech University (TTU)

Activities and Methods:

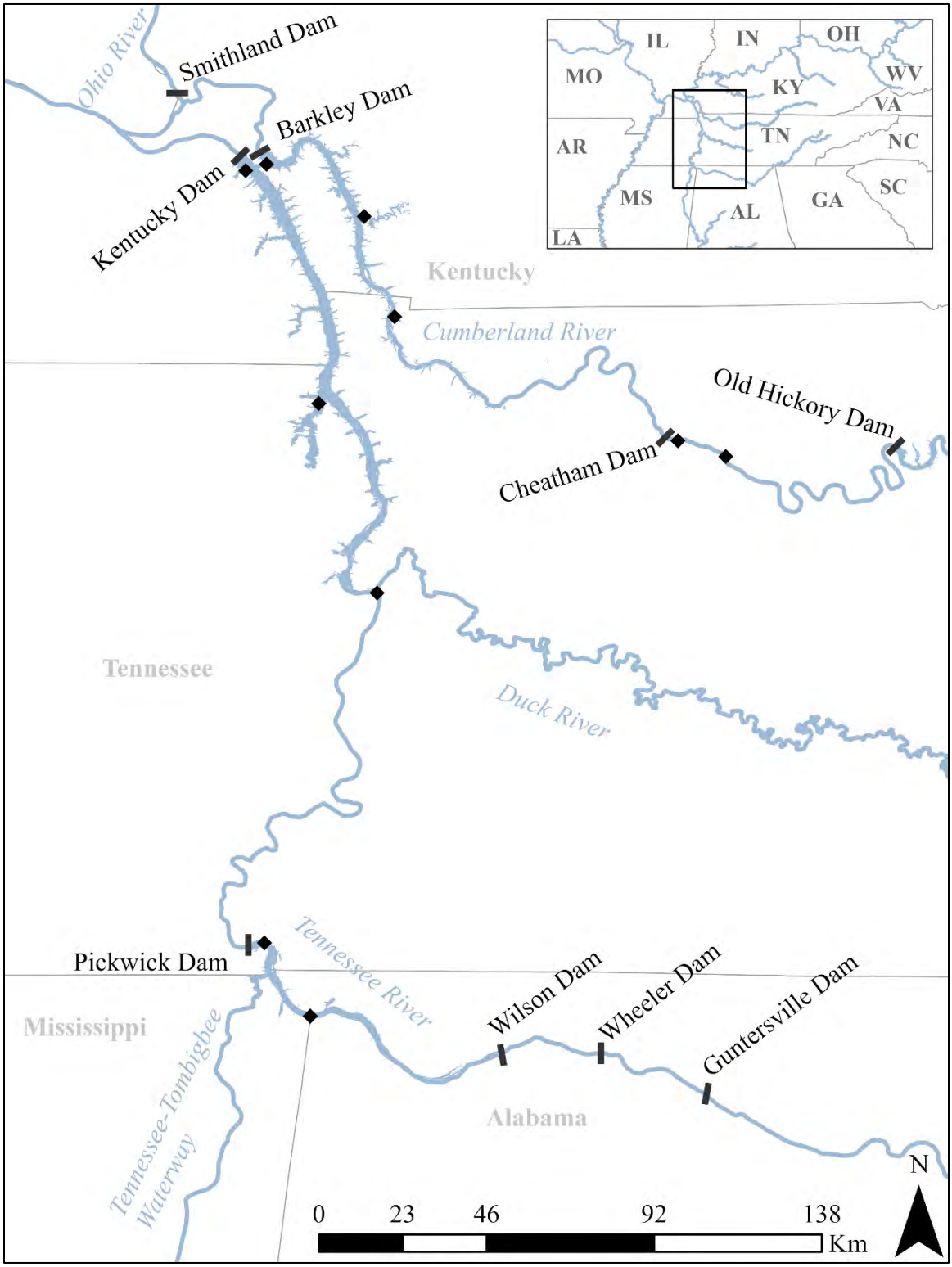
Objective 1: Multi-season sampling with gill nets and electrofishing will be used to evaluate relative abundance and density of adult bigheaded carp in Kentucky, Barkley, Cheatham and Pickwick reservoirs. Experimental gill nets will consist of mesh-sizes measuring 3.00, 3.50, 4.00, or 4.25 inches (bar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

Sampling gears, locations, and timing of deployments for all objectives will be adapted to seasonal water temperatures to ensure minimal mortality of bycatch, valuable sportfish, and prevent any detrimental effects to endangered species or valuable landscape features. In 2020, proposed sampling periods had to be modified due to safety concerns resulting from record high flooding and Coronavirus. Thus, 2021 and 2022 sampling seasons have been slightly altered from past work to increase flexibility and ensure sampling success.

Estimated Timetable for Activities:

Project Activity	Reservoir	Month	Year
Gill Netting	Kentucky, Barkley, Cheatham, and Pickwick	Spring (March-June), Fall (September-November)	2022
Adult Density Electrified Dozier Trawling	Kentucky, Barkley, Cheatham, and Pickwick	Summer (late June to early September)	2022
Final Report		Spring	2023

Map of Project Area:



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

Deterrent Strategy Planning for Asian Carp in the Ohio River Basin

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

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

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

Adult bigheaded carp have been recognized in the Tennessee and Cumberland rivers (tributaries to the Ohio River) for the last three decades with the first detection of Silver Carp in Tennessee in 1989, but a high recruitment event in 2015 caused a large 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. A Master's Thesis completed in 2016 was the first rigorous evaluation of age and growth of Silver Carp and Bighead Carp in Kentucky and Barkley reservoirs. Currently, Sub-Basin agencies and universities are collaborating to enhance that preliminary work by surveying relative densities to inform control needs, 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. Data will inform Tennessee River specific-models that include movement and control needs as are being applied in the Ohio River.

Efforts to understand and control invasive carp in the Tennessee River and Cumberland River have been increasingly supported in the last few years and federal funding has the ability to further enhance control and management capabilities. Cooperative efforts by partners have

resulted in over 750 Silver Carp implanted with acoustic transmitters and a cooperative group is engaged for data sharing and informing movements and potential deterrent placement. Cooperators include ADCNR, Murray State University, Mississippi State University, KDFWR, TWRA, USGS, TTU, MDWFP, and USFWS.

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

Objectives:

1. Characterize the need for deterrents and evaluate priority locations for deterrent placement to control movement of Asian carp in the Tennessee and Cumberland rivers.
2. Collect baseline movement information among reservoirs to inform Asian carp deterrent efficacy and lock and dam passage.

Agency: Tennessee Wildlife Resources Agency (TWRA)

Activities and Methods: 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 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. A focused effort to increase the number of tagged bigheaded carp in the upstream end of Kentucky Reservoir occurred in 2017, 2018, and 2019. Tennessee Technical University crews worked with TWRA and MDWFP to tag fish in upper Kentucky Reservoir and in Pickwick Reservoir. Additional tagging occurred in 2020; however, public-health restrictions due to COVID-19 and record high flows caused some impediments.

Capture of bigheaded carp to be implanted with acoustic telemetry transmitters is completed using short-set gill nets (e.g., 20 minutes) or electrofishing during cool water conditions. Transmitter implantation is completed with minimal handling including electro-anesthesia and immediate release. Tagging fish on the leading edge of invasion (i.e., at upstream reservoirs such as Pickwick and Cheatham reservoirs [Map 1]) is preferable to inform movement and lock and dam passage at locations that bigheaded carp are not currently established. Therefore, tagging will be attempted at upstream reservoirs. If sufficient numbers of fish (minimum number of 50) are not captured at upstream locations, more tags will be implanted at local proximity areas. The number of fish tagged will be increased in 2021 to help further inform movement through locks and dams. Collaboration with USGS partners in 2021 will enhance movement information and modeling to inform deterrents in the Tennessee and Cumberland rivers.

Acoustic telemetry receivers are currently deployed at the three most downstream dams on the Cumberland River and at the five most downstream dams on the Tennessee River (Map 1). Receivers at these locations will be maintained and monitored. Additionally, more receivers will

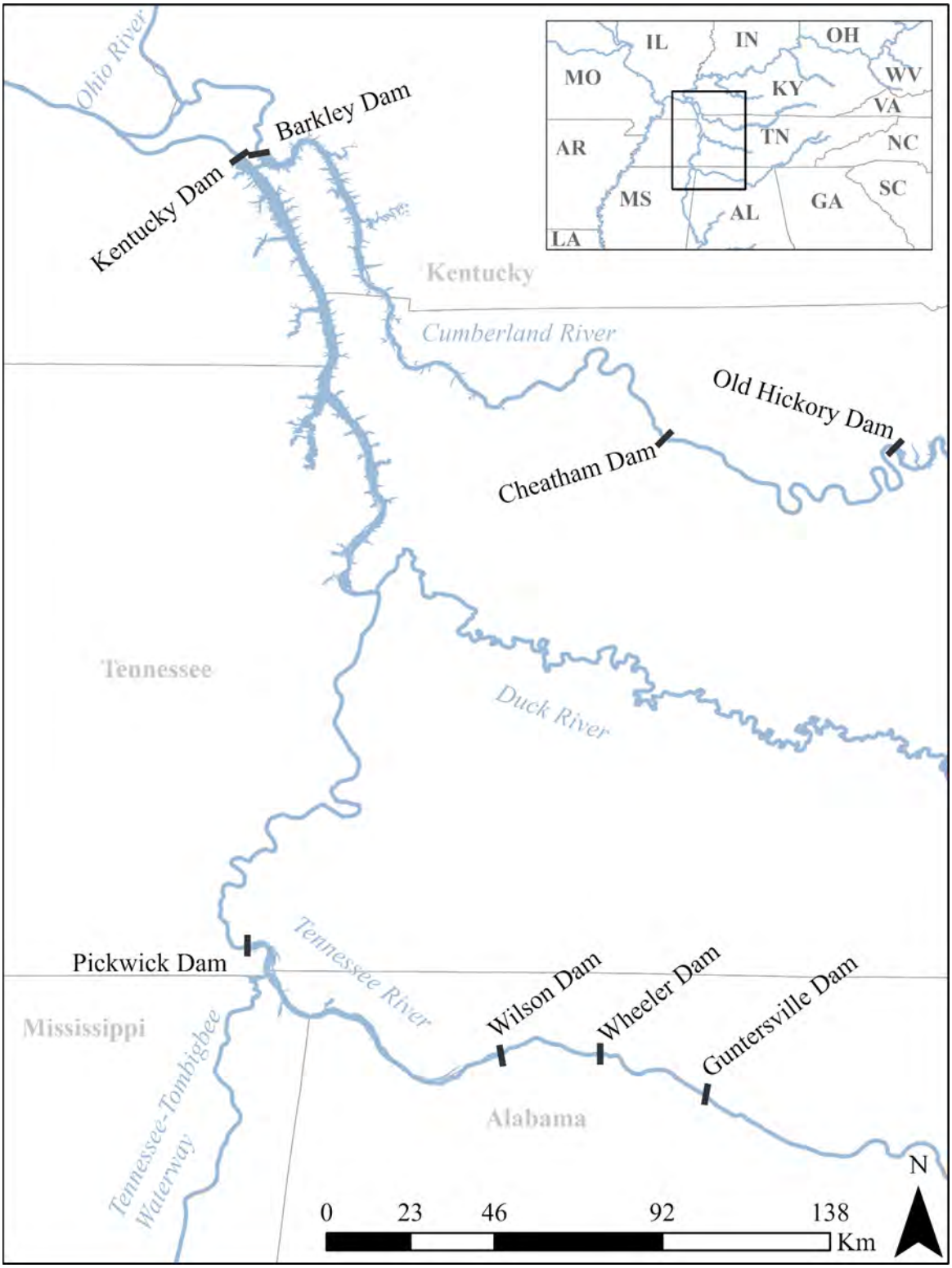
be deployed in 2021, and receiver arrays will be tested using tag-drags to verify reasonable tag detection efficiency (i.e., no major blind spots, obstructions, or other equipment failure).

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

Estimated Timetable for Activities:

Project Activity	Reservoir	Month	Year
Acoustic Tag implantation	Kentucky, Barkley, Pickwick and Cheatham reservoirs	water temperature dependent	fall 2021 and spring and fall 2022 (until all tags are at-large)
Acoustic Receiver deployment and maintenance	Kentucky, Pickwick, Wilson, Wheeler, Cheatham, Old Hickory	Seasonally (minimum of 4X annually) and as needed for maintenance	2021 and 2022
Data summarization/reporting	TNCR	Quarterly updates in congruence with data downloads	2021 and 2022

Map of Project Area:



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

Agency: Murray State University (MSU)

Activities and Methods:
MSU will partner with KDFWR, the USGS, and multiple research agencies to assess consistent Asian carp harvest efforts below Kentucky Dam as deterrence to dam passage. MSU will work with research entities and KDFWR to experiment with a variety of Asian carp harvest gears and methods to efficiently and consistently harvest Asian carp from the tailwater below Kentucky Dam, and to assess if consistent effort will create a deterrence to the invasive fishes' movement into Kentucky Lake. The USGS has proposed to work with MSU and KDFWR to study Asian carp movements towards and below Kentucky Dam pertaining to periodicity and water conditions, and the fishes' behavior in the presence of consistent removal efforts. MSU will coordinate efforts with the USGS and provide pertinent information to the USGS regarding removal efforts that may impact telemetry study results. MSU will be the principal investigator for Asian carp harvest efforts and will collect data associated with factors that affect harvest efficiencies. Water quality data will be collected by all participating entities to provide a better understanding of river conditions that compel Asian carp movements towards and through the dam. This research project will provide important insight for harvest potentials below dams and will provide guidance to fishers or agencies attempting to target and remove Asian carp in tailwater habitats across the Mississippi River basin. Additionally, in the process of conducting this research, it is expected that several million pounds of Asian carp will be removed annually from below Kentucky Dam, thereby reducing propagule pressure that is unimpeded to date.

MSU will conduct tracking of tagged Asian Carp within Kentucky and Barkley lakes to determine diurnal movements, distances traveled, and habitat usage. Manual tracking effort will be increased substantially to better inform fine scale movements of Silver Carp in Kentucky Lake. Additional silver carp in Kentucky Lake will be collected and surgically implanted with transmitters for this study. Transmitters which indicate fish depth will be used in order to gain more information on the behavior of Silver Carp. Native Paddlefish, which have been tagged for other projects, will also be tracked on a fine scale to estimate the habitat overlap between these species and Silver Carp. MSU will conduct analysis on information downloaded from stationary receivers in the TNCR basin by KDFWR and will provide associated reports.

Estimated Timetable for Activities:

Project Activity	Location	Month	Year
24hr manual tracking	KY Lake	Seasonally	2021-2022
24hr manual tracking	Lake Barkley	Seasonally	2021-2022
Receiver Deployment	Tennessee River	as needed	2021-2022
Receiver Deployment	Cumberland River	as needed	2021-2022
Implantation of Transmitters	Kentucky Lake	Seasonally	2021-2022
Contracted Removal as Deterrent	Kentucky Dam Tailwaters	As contractor is available	2021-2022
Project Technical Report	N/A	February	2022

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

Activities and Methods:
Kentucky will provide support to MSU for assessing consistent Asian carp harvest efforts below Kentucky Dam as deterrence to dam passage. The USGS has proposed to work with KDFWR and MSU to study Asian carp movements towards and below Kentucky Dam pertaining to periodicity and water conditions, and the fishes' behavior in the presence of consistent removal efforts. KDFWR will continue to assist with surgically implanting Asian carp with sonic transmitters, deploying stationary receivers, collecting data from the receivers, and support MSU contracted carp harvest efforts. The USGS will be responsible for telemetry data analysis and producing summaries regarding tagged fish movement in the tailwaters and through Kentucky Dam. Water quality data will be collected by all participating entities to provide a better understanding of river conditions that compel Asian carp movements towards and through the dam. This research project may provide better understanding of Asian carp movements and presence near dams in general and will provide important insight for harvest potentials below dams.

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

KDFWR continues to work with multiple agency partners to monitor the pool-to-pool movements of Asian carp in the middle and lower Ohio River. Movements of Asian carp among pools and comparisons of the possible open river conditions at various Locks & Dams will be used to determine the best options for the placement of Asian carp deterrent technologies.

KDFWR will continue partnering with MSU to conduct tracking of tagged Asian Carp within Kentucky and Barkley lakes to determine diurnal movements, distances traveled, and habitat usage. Resolution of the VEMCO stationary receiver array will also be improved. Additional receivers will provide a more accurate depiction of telemetered fish passage which will be used to further advise potential deterrent placements. Passage of Asian carp through other lock chambers on the Tennessee and Cumberland rivers is also being assessed by partners. In order to quantify fish passage and ultimately assess deterrence strategies in these river systems, tagging of additional Asian carp and placement of supplementary receivers is essential.

KDFWR is engaged in assisting the USFWS with testing of a Bio-Acoustic Fish Fence (BAFF) technology on the downstream approach to Lake Barkley Lock chamber (Map 2). In spring and fall, KDFWR will tag an additional 75 bigheaded carp below the lock structure with VEMCO transmitters. Some native fish species will also be implanted with VEMCO acoustic transmitters to assess movement around and through the lock structure throughout testing of the BAFF system. These will include 20 smallmouth buffalo, 20 paddlefish, and 20 freshwater drum in spring and fall of 2021. Fish will be collected by electrofishing and gill netting, and then

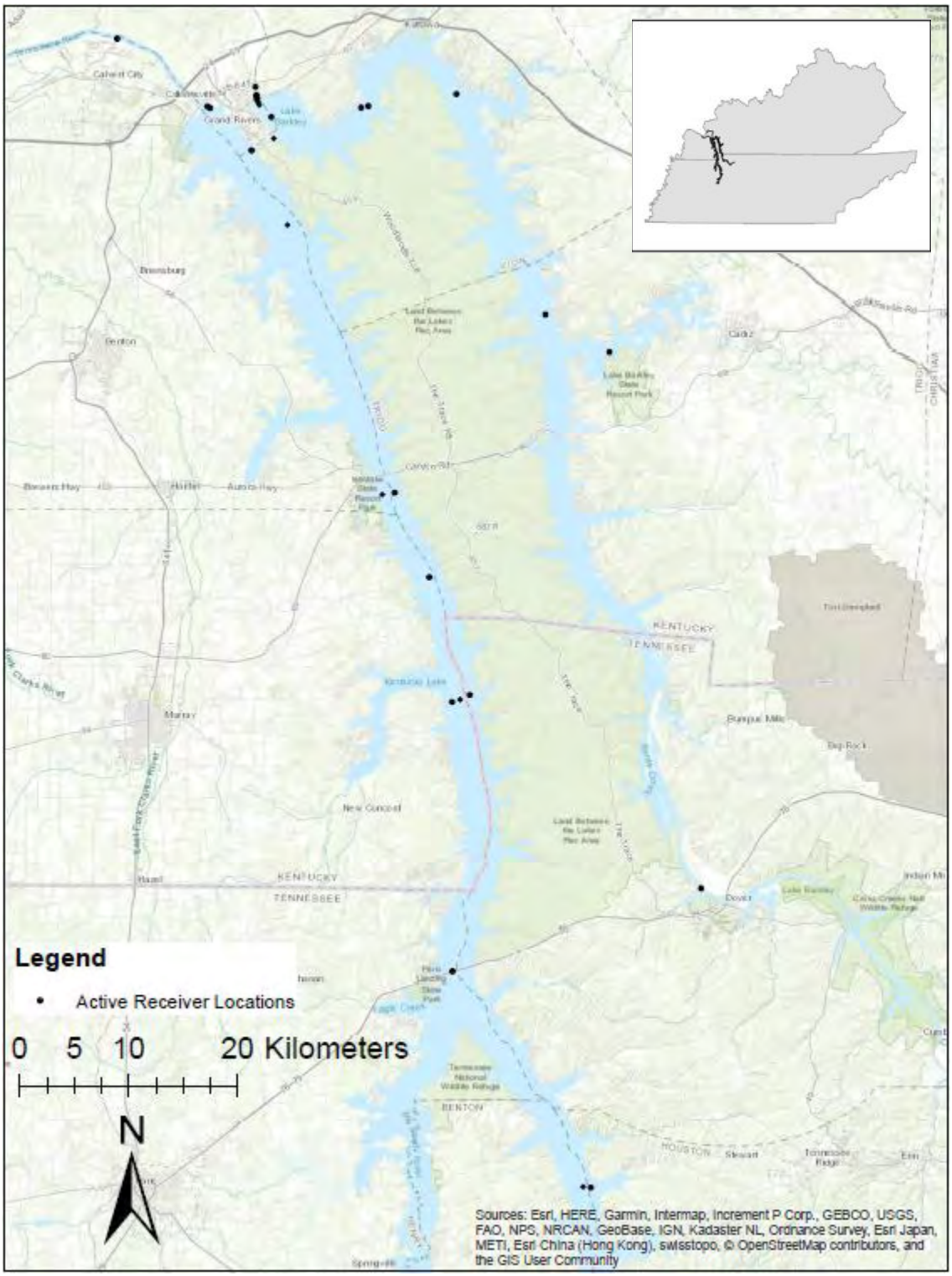
surgically implanted with transmitters. All VEMCO telemetry receivers will be maintained and data collected monthly. Analysis of data collected in the Kentucky portions of the Tennessee and Cumberland rivers will continue to be a joint effort with Murray State University. Receiver locations, acoustic tag numbers, and data collected will be promptly communicated to project partners. Data collected by all partner agencies will be analyzed to determine when fish passage through lock chambers is greatest and how deterrents could best be utilized on the Tennessee and Cumberland rivers.

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

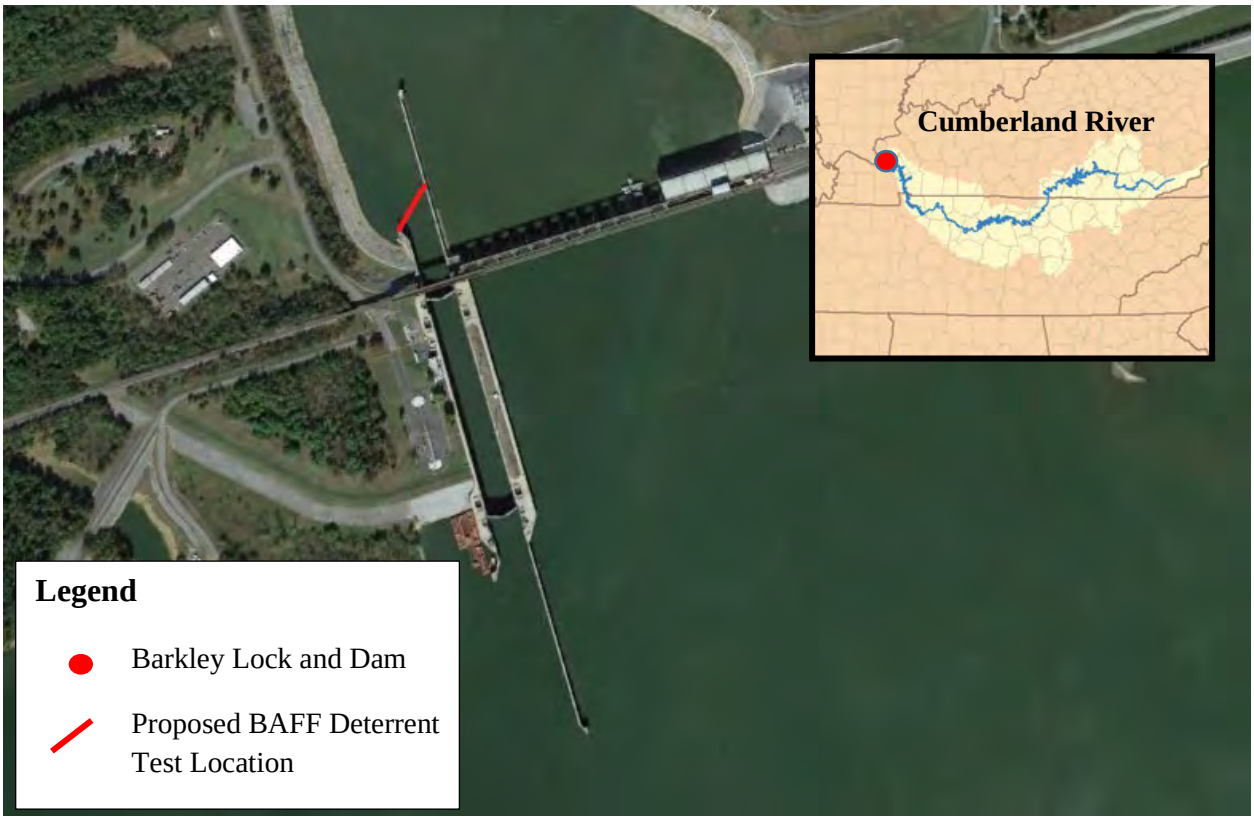
Estimated Timetable for Activities:

Project Activity	Location	Month	Year
24hr manual tracking	KY Lake	Seasonally	2021-2022
24hr manual tracking	Lake Barkley	Seasonally	2021-2022
Receiver Deployment	Tennessee River	as needed	2021-2022
Receiver Deployment	Cumberland River	as needed	2021-2022
Implantation of Transmitters	Barkley Dam Tailwaters	March, April, October, November	2021-2022
Downloading of Receivers	Kentucky Lake & Lake Barkley	Bi-Monthly	2021-2022
Downloading of Receivers	Kentucky Lock & Dam, Barkley Lock & Dam, Tailwaters	Monthly	2021-2022
Assist with Contracted Removal as Deterrent	Kentucky Dam Tailwaters	As contractor is available	2021-2022
Project Technical Report	N/A	February	2022

Map of Project Area:



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



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

TNCR data management application

Agency and Author: Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP), Dennis Reicke (dennis.riecke@wfp.ms.gov) and Mississippi State University, Steve Miranda (smiranda@sfr.msstate.edu)

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

Statement of Need: Data management, data analyses, and reporting are key components of a monitoring program. Although large expenditures are commonly made on data collection, the amount of resources allocated to data management, analyses, and reporting is relatively small and inadequate. The Tennessee and Cumberland River (TNCR) Invasive Carp Partnership is a collaborative network for monitoring invasive Asian carp and sharing data collected by individual members. Data collection by TNCR partners is guided by standardized sampling procedures developed to facilitate compatibility of data. To encourage further standardization, we will develop a system for digitizing data processing, analyses, and reporting. Products from this mechanization will focus on producing information useful to fish managers and policy makers in their decision making.

A similar application, FRAS, was developed for Mississippi Department of Wildlife Fisheries and Parks and is currently in use by the agency to store and analyze statewide fisheries data. This application is currently being expanded to include monitoring planning support. Also, an application to access telemetry data (FishTracks) was developed by the USGS Upper Midwest Environmental Sciences Center. Our application is expected to be similar to FRAS and able to interface with FishTracks.

Objectives:

1. Develop web or desktop applications to analyze, summarize, and distribute data collected by Tennessee and Cumberland Rivers (TNCR) collaborators through standardized procedures from stored data
2. Provide a platform for storing and sharing non-standard data relevant to TNCR collaborators but contributed by external agencies

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

Activities and Methods:

Objective 1: Develop web or desktop applications to analyze, summarize, and distribute data collected by Tennessee and Cumberland Rivers (TNCR) collaborators through standardized procedures from stored data. During this first year we will finalize standardized protocols for monitoring bigheaded carps in the Tennessee and Cumberland rivers. Guided by this protocol, we will start building an application to facilitate storage and processing of data collected under the protocol and make the data available to cooperators. Standard analyses and reports requested

by TNCR will be developed using the R program. The programs will focus on facilitating data sharing, use, and analysis. They will provide TNCR agencies with automated reports and resource managers with summary and visualization tools to analyze the spatial and temporal distribution of bigheaded carps in the TNCR region.

Objective 2: Provide a platform for storing and sharing non-standard data relevant to TNCR collaborators but contributed by external agencies. During this first year we will identify all relevant data bases available in the TNCR region. These may include contracted fishing, agency netting and electrofishing, water quality, and other collection operations. The TNCR app will provide centralized access to these ancillary datasets in a scalable, query-able, downloadable database format.

Estimated Timetable for Activities:

Project Activity	**Time Period (Season, Quarter, month/year)**
Complete monitoring protocols	Oct-Dec 2021
Complete app architecture based on protocols	Oct-Dec 2021
Complete list of existing databases	Oct 2021-Jan 2022
Request existing data bases	Feb-Sep 2022
Program data entry modules	Jan-Jun 2022
Program data storage modules	Jan-Sep 2022
Program data analyses modules	Jan-Sep 2022
Develop system for storing and downloading data	May-Sep 2022

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

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

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

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

This project will further develop standardized protocols to assess abundance and population dynamics of invasive carp and determine effectiveness of control measures. TWRA and KDFWR have invested in commercial carp removal programs, and the USFWS has funded a sound barrier experiment at Barkley Lock. To measure the success of these control measures, agencies need standardized sampling methods that will allow comparisons among water bodies and over time. Foundational research on carp sampling has been conducted by USFWS, KDFWR, TWRA, and TTU using USFWS Invasive Carp base funds and local funding sources. These projects have tested many sampling methods, identifying the best available methods for sampling carp. This project will increase capacity for standardized sampling in TN, KY, and AL. Ultimately, while Mississippi Department of Wildlife, Fisheries, and Parks is not requesting funding for this project for FY 2021, 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.

In this project, KDFWR will evaluate the response by the native fish community and their fisheries in the presence of Asian carp. Fisheries managers need 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. For example, all state agencies have been monitoring native sport fisheries in the TNCR, and the TVA has a long-term monitoring program for native fish communities in the Tennessee Valley. In this new project, the KDFWR will

evaluate the response of native fishes, such as gizzard shad, buffalo, and paddlefish, which compete directly with bigheaded carp for zooplankton.

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

Objectives:

1. Estimate Asian carp relative abundance, and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.
2. Examine Asian carp impacts on native fish communities.
3. Target and remove Asian carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

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

Activities and Methods:
Objective 1: KDFWR will use a combination of standardized sampling and monitoring of commercial harvest to evaluate relative changes in Asian carp abundance in Kentucky and Barkley lakes. Standard sampling with gill nets will be conducted at sixteen sites on Barkley and Kentucky reservoirs. These standard sites were selected to provide adequate sampling parameters, decrease conflict with anglers, and provide static locations to monitor changes in catch per unit effort (CPUE). Four embayment sites and four main channel sites were selected on each reservoir. These sites will be sampled once during the following seasons; spring (April), summer (July), and fall (October). A total of four nets will be fished at each location during sampling periods and in orientations specific to each location. Sampling will occur when the lake level is greater than 354’ in areas where water depth is a minimum of 13’. Nets will be deployed one hour before sunset and retrieved one hour after sunrise the following morning (according to the official rise and set tables). Specific coordinates will be determined for all sets, and nets will be set at the same locations each season and for each subsequent year of gill netting effort. Sinking experimental gill nets 10’ deep, 300’ total length, with 100’ panels of 3”, 4”, and 5” mesh will be fished overnight. Gill nets will be 12’ deep tied down to 10’ every 8’. Each of the 100’ panels of webbing will be hung with 30” stretch in 16” ties (3” square, 5 meshes per 16” of linear net; 4” square, 4 meshes per 16” of linear net; and 5” square, 3 meshes per 16” of linear net). Webbing used in each panel will be constructed of 8 ply, 0.2-mm twist mesh. Cross ties for these nets will be constructed from #15 white bonded twine through the webbing. Catch rates and species captured will be recorded for each gillnet mesh size.

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

The KDFWR Asian Carp Harvest Program requires commercial fishermen to report total weights of harvested Asian 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 estimate average weights of individual silver carp commercially harvested. This value will be used to determine the number of individual silver carp harvested during the study. This information will be an additional metric in the assessment of Asian carp population demographics.

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

Objective 2: During standard sampling described above, total length and weight data will be collected from bigmouth buffalo and paddlefish. During Paupier net sampling, total length and weight data will be recorded for gizzard shad as well. Measurements will be used for determining condition factors through relative weight analysis. Values will be monitored over time to determine if they will be useful to assess impacts that Asian 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 Asian carp species (Irons et al. 2007, Schrank et al. 2003).

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

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

Summer and fall of 2021, KDFWR will perform a random, non-uniform probability, roving creel survey on the Kentucky portion (45,600 a) of Lake Barkley through 30 November 2021. The Kentucky portion of the lake 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 Lake Barkley and Asian carp specific information is conducted by the creel clerk throughout the survey period. Data collected during the creel survey will be compared to historical surveys to determine changes in fish community, catch rates, angler use, opinions, and success. Changes occurring over the past decade when Asian carp populations have become more abundant in Lake Barkley will be reviewed thoroughly.

In spring of 2022, KDFWR will resume the creel survey in the tailwaters of Kentucky and Barkley lakes. Random, non-uniform probability creel surveys will be conducted from February 16, 2022 through November 15, 2022 in the Kentucky Tailwater and the Barkley Tailwater. The Kentucky Tailwater survey extends from the Kentucky Lake Dam downstream to the Interstate 24 bridge. The Barkley Tailwater survey extends from the Lake Barkley Dam downstream to the US Hwy 62 bridge. Dates and periods for surveys each week are randomly selected, and creels are conducted in each tailwater at least 10 days per month in each tailwater, including a minimum of 3 weekend days. Each day is divided into three periods: morning, afternoon, and late evening. The late evening period is only utilized for a portion of the survey to collect snagging and bow fishing data. Daily, access point surveys consisting of instantaneous angler counts and angler interviews will be conducted from the bank; no boat will be used. Timing of recreational fishers' counts are randomly chosen daily, and data is extrapolated accordingly to calculate daily average and total effort. An attempt to interview all recreational fishers each day will be made. Data collected during the creel surveys will be compared to historical surveys to determine changes in fish community, catch rates, angler use, and success. Recreational fishers

will also be administered an angler attitude questionnaire to gauge opinions regarding their levels of satisfaction with the fishery and on current or proposed regulations. Increasing Asian carp numbers in the tailwaters over the past decade has perpetuated a significant increase of bow fishing. During 2019, regulations were enacted in Kentucky to allow the sale of Asian carp harvested by recreational fishers. The 2022 creel survey will provide data to assess the effects of the new regulation.

Objective 3: KDFWR will continue to dedicate staff time towards observing commercial fishing and facilitating efforts to assess the impacts of targeted removal of Asian carp on non-target native species. Commercial fishers requesting to fish in the ACHP are required to provide daily reports including amount of fishing effort, the type of gear used, pounds harvested, and bycatch. Fishers are also required to list the number of fish caught for each species, fish released, and disposition. The information will be used to assess impacts of commercial harvest on bycatch species.

To verify commercial fishers' reports, KDFWR occasionally provides observers to record harvests (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 Asian carp harvested.

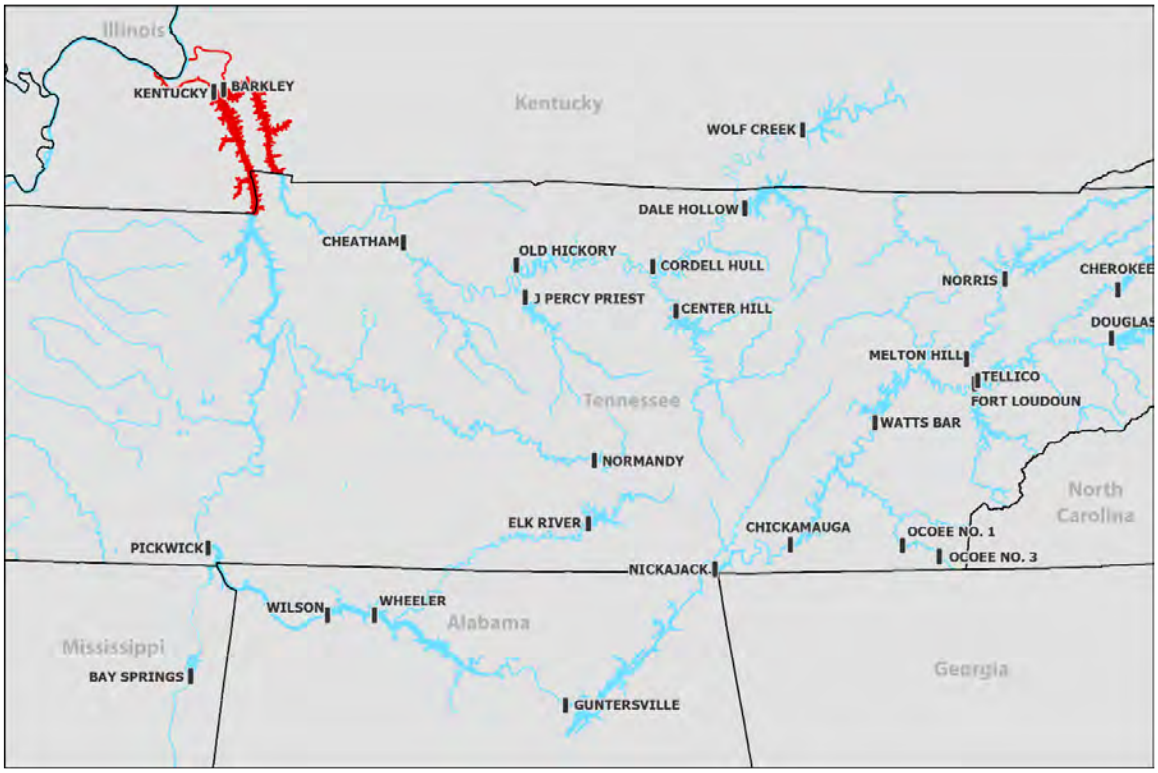
KDFWR will continue to offer contract fishing in Kentucky and Barkley lakes to ensure commercial fishing effort targeting Asian carp remains strong. Commercial fishers must apply for the contract program and once approved, will receive a designated price per pound for Asian carp species harvested from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

KDFWR staff will conduct targeted removal of Asian carp through electrofishing and gillnetting as time allows. Electrofishing will occur on the lower Cumberland River below Barkley Dam and the lower Tennessee River below Kentucky Dam. These areas have high densities of Asian carp in confined areas and will be targeted when conditions are most conducive for mass removal with this gear (i.e. low water elevation, warm water temperatures, reduced barge traffic). Gillnetting effort will be focused on Kentucky and Barkley lakes and may coincide with training new commercial fishers. Active sets will be used primarily, targeting large schools of Asian carp that can be encircled with nets and harvested. Previous years efforts included approximately 40 days of agency removal effort, however, a significant amount of staff time will be expended in FY21 and FY22 to assist other research and private entities to test new Asian carp harvest gears. Testing will be conducted as collaborative effort with entities including but not limited to Murray

State University, the US Fish and Wildlife Service, US Geological Survey, commercial processors or fishers, and other private entities. All gear types will be evaluated by appropriate staff from each agency or entity involved. KDFWR will support and assist with gear development and testing, and identification and clearing of Asian Carp Harvest Areas. KDFWR staff will be present when any experimental gears are tested. Fish population demographics will be recorded to assess gear efficiencies, bycatch, and determine potential of the methods to be used for assessing Asian carp abundances in the reservoirs. 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 Objectives 1 & 2.

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



Estimated Timetable for Activities:

Project Activity	Pool	Month	Year
Standard Asian Carp Sampling	Kentucky / Barkley	Spring, Summer, Fall	2021 - 2022
Collection of Asian Carp Demographics Information	Kentucky / Barkley	All Seasons	2021 - 2022
Ride Alongs with Commercial Fishermen	Kentucky / Barkley	All Seasons	2021 - 2022
Ride Alongs with Commercial Fishermen	Lower Tennessee / Cumberland Rivers	All Seasons	2021 - 2022
Tailwater Community Survey	Lower Tennessee / Cumberland Rivers	Spring and Fall	2021 - 2022
Testing of Experimental Harvest Gears	Kentucky / Barkley	All Seasons	2021 - 2022
Creel Survey	Barkley	Summer, Fall	2021
Creel Survey	Barkley / Kentucky Tailwaters	Spring, Summer, Fall	2022
Purchasing and Acquisition of Equipment	Kentucky / Barkley and their respective tailwaters	All Seasons	2021 - 2022
Paupier Net Sampling for Relative Abundance	Kentucky / Barkley	Fall and Spring	2021 - 2022
KDFWR Removal Efforts: Gill nets, Electrofishing, Paupier Net Boat	Kentucky / Barkley and their respective tailwaters	All Seasons	2021 - 2022
Clearing of Asian Carp Harvest Areas	Kentucky / Barkley	Fall, Winter, Spring	2021 - 2022
Observing MSU Contractor efforts	Kentucky / Barkley	All Seasons	2021 - 2022
Contract with Commercial Fishers Harvesting Asian Carp	Kentucky / Barkley and their respective tailwaters	All Seasons	2021 - 2022
Purchasing, Set Up, and Maintenance of Industrial Ice Machine	Kentucky / Barkley	As contractor is available	2021 - 2022

Agency: Murray State University (MSU)

Activities and Methods: MSU will work with KDFWR to elevate participation with testing new or different standard sampling technologies designed to assess abundances of Asian carp in Kentucky and Barkley lakes and their associated tailwaters. MSU will also conduct significant research on a variety of projects to assess gear efficiencies for targeting and removing mass numbers of Asian carp from Kentucky and Barkley lakes.

Objective 1: To supplement standard sampling with gill nets conducted by KDFWR, MSU will assist the USFWS to further examine the efficacy of the electrified Paupier sampling method to assess relative abundance trends of Asian carp in Kentucky Lake. Previous years' sampling by the USFWS have identified standard sampling criteria including electrical array designs and electricity output specifications, areas and diel periods most suitable for optimizing sampling efficiencies. Specific sampling regimes will be developed by the USFWS and closely mimic sampling efforts conducted with those gears in previous years (Towne et al. 2020). MSU will subcontract with a private entity with Paupier technology to bolster the sampling regime , which will improve statistical accuracy of relative abundance estimates. Electric fields of both Paupier net boats will be mapped by the USFWS and settings of electrofishing units will be determined by the USFWS. The USFWS, KDFWR and TWRA are also interested in research comparing sampling efficiencies between the Paupier and Dozer methods.

Demographics data will be collected from Asian carp captured as needed and included with KDFWR data for analyses.

Objective 2: During sampling described above, total length and weight data will be collected from gizzard shad, bigmouth buffalo, and paddlefish. Measurements will be used for determining condition factors through relative weight analysis. This information will be incorporated with data collected through KDFWR sampling.

Objective 3: MSU will contract at least one research entity to test various experimental harvest methods in Kentucky Lake to find potential increases in Asian carp removal efficiencies. The research will include sampling at least five Kentucky Lake bays, and executing at least three attempts in each bay to quantify harvest efficiencies. The research entity or contractor will be responsible for conducting all aspects of this experimental harvest methods research, including but not limited to: blocking designated bays with nets, herding the fish, seining, removal, transportation, fish disposal, and data collection for method used, effort in man hours, bycatch, pounds of Asian carp harvested, and field notes regarding complications identified or potential changes for increasing efficiency with that gear type.

In 2021, MSU will contract an entity to work with KDFWR to clear the remaining three "Asian carp harvest areas" of substrate debris. These harvest areas will be cleared for further mass-removal methods that MSU and KDFWR will test. Each harvest area will be approximately 300 x 100 meters, and they will be marked to inform fishers, researchers, and the public of their locations. Outreach to the public will be extensive to ensure they are aware of the reasons for the areas and do not place new structures within the buoy boundaries.

Data collected on fish captured through all removal efforts will be used to inform Objectives 1 & 2.

Estimated Timetable for Activities:

Project Activity	Pool	Month	Year
Paupier Net & Dozer Trawl Sampling	Kentucky / Barkley	October – November April	2021-2022
Clearing of Asian Carp Harvest Areas	Kentucky / Barkley	September – March	2021-2022
Contracted Experimental Harvest efforts	Kentucky / Barkley	All seasons	2021-2022

Agency: Tennessee Wildlife Resources Agency (TWRA)

Activities and Methods:

Objective 1:

Gillnetting – TWRA staff will identify fixed sites in Kentucky (6 sites), Pickwick (1), Barkley (3), Cheatham (3), and Old Hickory (3) lakes to set clusters of gillnets. Each site will be sampled at least twice a year, once during summer (July-Sept) and again in the winter (Nov-Jan). At each site, four overnight gillnet sets will be deployed. Nets will be distributed in embayments from the mouth to the back of the embayment (approximately 10-foot depth). Individual nets will be 300-ft in length with 100-ft panels of 3-, 4-, and 5-in mesh. Nets will be 12-ft deep, hobbled to 10-ft every eight feet; nets will have 0.5-in foamcore float line and 65-lb leadcore lead line. The webbing used in each of these panels will be constructed of 8 ply, 0.2-mm twist mesh. Catch of all species will be recorded by mesh size. We are not attempting to herd fish into nets using electrofishing, acoustic boats, or any other method. As further analyses are completed on data from previous years and similar sampling efforts, gill netting methods may be adjusted to fit the best available information. Any deviations from the sampling methodology provided above will be thoroughly described in the annual interim report.

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

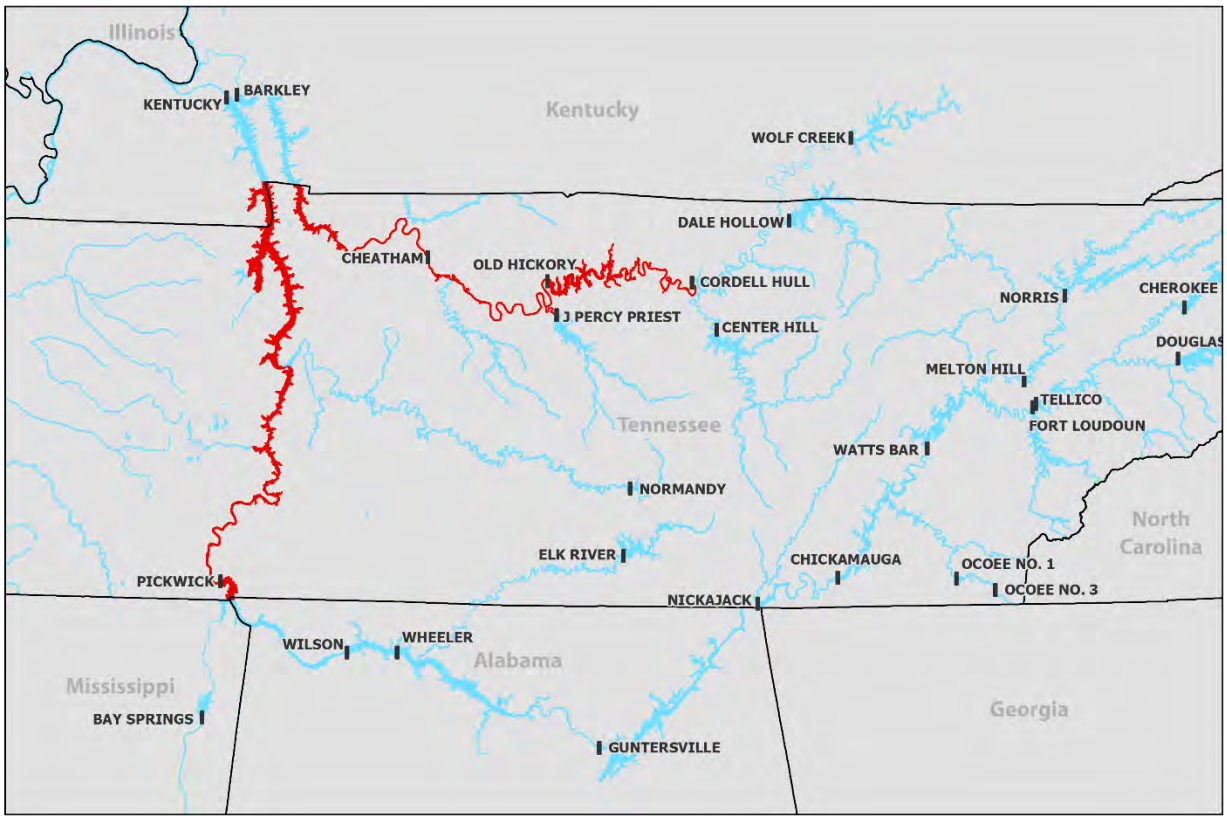
Fish Collected During Surveys – All carp species will be removed from the lake. Carp species (or a subsample) will be examined to determine species, length (mm), weight (g), and sex. Sex of bigheaded carp will be determined based on the morphology (serrated pectoral spines are males).

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

Objective 3:
ACHIP – TWRA will contract with licensed wholesale fish dealers to remove Asian 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 ACHIP purchases and quantify harvest.

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



Estimated Timetable for Activities:

Project Activity	Pool	Month	Year
Electrofishing/Dozer Trawl	Kentucky, Pickwick, Barkley, Cheatham, and Old Hickory lakes	July-Sept and Nov-Jan	2022
Gillnet	Kentucky, Pickwick, Barkley, Cheatham, and Old Hickory lakes	July-Sept and Nov-Jan	2022
Commercial Surveys	Sample carp harvested within ACHIP program (Agency specified lakes)	Mar-Apr, Jul-Aug, and Dec-Jan	2022
Targeted removal (ACHIP)	Agency specified lakes	ASAP	2021-2022

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

Activities and Methods:
Objective 1: Field work 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. ALWFF will survey Asian carp populations using a variety of standardized sampling methods, primarily gillnetting and electrofishing, to estimate relative abundance and population demographics. Surveys will be conducted at both pre-determined and random sites throughout the Alabama portion of the Tennessee River. Information obtained will be used to help define the "invasion front" of Asian carp in the Tennessee River basin within Alabama. All information from targeted 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 training purposes.

Gillnet Sampling: ALWFF will conduct gillnet sampling at predetermined sites on Pickwick Reservoir (3 sites), Wilson Reservoir (3 sites), and Wheeler Reservoir (4 sites). At each site, four gill nets will be set and fished overnight. Each site will be sampled a minimum of twice per year; once during the summer season and again in the fall. The number of total net-nights sampled will be determined by success rate. If fish are difficult to capture at a given location, then more net-nights of sampling may be necessary. Individual nets will be 300-ft in length with 100-ft panels of 3-, 4-, and 5-in mesh. Nets will be 12-ft deep, hobbled to 10-ft every eight feet; nets will have 0.5-in foam-core float line and 65-lb lead-core lead line. The webbing used in each of these panels will be constructed of 8 ply, 0.2-mm twist mesh. Catch of all Asian carp species will be recorded by mesh size.

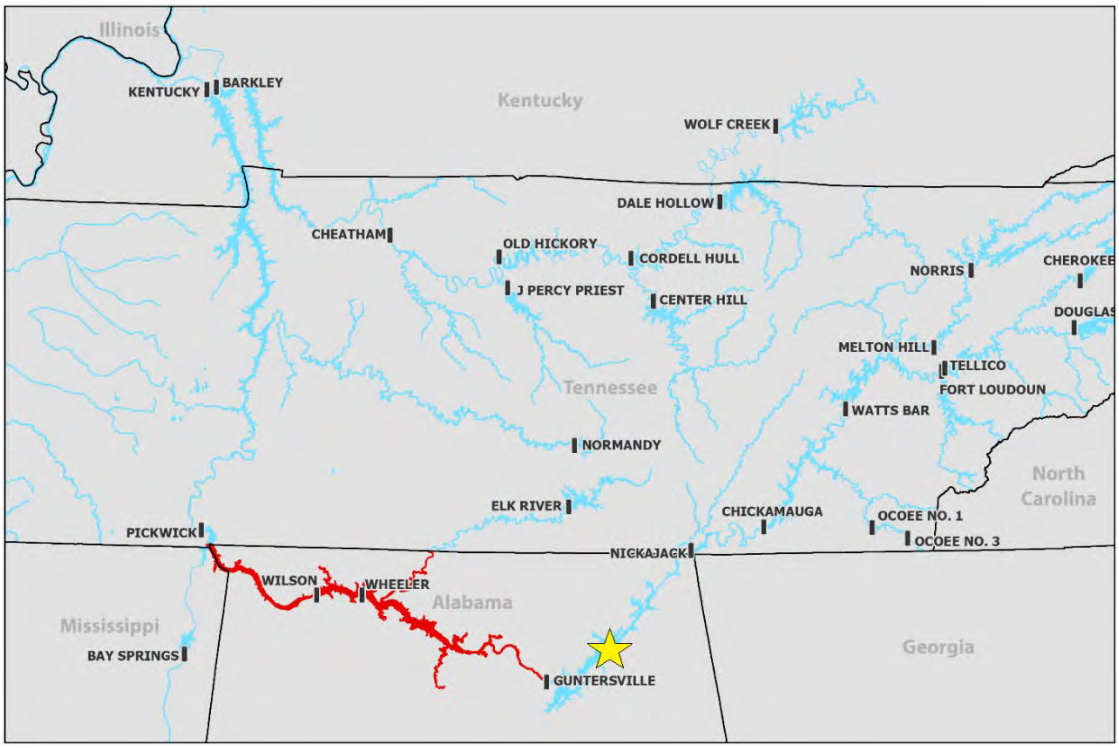
Dozer Trawl – ALWFF staff will conduct electrified dozer trawls as a standard method of sampling. Dozer trawl sites will be established in Pickwick, Wilson, and Wheeler Reservoirs. Multiple factors, such as logistics, feasibility, and scientific and statistical robustness, will be used in determining number and location of sampling sites. Specifications of the dozer trawl will be like those currently operated by TTU and USFWS's Columbia Field Office. Dozer trawl surveys will be seasonal, similar to gill netting, and conducted during the daytime. Sampling transects may include a variety of habitat types (i.e., backwaters, channel borders, shoreline areas, open water). Each trawl sample will be conducted for at least 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.

Fish Collected During Surveys – All collected Asian carp specimens, or an appropriate subsample, will be examined to determine species, length (mm), weight (g), and sex. Otoliths and/or fin rays will be removed from Asian carp for age and growth analysis. Other metrics may be collected if needed.

Objective 3: All Asian carp collected during the project sampling period will be removed during the fish survey work described in Objective 1; however, any Asian carp collected with a tracking

device will be documented and released immediately. This active removal of fish will be especially important to slow the upstream migration of Asian carp, since the leading edge of their migration in the Tennessee River basin is likely located in Alabama. All by-catch for each sampling gear will be recorded and any non-target fish will be released immediately after capture.

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



Estimated Timetable for Activities:

Project Activity	Location	Season	Year
Gillnetting	Pickwick, Wilson, and Wheeler reservoirs	All Seasons	2021 & 2022
Electrofishing	Pickwick, Wilson, and Wheeler reservoirs	Spring Summer, Fall	2021 & 2022

Literature Cited:

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.

Schrank, S. J., C. S. Guy, and J. F. Fairchild. 2003. Competitive Interactions between Age-0 Bighead Carp and Paddlefish. Transactions of the American Fisheries Society 132:6, 1222-1228.

Towne, K., E. Pherigo, W. Doyle, J. Kallis, and J. Goekler. 2020. Relative abundance and length distribution of silver carp in Kentucky Lake. Columbia Fish and Wildlife Conservation Office Sampling Report. United State Fish and Wildlife Service.

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

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

Cooperating Agencies: TWRA, Tennessee Technological University (TTU)

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

Invasive carp reproduction is not 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. No evidence of successful invasive carp reproduction has been detected during larval sampling efforts and the 2015 year class remains the dominant cohort of fish captured during sampling efforts since 2016. The larval and juvenile sampling in this plan are critical for understanding the source of carp in the TNCR and making relative management decisions (location and amount of harvest and deterrence projects).

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

Objectives:

1. Conduct systematic sampling to monitor for and document invasive carp spawning and recruitment.
2. Develop and implement monitoring programs for early detection of invasive carp in waters upstream of the current leading edge.

Agency: Tennessee Wildlife Resources Agency

Activities and Methods:

Objective 1: 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. Site selection and number of samples collected with each gear are being further developed and will consider previous efforts and new information from

Tennessee Valley Authority's FluEgg modeling. Most sampling efforts will likely utilize a combination of fixed and random sites.

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

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

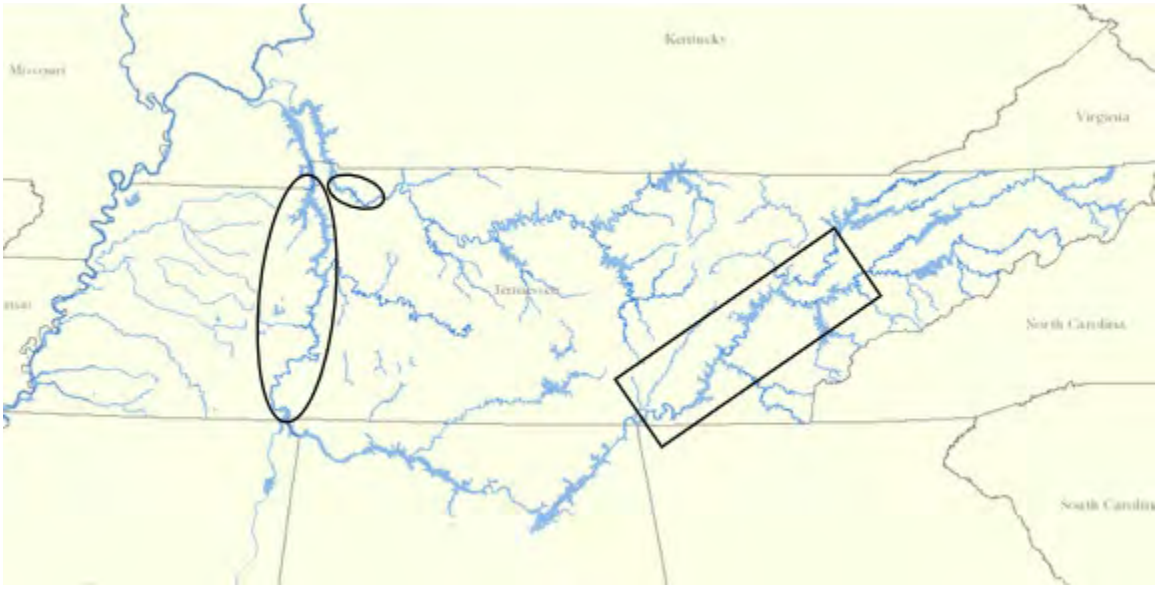
Mini fyke nets will be deployed during August. Approximately 40 nets will be run each week. Net leads are typically set oriented perpendicular to shore with the cod end stretched lakeward, preferably in less than 8-ft of water. Daytime sets of approximately 6 hours soak time will be used. Catch will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

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

Objective 2: 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 invasion front. Additional sampling, including dozer trawls, gill nets, and eDNA collection, will depend upon staff and partner (TTU) availability.

Map of Project Area:



Map depicting Tennessee waters. The large oval (Kentucky Lake; Tennessee River) and small oval (Lake Barkley; Cumberland River) have existing populations of invasive carp and will be the focus of efforts to monitor for successful carp reproduction. The rectangle encompasses waters of the Tennessee River above the current 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, 2022
Larval light traps	Kentucky and Barkley reservoirs	May-August, 2022
Mini fyke nets	Kentucky and Barkley reservoirs	August, 2022
Dozer trawls	Kentucky and Barkley reservoirs	June-December, 2022
Electrofishing	Nickajack, Chickamauga, Watts Bar, Ft. Loudoun, and Melton Hill dams	April-September, 2022
eDNA collection	Guntersville, Nickajack, Chickamauga, Watts Bar, and Ft. Loudoun reservoirs	TBD, 2022

Upper Mississippi River Sub-Basin Invasive Carp Partnership

The Upper Mississippi River Conservation Committee (UMRCC) is a partnership of the five mainstem Upper Mississippi River (UMR) states. The UMRCC Fisheries Technical Committee, which includes federal agency partners, completed a revised *Upper Mississippi River Fisheries Plan* in 2010. Goal 4 in the 2010 Fisheries Plan is to 'slow or eliminate the spread or introduction of aquatic nuisance species, including pathogens to the UMR.' The UMRCC Fisheries Technical Committee formed an Ad-hoc Asian Carp Team (UMRACT) to develop an Upper Mississippi River Basin Asian Carp Control Strategy Framework (UMRB Framework) to coordinate Asian 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 existing UMRCC's 2010 Fisheries Plan Goal 4.

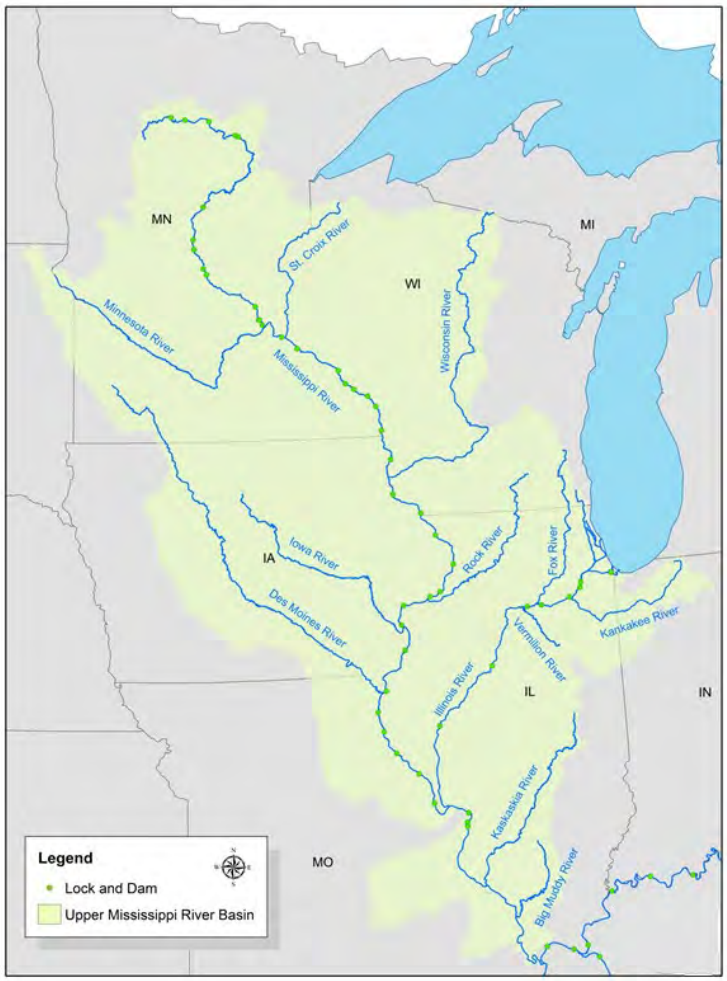


Figure 8. Map of the Upper Mississippi River Basin.

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

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

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

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

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

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

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

Objectives:

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

Agency: Minnesota Department of Natural Resources (MNDNR)

Activities and Methods:

Larval Trawling

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

Purse seine

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

The seine measures 2,000 ft. long and 40 ft. deep with 5 inch stretched mesh (2 ½" square mesh). The seine will also be constructed in panels connected with ½" braided poly rope and snap links to allow for reconfiguration to allow crews to use the seine as a standard commercial beach seine. The seine will be set using a small boat pulling one end of the net in a circular manner from another boat carrying the remainder of the seine. Once the seine is deployed, a purse line on the bottom of the net will be pulled tight to entrap the fish present within and the net will be hauled by winch or by hand to allow for the sorting of the enclosed fish. It is expected that the state contract commercial fisherman will transport and haul this seine due to its size and the expertise commercial fishermen have with setting a commercial-sized net of this complexity.

Electrofishing
Electrofishing will occur from May through September in a variety of habitats including backwaters, side channels, main channel borders, and over wing dikes. Sampling locations will be determined at the discretion of the sampler in a manner to target potential congregations of invasive carp throughout the field season. During large sampling events, electrofishing will be done in conjunction with gill netting to better push fish into large mesh gill nets.

A smaller electrofishing boat with an outboard jet motor will be used to sample shallow backwaters, in conjunction with the larger electrofishing boat. It is believed that juvenile invasive carps are a limiting life stage to their populations' growth and that juvenile invasive carps likely overwinter in anoxic backwaters.

Gill Netting
Gill netting and trammel netting will occur from March through December as time and conditions allow. Stationary large mesh gill nets of depths from 8 to 24 ft. with square mesh sizes of 3.5 to 6 in. will be used to target adult invasive carps. Stationary experimental gill nets 250 ft. in length and 6 ft. deep consisting of 50 ft. compliments of net with square mesh sizes 0.75, 1, 1.25, 1.5, 2 in. will be used to target juvenile invasive carps. Nets may be set either short term or overnight, with short-term sets favored when water temperatures are greater than 60º F.

Commercial Fishing

Commercial fishermen will be contracted to target invasive carp with both gill nets and seines on all monitored systems. MN DNR personnel will accompany contracted commercial fisherman to direct sampling locations and monitor efforts. Netting will occur at the discretion of MN DNR personnel in likely invasive carp habitats or as a response to captures. Fish collected that are also needed for age and growth analysis or tagging may be utilized. The number of fish caught by species will be recorded during gill netting operations and total weight harvested will be requested from the commercial fisherman for both gill netting and seining operations.

In addition, private commercial gill net and seine operations will be monitored when possible to observe for invasive carp. Sampling site locations, sampling dates, gear description, effort, habitat type (main channel border, backwater, wing dike, etc.), water depth, and crew details will be recorded for each net set.

Invasive Carp Tracking

Pursuant to Minnesota Statute 84D.05, invasive carp collected in Minnesota waters can be tagged and released by Minnesota Department of Natural Resources staff: “Permit for invasive carp. The commissioner may issue a permit to departmental divisions for tagging bighead, black, grass, or silver carp for research or control. Under the permit, the carp may be released into the water body from which the carp was captured. This subdivision expires December 31, 2021.” MNDNR is working through the legislative process to remove the sunset clause on this statute. Based on the tagging results, researchers will gain a better understanding of movement patterns and habitat preferences, while posing a very low risk to native fish populations or risk of increasing invasive carp populations. This information will be used to inform detection and removal efforts.

In 2020, multiple invasive carp were permitted to be tagged, released and then tracked by both passive telemetry (using an elaborate receiver array already in place) and active tracking (using finer scale tracking techniques) to determine preferred habitats and movement patterns. Ultimately the goal is to re-capture tagged fish and remove other invasive carp caught. Invasive carp caught, tagged, and released in Minnesota waters follow protocols defined in the MN DNR invasive carp tagging permit (MNDNR 2020).

In 2020, a real-time receiver was be deployed on the St. Croix River to provide the details of the tagged Bighead Carp (or subsequent tagged invasive carp) through emails and/or text messages. Similar to acoustic receivers already in place, the receiver (a VEMCO VR2C cabled receiver) is able to receive, decode, and log transmissions from tagged fish in the area including the fish’s unique identification number. In addition, this receiver is fitted with solar panels and a modem to transmit the data of specific fish electronically through 4G telecommunications to the MN DNR

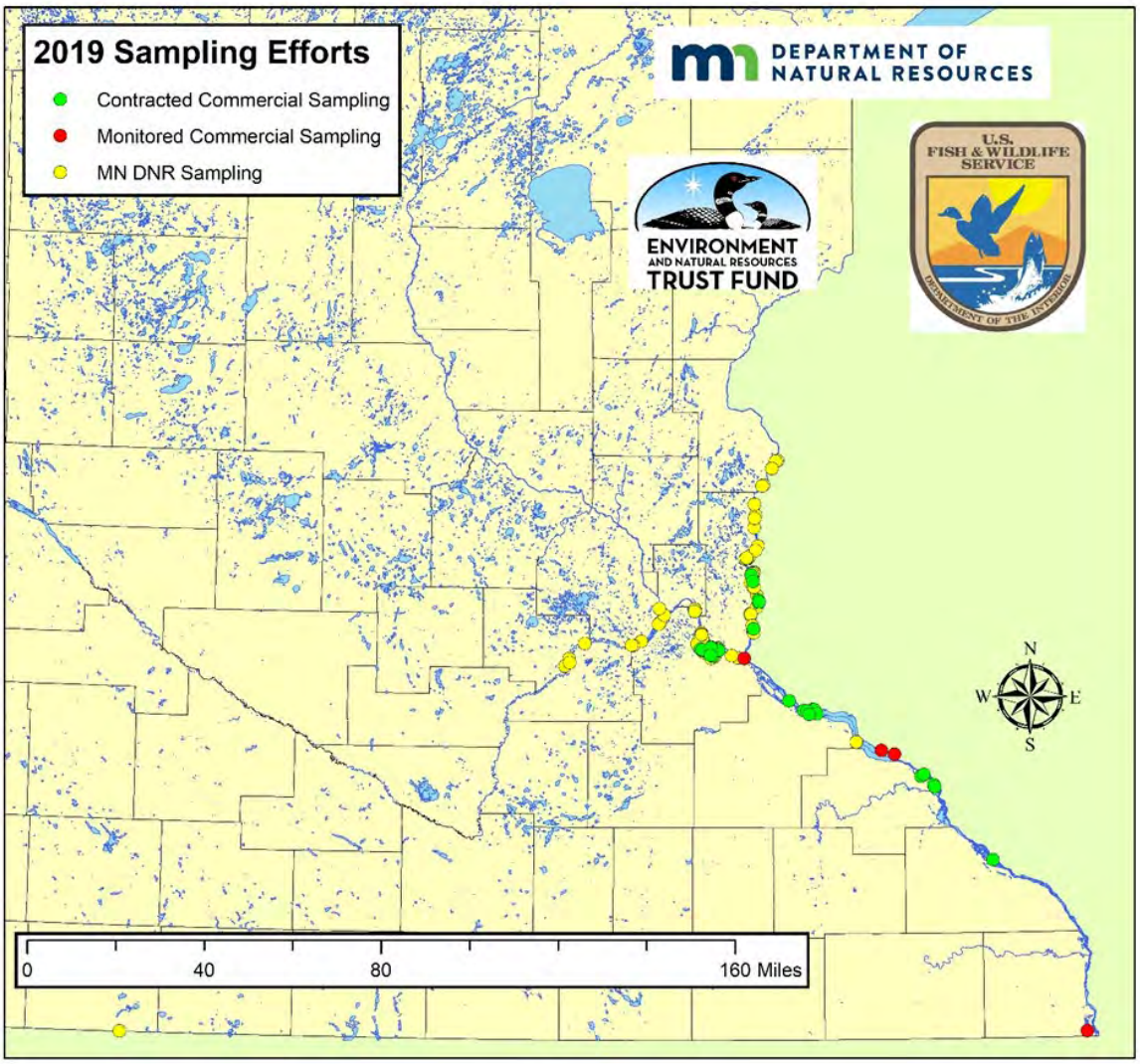
invasive carp crew without the need to be in the field actively tracking the fish. This real-time receiver was placed in an area that can be effectively blocked off and extensively sampled to provide the best opportunity for recapture or the capture of additional invasive carp schooling with the tagged individual. Additional real time receivers will be built and deployed in strategic locations.

The described activities require a special permit issued by DNR Division of Ecological and Water Resources (EWR; MNDNR 2020). For more details regarding this permit, please contact the MN DNR for a copy. For results from the first tagged invasive carp in Minnesota, see the 2017- Present invasive carp sampling reports.

Invasive Carp Response Actions

An appropriate combination of the above activities will be used to respond to captures of invasive carp in the presence front. In addition, the MN DNR implemented a Modified Unified Method exercise in Pool 8 as a test for this developing tool. Planning for the MUM began in July 2020 and involved weekly internal meetings between project managers and project sponsor, and monthly to bi-monthly meetings with partner agencies including USGS, USFWS and WI DNR. Planning and preparation for the MUM continued until the project occurred April 5 - 9, 2021. Substantial administrative and field-based planning and preparation was required to pull off this project. Thirty-one silver carp were captured and removed during the five day MUM event. All project partners were satisfied with the outcome of the project and expressed interest in continuing the partnership for future invasive carp management projects on the Mississippi River. All intentions set at the beginning of the project were met.

Map of Project Area:



Minnesota DNR 2021 invasive carp sampling area. Map depicts 2019 sampling locations which will be similar in 2021 with added effort in the furthest downstream reach (Pool 8).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Gill/Trammel Netting	March – November (2021/22)
Electrofishing	May – September (2021/22)
Larval Trawling	May – July (2021/22)
Commercial Seining	Year round (2021/22)
Commercial Gill Netting	Year round (2021/22)
Carp Tracking	Year round (2021/22)
Data Analysis	November – March (2021/22)
Annual Project Report / Executive Summary	April 2021 and 2022

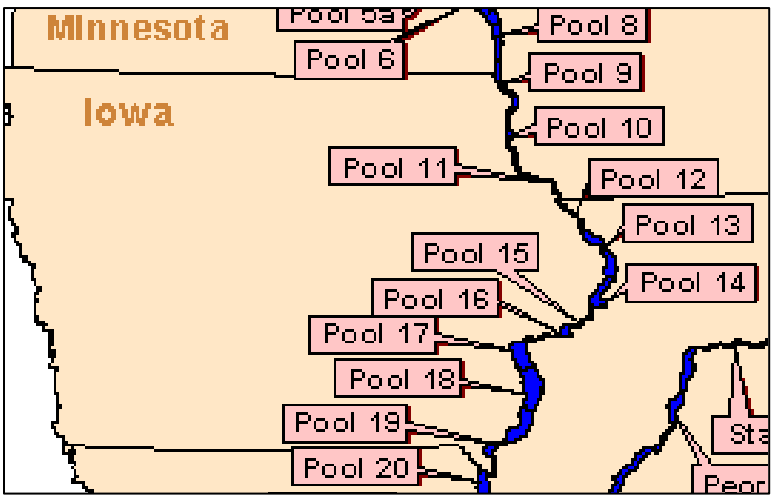
Agency: Iowa State University (IADNR)

Activities and Methods: Ichthyoplankton tows (0.5 m diameter net) will be conducted at the surface at a constant boat speed relative to the shoreline up to four minutes depending on debris load every 10 days during May and June 2022 in pools 14-16 of the Mississippi River. A General Oceanics flowmeter will be mounted in the mouth of the net to estimate volume of water filtered during each tow. Three tows will be conducted at each site parallel to river flow. At tributary confluences, samples will be collected 1 km upstream, 1 km downstream, and 1 km up tributary mouths to evaluate the contribution of tributaries to Asian carp reproduction. The first tow at each location will be in the main thalweg for drifting eggs and larvae (<24 hours post fertilization), the second in the middle of the river, and the third will be in an adjacent side channel for mobile larvae (>24 hours post fertilization). After each tow, ichthyoplankton net contents will be rinsed toward the cod end, placed in sample jars, and preserved in 95% ethanol.

Zooplankton will be collected in conjunction with each ichthyoplankton tow every 10 days. Samples will be collected from a stationary boat position in side channel and backwater habitats. Triplicate zooplankton samples will be collected at each site with an integrated tube sampler (5 cm diameter, 50 cm length), filtered through a 63-µm mesh sieve, combined into a composite sample, and preserved using Lugol's solution. In the laboratory, zooplankton samples will be identified to suborder or family and enumerated for total density (number/L).

Map of Project Area:

Map depicting pools in the Upper Mississippi River in Iowa. Ichthyoplankton will be sampled in pools 14, 15, and 16 at the mouths of the Wapsipinicon and Rock (Illinois) rivers and in pool 16 in the UMR. Map was obtained from https://www.umesc.usgs.gov/images/maps/rivers/all_pools_marked.gif



Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Ichthyoplankton tows and zooplankton sampling	May-June 2022
Sample processing in the laboratory	May - October 2022

Literature Cited:

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

Lead Agency and Author: US Fish and Wildlife Service (USFWS), Wesley Bouska (wesley_bouska@fws.gov) and Mark Fritts (mark_fritts@fws.gov)

Cooperating Agencies: Illinois Natural History Survey (INHS), and Illinois Department of Natural Resources (Western Illinois University), Missouri Department of Conservation (MDC), US Geological Survey (USGS).

Statement of Need: In the Upper Mississippi River, Lock and Dam 19 (LD19) in Keokuk, IA (rkm 2122), is a barrier to upstream fish movement except for movement through the navigation lock chamber (Wilcox et al. 2004). Contracted fishing and research funded through the UMR Invasive carp partnership show high densities of invasive carps below LD19 while populations above the dam exhibit drastically lower densities with limited reproduction (WIU & ILDNR 2018; MDC 2017). The Upper Mississippi River (UMR) invasive carp partnership has identified the area from LD 15 downstream to LD 19 as the Intensive Management Zone (IMZ) for Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*). Contracted removal efforts have been implemented in this zone since 2016, but the impacts of those efforts are largely unknown. Furthermore, additional contract removals in pools 20-22 were slated to begin in FY20 but were not fully implemented due to covid-19 safeguards. A robust stock assessment program is needed to more directly evaluate how populations of invasive carps may be affected by current contract removals and to forecast their future response to alternative removal strategies. A robust stock assessment program should incorporate information from multiple fishery-dependent and independent sources to provide the least-biased composite estimate of carp abundance, biomass, demographic distributions, and migratory tendencies. Therefore, the primary objective of this plan is to describe a unified stock assessment program that will provide a system of data-driven feedback loops that managers can use to evaluate the impacts of their previous management decisions and consider alternative management strategies for the future.

Sampling planned for 2020 was largely canceled due to work and travel restrictions related to covid-19. Hydroacoustic surveys and the accompanying physical sampling, did not occur. Attempts to evaluate invasive carp populations with hydroacoustics and physical sampling were last conducted in 2019 at pools 16-19. High water conditions and low carp densities resulted in no invasive carp being collected. Consequently, we did not have the robust fish community data necessary to calculate species specific density and abundance estimates, but hydroacoustic data across all pools showed significantly greater densities of large-bodied fishes occupying backwater habitats compared to side channels and main channel borders.

In FY21, stock assessment efforts, including hydroacoustics and fishery-independent physical sampling, will be shifted downstream to Pools 18-20. Pool 20 in particular has much higher densities of invasive carp. Physical sampling effort that will inform hydroacoustics will also be increased 2-3 fold within these pools. In addition to INHS collecting fishery-independent data with traditional electrofishing, and, to ensure the collection of robust fish community data that will be able to accurately describe the invasive carp population relative to other fishes, the USFWS will also be conducting sampling with a novel gear designed to increase catches of

invasive carp, the electrified dozer trawl (Hammen et al. 2018). Over time, these data will help us gain a better understanding of the amount of physical sampling necessary to accomplish this work across UMR pools of varying invasive carp densities and annual effort can then be adjusted accordingly.

Objectives:

1. Determine Silver and Bighead Carp population densities via hydroacoustics surveys in Pools 18-20.
2. Conduct fishery-independent monitoring to support hydroacoustics surveys and deliver data on demographic parameters of Silver and Bighead Carp in Pools 18-20.
3. Monitor spatial and temporal trends in Silver and Bighead Carp movements in response to contract removals and environmental changes using sonic telemetry in Pools 5A-20
4. Use light traps to establish an annual index of spawning activity by Asian carps in Pool 19.

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

Activities and Methods:

Hydroacoustics surveys in Pools 18-20

In support of Objective 1, the USFWS will conduct hydroacoustic surveys to obtain data on the relative abundance, size distribution, spatial distribution, and biomass of Bighead Carp and Silver Carp in Pools 18-20. Hydroacoustic sampling is the least size-biased sampling gear currently available to fisheries professionals, thereby providing more accurate relative abundance and size distribution information for stock assessment purposes. Furthermore, the large spatial coverage capabilities of hydroacoustics can provide more precise and accurate relative abundance estimates, particularly for patchily distributed fish such as invasive carp. However, hydroacoustics is not a stand-alone gear, and does require physical fish sampling to separate the overall fish community size distribution into species-specific distributions. Hydroacoustics should be considered as a component of a larger comprehensive stock assessment program that is required for monitoring invasive carp populations and evaluating control efforts.

USFWS will conduct mobile hydroacoustic surveys in pools 18-20 of the UMR. Hydroacoustic data will be collected similar to that described in MacNamara et al. (2016). USFWS will use two horizontally oriented split-beam transducers (200 kHz; BioSonics, Inc.) offset in angle to maximize water column coverage. Prior to each survey, each transducer will be calibrated on-axis following Foote et al. (1987). Surveys will be conducted from mid-September into October at selected areas of the main channel, side channels, bays and backwaters of pools 18-20. These pools will be subsampled using approximately four-mile long transects along the main channel such that a minimum of 35% of the main channel length of each pool will be sampled, in addition to adjacent off-channel habitats, similar to other large river hydroacoustic monitoring programs (Coulter et al. 2018).

Hydroacoustic data will be analyzed following MacNamara et al. (2016) using Echoview 11.2.3. Single targets will be detected using parameter values from Parker-Stetter et al. (2009). Multiple targets from a single fish will be grouped using Echoview's fish tracking algorithm to reduce the potential of over counting fish targets. The size of fish targets (total length; cm) will be estimated from mean acoustic target strength (dB) using a function specific to side-looking hydroacoustics (Love 1971). Hydroacoustic data will be informed by pool-specific fish community data that will be collected using several fisheries gears. Specifically, pool-specific proportions of fish will be determined for each 1 cm length group from 15-120 cm TL for Silver Carp, Bighead Carp, and other fish species. Length-specific proportions will then be used to categorize acoustically detected fish. Pool-specific length-weight regressions will then be used to estimate length-specific biomass for each species of interest, and density (numeric and mass) will be estimated.

In addition to pool-wide population surveys, additional surveys may also be conducted in FY21 at removal areas that feature real-time receivers. Using the same data collection methods as the pool-wide surveys, these surveys would be conducted before and after contracted harvest events to evaluate harvest efficacy and establish the relationship between hydroacoustic density estimates, harvest CPUE, and real-time fish detection data. Hydroacoustic surveys may also occur along MN/WI border waters of Pool 8 and areas requested by MN DNR upstream of Pool 8 may also be surveyed in an attempt to guide contracted fishers to invasive carp for removal.

Fishery-Independent Monitoring

In support of Objective 2, the USFWS will conduct fishery-independent sampling to collect information on the relative abundance of invasive carp within the UMR fish community. Additionally, physical captures of fishes will facilitate collection of important demographic information (aging structures, individual lengths and weights, sex, tissue samples for genetic and physiologic studies, etc.). Furthermore, hydroacoustics gear requires physical sampling to separate the overall fish community size distribution into species-specific distributions. Fishery-independent sampling, using traditional sampling gears like electrofishing, will be less size selective than commercial netting, and provide more complete estimations of the fish community size structure. The ability to detect small fishes could enhance the capacity to detect sources of invasive carp recruitment and deliver additional data to build mathematical models exploring the response of the UMR population to future contract harvest scenarios.

In FY21, the USFWS will conduct sampling in pools 18-20 using the electrified dozer trawl. The use of an experimental gear (the electrified dozer trawl) will complement the traditional LTRM style electrofishing that will be occurring simultaneously in these pools by INHS (see sections below) with the intent of increasing the capture probability of invasive carps. Dozer trawling sites will be selected through a stratified random sampling design that will cover main channel border, side-channel, and backwater habitats in each pool. In August and September of 2021, the USFWS will conduct fishery-independent dozer trawl surveys at up to 35 sites in pool 18, 50 sites in Pool 19, and 25 sites in Pool 20.

USFWS staff will be following an adaptive monitoring approach while implementing this program as an intertwined component of the larger comprehensive stock assessment. Sampling protocols may be re-evaluated in the future to include additional gears, and to expand or contract effort among pools depending on data needs and funding availability. Data generated via fishery-independent sampling will be integrated into a regional database designed to facilitate rapid data processing and sharing with invasive carp researchers. These data will also be available to other researchers studying elements of UMR fish communities. The USFWS will submit a brief annual report to summarize the data.

Telemetry

In support of Objective 3, the USFWS will continue to maintain an extensive acoustic telemetry network in Pools 5a-20. Over 500 Silver Carp and Bighead Carp currently carry functional tags and provide information on the movements of invasive carp throughout the UMR. The primary function of the telemetry program is to provide information about congregations of invasive carp to maximize contract harvest efforts, identify priority locations for potential deterrent technologies and determine both individual and mass movements of invasive carp among pools and tributaries of the UMR. Real-time receivers will be deployed in Boston Bay (Pool 18), Cleveland Slough (Pool 17), Big Timber (Pool 17), and Credit Island (Pool 16) to provide daily updates to INHS and the contracted commercial fishers from March-Nov 2021. This specialized technology allows INHS personnel to accurately direct the timing and location of fishing efforts to maximize harvest rates. The USFWS will coordinate efforts with multiple agencies including MDC, who maintain receivers in the UMR below Pool 20; MN DNR, who maintain receivers in the UMR above Pool 5a (see sections below); INHS, who use stationary and real-time receiver data to direct commercial fishing removals; and USGS who also maintain telemetry equipment on the UMR and house the telemetry database.

Data generated from the telemetry program are being used to monitor spatial and temporal trends in Silver and Bighead Carp movements in response to contract removals, actively direct contract removal efforts, and increase the efficiency of control and deterrence techniques and technologies. These data are also being used to generate complex temporal-spatial analyses that will be used to produce scientific manuscripts during FY 21-22.

Map of Project Area:

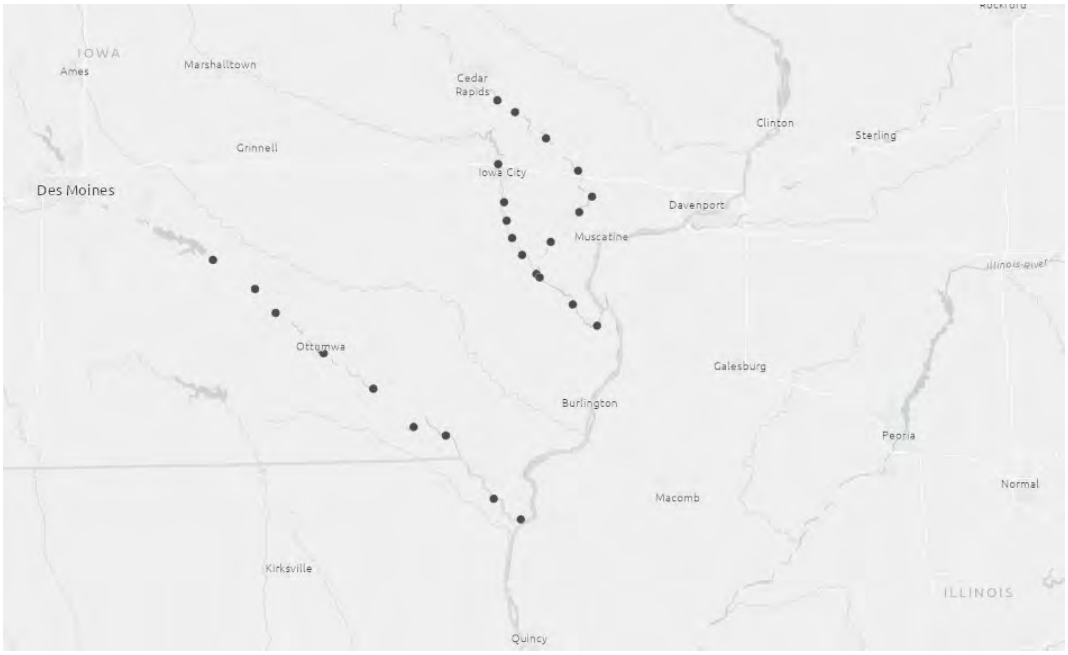
Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Hydroacoustic evaluation concurrent with removals	16-19	Spring	2021
Hydroacoustic Pool Surveys	18-20	Fall	2021
Hydroacoustic Surveys in MN/WI Border Waters	8	Spring	2021
Fishery-Independent Data Collection	18-20	Aug/Sept	2021
Deploy Acoustic Array	5a-20	Spring	2021
Capture and Tag Additional Invasive Carp	TBD	TBD	2021
Download Data from Stationary Receivers	5a-20	Every 4-6 weeks	2021
Annual Report	3-21	March	2022

Agency: Iowa State University (IADNR)

Activities and Methods: In support of Objective 3, Iowa State University will install acoustic receivers in the Des Moines, Iowa, and Cedar rivers to provide better detection coverage of existing receivers (n=3 in Des Moines River, n=5 in Iowa and Cedar rivers) within the rivers currently operated by Missouri Department of Conservation and US Fish and Wildlife Service. We will then tag 60 invasive carp in the Des Moines River (30 between Red Rock and Ottumwa, 30 below Ottumwa) and 30 in the Iowa River during the summer and fall when individuals from the Mississippi River would not be migrating up tributaries for spawning. Battery life of Vemco V16 acoustic tags is up to 10 years. We will monitor movement of fish for multiple years to assess seasonal movement under various annual flow regimes. We can then evaluate movement patterns of these fish compared to those already tagged in the Mississippi River to test for variation in movement and behaviors and upstream and downstream passage through the Ottumwa Dam among the different groups.

Map of Project Area:



Potential acoustic receiver deployment locations in the Des Moines, Iowa, and Cedar rivers in southeastern Iowa.

Estimated Timetable for Activities:

Project Activity	Season
Deploy acoustic receivers in tributaries	Summer 2021-Spring 2022
Tag invasive carp with acoustic tags	Fall 2021-Spring 2022
Download acoustic receivers and assess movements	Summer 2022

Agency: Illinois Natural History Survey (INHS) and the Illinois Department of Natural Resources (IL DNR)

Activities and Methods:

Fishery-independent sampling

In support of Objective 2, the INHS will conduct fishery-independent sampling to collect information on the relative abundance of invasive carp within the UMR fish community. Physical captures of fishes will facilitate collection of important demographic information (individual lengths and weights, etc.), and additionally will provide the information needed to separate the hydroacoustics overall fish community size distribution into species-specific distributions. Fishery-independent sampling using traditional sampling gears like electrofishing will be less size selective than commercial netting, and provide more robust estimations of the fish community size structure. The ability to detect small fishes could enhance our capacity to

detect sources of invasive carp recruitment and deliver additional data to build mathematical models exploring the response of the UMR population to future contract harvest scenarios.

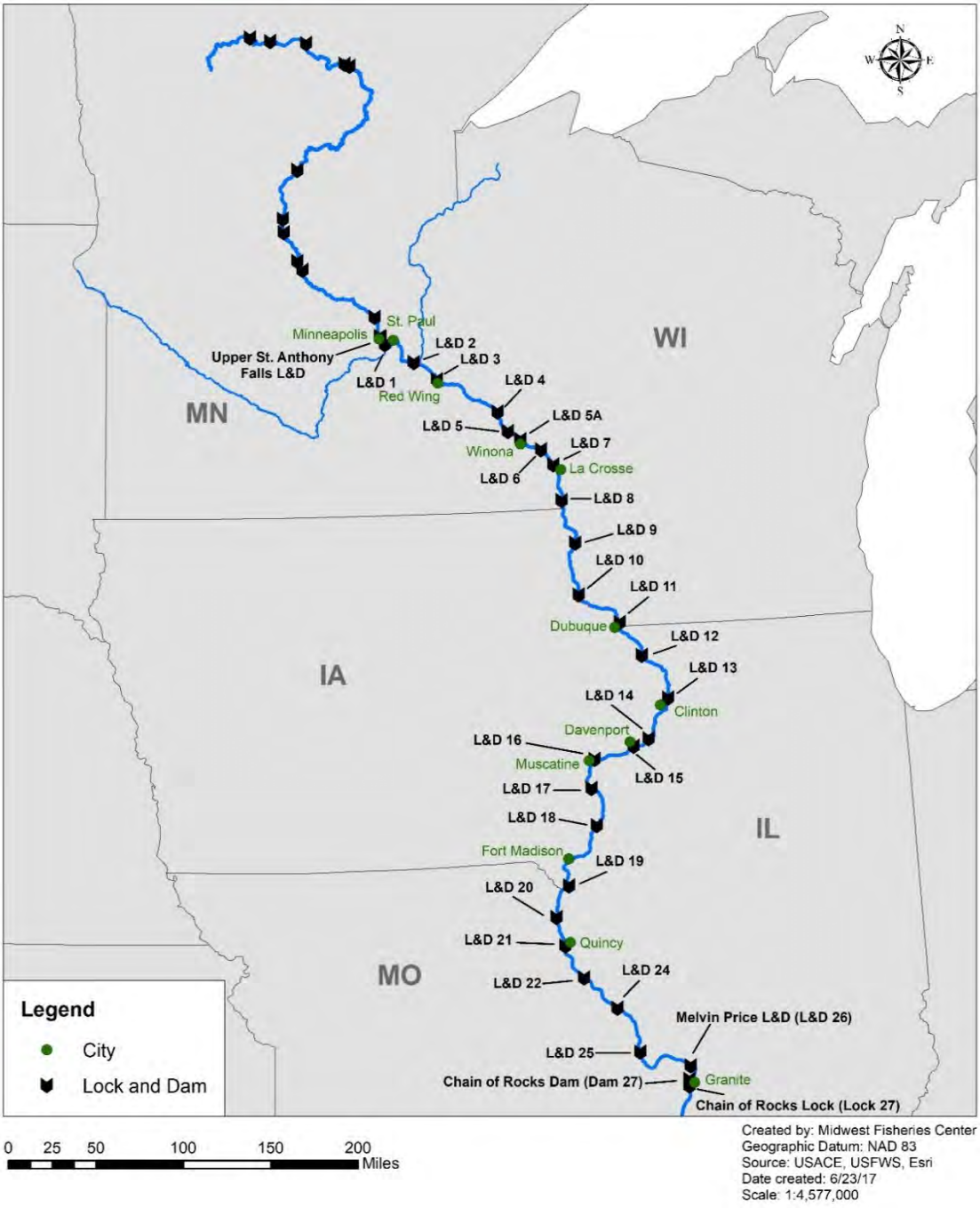
The INHS Illinois River Biological Station currently maintains an extensive standardized electrofishing program called the Long-term Survey and Assessment of Large River Fishes in Illinois or the Long-term Electrofishing Program (LTEF). The program uses pulsed-direct current electrofishing to sample fish communities at randomly selected locations throughout Pools 16-21 of the Mississippi River. The program operates on a tri-annual sampling schedule and traditionally has limited sampling to main channel border habitats. However, starting in FY19, additional funding was provided to expand sampling in Pools 16-19 to backwater and side-channel habitats that represent preferred habitats for invasive carp.

After a covid-related hiatus in 2020, the LTEF program in FY21 will again provide supporting data that can be used to calibrate estimates of invasive carp derived from hydroacoustics surveys as well as a source of information about the relative abundance of invasive carp in the UMR. Expanded LTEF effort in FY21 will be focused on Pools 18-20. Electrofishing sites will be selected through a stratified random sampling design that will represent main channel border, side-channel, and backwater habitats in each pool. In the fall of 2021, the INHS will conduct additional fishery-independent electrofishing surveys at up to 30 sites in pool 18, 40 sites in Pool 19, and 20 sites in Pool 20.

Larval light trapping

Evidence of invasive carp reproduction was detected as early as 2009 in pool 19 of the Upper Mississippi River, indicating that areas of the UMR above LD19 are capable of providing the hydrological requirements needed for successful invasive carp spawning, egg maturation, and development. This also indicates that adult invasive carp have reached densities high enough to allow potential mates to find each other and spawn successfully. Monitoring for larval and juvenile invasive carps in pool 19 will detect and quantify invasive carp reproduction and any potential reproductive response by invasive carp to control strategies. Sampling will be conducted with light traps at specific sites in pool 19 as an annual index of spawning activity. Data processing (e.g., larval sorting and identification, and data analysis) will occur during the fall and winter months.

Map of Project Area:



Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Fishery-Independent Data Collection	18-20	Fall	2021
Larval Light Trapping	19	Spring	2021
Executive Summary	14-19	October	2021
Annual Report	14-19	March	2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods:

Telemetry

In support of Objective 4, MDC will continue to maintain an extensive acoustic telemetry network from Pool 20 downstream into the Lower Mississippi River. MDC has over 200 Silver and Bighead Carp with active transmitters in Pool 20. The primary function of the telemetry program below Lock and Dam 19 is to provide information about invasive carp passage above Lock and Dam 19 into the Intensive Management Zone and to identify potential deterrent locations, but it also provides information about movements of invasive carp among pools and tributaries of the UMR and other basins. Specifically, the funds requested this fiscal year will allow MDC to increase coverage in the lower pools (20-26). A pair of stationary receivers will be placed above and below each lock and dam to track the number of tagged invasive carp within each pool, individual residency time, and transition rates between pools and basins.

Data from the lower pool telemetry efforts will help fill in information gaps, inform removal efforts, and describe movements of invasive carp in response to contract removal. These data will also be available to inform complex temporal-spatial models (i.e., SEACarP) that could be developed for the UMR.

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

Map of Project Area:

Estimated Timetable for Activities:

Project Activity	Pool	Season	Year
Deploy Acoustic Array	20-26	Summer/Fall	2021
Capture and Tag Additional Invasive Carp	20-26	Fall	2021
Download Data from Stationary Receivers	20-26	Every 4-6 weeks	2021/2022
Annual Report	20-26	March	2022

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Contract Fishing for Asian Carp Detection and Removal

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

Cooperating Agencies: Missouri Department of Conservation (MDC), Iowa Department of Natural Resources(IADNR), US Fish and Wildlife Service (FWS)

Statement of Need: Adult bighead, grass, and silver carps are present in varying abundance in Upper Mississippi River (UMR); however black carp have not been collected above Lock and Dam 19 (LD19). Dense populations of bighead, grass, and silver carps with reproduction do exists in the lower pools of the Upper Mississippi River (20-26) and moderate populations with limited reproduction/recruitment occur in Pools 18 and 19, with some recent commercial catches being reported as far upstream as the Rock River and Pool 14. Bighead carp and silver carp (Asian 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 Asian carp above LD19, especially a large year class in 2016, indicates that Asian carp populations have reached densities capable of detectable reproduction. To combat this population expansion and decrease Asian carp densities at the established front (pools 16, 17, 18, and 19), additional measures are needed to monitor, control and manage Asian carp while densities are still low and manageable. We propose to use commercial fishers to intensively target Asian carp species for removal at the established front and invasion front (reaches above pool 16) and determine population abundance to determine the effects of harvest. This reduction in densities will alleviate upstream pressure on potential pinchpoints at Lock and dam 14 and 15, which provide an additional defense to slow the spread and establishment upstream. Removal efforts in pools below Lock and Dam 19, may not directly affect the reduction in reproduction and recruitment in the Intensive Management Zone, but it will reduce the overall density of Asian carp in the pools in the secondary management zone (Pools 20-22). This reduction in density below Lock and Dam 19 will decrease the number of Asian carp attempting to pass upstream into the Intensive Management Zone, which will be key in aiding the upstream removal efforts.

Decreasing the abundance and removal of Asian 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 Asian 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 Asian 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 Asian 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 Asian carp spawning, egg maturation, and development. This is reinforced with FWS/USGS telemetry movement information. Furthermore, this indicates that Asian carp have reached densities high enough to allow for potential mates to find each other and spawn successfully. The highest abundance of adult Asian carp above LD19 occurs in pools 17, 18, and 19, and larvae and young-of-year Asian 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 Asian 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 Asian carp Action Plan). Learning from the Illinois River model, a multipronged approach with removal above the invasion front in Pools 14-19 and removal efforts below Lock and Dam 19 in Pools 20-22 will not only reduce the likelihood of upstream expansion and but also reduce the overall abundance of Asian carp.

Objectives:

1. Targeted removal of Asian carp species in UMR pools 14-22 using contracted commercial fishers and intensive agency netting in Pools 14-19.
2. To intensively target backwaters in Pools 14-19 for Asian carp removal by contracted commercial fishers during periods of peak backwater aggregation for 4 weeks in March and April, 2022
3. Collect Asian carp demographic information that can be used to inform harvest from Pools 16-22.

Agency: Illinois DNR (Illinois Natural History Survey)

Activities and Methods: The sampling design includes agency sampling and the use of contracted commercial fishers to intensively capture Asian 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 Asian carp species per boat, per week. Total length will be recorded for all or a subset of bycatch per boat, per week. Asian 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 Asian carp biomass. Body condition and gonad weight will be collected monthly and aging structures collected in November through January to be consistent with previous sampling. These data will be used to monitor for declining trends in density dependent response variables in response to harvest and also to help inform spatially explicit models to help direct fishing effort.

All fish removed throughout the study will be transported daily to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA) where all fish will be iced down in large totes and used as fertilizer or as cut bait. Fish cannot be marketed and sold by the contracted commercial fishers and the fish cannot be used for human consumption. All INHS biologists and technicians participating in the removal will be required to possess an Illinois sportfishing license.

Objective 1: Targeted removal of Asian 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 Asian 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 Asian 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 Asian carp are present but not in high enough densities to effectively target large numbers of Asian 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 Asian carp species above LD 19 is 200,000-300,000 lbs.

Length and weight will be recorded from each Asian carp prior to being sacrificed; individual jaw tag numbers will be recorded for all recaptured Asian 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 Asian carp species, will be removed and transported to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA) for use as liquid fertilizer

Objective 2: To intensively target backwaters in Pools 14-19 for Asian carp removal by contracted commercial fishers during periods of peak backwater aggregation for 4 weeks in March and April, 2021

Three additional fishing crews will fish and remove Asian carp for a 4 week period in March and April in Pools 14-19 (time period of high density Asian carp backwater aggregation). This four week window has consistently been shown by USFWS-La Crosse to be a time of high density Asian 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 Asian 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 Asian 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 Asian 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.

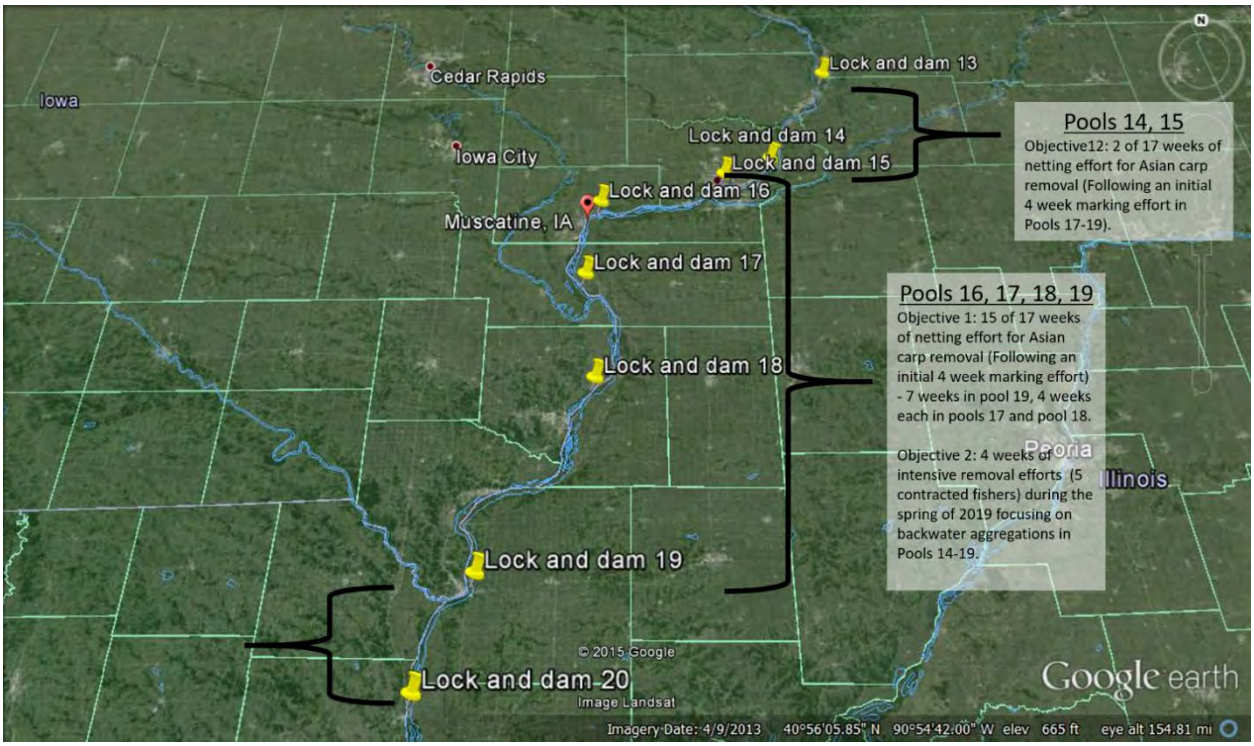
Length and weight will be recorded from each Asian carp prior to being sacrificed; individual jaw tag numbers will be recorded for all recaptured Asian carp. Non-target bycatch will be identified to species, enumerated, and condition recorded (i.e. healthy, moribund, dead) prior to release. All non-native species, other than Asian carp species, will be removed and transported daily to Darrick Garner (Palmyra, MO) or Shafer Fisheries (Fort Madison, IA).

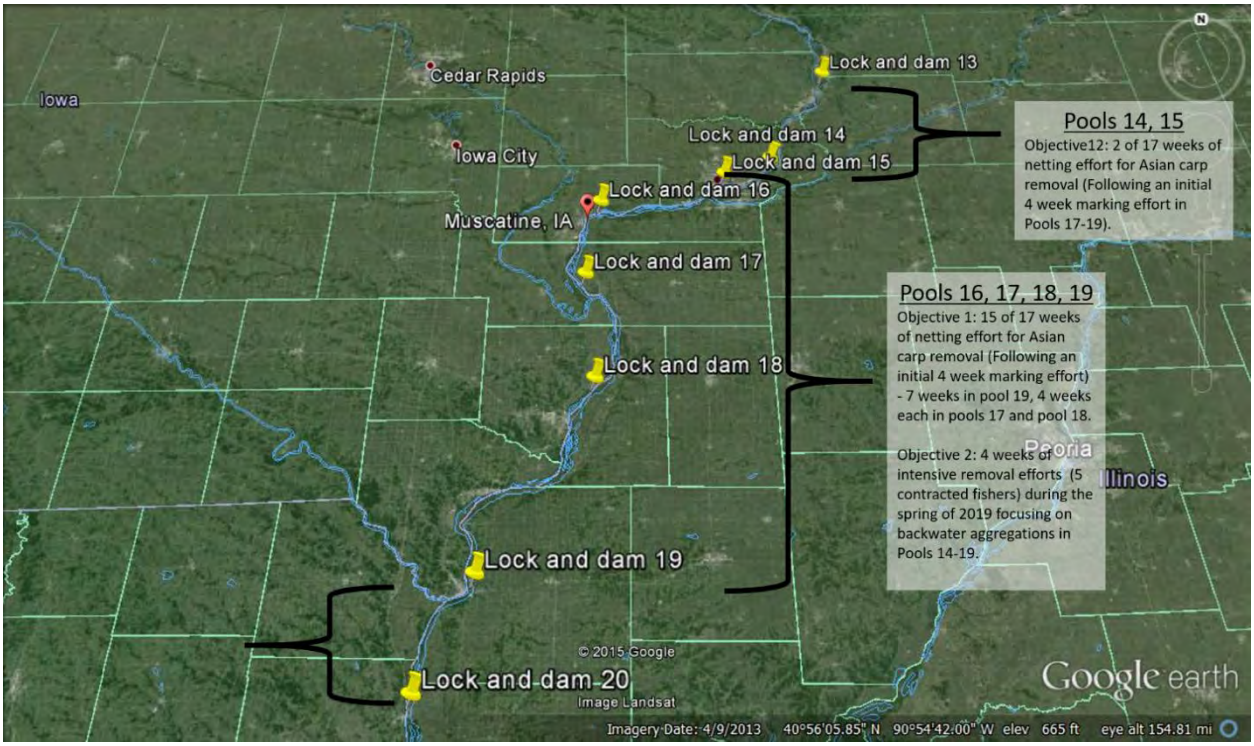
Objective 3: Collect Asian carp demographic information that can be used to inform harvest from Pools 16-19

During contracted fishing, INHS crews will monthly collect up to 100 bighead carp and silver carp (50 per species) from Pools 16-19. Fish length and weight will be recorded to incorporate into body condition and vital rates analysis. All fish will be dissected, gonads visually staged, removed and weighed for GSI and egg condition analyses. Additionally, within the time range of November through January, 100 fish of each species from Pools 16-19 will be collected and aging structures removed (pectoral spines, postcleithra, and lapillus otoliths) to be used in model growth and vital rate analyses. These data will be used to monitor for declining trends in density dependent response variables in response to harvest and also to help inform spatially explicit models to help direct

fishing effort. All results will be summarized in the annual report and formatted for SEACARP modeling.

Map of Project Area:





Estimated Timetable for Activities:

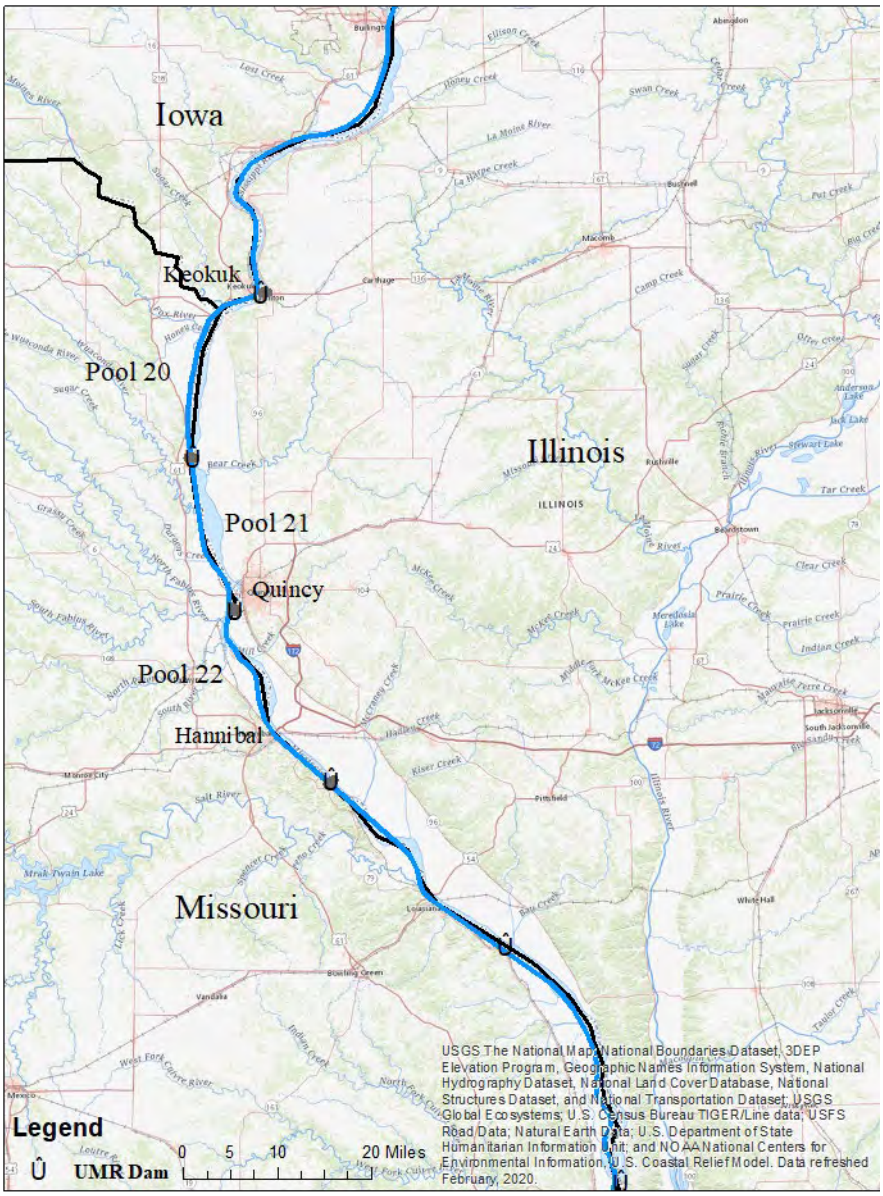
Project Activity	Pool	Month	Year
Harvest	14-19	August-July	2021-2022
Intensive harvest	16-19	April	2021
Demographics	14-19	Yearly	2021-2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: MDC will continue an Asian carp harvest program that will employ contract fishing to support Objective 1. Methods have been employed during 2020 and by neighboring states and will inform the most effective approach for 2021 Missouri Asian carp control and management. Missouri removal efforts will occur in Pools 20, 21, and 22 to alleviate upstream pressure on Lock and Dam 19 and further spread into the Intensive Management Zone above Lock and Dam 19. Removal efforts will take place in the fall and winter of 2021 as river conditions permit and contracts are in place. Effort will be spread throughout the three pools with an overall goal of removing at least 1,000,000 pounds.

In support of Objective 3, the agency will cost share to support a biologist that will be coordinating removal efforts, pick up for harvested Asian carp by contractor (coordinating with IL and KY for pick up if a certain number of pounds are harvested), and the collection of fishery dependent demographic data. Similar to what INHS and IDNR will be doing in the upper pools, length and weight will be recorded from Asian carp prior to being sacrificed and bycatch will be identified to species, enumerated, and disposition will be recorded (i.e., healthy, moribund, dead) prior to release. MDC biologist will collect up to 100 Bighead and Silver carp (50 per species) to collect more specific data such as sex, GSI, and fecundity. The aging structure (lapilli otoliths) will be collected from those 100 individuals from in Pool (20-22) to be used to populate harvest models and also serve as a measure to look at trends through time to evaluate the effects of harvest.

Map of Project Area:



Estimated Timetable for Activities:

Activity	Pool	Time Period (Season, month/year)
Asian carp removal	20,21,22	Fall and Winter 2021
Demographic Data Collection	20,21,22	Fall and Winter 2021
Data Summary/Analysis	20,21,22	Winter 2021/2022
Annual Report	20,21,22	Mar-22

Literature Cited:

2020 Asian Carp Action Plan. http://www.asiancarp.us/PlansReports.

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

Lead Agency and Author: US Geological Survey, UMESC, Andrea Fritts (afritts@usgs.gov)

Cooperating Agencies: Illinois Natural History Survey (INHS), Missouri Department of Conservation (MDC), US Fish and Wildlife Service (USFWS), US Army Corp of Engineers (USACE)

Statement of Need: Invasive carp are established in the upper, middle, and lower Mississippi River and their expansion upstream threatens a variety of aquatic ecosystem services including fishing and recreational boating. The physical and operational characteristics of Lock and Dam (LD) 19 restrict upstream migration of fishes because the only upstream fish passage route is through the lock chamber. This restriction might be hindering consistent reproduction and recruitment of invasive carps enough to reduce their abundance upstream of LD19. Locks and Dams 14 and 15 (upriver of LD19) are infrequently at open-condition and may also be limiting the continued upstream expansion of invasive carps. Upstream passage of fishes at these locations would be limited to the lock chamber for the majority of the year (Wilcox et al. 2004; Bouska 2021).

Acoustic deterrents have been developed for limiting the range of fish, and those systems show promise in deterring invasive carps. To date, small-scale acoustic deterrents have been tested on many native fishes and invasive carps in labs, outdoor ponds, and small rivers (Vetter et al. 2015, 2017; Murchy et al. 2017). Federal, state, and local partners approved the opportunity to test an experimental underwater Acoustic Deterrent System (uADS) at LD19 on the Mississippi River and this system was installed during Jan-March 2021. Testing of an uADS at a pinch-point dam, such as LD19, may help to prevent immigration into the Intensive Management Zone (IMZ) from Pool 20 and minimize the continued expansion of invasive carp populations in the UMR (Whitledge et al. 2019).

Lock and Dam 19 is an optimal location to test an experimental uADS because fish can only move upstream through the lock chamber and because this location has five years of historical fish passage data that has been collected by the UMR Invasive Carp Team. The partnership has successfully evaluated the seasonal timing of passages of invasive carps and native fish species and evaluated the relation of fish upstream passages with the operation of the lock for river vessels (Fritts et al. 2021). A pivotal discovery from the ongoing work has been the identification of a differential motivation of invasive carps to complete upstream passage at LD19. Invasive carps that were originally tagged upstream of LD19 and moved downstream on their own volition were much more likely to complete upstream passage than invasive carps tagged downstream of LD19 in Pool 20 (Fritts et al. 2021). This observation prompted an experimental translocation effort in 2019, which confirmed the increased likelihood of upstream passage of fish that had prior experience in locations upstream of LD19. In addition, the partnership has gained insights into behavior of invasive carps tagged with depth-sensitive transmitters. Data

from these tags provided information about the position of a fish within the water column at LD19 and how fishes interact and respond to river vessel presence in the downstream lock approach and the lock chamber. During spring 2021, four native species (i.e. bigmouth buffalo, lake sturgeon, paddlefish, flathead catfish) were dual tagged with depth-sensitive transmitters to improve understanding of how native species react to the uADS and river vessels at LD19.

Passage data for invasive carps and native species (i.e., paddlefish, bigmouth buffalo) has also been studied at LD15 over the past four years. Locks and Dams 14 and 15 have both been considered as potential locations for deterrents and it is critical to have baseline information on behavior of native and invasive species to inform management decisions including the potential development of uADS at these sites (Upper Mississippi River Asian Carp Partnership 2018).

State and federal partners have identified evaluating the effects of an uADS on native species as a high priority. Vemco telemetry data are currently being collected by MDC, INHS, USFWS and USGS from previously tagged fish (invasive carps and native species) moving through longitudinal and fine-scale arrays of Vemco acoustic receivers at LD 19 and LD 15 (Fig. 1-4). Many of the previously tagged fish will continue to be tracked in addition to the newly tagged fishes. FY21 funds are requested to purchase acoustic transmitters (n = 200) and to provide funding for 1/3 time for an INHS staff member to assist with the deterrent project (e.g., tagging and downloading receivers). Our project proposes continued collection of movement data using Vemco receiver arrays and acoustically tagged fish in the UMR to evaluate the effects of the uADS at LD 19 on invasive carps and native species. Vemco transmitters (n = 100) will be used to tag native fishes in Pool 20 (e.g., bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye) to evaluate native fish response to the uADS. The additional Vemco transmitters (n = 100) will be used to tag invasive carp in proximity to LD 14 and 15 to increase the amount of baseline passage information available at these locations that may be considered for future deterrent implementation. Paddlefish and bigmouth buffalo tags are still active in this area and will continue to provide information on native fish passage at LD 14 and 15.

This project directly addresses multiple aspects of the UMR sub-basin framework, including providing information on evaluating and implementing deterrent measures at strategic pinch points to prevent dispersal of invasive carp and supporting research to develop new containment technologies. This project also closely aligns with the goal of containing expansions of invasive carps in the UMR while minimizing impacts to native species movement.

Objectives:

1. Assess fish behavior and passage rates of invasive carps and native fishes at LD19 to evaluate the performance of an experimental underwater Acoustic Deterrent Systems (uADS) to deter invasive carps while minimizing effects to native species
2. Analyze depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD19

3. Evaluate fish passage dynamics (e.g., route, timing, relation with environmental variables) for baseline information at LD15 and LD14
4. Use USACE Lock Queue Reports to inform the relationship between fish movements and behavior in relation to lock structures and operation at LDs 14, 15, and 19

Agency: Illinois Natural History Survey (INHS)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14 (Fig. 2-4). In 2021, depth-sensitive transmitters were implanted into 4 paddlefish, 19 bigmouth buffalo, 25 flathead catfish, and 3 lake sturgeon in P20. USGS and partners translocated invasive carps and bigmouth buffalo from locations upstream of LD19 to Pool 20 during spring of 2021 for the uADS evaluation. These fish will be monitored to evaluate the response of invasive carps and native species to the uADS.

FY2021 funds will be used to purchase 200 Vemco transmitters to enhance understanding of native fish behavior in response to the uADS and to collect baseline data on invasive carp passage at LD14 and LD15. (Cost per transmitter = $350; cost for 200 transmitters = $70,000.) Native fish species that may be tagged at LD19 include bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye. Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate. All acoustic transmitters will operate at the same frequency as existing tags in this stretch of the river. FY2021 funds will also be used to provide funding for 1/3 time for an INHS staff member to assist with the deterrent project (e.g., tagging and downloading receivers).

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: US Fish and Wildlife Service (USFWS)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14. The USFWS longitudinal receiver array will be redeployed in pools 5A-19 in the spring of 2021 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate. Tagged fishes will continue to be acoustically tracked to determine the frequency of dam passage and environmental conditions associated with passage.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Deploy longitudinal receiver array	Spring, summer 2021, 2022
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: Missouri Department of Conservation (MDC)

Activities and Methods: Collaborating agencies will continue to quantify native and non-native fish passage in the UMR with special emphasis on LDs 19, 15, and 14. The USFWS longitudinal receiver array will be redeployed in pools 5A-19 in the spring of 2021 and the MDC stationary array will be maintained in pools 19-26 (Fig. 1). Fish tagging will occur during fall 2021 and/or spring 2022 and will be a collaborative effort between INHS, MDC, USFWS, and USGS. Individual fish will be weighed and measured for total length or fork length as appropriate. Tagged fishes will continue to be acoustically tracked to determine the frequency of dam passage and environmental conditions associated with passage.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Maintain longitudinal receiver array	Spring, summer, winter 2021, 2022
Tagging	Fall 2021, Spring 2022
Receiver downloads	Quarterly during 2021, 2022

Agency: US Geological Survey (USGS)

Activities and Methods: Fine-scale arrays have been deployed at LD19 (Fig. 2) and LD15 (Fig. 3). During 2021, an additional array was deployed at LD14 (Fig. 4). These arrays will be maintained during 2021-2022. The USGS and the USACE-Engineer Research and Development Center (ERDC) will operate and maintain the experimental uADS at LD19 for up to three years. In collaboration with partners, USGS will analyze telemetry data from the Vemco arrays and the HTI telemetry system deployed at LD19. These telemetry data will be used to evaluate how environmental conditions (e.g., flow, water temperature, season, diel period), lock operations, and operation of the uADS affect native species and invasive carp movement and behavior (including passages) at LD19. USGS will analyze Vemco depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD19 and how fishes respond to the uADS and the operation of the lock for river vessels. In collaboration with INHS, MDC, and USFWS, USGS will tag and translocate bigmouth buffalo and invasive carps (i.e., silver carp, bighead carp, and grass carp) from Pool 19 to Pool 20 with HTI tags during spring 2022 to evaluate the performance of the experimental uADS. No USFWS UMR funds are requested for this translocation component of the study; transmitters will be supplied by USGS in support of the deterrent project.

Silver carp and bighead carp will be tagged in proximity to LDs 14 and 15 to evaluate fish passage dynamics (e.g., route, timing, relation with environmental variables) for baseline information at these locks and dams that are infrequently at open river condition (Wilcox et al. 2004; Bouska 2021). These data will help to inform future decisions on the need for and how to go about deploying deterrents for invasive carps at these locations, while minimizing impacts to native fishes.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Maintain Vemco arrays at LDs 19, 15, 14	Quarterly during 2021, 2022
Tagging	Fall 2021, Spring 2022
Analyze fish behavior, passages, and depth data	Winter 2021, Summer 2022

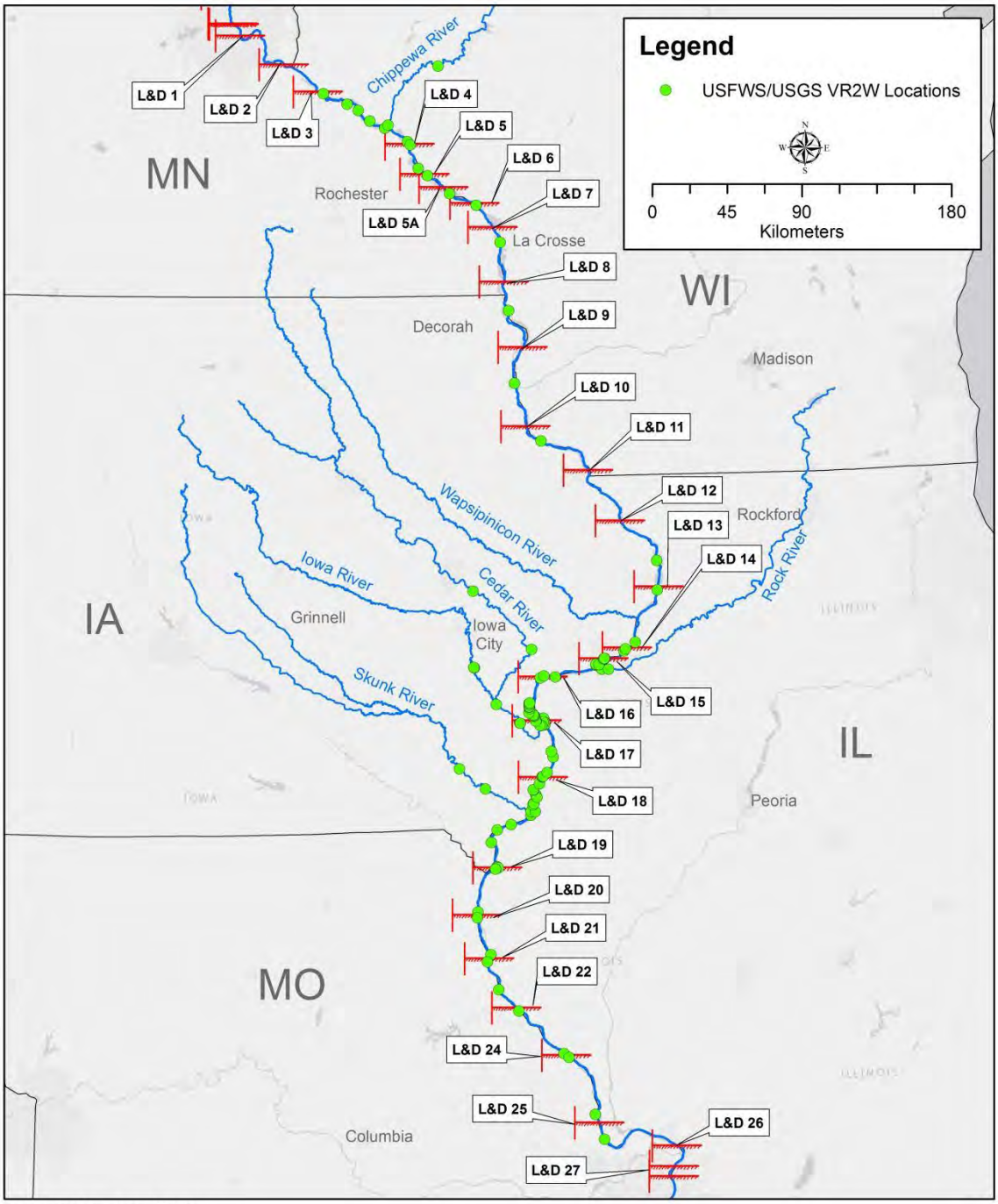
Agency: US Army Corp of Engineers (USACE)

Activities and Methods: In collaboration with partners, the USACE will support studies at strategic locations (e.g. pinch-point dams) to better understand how to deploy deterrents at lock chambers to deter invasive carp while minimizing effects to native species. The USACE will provide Lock Queue Reports for LD19, 15, and 14 on a quarterly basis to evaluate fish movements in relation to lock structures and operation.

Estimated Timetable for Activities:

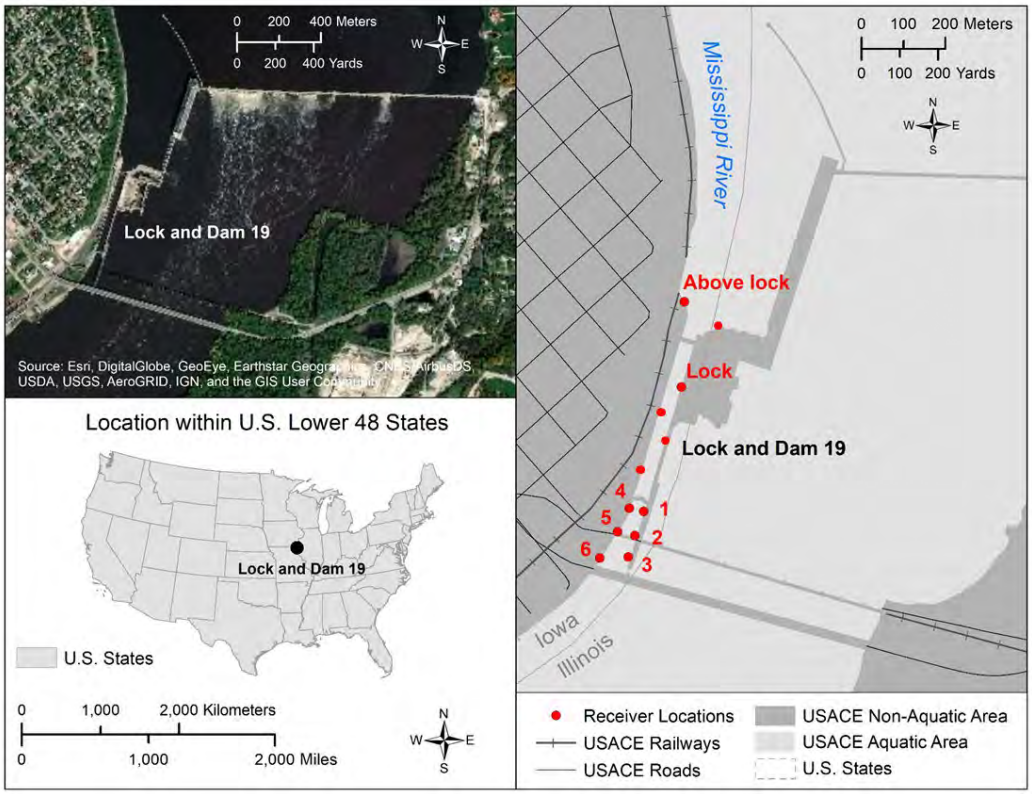
Activity	Time Period (Season, month/year)
Provide Lock Queue Reports for LDs 19,15,14	Quarterly during 2021, 2022

Map of Project Area:

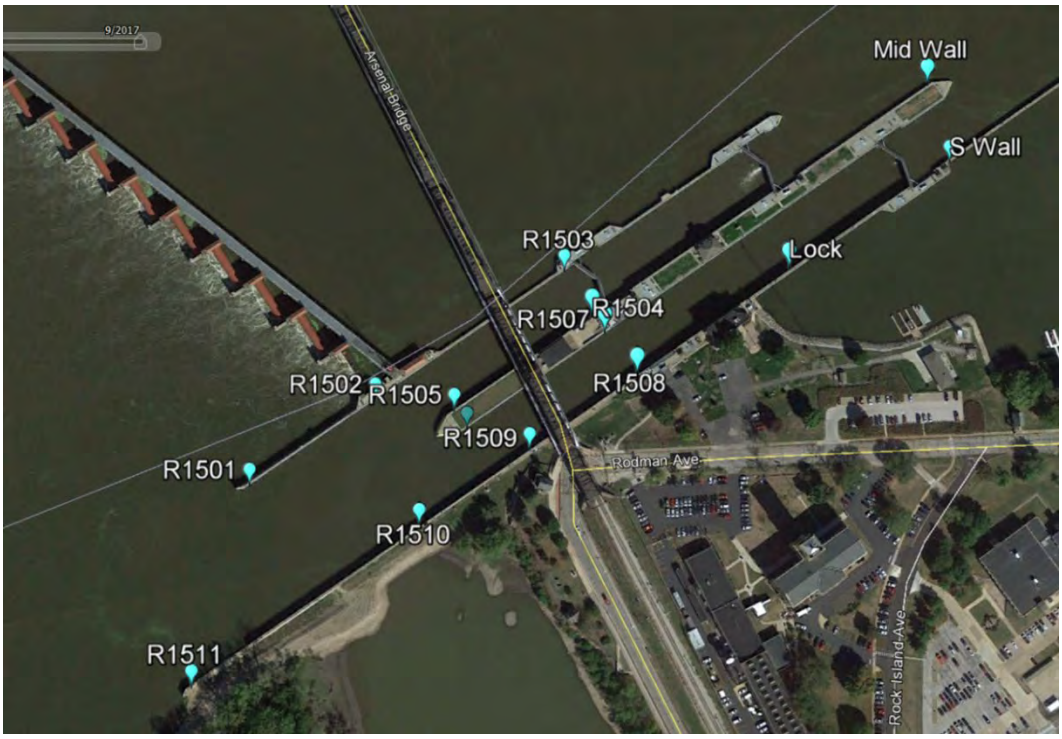


Map created by: Jeena Credico
Sources: USFWS, USGS, and Esri
Scale: 1:3,050,000
Projection: NAD 83 UTM Zone 15N

Locations of stationary receivers in the large-scale longitudinal array deployed in the Mississippi River basin. Receivers are maintained by USFWS and Missouri Department of Conservation.



Location of receivers completing the fine-scale array in the lock approach at Lock 19.



Location of receivers completing the Vemco array in the lock approach at Lock 15.

Location of receivers completing the Vemco array in the lock and lock approaches at Lock and Dam14.

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eDNA Monitoring in the Upper Mississippi River Basin

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Statement of Need: The Intensive Management Zone (IMZ) for Invasive carp (Silver and Bighead carp specifically) in the Upper Mississippi River (UMR) encompasses pools 16-19. Within this zone, a diverse array of management actions and monitoring strategies are being implemented to control and research the established Invasive carp population present there. Hypothetically, a shift in the established population of Invasive carp would first be detectable in the pools immediately upstream of the IMZ. Pools 13 and 14 represent this transitional zone between where Invasive carp are established and reproducing, and where they are more scarce. While Invasive carp are captured and observed in these pools, there is not believed to be an established population. These two pools are not rigorously sampled by other USFWS Invasive carp monitoring efforts. When utilize as part of a long-term monitoring program, eDNA can potentially give evidence to changes in Invasive carp presence over time or a shift in the upstream front of the established population. Unpublished telemetry data from Pool 18 show that tagged fish move into backwater habitats in the spring, when water temperatures are between about 8-15 °C, and reside there prior to making spawning runs to tributaries (Kyle Mosel, USFWS, personal communication). Mize et al. (2019) showed that the probability of detecting eDNA was greater in a UMR habitat characterized by low flow (e.g. a backwater) in the spring and fall. Pools 13 and 14 contain abundant backwater and off-channel habitat that may be suitable for spring congregations of Invasive carp. The goal of sampling Pool 13-14 is to assess trends in eDNA presence in backwaters over time, which may indicate changes in the Invasive carp population in those pools. These data may also be used to prioritize areas to implement or ramp up efforts with traditional capture gears to support Invasive carp telemetry tagging and removal efforts outside of the IMZ, if desired in the future. This project relates to Goal 2 of the Upper Mississippi River Basin Framework, specifically *Strategy 2.1: Continue the UMR comprehensive monitoring program to maintain a current understanding of Asian carp distribution at all life stages for early detection, prevention, response, control and containment* and *Strategy 2.5: Develop and implement new early detection and monitoring tools to supplement eDNA.* Additionally there is a need to continually refine eDNA technology and sampling strategy. Collecting samples from areas of confirmed Invasive carp presence at the time of sampling can help to continually refine and strengthen our understanding of eDNA detection probability and utility. The Credit Island backwater in Pool 16 offers an ideal location for this due to the presence of a real-time telemetry receiver which constantly detects and logs the presence of tagged invasive carp and transmits data to biologists in real-time.

Further upstream in the UMR in Pool 8, there has been an increase in the number of Silver carp captures. Due to the recent and repeated captures of numerous Silver carp in the spring of 2020, and the continued sporadic captures throughout 2020 and into 2021, USFWS will also sample for Invasive carp DNA in targeted backwaters of Pool 8 of the UMR in coordination with efforts by the Minnesota Department of Natural Resources and the U.S. Geological Survey to conduct a Modified Unified Method (MUM) for Invasive carp removal. eDNA will be collected in March, after ice out, and will immediately precede the MUM removal efforts. eDNA data from this

effort will inform MN DNR of potential Invasive carp presence and those data will be compared to actual capture data from the MUM to infer detectability of Silver and Bighead carp in Pool 8.

Objectives:

1. Monitor for Invasive Carp eDNA in targeted backwaters within the pools immediately upstream of the Intensive Management Zone
2. Inform managers of potential trends in Invasive carp presence and provide data to support the prioritization of new backwaters to target with traditional capture methods
3. Refine detection probability and optimal sampling design of eDNA in the UMR

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

Activities and Methods: In FY21, eDNA samples will be collected from pools 13, 14 and 16 of the UMR primarily in the spring, as that is the season where Invasive carp are congregated in these habitats. If personnel and lab capacity allow, samples will also be collected in the fall to serve as a secondary time point for collection, with the recognition that Invasive carp may not be as abundant in these locations at that time of year. Due to prolonged flooding and the pandemic in recent year, spring eDNA data collections have not occurred since 2018 in these pools. Fall collections have occurred each year since 2018, although at a limited capacity in 2020 due to the pandemic. Sampling in the intended pools is expected to be completed as normal in 2021. Pools 13 and 14 will be sampled to fulfill objective 1 and 2 of this work plan. Three and five backwaters will be targeted in Pools 13 and 14, respectively (see maps below), and 80 samples will be collected per backwater, plus 8 quality control field blanks. Sampling and preservation procedures will follow the USFWS Quality Assurance Project Plan (QAPP 2020, https://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf).

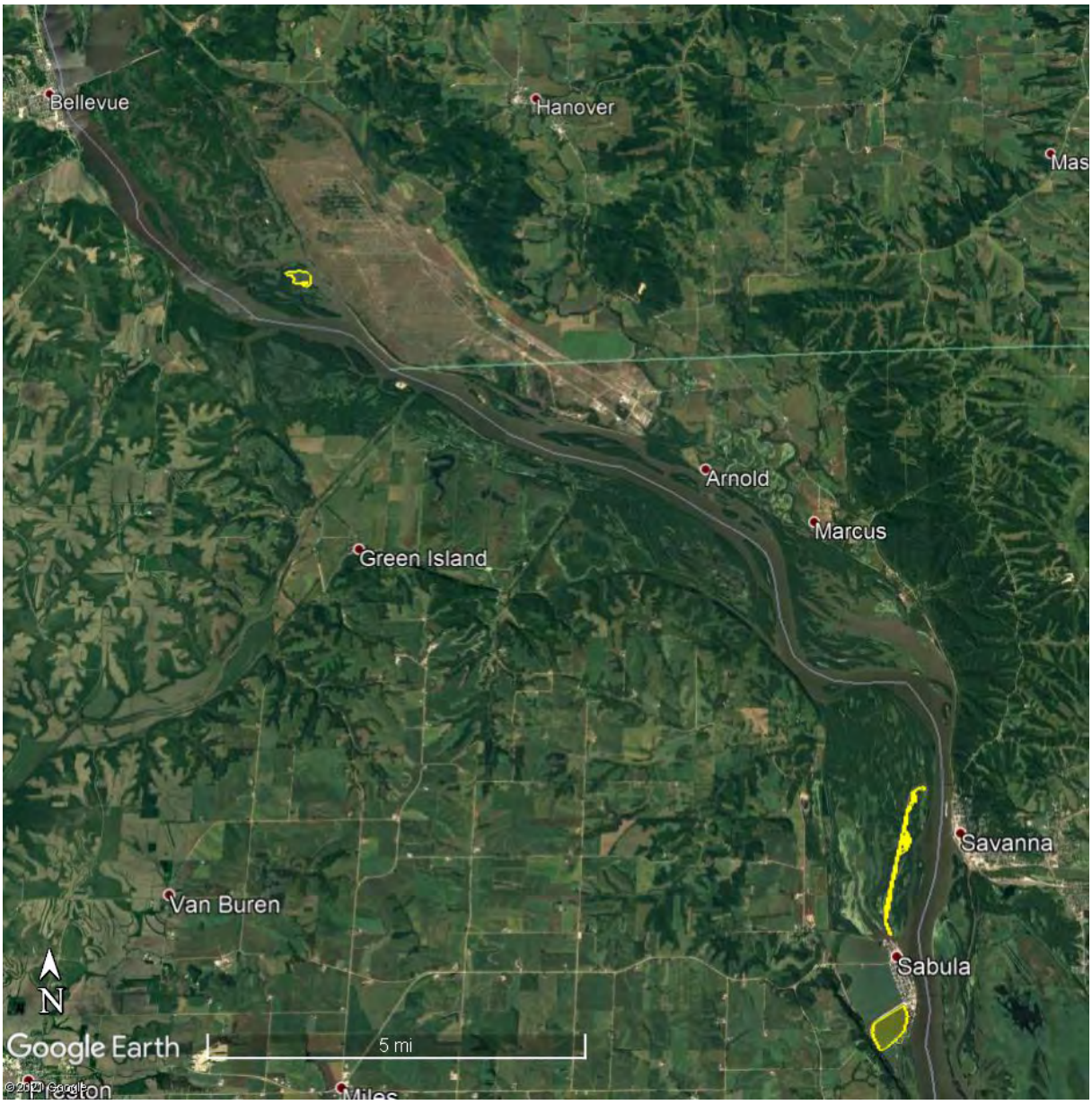
The Credit Island backwater in Pool 16 (see map below) will be sampled for Invasive carp DNA in fulfillment of objective 3. Sampling will occur at the same time points and follow the same procedures as Pool 13 and 14 sampling. Data will be compared with real-time telemetry detections of tagged Bighead and Silver carp. Over time, those data will be analyzed to determine relative trends and observed relationships between Invasive carp presence and eDNA detections. Those data will be used to refine eDNA sampling strategy and inform realistic detection probability. Additionally, those data may be used in the future to infer minimum Invasive carp presence in regularly monitored eDNA backwaters in other pools.

Additionally, five backwaters in Pool 8 (Figure 5) will be targeted and sampled for Invasive carp DNA in March, following ice out. In each backwater, 100 samples and 10 quality control field blanks will be collected. Sampling and preservation procedures will follow the QAPP.

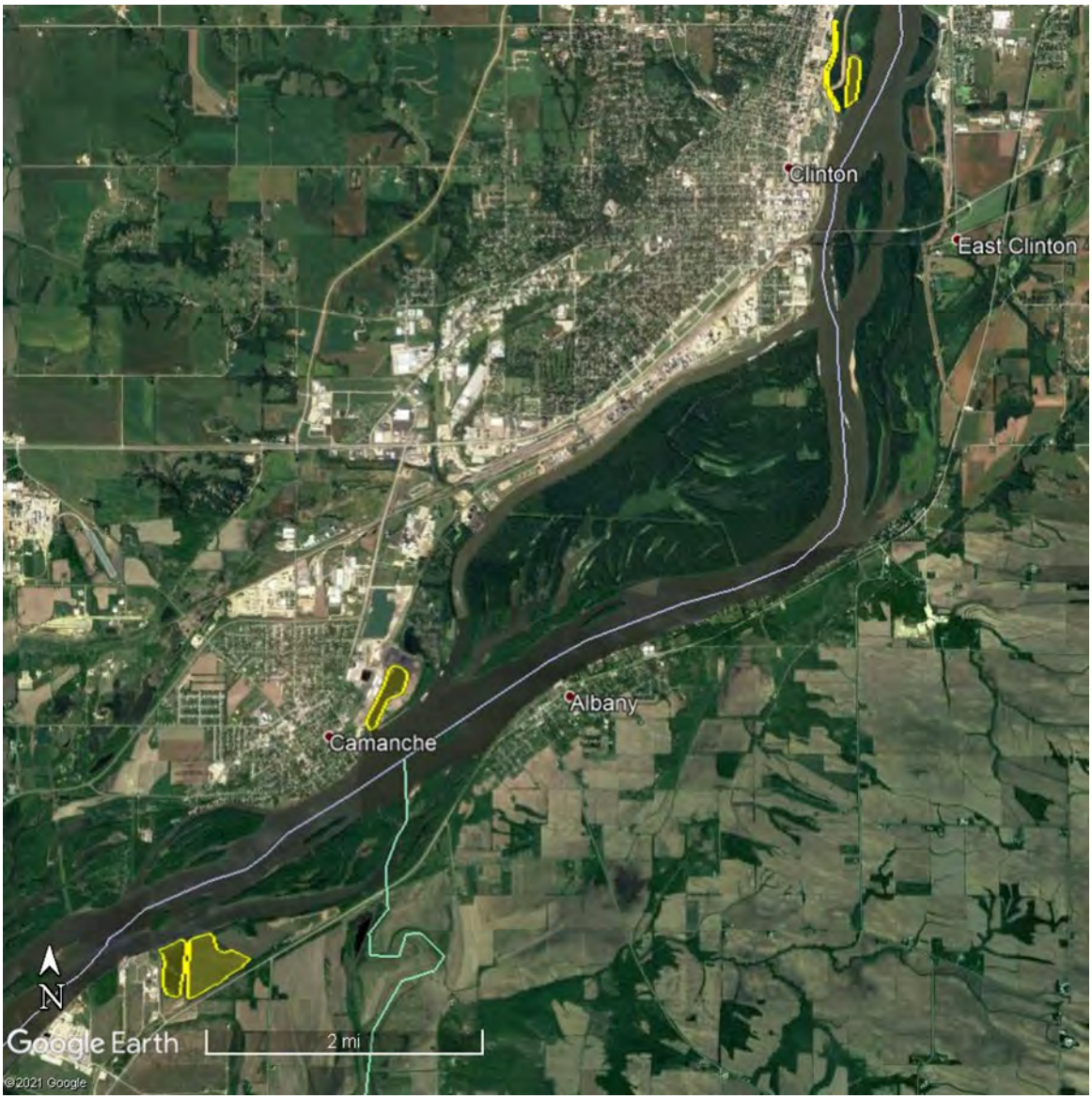
Results of eDNA sampling in the UMR will be reported as positive/negative for Invasive carp DNA. The possible results can include No Detection, Invasive carp detection (not specific to

species, Silver carp detection, Bighead carp detection, and Both Silver and Bighead carp detection together. Results will be provided to the partner state(s) in the form of sampling summaries with accompanying maps, and then posted online. Data will be summarized for an annual report and results will be used to advise the need for physical sampling and/or recommend changes to the eDNA sampling design in future years.

Maps of Project Area:



Three backwater areas in Pool 13 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.



Five backwater areas in Pool 14 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.

One of five backwater sites in Pool 14 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021

Credit Island backwater, in Pool 16, where Bighead and Silver carp eDNA samples will be collected in 2021.

Five backwater areas in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Pool 8	March
Pool 13, 14, 16	April-May
Pool 13, 14, 16	October-November

Agency: U.S. Geological Survey (USGS)

Activities and Methods: In FY21, we will collect water samples for eDNA isolation from Pools 8, 10, 12, 13, 17, and 19 in both summer (June-July) and fall (October-November). At each pool and time point, we will collect 50 samples, plus field blanks for negative controls. Sampling points will remain the same as previous years; should exact locations not be accessible due to water conditions, we will attempt to sample the nearest point. Each sample will consist of a 50 ml grab sample that will be centrifuged, and eDNA extracted from the resulting pellet. Carp eDNA will be amplified using a quantitative PCR assay that can differentiate between bighead carp and silver carp (Erickson et al. 2017). These methods will address objectives 1 and 2.

In Spring 2021, we sample 10 sites across Pool 8 that represent the location of MUM efforts. Each site will have samples collected at 5 different points. Note that the exact sampling locations related to the MUM are different than the exact points for Pool 8 multiyear monitoring for objectives 1 and 2, although there is some overlap in area. Sampling will occur 1-2 weeks before the MUM and 1-2 weeks following the MUM. If a MUM occurs in Fall 2021, we plan to sample at the same time interval pre- and post-MUM. Water collection for MUM eDNA sampling will consist of filtering up to 500 ml (or until filter clogs) using 1.2 micron PCE filters (qPCR amplification will not change). This will allow our results to be consistent with sampling conducted at Pool 8 MUM sites in Fall 2020. These methods will address our Objective 3.

Finally, we will directly compare grab samples/centrifugation and filtering during our summer and fall monitoring in Pool 8. At each of the 50 sampling points, we will concurrently collect a grab sample for centrifugation while simultaneously filtering a water sample. These methods will address Objective 4.

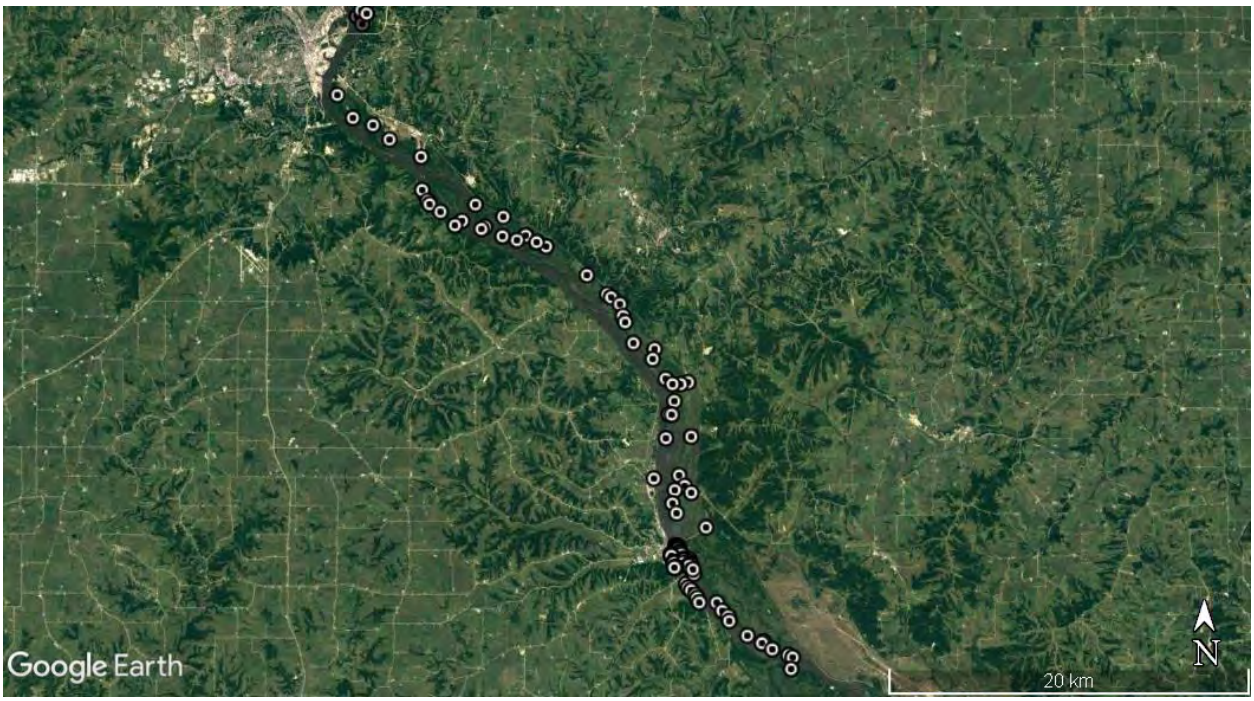
For all objectives and methods, results will be categorized as positive and negative by each species. Therefore, there are four different outcomes for each method (negative, positive both species, positive bighead carp, positive silver carp). For objectives 1-3, we will summarize and map results to share with cooperating agencies and for publication. Objective 4 will serve as a basis for estimating detection probability between the two methods, although additional sampling years may be necessary to precisely estimate detection.

Map of Project Area:

Sampling points in Pool 19 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

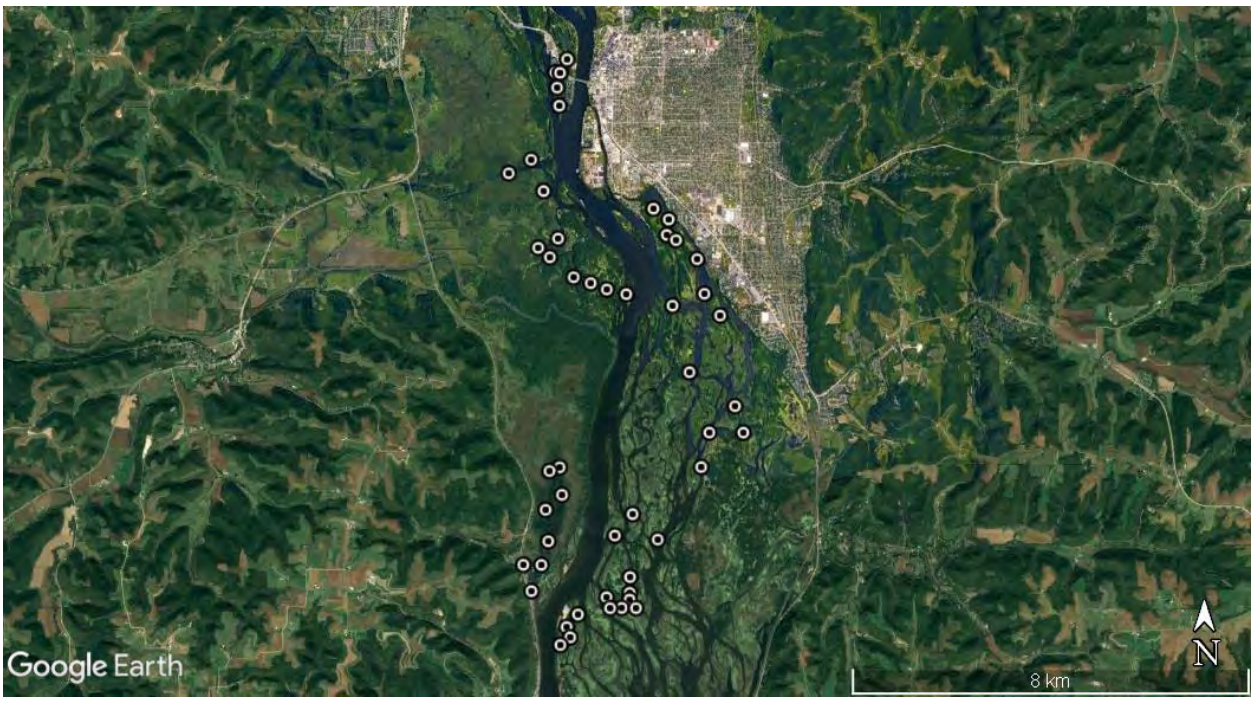
Sampling points in Pool 17 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 13 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.



Sampling points in Pool 12 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 10 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.



Sampling points in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of ongoing monitoring.

Sampling points in Pool 8 of the UMR to be targeted for Bighead and Silver carp eDNA sample collection in 2021 as part of monitoring around the Modified Unified Method (MUM) capture events.

Estimated Timetable for Activities:

Activity	Time Period (Season, month/year)
Pool 8	March (pre-MUM)
Pool 8	April (post-MUM)
Pool 8, 10, 12, 13, 17, 19	June-July
Pool 8	September-October (pre- and post-MUM if Fall MUM
Pool 8, 10, 12, 13, 17, 19	October-November

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