Interim Summary Report

2024

Invasive Carp Monitoring and Response Plan

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Acronyms and Abbreviations List

Acronym and Abbreviation	Definition
2DKS	2-Dimensional Kolmogorov-Smirnov
AIC	Akaike Information Criteria Corrected
AIS	Aquatic Invasive Species
ARIS	Adaptive Resolution Imaging Sonar
C	Celsius
Cal-Sag	Calumet-Saganashkee
CarpDAT	Invasive Carp Database
CAWS	Chicago Area Waterway System
CERC	Columbia Environmental Research Center
CO2	Carbon Dioxide
CPO	Conservation Police Officer
CPUE	Catch per Unit Effort
CRP	Contingency Response Plan
CSSC	Chicago Sanitary and Ship Canal
DC	Direct Current
DNA	Deoxyribonucleic Acid
EDBS	Electric Dispersal Barrier System
eDNA	Environmental Deoxyribonucleic Acid
EF	Electrofishing
EPA	Environmental Protection Agency
ERDC	Environmental Research and Development Center
FAQ	Frequently Asked Questions
FWCO	Fish and Wildlife Conservation Office
FY	Fiscal Year
GLFC	Great Lakes Fishery Commission
HM	Heidelberg Materials
IAP	Incident Action Plan
ICRCC	Invasive Carp Regional Coordinating Committee
ICS	Incident Command System
ILDNR	Illinois Department of Natural Resources
ILRCdb	Illinois River Catch Database

Acronym and Abbreviation	Definition
in	inch
INHS	Illinois Natural History Survey
ISR	Interim Status Report
ISU	Invasive Species Unit
IWW	Illinois Waterway
KDFWR	Kentucky Department of Fish & Wildlife Resources
kHz	Kilohertz
L&D	Lock and Dam
LTEF	Long Term Illinois River Fish Population Monitoring Program
LTRM	Long-term Resource Monitoring
LTRMP	Long term Resource Monitoring Program
m^3	Cubic Meter
m	Meter
MAM	Multi-Agency Monitoring
MDC	Missouri Department of Conservation
mm	Millimeter
mmol/mol	Millimole per mole
MOU	Memorandum of Understanding
MRP	Monitoring and Response Plan
MRWG	Monitoring and Response Work Group
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
OTN	Ocean Tracking Network
QA/QC	Quality Assurance/Quality Control
qPCR	Quantitative Polymerase Chain Reaction
RAFT	Riverine Acoustic Fish Telemetry Network
RM	River Mile
SCAA	Statistical Catch-at-Age
SEICarP	Spatially Explicit Invasive Carp Population
SIM	Seasonal Intensive Monitoring
SIU	Southern Illinois University
spp.	Species
SPL_{rms}	Sound Pressure Level – Root mean square

Acronym and Abbreviation	Definition
Sr:Ca	Strontium:calcium
TL	Total length
uADS	Underwater acoustic deterrent system
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UMESC	Upper Midwest Environmental Sciences Center
yds	Yards
VPS	Vemco Positioning System
v/cm	Volts per centimeter
YOY	Young-of-Year
VPS	Vemco Positioning System

EXECUTIVE SUMMARY

This Invasive Carp Interim Summary Report (ISR) was prepared by the Monitoring and Response Work Group (MRWG) and released by the Invasive Carp Regional Coordinating Committee (ICRCC). It is intended to act as an update to previous ISRs and present the most up-to-date results and analysis for a host of projects dedicated to preventing invasive carp from establishing populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. Specifically, this document is a compilation of the results of 21 projects, each of which plays an important role in preventing the expansion of the range of invasive carp and furthering the understanding of invasive carp location, population dynamics, behavior, and the efficacy of control and capture methods. The MRWG has also completed a companion document, the 2025 Invasive Carp Monitoring and Response Plan (MRP) for the Illinois Waterway.

The term "invasive carp" generally refers to four species of carp native to central and eastern Asia that were introduced to the waters of the United States and have become highly invasive. The four species generally referred to by the "invasive carp" moniker are:

- **Bighead Carp** (*Hypophthalmicthys nobilis*)
- **Silver Carp** (*Hypophthalmicthys molitrix*)
- **Grass Carp** (*Ctenopharyngodon idella*)
- **Black Carp** (*Mylopharyngodon piceus*)

The 2024 results for 21 projects are summarized in this ISR. Also included in this ISR is an update to Appendix A: Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal. The Upper Illinois Waterway Continency Response Plan (CRP) is an important component of the effort to prevent invasive carp from establishing a presence in the Illinois Waterway; therefore, the CRP is also identified in the project location crosswalk included in the ISR, but the CRP is a separate document that can be found on https://icrcc.fws.gov. The summaries in the ISR document the purpose, objectives, and methods for each project, in addition to providing an analysis of results and recommendations for future actions. The projects are grouped into three general categories:

- **Detection:** Determine the distribution and abundance of invasive carp to guide response and control actions.
- **Management and Control:** Prevent the upstream passage of invasive carp toward Lake Michigan via the use of barriers, mass removal, and understanding the best methods for preventing passage.
- **Response:** Establish comprehensive procedures for responding to invasive carp population status changes, test these procedures through exercises, and implement if necessary.

Presented below are project highlights by category, which provide a brief snapshot of project accomplishments during 2024. A link to the corresponding project is provided at the end of each highlight.

HIGHLIGHTS OF 2024 EFFORTS

Detection Projects

- Led by Illinois Department of Natural Resources (ILDNR), MRWG agencies completed two 2-week Seasonal Intensive Monitoring (SIM) events with conventional gears in the CAWS upstream of the Electric Dispersal Barrier System (EDBS) in 2024; no live Silver Carp or Bighead Carp were captured or observed during 2024 SIM events. (SEASONAL INTENSIVE MONITORING IN THE CAWS)
- Staff supporting the 2024 spring SIM event captured and removed two Grass Carp one each from Lake Calumet and one from the Little Calumet River. (SEASONAL INTENSIVE MONITORING IN THE CAWS)
- No invasive carp were detected upstream of Brandon Road Lock and Dam. (SUPPORT FOR EARLY DETECTION IN THE ILLINOIS WATERWAY)
- No small invasive carp were captured in Lockport, Brandon Road, Dresden Island, Marseilles, or Starved Rock pools. (SUPPORT FOR EARLY DETECTION IN THE ILLINOIS WATERWAY)
- From April to early October 2024, Illinois Natural History Survey (INHS) staff collected 716 ichthyoplankton samples from 10 sites from the Brandon Road to Alton navigation pools of the Illinois Waterway (IWW). The sampling results indicate that 2024 was among the top four years of invasive carp reproductive productivity, although abundance of juvenile invasive carp was low in 2024. (ASSESSMENT OF INVASIVE CARP REPRODUCTION AND ECOSYSEM RESPONSE IN THE ILLINOIS WATERWAY)
- In 2024, INHS and Eastern Illinois University collected 246 ichthyoplankton samples from Illinois River tributaries. Large-diameter eggs and invasive carp larvae were collected from the Spoon and Sangamon rivers. No evidence of invasive carp reproduction was observed in other Illinois River tributaries. (ASSESSMENT OF INVASIVE CARP REPRODUCTION AND ECOSYSEM RESPONSE IN THE ILLINOIS WATERWAY)
- U.S. Fish and Wildlife Service (USFWS) staff collected 1,040 environmental deoxyribonucleic acid (eDNA) samples upstream of the EDBS and 220 eDNA samples in Powderhorn Lake (control site); positive detections were few and consistent with previous sampling years. (STRATEGY FOR eDNA SAMPLING IN THE CAWS)
- USFWS staff reported that no eDNA was detected in the 94 samples collected in the Chicago Area Ponds in 2024. (ALTERNATIVE PATHWAY SURVEILLANCE IN ILLINOIS – URBAN POND MONITORING)
- During the ILDNR Office of Law Enforcement annual in-service training, 150 Conservation Police Officers received the first statewide aquatic invasive species enforcement training. (ALTERNATE PATHWAY SURVEILLANCE IN ILLINOIS – LAW ENFORCEMENT)

Management and Control Projects

- In 2024, USFWS collected and processed over 1,500 otolith aging structures from six pools of the Illinois River, which provided pool-specific age-structure metrics. (INVASIVE CARP DEMOGRAPHICS – MULTIPLE AGENCY MONITORING SUPPORT)
- During the 2024 multiple agency monitoring (MAM) sampling event, 372 small Silver Carp (less than 6 inches or 152.4 mm) were captured in the lower three pools of the Illinois River. This represents a significant increase in spawning over 2023 but is still a relatively minor spawning pulse in the historical context of longer-term La Grange pool sampling. (MULTIPLE AGENCY MONITORING OF THE ILLINOIS RIVER FOR DECISION-MAKING)
- Led by Southern Illinois University (SIU), the 13th year of standardized monitoring of bigheaded carp (i.e., Bighead Carp and Silver Carp) densities was completed in 2024 from Alton to Dresden Island pools. These data allow for long-term assessments and comparisons of density trends across space and through time. (INVASIVE CARP STOCK ASSESSMENT IN THE ILLINOIS RIVER)
- Large target fish (greater than 12 inches) densities in mobile hydroacoustic surveys conducted in Lockport, Brandon Road, and Dresden Island pools in 2024 were higher than in recent years. Since hydroacoustic surveys cannot validate fish observations to a species level, additional effort via traditional sampling is typically done following reports of higher abundance. In 2024, after seeing abnormal peaks of large fish targets at the EDBS, the U.S. Army Corps of Engineers (USACE) was alerted and personnel conducted electrofishing surveys. It was determined through this additional surveillance that the large targets were likely schools of gizzard shad moving upstream. (ILLINOIS WATERWAY HYDROACOUSTICS)
- SIU maintained the stationary acoustic telemetry receiver array throughout the Illinois River, ensuring sufficient surveillance efforts occurred to detect adult movements among pools and toward the invasion front. (SIU LONGITUDINAL RECEIVER ARRAY AND TAGGING)
- No known live tagged fish have crossed the EDBS in the upstream direction. (USACE TELEMETRY MONITORING PLAN)
- In April 2024, USFWS implanted 200 V-9 acoustic transmitters inside invasive carp – 150 in Peoria Pool and 50 in Starved Rock Pool. An additional 17 Silver Carp were tagged in Starved Rock Pool with viable tags from recaptured fish in 2023. (TELEMETRY SUPPORT FOR THE SPATIALLY EXPLICIT INVASIVE CARP POPULATION MODEL (SEICarP))
- ILDNR, working with contracted fishers, removed 572 Bighead Carp, 54,211 Silver Carp and 142 Grass Carp from the IWW. The total estimated weight of invasive carp removed is 640 tons (1,281,000 pounds). (CONTRACTED COMMERCIAL FISHING BELOW THE ELECTRIC DISPERSAL BARRIER)
- Supported by ILDNR, contracted fishers removed more than 6.3 million pounds of invasive carp from the Peoria, La Grange and Alton pools of the Illinois River in 2024. (INVASIVE CARP ENHANCED CONTRACT REMOVAL PROGRAM)

- ILDNR continued to see positive media coverage of the Copi brand and the development of new value-added products and new distributors and sales outlets. (INVASIVE CARP ENHANCED CONTRACT REMOVAL PROGRAM)
- The U.S. Geological Survey (USGS) Invasive Carp Open Data Hub was published in 2024 and is available to the public and invasive carp researchers. (USGS INVASIVE CARP DATABASE MANAGEMENT AND INTEGRATION SUPPORT)
- Results from the SEICaRP model suggest that harvest of invasive carp from the downstream pools (Alton – Peoria pools; source population) remains more effective than harvest from upstream pools (Starved Rock – Dresden Island pools; sink population) at reducing the Dresden Island population. (SUPPORT FOR INVASIVE CARP POPULATION MODELING IN THE ILLINOIS RIVER)
- In 2024, INHS and ILDNR completed 66 paired hoop nets baited with cottonseed-based baits, 66 paired hoops nets baited with clams, and 66 un-baited paired hoop nets within the La Grange and Alton Reaches of the Illinois River. No Black Carp were captured during these efforts; three captures were made by commercial fishers within the lower Illinois River. (ENHANCED DETECTION OF BLACK CARP IN THE LOWER ILLINOIS RIVER)
- Within Illinois waters in 2024, 89 Black Carp were reported with three Black Carp reported from the Alton Pool of the Illinois River. (DATA COLLECTION FROM COMMERCIAL FISHERS AND RECREATIONAL ANGLER CAPTURES OF BLACK CARP IN THE LOWER ILLINOIS RIVER)

Response Projects

- No responses were conducted in 2024.
- Incident Command System training was held for MRWG co-chairs and key MWRG field staff from multiple agencies.

INTRODUCTION

The 2024 Interim Summary Report (ISR) presents a comprehensive accounting of project results from activities completed by the invasive carp Monitoring and Response Work Group (MWRG) in 2024. These projects have been carefully selected and tailored to contribute to the overall goal of preventing invasive carp from establishing self-sustaining populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. Efforts to prevent the spread of invasive carp to the Great Lakes have been underway for over 14 years. Throughout this time, goals, objectives, and strategic approaches have been refined to focus on five key objectives:

(1) Determining the distribution and abundance of any invasive carp in the CAWS and using this information to inform response removal actions.

(2) Removing any invasive carp found in the CAWS to the maximum extent practicable.

(3) Identifying, assessing, and reacting to any vulnerability in the current system of barriers to prevent invasive carp from moving into the CAWS.

(4) Determining the leading edge of major invasive carp populations in the Illinois River and the reproductive successes of those populations.

(5) Improving the understanding of factors behind the likelihood that invasive carp could become established in the Great Lakes.

The 21 projects presented in this document represent the results of efforts undertaken in 2024 to further the implementation of each of these objectives. Also included in this ISR is an update to Appendix A: Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal. The Upper Illinois Waterway Continency Response Plan (CRP), which includes the Barrier Maintenance and Fish Suppression update, is an important component of the effort to prevent invasive carp from establishing a presence in the Illinois Waterway; therefore, the CRP is also identified in the project location crosswalk included in the ISR, but the CRP is a separate document that can be found on https://icrcc.fws.gov. To align with the 2024 Monitoring and Response Plan, the projects have been organized by MRWG work group.

Table 1 provides a current list of MRWG work groups, including leads, co-leads, and respective agencies.

Table 1. MRWG Work Group and Leads

Work Group	Lead	Agency	Co-Lead(s)	Agency
Contingency Response	Nick Barkowski	USACE	Alex Catalano Mindy Barnett	USACE ILDNR
Detection	Steve Butler	INHS	Jen-Luc Abeln Joe Parkos	USFWS INHS
Monitoring	Jim Lamer	INHS	Eli Lampo	ILDNR
Hydroacoustics	Jim Garvey	SIU	Elizabeth Harrell	USFWS
Telemetry	Marybeth Brey	USGS	Alex Catalano	USACE
Removal	Allie Lenaerts	ILDNR	Justin Widloe	ILDNR
Modeling	Richie Erickson	USGS	Benjamin Marcek	USFWS
Behavioral Deterrents	Marybeth Brey	USGS	Christa Woodley Nick Barkowski	USACE USACE
Black Carp	Rob Simmonds	USFWS	-	-

BACKGROUND

Invasive carp are native to central and eastern Asia, with a wide distribution throughout eastern China. They typically live in river systems and have predators and competitors in their native habitats that are well adapted to compete with invasive carp for food sources, thus limiting their population growth. In the early 1970s, invasive carp were intentionally imported to the United States (U.S.) for use in aquaculture and wastewater treatment detention ponds. In these settings, invasive carp were used to control the growth of weeds, algae, and pests. By 1980, invasive carp had been captured by fishermen in river systems in Arkansas, Louisiana, and Kentucky.

Flooding events during the 1980s and 1990s allowed invasive carp to greatly expand their range from isolated detention ponds to natural river systems. Invasive carp are currently widespread in the Mississippi River basin, including the Ohio River, Missouri River, and Illinois River. Areas with large populations of invasive carp have seen an upheaval of native ecosystem structure and function. Invasive carp are voracious consumers of phytoplankton, zooplankton, and macroinvertebrates. They grow quickly and are highly adapted for feeding on these organisms, allowing them to outcompete native species and quickly grow too large for most native predators to prey upon. As a result, their populations have exploded in the Mississippi River basin.

The term “invasive carp” generally refers to four species of carp native to central and eastern Asia that were introduced to the waters of the United States and have become highly invasive. The four species generally referred to by the “invasive carp” moniker are:

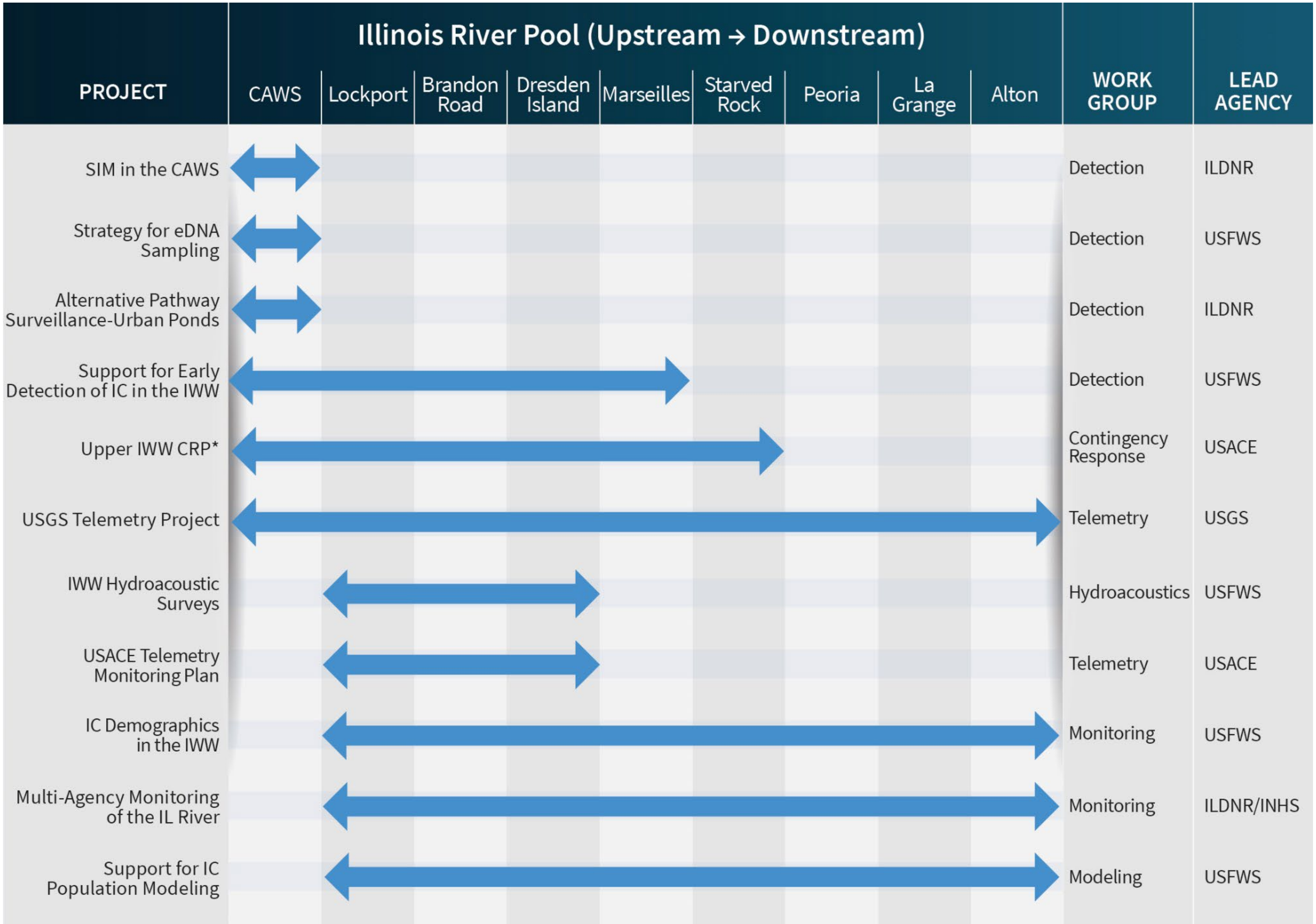
- **Bighead Carp** (*Hypophthalmicthys nobilis*)
- **Silver Carp** (*Hypophthalmicthys molitrix*)
- **Grass Carp** (*Ctenopharyngodon idella*)
- **Black Carp** (*Mylopharyngodon piceus*)

The expansion of invasive carp populations throughout the central U.S. has had enormous impacts on local ecosystems and economies. Where invasive carp are present, the native ecosystems have been altered, resulting in changes to the populations and community structure of aquatic organisms. The trademark leaping behavior of startled Silver Carp has also impacted recreational activities where they are populous, presenting a new danger to people on the water. Current academic studies estimate that the economic impact of invasive carp is in the range of billions of dollars per year. A central focus of governmental agencies is preventing the spread of invasive carp to the Great Lakes. Ecological and economic models forecast that the introduction of invasive carp to the Great Lakes could have enormous impacts.

In response to the threat posed to the Great Lakes by invasive carp, the Invasive Carp Regional Coordinating Committee (ICRCC) and the MRWG present the following projects to further the understanding of invasive carp, improve methods for capturing invasive carp, and directly combat the expansion of invasive carp range.

PROJECT LOCATIONS

To clearly depict the geospatial scale and focus of the projects included in this ISR, the MRWG has prepared a project location crosswalk. This crosswalk tool allows readers to understand where a specific project focuses its efforts and quickly discern all projects that are operating in a specific portion of the Illinois Waterway (IWW) and CAWS. Projects more broad in scope that do not target a particular reach are marked with asterisks (**).


PROJECT
Illinois River Pool (Upstream → Downstream)
CAWS
Lockport
Brandon Road
Dresden Island
Marseilles
Starved Rock
Peoria
La Grange
Alton
WORK GROUP
LEAD AGENCY
SIM in the CAWS
Detection
ILDNR
Strategy for eDNA Sampling
Detection
USFWS
Alternative Pathway Surveillance-Urban Ponds
Detection
ILDNR
Support for Early Detection of IC in the IWW
Detection
USFWS
Upper IWW CRP*
Contingency Response
USACE
USGS Telemetry Project
Telemetry
USGS
IWW Hydroacoustic Surveys
Hydroacoustics
USFWS
USACE Telemetry Monitoring Plan
Telemetry
USACE
IC Demographics in the IWW
Monitoring
USFWS
Multi-Agency Monitoring of the IL River
Monitoring
ILDNR/INHS
Support for IC Population Modeling
Modeling
USFWS

PROJECT	Illinois River Pool (Upstream → Downstream)									WORK GROUP	LEAD AGENCY
	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton		
Assessment of IC Reproduction			↔	↔	↔	↔	↔	↔	↔	Detection	INHS
Contract Fishing for IC Removal Near the EDBS				↔	↔	↔				Removal	ILDNR
SIU Longitudinal Receiver Array and Tagging				↔	↔	↔	↔	↔	↔	Telemetry	SIU
IC Stock Assessment in IL River				↔	↔	↔	↔	↔	↔	Hydroacoustics	SIU
Field Testing of an Underwater ADS					↔					Behavioral Deterrents	USGS
Telemetry Support for the SEICarP						↔	↔			Telemetry	USFWS
Enhanced IC Removal in the Lower Illinois River							↔	↔	↔	Removal	ILDNR
Data Collection from Captures of Black Carp in Lower IL River							↔	↔	↔	Black Carp	ILDNR
Enhanced Detection of Black Carp								↔	↔	Black Carp	ILDNR
Alternative Pathway Surveillance – Law Enforcement**										Detection	ILDNR
IC Database Management /Integration Support**										Modeling	USGS

*Upper Illinois Waterway Contingency Response Plan is a separate document posted on https://icrcc.fws.gov

** Project is more broad in scope and does not target a particular reach.

DETECTION WORK GROUP PROJECTS

- Seasonal Intensive Monitoring in the CAWS
- Support for Early Detection in the Illinois Waterway
- Assessment of Invasive Carp Reproduction and Ecosystem Response in the Illinois Waterway
- Strategy for eDNA Sampling in the CAWS
- Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring
- Alternative Pathway Surveillance in Illinois – Law Enforcement

SEASONAL INTENSIVE MONITORING IN THE CAWS

Participating Agencies: ILDNR (lead); INHS, USFWS, USACE, and SIU (field support); USCG (waterway closures when needed), USGS (flow monitoring when needed); MWRDGC (waterway flow management and access); and USEPA and GLFC (project support); Madison Myers, Andrew Wieland, MJ Oubre (INHS); Allison Lenaerts, Claire Snyder, Justin Widloe, Eli Lampo, Mindy Barnett, Brian Schoenung (ILDNR)

MWRG Work Group: Detection

Pools Involved: CAWS

INTRODUCTION AND NEED

Detections of invasive carp (Silver Carp and Bighead Carp) eDNA upstream of the EDBS in 2009 initiated the development of a monitoring plan that utilized boat electrofishing and contracted commercial fishers to sample for invasive carp at five fixed sites upstream of the barrier. Random area sampling began in 2012, increasing the chance of detecting invasive carp in the CAWS beyond the designated fixed sites. Extensive sampling performed upstream of the EDBS from 2010 through 2013 resulted in one Bighead Carp being collected in Lake Calumet in 2010. Fixed site and random area sampling efforts were then reduced upstream of the barrier to two SIM events from 2014 to 2024. Following effort reduction, one Silver Carp was collected in the Little Calumet River in 2017, resulting in a rapid interagency contingency response effort. One additional Silver Carp was captured in 2022 in Lake Calumet outside of SIM sampling. Effort reduction upstream of the EDBS allows for increased monitoring efforts downstream of the barrier. Increased sampling downstream of the EDBS focuses sampling efforts at the leading edge (Dresden Island Pool) of the invasive carp population, which serves to reduce their numbers in that area, reducing the risk of individuals moving upstream toward the EDBS and Lake Michigan by way of the CAWS. Results from the SIM upstream of the EDBS contribute to our understanding of invasive carp abundance in the CAWS and guide actions designed to remove invasive carp from areas where they have been captured or observed.

OBJECTIVES

- Determine invasive carp population abundance through intense fixed, random, and targeted sampling efforts at locations deemed likely to hold fish.
- Remove invasive carp from the CAWS upstream of the EDBS.

PROJECT HIGHLIGHTS

- Completed two 2-week SIM events with conventional gears in the CAWS upstream of the EDBS in 2024.
- No live Silver Carp or Bighead Carp were captured or observed during SIM 2024. One live Bighead Carp was captured in Lake Calumet in 2010, and one live Silver Carp was captured in the Little Calumet River in 2017, with no other captures or observations in any other years. One dead Silver Carp was observed in 2018 on the banks of the Cal-Sag Channel, and another dead Silver Carp was observed in 2022 on the banks of the Calumet River. One live Silver Carp was captured in Lake Calumet in 2022 outside of SIM sampling. For more information

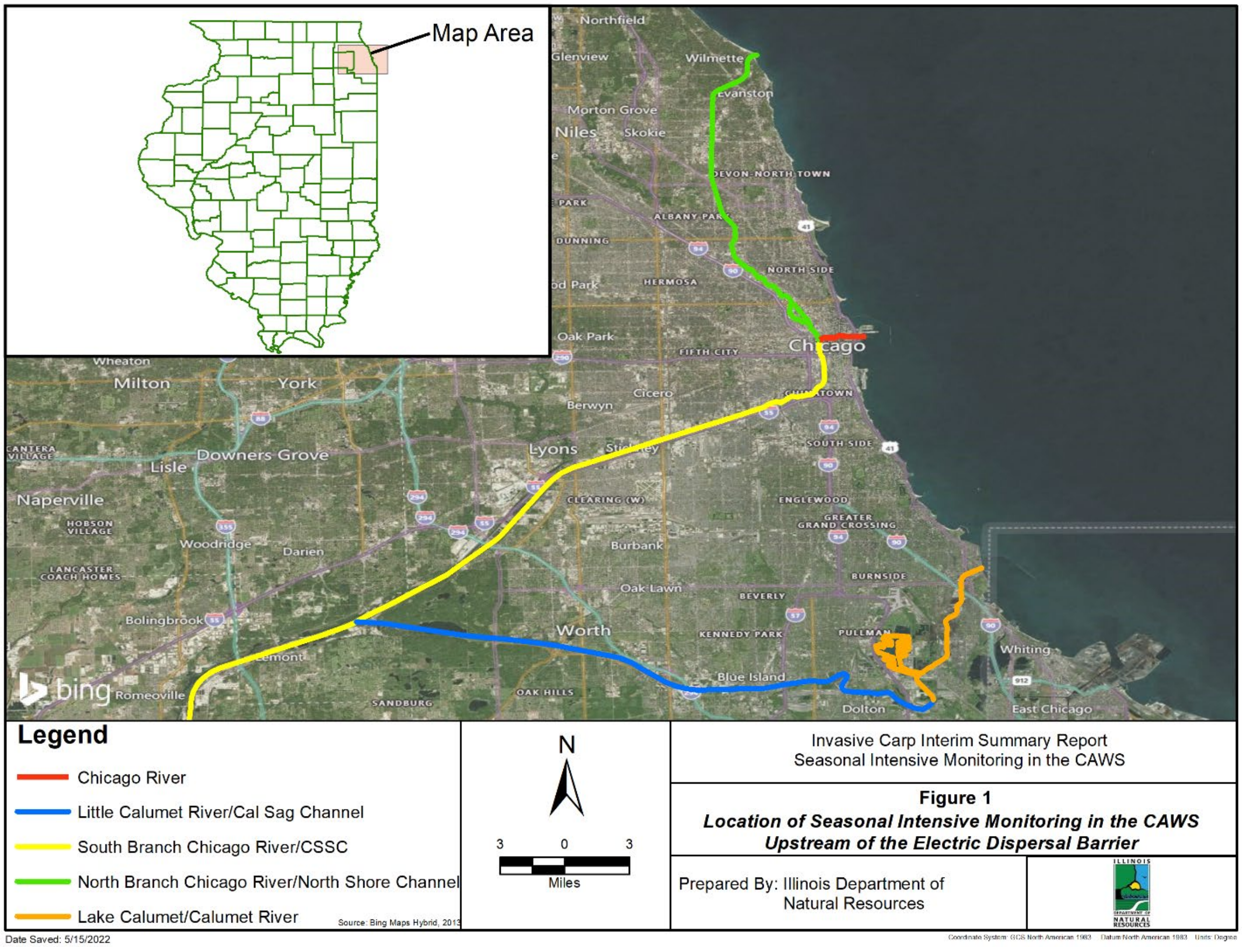
on response actions, please refer to the Response Project section of the appropriate year's ISR (2022 Invasive Carp Interim Summary Report).

- Two Grass Carp were captured and removed from Lake Calumet and the Little Calumet River during the spring SIM. From 2010 to 2024, a total of 69 Grass Carp upstream of the EDBS have been removed in the CAWS.
- An estimated 3,243.1 person-hours were spent completing 140 hours of electrofishing, setting 160.2 kilometers (99.5 miles) of gill net, and setting 2.9 kilometers (1.8 miles) of commercial seine in 2024.
- Across all locations and gears, 34,519 fish were sampled, representing 60 species and 3 hybrid groups in 2024.
- An estimated 47,566.6 person-hours have been spent completing 1869.2 hours of electrofishing, setting 1,913.4 kilometers (1188.9 miles) of gill/trammel net, setting 30.7 kilometers (19.1 miles) of commercial seine, and 114.2 net nights of tandem trap nets, hoop nets, fyke nets, and pound nets since 2010.
- From 2010 to 2024, a total of 590,382 fish representing 88 species and 7 hybrid groups were sampled.
- YOY Gizzard Shad (n = 143,925) were examined, and no YOY invasive carp were found when sampling from 2010 to 2024.
- Non-native species (n = 16) have been captured, accounting for 15 percent of the total number of fish caught and 15 percent of the total species since 2010.

METHODS

Pulsed DC-electrofishing, gill nets, and a commercial seine were used to monitor for invasive carp in the CAWS upstream of the EDBS (Figure 1). In previous years, trammel nets, deep water gill nets, fyke nets, and pound nets were also used. Those gear specifications can be found in prior ISRs. Intensive electrofishing and netting occurred at five fixed-site and four random-site sampling areas. Random sites were generated with GIS software from shape files of designated random site areas. In 2024, random site sampling also took place within fixed site areas, as it was found that the effort level (number of sampling sites per river kilometer) in fixed site areas was much lower than in random site areas. Adding random sites into fixed-site sampling areas increased effort levels within the fixed-site areas and allowed for more thorough surveillance in areas that might hold invasive carp, such as the Little Calumet River and Lake Calumet. For a more detailed description of fixed and random sampling areas, see the 2024 MRP (2024 Invasive Carp Monitoring and Response Plan). Decontamination protocols for PDC electrofishing and netting can also be found in the 2024 MRP.

Figure 1. *Location of SIM in the CAWS upstream of the EDBS.*

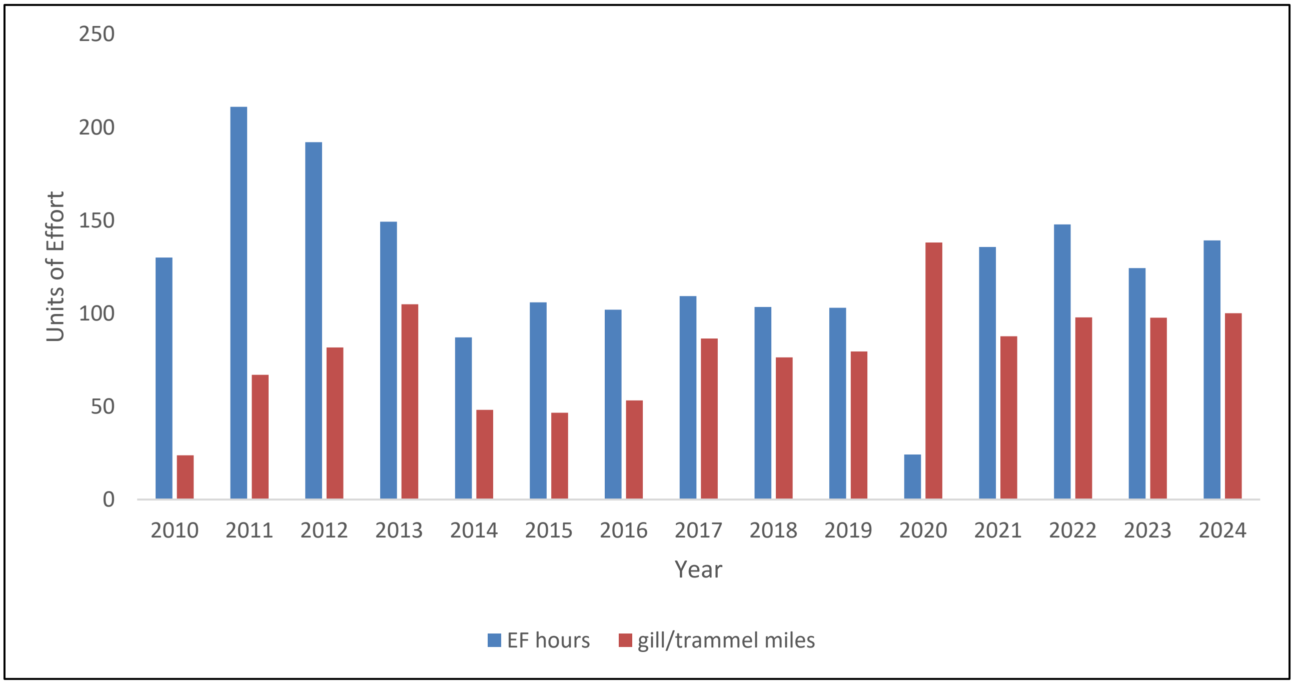


RESULTS AND DISCUSSION

SIM sampling in 2024 took place from May 13 to 24 and September 30 to October 11, for a total of 20 sampling days. Sampling in 2023 also took place in May and October. From 2014 to 2020, sampling events were conducted in June and September. To continually focus monitoring efforts on the leading edge of the invasive carp population below the EDBS, the same reduced sampling effort protocols established in 2014 upstream of the barrier were followed in 2024 (Figure 2). Sampling events in the spring and fall were both preceded by eDNA monitoring (see "Strategy for eDNA Sampling in the CAWS" report in this ISR for more information on protocols and results). Effort in 2024 was 140 hours of electrofishing (560 transects), with an estimated 1,610 person-hours; 160.2 kilometers (99.5 miles) of gill netting (876 sets), with an estimated 1,425.8 person-hours; and 2.9 kilometers (1.8 miles) of commercial seine, with an estimated 210 person-hours (Table 1).

Across all locations and gears, 34,519 fish representing 60 species and 3 hybrid groups were sampled in 2024 (Table 2). Gizzard Shad (33.9%), Largemouth Bass (11.2%), Common Carp (9.9%), Freshwater Drum (6.6%), Bluegill (5.4%), Bluntnose Minnow (4.9%), Emerald Shiner (4.7%), and Pumpkinseed (4.2%) were the predominant species, comprising 80.8 percent of all fish sampled. Twelve non-native species were sampled, including Common Carp and hybrids (Common carp x goldfish), Round Goby, Alewife, Goldfish, White Perch, Oriental Weatherfish, Grass Carp, Chinook Salmon, Coho Salmon, Brown Trout, and Rainbow Trout. Non-native species made up 16.6 percent of the total species collected and 13.5 percent of the total fish by count in 2024. In addition, 4,974 YOY Gizzard Shad were examined, and none were found to be YOY invasive carp. No live Bighead Carp or Silver Carp were captured or observed.

Figure 2. *Total electrofishing and trammel/gill netting effort at fixed and random sites in the CAWS upstream of the EDBS, 2010 to 2024.*



An estimated 47,566.5 person-hours have been expended monitoring fixed and random sites upstream of the EDBS since 2010. From 2010 to 2024, the total effort consisted of 1,869.2 hours of electrofishing (7,571 transects); 1,913.4 kilometers (1,188.9 miles) of gill/trammel net (10,482 sets); 30.7 kilometers (19.1 miles) of commercial seine hauls; and 114.2 net nights of hoop, pound, and fyke nets (Table 3). Hoop net use was suspended after 2013 due to low gear efficiency. A total of 590,382 fish representing 88 species and 7 hybrid groups have been sampled since 2010 (Table 3). Gizzard Shad, Common Carp, Bluegill, Largemouth Bass, Bluntnose Minnow, and Pumpkinseed were the predominant species sampled, accounting for 82 percent of all fish collected. Since 2010, 16 non-native species have been caught, including Alewife, Bighead Carp, Brown Trout, Chinook Salmon, Coho Salmon, Common Carp and hybrids, Goldfish, Grass Carp, Oriental Weatherfish, Rainbow Smelt, Rainbow Trout, Round Goby, Silver Arrowana, Silver Carp, Tilapia, and White Perch and hybrids. Non-native species constitute 15 percent of the total number of fish caught and 15 percent of the total species. Since 2010, 143,925 YOY Gizzard Shad have been examined, with no YOY invasive carp being identified. One live Bighead Carp was caught in a trammel net in Lake Calumet in 2010, and one live Silver Carp was captured in a trammel net in the Little Calumet River on June 22, 2017, with no other captures or observations in other years. One live Silver Carp was captured in Lake Calumet on August 4, 2022, outside of SIM sampling. For more information on this capture and the subsequent response, please see the Response Projects section of the 2022 ISR.

RECOMMENDATIONS

We recommend continuing use of SIM upstream of the EDBS. SIM with conventional gears represents the best available tool for localized detection and removal of invasive carp to prevent them from becoming established in the CAWS or Lake Michigan.

REFERENCES

Invasive Carp Monitoring and Response Work Group. 2023. 2023 Monitoring and Response Plan for Invasive Carp in the upper Illinois River and Chicago Area Waterway System. Illinois, Chicago.

Table 1. *Summary of effort and catch data for SIM in the CAWS upstream of the EDBS, 2024.*

Effort and Catch	Lake Calumet/ Calumet River	Little Calumet River/Cal Sag	S. Branch Chi. River/CSSC	Chicago River	N. Branch Chi River/N. Shore	Total
Electrofishing Effort	-	-	-	-	-	-
Estimated person-hours	747.5	365	252.5	5	240	1610
Samples (transects)	230	150	88	2	90	560
Electrofishing hours	57.5	37.5	22	.5	22.5	140
Electrofishing Catch	-	-	-	-	-	-
All fish (*N*)	9787	10144	2657	0	7755	30343
Species (*N*)	42	45	25	0	39	60
Hybrids (*N*)	2	2	2	0	1	3
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/hr)	170.2	270.5	120.7	0	344.66	226.5
Netting Effort	-	-	-	-	-	-
Estimated person-hours	584	350	180	36	280	1430
Samples (net sets)	336	284	124	24	108	876
Miles of net	38.2	32.2	14.1	2.7	12.3	99.5
Netting Catch	**-**	-	-	-	-	-
All fish (*N*)	599	508	182	27	104	1420
Species (*N*)	14	14	5	3	4	18
Hybrids (*N*)	0	1	0	0	1	1
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/100 yds of net)	1.1	1.2	1.4	1.8	2.07	1.5
Seine Effort	-	-	-	-	-	-
Estimated person-hours	210	0	0	0	0	210
Samples (seine hauls)	4	0	0	0	0	4
Miles of seine	1.8	0	0	0	0	1.8
Seine Catch	**-**	0	0	0	0	-
All fish (*N*)	2756	0	0	0	0	2756
Species (*N*)	20	0	0	0	0	20
Hybrids (*N*)	0	0	0	0	0	0
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/seine haul)	689	0	0	0	0	689

Table 2. *Total number of fish captured with electrofishing (EF), trammel/gill nets (Nets), and commercial seine (Seine) in the CAWS upstream of the EDBS during SIM 2024.*

Species	Cal River	Cal River	Chicago River	Chicago River	CSSC-S Branch	CSSC-S Branch	Lake Calumet	Lake Calumet	Lake Calumet	Little Cal-Cal Sag	Little Cal-Cal Sag	N Branch-N Shore	N Branch-N Shore	All Sites
-	EF	Nets	EF	Nets	EF	Nets	EF	Nets	Seine	EF	Nets	EF	Nets	All Gears
Alewife	23	0	0	0	0	0	180	0	0	16	0	48	0	267
Banded killifish	110	0	0	0	32	0	311	0	0	89	0	8	0	550
Bigmouth buffalo	1	0	0	0	0	0	7	5	2	0	6	0	0	21
Black buffalo	2	6	0	0	0	0		25	2	0	6	0	0	41
Black bullhead	4	0	0	0	8	0	89	1	0	3	0	0	0	105
Black crappie	3	0	0	0	0	0	16	0	57	4	0	30	0	110
Blackstripe topminnow	-	0	0	0	0	0	-	0	0	65	0	39	0	104
Bluegill	132	0	0	0	291	0	413	0	0	533	0	479	0	1848
Bluntnose minnow	156	0	0	0	244	0	489	0	0	403	0	390	0	1682
Bowfin	9	0	0	0	0	0	46	0	2	9	0	0	0	66
Brook silverside	43	0	0	0	0	0	5	0	0	14	0	12	0	74
Brown bullhead	4	1	0	0	0	0	52	0	0	1	0	1	0	59
Brown trout	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Bullhead minnow	0	0	0	0	0	0	0	0	0	0	0	7	0	7
Carp x goldfish hybrid	3	0	0	0	4	0	5	0	0	0	1	0	0	13
Central stoneroller	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Channel catfish	5	2	0	1	47	3	39	9	36	69	10	7	2	230
Channel shiner	12	0	0	0	0	0	0	0	0	0	0	0	0	12
Chinook Salmon	12	2	0	0	0	0	25	2	0	0	1	0	0	42
Coho salmon	2	0	0	0	0	0	1	0	0	0	0	2	0	5

Species	Cal River	Cal River	Chicago River	Chicago River	CSSC-S Branch	CSSC-S Branch	Lake Calumet	Lake Calumet	Lake Calumet	Little Cal-Cal Sag	Little Cal-Cal Sag	N Branch-N Shore	N Branch-N Shore	All Sites
-	EF	Nets	EF	Nets	EF	Nets	EF	Nets	Seine	EF	Nets	EF	Nets	All Gears
Common carp	134	73	0	26	316	138	728	134	2	1104	288	473	101	3517
Emerald shiner	153	0	0	0	104	0	78	0	0	962	0	313	0	1610
Fathead minnow	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Flathead catfish	1	2	0	0	0	0	7	0	1	0	1	0	0	12
Freshwater drum	23	62	0	0	3	13	94	152	1754	93	95	6	1	2296
Gizzard shad	74	1	0	0	369	0	326	0	664	2352	3	2964	0	6753
Gizzard Shad < 6 in	178	0	0	0	919	0	796	0	0	2642	0	439	0	4974
Golden shiner	0	0	0	0	78	0	54	0	0	39	0	270	0	441
Goldfish	3	0	0	0	2	0	174	0	69	25	2	42	0	317
Grass Carp	0	0	0	0	0	0	0	1	0	0	1	0	0	2
Green sunfish	45	0	0	0	54	0	47	0	0	109	-	23	0	278
Hybrid Sunfish	0	0	0	0	4	0	0	0	0	0	0	3	0	7
Largemouth bass	490	0	0	0	107	0	1366	3	41	871	3	986	0	3867
Mimic shiner	0	0	0	0	0	0	0	0	0	9	0	0	0	9
Northern pike	3	0	0	0	0	0	4	1	9	1	0	6	0	24
Northern sunfish	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Orangespotted sunfish	0	0	0	0	0	0	1	0	0	1	0	0	0	2
Oriental Weatherfish	0	0	0	0	2	0	0	0	0	2	0	23	0	27
Pumpkinseed	142	0	0	0	24	0	617	1	0	508	0	143	0	1435
Quillback	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Rainbow trout	3	0	0	0	0	0	1	0	0	0	0	0	0	4
River carpsucker	24	3	0	0	0	0	0	0	0	0	0	0	0	27
Rock bass	131	0	0	0	0	0	209	0	5	10	0	134	0	489
Round Goby	185	0	0	0	12	0	67	0	0	3	0	3	0	270

Species	Cal River	Cal River	Chicago River	Chicago River	CSSC-S Branch	CSSC-S Branch	Lake Calumet	Lake Calumet	Lake Calumet	Little Cal-Cal Sag	Little Cal-Cal Sag	N Branch-N Shore	N Branch-N Shore	All Sites
-	EF	Nets	EF	Nets	EF	Nets	EF	Nets	Seine	EF	Nets	EF	Nets	All Gears
Sand shiner	30	0	0	0	0	0	0	0	0	4	0	1	0	35
Smallmouth bass	475	0	0	0	0	0	144	0	6	15	0	0	0	640
Smallmouth buffalo	42	22	0	0	0	28	63	85	83	24	91	0	0	438
Spotfin shiner	0	0	0	0	0	0	31	0	0	15	0	107	0	153
Spottail shiner	0	0	0	0	0	0	20	0	0	12	0	35	0	67
Unidentified buffalo	0	0	0	0	0	0	0	4	0	0	0	0	0	4
Walleye	0	1	0	0	3	0	0	0	2	0	0	7	0	13
Warmouth	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Western mosquitofish	0	0	0	0	26	0	0	0	0	25	0	0	0	51
White bass	37	0	0	0	0	0	9	0	12	28	0	39	0	125
White crappie	0	0	0	0	0	0	5	0	6	0	0	2	0	13
White perch	4	0	0	0	0	0	8	0	3	32	0	15	0	62
White sucker	19	1	0	0	7	0	0	0	0	17	0	565	0	609
Yellow bass	0	0	0	0	1	0	5	0	0	8	0	1	0	15
Yellow bullhead	7	0	0	0	0	0	48	0	0	12	0	14	0	81
Yellow perch	62	0	0	0	0	0	419	0	0	10	0	118	0	609
Total fish (N)	2787	176	0	27	2657	182	7000	423	2756	10144	508	7755	104	34519
Total species (N)	40	12	0	3	23	4	41	13	19	43	14	37	3	60
Total hybrids (N)	0	0	0	0	2	0	1	0	0	0	1	1	0	2
*: non-native species														

Table 3. *Summary of effort and catch data for all fixed and random site monitoring in the CAWS upstream of the EDBS 2010* to *2024.*

Effort and Catch	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Electrofishing Effort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estimated person-hours	1,280	2,180	4,330	1,528	945	990	990	990	990	1,118	195	1,350	1,260	1,440	1,610	**21,196**
Samples (transects)	519	844	765	588	348	422	407	437	414	412	127	592	620	516	560	**7,571**
EF (hrs)	130	211	192	149.3	87.1	106	102	109	103.5	103	28.7	136	148	124.3	140	**1,870**
Electrofishing Catch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
All fish (N)	33,688	52,385	97,510	45,443	24,492	28,549	22,557	26,198	26,944	18,247	5,244	26,134	28,214	41,444	34,519	**511,568**
Species (N)	51	58	59	56	56	61	59	58	60	48	39	53	65	60	60	**90**
Hybrids (N)	3	3	3	2	2	2	2	2	2	2	1	4	2	3	3	**8**
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Silver Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
CPUE (fish/hr)	259.1	248.3	507.9	304.4	281.2	269.3	221.1	239.7	260.3	177.2	182.7	192.2	190.8	333.4	226.5	**275.8**
Netting Effort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estimated person-hours	885	1,725	3,188	1,932	1,125	1,125	1,125	1,485	1,148	1,440	2,655	2,070	1,588	1,416.5	1,430	**24,337.5**
Samples (net sets)	208	389	699	959	440	445	498	803	710	711	1252	772	860	860	876	**10,482**
Miles of net	23.8	67	81.7	104.9	48.2	46.6	53.3	86.5	76.6	79.7	138.2	87.7	98	97.6	99.5	**1,189.3**
Netting Catch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
All fish (N)	2,439	4,923	3,060	4,195	1,461	1,062	1,283	1,917	1,174	1,622	1,964	1,321	1,641	1,513	1,420	**30,995**
Species (N)	17	20	20	30	18	13	18	14	23	19	18	17	57	18	18	**43**
Hybrids (N)	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	**2**
Bighead Carp (N)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Silver Carp (N)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
CPUE (fish/100 yds of net)	5.8	4.2	2.1	2.3	1.7	1.3	1.4	1.3	0.9	1.2	0.81	0.9	1.0	0.06	1.5	**1.5**
Seine Effort	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estimated person-hours	0	0	0	135	135	135	135	135	135	135	135	210	328	210	210	**2,038**

Effort and Catch	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Samples (seine hauls)	0	0	0	3	2	3	3	4	3	4	4	4	4	4	4	**42**
Miles of seine	0	0	0	1.4	0.9	1.4	1.4	1.8	1.4	1.8	1.8	1.8	1.8	1.8	1.8	**19**
Seine Catch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All fish (N)	0	0	0	7,577	1,725	5,989	3,765	2,763	3,110	7,457	2,879	3,490	7,181	1,949	2,756	**50,641**
Species (N)	0	0	0	15	11	14	15	10	10	16	11	18	19	21	20	**30**
Hybrids (N)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silver Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CPUE (fish/seine haul)	0	0	0	2,525.7	862.5	1,996.3	1,255.0	690.8	1,036.7	1,864.3	719.8	872.5	1,795.3	487.3	689	**1,260.1**
Hoop/Trap Net/ Tandem Trap Net	**-**	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Estimated person-hours	0	0	0	0	0	30	28	135	135	0	0	0	0	0	0	**328**
Samples (sets)	0	0	0	11	0	4	3	8	7	0	0	0	0	0	0	**33**
Net-days	0	0	0	25.2	0	16	12	52.1	43	0	0	0	0	0	0	**148.3**
Hoop/Trap Net/ Tandem Trap Net Catch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
All fish (N)	0	0	0	93	0	172	102	294	693	0	0	0	0	0	0	**1,354**
Species (N)	0	0	0	17	0	17	15	17	19	0	0	0	0	0	0	**34**
Hybrids (N)	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	**2**
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silver Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CPUE (fish/net-day)	0	0	0	3.7	0	10.75	8.5	5.6	16.1	0	0	0	0	0	0	**9.1**
Estimated person-hours	0	0	0	0	0	0	0	0	135	0	0	0	0	0	0	**135**
Net-days	0	0	0	0	0	0	0	8.9	0	0	0	0	0	0	0	**8.9**
All fish (N)	0	0	0	0	0	0	0	646	0	0	0	0	0	0	0	**646**
Species (N)	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	**15**
Hybrids (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**

Effort and Catch	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Bighead Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Silver Carp (N)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
CPUE (fish/net-day)	0	0	0	0	0	0	0	72.6	0	0	0	0	0	0	0	**72.6**

SUPPORT FOR EARLY DETECTION IN THE ILLINOIS WATERWAY

Participating Agencies: USFWS Carterville FWCO (lead), ILDNR, USGS, INHS, SIU USACE – Chicago District

MWRG Work Group: Detection

Pools Involved: Marseilles, Dresden Island, Brandon Road, Lockport, CAWS

INTRODUCTION AND NEED

The large (greater than 153 mm) Bighead and Silver Carp invasion front in the IWW is currently in the Dresden Island Pool, approximately 16 kilometers downstream of the EDBS and 76 kilometers downstream from Lake Michigan (ICRCC 2023). The small (less than 153 mm) Bighead Carp and Silver Carp invasion front in the IWW is currently in the Peoria Pool, though small fish were found in Starved Rock Pool in 2015, 2021, and 2022 (ICRCC 2023). The objective of this project is to specifically target the detection of individual invasive carp (all four species) at and above the invasion fronts. This project differs from other IWW monitoring actions by using methods focused on finding invasive carp individuals rather than generalized population and assemblage sampling methods (see the Multiagency Monitoring of the Illinois River for Decision Making, Invasive Carp Stock Assessment in the Illinois River, and The Illinois Waterway Hydroacoustics projects in this document for more information).

OBJECTIVES

- Conduct monthly fixed and randomized electrofishing and gill net sampling targeted for large invasive carp in Brandon Road and Lockport Pools from March to November 2024.
- Conduct monthly fixed and randomized electrofishing, dozer trawling, and mini-fyke netting sampling targeting small invasive carp in Dresden Island Pool, Marseilles Pool, and the Kankakee River from June to November 2024.
- Monitor for changes in adult bigheaded carp population in Dresden Island Pool and Kankakee River in March through November 2024.
- Remove all invasive carp captured during sampling.
- Report invasive carp detections outside of the current designated status.

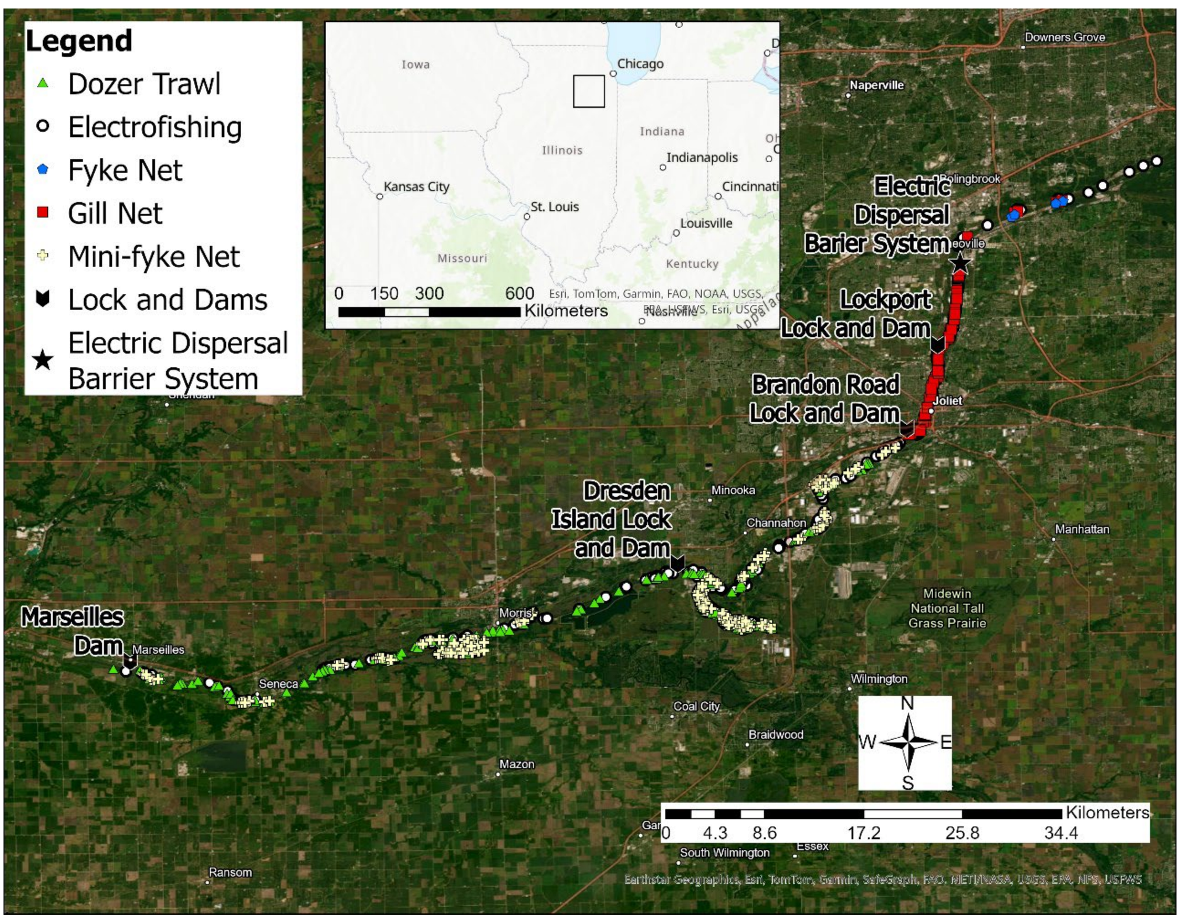
PROJECT HIGHLIGHTS

- No large invasive carp were detected upstream of Brandon Road L&D.
- No small invasive carp were detected in Marseilles, Dresden Island, Brandon Road, or Lockport pools.
- USFWS field personnel, in partnership with ILDNR, USGS, INHS, and SIU, captured and removed one large Bighead Carp, 305 large Silver Carp, and 8 large Grass Carp from Marseilles, Dresden Island, and lower Kankakee River pools during 2024.
- 604 electrofishing runs, 305 electrified dozer trawls, 169 gill net sets, and 375 mini-fyke net sets were completed across all pools between February 26 and November 25, 2024.

METHODS

Target analysis completed in previous years identified a combination of fixed and random site sampling, including habitat stratifications, utilizing appropriate gear types for both large and small invasive carp life stages, and electrofishing power goals targeting invasive carp (Young *et al.* 2023). Sampling site selection in 2024 considered areas to target or avoid based on professional experience from previous sampling years. Fixed sites were located in previous capture sites or similar habitats spaced across the pool. Random sites were stratified by habitat type, such as main channel borders, side channels, and backwaters, proportionally by the spatial area of each habitat. Areas not compatible with a respective gear type were relocated to compatible sites within the same habitat type whenever possible. Gears selected for Marseilles and Dresden Island Pools and the lower Kankakee River were daytime boat electrofishing, electrified dozer trawling, and mini-fyke netting. Gears selected for Brandon Road and Lockport Pools were daytime boat electrofishing and gill netting. All captured invasive carp were measured for total length (mm) and mass (grams) and euthanized. All other fish captured were identified to the species level and enumerated. Native and non-harmful fish species were released, and other invasive species were euthanized. Yearly sampling sites for 2024 are shown in Figure 1.

Figure 1. *Sites sampled by the USFWS Carterville FWCO in 2024.*



Rarefaction is a common analysis done to assess the effectiveness of a fishery sampling program (Radinger *et al*. 2019). Species richness estimates were made using the Mao Tau method for species accumulation (Colwell, Mao & Chang 2004) and using 1000 resamples within each study area by gear. These analyses were performed in R 4.4.2 (R Core Team 2024).

In collaboration with USGS and the modeling workgroup, occupancy modeling was used to assess the probability that bigheaded carp were occupying sampled locations and this project's probability of detecting them (MacKenzie et al. 2017). Monthly sampling events were treated as revisits for each pool during their collection year. Sites were assigned a binary detection or non-detection based on site observations within a sampling event. A gear type and year combination were used in the model to account for changes in sampling protocols across years. This also allowed pools without detections to have detection probability estimates that were informed by pools with detections.

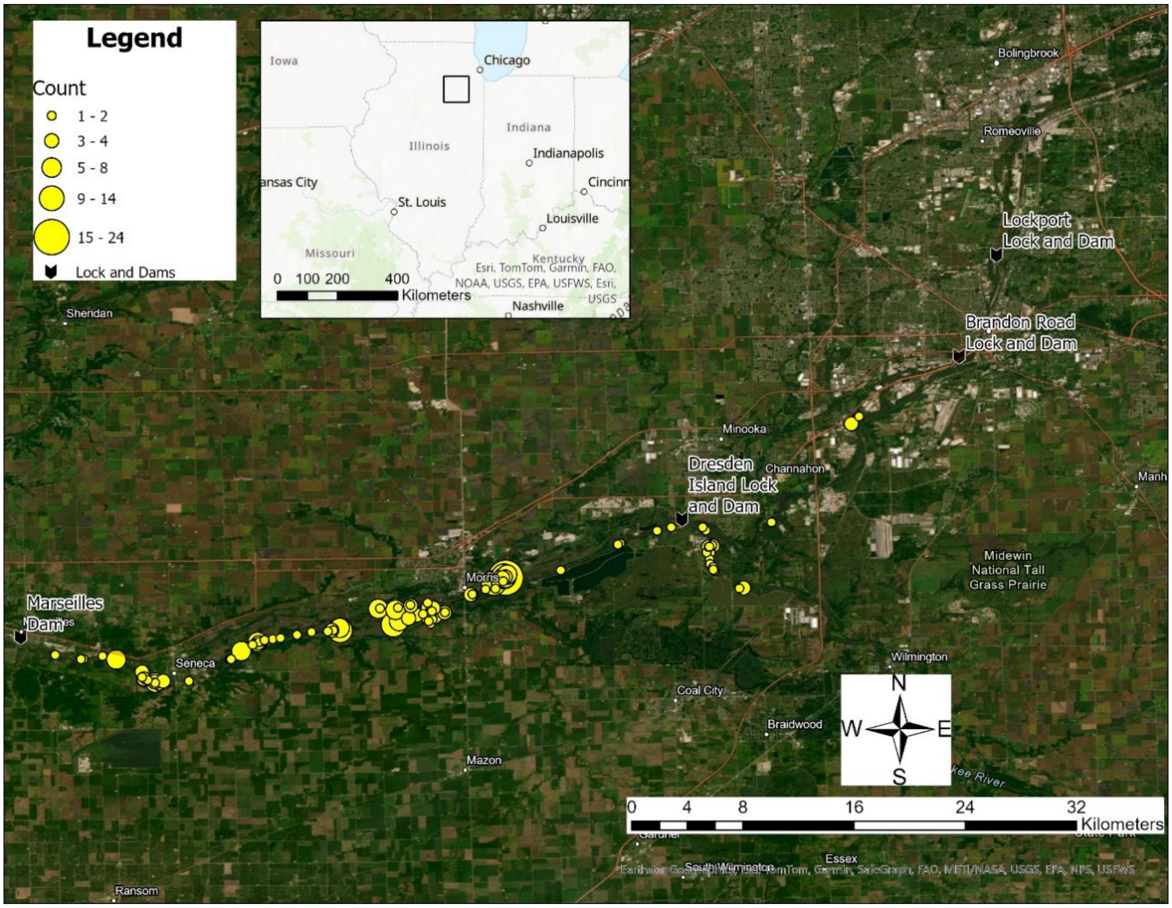
RESULTS AND DISCUSSION

USFWS sampled 1,458 sites across four IWW pools (Marseilles, Dresden Island, Brandon Road, and Lockport) and the lower Kankakee River for large and small invasive carp between February 26 and November 25, 2024. A total of 314 large invasive carp were captured (see Figure 2). **No small invasive carp were observed in this sampling, and no invasive carp were found outside of their known range**. The total effort consisted of 151.3 hours of boat electrofishing, 25.4 hours of electrified dozer trawling, 33,400 yards (18.9 miles) of gill nets deployed, 362.9 net-nights of mini-fyke netting, and 5.8 net-nights of fyke netting. The USFWS captured 90,628 fish that were not invasive carp in 2024, consisting of 85 species and six hybrid taxa.

Species accumulation curves for electrofishing and gill netting reached near asymptote for the pools they were deployed in, except for the Des Plaines (Figure 3). Dozer trawl and mini-fyke curves reached near asymptote for Marseilles Pool but may need a more samples in Dresden Island pool and the lower Kankakee River to indicate that there is a sufficient likelihood that few species went unsampled (Figure 3). The Des Plaines had few samples due to the sampling area being accessible only during high water events, so effort-based community analyses may consistently produce results indicating more effort is required to capture the breadth of the species community.

Occupancy models showed that current detection probabilities were relatively high (>75%) for dozer trawl and electrofishing, but relatively low (<30%) for mini-fyke nets and gill nets across all pools (Figure 4). Individual sites detection probability was low (generally <15%), not unexpected for an invasion front, but didn't vary considerable across years (Figure 5). The 2022 gill net estimate is derived from a single net set, thus not a reliable estimator for the gear. Detection probability increased less than 10%, even at 50% increase scenarios for dozer trawl and electrofishing in the lower three pools. Poor detection probability for gill nets and mini-fyke nets is likely driven by their use in areas upstream of known invasion fronts resulting in no captures of bigheaded carp in their targeted size class. These gears are known to capture bigheaded carp in other pools of the Illinois River, so additional data or different analyses may be needed to produce more accurate detection probabilities.

Figure 2. *Location map of invasive carp captured by USFWS Carterville FWCO in 2024.*



RECOMMENDATIONS

- Continue early detection monitoring for all life stages of invasive carp in the Upper IWW to provide additional assurance that adult invasive carp are absent from the area upstream of Brandon Road L&D and small invasive carp are absent from the area upstream of Marseilles L&D.
- Dresden Island dozer trawl efforts are being partially converted into Multiagency Monitoring of the Illinois River for Decision Making efforts.
- Continue to refine detection methods and effort using professional experience and model-based estimates to increase efficiency and effectiveness of the project.

Figure 3. *Species accumulation curves by pool by gear from USFWS Carterville FWCO captures in 2024.*

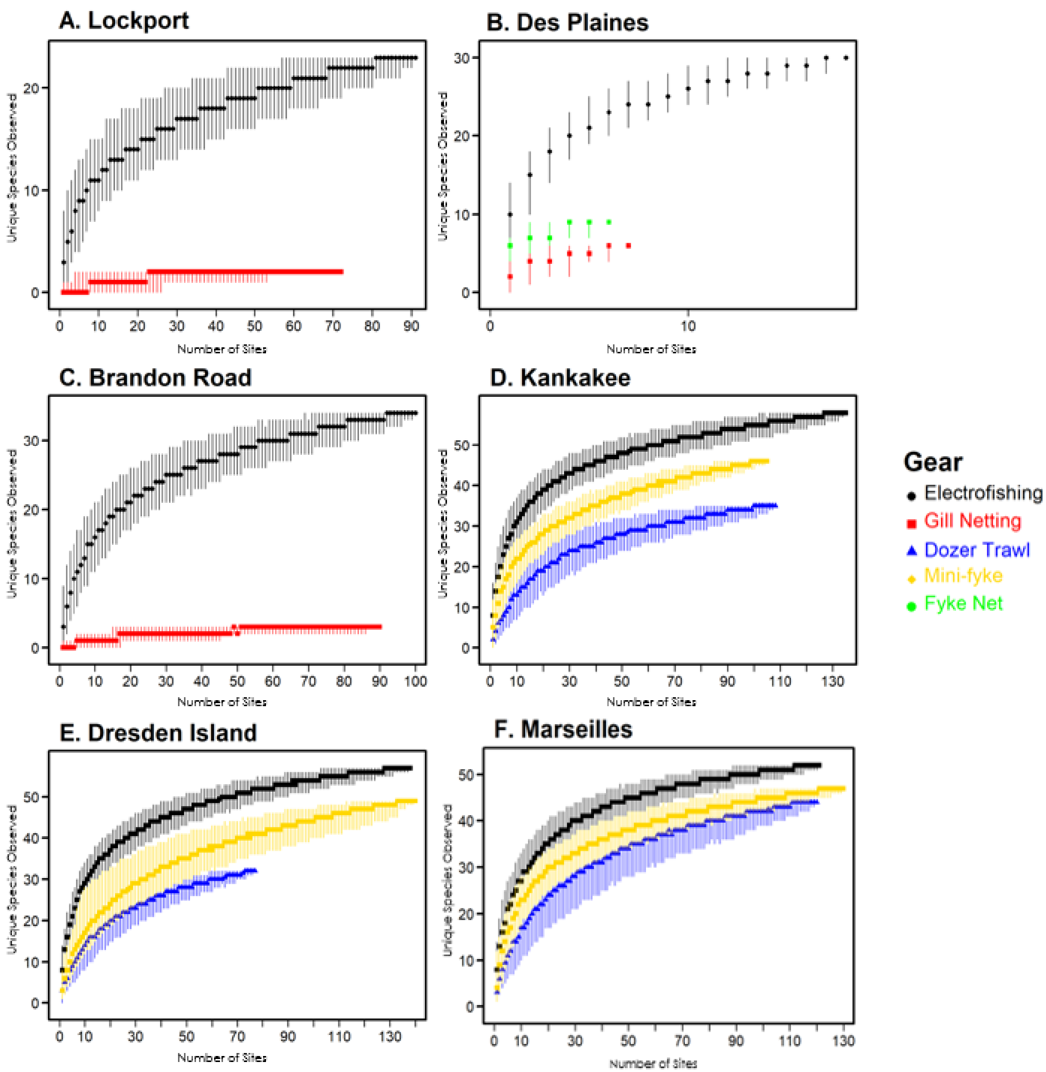


Figure 4. *Effort-based sampling scenarios for each gear type in each pool, that the gear is currently used in, and reflect the Current (average monthly) and predicted detection probabilities. The Even sampling scenario assumes the amount of effort is distributed equally across the pools.*

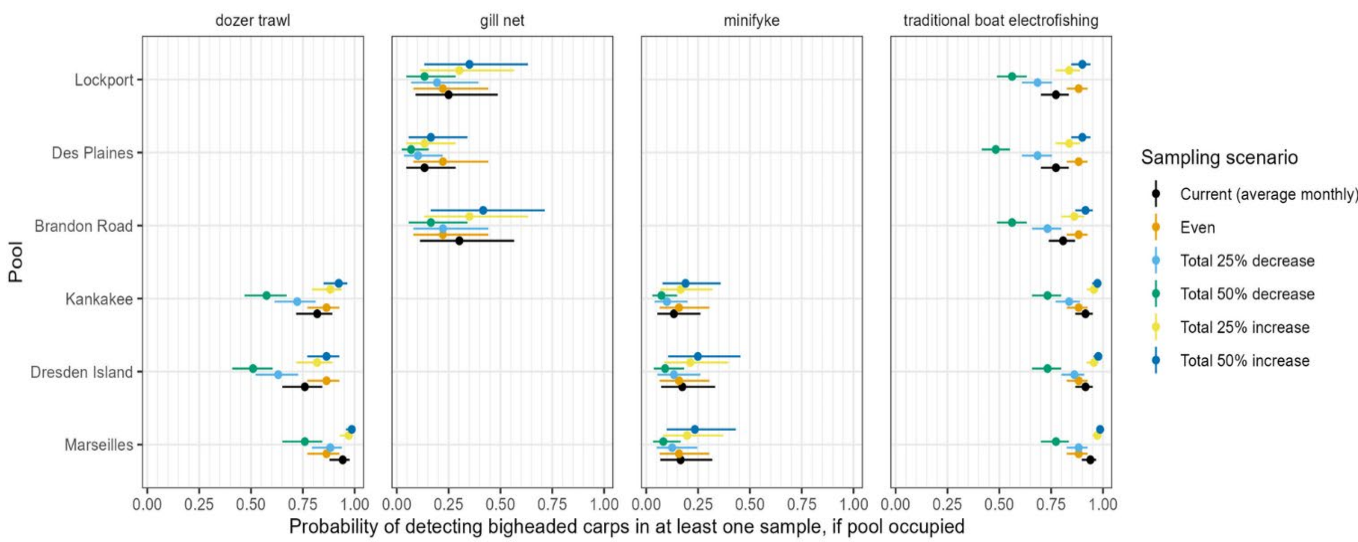
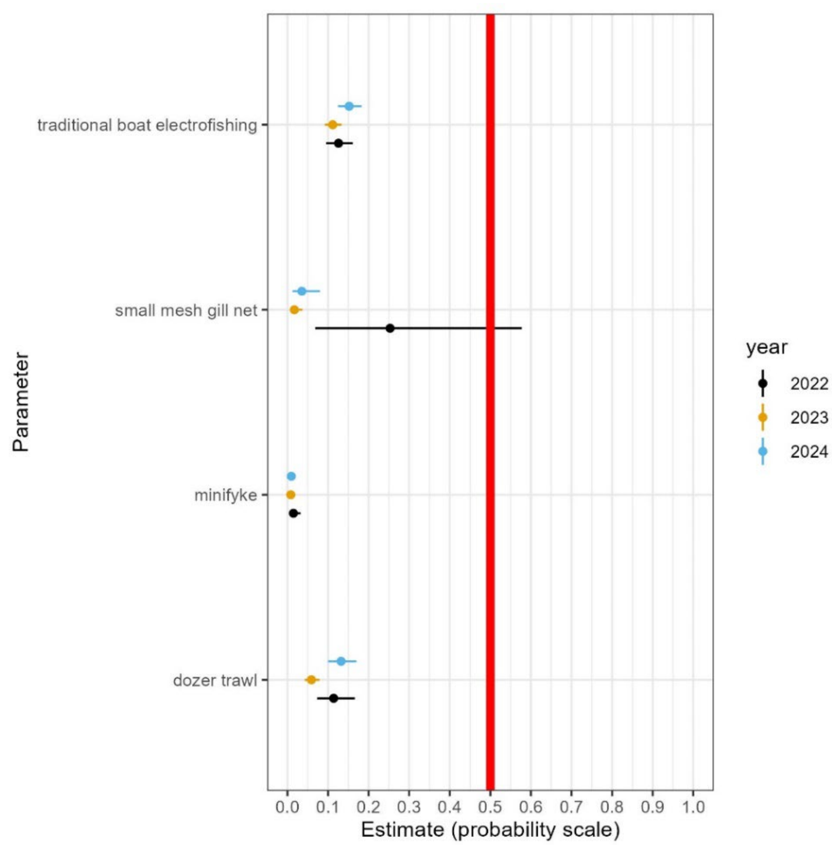


Figure 5. *Estimated individual site detection probability for gears across years.*



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ASSESSMENT OF INVASIVE CARP REPRODUCTION AND ECOSYSEM RESPONSE IN THE ILLINOIS WATERWAY

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MWRG Work Group: Detection

Pools Involved: Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, Alton; major tributaries (Kankakee River [Dresden Island], Fox River [Starved Rock], Vermilion River [Peoria], Mackinaw River [La Grange], Spoon River [La Grange], Sangamon River [La Grange])

INTRODUCTION AND NEED

Successful reproduction is fundamental to the establishment and spread of invasive species (Moyle and Marchetti 2006; Lockwood et al. 2013). Understanding the spatial and temporal dynamics of reproduction by invasive fish can offer insight into the risk of further population expansion, factors influencing recruitment to the population, and the success of control measures. Invasive carp exhibit reproductive traits that have contributed to their success as invaders in the Mississippi River basin: high fecundity (Williamson and Garvey 2005; Lenaerts et al. 2023), flexible reproductive behavior (DeGrandchamp et al. 2007; Coulter et al. 2013), multiple batch spawning (Camacho et al. 2023; Tucker et al. 2020), and high dispersal rates of offspring (Deters et al. 2013; Coulter et al. 2016). Evaluating invasive carp reproduction and the distribution of early life stages in different sections of the IWW and its tributaries is needed to monitor for changes in the reproductive front of invasive carp populations in this system, to monitor for potential reproduction by the newly expanding Black Carp population in Illinois, and to better understand the impacts of removal efforts on the reproductive capacity of these populations. Reproduction and recruitment of invasive carp in the IWW are highly variable among years (Gibson-Reinemer et al. 2017; Parkos et al. 2023), and multiyear efforts are necessary to assess the magnitude, location, and timing of reproduction, as well as to evaluate the relationship between invasive carp stock abundance and reproductive output to determine if removal efforts are reducing invasive carp densities enough to degrade their ability to perpetuate themselves through reproduction.

The magnitude of invasive carp reproduction varies considerably among the pools and tributaries of the IWW (Parkos et al. 2023; Schaick et al. 2023). Reproduction by invasive carp in the upper navigation pools of the IWW is of concern due to the risk of expansion of the invasion front toward Lake Michigan and the increased potential for these species to challenge the EDBS. Observations of eggs, larvae, and juveniles in the upper Illinois River indicate that some reproduction and potential recruitment occurs above Starved Rock L&D in some years (Zhu et al. 2018; Parkos et al. 2023). Due to egg and larval drift, reproduction in upper river pools may also be an important source for recruits in downstream pools, particularly the Peoria Pool.

Invasive carp reproductive output is more consistent downstream of Starved Rock L&D but still varies by several orders of magnitude over the years. Invasive carp spawning also appears to occur in smaller tributary rivers in some years. Large populations of invasive carp can be found in several tributaries of the Illinois River (Sangamon, Spoon, and Mackinaw rivers), although the magnitude of reproductive output varies considerably among these rivers (Schaick et al. 2023). The contribution of tributaries to the reproductive productivity of system-wide invasive carp populations is not well understood, but these rivers may be an important source of early life stages to some navigation pools in some years. Monitoring for any changes to these patterns can help to evaluate the risk for further population growth in the upper Illinois River or determine if harvest efforts are effectively reducing the capacity of invasive carp populations to replenish themselves.

Complementary annual assessments of invasive carp reproduction and stock density provide data needed to quantify stock-reproduction relationships and evaluate the impact of invasive carp removal efforts on the reproductive potential of these populations. The relationship between invasive carp spawning stock density and the magnitude of reproduction provides evidence of both diminished reproductive output at low adult abundances and density-limitation of reproductive output at very high adult densities (Parkos et al. 2023). Continuing the assessment of the reproductive productivity of invasive carp populations may therefore aid in evaluating the success of control efforts and refine our understanding of potential compensatory responses to harvest.

OBJECTIVES

Ichthyoplankton are being sampled in the IWW and its tributaries to:

- Monitor for potential changes in the reproductive front of invasive carp populations.
- Monitor for Black Carp reproduction in the IWW.
- Quantify the relationship between invasive carp adult density, reproductive output, and recruitment.

PROJECT HIGHLIGHTS

- From late April to early October 2024, 716 ichthyoplankton samples were collected from 10 sites from the Brandon Road to Alton navigation pools of the IWW. 2024 was among the top four years of invasive carp reproductive productivity.
- Invasive carp eggs were collected in samples from all pools in and downstream of the Marseilles Pool, and larvae were collected in the Peoria, La Grange, and Alton pools during 2024. Several large precipitation events from late April to late July triggered multiple bouts of spawning. No evidence of invasive carp reproduction was detected upstream of Dresden Island L&D in 2024.
- In 2024, 246 ichthyoplankton samples were collected from Illinois River tributaries. Large-diameter eggs and invasive carp larvae were collected from the Mackinaw, Spoon, and Sangamon rivers, but no evidence of invasive carp reproduction was observed in other Illinois River tributaries in 2024. As in the main channel of the IWW, invasive carp reproductive output was high in tributaries in 2024 relative to previous study years.

- Updated analyses examining factors affecting invasive carp reproductive output found similar results to previous modeling efforts in that both adult invasive carp density and environmental conditions influence spatiotemporal variation in the magnitude of invasive carp reproduction. Invasive carp egg drift is predicted to be highest at intermediate densities of adults and during years with warmer water temperatures during May and higher flows during May and June.
- Juvenile invasive carp abundances were found to be related to total annual invasive carp egg and larval drift such that when egg and larval production was low, juvenile invasive carp abundances were also consistently low, whereas years with higher reproductive output produced highly variable juvenile abundances.

METHODS

Ichthyoplankton sampling occurred at 10 sites in the CSSC, Des Plaines River, and Illinois River downstream of the EDBS in 2024 (Figure 1). Additional sampling occurred in six tributary rivers (Kankakee, Fox, Vermilion, Mackinaw, Spoon, and Sangamon rivers). Sampling occurred weekly from late April to mid-July and biweekly from mid-July to the beginning of October. At main channel sites, a minimum of four ichthyoplankton samples were collected at each site on each sampling date. Sampling transects were located on each side of the navigation channel, parallel to the bank, at both upstream and downstream locations within each study site. At tributary sites, three samples (one mid-channel and one on each side of the channel) were collected on each sampling date. Tributary samples were collected far enough upstream of the confluence of each tributary with the mainstem Illinois River to ensure any fish eggs or larvae collected were derived from the tributary itself rather than potentially originating in the Illinois River.

All samples were collected using a 0.5-meter diameter ichthyoplankton push net with 500- micrometer mesh. The net was pushed upstream using an aluminum frame mounted to the front of the boat to obtain each sample. Boat speed was adjusted to obtain 1.0 to 1.5 meters per second water velocity through the net. The flow was measured using a flow meter mounted in the center of the net mouth and was used to calculate the volume of water sampled. Fish eggs and larvae were collected in a meshed tube at the tail end of the net, transferred to sample jars, and preserved in 90 percent ethanol.

In the laboratory, main channel ichthyoplankton samples collected from May to mid-July were screened for the presence of species-specific invasive carp DNA derived from eggs or larvae. Sample ethanol was exchanged with fresh molecular-grade ethanol to minimize the potential for DNA not derived from eggs or larvae to affect results, and samples were gently inverted five times in the refreshed ethanol to mix contents. After a rest period during which detritus settled, aliquots of sample preservatives were removed to screen for the presence of invasive carp DNA. Following DNA extraction, assays for the four taxa of invasive carp were run in dual duplex reactions, following qPCR methodology (Wozney and Wilson 2017; Fritts et al. 2019). The number of DNA copies from each taxon present in each extraction replicate was quantified and used to assess the probability that eggs or larvae of each species of invasive carp were present in the sample.

Following extraction of qPCR aliquots, fish eggs and larvae were separated from other materials in each sample, and all larval fish were identified to the lowest possible taxonomic unit under dissecting microscopes. Fish eggs were separated by size, with all eggs having a membrane diameter larger than 3 mm being identified as potential invasive carp eggs and retained for later genetic analyses. Invasive carp larvae were identified according to Chapman (2006) and by comparison to a developmental series of larvae obtained from a hatchery (Osage Catfisheries, Inc.; Osage Beach, Missouri). Larval fish and egg densities were calculated as the number of individuals per cubic meter of water sampled.

Densities of invasive carp eggs and larvae were summarized by sampling location through time and compared to water temperature and river discharge to examine spatial patterns in invasive carp reproduction, identify conditions associated with spawning, and assess trends in invasive carp reproductive output. An index of annual invasive carp egg totals was estimated for each monitoring site by multiplying mean egg density on each sampling date by discharge to standardize egg abundances observed under varying discharge conditions, then scaling these estimates from a single second to a 24-hour period and summing these estimates across sampling dates.

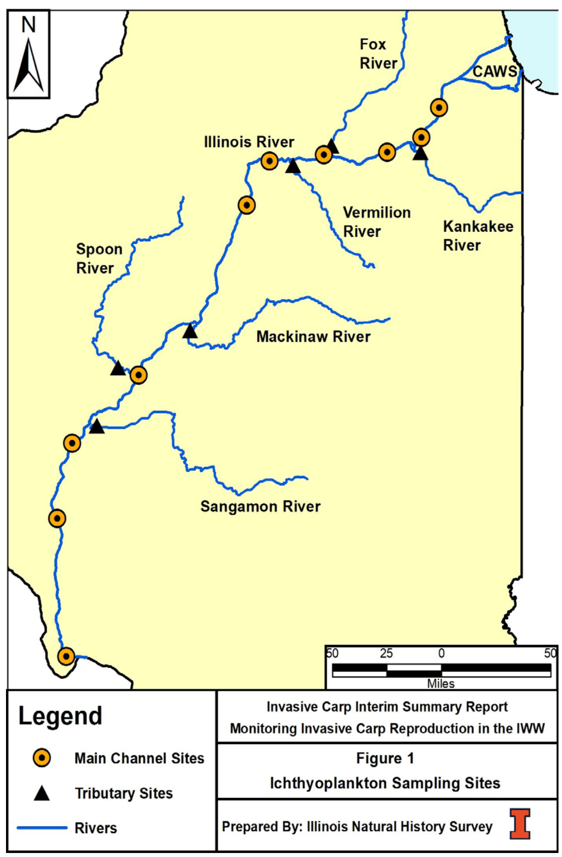
Updated analyses examining the influence of adult spawning stock density and environmental factors on invasive carp reproductive output were conducted using data collected through 2022 to assess the potential for invasive carp harvest efforts to diminish the reproductive potential of invasive carp populations in targeted navigation pools. Invasive carp spawning stock density estimates were generated by annual hydroacoustic surveys conducted by SIUC.

Water temperatures were obtained from USGS gages at Seneca (USGS 5543010) to represent the upper Illinois River pools and at Florence (USGS 5586300) to represent La Grange Reach locations. Discharge data for each pool was obtained from upstream USACE gages located at the Dresden Island, Marseilles, and Starved Rock lock and dams. Data from the USGS gage at Kingston Mines (USGS 5568500) was used for La Grange Pool discharge.

Based on probable spawning locations identified by FluEgg model analysis of invasive carp egg collections (Zhu et al. 2018), annual egg totals in each navigation pool were related to the combined density of adult invasive carp within that pool and the next upstream pool. Mixed- model methodology with a repeated measures framework was used to model annual egg totals as a function of adult density and spring warming and discharge variables (May through June period). The same environmental factors used in previous analyses (Parkos et al. 2023) were included in candidate models. These included cumulative degree days (base 18°C) through the end of June and both the mean and coefficient of variation of mean daily discharge during May and June. Cumulative degree days through June and mean May through June discharge were highly correlated, so these were not included together in any models. A null model (i.e., intercept only) was included for comparison to assess whether there was meaningful support for any of the models in the set. To facilitate the comparison of empirical support for each model, Akaike information criteria corrected (AICc) for small sample size, and AICc weights were computed for each model (Anderson 2008).

In order to assess relationships between combined egg and larval abundances and subsequent abundance of juvenile invasive carp, CPUE of age-0 invasive carp species (Silver Carp ≤ 125 mm, Bighead Carp ≤ 125 mm, Grass Carp ≤ 200 mm) during 2012 – 2022 was obtained from the Long Term Resource Monitoring Program (Gutreuter et al. 1995) and Long Term Illinois River Fish Population Monitoring Program (McClelland et al. 2012, Fritts et al. 2017) database. Because no age-0 invasive carp have been captured by LTRM Program or LTEF sampling in or upstream of the Starved Rock Pool, analyses were limited to the La Grange and Peoria pools. Only pulsed-DC electrofishing captures of juvenile invasive carp from unstructured main-channel border habitats were used to have data from a consistent gear type and hydrogeomorphic stratum in the analysis. Because eggs and larvae are not always identified to species, juvenile CPUE was combined across all invasive carp taxa. LTRM and LTEF sampling is conducted across three time periods (Period 1 = June 15 – July 31, Period 2 = August 1 – September 14, Period 3 = September 15 – October 31), so mean (+ 1 SE) CPUE was examined separately for each period in each navigation pool. Due to high heterogeneity in CPUE among time periods and pools, and the presence of extreme outliers, the harmonic mean of juvenile invasive carp catch rates across sampling periods was used as a conservative estimate of annual relative abundance of juvenile invasive carp in each pool. Because mean age-0 invasive carp CPUE was estimated at the pool scale, but ichthyoplankton is sampled at multiple sites within the La Grange and Peoria pools, the site with the highest annual total egg and larval drift was used as the estimate for the annual total for each pool. Total annual drift of invasive carp eggs and larvae were not highly correlated with each other and only eggs were collected in some years whereas only larvae were collected in other years. Therefore, the combined total of invasive carp egg and larval drift was used as a comprehensive index of annual invasive carp reproductive output. Because scatterplots of the harmonic mean of age-0 invasive carp CPUE versus total annual invasive carp egg and larval drift indicated substantial heteroscedasticity, a 2-dimensional Kolmogorov-Smirnov (2DKS) test (Garvey et al. 1998) was used to evaluate if invasive carp reproductive output was related to subsequent juvenile abundances.

Figure 1. *Map of ichthyoplankton sampling sites in the IWW (circles) and tributary rivers (triangles).*



RESULTS AND DISCUSSION

In 2024, ichthyoplankton monitoring in the IWW collected 716 samples. Tributary sampling collected an additional 246 samples. Overall invasive carp reproductive productivity in the Illinois River (Figure 2) and in tributaries (Figure 3) was high during 2024, placing it among the top four years for invasive carp reproduction. Large precipitation events during late April, mid-May, late June, and late July resulted in multiple increases in water levels during 2024, triggering several bouts of invasive carp spawning (Figure 4). During May 6-29, 2024, invasive carp eggs were collected in the Marseilles Pool and all sites downstream of Starved Rock L&D, with extremely high egg densities observed in the La Grange and Alton pools. A large spawning aggregation of Silver Carp was observed at the confluence of the Mackinaw River on May 7, and large numbers of invasive carp eggs were collected in La Grange Pool tributaries during this week. Extremely large aggregations of Silver Carp were observed downstream of Starved Rock L&D on May 14, with males milting heavily. A small number of invasive carp eggs were collected in the Starved Rock Pool on this date, with additional eggs collected downstream in the Peoria, La Grange, and Alton Pools, and in La Grange Pool tributaries. Low densities of invasive carp eggs continued to be collected from the Peoria, La Grange, and Alton pools through the second week of June, but declined afterwards. However, following an increase in discharge during the third week of July, large numbers of invasive carp eggs were observed at sites in the Peoria and La Grange pools. A large spawning aggregation of Silver Carp was observed at Havana in the La Grange Pool and large numbers of invasive carp eggs were also collected from the Spoon River at this time. Water levels declined the following week and remained low and relatively stable for the remainder of the 2024 sampling period. No further evidence of invasive carp reproduction was observed after the third week of July (Figure 4). No potential evidence of invasive carp reproduction was observed upstream of the Marseilles Pool during 2024. Laboratory processing of extracted DNA from qPCR aliquots, now primarily used to identify the potential presence of Black Carp eggs or larvae, is in progress and results will be reported as soon as they are available.

Tributary sampling collected an additional 194 ichthyoplankton samples in 2023. The Kankakee, Fox, Spoon, and Sangamon rivers were all sampled consistently, but low water levels prohibited access to the Vermilion and Mackinaw rivers on many sampling dates. Large-diameter eggs and invasive carp larvae were collected from the Spoon and Sangamon rivers, but no evidence of invasive carp reproduction was observed in other Illinois River tributaries during 2023. Peak densities of large-diameter eggs and invasive carp larvae were very low in the Spoon and Sangamon rivers in 2023 relative to other recent study years (Figure 4). Substantial increases in discharge in May, particularly in the Sangamon River, were associated with nearly all the invasive carp reproductive output observed in tributaries during 2023 (Figure 5). After May, tributary water levels were generally very low for the remainder of summer 2023. Small increases in discharge in July and August did not result in any evidence of invasive carp reproduction. A single large-diameter egg collected in late July in the Spoon River was sampled during low-flow conditions. Eggs collected from tributaries in 2023 are being submitted for genetic sequencing to verify their identities.

Figure 2. *Index of total annual invasive carp egg and larvae drift in the La Grange (Havana), Peoria (Henry), Starved Rock (Ottawa), and Marseilles (Morris) navigation pools from 2012 to 2023. The index of total annual egg and larvae drift was estimated by summing observed egg and larval densities standardized by site-specific discharge and scaled to 24-hour intervals.*

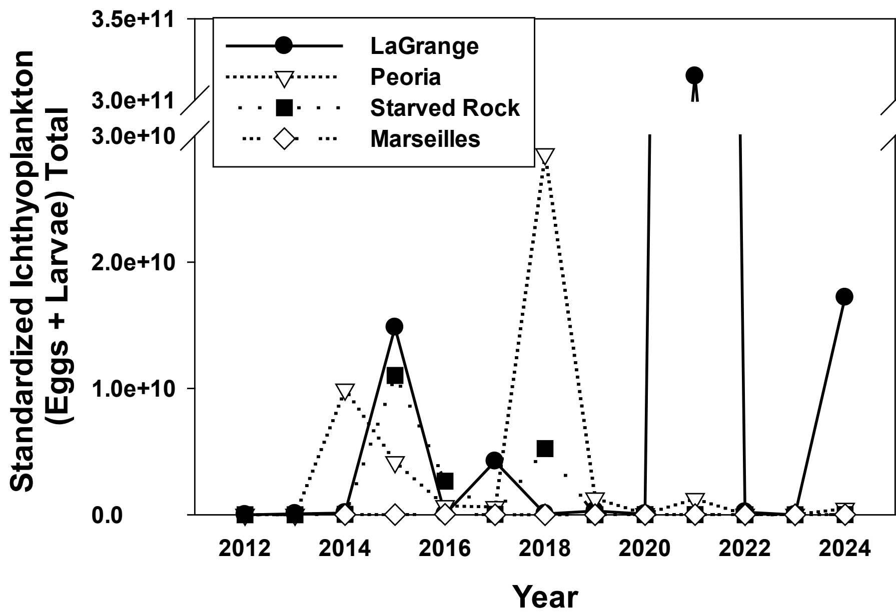


Figure 3. *Index of total annual invasive carp egg and larvae drift in the Sangamon, Spoon, and Mackinaw rivers from 2012 to 2024. The index of total annual egg and larvae drift was estimated by summing observed egg and larval densities standardized by site-specific discharge and scaled to 24-hour intervals.*

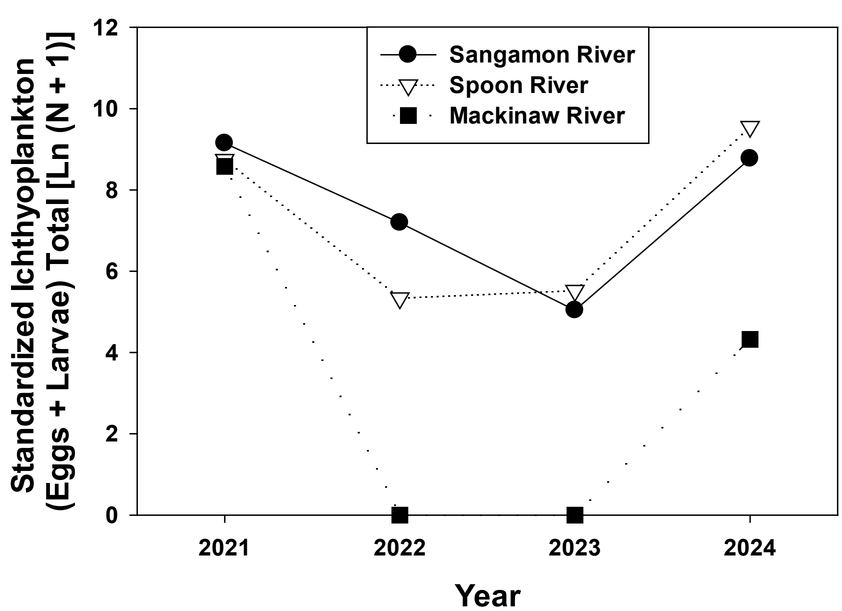


Figure 4. *Densities (number/cubic meter; note log scale) of invasive carp eggs (top panel) and larvae (middle panel) collected from main channel sites of the IWW in 2024. Mean daily gage height (meters) and water temperature (°C) of the Illinois River from April through October 2024 (bottom panel) were obtained from USGS gage 55836300 at Florence, Illinois.*

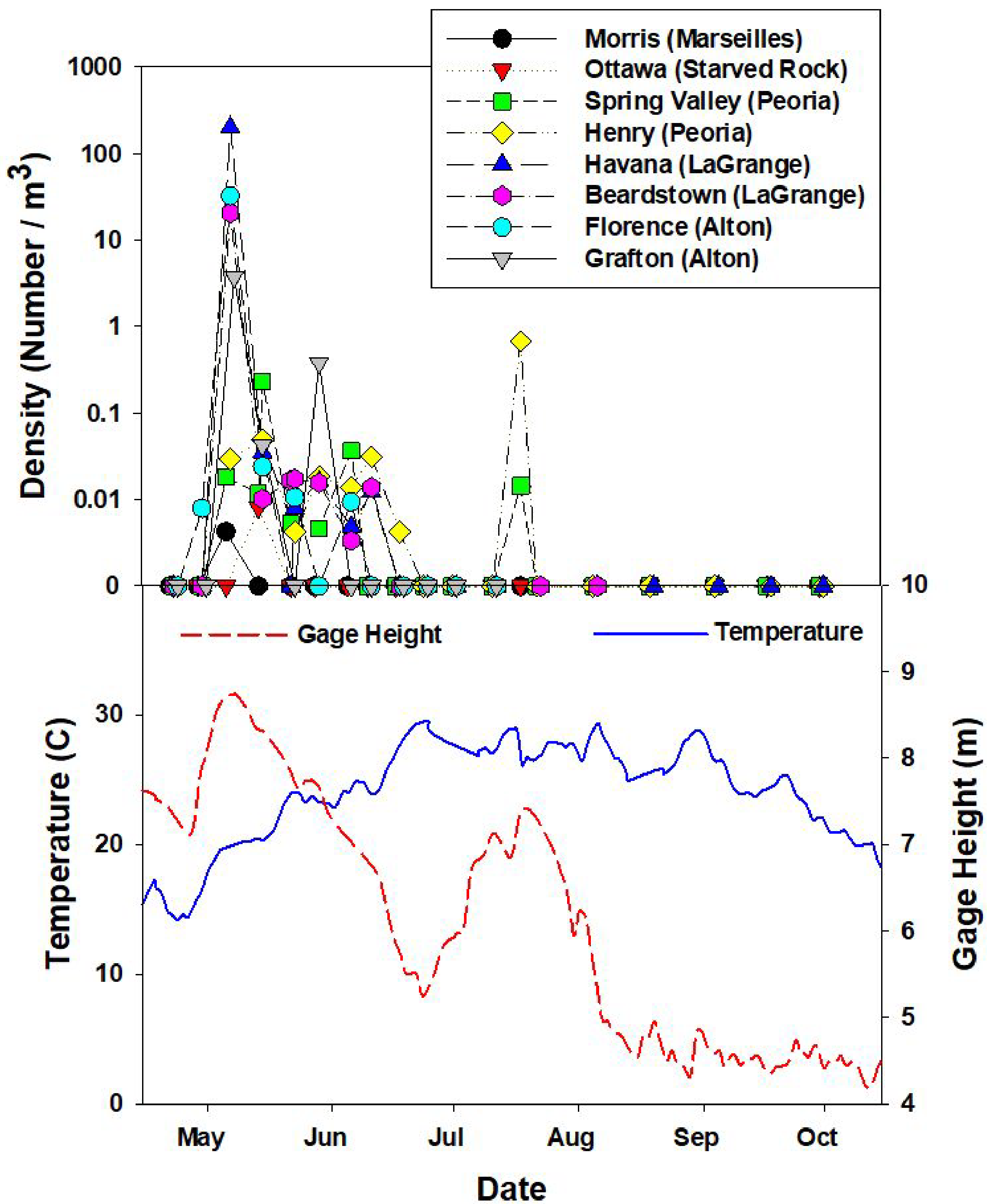
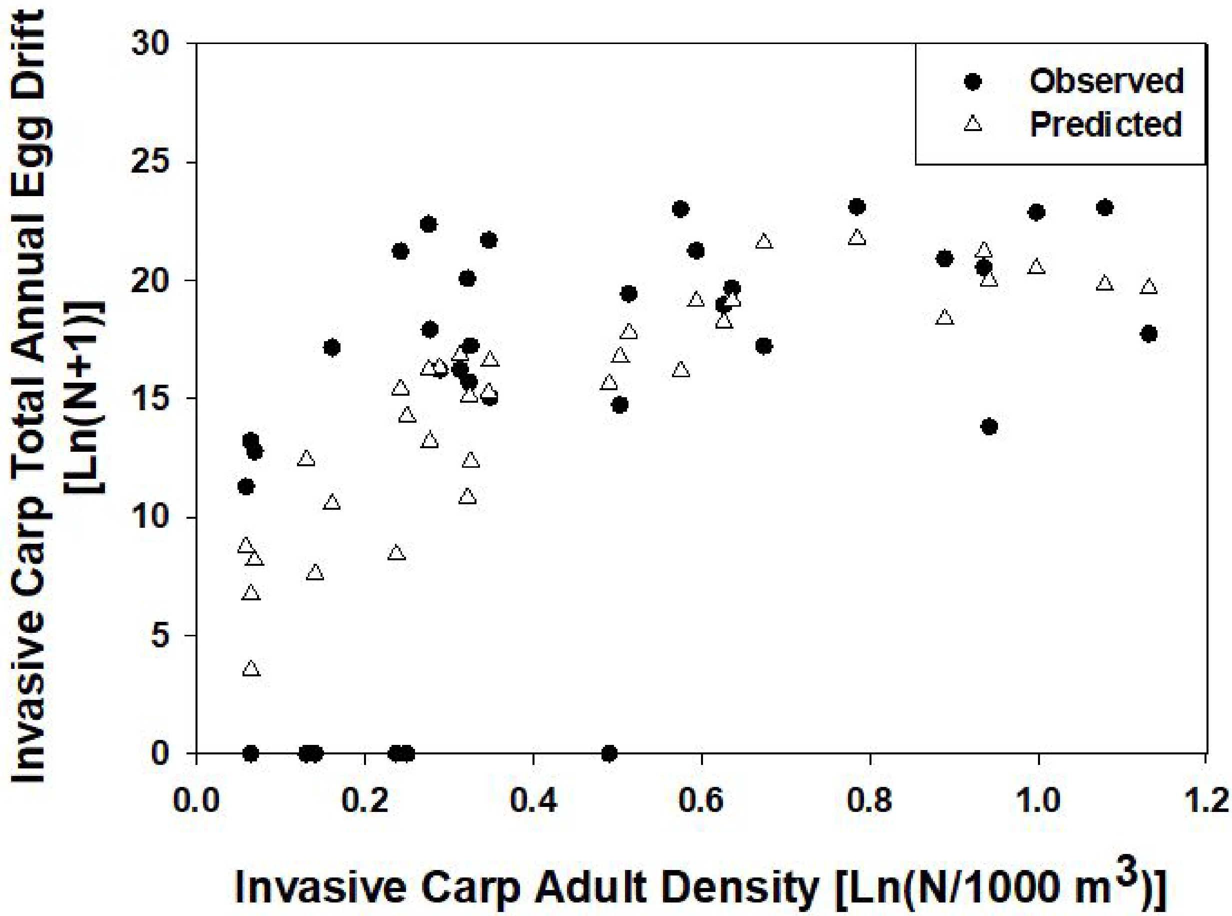


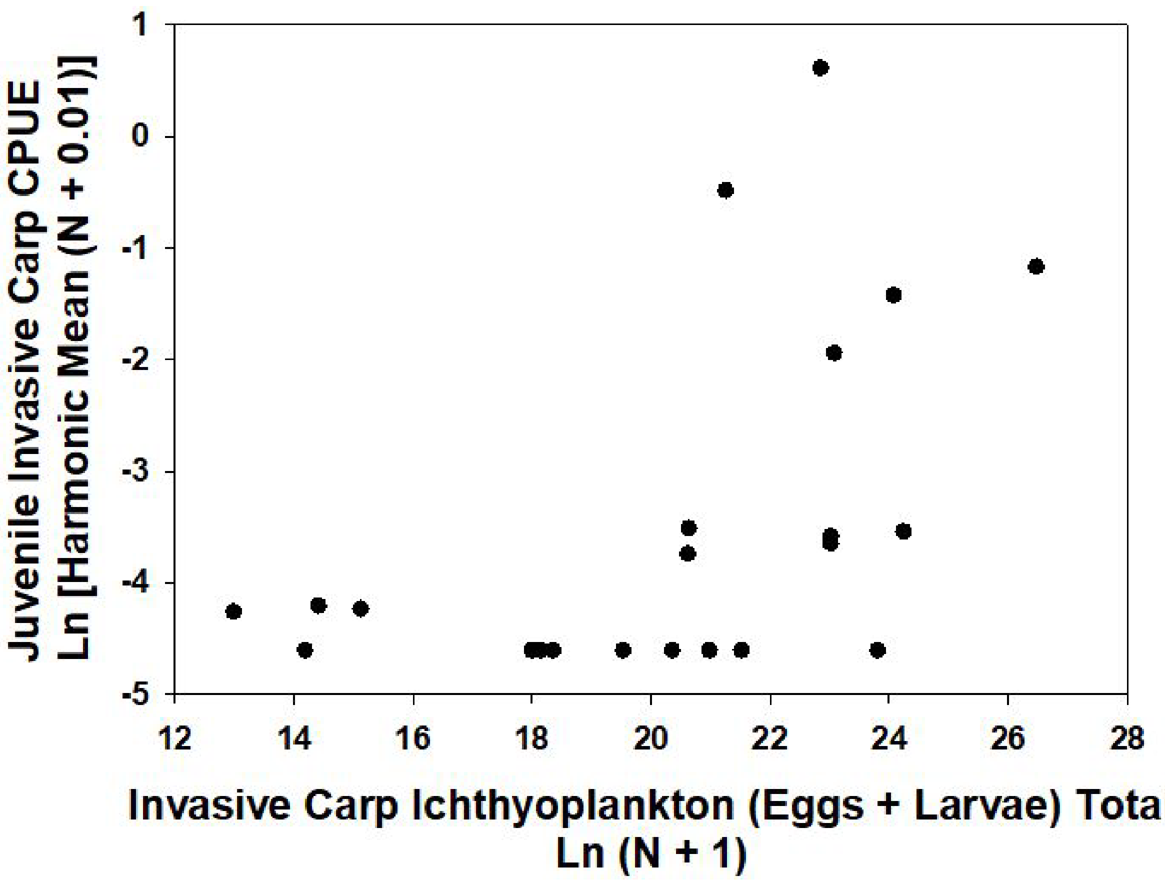
Figure 5. *Observed invasive carp total annual egg drift (dark circles) and modeled predictions (open triangles) derived from a model including adult invasive carp density, mean daily discharge, and cumulative degree days through the end of May (base 18°C) plotted with associated invasive carp adult densities in navigation pools of the IWW during 2014 through 2022 (dark circles). Invasive carp total annual egg drift was calculated by summing observed egg densities standardized by site- specific discharge and scaled up over 24-hour intervals. Adult invasive carp densities were estimated from autumn hydroacoustic surveys in each navigation pool.*



Updated analyses examining factors affecting invasive carp reproductive output found similar results to previous modeling efforts in that both adult invasive carp density and environmental conditions during the May through June period influenced spatiotemporal variation in the magnitude of invasive carp reproduction. A quadratic relationship between total annual egg drift and adult invasive carp density was more supported by the data than a linear relationship, and models that included adult invasive carp density were more supported by the data than those that only included environmental variables. The most supported candidate model included the quadratic relationship with adult density, mean daily discharge during May and June, and cumulative growing degree days through the end of May. Invasive carp egg drift was highest at sites that had intermediate densities of adults within and upstream of the pool containing the monitoring site (Figure 5) and during years with higher mean daily discharge during May and June and warmer water temperatures through the end of May.

Juvenile invasive carp catch rates were highly variable among years and between navigation pools. Combined estimates of juvenile invasive carp relative abundance in each pool were related to total annual invasive carp egg and larval drift (2DKS test: D = 0.186, P = 0.002). During years when estimated total egg and larval drift were low ($X_{threshold}$ = 20.62, e^x = 904,814,039 total eggs + larvae), subsequent juvenile abundances were also consistently low ($Y_{threshold}$ = -3.69, e^x = 0.02 fish/15-minute effort). However, years with higher reproductive output produced highly variable juvenile abundances (Figure 6).

Figure 6. *Relationship between the harmonic means of age-0 invasive carp CPUE (N/15 minute effort) obtained by pulsed-DC electrofishing during LTRMP and LTEF sampling efforts across three time periods (Period 1 = June 15 – July 31; Period 2 = August 1 – September 14; Period 3 = September 15 – October 31) and total annual invasive carp egg and larval drift observed via ichthyoplankton sampling in the La Grange and Peoria pools of the Illinois River during 2012 – 2022. Invasive carp total annual egg drift was calculated by summing observed egg densities standardized by site-specific discharge and scaled up over 24-hr intervals.*



Invasive carp total annual reproductive output has varied considerably across study years. Both warming and discharge variables have been found to affect the magnitude of invasive carp reproduction in the Illinois River (Parkos et al. 2023). Reproductive output was high during 2015, 2018, 2021, and 2024, when warmer springs coincided with high amounts of precipitation during the May to mid-July period. In contrast, years with cool springs and low rainfall after May, as occurred during 2022 and 2023, consistently fail to produce large spawning events. Several studies have noted that invasive carp spawning tends to be observed within a predictable range of temperatures (Cudmore & Mandrak 2004, Kolar et al. 2007, Deters et al. 2013, Larson et al. 2017). In both their native and introduced ranges, most of the invasive carp reproductive output also coincides with flood pulses (Lohmeyer & Garvey 2009, Jiang et al. 2010, Li et al. 2013, Larson et al. 2017). Invasive carp are capable of spawning multiple times each year (Papoulias et al. 2006, Tucker et al. 2020, Lenaerts et al. 2023) and years with frequent and widespread precipitation events may result in repeated bouts of spawning. However, spawning after mid-July is typically limited in magnitude, if it occurs at all (Parkos et al 2023). Individuals spawning during July – October may be energetically depleted from earlier spawning attempts, and the environmental conditions that typically occur during this period across the central U.S. are less conducive for synchronizing mass spawning. Therefore, conditions during the May to mid-July period appear to be critical determinants of annual variation in invasive carp reproductive output in the Illinois River.

Tributaries exhibited a similar pattern to the main channel in 2024, with large numbers of eggs and larvae present following widespread precipitation events. In years with high region-wide spring and summer precipitation, when high flow events are common to all waterways, the timing and magnitude of invasive carp reproduction appears to be similar among tributaries and the mainstem Illinois River. During years with drier conditions and low water levels, localized rain events can have a much greater effect on the hydrographs of smaller river systems and therefore on invasive carp spawning activity in these rivers. Spawning by invasive carp in smaller tributary rivers appears to be widespread across their invaded range (Camacho et al. 2023, Hayer et al. 2023, Schaick et al. 2023). However, individual tributaries vary greatly in the consistency and magnitude of invasive carp reproductive output. Invasive carp spawning appears to consistently occur in the Spoon and Sangamon rivers, whereas the Mackinaw, Vermilion, and Fox rivers appear to offer less favorable conditions for invasive carp reproduction. Tributaries with larger watersheds, higher discharge, greater turbidity, and higher temperatures have been found to produce higher abundances of invasive carp eggs (Schaik et al. 2023). Local habitat conditions and differences in spawning stock characteristics among tributaries also likely contribute to observed differences in reproductive output.

The overall contribution of tributaries to basin-wide invasive carp egg and larval production likely varies among years depending on the timing and magnitude of precipitation events and the subsequent effects on individual watersheds. The relative contribution of invasive carp eggs or larvae spawned in tributaries to later life stages is also unknown and could also vary substantially depending on the proximity of each tributary to appropriate nursery habitats in the main channel. If tributary rivers are found to be important sources of recruits for invasive carp populations, management strategies may need to account for invasive carp populations in these smaller systems as well as in main channel habitats (Camacho et al. 2023, Williams et al. 2023).

No evidence of invasive carp reproduction was observed upstream of the Marseilles Pool in 2024, and despite the overall high magnitude of invasive carp reproduction in the Illinois River in 2024, reproductive output upstream of the Starved Rock L&D was relatively limited. The magnitude of reproductive output observed upstream of Starved Rock L&D has been extremely variable among years. Changing adult population densities in the Upper IWW may account for some of this variation, as adult spawning stock density is known to affect variation in the magnitude of invasive carp reproductive output (Parkos et al. 2023), and harvest efforts have reduced invasive carp densities upstream of Starved Rock L&D over the past decade (MacNamara et al. 2016; Love et al. 2018). The slower spring warming rate and flashier hydrology of the upper Illinois River relative to the lower river may also present less pronounced environmental cues to synchronize spawning in many years. The tailwaters of the Marseilles and Dresden Island dams appear to be likely spawning areas (Zhu et al. 2018), but other than 3 Silver Carp larvae collected in the Dresden Island Pool in 2015, no potential evidence of invasive carp spawning upstream of the Dresden Island L&D has been observed to date.

Grass Carp occur farther upstream in the IWW than bigheaded carp, including upstream of the EDBS on the CSSC, and are already present in the Great Lakes basin (Chapman et al. 2013; Embke et al. 2016; Chapman et al. 2021). The Silver Carp population front is currently located in the Dresden Island Pool, although sporadic captures of Silver Carp in the Brandon Road Pool and the CAWS have occurred over the past decade (MRWG 2023). Continued monitoring for invasive carp reproduction in the Upper IWW will be necessary to identify changes in the distribution patterns of early life stages in this section of the river and assess if continuing harvest efforts are successfully diminishing reproductive output toward the leading edge of the invasion front.

No evidence of Black Carp reproduction has been found in the Illinois River to date, but adult Black Carp are being captured with increasing frequency as far upstream as the Peoria Pool. Continued monitoring for Black Carp reproduction in the lower Illinois River, using qPCR screening to identify samples that might contain early life stages of Black Carp and genetic sequencing of potential Black Carp eggs and larvae, will be necessary to establish the earliest known reproductive front of this species in this system.

Previous assessments have identified discharge and temperature variables as important factors affecting variation in total reproductive output (Parkos et al. 2023), and although the current analysis identifies a somewhat different suite of environmental variables, the conclusion that warmer springs with higher flows contribute to higher annual reproductive output remains consistent. Monitoring for changes in invasive carp reproductive potential must therefore take environmental variability into account. The relationship between invasive carp spawning stock density and total annual egg drift continues to provide evidence of both diminished reproductive output at low adult abundances and density-limitation of reproductive output at very high densities of adults. This suggests that there is potential to reduce invasive carp adult densities enough to degrade their reproductive productivity, but there is also the potential for compensatory reproductive output if insufficient numbers of adults are removed.

Reduced functional connectivity between navigation pools in the Upper IWW (Lubejko et al. 2017; Coulter et al. 2018; Zielinski et al. 2018) may contribute to a lack of compensatory reproductive response at low stock densities, thereby increasing the effectiveness of removal efforts of these more isolated invasive carp populations. However, immigration may complicate removal efforts downstream of Starved Rock L&D, where movement rates between navigation pools are likely much higher (Coulter et al. 2018). Even if invasive carp reproductive potential is greatly reduced, the invasive carp stock-recruitment relationship remains unclear. Recruitment may vary considerably for a given magnitude of reproductive output. However, reproduction is a prerequisite for successful recruitment and there is presumably some threshold of reproductive output below which density-dependent processes cannot compensate to produce even modest year classes.

The relationship between annual invasive carp ichthyoplankton totals and age-0 invasive carp relative abundance is encouraging, in that below a threshold of total egg and larval drift, juvenile abundances were also consistently low. Given that egg production is known to be reduced at lower adult spawner densities, it is therefore reasonable to conclude that if adult densities are sufficiently reduced, that production of juvenile invasive carp will likewise be limited. Hydrology is known to be a strong driver of invasive carp year-class strength (Gibson-Reinemer et al. 2017, Sullivan et al. 2018), but whether certain flow conditions contribute to recruitment failures due to lack of spawning, poor survival of eggs and larvae, and/or poor survival of juveniles has been uncertain. It appears that low production of eggs and larvae indeed results in similarly low production of juvenile invasive carp, but higher reproductive output also does not guarantee high juvenile abundances. Thus, multiple mechanisms operating across invasive carp early life history likely influence recruitment at least to the juvenile stage. Flood timing and duration have been suggested to be important factors regulating production and survival of invasive carp cohorts (Gibson-Reinemer et al. 2017, Sullivan et al. 2018). These factors may affect not only the magnitude and timing of spawning, but also areas of larval settlement and the duration of access to floodplain resources by juvenile invasive carp, which may contribute to the observed variability in juvenile abundances following high levels of ichthyoplankton production. However, hydrology is a factor that is difficult to control via management actions at the watershed scale, whereas adult abundances can be manipulated through harvest efforts. Additional investigation of relationships between invasive carp reproductive output, juvenile abundances, and year class strength is warranted to provide a clearer understanding of recruitment mechanisms, identify recruitment bottlenecks, assess potential compensatory responses among different life stages, and determine thresholds of adult population reduction that may serve as targets to achieve recruitment overfishing for invasive carp.

RECOMMENDATIONS

Ichthyoplankton sampling should continue to monitor for invasive carp reproduction, particularly upstream of the Peoria Pool, to evaluate any changes in the invasive carp reproductive front and assess the effects of invasive carp harvest activities on the reproductive potential of these populations. Ichthyoplankton sampling downstream of Starved Rock L&D should continue to monitor for potential Black Carp reproduction. Quantitative PCR screening will be necessary for assessing the likelihood that samples from the Lower IWW contain Black Carp specimens. Relationships between reproductive output and recruitment of invasive carp should be investigated to provide a more complete understanding of recruitment mechanisms and evaluate potential compensatory responses among different life stages to invasive carp harvest efforts. A density- dependent relationship between spawning stock and the embryo life stage has been identified (Parkos et al. 2023), and it appears that low production of invasive carp eggs and larvae is associated with consistently low abundances of juvenile life stages. Identifying factors affecting linkages among all early life stages and those that most influence ultimate year class strength would provide a mechanistic understanding of invasive carp recruitment variation and thus facilitate development and refinement of control efforts for these invasive fishes. Further FluEgg modeling (Zhu et al. 2018) is needed to determine the consistency of invasive carp spawning locations in the IWW and provide information to confirm the relevant adult spawner density for the assessment of stock-reproductive productivity and stock-recruitment relationships. Ichthyoplankton monitoring in tributary rivers should further evaluate the relative contribution of these systems as sources of eggs and larvae to the main channel of the Illinois River. Even if La Grange Pool tributaries consistently export a high proportion of eggs to the main channel of this pool, the influence of these eggs to downstream larval densities and later life stages needs to be considered to determine if tributary spawning provides any significant contribution to basin-wide recruitment.

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STRATEGY FOR eDNA SAMPLING IN THE CAWS

Participating Agencies: USFWS (lead), Matt Petasek (USFWS), Green Bay FWCO

Location: Lake Calumet, Little Calumet River, Powderhorn Lake

MRWG Work Group: Detection

Pools Involved: CAWS

INTRODUCTION AND NEED

Monitoring with multiple gears in the CAWS has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of invasive carp from establishing in the Great Lakes. Since 2009, eDNA sampling has been conducted annually as a surveillance tool to monitor the genetic presence of Bighead Carp and Silver Carp in the CAWS and maintain vigilance above the EDBS. Beginning in 2013, eDNA results no longer automatically triggered any response action through the MRP. A low baseline level of invasive carp DNA signal has been consistently detected in the CAWS and attributed to a combination of vectors. This consistent level of minimal or zero positive eDNA detections annually and the limited captures of live Bighead Carp and Silver Carp by traditional sampling gears above the EDBS supports the assumption that there is not a self-sustaining, reproducing population of these invasive carp above the barrier.

OBJECTIVES

Sample for Bighead Carp and Silver Carp DNA in targeted areas of the CAWS to maintain vigilance and complement other ongoing monitoring efforts above the EDBS.

PROJECT HIGHLIGHTS

- USFWS staff collected 1,040 samples upstream of the EDBS and 220 samples in Powderhorn Lake (control site).
- Positive detections were few and consistent with previous sampling years.

METHODS

USFWS staff from the Green Bay FWCO conducted spring and fall sampling above the EDBS in the CAWS in conjunction with the SIM efforts. For each event, 330 samples (300 samples plus 30 field blanks) were collected in Lake Calumet, 110 samples (100 samples plus 10 field blanks) were collected in the Marine Services Marina on the Little Calumet River, and 110 samples (100 samples plus 10 field blanks) were collected in Powderhorn Lake (see maps beginning on page 43). These followed the sample collection and processing procedures followed the 2024 Quality Assurance Project Plan (USFWS 2024). In the Grand Calumet River, 80 water filter samples were collected for each event. These samples were collected and processed differently due to access and river conditions that precluded the use of a boat. Field blanks were taken in addition to regular monitoring samples. Field blanks are a quality control measure and are not included when describing detection rates. All samples were analyzed for the presence of carp eDNA with three marker sets: Silver Carp only, Bighead Carp only, and non-specific invasive carp. The non-specific invasive carp marker set can detect either Bighead Carp or Silver Carp but is not specific enough to differentiate between the two species. This is reported as a non-specific "invasive carp" detection. If both species-specific markers are detected in a water sample, it is reported under the "bighead AND silver" category. The "invasive carp detection" category was added to the reported results in the 2021 field season. This marker set has always been used in lab analysis but was not publicly reported in previous years.

RESULTS AND DISCUSSION

In the Spring sampling event, there were zero positive eDNA detections at all sites. In the Fall sampling event in Lake Calumet, there was a 0.33 percent positive detection rate (invasive carp-only detection type). There were zero positive eDNA detections in the Marine Services Marina on the Little Calumet River and in the Grand Calumet River. The detection rate in Lake Calumet is consistent with the results from previous surveys. Results can be viewed on the USFWS Bighead Carp and Silver Carp Environmental DNA Monitoring ArcGIS dashboard.

In 2022, Powderhorn Lake was added as a control site. In 2024, there were zero positive eDNA detections in both the Spring and Fall sampling events.

RECOMMENDATIONS

eDNA sampling efforts in the CAWS are a long-standing part of the USFWS Invasive Carp eDNA Early Detection and Monitoring Program and will continue semi-annually for the foreseeable future. The USFWS will continue to investigate how secondary vectors, such as birds, may contribute to DNA signals in the sampled water of the CAWS. Therefore, it's recommended that USFWS continue to conduct eDNA monitoring in these locations, similar to previous years. As the additional monitoring of Powderhorn Lake may help gauge if birds are substantial secondary vectors of invasive carp, continued sampling of this site is also recommended.

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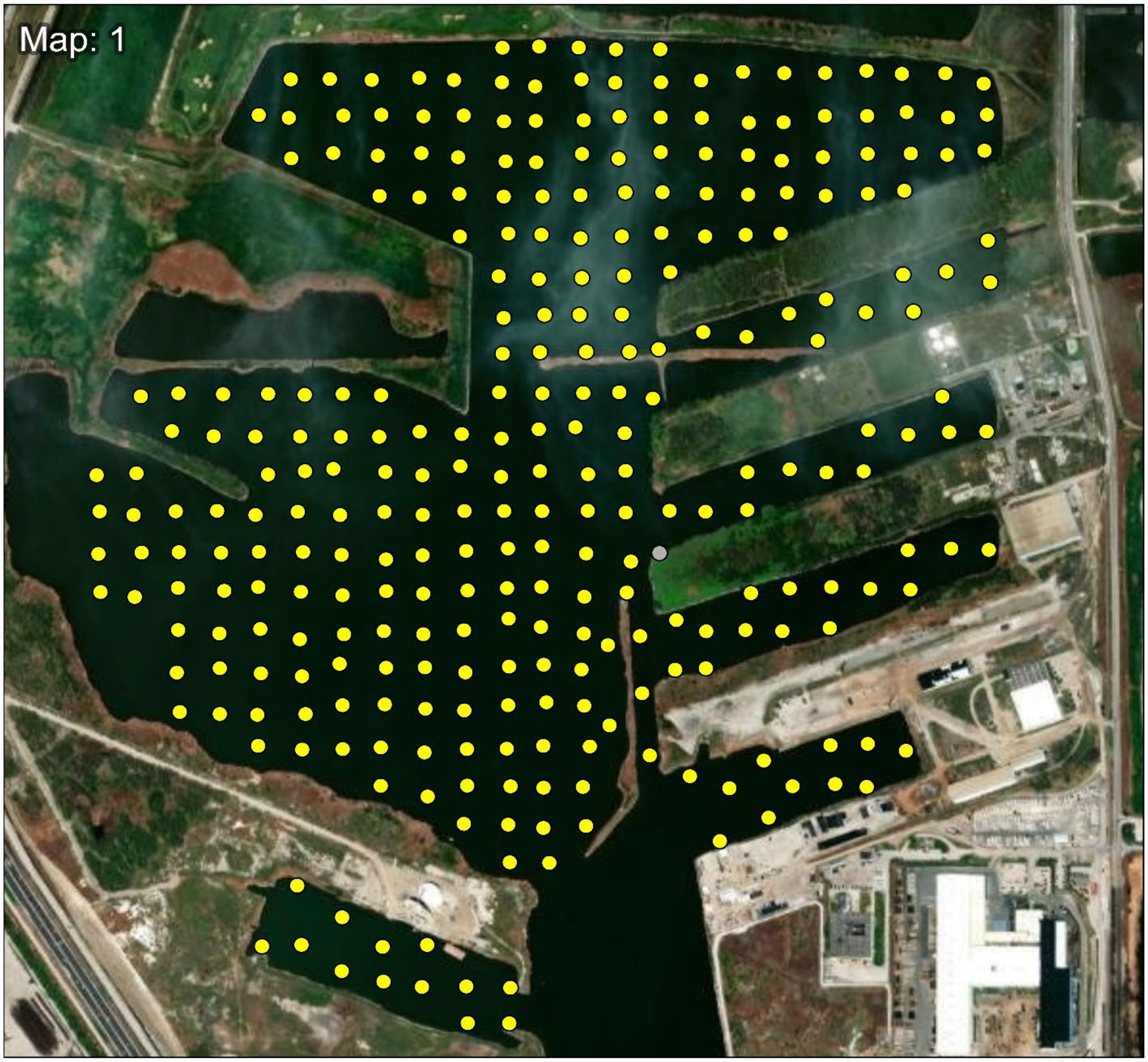
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Lake Calumet/Little Calumet River**
Sampling Period: Week of June 21, 2024
Number of Samples Collected: 330



eDNA Detection Status

- No detection data
- No eDNA detected

The USFWS makes no warranty for use of this map and cannot be held liable for actions or decisions based on map content.

0 0.1 0.2 0.3 0.4 0.5 0.6 mi
0 0.1 0.2 0.4 0.6 0.8 km

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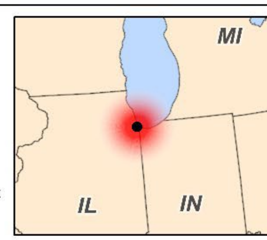
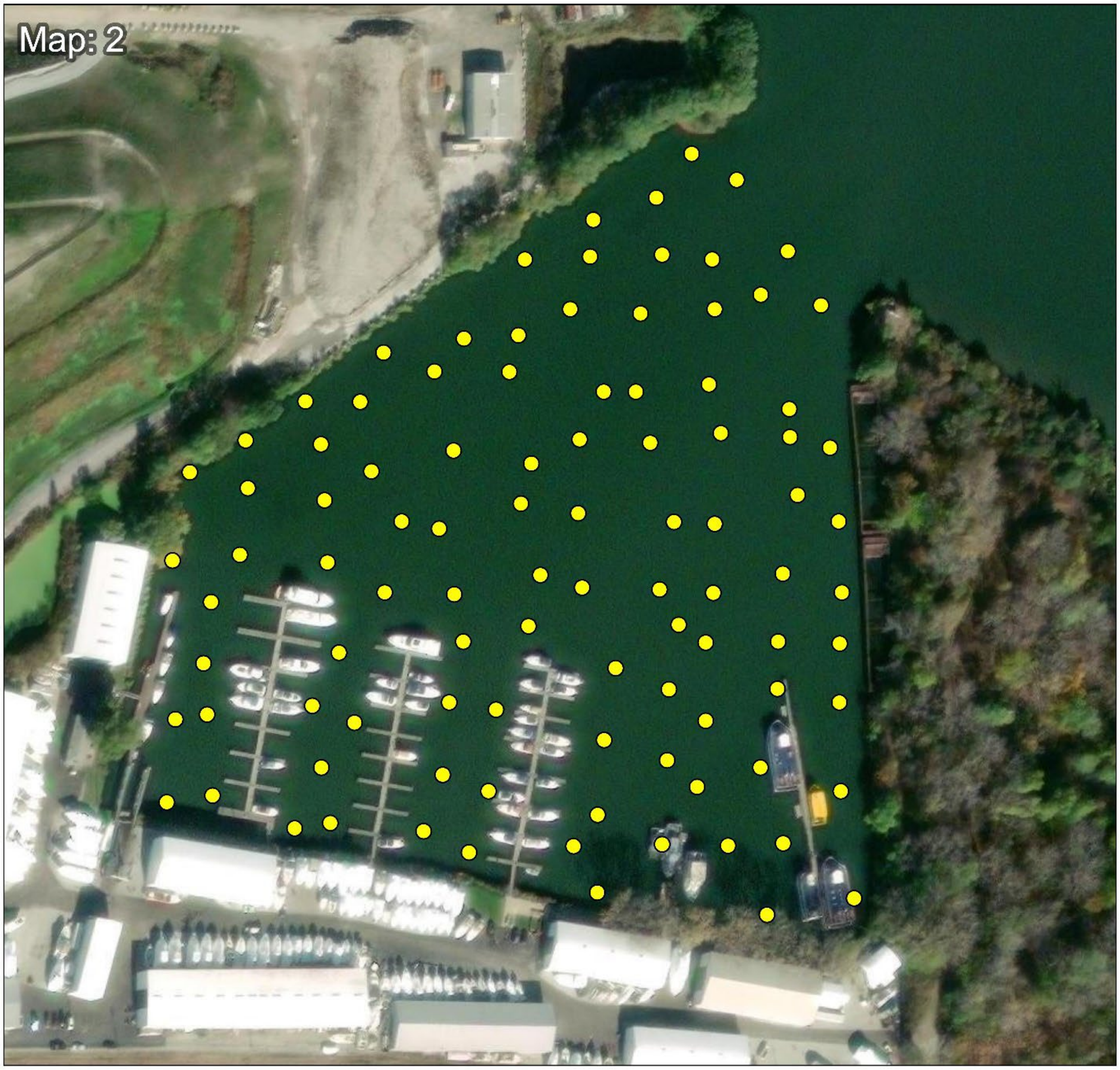
N W E S



U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Lake Calumet/Little Calumet River**
Sampling Period: Week of June 21, 2024
Number of Samples Collected: 110



eDNA Detection Status

- No detection data
- No eDNA detected

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0 — 0.1 mi
0 — 0.1 — 0.2 km

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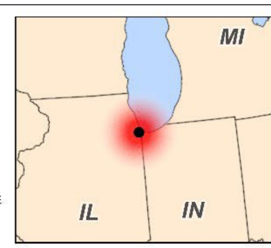
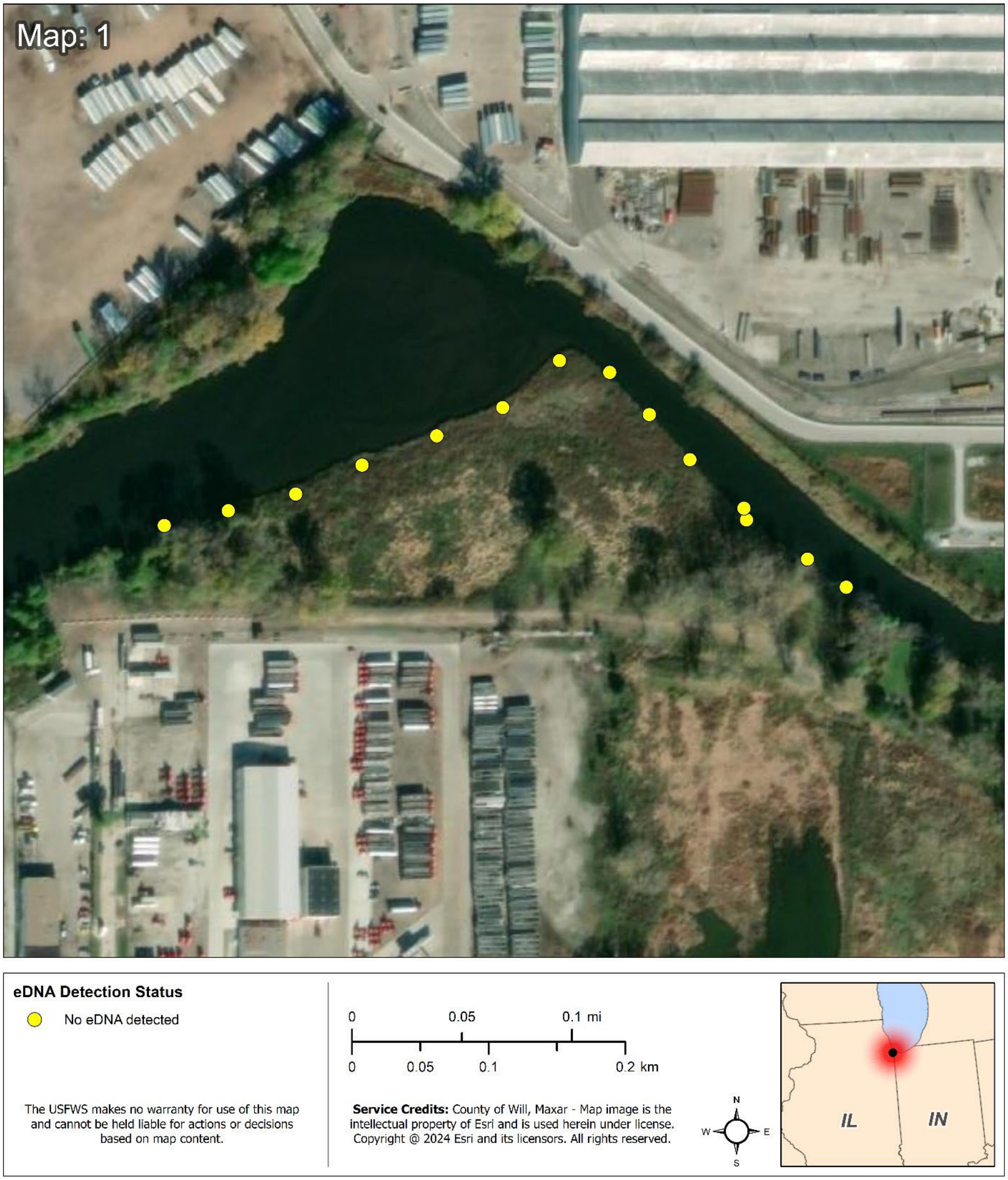
N W E S



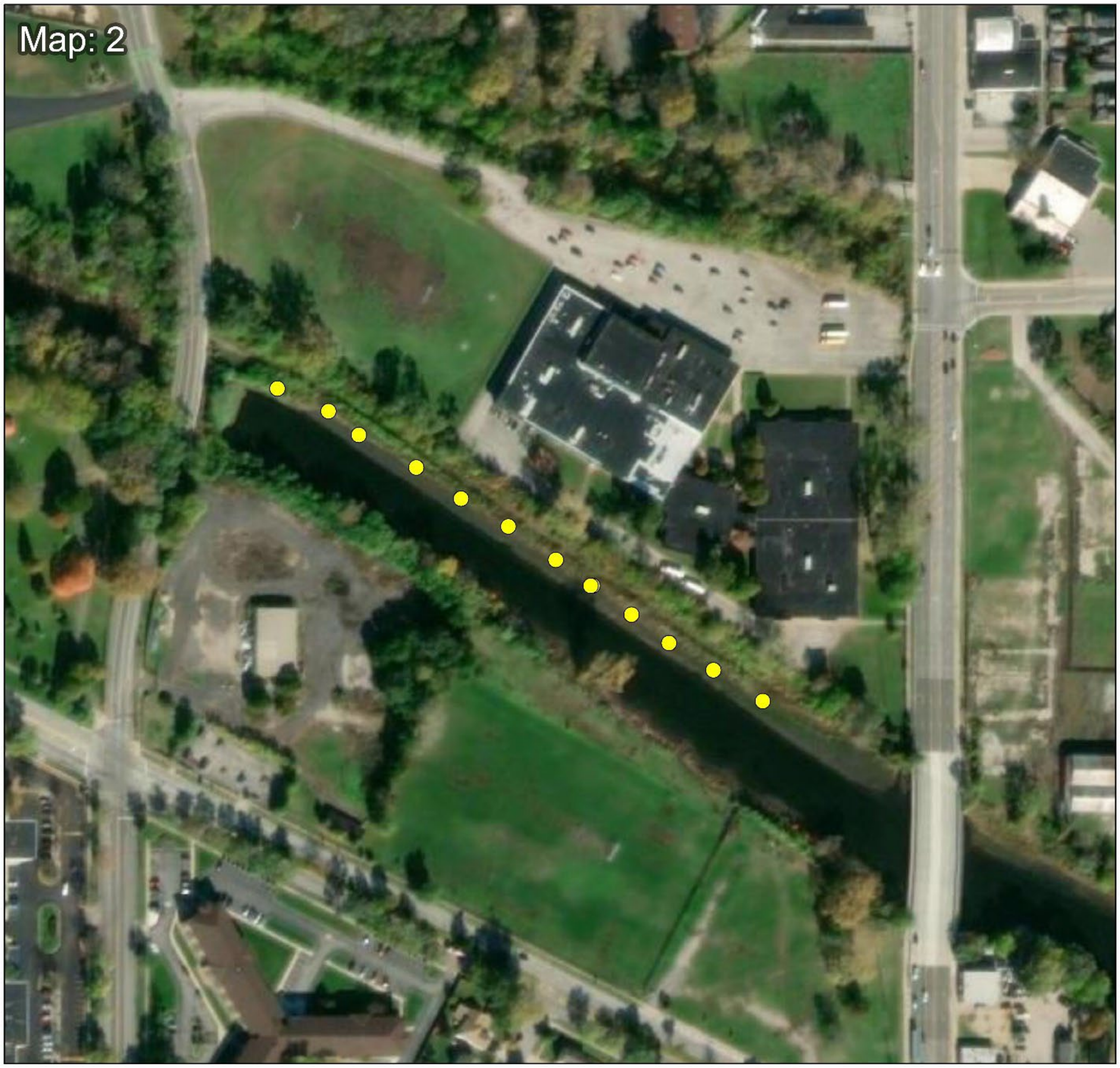
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of May 28, 2024
Number of Samples Collected: 14



U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of May 28, 2024
Number of Samples Collected: 13



eDNA Detection Status

No eDNA detected

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0 0.05 0.1 mi
0 0.05 0.1 0.2 km

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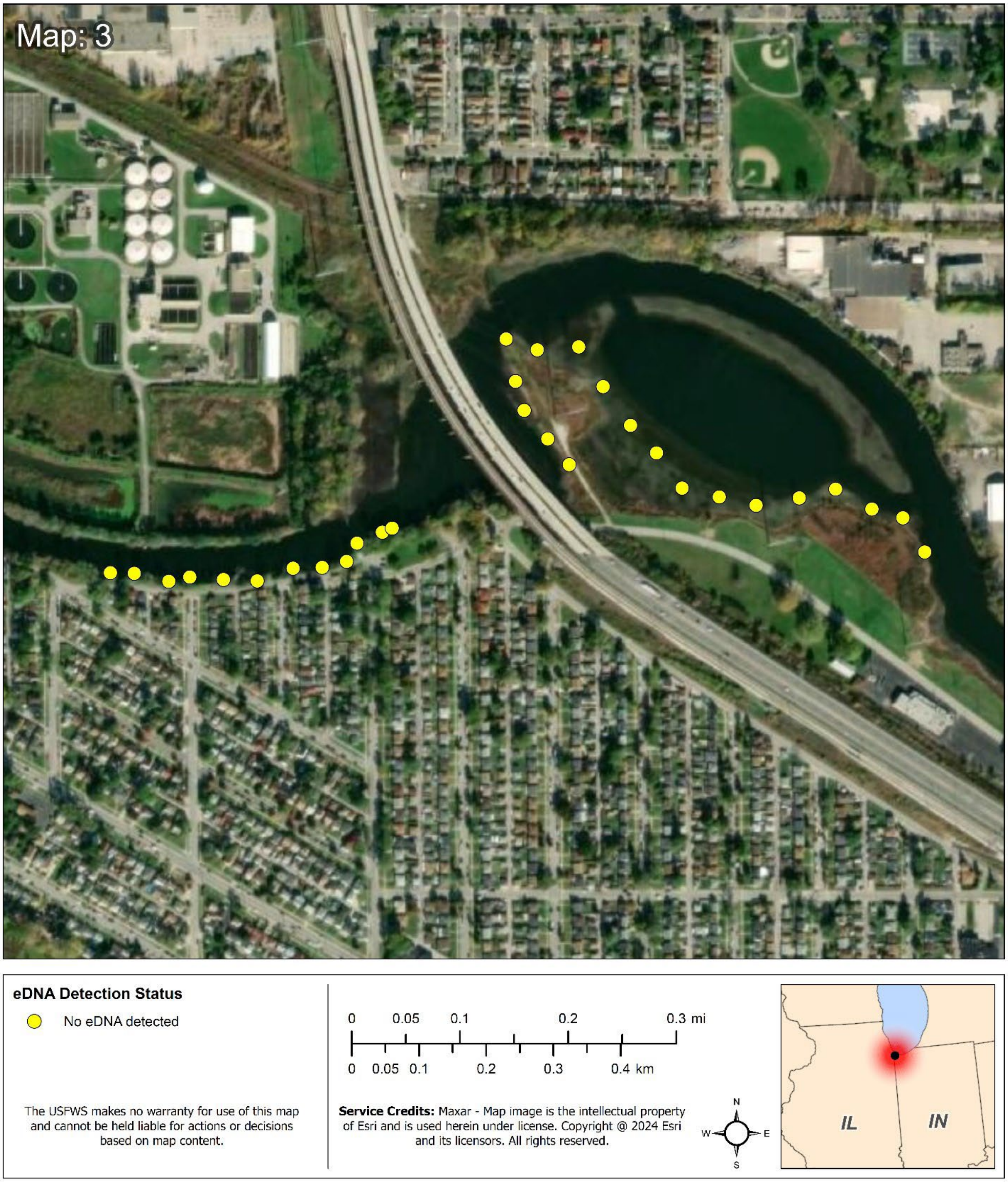
N W E S

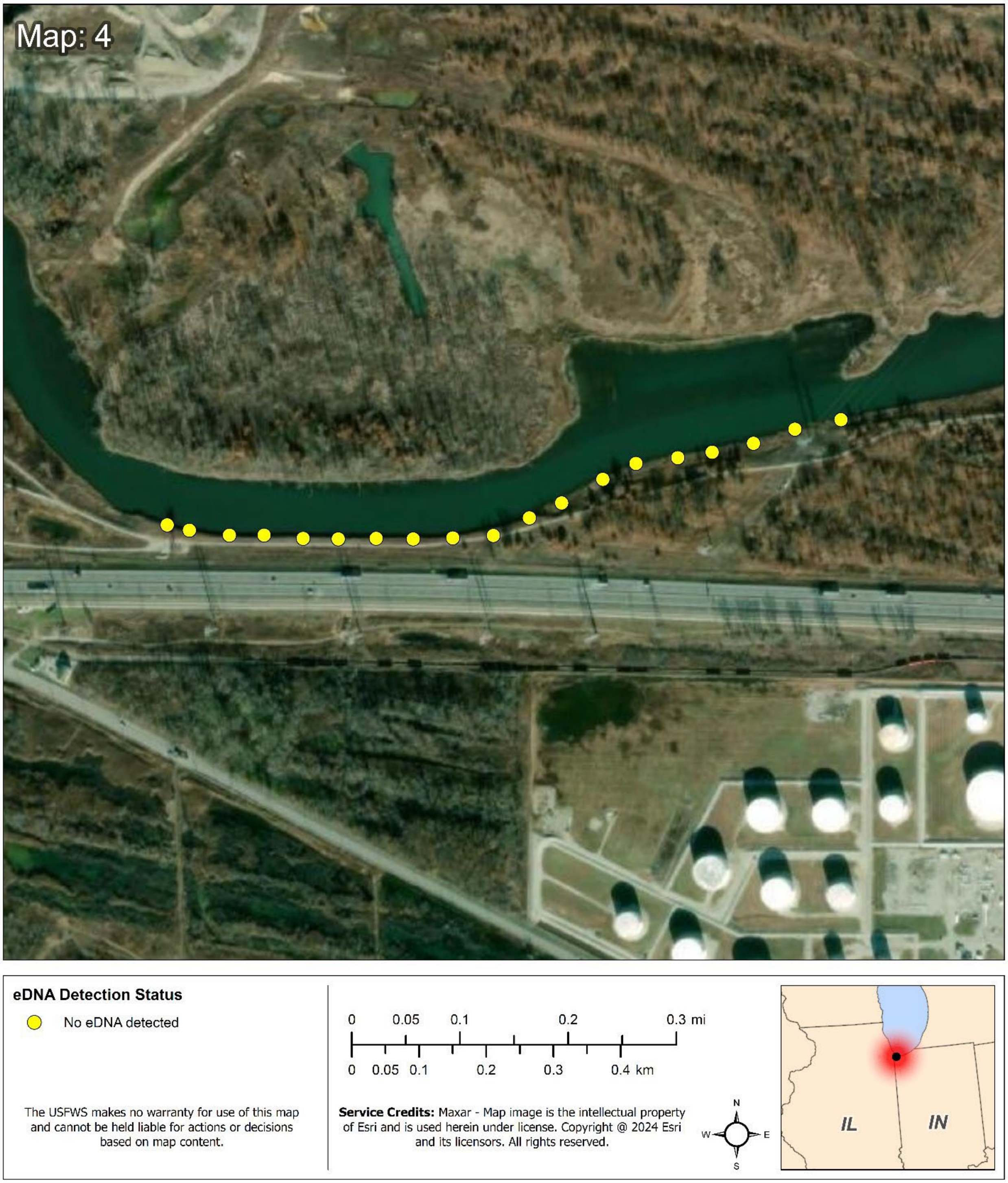
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of May 28, 2024
Number of Samples Collected: 33



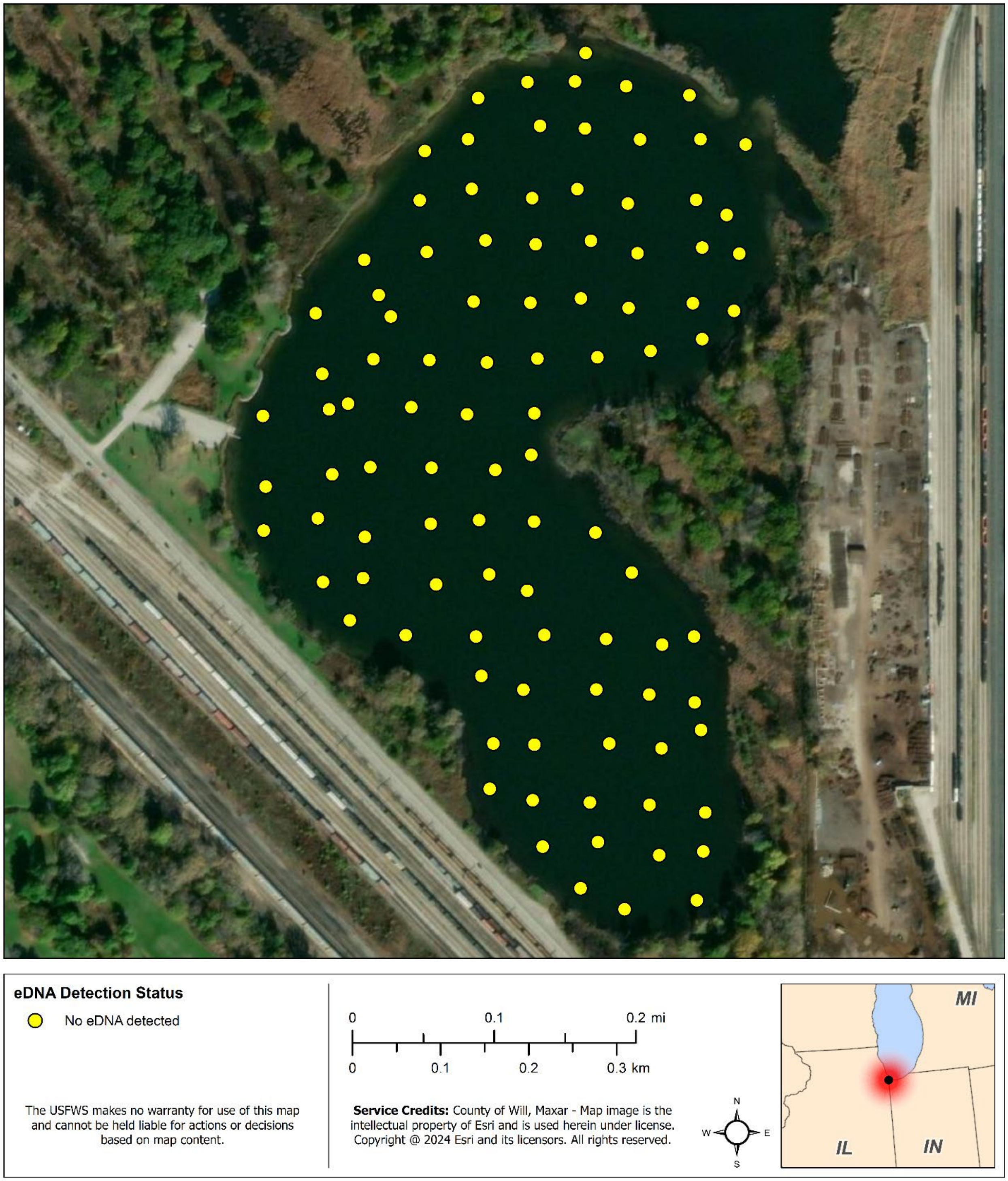
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of May 28, 2024
Number of Samples Collected: 20



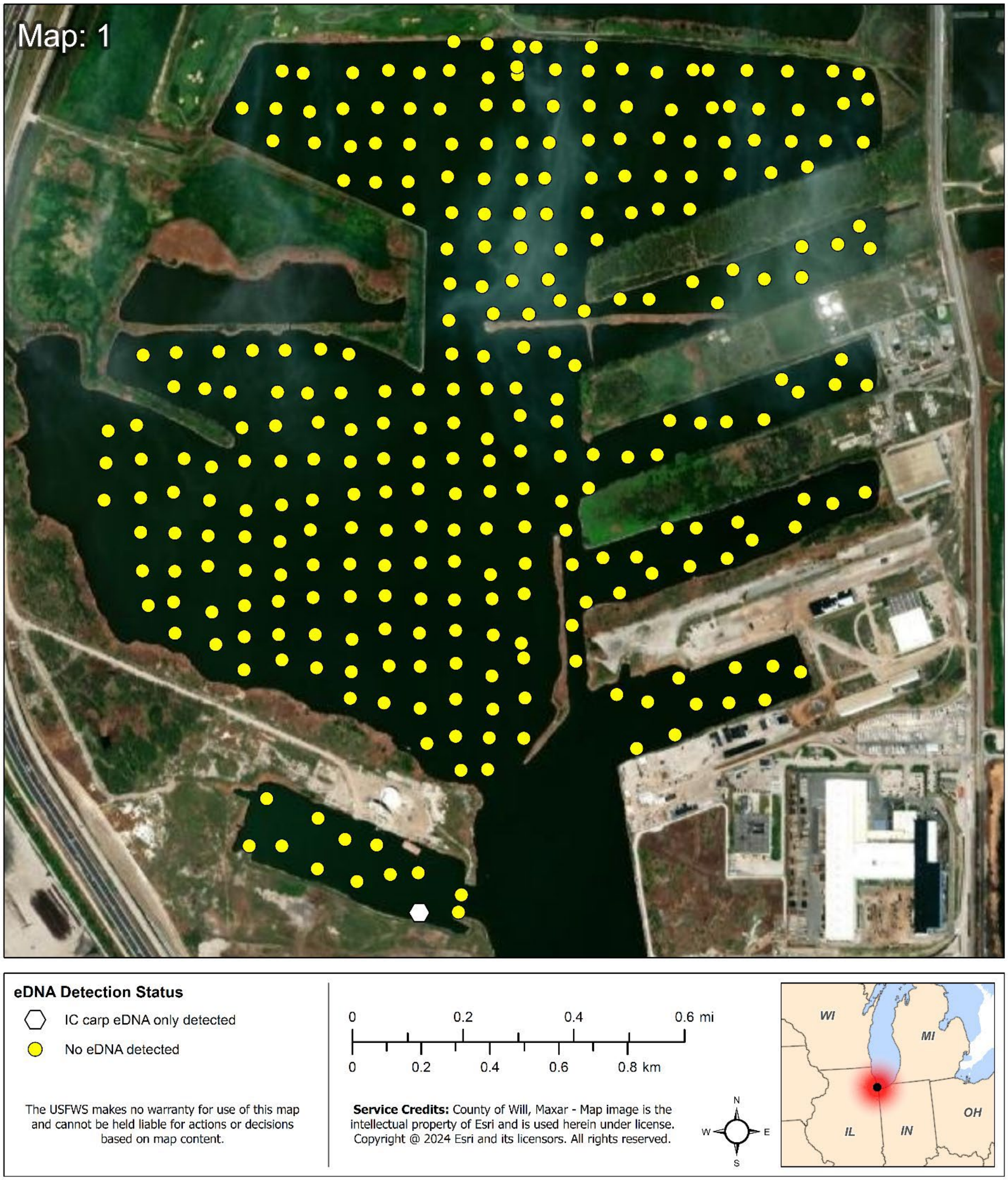
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Powderhorn Lake**
Sampling Period: Week of June 3, 2024
Number of Samples Collected: 110



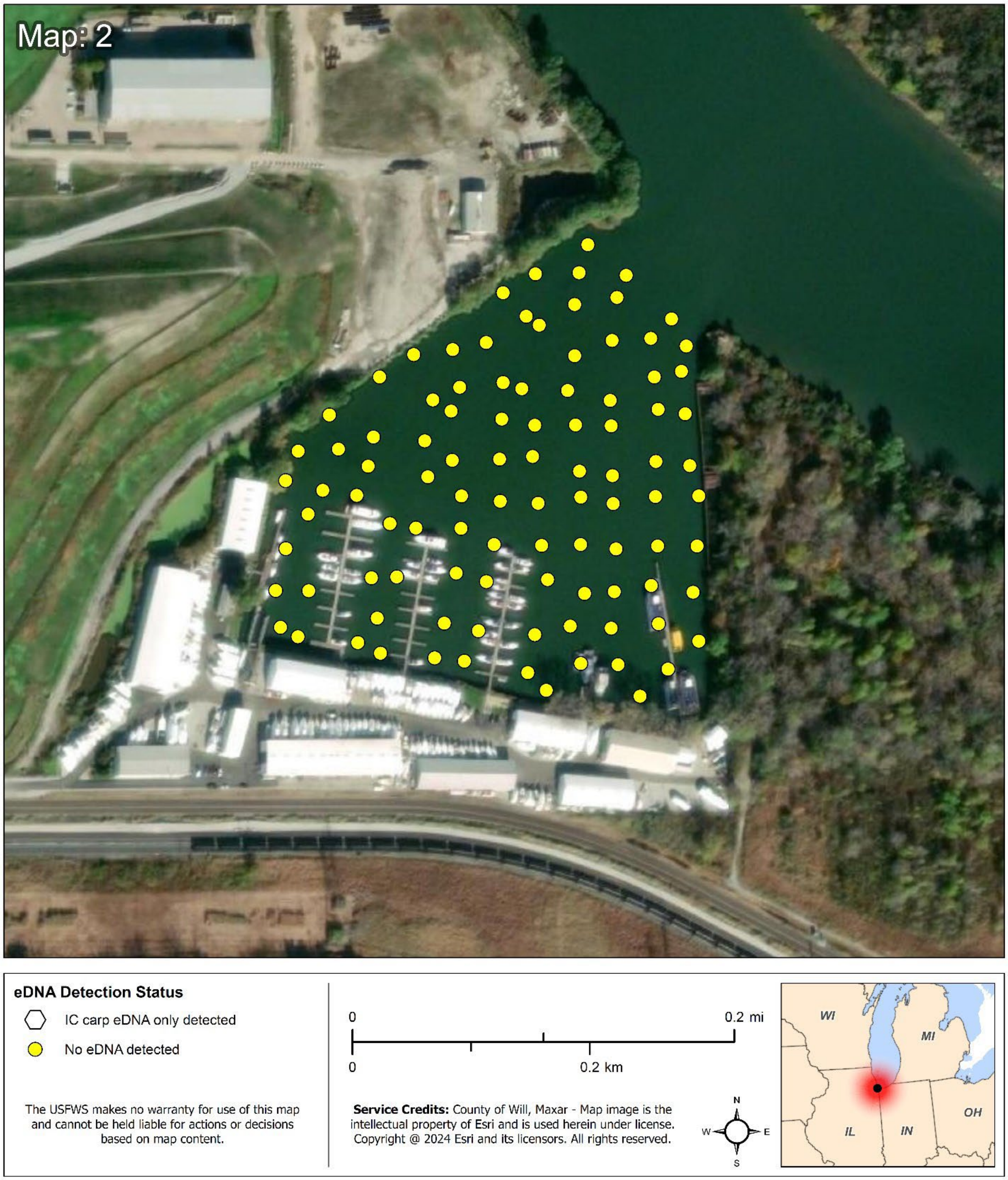
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Lake Calumet/Little Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 330



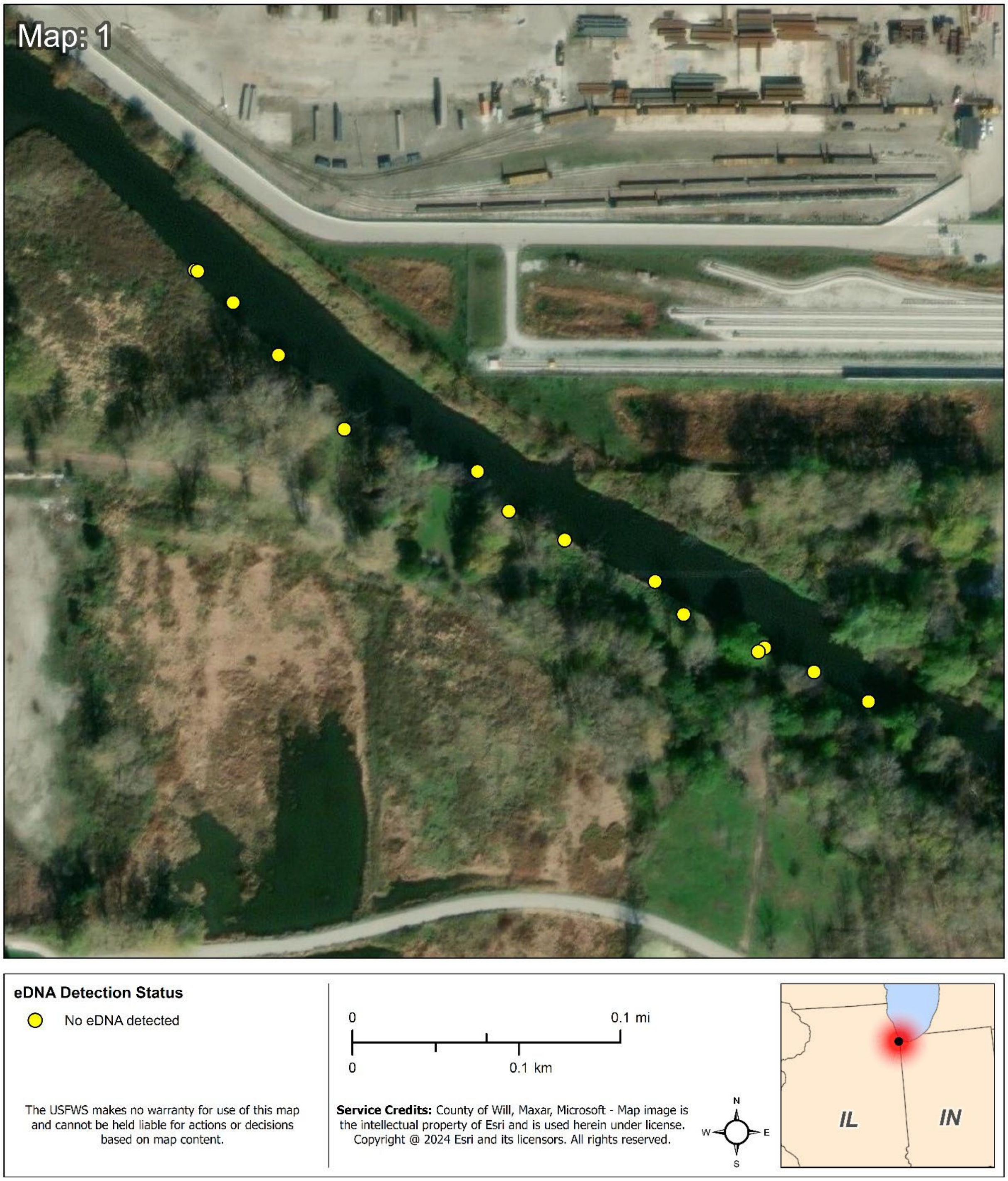
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Lake Calumet/Little Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 110



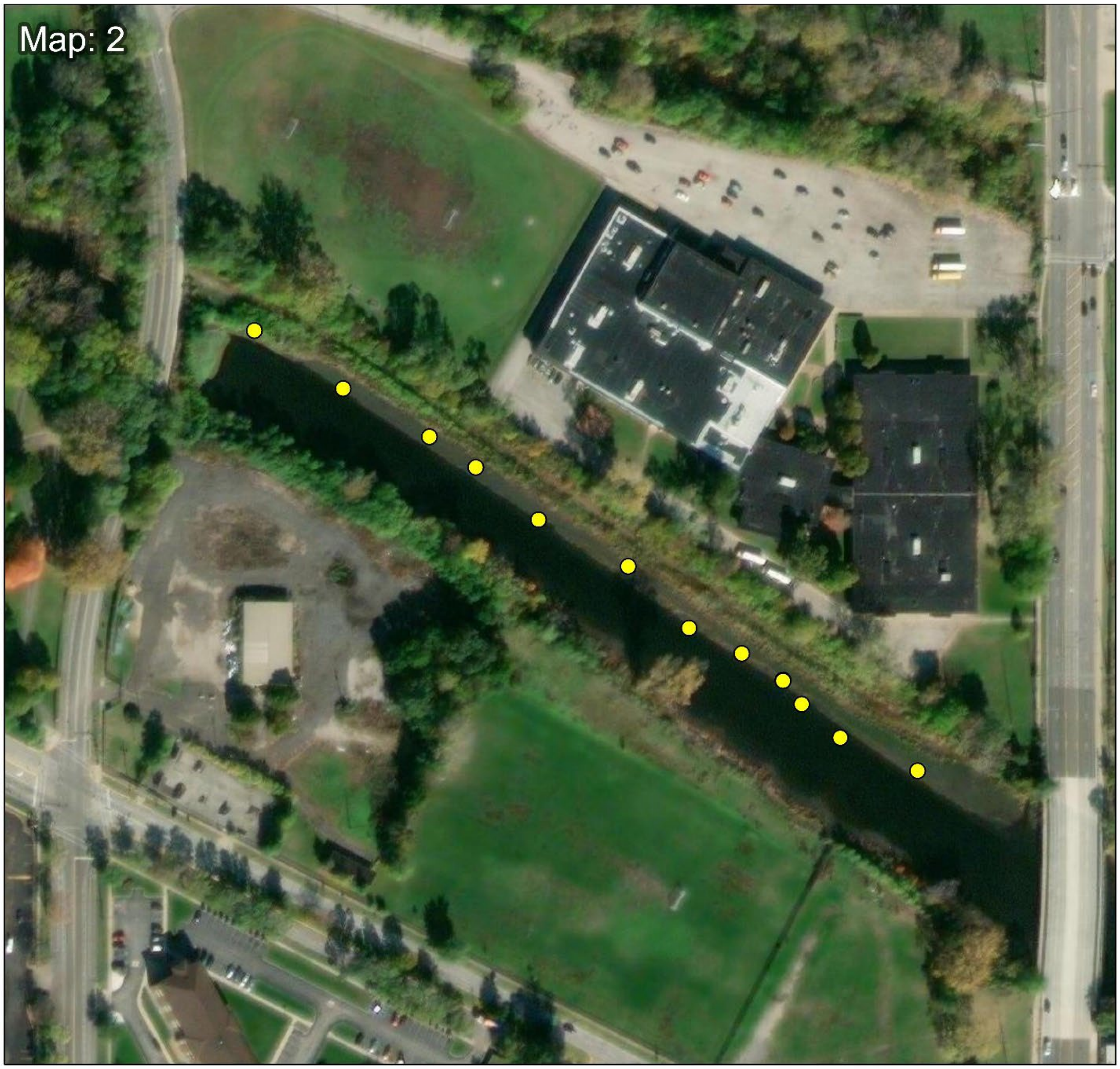
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 14



U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 13



eDNA Detection Status

No eDNA detected

0 0.1 mi
0 0.1 km

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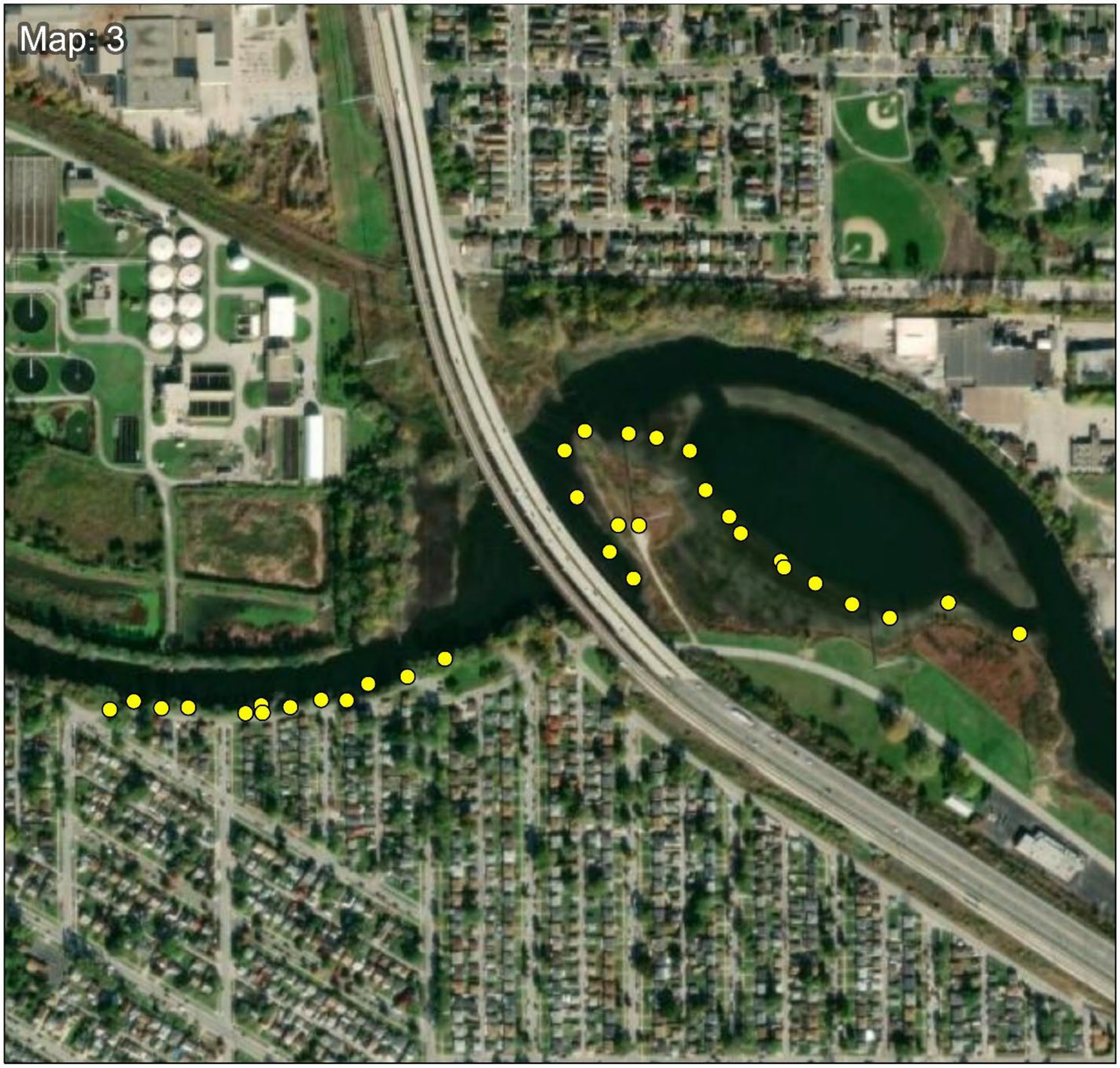
U.S. Fish and Wildlife Service

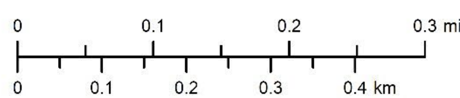
Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 33

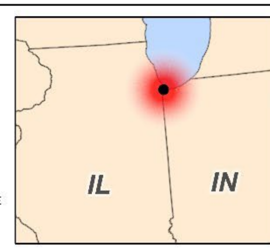


eDNA Detection Status

No eDNA detected

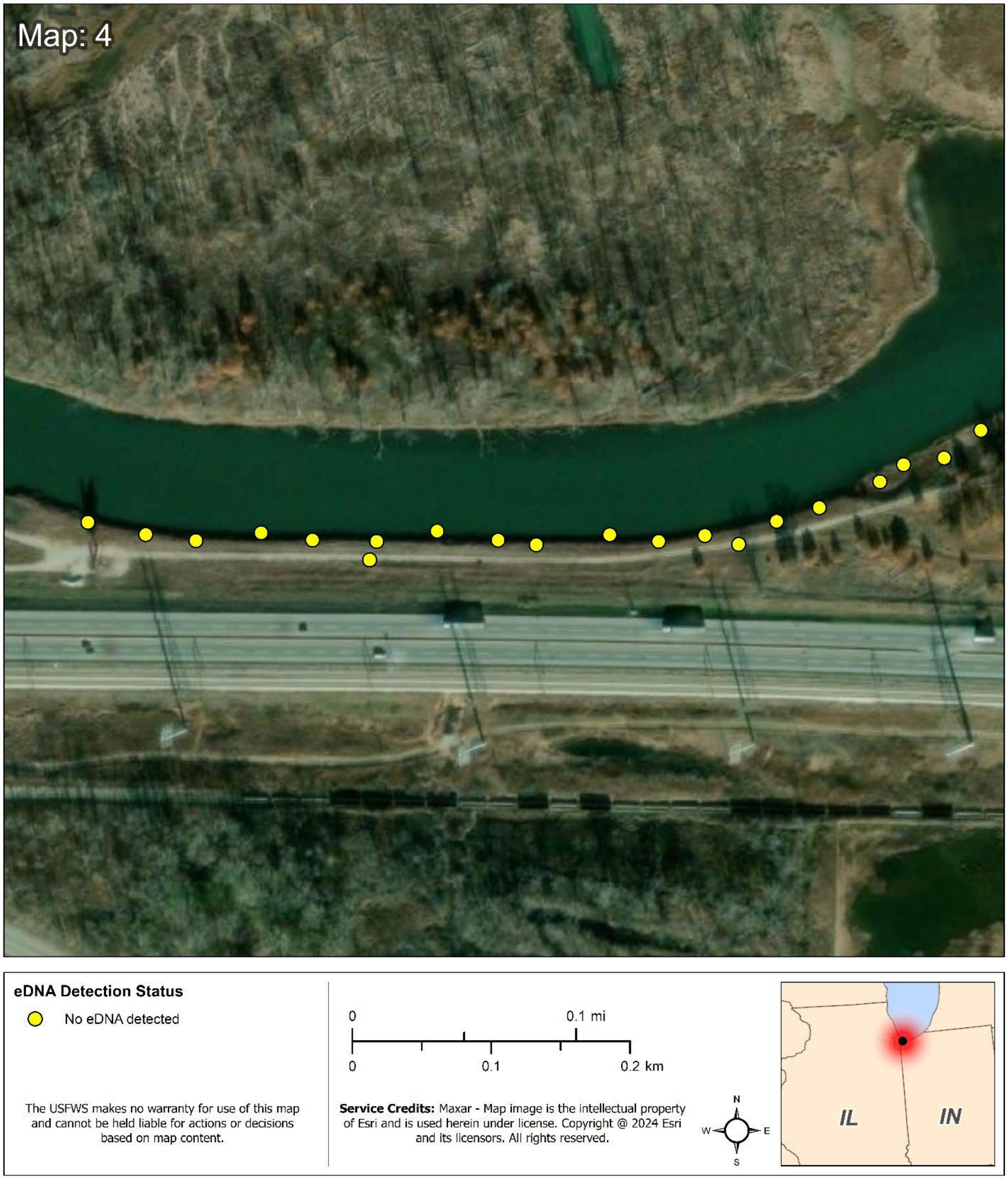
The USFWS makes no warranty for use of this map and cannot be held liable for actions or decisions based on map content.





U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Grand Calumet River**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 20



U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Powderhorn Lake**
Sampling Period: Week of September 23, 2024
Number of Samples Collected: 110

eDNA Detection Status

No eDNA detected

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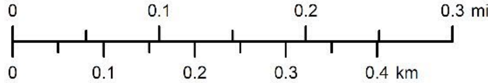

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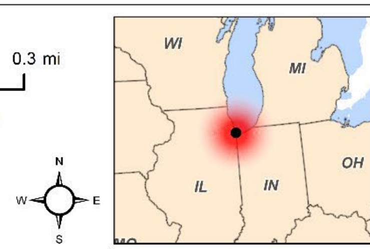


ALTERNATIVE PATHWAY SURVEILLANCE IN ILLINOIS – URBAN POND MONITORING

Participating Agencies: ILDNR (lead), SIU, USFWS. Justin Widloe, Eli Lampo, Claire Snyder, Brian Schoenung, Allison Lenaerts, Andrew Wieland, Mitch Rosanditch, Amanda Carter (ILDNR); and Dr. Greg Whitledge (SIU); Nick Frohnauer (USFWS)

MRWG Work Group: Detection

Pools Involved: CAWS

INTRODUCTION AND NEED

The ILDNR fields many public reports of observed or captured invasive carp. All reports are taken seriously and investigated through phone/email correspondence with individuals making a report, requesting and viewing pictures of suspect fish, and visiting locations where fish are being held or reported to have been observed. In most instances, reports of invasive carp prove to be native Gizzard Shad or stocked non-natives, such as trout, salmon, or Grass Carp. Reports of Bighead Carp or Silver Carp from valid sources and locations where these species are not known to previously exist elicit a sampling response with boat electrofishing and trammel or gill nets.

OBJECTIVE

- Sample fishing ponds in the Chicago Metropolitan area included in the ILDNR Urban Fishing Program using conventional gears (electrofishing and trammel/gill nets) and using eDNA testing for the presence of invasive carp.

PROJECT HIGHLIGHTS

- No eDNA was detected in the 94 samples taken in 2024.
- Since 2011, 35 Bighead Carp have been removed from six Chicago area ponds using electrofishing and trammel/gill nets, three of which are on display at the Shedd Aquarium in Chicago.
- Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have also been removed from Chicago area ponds since 2008.
- Two Bighead Carp were incidentally caught by fishermen in Chicago area ponds – one in 2016 and one in 2021.
- 20 of the 21 ILDNR Chicago Urban Fishing Program ponds have been sampled with nets and electrofishing.
- Two Bighead Carp were removed from Humboldt Park in 2022. After the removal, that pond tested negative for invasive carp eDNA.

METHODS

Pulsed DC-electrofishing and trammel/gill nets are used to sample urban fishing ponds when a response is warranted. A map of all the Chicago area fishing ponds that were sampled or inspected as part of this project can be found in Figure 1.

RECOMMENDATION

We will investigate reports of invasive carp sightings or captures in Chicago area ponds based strictly on photographic evidence or reports from credible sources.

Figure 1. *Chicago area fishing ponds from which invasive carp have been removed and those from which no invasive carp have been collected or reported.*

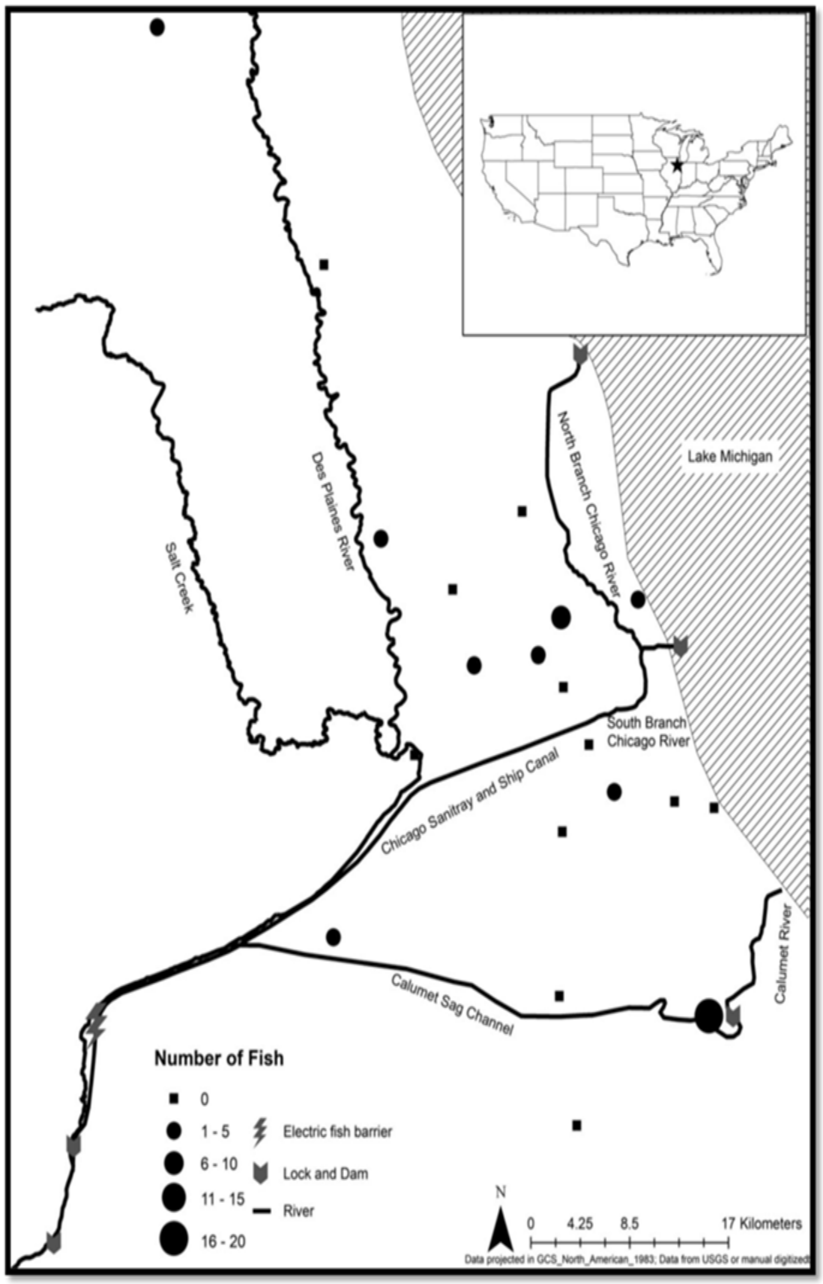


Figure 2. *USFWS report of eDNA sampling in the Chicago area ponds in July 2024 and maps of the eDNA sampling locations.*

U.S. Fish and Wildlife Service

2024 Bighead and Silver Carp eDNA Monitoring - Communication of Results

Receiving entities: State of Illinois

Date Transmitted: 9/9/2024

Location: CAWS - Chicago area urban ponds

This packet contains summary data and spatial representation of eDNA samples analyzed by the US Fish and Wildlife Service. These results will be made public in accordance with US Fish and Wildlife Service guidelines. All sampling and analysis was conducted in accordance with the USFWS Quality Assurance Project Plan (https://www.fws.gov/media/quality-assurance-project-plan-edna-monitoring-bighead-and-silver-carps).

Symbols to display results are as follows:

⬡ Invasive Carp eDNA detected. Represents a positive detection at the marker set ACTM 1/3. This marker set can detect either Bighead Carp, Silver Carp or both but is not specific enough to say which species of the two.

▲ Silver Carp eDNA only detected. Represents a positive detection at the marker set SCTM 4/5. This marker set can detect Silver Carp only.

■ Bighead Carp eDNA only detected. Represents a positive detection at the marker set BHTM 1/2. This marker set can detect Bighead Carp only.

◆ Bighead and Silver Carp eDNA detected. Represents a positive detection at both SCTM 4/5 AND BHTM 1/2. DNA from both species was detected in the water sample.

● No positive detections at any of the markers.

● No detection data.

Table 1. Bighead and Silver Carp eDNA Early Detection Results for the Chicago Ponds for the week of July 22, 2024.*

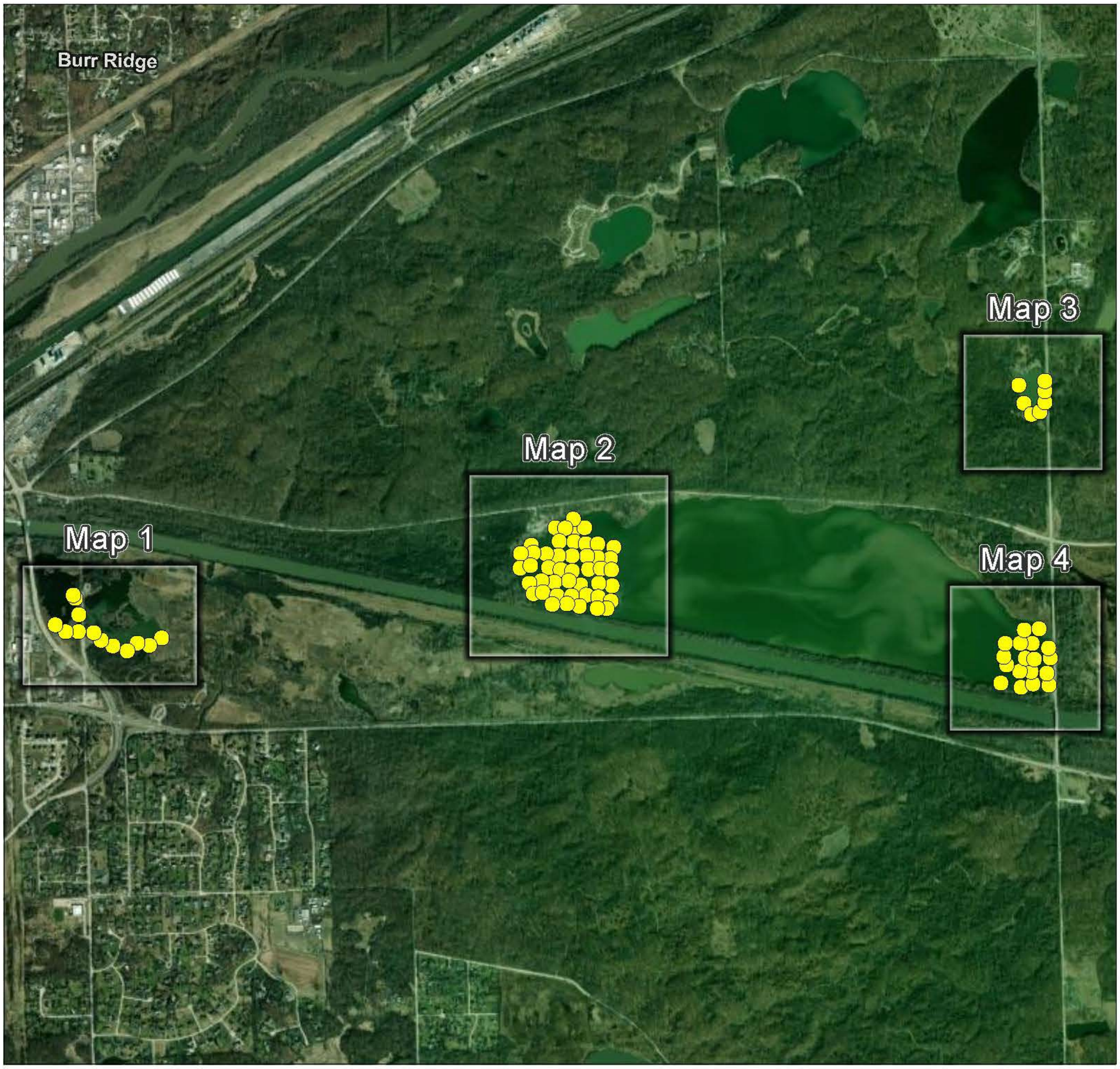
eDNA Detection Status	FREQUENCY
No eDNA detected	94

*Field control blanks included in total number of samples collected.
**Additional lab notes if applicable

For questions or additional information, contact:
Nick Frohnauer, USFWS Region 3 eDNA Coordinator
Nicholas_Frohnauer@fws.gov
612-431-5829

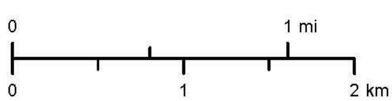
U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Chicago Ponds**
Sampling Period: Week of July 22, 2024
Number of Samples Collected: 94



eDNA Detection Status

No eDNA detected



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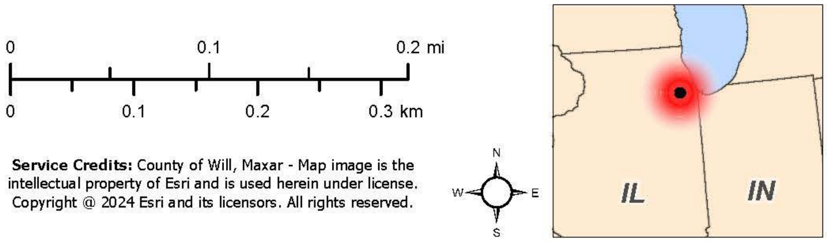
Bighead and Silver Carp eDNA Early Detection Results for the **Chicago Ponds**
Sampling Period: Week of July 22, 2024
Number of Samples Collected: 15

eDNA Detection Status

No eDNA detected



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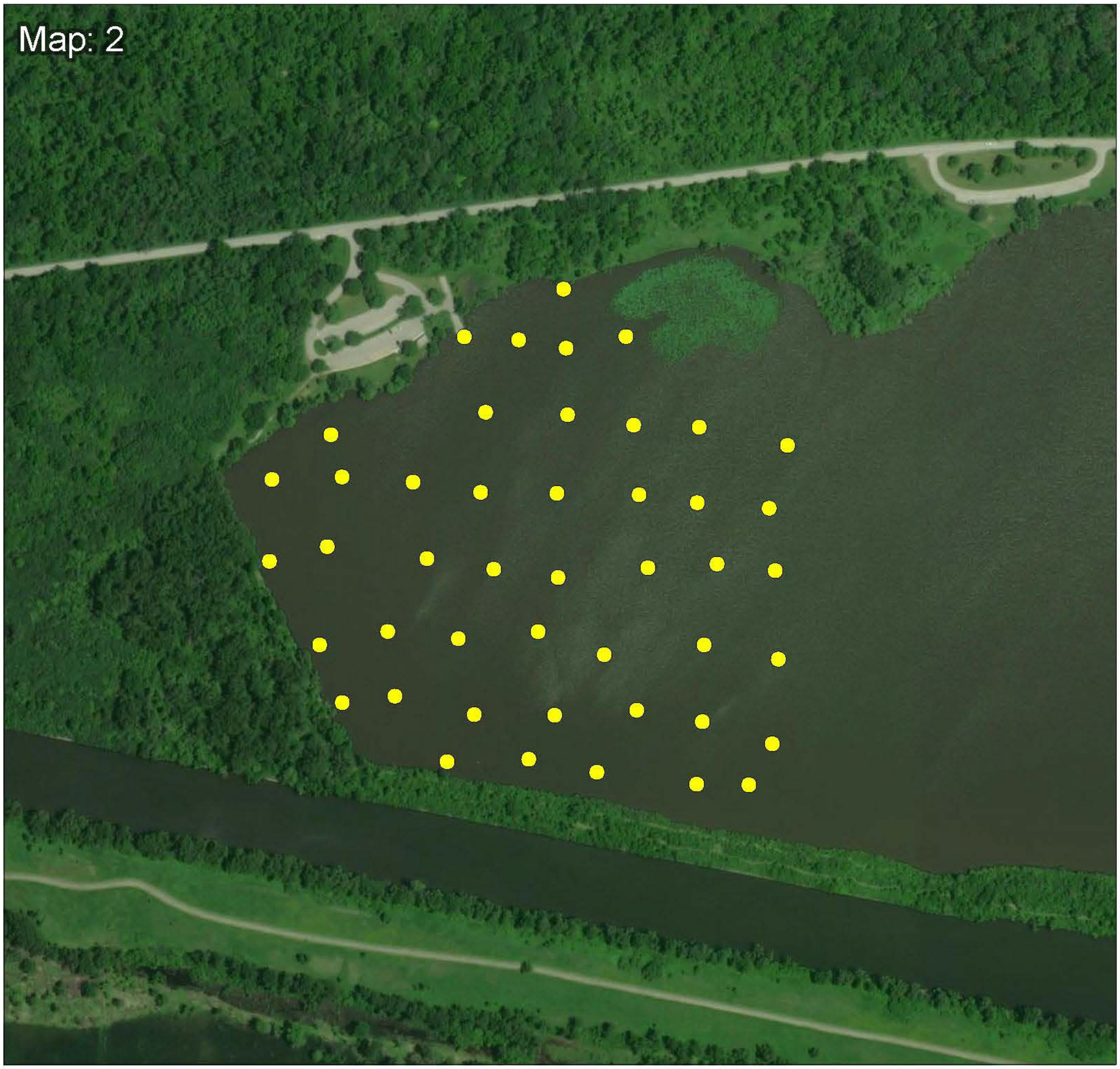
Bighead and Silver Carp eDNA Early Detection Results for the **Chicago Ponds**
Sampling Period: Week of July 22, 2024
Number of Samples Collected: 51



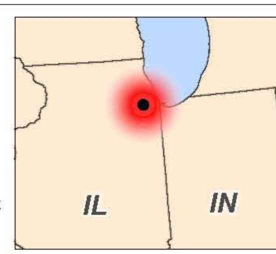
eDNA Detection Status

No eDNA detected

0 0.1 0.2 0.3 mi

0 0.1 0.2 0.3 0.4 km

N W E S



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U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Chicago Ponds**
Sampling Period: Week of July 22, 2024
Number of Samples Collected: 8

eDNA Detection Status

No eDNA detected

Scale: 0 – 0.1 mi; 0 – 0.1 km

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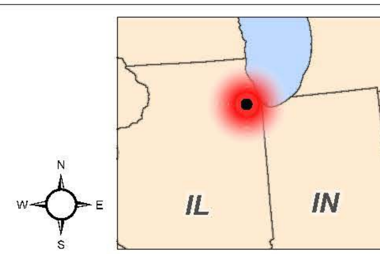
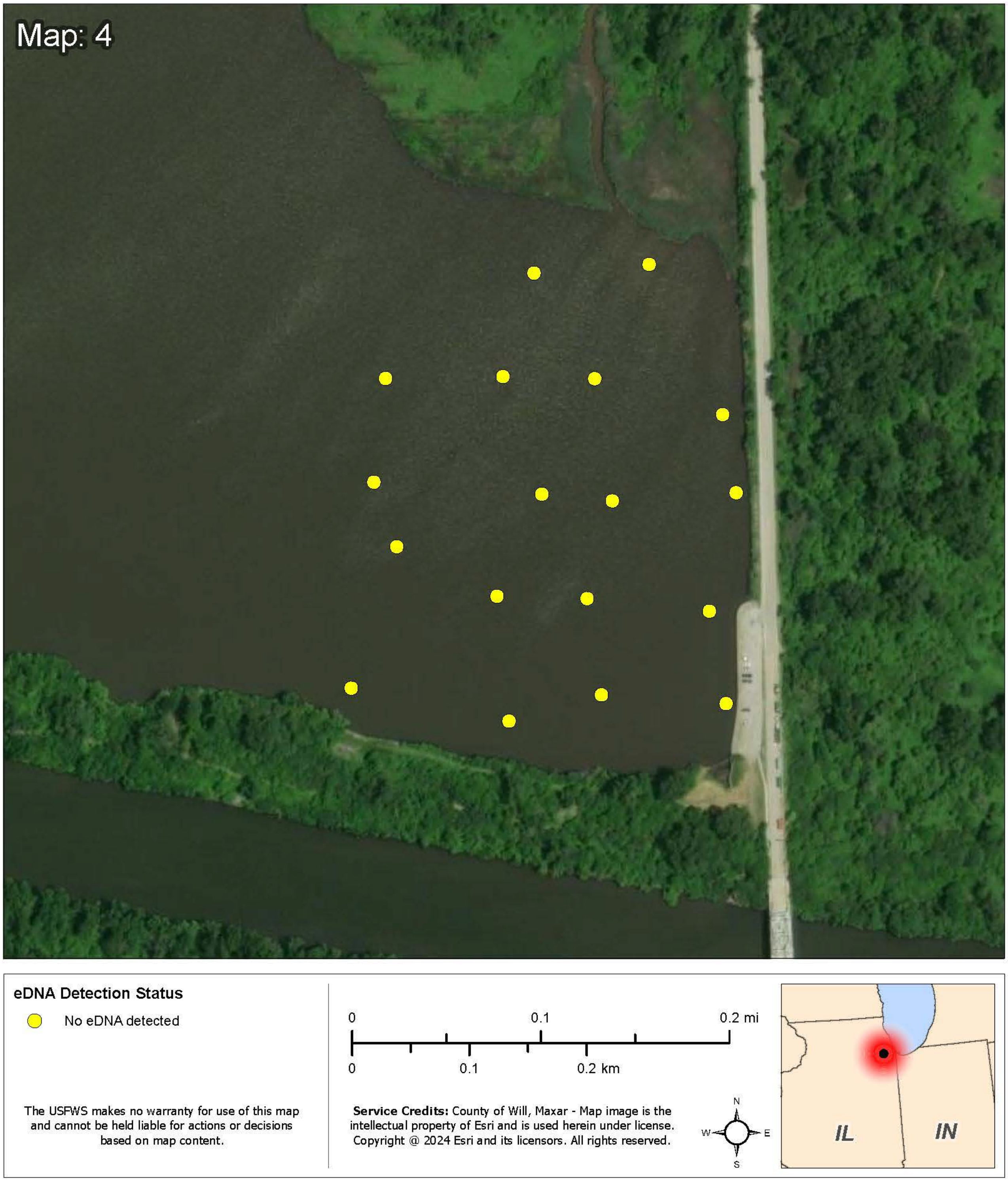


U.S. Fish and Wildlife Service

Bighead and Silver Carp eDNA Early Detection Results for the **Chicago Ponds**
Sampling Period: Week of July 22, 2024
Number of Samples Collected: 20



ALTERNATE PATHWAY SURVEILLANCE IN ILLINOIS – LAW ENFORCEMENT

Participating Agencies: ILDNR (lead); Brandon Fehrenbacher (ILDNR)

MRWG Work Group: Detection

Pools Involved: N/A

INTRODUCTION AND NEED

The ILDNR ISU is a specialized law enforcement component of the ICRCC. Illegal activities within commercial fishing, aquaculture, transportation, bait, pet, aquarium, live fish market, and sport fishing industries increase the risk of invasive carp or other species being introduced and established into new waters. ISU searches for and apprehends individuals and businesses violating regulations enacted to protect our waterways. These concentrated efforts firmly establish, on an annual basis, that human activities remain a foreseeable risk to invasive species expansion. It is critical, therefore, that local, state, and federal agencies tasked with resource protection establish and train specialized units. ISU provides qualified experts to liaise with other law enforcement personnel, non-law enforcement personnel from different divisions or agencies, and the public searching for answers to their focused inquiries.

OBJECTIVES

- Complete a minimum of 10 documented aquatic organisms in trade industry inspections.
- Train a minimum of 20 Conservation Police Officers in organisms in trade enforcement.
- Implement a minimum of 5 intel-based enforcement operations.

PROJECT HIGHLIGHTS

150 Conservation Police Officers received aquatic invasive species enforcement training during a 3-hour workshop incorporated into the ILDNR Office of Law Enforcement's annual in-service training. This event marked the first statewide aquatic invasive species enforcement training for Illinois Conservation Police Officers. ISU partnered with resources experts from the Illinois Natural History Survey and Illinois-Indiana Sea Grant to heighten officers' awareness of identifying aquatic invasive species and the illegal activities associated with them. University of Illinois staff helped develop the workshop and determine the effectiveness of the training by administering participant surveys. The training included plant, fish, and crayfish experts, PowerPoint presentations, and live lab identification training. ISU guided officers in enforcing AIS regulations during the workshop's law enforcement segment. ISU developed and distributed quick reference enforcement guides featuring Black Carp, Grass Carp, Silver Carp, and Bighead Carp; snakehead (fish); marbled, rusty, and red swamp crayfish; and various invasive plant species. The guides listed the pathways officers were most likely to encounter each species, addressed common questions, and provided various enforcement options available to officers. The workshop inspired officers who may not have previously understood the value of AIS enforcement and provided CPOs the confidence to interact with the public on AIS issues. Feedback and post-workshop results were overwhelmingly positive.

METHODS

ISU enforcement activity was generated from suspect surveillance operations, on-site facility inspections, focused enforcement details, audits, topic-specific monitoring of the Internet, public complaints, and government agency-related leads.

RESULTS AND DISCUSSION

Aquatic organisms in trade industry inspections led to the discovery of several notable violations which produced valuable intel for the implementation of focused enforcement details. However, the enforcement details did not identify criminal behavior directly associated with the illegal possession, sale, or transportation of live invasive carp. Direct engagement with industry stakeholders provides an opportunity to improve communications and is critical in regulatory oversight by holding businesses and individuals accountable for their harmful behaviors.

Snippets of the enforcement actions include:

- ISU successfully apprehended the owner of a business who unlawfully sold live invasive crayfish despite several outreach efforts notifying the public of crayfish prohibitions. ISU initiated a covert operation and purchased live red swamp crayfish from the seller who stated during the transaction, that the Illinois Conservation Police didn't have the resources to go after small-time operations like his. The investigation discovered that 26 shipments of live crayfish were illegally imported into Illinois with an estimated market value of $38,715.00. The seller was indicted on felony charges with the case disposition pending.
- ISU cited the owner of a fish hatchery in Ohio for unlawfully importing live viral hemorrhagic septicemia (VHS) susceptible species into Illinois without an ILDNR VHS Susceptible Species permit or a non-resident aquatic life dealer's license. The investigation was initiated after Ohio wildlife investigators discovered evidence of illegal fish shipments into Illinois during a commercial aquaculture inspection. The joint-agency investigation prevented an illegal shipment of 2,500 pounds of live fish scheduled to be stocked into a northeast Illinois lake. The fish hatchery owner also received several citations from the Ohio DNR for aquaculture permit and fish transportation violations.
- ISU coordinated an 8-month investigation of an Illinois licensed wholesale aquatic life dealer buying native fish species from commercial fishermen and falsifying invoices and receipts by recording all purchases as invasive carp. This activity produced an unfair advantage to the industry, reduced the number of available native species for fish buyers, and produced an underreporting of commercially caught native species. CPOs inspected commercial fishermen at boat ramps after they returned from fishing and documented the inspections on reports that ISU compared to the aquatic life dealer’s purchase records. ISU interviewed the owner and employees of the business who confessed to the crime when all the evidence was presented against them.
- ISU directed the development of a multi-agency AIS enforcement project targeting distributors of invasive aquatic plant species throughout the Great Lakes basin. Twenty-eight online aquatic plant retailers throughout the U.S. were identified as sellers of at least

one prohibited plant species. Those businesses were sent notifications advising them to cease illegal sales and shipments. The final phase of the project is underway to determine compliance and criminally charge those who ignored previous outreach efforts.

- ISU discovered an unpermitted aquaculture facility purchasing untested VHS susceptible species in Wisconsin. The owner of the facility transported the fish into Illinois and was raising them in outside tanks adjacent to the Fox River. ISU also cited a Tennessee fish hatchery that sold and stocked VHS susceptible species to five different Illinois customers without VHS import permits.

RECOMMENDATIONS

- Encourage the establishment of permanent Organisms in Trade Law Enforcement Units.
- Seek expansion of AIS training for CPOs to further aid in bridging the gap between law enforcement and non-law enforcement personnel.
- Prioritize proactive enforcement to mitigate the need for retractive responses.

MONITORING WORK GROUP PROJECTS

- Invasive Carp Demographics – Multiple Agency Monitoring Support
- Multiple Agency Monitoring of the Illinois River for Decision-Making

INVASIVE CARP DEMOGRAPHICS – MULTIPLE AGENCY MONITORING SUPPORT

Participating Agencies: USFWS Columbia FWCO (lead); USFWS Carterville- Wilmington FWCO; INHS and ILDNR; Edward Sterling, Bryon Rochon, Jahn Kallis, Jason Goeckler (USFWS Columbia FWCO)

MRWG Work Group: Monitoring

Pools Involved: Alton, La Grange, Peoria, Starved Rock, Marseilles, Dresden Island, Brandon Road, Lockport; Illinois River

INTRODUCTION AND NEED

Detection and monitoring of invasive carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) populations in the Illinois River is critical for achieving management goals. To address this important information need, natural resource agencies collaborate to implement a standardized multiple gear sampling approach; the Multiple Agency Monitoring of the Illinois River for Decision Making project. This standardized multi-gear sampling approach provides an accurate, comparable, and representative understanding of invasive carp distribution and abundance throughout the Illinois River. Additionally, incorporating age data collections into these efforts provides the information needed (e.g., age structure) to inform stock assessment models used to quantify the success of control efforts.

The USFWS's Invasive Carp Demographic project is collaborative with the *Multiple Agency Monitoring of the Illinois River for Decision Making* project. This project includes electrified dozer trawl sampling and laboratory processing of field samples. Please see the *Multiple Agency Monitoring of the Illinois River for Decision Making* in this report for electrified dozer trawl sampling methodology. The physical capture data from this project is summarized in the MAM ISR and hereafter is not discussed. The focus of this report is solely on age structure results.

OBJECTIVES

In addition to the Multiple Agency Monitoring of the Illinois River for Decision Making project objectives, the objectives of the Invasive Carp Demographics project include:

- Coordinate with MAM of the Illinois River for Decision Making project to provide an additional gear type (i.e., electrified dozer trawl) to existing standardized sampling protocols to complete field sampling, data processing and analysis, and reporting to achieve MAM of the Illinois River for Decision Making project objectives.
- Provide Silver Carp age structure results in pools of the Illinois River.

PROJECT HIGHLIGHTS

- From 2018 to 2024, over 5,300 lapilli otolith aging structures were collected and processed from six pools of the Illinois River, providing pool-specific age structure metrics.

METHODS

The USFWS-Columbia FWCO and Wilmington substation collected fisheries-independent data including age, size, and sex during three time periods (June–October) in the Alton, La Grange, Peoria, Starved Rock, Marseilles, Dresden Island, Brandon Road, and Lockport Pools using a random design stratified by habitat type (i.e., backwaters, island side channels, main-channel borders). Sampling was conducted using the electrified dozer trawl (Hammen et al. 2019; Drews 2020). Further detail describing fish collection procedures are provided in the MAM ISR.

During time period three of MAM (September 15–October 31), lapilli otoliths were extracted from the first 200 Silver Carp captured in each river reach (i.e., Lower Pools: Alton, La Grange, and Peoria pools, Upper Pools: Starved Rock, Marseilles, and Dresden Island pools) with a maximum of 20 Silver Carp per transect. Otoliths were extracted from any Silver Carp in an unfilled length bin (10/50 mm TL) following the first 200 collected. These data represent the age structure of the population. To help characterize the age structure of the fishery, additional lapilli otoliths were collected from invasive carp (200 invasive carp/pool) in the lower six pools of the Illinois River, where available, using fisheries-independent (i.e., standard electrofishing) and fisheries-dependent (i.e., commercial gillnets) methods. These additional collections were necessary to help inform the population age structure that is exploited by fishers, and to help provide inputs for the statistical catch-at-age model. Fishery-dependent age structures were provided through collaboration with ILDNR, INHS, and the USFWS-Wilmington substation.

Lapilli otoliths collected from this sampling effort were aged by personnel from the USFWS-Columbia FWCO. One otolith per fish was prepared by sanding on a transverse plane until reaching the nucleus. Prepared otoliths were mounted in putty, submerged in glycerol, illuminated with a fiber optic light, and viewed using a dissecting scope. Three independent readers aged each otolith and a final age was recorded using a minimum of 2/3 consensus (Maceina and Sammons 2006; Seibert and Phelps 2013). If a 2/3 consensus could not be reached, the otolith was omitted from our dataset.

RESULTS AND DISCUSSION

Field collection summary results coinciding with objective number one are described in the Multiple Agency Monitoring of the Illinois River for Decision Making ISR.

Summary results addressing objective two, which is to provide Silver Carp age structure results for pools of the Illinois River are reported here. The age structure collection included collaboration with the MAM project and the Contracted Commercial Fishing Below the Electric Dispersal Barrier project to build a large age structure dataset using lapilli otoliths from fall caught fish. These data are critical for determining population age structure, estimating growth, and parameterizing stock assessment models, such as catch-at-age models.

Results from 2021–2023 collections were updated with 2024 data. Specific methods for age structure collections between 2021–2023 can be found in the 2022 Demographics ISR (Project: Invasive Carp Demographics, ICRCC-MRWG 2022). Laboratory data have been shared with the MRWG to be incorporated into the overall MRWG database. These data will be used by the MRWG Modeling Work Group as important inputs for SCAA models recommended by the Quantitative Fisheries Center personnel at Michigan State University.

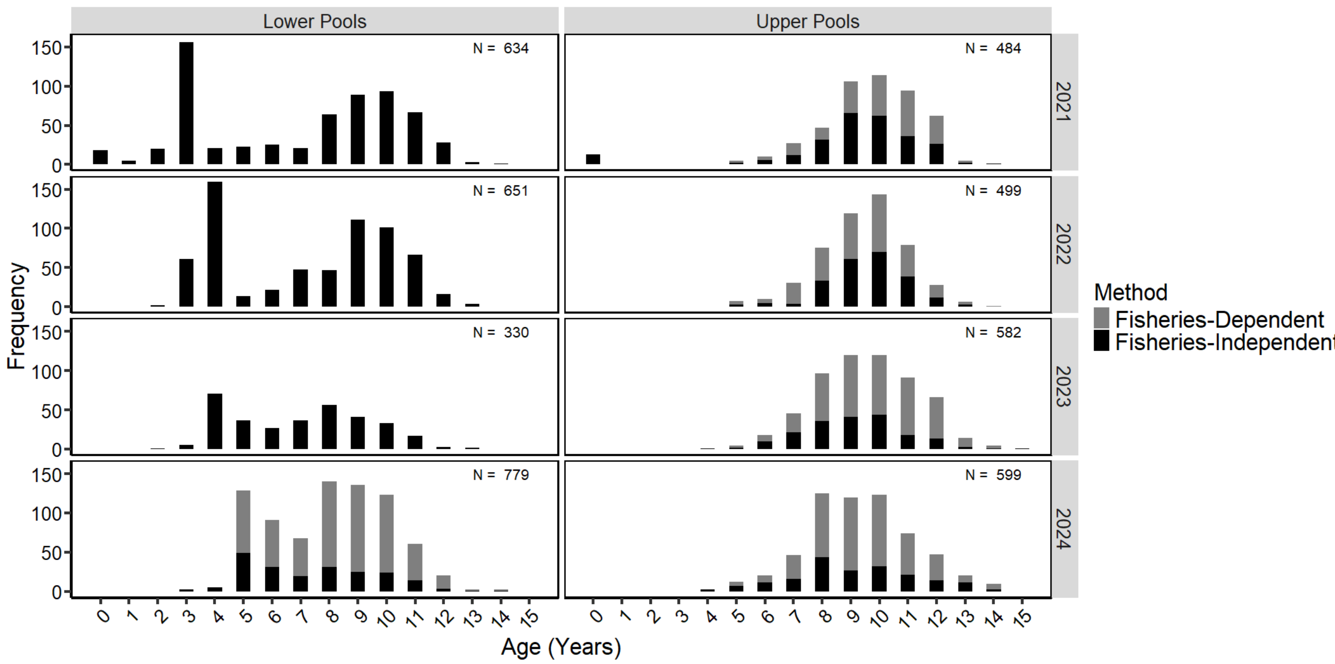
In 2024, 1,386 invasive carp (1,378 Silver Carp) were captured and lapilli otolith age structures were removed during the fall period in the lower six pools of the Illinois River. No invasive carp were captured in Brandon Road or Lockport pools. In total, 392 age samples were collected with electrified gears (i.e., electrified dozer trawl and standard electrofishing), and 994 age samples were collected with fisheries-dependent gears (i.e., gillnet).

Table 1. *Fall 2024 age collection summary data, including Silver Carp total catch (number fisheries- independent, number fisheries-dependent), Bighead Carp total catch (number fisheries-independent, number fisheries-dependent), total length (TL) range, and age (years) range of invasive carp captured.*

Pool	Silver Carp (#)	Silver Carp (#)	Bighead Carp (#)	Bighead Carp (#)	TL Range (mm)	Age Range (years)
-	**Independent**	**Dependent**	**Independent**	**Dependent**	-	-
Dresden Island	11	87	0	4	625-1208	5-16
Marseilles	76	134	0	2	552-996	4-16
Starved Rock	100	191	0	0	558-772	5-14
Peoria	75	186	0	0	454-970	3-13
La Grange	65	191	0	2	541-823	4-13
Alton	65	197	0	0	492-792	3-14

Age-frequency histograms provided insights into recruitment patterns and the relationship between age and upstream movement. Although young, immature fish (< age-5) were common in the lower three pools, these age classes were largely unrepresented in the upper pools, with an exception being 13 age-0 fish captured in Starved Rock Pool during 2021. Age structure of older fish (> age-5) was similar between lower and upper pools (Figure 1). We observed strong 2018 and 2019 year classes in the lower pools, which were age-5 and -6 in 2024 (Figure 1). Studies have documented a large 2019 cohort in the Mississippi and Missouri River basins, which could be the source of the cohort identified through our work (MICRA 2023). These two young cohorts were observed in Alton, La Grange and Peoria pools, but have yet to disperse upstream in appreciable numbers. However, they are entering maturity, which may affect their upstream dispersal rates. Furthermore, age structure in the lower pools began to trend towards younger populations in 2023 compared to 2021 and 2022. This could indicate that the large 2018 and 2019 cohorts are displacing older fish to distribute upstream. The upper pools continue to maintain a generally older, migrant population (Figure 1). The fisheries-dependent age structures also appeared similar to the fisheries-independent collections, providing confidence that our fisheries-independent sampling is describing the same population that is being targeted for removal (Figure 1).

Figure 1. *Pool-specific (Lower Pools- Alton, La Grange, and Peoria* pools; *Upper Pools- Starved Rock, Marseilles, and Dresden Island* pools) *Silver Carp age frequency data in the lower six pools of the Illinois River. Fisheries-independent samples collected during fall 2021 through 2024 using the electrified dozer trawl and standard electrofishing are indicated in black, and fisheries-dependent age structures collected during fall 2021 through 2024 are indicated in gray.*



RECOMMENDATIONS

Biological systems are inherently complex and respond unpredictably (Coulter et al. 2018). Collections of high-quality demographic data enable managers to understand population responses to harvest, thus providing tools to inform management and control efforts. Herein, we described results from four years of fisheries-independent age structure collections and available fisheries-dependent collections. We recommend continued monitoring through fisheries-independent and fisheries-dependent age structure collections to inform demographic information of Silver Carp populations in the Illinois River. Demographic rates provide important information to evaluate Silver Carp effects on native species, trigger response actions (e.g., contingency plan), evaluate control efforts, and explore alternative management and harvest scenarios using model-based tools. Our continued collaboration with the MAM project to provide efficient, high-quality fisheries-independent data and the Contracted Commercial Fishing Below the Electric Dispersal Barrier project to provide efficient fisheries-dependent age structure collections is essential for modeling efforts. We also recommend continued coordination with MRWG workgroups to address monitoring objectives, increase efficient demographic data collections, and provide high-quality data to support ICRCC and MRWG needs.

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MULTIPLE AGENCY MONITORING OF THE ILLINOIS RIVER FOR DECISION-MAKING

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Participating Agencies: ILDNR, INHS (co-leads); USACE – Chicago District (field support)

MRWG Work Group: Monitoring

Pools Involved: Lockport, Brandon Road, Dresden Island (includes a portion of the Kankakee River), Marseilles, Starved Rock (includes a portion of the Fox River), Peoria, La Grange, Alton pools of the Illinois River below the EDBS (Figure 1).

INTRODUCTION AND NEED

Detection and monitoring populations of invasive carp (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) in pools below the EDBS are pertinent to understanding their upstream progression and minimizing the risk of establishment above the EDBS. Surveillance is particularly important in pools directly upstream for each invasive carp species known expanse: Bighead Carp and Silver Carp are within Dresden Island Pool, Grass Carp is within the CAWS, and Black Carp is within Peoria Pool. Extensive monitoring also provides managers with the ability to evaluate the impacts of management actions (e.g., contracted removal) and collect data to assist other projects (e.g., SEICarP). Data collected from a standardized multiple-gear sampling approach has been used to create accurate and comparable relative abundance estimates of specific species and detect the presence of previously unrecorded invasive species (Ickes et al. 2005). A standardized multiple-gear approach was used here to create a comprehensive dataset that provided an understanding of the current geographic range of invasive carp across all pools downstream of the EDBS, their abundances, the threat they pose to enter Lake Michigan, and to begin evaluating impacts of current invasive carp management.

OBJECTIVES

- Monitor the geographic distribution and abundance of adult and juvenile invasive carp in pools below the EDBS downstream to Alton Pool.
- Provide comparable data capable of detecting spatial and temporal changes in populations of invasive carp and the native fish community throughout the entire Illinois River Waterway between the EDBS and Alton Pool.
- Provide other projects (e.g., Contracted Invasive Carp Removal, Telemetry Monitoring, SEICarP model, etc.) with necessary Silver Carp demographic and fish community data to inform management decisions.

PROJECT HIGHLIGHTS

- In 2024, 181 hours of electrofishing, 998 hoop netting net nights, 447 minnow fyke netting net nights, 92 standard fyke netting net nights, and 51 hours of dozer trawling were completed.

- In 2024, 279,938 fish were captured, representing 91 species, 7 hybrid species, and 8 unknown species from family groups (e.g., small individuals from Cyprinidae, Catostomidae, Centrarchidae, etc.)
- Zero invasive carp (large or small) were captured in Lockport or Brandon Road pools in 2024.
- The leading edge of the Bighead Carp and Silver Carp populations remained around river mile 281 (north of I-55 Bridge within the Dresden Island Pool near the Rock Run Rookery) in 2024.
- 372 small Silver Carp (less than 6 inches or 152.4 mm) were captured during MAM sampling in 2024 in the lower three pools of the Illinois River. This represents a significant increase in spawning over 2023, but still a relatively minor spawning pulse in the historical context of longer-term La Grange pool sampling.

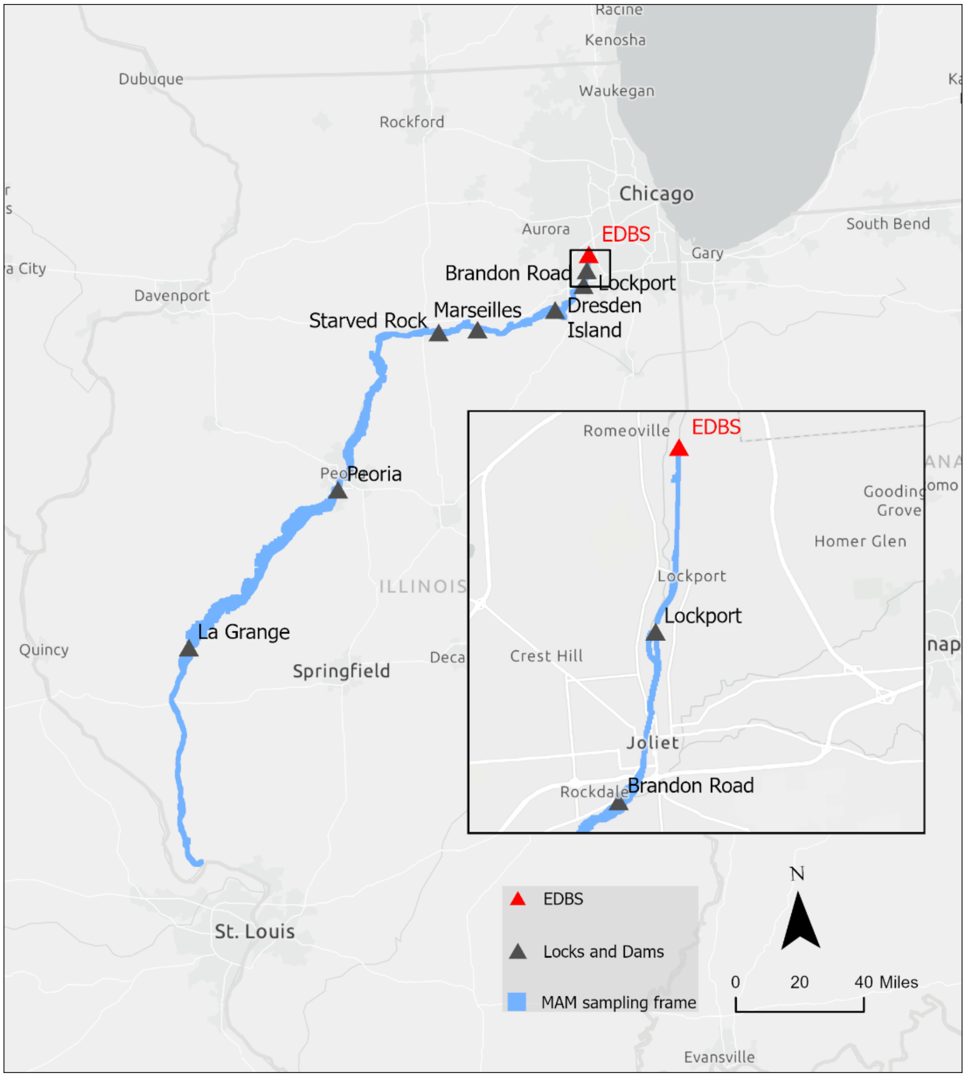
METHODS

The MAM of the Illinois River for Decision Making used the standardized, multi-gear approach developed by the USACE's Upper Mississippi River Restoration Program (Ratcliff et al. 2014) to monitor invasive carp populations in the Illinois River Waterway below the EDBS. This approach utilized daytime boat pulsed DC electrofishing, standard fyke netting, minnow (hereafter mini) fyke netting, and paired large and small hoop netting in a stratified random approach. Detailed descriptions of gear specifications and sampling protocol can be found in Ratcliff et al. (2014).

Data collected external to the invasive carp MRWG MRP were incorporated due to the standardized nature to create a comprehensive dataset that included all pools of the Illinois River. USGS and INHS provided data outside of the MRWG MRP. Data were provided in the preliminary format to meet the need for timely best science on the condition that neither USGS, INHS, nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data.

Overall relative abundance indices and pool-specific relative abundance indices within each pool below the EDBS were generated for each invasive carp species within each gear type from the comprehensive dataset. Calculating absolute abundance requires extensive data collection and a probability-based array, which can be extremely costly and time-consuming (Hayes et al. 2007). A relative abundance index is considerably easier, less expensive, and less time-consuming, all while directly relating to the absolute abundance (Pope et al. 2010). The relative abundance index of CPUE was calculated as the number of fish per hour for electrofishing and dozer trawling and the number of fish per net night (24 hours) for fyke net, mini fyke net, and hoop net samples. When drawing comparisons across active gears, CPUE was calculated as the number of fish per 'deployment.' Which represents the standard time that gear is typically deployed per sampling protocols (15 minutes for electrofishing and 5 minutes for dozer trawling).

Figure 1. *Map depicting sampling coverage for MAM Sampling in 2024.*



RESULTS AND DISCUSSION

Electrofishing Effort and Catch

Total sampling effort included 181 hours of boat electrofishing (hereafter electrofishing; 719 transects) downstream of the EDBS in 2024. Electrofishing yielded 74,334 individual fish representing 91 species, seven hybrid species, and small, unknown individuals from eight family groups (Cyprinidae, Catostomidae, etc.) for a CPUE of 413.0 fish per hour. In 2024, the electrofishing catch was dominated by Gizzard Shad (32.6 percent; n = 24,232), Emerald Shiner (20.0 percent; n = 14,876), Bluegill (10.2 percent; n= 7,574), and Bluntnose Minnow (3.3 percent, n=2,427). The percentage (1.6 percent) of electrofishing catch comprised of Silver Carp in 2024 was similar to 2022 (2.0 percent) and 2023 (1.3 percent) but much less than 2021 (14.7 percent). A total of 1,221 Silver Carp were captured using electrofishing in 2024, which is the lowest number since the inception of MAM in 2021, and Silver Carp catch also has decreased each year since 2021 (2021 = 7,325; 2022 = 1,764; 2023 = 1,451). The overall

CPUE of Silver Carp in 2024 was 6.8 per hour, and CPUE also has decreased each year since 2021 (2021 = 41.6 per hour, 2022 = 10.3 per hour, 2023 = 8.5 per hour). Silver Carp CPUE was highest in Peoria Pool, with slightly lower CPUE in the upstream Starved Rock Pool and downstream through the lower Illinois River pools (Figure 1), with no Bighead, Grass, or Silver carps captured during electrofishing in the pools nearest to the EDBS (Dresden Island, Brandon Road, and Lockport pools) during 2024. Zero Silver Carp were captured using electrofishing in Dresden Island Pool in 2022-2024, but three Silver Carp were captured there in 2021. In 2024, two large (>153 mm [6 inches]) Bighead Carp were captured during electrofishing in La Grange Pool, and 52 total Grass Carp were captured from Starved Rock (n = 6), Peoria (n = 18), La Grange (n = 26), and Alton (n = 2) pools. Of the Silver Carp captured in 2024 during electrofishing, among all the pools, 2.6 percent (32 of 1,221) of individuals were small (<153 mm [6 inches]) and the remaining 97.4 percent were large (>153 mm [6 inches]). In comparison, 79.3 (n = 5,740) percent of Silver Carp captured in 2021 were small, zero small Silver Carp were captured in 2022, and 0.3 percent (5 of 1,451) of all Silver Carp captured in 2023 were small.

Mini Fyke Netting Effort and Catch

Total sampling effort included 447 mini fyke nets downstream of the EDBS in 2024. Mini fyke netting yielded 196,112 fish representing 77 species, three hybrid species, and small, unknown species from eight family groups (Cyprinidae, Catostomidae, etc.). for a CPUE of 450.8 fish per net night. Most of the minnow fyke catch was comprised of Gizzard Shad (35.6 percent; n = 69,859), Emerald Shiner (31.7 percent; n = 62,123), Western Mosquitofish (4.7 percent; n = 9,242), and Grass Carp (4.0 percent, n = 7,839); 338 Silver Carp also were captured in minnow fyke nets in 2024. All 338 Silver Carp were small (<153 mm [6 inches]), of which two small Silver Carp were captured in Peoria Pool, 288 in La Grange Pool, and 48 in Alton Pool. In comparison to previous catch of Silver Carp in mini fyke nets, two small Silver Carp were captured in 2023, zero Silver Carp were captured in 2022, and 50,619 Silver Carp were caught in 2021 (predominantly small individuals). All of the 7,839 Grass Carp captured were from La Grange Pool, with all but one Grass Carp captured being small.

Hoop Netting Effort and Catch

Total sampling effort included 499 hoop nets (998 hoop net nights) downstream of the EDBS in 2024. Hoop netting yielded 6,293 fish representing 38 species, 2 hybrid species, and small, unknown species from 1 family group (Cyprinidae, Catostomidae, etc.) for a CPUE of 6.3 fish per net night. Channel Catfish comprised the largest proportion of hoop net catch (50.7 percent; n = 3,189), followed by Smallmouth Buffalo (21.3 percent; n = 1,341), Common Carp (7.9 percent; n = 495), and Bluegill (6.9 percent; n = 437). No invasive carps were captured in Lockport, Brandon Road, Dresden Island, or Marseilles pools during hoop netting in 2024, but invasive carps (only large individuals) were captured in the other downstream pools. Those captures included 73 Silver Carp, 18 Grass Carp, and two Bighead Carp. The catch of invasive carps in hoops nets has been similar since 2021.

Fyke Netting Effort and Catch

Total sampling effort included 92 fyke nets downstream of the EDBS in 2024. A total of 3,002 fish representing 41 species and one hybrid species were captured during fyke netting with a CPUE of 30.6 fish per net night. Fyke net catch in 2024 was dominated by Bluegill (47.9 percent; n = 1,436), Shortnose Gar (9.7 percent; n = 291), White Crappie (6.7 percent; n = 201), and White Bass (5.6 percent; n= 168).

One Grass Carp and two Silver Carp were captured during fyke netting; neither of those individuals were small. All invasive carp captured during fyke netting were collected from Peoria Pool downstream, although no fyke net samples were collected in Lockport, Brandon Road, or Alton pools due to a lack of suitable connected backwater habitat for this gear. Since 2021, higher catch rates of invasive carps have been found in the lower river pools of Peoria, La Grange, and Alton pools compared to the upper river.

Dozer Trawl Effort and Catch

Total sampling effort included 51 hours of dozer trawling (616 transects) downstream of the EDBS in 2024. A total of 111,386 fish representing 71 species, three hybrid species, and small unknown individuals from four family groups (Catostomidae, Centrarchidae, Cyprinidae, etc.) were captured during dozer trawling with a CPUE of 2,184.0 fish per hour. Dozer trawl catch in 2024 was dominated by Gizzard Shad (83.6 percent; n = 93,162), Emerald Shiner (4.3 percent; n = 4,870), Silver Carp (3.8 percent; n = 4,238), and Smallmouth Buffalo (1.0 percent; n= 1,078). Two Bighead Carp, 44 Grass Carp, and 4,238 Silver Carp were captured during dozer trawling. All invasive carps were large individuals except for two small (<153 mm [6 inches]) Silver Carp captured in La Grange Pool and one small Grass Carp captured in Alton Pool. Invasive carps were captured as far upstream as Dresden Island Pool, though not further upstream than MAM had detected them in earlier years.

Comparisons of Adult Invasive Carp Catch

Among the two active gears – daytime electrofishing and dozer trawling – CPUE was highest below Marseilles Pool (Figure 2). Mean relative abundance of adult Silver Carp from electrofishing samples showed slight declines in 4 out of 5 pools from 2023 to 2024, with the only exception being Starved Rock Pool (Figure 3). This slight uptick in Starved Rock is minor compared to the long-term decline visible across six years of MAM sampling in that pool. 2024 estimates from Peoria and Alton Pools suggest a (at least temporary) stall of longer-term increases in those Pools. Marseilles and La Grange continued their trends of long-term decline. Silver Carp in the Dresden Island Pool remained undetected for the third straight sampling year. Most interannual differences in mean CPUE are likely not statistically significant, but visualizing longer-term trends can give a better sense of the trajectory of these pools' Silver Carp populations. Annual differences in dozer trawl sampling were more variable, but dozer trawl samples confirmed the uptick in Starved Rock Pool seen in electrofishing samples (Figure 4). With two years of pool-wide relative abundance estimates from dozer trawl, it is more challenging to place annual differences in the context of longer-term variability. Continued dozer trawl sampling should improve its utility as a sentinel of change and provide an important long-term complement to electrofishing. While both gears intend to provide pool-wide estimates of relative abundance, enabled by the statistically robust and stratified-random sampling design of the MAM program, each gear samples slightly different habitat and likely have different catchability characteristics. As with all gears, it remains critical to consider gear-specific context dependencies when evaluating data across these two gear types.

Figure 2. *A comparison of mean (+- 95% CI) CPUE of adult Silver Carp captured using electrofishing in 2024 among the various pools of the Illinois River Waterway and its tributaries. CPUE is calculated as fish per deployment, where a typical deployment is a 15 minute electrofishing run or 5 minute dozer trawl run. Adult Silver Carp are defined as >= 153mm (6 in) in total length. Empty circles indicate values of zero. Missing circles indicate no sampling.*

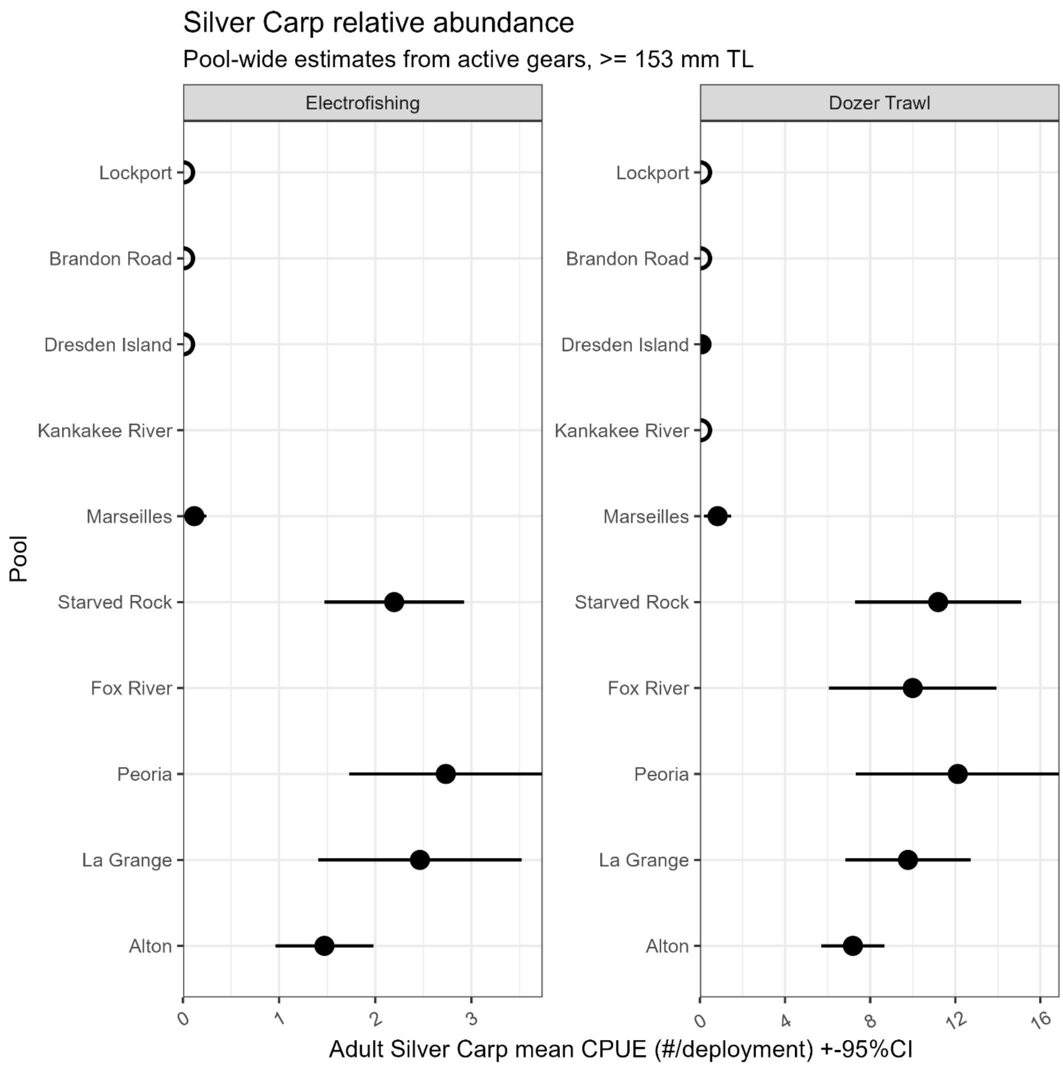


Figure 3. *A comparison of mean (+- 95% CI) CPUE of adult Silver Carp captured using electrofishing among the various pools of the Illinois River Waterway from the inception of the MAM program (2019) through 2024. CPUE is calculated as fish per hour of electrofishing. Adult Silver Carp are defined as >= 153mm (6 in) in total length. Empty circles indicate values of zero.*

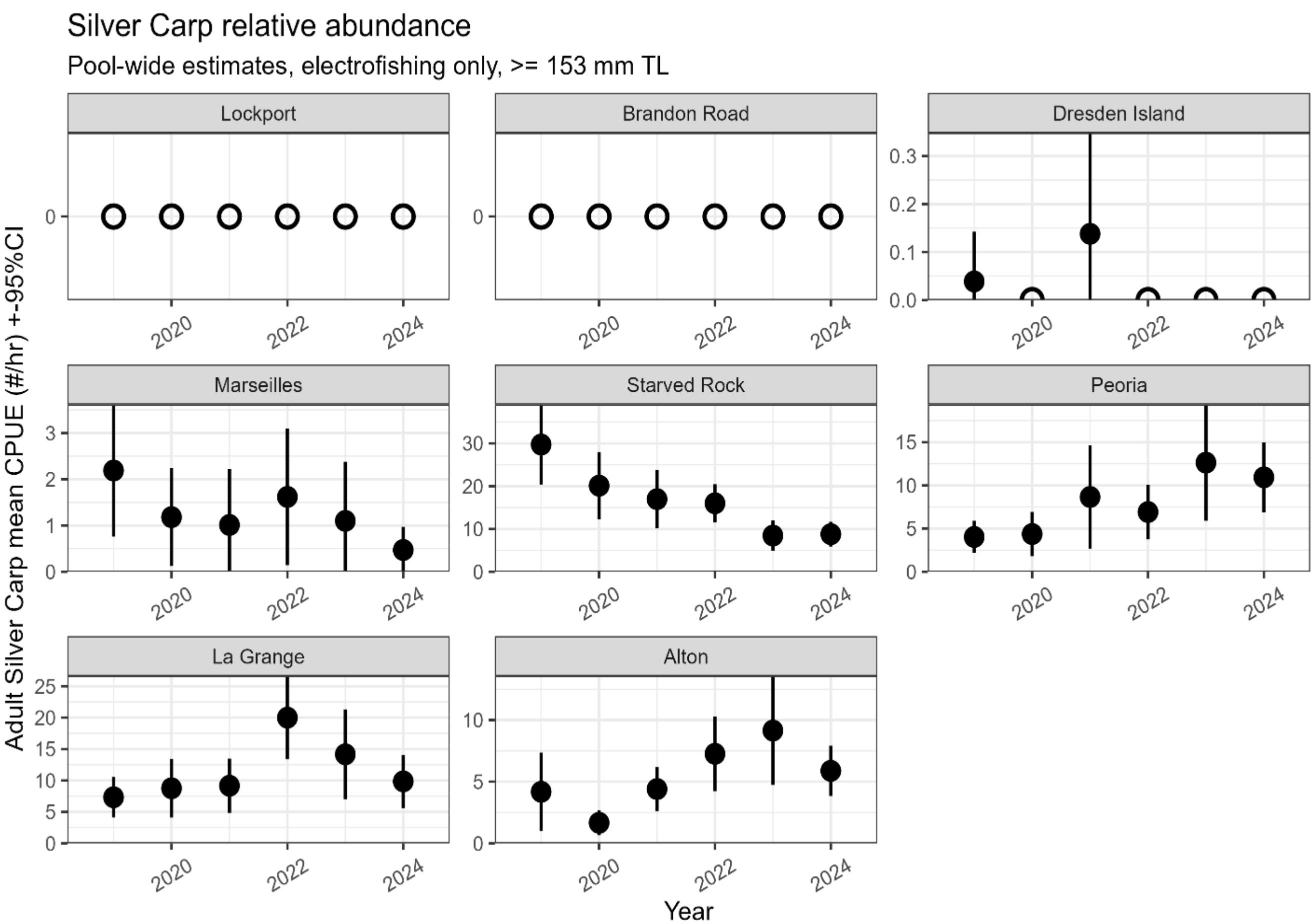
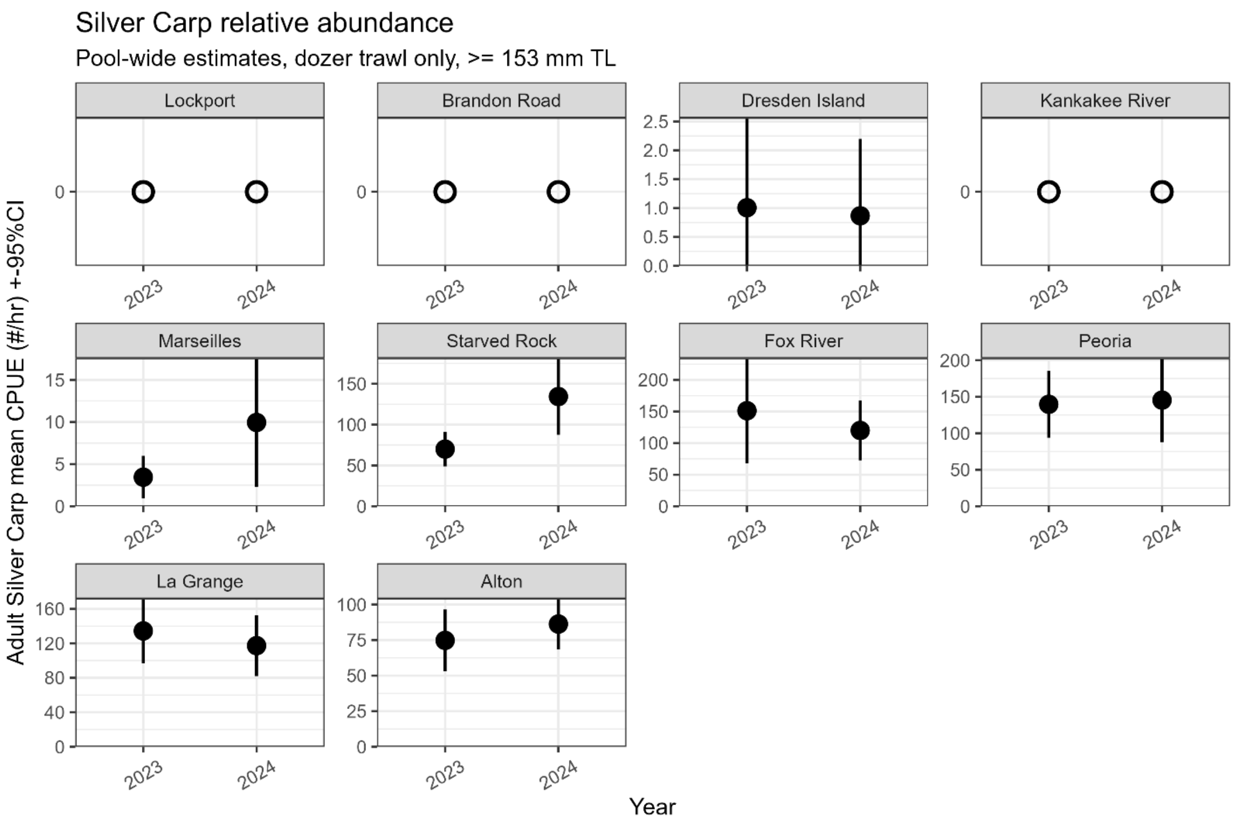


Figure 4. *Overall size structure distribution of Silver Carp captured in all pools of the Illinois River and Fox River tributary. All gear types (electrofishing, electrified dozer trawl, fyke netting, hoop nets, and mini fyke nets) were aggregated together.*



Size Structure

Across gears, Bighead Carp catches were between 750 and 1000 millimeters (mm) total length (n = 6), Grass Carp catches were between 10 and 1030 mm (n = 7954), and Silver Carp catches were between 10 and 996 mm (n = 5882) in 2024. Mean Silver Carp length was larger in upper river reaches compared to lower river reaches (Figure 5). In the Dresden Island Pool – the upstream most pool with Silver Carp detections – four Silver Carp were caught with a mean total length of 880 mm. Size structures of adult Silver Carp in 2024 across the river remained relatively static as compared to 2023, with the exception of Alton Pool which has shown a continuing (albeit slowing) upward trend from 2019-2024 (Figure 6). Juvenile Silver Carp, defined as being <153 mm [6 inches] in total length, were detected in the three lower reaches of the river (Figure 4). These individuals represent a very small portion of the total kernel density distribution of Silver Carp individuals, and they likely represent a minor recruitment pulse as compared to the strong recruitment class of 2021 (Figure 6).

Figure 5. *Frequency of total length in captured Silver Carp individuals less than (left) and greater than or equal to (right) 153 mm [6 inches], a rough cutoff for juveniles and adults, in 2024. Individuals are from all MAM gears.*

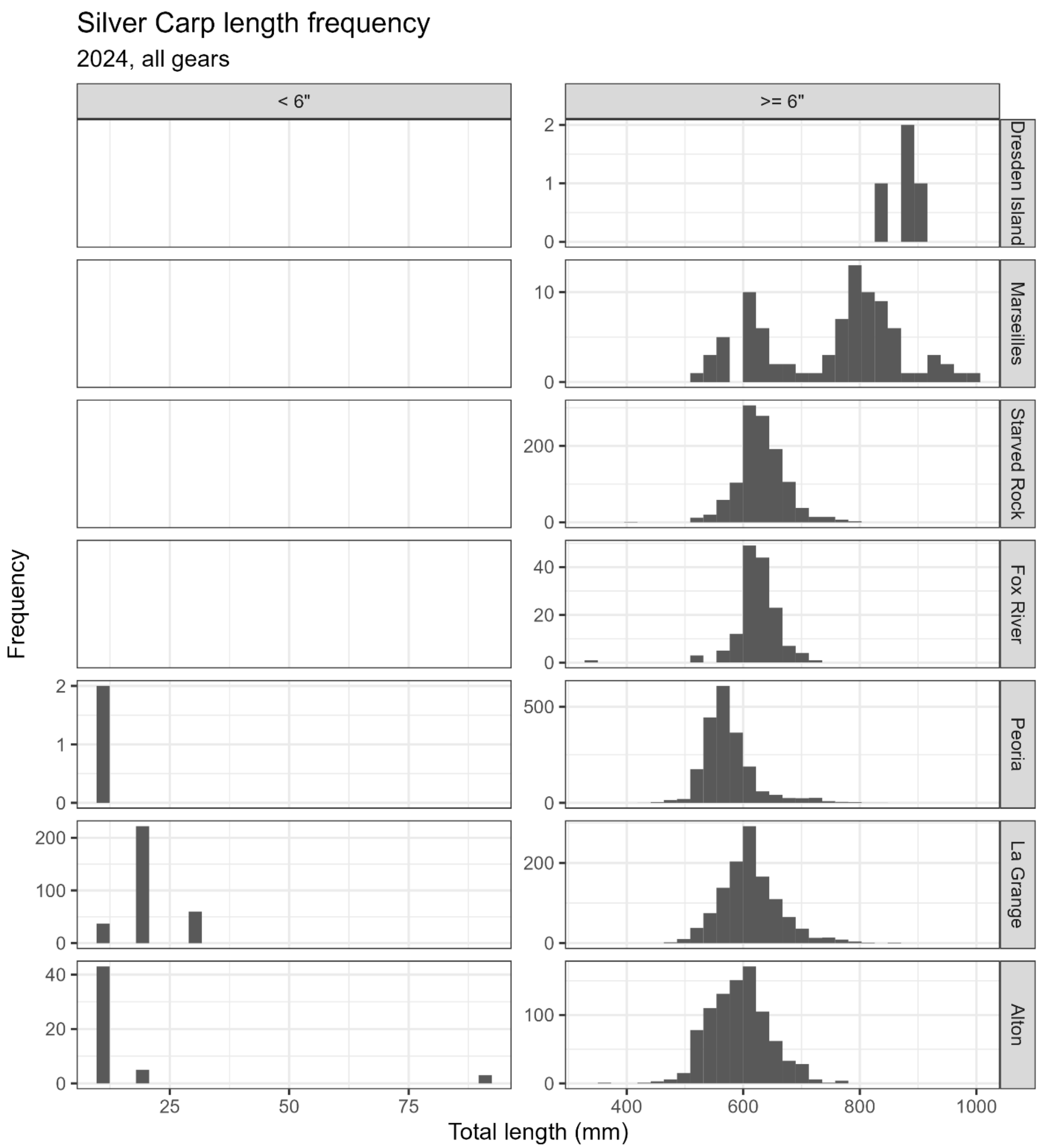
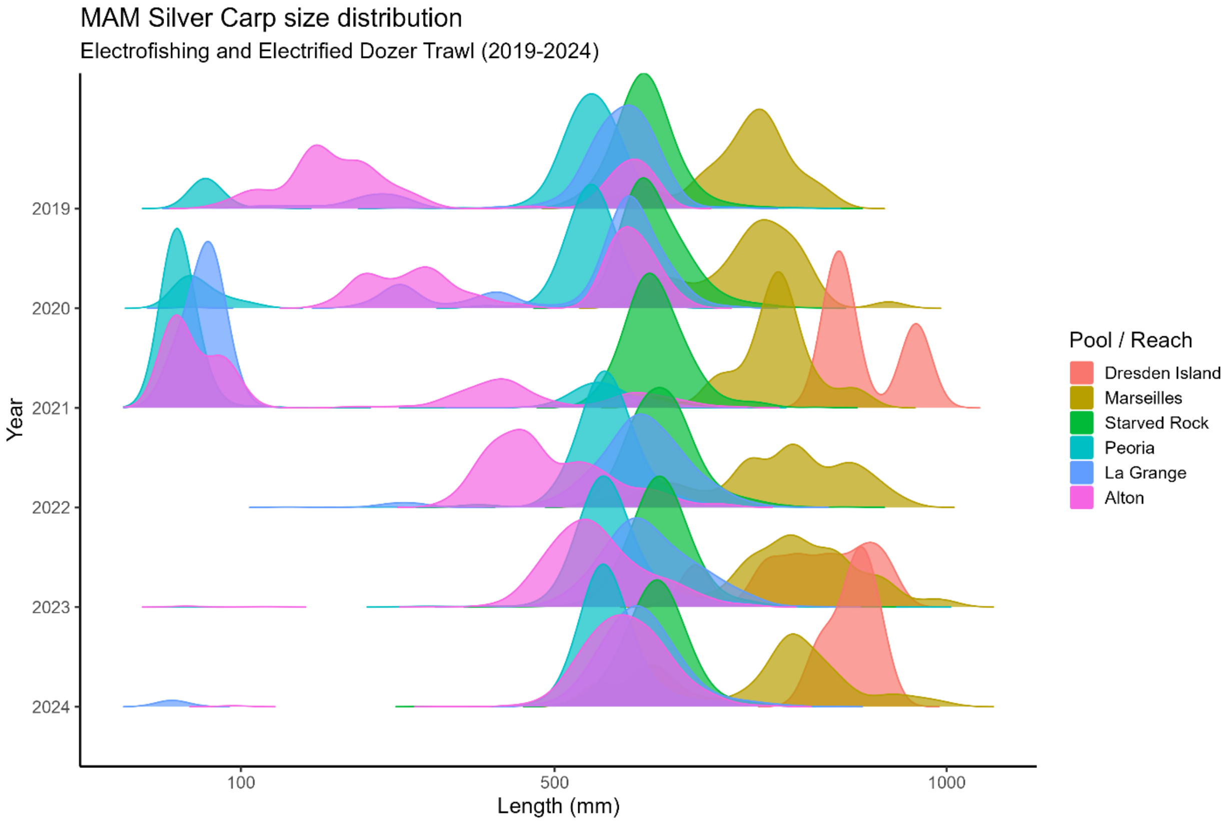


Figure 6. *Kernel density of total length among Silver Carp individuals captured from 2019-2024 from both active gears, electrofishing and dozer trawl.*



Adaptive Monitoring

Monitoring the leading edge of the invasion is critical for assessing the spread of the population and potential pressure on the EDBS. Low relative abundances in the Dresden Island Pool likely approach the detection sensitivity thresholds of our monitoring gears, making precise estimates of relative abundance difficult to calculate. The MAM programs' strength lies in its stratified-random sampling design that enables robust estimators of relative abundance, useful for spatial and temporal comparison at the pool-wide scale, and changes to that sampling design compromise long-term trend monitoring. However, carefully adapting the program to allocate some targeted sampling effort at the invasion front could help boost detection frequencies and thereby increase precision around estimates of relative abundance locally. This added precision may be critical for obtaining the statistical power to detect relatively small population changes, which have outsized importance at the leading edge of the invasion. While targeted sampling adds little value to the program's pool-wide metrics, it may add utility for characterizing areas of highest priority. Strategically allocating some sampling effort while retaining the broader stratified-random sampling framework – an act of 'Adaptive Monitoring' – can help us achieve dual goals: maintaining the program's ability to monitor long-term, pool-wide trends in invasive carp populations while flexibly answering the most pressing, management-relevant questions at smaller spatial and temporal scales.

To guide this targeted sampling, we integrated historical sampling data from MAM and other sources of sampling near the invasion front. These historical detection data, along with anecdotal evidence from field crews, informed the creation of a targeted sampling grid where invasive carp detections may be most likely (Figure 7). This 'Carp Likely' stratum of the river will receive continued monitoring, offering an adaptation of the MAM program to maintain its core sampling design (and importantly, backwards compatibility with data already collected) while attempting to boost precision in areas where small changes have outsized management implications. In 2024, we randomly selected 63 sites for electrofishing within this 'Carp Likely' grid near the confluence of the Dresden Island Pool and the Kankakee River (Figure 8). No invasive carp were captured in these 63 'Carp Likely' samples, though carp were observed in the water visually at 2 out of 63 sites, indicating that imperfect catchability may be hindering detection rates. Targeted effort is planned to continue within this supplemental sampling grid in 2025, possibly with more liberal electrofishing power parameters to improve catchability at the potential cost of standardized comparison to data from outside the 'Carp Likely' grid.

Figure 7. *The Dresden Island Pool and Kankakee River confluence area where adaptive monitoring took place in 2024 to try and improve precision around Silver Carp relative abundance estimates at the upstream leading edge of the invasion. Circles indicate historical Silver Carp detection data from partner agencies (red = detection, white = non-detection). White squares indicate the newly established grid of possible sampling sites.*

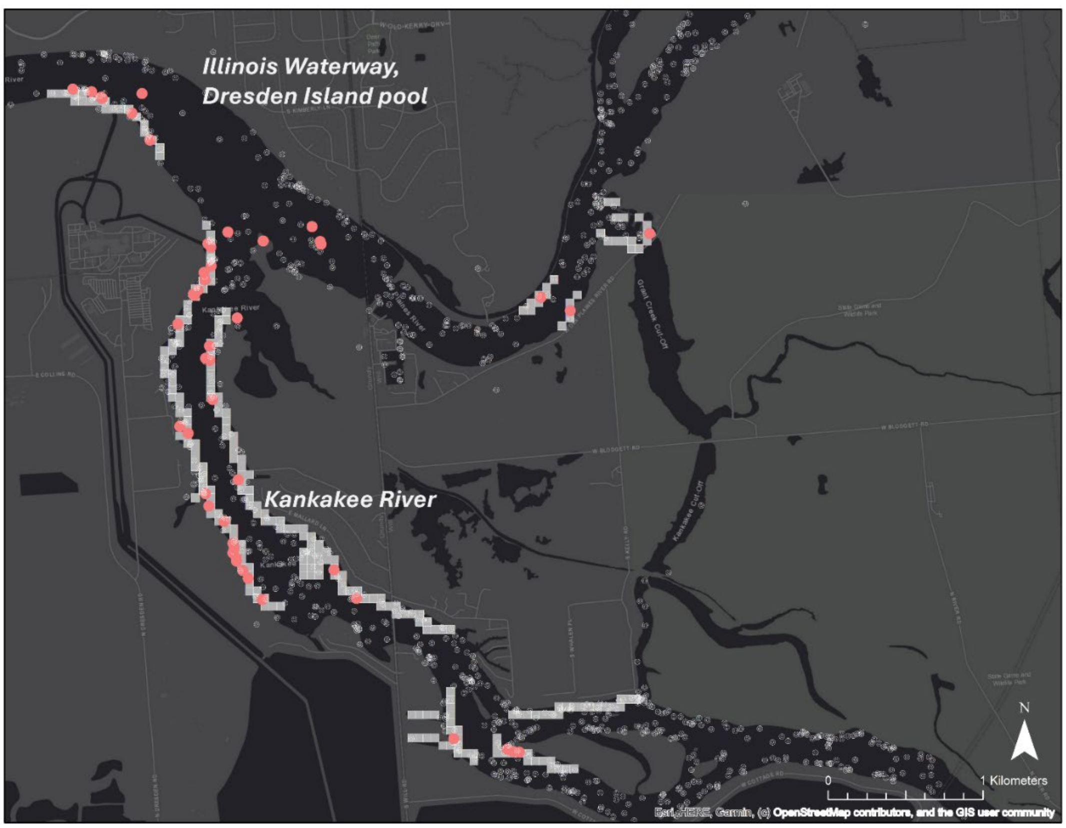
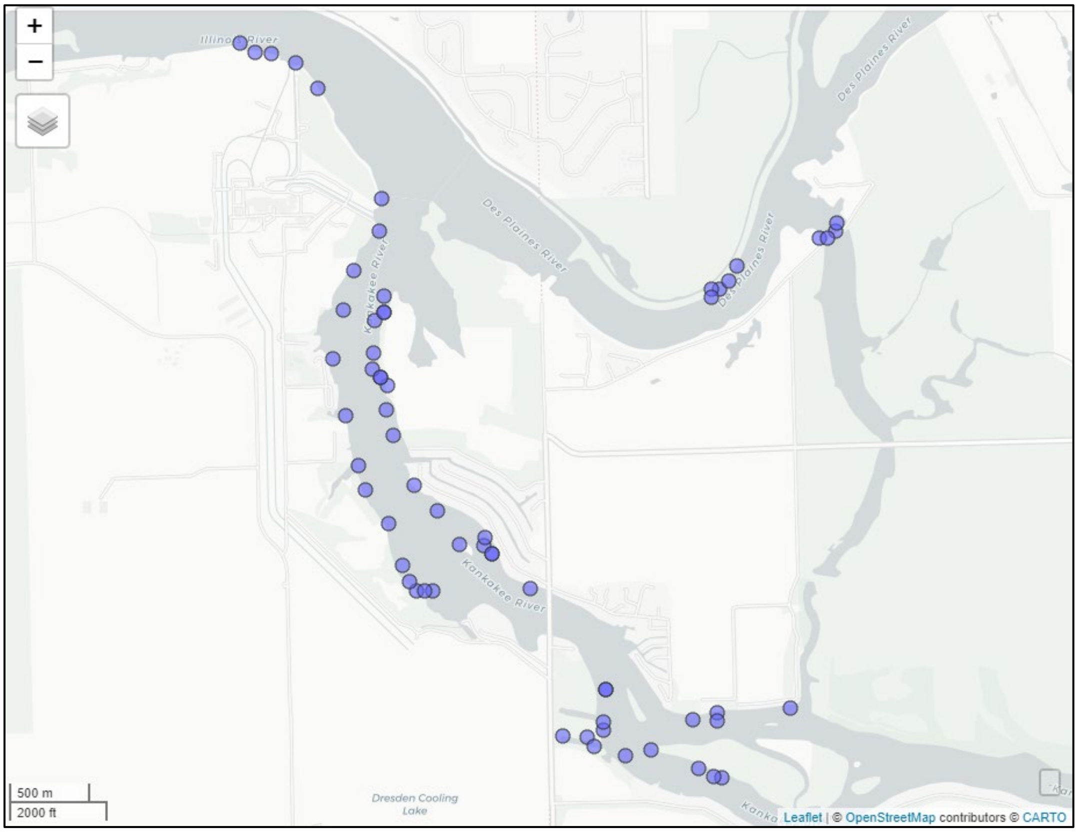


Figure 8. *Electrofishing site locations sampled as part of the 'Carp Likely' supplemental sampling grid at the Dresden Island Pool and Kankakee River confluence area. Zero invasive carp were captured across these 63 samples.*



RECOMMENDATIONS

Implementing a standardized multi-gear sampling approach has created a comparable and comprehensive picture of invasive carp dynamics throughout the entire Illinois River Waterway, allowing for a holistic assessment. Standardization continues to allow monitoring projects outside of the MRP to be incorporated (e.g., dozer trawl from USFWS this year), amplifying the robustness of the picture of invasive carp status and detections in the Illinois River Waterway. The leading edge of invasive carp within the Illinois River Waterway does not appear to have encroached closer to the EDBS, with Bighead Carp and Silver Carp remaining in Dresden Island Pool. Despite no invasive carp detections in 2024, a pilot study that combines targeted and random sampling approaches will continue in 2025 to gain further precision on mean CPUE estimates of invasive carp in Dresden Island Pool, at the leading edge of the invasion, to allow greater statistical power in detecting relatively small interannual changes to CPUE. No Black Carp were detected during the monitoring. The numbers and catch rates of small invasive carp (less than 6 inches) were greater than what was found in 2023, but far less than what was found in 2021, the last recorded large spawning event, indicating that 2024 may have been a poor reproductive year, with no major spawning event. The invasive carp caught smaller than 6 inches (n = 372) were caught in the lower three pools, with the vast majority (n = 370) caught in the lowest two pools. We recommend continued sampling below the EDBS using a multi-gear approach that includes electrofishing, fyke netting, hoop netting, mini fyke netting, and dozer trawling. Minimally, the same level of effort should occur, and future effort levels should follow statistical power analyses when reasonable. Finally, data collected from projects outside using the same standardized methods of the MRP should continue to be incorporated into this dataset when allowed and appropriate. The inclusion of these data allows for formulating the most comprehensive picture of invasive carp expansion and response within the Illinois River Waterway.

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HYDROACOUSTICS WORK GROUP PROJECTS

- Invasive Carp Stock Assessment in the Illinois River
- Illinois Waterway Hydroacoustics

INVASIVE CARP STOCK ASSESSMENT IN THE ILLINOIS RIVER

Participating Agencies: SIU (lead); additional assistance from/collaboration with ILDNR, USACE, USGS, INHS, USFWS; David Coulter, Cameron Davis, Jim Garvey, Tanya Fendler, Joe Mruzek (SIU)

MRWG Work Group: Hydroacoustics

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, Alton

INTRODUCTION AND NEED

Management goals for bigheaded carp in the Illinois River focus on limiting upstream dispersal through monitoring, assessing movement barriers, and reducing abundance through contracted harvest. Bigheaded carp spatial distributions vary seasonally and annually; quantifying how spatial distributions change through time will help target contracted harvest to maximize removal efforts and minimize costs. Additionally, long-term information on bigheaded carp population characteristics, distributions, and movements, especially along the population front in the upper Illinois River, can provide data to parameterize population models. These models simulate the effects of various management actions (e.g., harvest scenarios and locations of enhanced deterrent technologies) to determine which options are most likely to achieve management goals.

Since 2012, SIU has been monitoring bigheaded carp densities via hydroacoustic sampling throughout the Illinois River (Alton to Dresden Island pools). This monitoring continues to be a useful metric to evaluate long-term changes in bigheaded carp abundance. By monitoring densities across multiple years throughout the river, long-term trends can be identified and related to environmental conditions, reproduction, or management actions. Broad-scale density estimates also help inform management actions in the upper river near the invasion front. It is currently unclear what is the extent to which bigheaded carp in the Illinois River exhibit density-dependent effects on reproduction, condition, growth, and movement. Collecting long-term data, particularly density and movement data, will also help quantify these patterns that will better inform management decisions, ensure sufficient surveillance efforts, and improve models predicting population response to management actions.

While annual monitoring provides a snapshot to document long-term trends in bigheaded carp abundance, seasonal surveys can be used to help improve removal by identifying and directing harvest efforts to high-density locations. Dresden Island Pool represents the current population front for the adult bigheaded carp invasion in the Illinois River, while Marseilles Pool is the most upstream pool where YOY have been found. Frequent hydroacoustic surveys of bigheaded carp densities in these pools identify locations where bigheaded carp aggregate to inform harvest efforts.

The SEICarP model of bigheaded carp in the Illinois River assesses how bigheaded carp populations respond to various management actions (e.g., location and intensity of harvest; location and effectiveness of deterrent technologies). This model draws on a variety of data, including bigheaded carp densities and movement data. Collaborations between MRWG Modeling and Telemetry Work Groups have identified data needs, primarily with a better understanding of inter-pool movements. To this end, model support consisted of maintaining the Illinois River stationary telemetry array to quantify inter-pool movements and deployment of additional acoustic telemetry tags in bigheaded carp (numbers set based on Telemetry Work Group determinations). Movement information from telemetry efforts is also critical for maintaining sufficient surveillance efforts to detect potential changes in bigheaded carp spatial distributions (e.g., upstream movements), especially in supporting surveillance efforts with real-time acoustic telemetry receivers.

OBJECTIVES

- Quantify invasive carp densities every other month in Dresden Island and Marseilles pools using mobile hydroacoustic surveys to pinpoint high-density areas that can be targeted during contracted removal.
- Conduct hydroacoustic surveys at standardized sites from Alton to Dresden Island pools during the fall to assess long-term density trends.
- Maintain SIU's extensive acoustic telemetry array currently in place in the entire Illinois River used to collect movement information and maintain adult surveillance efforts. Share collected data with Telemetry and Modeling Work Groups.

PROJECT HIGHLIGHTS

- Repeated hydroacoustic surveys in Dresden Island and Marseilles pools identified as areas of high bigheaded carp density and showed how these locations changed over time. These data helped direct contracted removal efforts.
- The 13th year of standardized monitoring of bigheaded carp densities was completed in 2024 from Alton to Dresden Island pools. These data allow for long-term assessments and comparisons of density trends across space and through time.
- Maintaining the stationary acoustic telemetry receiver array throughout the Illinois River ensured sufficient surveillance efforts occurred to detect adult movements among pools and toward the invasion front.

METHODS

Hydroacoustic Surveys – Bi-monthly Heat Maps and Fall Standardized Surveys

Repeated hydroacoustic surveys in the upper Illinois River (Dresden Island and Marseilles pools) were completed in April 2024. Final surveys in these pools and throughout other Illinois River pools (Starved Rock through Alton pools) were completed in the fall of 2024. These full river scans are conducted at 49 predetermined transects, covering a variety of river microhabitats. All hydroacoustic sampling methods, designs, and analyses followed those outlined in MacNamara et al. (2016). Surveys were completed before the fall Unified Method event in Dresden Island Pool to inform removal about density hotspots prior to harvest and to assess the impacts of removal on the population.

Telemetry – Adult Movements

Utilizing an array of 51 Vemco 69-kilohertz stationary receivers maintained by SIU (Abeln 2018) as well as stationary receivers maintained by partner agencies (USGS, USACE, USFWS, and MDC), the movements of Silver Carp and Bighead Carp implanted with internal transmitters (Vemco V16 transmitters) were monitored from Alton Pool upstream through Dresden Island Pool. Additional stationary receivers were deployed and maintained by other agencies in the Telemetry Work Group in other locations of the IWW. Additionally, other fish species implanted with 69-kilohertz transmitters by other members of the Telemetry Work Group can be detected by this array. Stationary receivers were downloaded in May and November of 2024, with data initially checked to remove false detections, and uploaded to the USGS FishTracks database. Once receivers are downloaded in early 2025, the full 2024 fish detection data will be analyzed to identify upstream and downstream passages through lock and dam structures (e.g., Lubejko et al. 2017*)*. Additional acoustic telemetry tags were deployed n = 254) to replace expiring tags.

RESULTS AND DISCUSSION

Hydroacoustic Surveys – Bi-monthly Heat Maps and Fall Standardized Surveys

Repeated mobile hydroacoustic surveys in Dresden Island and Marseilles pools identified colocations where bigheaded carp aggregated and determined how these locations changed throughout the year. Density maps (Figure 1) were provided to MRWG members, which helped focus contracted harvest efforts. This sampling was conducted every other month, from May until November. Data through Fall 2023 have been processed in the upper (Figure 2) and lower (Figure 3) Illinois River. These data show variation in the density of ensonified carp targets across river macrohabitat, with the greatest density in main and side channels (Figure 4). Mobile hydroacoustic sampling was completed in October 2024 from Alton through Dresden Island pools to inform long-term population monitoring (Figure 5). Processing of these 2024 fall density data is ongoing.

Telemetry – Adult Movements

In 2024, 254 tags were implanted into bigheaded carp in Alton and La Grange (Figure 3). These additional tags will maintain sufficient adult surveillance efforts (e.g., early detection of movements past real-time receivers). SIU stationary receivers were retrieved and downloaded from Dresden Island Pool through Alton Pool. All detection data downloaded from stationary receivers were screened to remove false fish detections and submitted for inclusion in the USGS-managed FishTracks telemetry database. Dam passages were most common in the lower river pools (Table 1).

Figure 1 *Example heatmap displaying bigheaded carp spatial distributions in the lower portion of Dresden Island Pool sampled in October 2024 with mobile hydroacoustic sampling. Densities were observed using mobile hydroacoustic surveys.*

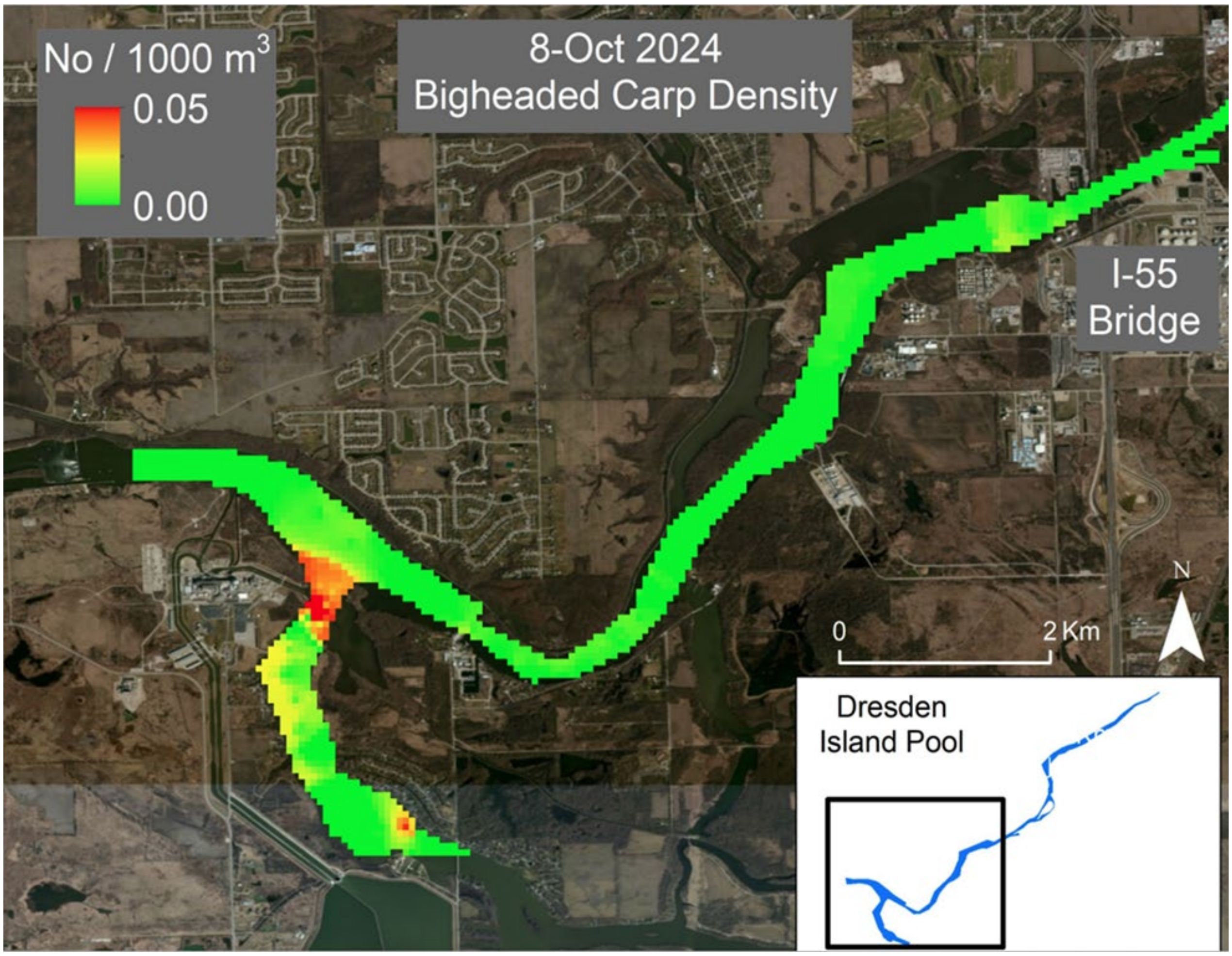


Figure 2. *Densities of bigheaded carp in the upper Illinois River during falls 2012 through 2023 as estimated from standardized hydroacoustic surveys in each pool.*

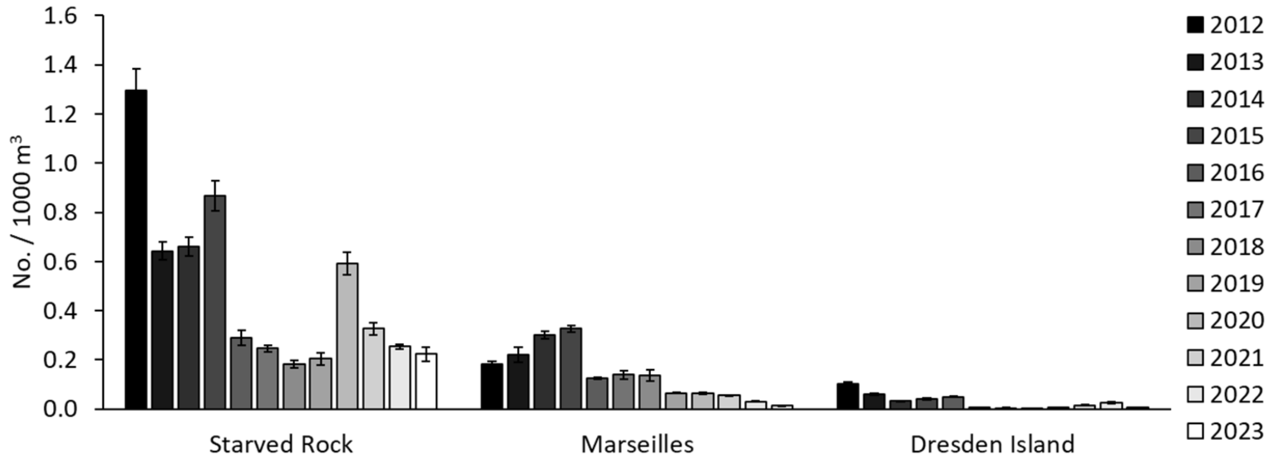


Figure 3. *Densities of bigheaded carp in the lower Illinois River during falls 2012 through 2023 as estimated from standardized hydroacoustic surveys in each pool.*

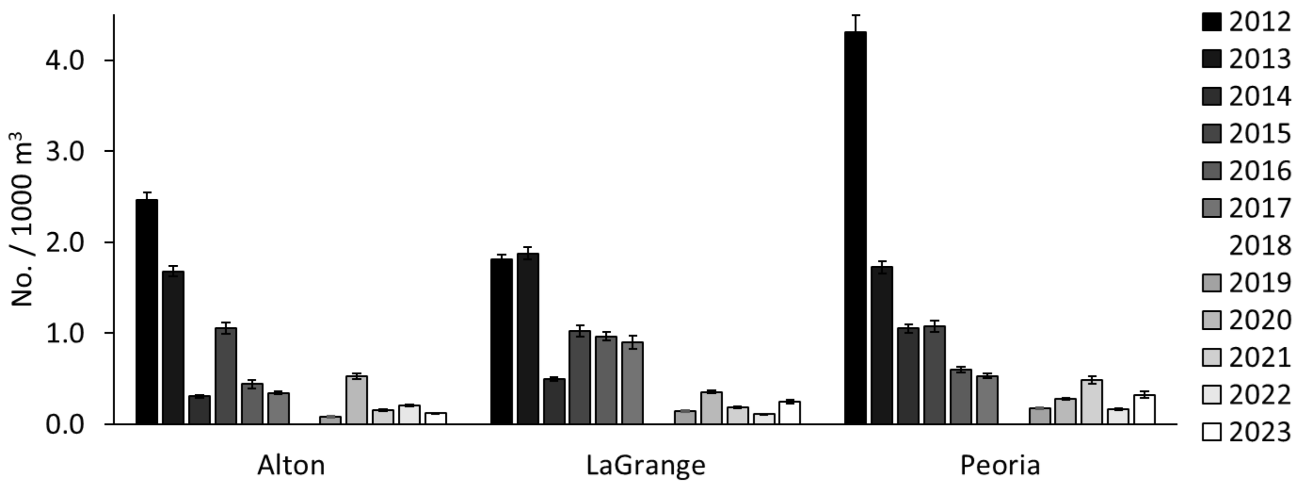


Table 1. *Table summarizing unique bigheaded carp upstream and downstream dam passages in 2023 (a) and 2024 (b). Tag data from SIU, USACE, MDC, Purdue, KDFWR, USGS-UMESC, USFWS Wilmington, and USFWS LaCross were used in these summaries.*

2023 (a)	Upstream	Downstream	2024 (b)	Upstream	Downstream
La Grange	50	78	La Grange	2	53
Peoria	17	32	Peoria	29	11
Starved Rock	7	8	Starved Rock	54	58
Marseilles	0	1	Marseilles	0	0
Dresden	0	0	Dresden	0	0

Figure 4. *Density of carp targets across surveyed river macrohabitat in 2024.*

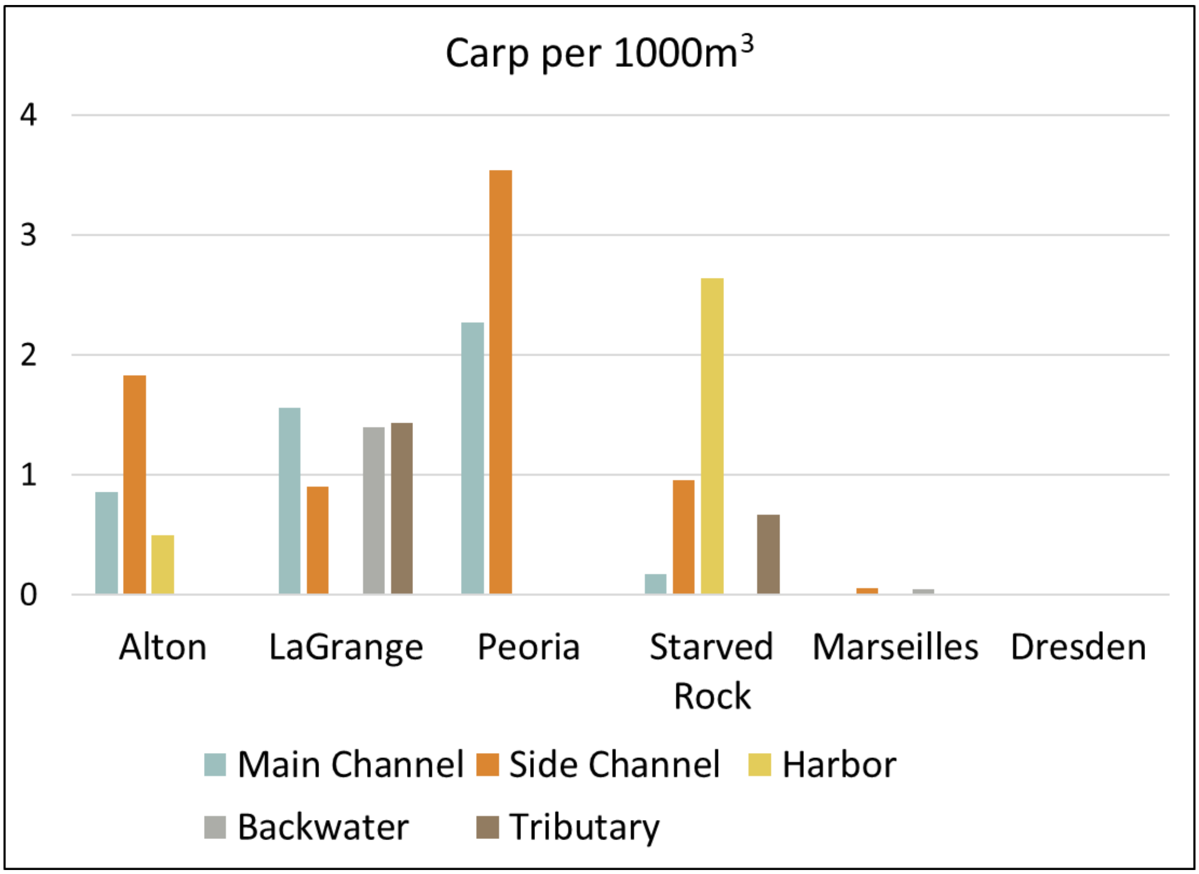
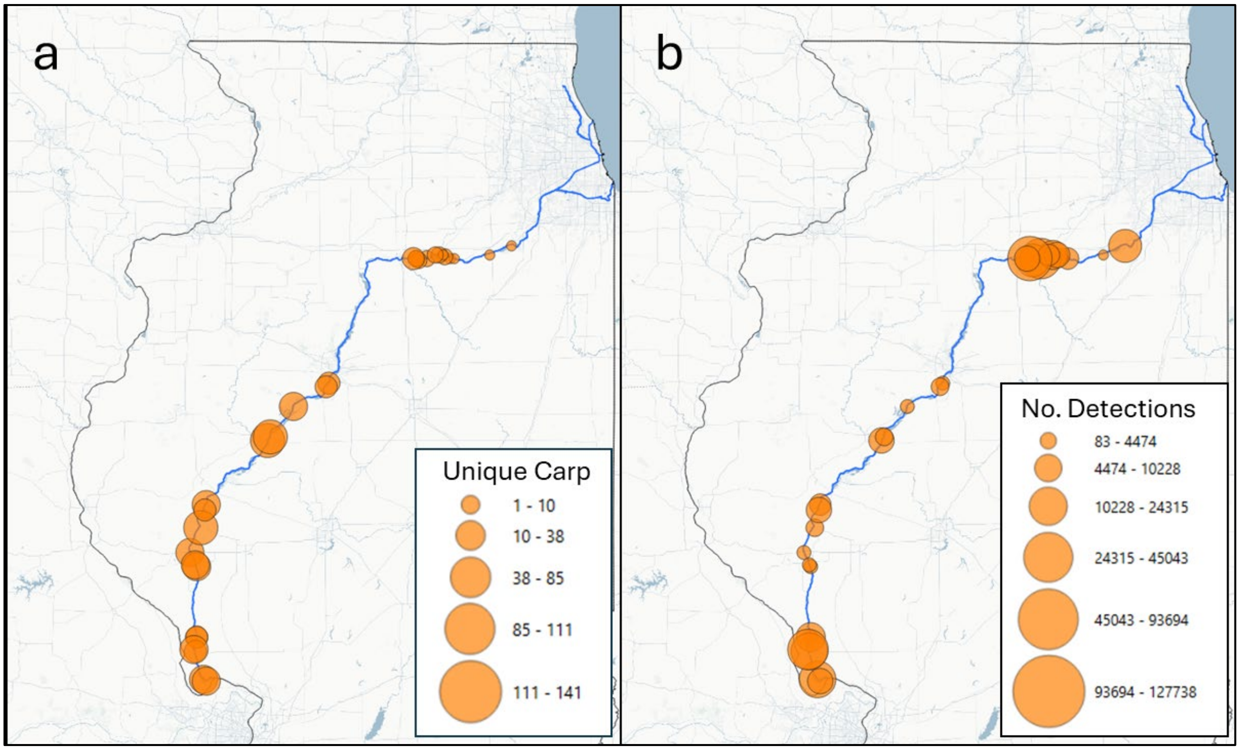


Figure 5. *Map of SIU's passive receiver array (orange dots) in the Illinois River. Dot size is scaled by the number of unique individuals tagged carp (a) and by the total number of detections (b) recorded in 2024.*



RECOMMENDATIONS

Hydroacoustic surveys are needed to inform (via spatial distribution maps) contracted removal and Unified Method events in the upper Illinois River pools, as the resulting data can increase harvest efficiency. Bigheaded carp spatial distributions change over time and are not consistent across years, necessitating repeated surveys in Dresden Island and Marseilles pools to direct harvest efforts to appropriate locations. Standardized fall hydroacoustic surveys from Alton through Dresden Island pools are also needed to monitor long-term population trends that act as an additional surveillance tool and can assist in making management decisions.

Continued collection of telemetry movement data will serve to maintain sufficient adult surveillance efforts for detecting movement among pools, including possible movement toward the invasion front. Movement data will also be needed to improve and update movement models used in the SEICarp model. It will also be important to continue to assess annual variation in dam passages and how passage rates vary as densities of bigheaded carp change throughout the Illinois River (e.g., due to removal efforts and reproduction in lower river pools).

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ILLINOIS WATERWAY HYDROACOUSTICS

Participating Agencies: USFWS Carterville FWCO (lead) and USACE Chicago District (field and logistical support)

MRWG Work Group: Hydroacoustics

Pools Involved: Dresden Island, Brandon Road, Lockport

INTRODUCTION AND NEED

The EDBS, located within the CSSC, operates to prevent the inter-basin transfer of fish between the Mississippi and Great Lakes basins (USACE 2010; USACE Chicago District *n.d.*). Observational evidence from previous studies suggests fish may be able to bypass the electric barrier by swimming alongside metal-hull barges or by being involuntarily dragged by barges (Parker *et al.* 2015). Having a greater understanding of the spatial and temporal patterns of fish abundance within and below the EDBS is important to barrier management, as it allows operational and maintenance decisions to be made in sync with an understanding of potential risk. To determine these periods of elevated risk, split-beam hydroacoustic surveys were performed within and below the EDBS monthly throughout 2024. Split-beam hydroacoustic surveys of the Lockport, Brandon Road, and Dresden Island navigation pools of the Upper IWW were also conducted to evaluate the potential for the upstream spread of invasive carp and increased pressure on the EDBS from the pools immediately downriver.

Understanding fish assemblage dynamics throughout the Upper IWW allows the findings from a range of other research activities at the EDBS to be put into a system-wide context, enabling more refined interpretations of results and allowing managers to make informed decisions.

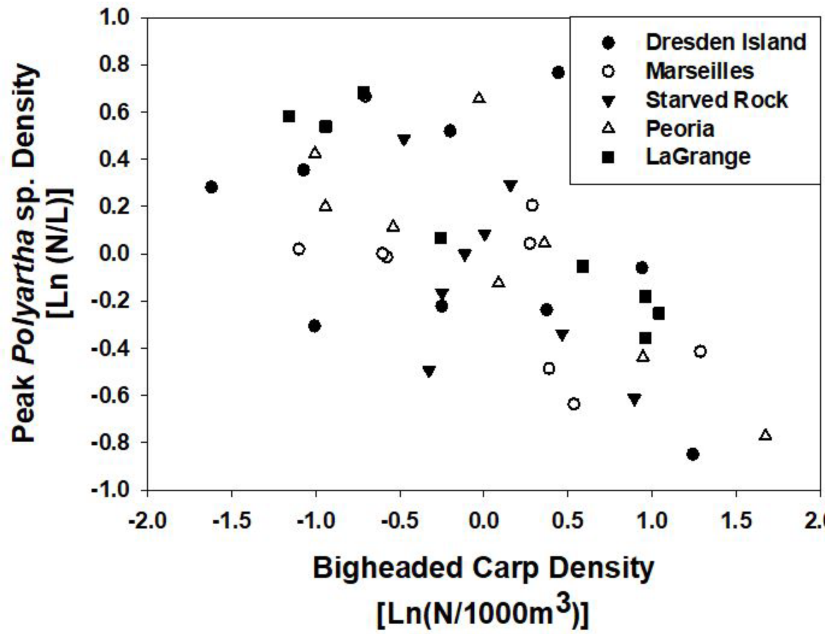
OBJECTIVES

- Evaluate the abundance of fish within and directly below the EDBS monthly throughout the year to inform contingency response and barrier management.
- Determine the density of fish in the three upper navigation pools within the Upper IWW.
- Identify changes in large fish abundance and distribution that could indicate the potential risk of further upstream spread of invasive carp.

PROJECT HIGHLIGHTS

- Mobile hydroacoustic surveys at the EDBS now report the average targets detected from the three-run survey.
- Surveys at the EDBS completed in May 2024 detected the highest abundances of large targets within the EDBS compared to historical data (average of 9.33 targets on May 13).
- Large target abundances directly downstream of the EDBS across surveys were higher compared to previous years. The highest abundance occurred on August 1 with an average of 23.33 large targets detected.

Figure 1. *Partial residuals plot of peak Polyartha sp. density in relation to annual bigheaded carp (Silver Carp + Bighead Carp) density in five navigation pools (Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange) of the IWW during 2012 to 2022. Partial residuals were calculated by accounting for principal components of environmental variables measured in the month prior to dates of peak Polyartha sp. density.*



METHODS

Acoustic Fish Surveys at the EDBS

Horizontal, split-beam hydroacoustic surveys were conducted monthly at the CSSC EDBS from January 4 - December 2, 2024, to provide regular monitoring of large target abundance and distribution patterns. Survey transects began approximately 1.2 kilometers below the EDBS at 41.629521 N, -88.061659 W. The survey vessel followed a path close to the east wall traveling north with the side-looking hydroacoustic transducers aimed toward the west wall. Each transect continued through the EDBS, paused briefly to allow bubbles and wake to disperse, turned south, and then traveled closely along the west wall back to the survey start point. Three consecutive replicate hydroacoustic samples took place on each survey date.

Survey equipment consisted of a pair of Biosonics® 200-kilohertz split-beam transducers mounted in parallel on the port side of the research vessel 0.4 meters below the water surface on a dual-axis mechanical rotator. Transducer sampling angles were set and monitored each survey to maintain values of approximately -3.3˚ and -9.9˚ below the water surface to maximize coverage, minimize beam overlap, and allow targets oriented with the flow to be pinged near side-aspect. Split-beam acoustic data was collected using Visual Acquisition v.6.4® at a range of 0 to 50 meters from the transducer face, with a ping rate of 5 pings per second and a 0.4-millisecond pulse duration. Data collected less than 1 meter from the transducer face were removed during post-processing to avoid near-field interference. The water temperature was measured and input into Visual Acquisition v.6.4® prior to all data collection. A tungsten carbide calibration sphere was used for on-axis calibration of the split-beam acoustic transducers following methods from Demer *et al.* (2015).

Split-beam hydroacoustic data were post-processed in Echoview® v. 14.0. Data was loaded into a mobile survey template to identify and estimate the size and location of single fish targets based on target strength and angular position. Data post-processing followed standard methods outlined in Bouska *et al.* (2023). The analysis template followed the general methods reported in MacNamara *et al.* (2016), and single targets were detected using parameter values from Parker-Stetter *et al.* (2009). Data that was collected outside of the analysis bounds (analysis bounds: between 41.629521 N and the Demonstration Barrier's upper parasitic structure) was removed from further analysis, a bottom line was digitized and checked by hand, areas of bad data caused by air bubbles and other sources of acoustic noise were removed, single targets were identified using a threshold of > -70 decibels for target acceptance, and fish tracks were identified using the "single target detection – split-beam (method 2)" algorithm within the Echoview Fish Tracking Module®. Large targets were classified as those with a total strength greater than or equal to -28.7 decibels (≥12 inches [30.5 centimeters] total length based on the mean temperature-compensated side-aspect total strength of a fish) (Bouska *et al.*2023). Each individual large target was also spatially located within the water column using the split-beam transducer's capabilities, assigned X, Y, and Z positional coordinates, and classified as "within EDBS" or "below EDBS" based on location.

IWW Pool Surveys

To quantify the density and spatial distribution of the fish community in the Upper IWW, hydroacoustic surveys were conducted in Dresden Island, Brandon Road, and Lockport navigation pools in September 2024. The surveys were conducted using the same equipment, collection techniques, and analysis methods as were employed during the hydroacoustic surveys at the EDBS. Within each navigation pool, upstream and downstream transects were sampled near the channel margin, with transducers facing outwards toward the middle of the channel. An additional pool scan was conducted in Dresden Island on March 20, 2024, to inform local harvesters of the density and spatial distribution of large targets, and potentially invasive carp, for removal efforts.

RESULTS AND DISCUSSION

Fish Surveys Within and Below the EDBS

Results from the hydroacoustic surveys conducted within the EDBS indicated the regular presence of multiple large targets greater than 12 inches within the EDBS from January to December 2024e (mean = 2.21 large targets detected per survey; the range was 0 to 9.33 large targets across 2024; Figure 1 [A]). Survey on May 13, 2024 (3.99 targets) observed the highest average of large targets in the EDBS since project inception. Likewise, 2024 had the highest number of large targets detected immediately downstream of the EDBS (mean= 9.79 large targets detected per survey; range= 0.67 to 23.33 large targets across 2024; Figure 1 [B]). The cause of these elevated abundances is unknown. While the number of large targets is higher compared to previous years, patterns of large targets detected within and below the EDBS were similar (Figure 1).

IWW Pool Surveys

Results from hydroacoustic surveys conducted in Dresden Island, Brandon Road, and Lockport Pools in 2024 illustrated higher large target abundance compared to previous years. Both Dresden Island and Lockport pools had the highest density since project inception for their respective pools. Dresden Island had a density of 19.34 large targets/100,000m^3 and Lockport had a density of 7.93 large targets/100,000m^3 (Figure 2). Although Brandon Road had a high density (6.99 large targets/100,000m^3) compared to previous years it was less than the record high in 2023. The exact cause for the elevated abundances in 2024 is unknown, and overall, the density for all three pools has been gradually increasing over the years.

An additional hydroacoustic survey of Dresden Island was conducted on March 20, 2024. A heatmap of the location and density of large targets was produced and given to local harvestmen to assist in their invasive carp removal efforts (Figure 3). A total of 56 large targets were detected in 4,668,120m^3 of water. The large target density was 1.2 large targets/100,000m^3.

Figure 2. Average *number of large targets (greater than or equal to -28.7 decibels) observed within (A) and immediately downstream (B) of the EDBS during split-beam hydroacoustic surveys conducted from January through December 2024 compared with the average for past surveys from 2018 to 2023.*

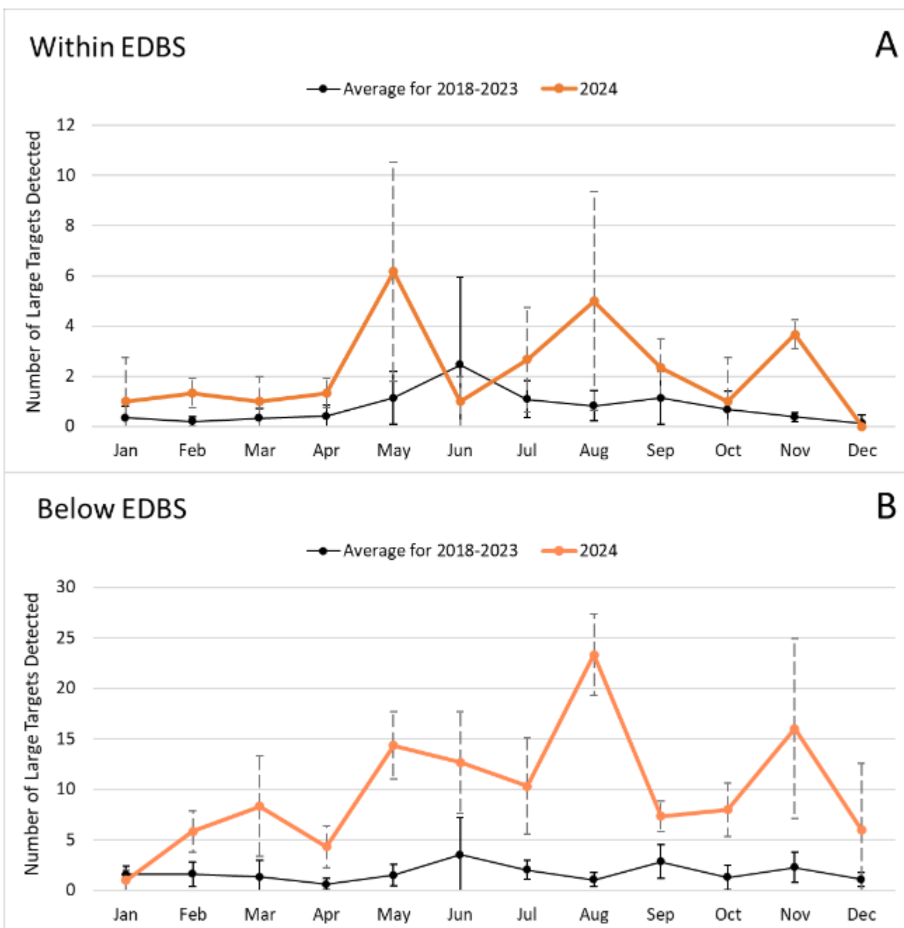


Figure 3. *Density of large targets (greater than or equal to -28.7 decibels) from split-beam hydroacoustic surveys conducted in Dresden Island (A), Brandon Road (B), and Lockport (C) Pools from 2018 to 2024. Large target density was calculated by dividing the number of observed large targets by the water volume sampled during the survey. Months lacking data indicate that a survey was not completed in that month during that year. If a survey was completed and zero large fish targets were detected, a "0" is reported corresponding to the year the survey was conducted.*

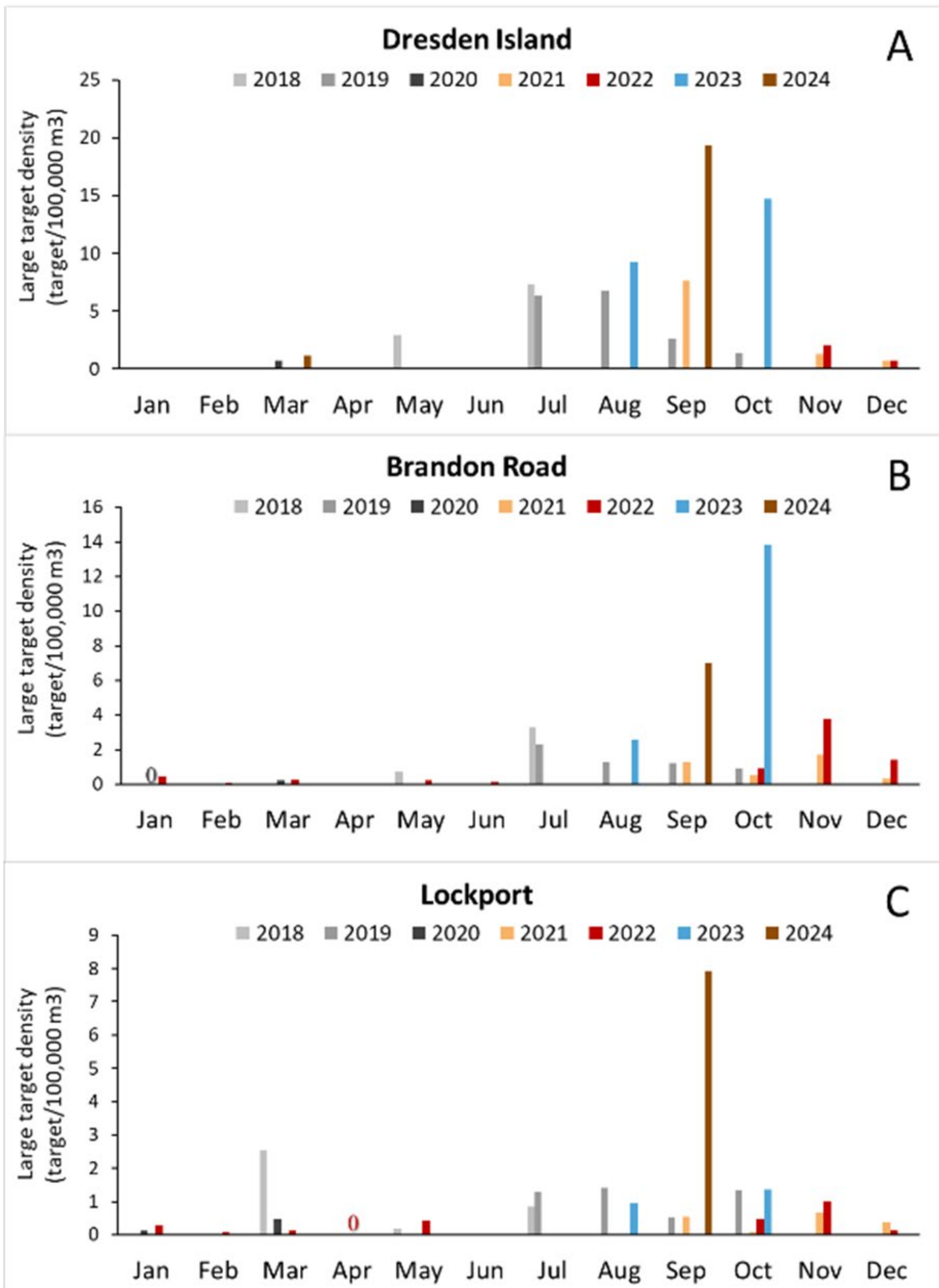
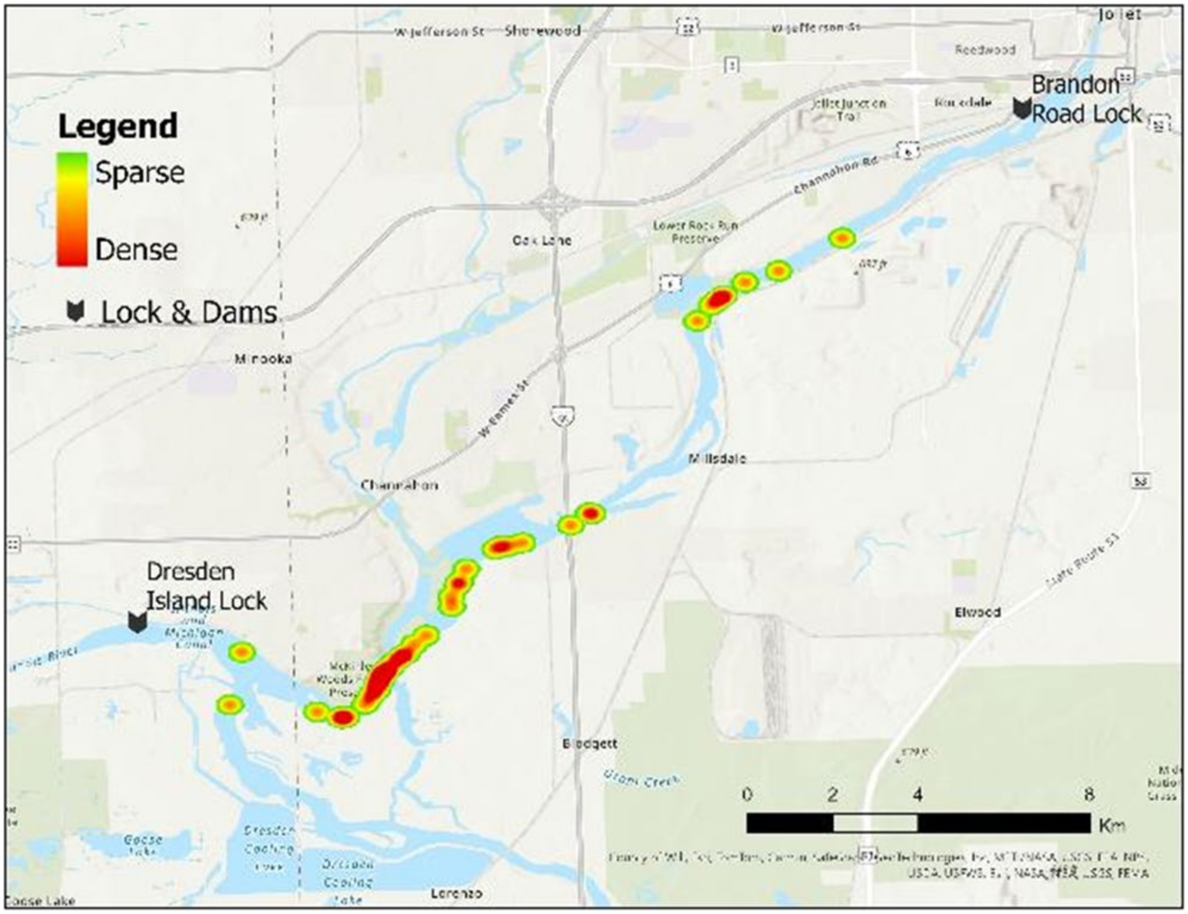


Figure 4. *Heatmap of large targets (greater than or equal to -28.7 decibels) from split-beam hydroacoustic surveys conducted in Dresden Island Pool on March 20, 2024.*



CONCLUSION

The IWW Hydroacoustics project accomplished its objectives in 2024 by providing insights into trends in abundance of large fish near and immediately downstream of the EDBS and at the invasive carp invasion front (Invasive Carp Problem 2022). While 2024 observations had the highest abundances of fish targets in the EDBS since project inception, the likelihood of these targets being invasive carp is perceived to be low. Immediately after seeing abnormal peaks of large fish targets at the EDBS, USACE was alerted, triggering response efforts. It was determined that the targets were likely schools of gizzard shad moving upstream. Additionally, no invasive carp were observed in any partner effort above Brandon Road L&D. These findings suggest that sufficient measures are currently being implemented to prevent the upstream movement of invasive carp.

RECOMMENDATIONS

- Continue to conduct mobile hydroacoustic surveys at the EDBS on a monthly basis in 2025. Further discussions will be held in 2025 to determine if any changes need to be made for these surveys.

- Continue to coordinate with local fisherman to conduct a hydroacoustic scan to assist in invasive carp removal efforts.
- Conduct a single hydroacoustic pool scan in the fall of 2025 in Dresden Island, Brandon Road, and Lockport pools in coordination with SIU hydroacoustic efforts.

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TELEMETRY WORK GROUP PROJECTS

- USGS Telemetry Project
- SIU Longitudinal Receiver Array and Tagging
- USACE Telemetry Monitoring Plan
- Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)

USGS TELEMETRY PROJECT

Participating Agencies: USGS (lead), SIU, USACE, ILDNR, USFWS, INHS; Marybeth Brey, Jessica Stanton, Doug Appel, and Andrea Fritts (USGS, Upper Midwest Environmental Sciences Center); Ryan Jackson (USGS, Central Midwest Water Science Center)

MRWG Work Group: Telemetry

Pools Involved: Alton, La Grange, Peoria, Starved Rock, Marseilles, Dresden Island, Lockport, CWS, Des Plaines River

INTRODUCTION AND NEED

Tagging and tracking bigheaded carp (i.e., Bighead Carp and Silver Carp) and surrogate fish species with acoustic transmitters has become an invaluable management tool in the Upper IWW (i.e., upper Illinois River, lower Des Plaines River, and the CAWS). For example, movement probabilities between adjacent navigation pools need to be estimated to parameterize population models being developed to answer specific management questions, such as the SEICarP model—a population model used in scenario planning by the MRWG to evaluate alternative management actions (Kallis et al. 2023) or the Metapopulation Integral Projection Model (MetaIPM) extension of SEICarP model (Erickson et al. 2023). Movement probabilities are estimated from the telemetry data obtained from a longitudinal network of strategically placed receivers that detect bigheaded carp that have been implanted with acoustic transmitters (i.e., tagged). In addition, fish removal by contracted fishers has become the primary method of controlling bigheaded carp in the upper Illinois and lower Des Plaines rivers. Variable patterns in bigheaded carp distribution, habitat, and movement, influenced by seasonal and environmental conditions, make targeting bigheaded carp for removal and containment challenging and costly. Understanding these movement patterns for bigheaded carp through modeling and real-time telemetry applications informs removal efforts and facilitates monitoring and contingency actions based on fish movements.

To develop a better understanding of fish movement dynamics to meet management objectives, an existing network of real-time and data-logging acoustic receivers in the Upper IWW is collaboratively managed by a multi-agency team (see Participating Agencies section above; Figure 1). The Telemetry Work Group was established by the MRWG to ensure the multi-agency telemetry efforts are coordinated to efficiently and effectively meet the MRWG goals. This work group plans and executes the placement of receivers, tagging of bigheaded carp with acoustic transmitters, and management of the telemetry data. After the establishment of a standardized telemetry database (the RAFT Network, moved to the USGS Database project in 2020), two primary objectives of the Telemetry Work Group to meet the MRWG goals remained. These include (1) providing movement probabilities and telemetry data for population modeling efforts (e.g., population or stock assessment modeling) and (2) deploying, maintaining, and serving data from real-time acoustic receivers to inform contingency planning and fish removal. The specific objectives of the group are assessed annually, and each partner agency has their own tasks. The 2024 USGS-specific objectives are outlined here.

OBJECTIVES

Telemetry in Support of Population Modeling

- Coordinate collection of multi-agency telemetry data to prepare for updating the movement probabilities for the Illinois River in 2026. Summarize multi-agency data as requested or appropriate for movement or population modeling.
- Conduct a feasibility study to estimate fishing mortality from existing telemetry and mark-recapture data from the Illinois River. USGS and SIU will develop a study plan to use existing telemetry data with and without mark-recapture data from the Starved Rock and Marseilles pools of the Illinois River to refine fishing mortality and population estimates of invasive carp in the upper Illinois River.
- Estimate immigration and emigration rates: Use telemetry data from the multi-agency telemetry work group to assess the timing and duration of Silver Carp immigration into and emigration out of the Illinois River (at Alton).
- Explore the inclusion of additional parameters and predictor variables in a comprehensive invasive carp movement model. USGS, in coordination with the modeling work group, will explore the ability to use existing or collect supplemental telemetry data to parameterize population models that could incorporate fish density, variable environmental parameters (e.g., river flow conditions), or individual-level parameters (e.g., fish length and weight).

Real-time Telemetry in Support of Barrier Evaluations and Contingency Planning

- Maintain real-time receiver network: Deploy, maintain, and serve data from real-time acoustic receivers to inform decisions on contingency actions and the USACE barrier evaluation.

PROJECT HIGHLIGHTS

- *Movement Probability Model:* A manuscript of Bayesian multi-state model was published in 2024 (Stanton et al. 2024). Updated multi-state movement probabilities can be estimated, as determined by the needs of the modeling work group. Future estimates will focus on estimating movement between the lower river (Alton, La Grange, and Peoria pools) and upper river (Starved Rock, Marseilles, and Dresden Island) to inform the statistical catch-at-age model being developed by the USFWS.
- *Immigration and Emigration of Silver Carp:* In 2024, 90 Silver Carp tagged outside the Illinois River were detected in the Illinois River. Temporary immigrants (i.e., those leaving the Illinois River before the end of the year) made up 56.7% (n = 51) of the fish detected.
- *Real-time Receiver Network and Alert System*: Five real-time receivers were maintained in the upper IWW in 2024. A simplified alert system for bigheaded carp detections in areas of management interest was maintained in 2024. No bigheaded carp were detected on real-time receives upstream from Brandon Road L&D. Two Silver Carp were detected by the real time receiver below Brandon Road L&D (No. 4).

Figure 1. *Locations of 69 kHz acoustic telemetry receiver on the IWW (blue = SIU, orange = USFWS, purple = USGS, green = USACE, and yellow = USGS maintained real-time receivers).*

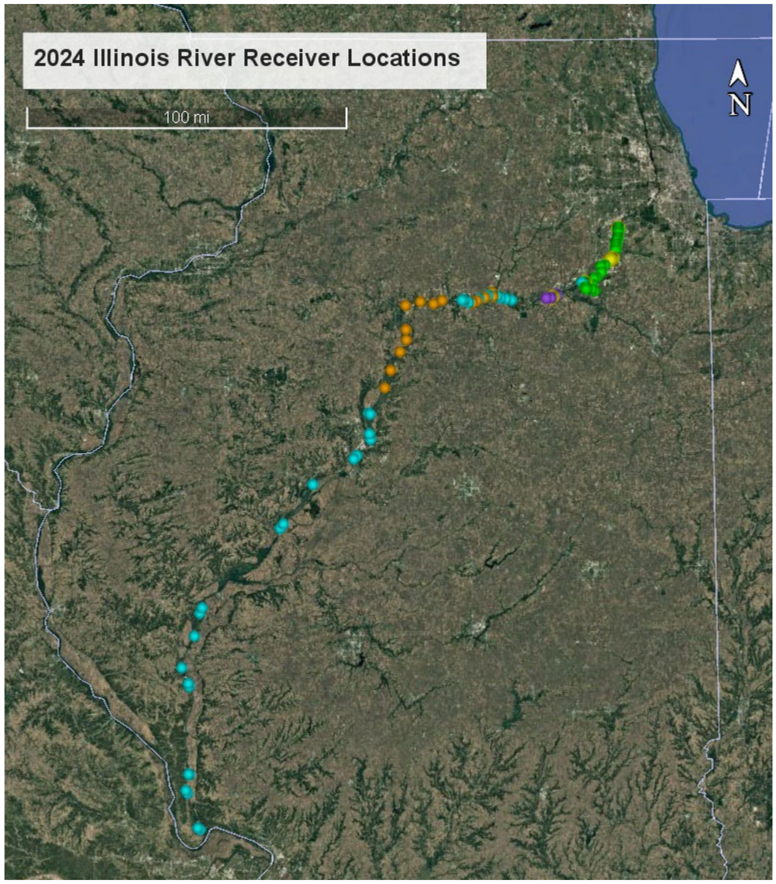

Table 1. *Locations of real-time receivers on the Upper IWW. Available at:* https://il.water.usgs.gov/data/Fish_Tracks_Real_Time

No.	Station	Location
1	Chicago Sanitary and Ship Canal above the EDBS	Lemont, IL
2	Chicago Sanitary and Ship Canal below the EDBS	Romeoville, IL
3	Des Plaines River above Brandon Road L&D	Rockdale, IL
4	Des Plaines River below Brandon Road L&D	Rockdale, IL
5	Illinois River above Dresden Island L&D	Minooka, IL

METHODS

Movement Probability Model. The USGS, in collaboration with personnel from the Telemetry Work Group and Modeling Work Group of the MRWG, developed a Bayesian multi-state movement model to estimate inter-pool movement probabilities that were necessary for SEICarP. The model can be modified, and re-run parameters can be estimated again as more data become available or other population modeling efforts are desired. Bayesian methods were used to create a model syntax that maximizes user customizability and extensibility.

Estimating fishing mortality and/or population size using mark-recapture and acoustic telemetry data. USGS and SIU will develop a study plan to use existing telemetry data with and without mark-recapture data from the Starved Rock and Marseilles pools of the Illinois River to refine fishing mortality and population estimates of invasive carp in the upper Illinois River.

Immigration and Emigration of Silver Carp. Acoustic telemetry data from receivers located in the Alton and La Grange pools of the Illinois River, at the confluence of the Illinois and Mississippi rivers and within pool 26 of the Mississippi River will be used to evaluate the movement of Silver Carp between the Illinois and Mississippi rivers. Data from Silver Carp tagged both within and outside of the Illinois River will be included in an extension of the Bayesian multi-state model (Stanton et al. 2024) to estimate immigration and emigration of these fish.

Real-time Receiver Network and Alert System. A network of five real-time receivers was redeployed and maintained in the Upper IWW by USGS crews in the spring and summer of 2024. Data access for these receivers was maintained online. Real-time alerts were provided to key personnel via email, as requested by partner agencies. An alert system, developed in 2023, was maintained to summarize daily or weekly detection data into one email alert. Users can now request alert summaries for detections on individual receivers or for all receivers. Updates for the real-time receiver located below the EDB are also shared monthly with the corresponding USFWS hydroacoustic survey data.

RESULTS

Telemetry in Support of Modeling

Movement probability model. The new model was developed and successfully run on the 2012 to 2019 dataset (Stanton et al. 2023) of tagged Silver Carp and Bighead Carp in the Illinois River. A manuscript describing the model and results has been published (Stanton et al. 2024). Data collection and fish tagging will continue with partner agencies through 2025, and we will work with the Modeling Work Group to determine the best way to support population modeling efforts using telemetry collected beyond 2019. In 2024, the multi-agency partnership detected 707 active 69-kHz acoustic transmitters (i.e., "tags") from Silver Carp in the Illinois River. These fish were tagged by one of nine agencies or groups throughout the Mississippi River Basin (Illinois River [n = 612] and outside the Illinois River [n = 95]). The preliminary summary of Silver Carp passage in 2024 can be found in Table 2. Note that fish could be counted moving through multiple locks and dams or pools. Additional data analyses are ongoing.

Table 2. *Summary of known tagged Silver Carp making upstream and downstream passage through the Illinois River locks and dams in 2024.*

Lock and Dam	Downstream	Upstream	Individuals
La Grange	98	120	130
Peoria	46	64	73
Starved Rock	27	11	35
Marseilles	11	1	12
Dresden Island	5	1	6

Feasibility study to estimate fishing mortality from existing telemetry and tag-return data from the Illinois River. USGS worked with USFWS to create a model to guide managers in tag-return studies to estimate fishing mortality. The manuscript has been accepted for publication (Stanton et al. In Press). USGS also worked with SIU to develop a study plan to incorporate existing telemetry data into the mark-recapture data collected in the Marseilles and Starved Rock pools from 2012 and 2013. The contract for this work was delayed in 2024 and is now delayed indefinitely.

Immigration and Emigration of Silver Carp: In 2023, 261 Silver Carp were detected on receivers located in Mississippi River pool 26 or in the Alton pool of the Illinois River. Of those, 92 Silver Carp were detected in both pools. At the end of 2023, 21 tagged Silver Carp immigrated and remained in the Illinois River and 71 fish had moved to the Mississippi River. Ninety-five Silver Carp tagged outside the Mississippi River were detected in the Illinois River in 2024. After removing fish tags expected to be dead or "false detections," temporary immigrants (i.e., those leaving the Illinois River before the end of the year) made up 56.7% (n = 51) of the fish detected. Additional 2024 results will be available in 2026.

Real-time Receiver Network

USGS personnel monitored, downloaded, and maintained data from five real-time receivers in the Upper IWW in 2023. Locations of the five real-time receivers in the Upper IWW are shown in Table 1). Two additional receivers, located in the Marseilles Pool, are also maintained by the USGS, but these are funded by another (deterrent) project. Data from receivers are used to alert partner agencies when bigheaded carp tagged with ultrasonic transmitters are detected. Four real-time receivers are in areas of management concern (upstream of the bigheaded carp invasion front in upper Dresden Island Pool; receiver locations one through four in Table 1). Receivers No. 1 through 3 (i.e., those upstream of Brandon Road L&D) did not detect any confirmed bigheaded carp in 2023. Receiver No. 4 (Des Plaines River below Brandon Road L&D) detected one Silver Carp on two dates in July 2023. All the receivers were accessed remotely, and the data were made available online. Detection data and summaries were shared with partners throughout the year.

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SIU LONGITUDINAL RECEIVER ARRAY AND TAGGING

Participating Agencies: SIU (lead); additional assistance from/collaboration with ILDNR, USACE, USGS, INHS, USFWS; David Coulter, Cameron Davis, Jim Garvey, Tanya Fendler, Joe Mruzek (SIU)

MRWG Work Group: Telemetry

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, Alton

INTRODUCTION AND NEED

Management goals for bigheaded carp in the Illinois River focus on limiting upstream dispersal through monitoring, assessing movement barriers, and reducing abundance through contracted harvest. Bigheaded carp spatial distributions vary seasonally and annually; quantifying how spatial distributions change through time will help target contracted harvest to maximize removal efforts and minimize costs. Additionally, long-term information on bigheaded carp population characteristics, distributions, and movements, especially along the population front in the upper Illinois River, can provide data to parameterize population models. These models simulate the effects of various management actions (e.g., harvest scenarios and locations of enhanced deterrent technologies) to determine which options are most likely to achieve management goals.

The SEICarP model of bigheaded carp in the Illinois River assesses how bigheaded carp populations respond to various management actions (e.g., location and intensity of harvest; location and effectiveness of deterrent technologies). This model draws on a variety of data, including bigheaded carp densities and movement data. Collaborations between MRWG Modeling and Telemetry Work Groups have identified data needs, primarily with a better understanding of inter-pool movements. To this end, model support consisted of maintaining the Illinois River stationary telemetry array to quantify inter-pool movements and deployment of additional acoustic telemetry tags in bigheaded carp (numbers set based on Telemetry Work Group determinations). Movement information from telemetry efforts is also critical for maintaining sufficient surveillance efforts to detect potential changes in bigheaded carp spatial distributions (e.g., upstream movements), especially in supporting surveillance efforts with real-time acoustic telemetry receivers.

OBJECTIVES

- Continue tagging invasive carps to replace those tags that expire or are lost due to natural mortality. This maintains effective coverage of movement patterns of invasive carps.
- Expand tagging in the lower Illinois River to improve models of movement in these pools and the Mississippi River.
- Maintain SIU's extensive acoustic telemetry array currently in place in the entire Illinois River used to collect movement information and maintain adult surveillance efforts. Share collected data with Telemetry and Modeling Work Groups.

PROJECT HIGHLIGHTS

- Maintaining the stationary acoustic telemetry receiver array throughout the Illinois River ensured sufficient surveillance efforts occurred to detect adult movements among pools and toward the invasion front.

METHODS

Telemetry – Adult Movements

Utilizing an array of 51 Vemco 69-kilohertz stationary receivers maintained by SIU (Abeln, 2018) as well as stationary receivers maintained by partner agencies (USGS, USACE, USFWS, and MDC), the movements of Silver Carp and Bighead Carp implanted with internal transmitters (Vemco V16 transmitters) were monitored from Alton Pool upstream through Dresden Island Pool. Additional stationary receivers were deployed and maintained by other agencies in the Telemetry Work Group in other locations of the IWW. Additionally, other fish species implanted with 69-kilohertz transmitters by other members of the Telemetry Work Group can be detected by this array. Stationary receivers were downloaded in May and November of 2024, with data initially checked to remove false detections, and uploaded to the USGS FishTracks database. Once receivers were downloaded in early 2025, the full 2024 fish detection data were analyzed to identify upstream and downstream passages through lock and dam structures (e.g., Lubejko et al., 2017). Additional acoustic telemetry tags were deployed (n = 254) to replace expiring tags (Figure 1).

RESULTS AND DISCUSSION

Telemetry – Adult Movements

In 2024, 254 tags were implanted into bigheaded carp in Alton and La Grange (Figure 1). These additional tags will maintain sufficient adult surveillance efforts (e.g., early detection of movements past real-time receivers). SIU stationary receivers were retrieved and downloaded from Dresden Island Pool through Alton Pool. All detection data downloaded from stationary receivers were screened to remove false fish detections and submitted for inclusion in the USGS-managed FishTracks telemetry database. Dam passages were most common in the lower river pools (Table 1; Figure 2).

Table 1. *Table summarizing unique bigheaded carp upstream and downstream dam passages in 2023 (a) and 2024 (b). Tag data from SIU, USACE, MDC, Purdue, KDFWR, USGS-UMESC, USFWS Wilmington, and USFWS LaCrosse were used in these summaries.*

2023 (a)	Upstream	Downstream	2024 (b)	Upstream	Downstream
La Grange	50	78	La Grange	2	53
Peoria	17	32	Peoria	29	11
Starved Rock	7	8	Starved Rock	54	58
Marseilles	0	1	Marseilles	0	0
Dresden	0	0	Dresden	0	0

Figure 1: *Histogram summarizing the sex and location breakdown of the 254 carp tagged by SIU in 2024.*

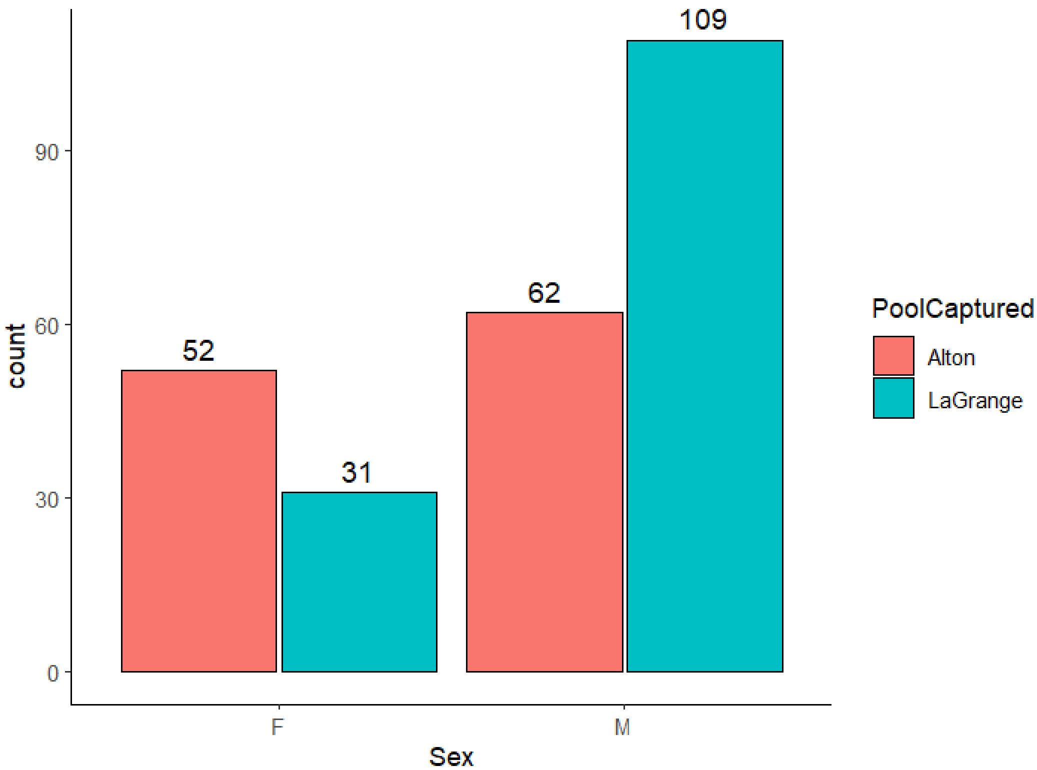
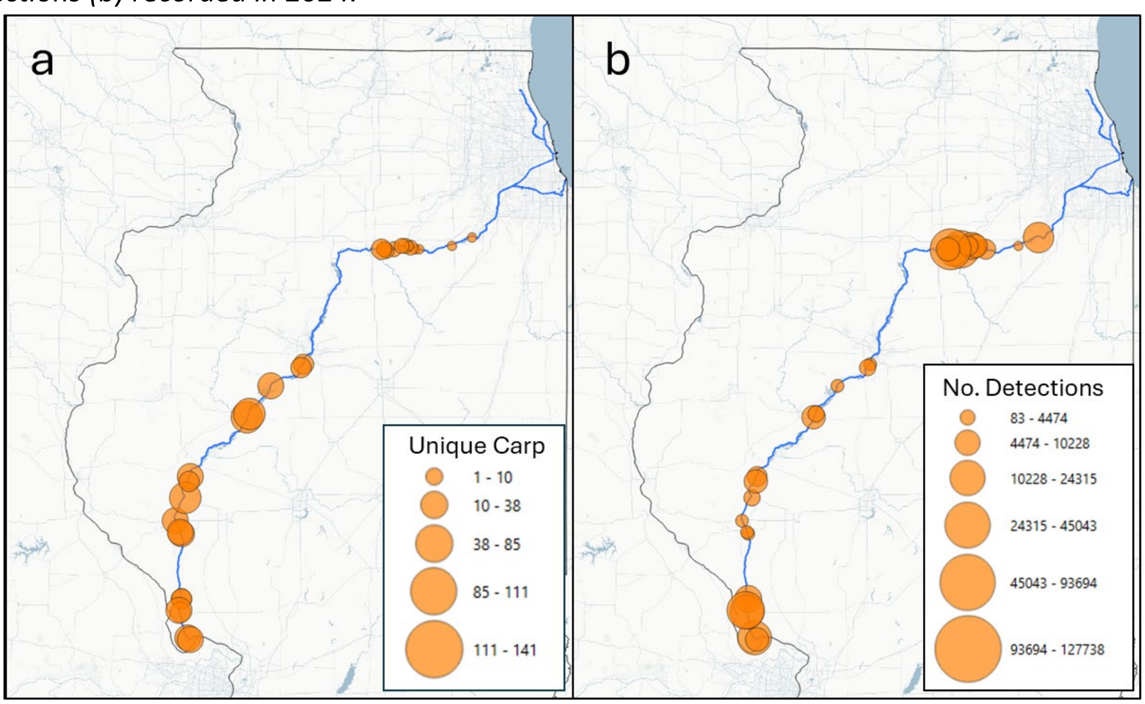


Figure 2. *Map of SIU's passive receiver array (orange dots) in the Illinois River. Dot size is scaled by the number of unique individuals tagged carp (a) and by the total number of detections (b) recorded in 2024.*



RECOMMENDATIONS

Continued collection of telemetry movement data will serve to maintain sufficient adult surveillance efforts for detecting movement among pools, including possible movement toward the invasion front. Movement data will also be needed to improve and update movement models used in the SEICarp model and allied spatially explicit modeling of density-dependent patterns of movement among pools toward the Great Lakes. It will also be important to continue to assess annual variation in dam passages and how passage rates vary as densities of bigheaded carp change throughout the Illinois River (e.g., due to removal efforts and reproduction in lower river pools).

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Lubejko, M. V., G. W. Whitledge, A. A. Coulter, M. K. Brey, D. C. Oliver, & J. E. Garvey, 2017. Evaluating upstream passage and timing of approach by adult bigheaded carps at a gated dam on the Illinois River. River Research and Applications 33: 1268–1278. https://doi.org/10.1002/rra.3180.

USACE TELEMETRY MONITORING PLAN

Participating Agencies: USACE (lead); USFWS, SIUC, ILDNR, USGS, and MWRDGC (field and project support); Alexander Catalano, John Belcik, Dayla Dillon, and Nicholas Barkowski (USACE – Chicago District)

MRWG Work Group: Telemetry

Pools Involved: Dresden Island, Brandon Road, Lockport

INTRODUCTION

Acoustic telemetry has been identified within the ICRCC Action Plan as one of the primary tools to assess the efficacy of the EDBS. The following report summarizes methods and results from implementing a network of acoustic receivers to track the movement of Bighead Carp and Silver Carp in the Dresden Island Pool and associated surrogate fish species (locally captured surrogate species: Common Carp) in the area around the EDBS within the CSSC. This network was installed and is maintained through a partnership between the USACE and other participating agencies as part of the MRWG MRP (MRWG 2020).

The purpose of the telemetry program is to assess the effect and efficacy of the EDBS on tagged fish in the CSSC and assess the behavior and movement of fish in the CAWS and Upper IWW using acoustic telemetry.

GOALS AND OBJECTIVES

- Goal 1: Determine if the upstream passage of the EDBS by tagged fish has occurred and assess the risk of Bighead Carp and Silver Carp presence (barrier efficacy).
    - Objective: Monitor the movements of tagged fish near the EDBS using receivers placed immediately upstream and downstream of the EDBS.
- Goal 2: Identify lock operations and vessel characteristics that may contribute to the passage of Bighead Carp, Silver Carp, and surrogate species through navigation locks in the Upper IWW.
    - Objective 1: Monitor the movements of tagged fish at Dresden Island, Brandon Road, and Lockport locks and dams using stationary receivers placed above and below each lock (N=5) and within Lockport Lock (N=1), Brandon Road lock (N=1), and Dresden Island Lock (N=1).
    - Objective 2: Review and compare standard operating protocols and vessel lockage statistics for Lockport, Brandon Road, and Dresden Island locks for comparison of known fish passage events.
- Goal 3: Evaluate temporal and spatial patterns of habitat use at the leading edge of the Bighead Carp and Silver Carp invasion front.
    - Objective 1: Determine if the leading edge of the Bighead Carp and Silver Carp invasion (currently RM 286.0) has changed in either the up or downstream direction.

  - Objective 2: Describe habitat use and seasonal movement in the Upper IWW and tributaries where Bighead Carp and Silver Carp have been captured and relay information to the population reduction program undertaken by ILDNR and commercial fishermen.
- Additional Objectives:
  - Integrate information between agencies conducting related acoustic telemetry studies.
  - Download, analyze, and post telemetry data for information sharing.
  - Maintain existing acoustic network and rapidly expand to areas of interest in response to new information.
  - Support the modeling efforts by USFWS with supportive data and adjust the network accordingly in consultation with the Telemetry Work Group.

PROJECT HIGHLIGHTS

- To date, USACE has acquired 53.5 million detections from 8,932 tagged fish.
- No known live tagged fish have crossed the EDBS in the upstream direction.
- A high percentage of tagged surrogate fish in the lower Lockport Pool continue to be detected near the EDBS.

METHODS

In March 2024, 26 Silver Carp, one Bighead Carp, and one hybrid Silver-Bighead Carp (bigheaded) were tagged within Dresden Island Pool. In November 2024, three Common Carp were captured and tagged, with two released in Lockport Pool and one released into Brandon Road Pool. As of November 2024, USACE had 55 Common Carp tags active (37 detected on 2+ receivers in 2024) in Lockport Pool, 29 Common Carp tags active (11 detected on 2+ receivers in 2024) in Brandon Road Pool, and 104 tags active (85 detected on 2+ receivers in 2023) in Dresden Island Pool. There are 23 invasive carp tags and 20 Common Carp tags expected to expire in in 2025. All receiver download files as well as tagged fish data was uploaded to the USGS RAFT database.

Tagged surrogate fish have been previously released below the EDBS, but no tagged invasive carp were released above Brandon Road L&D. No invasive carp caught in Lockport or Brandon Road pools would be tagged and returned, as these areas are above the known upstream extent of the invasion front. Displaced fish exhibit site fidelity and attempt to return to their original capture location. As such, to induce more approaches to the EDBS, many of the surrogate fishes previously released within lower Lockport Pool were originally captured from upper Lockport Pool. There are several fish previously captured above the EDBS and released below the EDBS with active tags.

Methods for stationary receiver deployment and downloads were maintained from previous years' efforts. After deployment, data retrieval occurred bi-monthly throughout the season by downloading stationary receivers. A detailed description of methods can be found in the MRP and ISR (2012). Stationary receivers that were removed from the Kankakee River for winter in November 2023 were redeployed in March 2024. All other receivers within USACE network remained deployed over that same period. The layout of receiver positions within the study remained almost the same as the previous years with additional receivers being deployed at newly identified areas of interest (MRP 2020, 2021). The revised study area was covered by 44 USACE stationary receivers extending approximately 33.5 RM from the Cal-Sag Channel in Worth, Illinois, to the Dresden Island L&D on the Illinois River in Channahon, Illinois.

Barrier Efficacy – Barrier efficacy was assessed through 12 stationary receivers—four upstream and eight downstream of the EDBS within Lockport Pool. Receivers were placed in Lockport Lock, at the lock entrance, in areas offering shallow habitat, near the EDBS, and at the confluence of the CSSC and Cal-Sag Channel. Receiver data were analyzed for individual fish detections that would indicate an upstream or downstream passage through the EDBS. Additionally, data were analyzed to assess temporal and spatial distribution patterns within lower Lockport Pool. All detections were recorded and compiled into the detection data set. Detections underwent quality assurance/quality control review to remove false detections and dead fish.

Inter-pool Movement – Four pools are defined within the study area, demarcated by the lock and dams within the system and the EDBS. Lockport Pool is defined as all waters upstream of Lockport L&D, including the CSSC and Cal-Sag Channel. Within this analysis, the pool is further separated into upper Lockport and lower Lockport. Lower Lockport Pool is characterized by the area downstream of the EDBS and upstream of Lockport L&D, while upper Lockport consists of the area upstream of the EDBS to the CSSC and Cal-Sag Channel. The remaining pools include Brandon Road Pool and Dresden Island Pool, which includes the Des Plaines and Kankakee Rivers. VR2W/VR2Tx receivers were placed above and below each lock and dam, as well as at any other potential transfer point between pools. Data from the VR2W/VR2Tx receivers was analyzed for probable inter-pool movement. Dates with the nearest time interval and the pathway used for each passage were recorded for each tagged fish found to have moved between pools.

Invasive Carp Movement Analysis – A total of 85 USACE-tagged invasive carp were included for analysis within the Dresden Island Pool in 2024. The movement of individual fish was tracked via stationary receivers strategically placed throughout the Des Plaines and Kankakee Rivers

RESULTS AND DISCUSSION

The results discussed in this section will address the three goals of the study. While no tagged fish have been released upstream of the EDBS by USACE for several years, the Shedd Aquarium released 80 fish comprised of Largemouth Bass, Common Carp, Bluegill, Pumpkinseed, Black Crappie, Green Sunfish, and Walleye. The Chicago District continues to maintain receivers upstream of the EDBS to monitor any movement of fish from below the barrier. Results to date have shown that zero known live tagged fish have crossed the EDBS in the upstream (northward) direction.

- Goal 1: Determine if the upstream passage of the EDBS by tagged fish has occurred and assess the risk of Bighead Carp and Silver Carp presence (barrier efficacy).

In 2024, 55 tagged surrogate fish with active transmitters were at large between Lockport L&D and the EDBS. Seven stationary receivers detected the movement of 37 tagged surrogate fish throughout the pool on two or more receivers in 2024. Only these 37 fish were used for analysis. A total of 32 unique tagged Common Carp were detected near the EDBS. There was a total of 2,511,690 detections within lower Lockport Pool and zero detections in upper Lockport Pool, indicating no passage of tagged fish through the EDBS.

- Goal 2: Identify lock operations and vessel characteristics that may contribute to the passage of Bighead Carp, Silver Carp, and surrogate species through navigation locks in the Upper IWW.

From 2010 to 2024, there were 116 occurrences of tagged fish moving downstream and 55 occurrences of upstream movement between navigation pools (Table 1). There were four occurrences of inter-pool movement by three tagged fishes (all Common Carp) in 2024. One Common Carp moved downstream from Brandon Road to Dresden Island, and then back upstream from Dresden Island to Brandon road. Two Common Carp moved downstream from Lockport to Brandon Road. There were six downstream passages of invasive carp (five Silver Carp and one Bighead Carp) through Dresden Island L&D. All five Silver Carp passages occurred during the month of April and the Bighead Carp passage occurred during June. Four of the Silver Carp continued downstream and passed through Marseilles L&D into Starved Rock Pool, each passing within 1 day of when those fish had individually passed through Dresden Island L&D. Only one upstream passage through Dresden Island Lock occurred by a Silver Carp and this occurred during May. Bear Trap Dam Control Works was not opened in 2024, as a result no passages through Bear Trap occurred in 2024.

Table 1. *Total occurrences of inter-pool movement by tagged fish from 2010 to 2024.*

Location	Up	Down	Total
Lockport Lock	23	28	51
Control Works	4	36	40
Brandon Road	6	17	23
Dresden Island	22	35	57

- Goal 3: Evaluate temporal and spatial patterns of habitat use at the leading edge of the Bighead Carp and Silver Carp invasion front.

USACE tagged 26 Silver Carp (895 mm ± 70 mm), one Bighead Carp (1151 mm) and one Hybrid Silver-Bighead Carp (1027 mm) on March 26, 2024, in collaboration with ILDNR commercial fishing. These fish were captured in Rock Run Rookery but released in the main channel outside of Rock Run Rookery.

A total of 85 invasive carp in Dresden Island Pool across 23 USACE receivers and two USGS real-time receivers were included for analysis. Similar to previous years, a large number of tagged invasive carp were detected within the Constellation Energy Nuclear discharge canal, and followed the similar pattern of using the warm water within the canal when the main channel drops to around 15°C and start to exit the canal when main channel temperatures near 20°C. Collaboration with USGS and ILDNR to place a real-time receiver within the discharge has led to increased removals within the discharge canal. Five additional receivers were placed within the Constellation Energy cold water canals in early 2024 to evaluate invasive carp use of the canals. Twelve unique invasive carp were detected within the cold water canals with a majority of these detections occurring in the months of April and July.

Two tagged Silver Carp were detected at the receivers immediately below Brandon Road Lock. The first Silver Carp was detected on July 10th and was detected for approximately 3.5 hours before moving back downstream. The second Silver Carp was detected on August 1st and was detected for approximately 6 hours before moving downstream. Both fish appeared to move upstream around rising hydrograph conditions simulating a possible upstream spawning migration. Similar trends have been observed in previous years across the IWW.

Extensive use of Rock Run Rookery by Silver Carp took place this year, opposite of what was seen in 2022-2023 where no invasive carp were detected in Rock Run Rookery. Of the 28 invasive carp tagged in Rock Run Rookery, 20 returned to Rock Run within several weeks. None of the invasive carp tagged in the lower Dresden Island Pool were detected in Rock Run Rookery during 2024. Historical data shows similar trends where a large proportion of detected invasive carp within Rock Run Rookery were tagged in Rock Run Rookery, and very few fish tagged outside of Rock Run Rookery were detected inside the backwater.

RECOMMENDATIONS

USACE recommends continuing the telemetry program and maintaining the target level of surrogate species and invasive carp tags within the system by replacing expired tags throughout all three pools below the EDBS in the spring and fall of 2025. USACE will continue to collaborate with MRWG partners to maximize our understanding of invasive carp movement and biology within the Dresden Island Pool. USACE recommends continued collaboration with MRWG partners to perform comparisons of surrogate species to Bighead Carp and Silver Carp. Understanding how well Common Carp and other surrogates represent the behavior of invasive carp is important in determining the usefulness of the data collected from those surrogate species near the EDBS.

USACE recommends maintaining acoustic receivers within the Constellation Energy Nuclear Power Plant cold water canals for an additional year to further identify timing of when invasive carp are using the canals and susceptible to commercial removals. Additional tagging of invasive carp in the middle pool (I-55 downstream to the confluence of the Kankakee and Des Plaines rivers) is recommended to determine if middle pool tagged fish are utilizing Rock Run Rookery as well or if Rock Run Rookery fish may be originating from other locations. USACE will provide assistance of tagging and monitoring around the INHS one-way passage devices being used in Dresden Island to determine ways to optimize removals within key habitats (Rock Run Rookery) being used by invasive carp.

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TELEMETRY SUPPORT FOR THE SPATIALLY EXPLICIT INVASIVE CARP POPULATION MODEL (SEICarP)

Participating Agencies: USFWS, Carterville FWCO Wilmington Substation (lead), SIU, USACE, USGS

MRWG Work Group: Telemetry

Pools Involved: Peoria and Starved Rock

INTRODUCTION AND NEED

The SEICarP model was developed as a means of assessing the invasive carp population status in the IWW. SEICarP is a movement probability model used to inform researchers how invasive carp populations respond to management strategies (Brey *et al*. 2022). The model functions as an important tool that can be used by fisheries managers to inform harvest and control of adult invasive carp (primarily Silver Carp and Bighead Carp) in the IWW. Harvesting from source populations downriver to reduce propagule pressure and physical barriers (dams) is believed to reduce movement probabilities upstream (Kallis *et al*. 2022; Baker 2017). The USFWS telemetry data complements telemetry data being collected throughout the IWW describing inter-pool transfer of adult invasive carps and is used to parameterize the movement probability component of the SEICarP model. This research provides an improved understanding of invasive carp movement in the IWW and its effects on population dynamics. Variations in invasive carp movement, distribution, and habitat in the IWW make targeting invasive carp challenging and costly (ICRCC 2024). A multi-agency telemetry array maintained across the pools in the upper IWW provides the parameters for the SEICarP model. A large telemetry array can be used to better understand movement patterns to inform harvesting efforts and facilitates monitoring and contingency actions based on invasive carp movement through these joint efforts (ICRCC 2024). The USFWS Wilmington FWCO's involvement maintains an acoustic telemetry array that spans the Peoria and Starved Rock pools.

OBJECTIVES

- Collectively tag 150 individual adult invasive carp within Peoria and Starved Rock pools, primarily Silver Carp.
- Tag an additional 17 invasive carp in Starved Rock Pool using recovered tags from harvesting efforts in 2023.
- Deploy and maintain an array of 69-kilohertz receivers (Innovasea) within Peoria and Starved Rock pools to enhance detections of transient fish and inter-pool movement.
- Provide data from the acoustic receiver array to the MRWG Telemetry Work Group for use in the SEICarP model.

PROJECT HIGHLIGHTS

- Two hundred V-9 acoustic transmitters *(*Innovasea) were implanted inside invasive carp in April 2024; 150 in the Peoria Pool, 50 in the Starved Rock Pool.

- An additional 17 Silver Carp were tagged in Starved Rock Pool with viable tags from recaptured fish in 2023.
- Data from the eighteen (13 VR2Tx, 6 VR2W) 69 kHz acoustic receivers was collected, processed, and provided to the Telemetry Work Group.

METHODS

The location of each receiver station in the Peoria and Starved Rock pools are shown in Figure 1. Eighteen 69 kHz "Innovasea" acoustic receivers were deployed in March 2024 and were downloaded bi-monthly through December 2024. The data was uploaded to the USGS RAFT network within two weeks of being collected. With direction from the Telemetry Work Group, all receivers were tethered to trees to reduce the loss of the receiver. Receivers were placed a minimum of five river kilometers away from other agency's receiver arrays. This ensured there would be no overlap in the arrays and would maximize movement detection. The receivers were removed and downloaded in December 2024 to prevent potential ice flows from breaking receivers from their tethers. The receiver array will be redeployed in March 2025 with the beginning of the new monitoring season.

RESULTS AND DISCUSSION

A total of 897,835 detections from 312 fish were recorded across the 18 USFWS-maintained 69 kHz receiver array from March 3 to December 16 of 2024 (Table 1). This was lower than last year's result (1,938,634 detections from 463 fish). This could be due, in part, to decreasing the receivers in the array from 20 in 2023 to 18 in 2024. Two hundred-twelve fish tagged by USFWS between the years 2022 and 2024 were detected in the array. Eight inter-pool movements were recorded between April 2 and July 18 of 2024 (Table 2). All data was uploaded to the USGS RAFT by February 2025. Figure 2 summarizes the total number of fish detected within each movement category.

During this season, two receivers (lower Peoria Lake Point River Left RM 164.8 and Chillicothe Bridge Peninsula RM 182.4) were replaced by spare receivers, and one receiver (Peru DS Route 251 Bridge RM 222.8) was recovered by commercial fishermen near Henry, Illinois.

Figure 1. *Locations of USFWS Carterville FWCO acoustic receiver stations across Peoria and Starved Rock pools.*

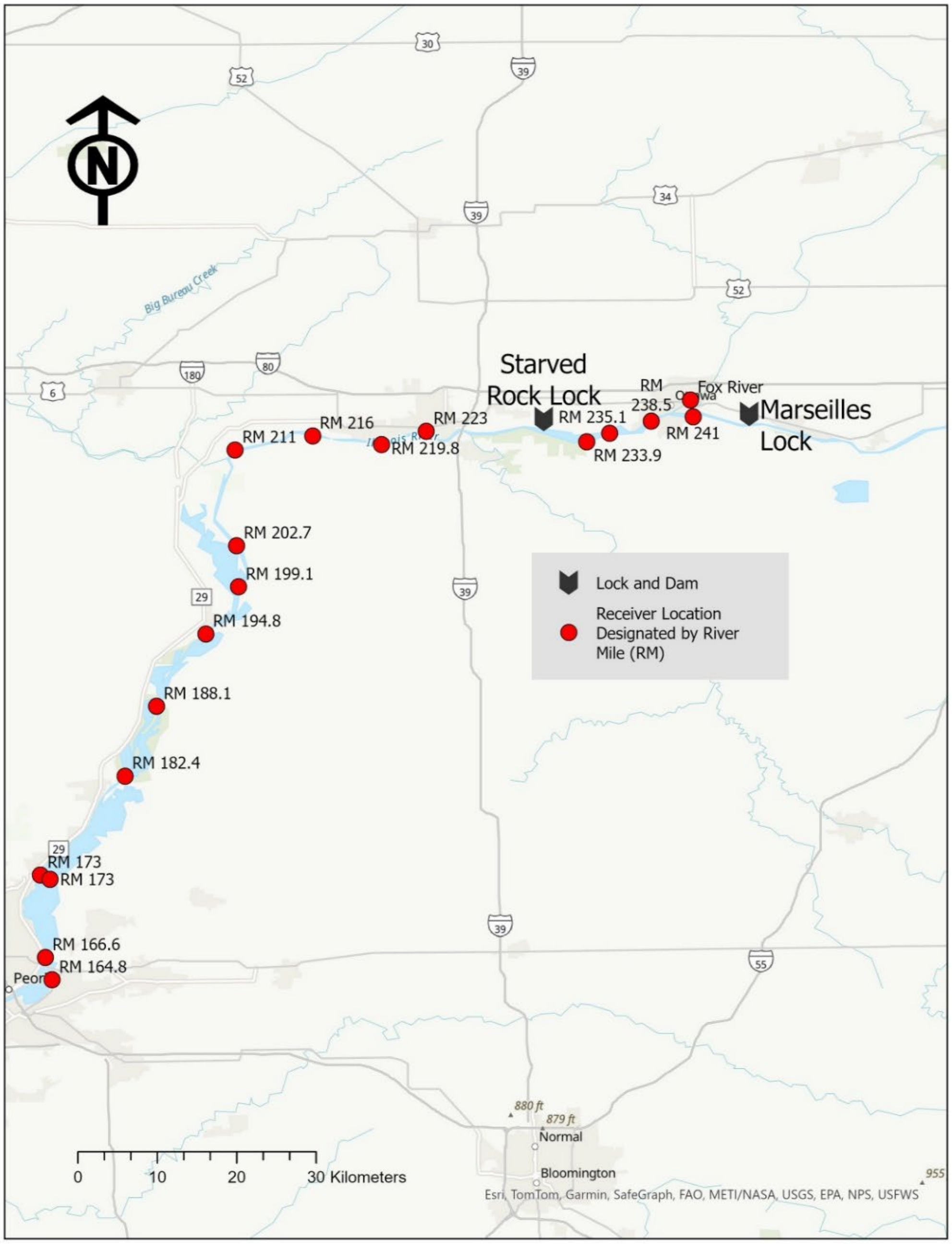


Table 1. *Data downloaded from 69-kilohertz Innovasea VR2Tx and VR2W receivers from March 3 to December 16, 2024. "Receiver Number" corresponds to receivers shown in Figure 1.*

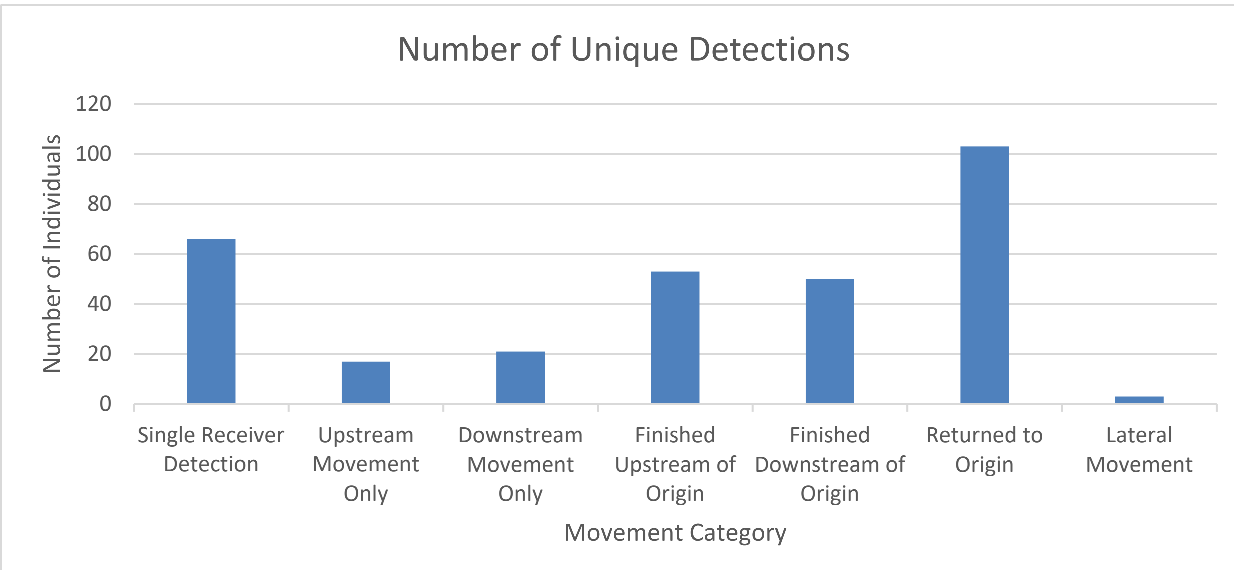
Receiver ID	River Mile	Station Name	Number of Fish	Number of Detections
VR2Tx-489204	164.8	Lower Peoria Lake Point River Left	102	69,768
VR2Tx-489205	166.6	Peoria Lake Narrows	91	6,539
VR2W-137065	173.0	Upper Peoria Lake River Right	84	19,466
VR2Tx-489207	173.0	Upper Peoria Lake River Left	77	11,019
VR2Tx-489206	182.4	Chilli Bridge Peninsula	79	83,265
VR2W-137064	188.1	Lacon MC Sawyer Slough	118	33,436
VR2Tx-489208	194.8	US Upper Henry Island	112	105,552
VR2Tx-489209	199.1	Senachwine Lake Peninsula	107	7,215
VR2Tx-489211	202.7	Lower Twin Sisters Island	109	13,352
VR2W-137066	211.0	MC near Depue Lake Channel	150	50,594
VR2Tx-489039	216.0	US of Clark Island	144	26,485
VR2W-129785	219.8	US Spring Valley River Left	164	58,924
VR2Tx-489037	223	Peru DS Route 251 Bridge	146	22,790
VR2Tx-489212	233.9	Lone Point Delbridge Side Channel	31	136,322
VR2Tx-490949	235.1	MC Sheehan Island	36	62,760
VR2Tx-489040	238.5	Hitt-Mayo Straight	31	34,782
VR2W-129787	Fox River	Fox River Island US of Rt 6 Bridge	16	14,213
VR2Tx-490950	241.0	Bulls Island MC Abandoned Harbor	37	141,354
		Total unique transmitters and detections	**312**	**897,835**

Table 2. *Upstream (US) and downstream (DS) inter-pool movement events between Starved Rock (SR) and Peoria (PA) pools between April and July of 2024.*

PA → SR	PA → SR	SR ↔ PA
Single fish on 5/21/2024	Five individual fish between 5/18/2024 and 7/18/2024	Two separate fish moved DS to Peoria and back US to Starved Rock between 4/2/2024 and 7/3/2024

Figure 2 summarizes the movement categories from the beginning to the end of the fish's detection period. Detection periods are detections made by tagged individuals between receiver deployments and data retrieval. Results from the number of fish detected within seven movement categories show that most of the fish were returning to their beginning point of origin at the end of their detection period. The second highest group were fish detected by a single receiver. These detections showed no longitudinal movements by these individuals; detections were fish swimming within the detection field of that receiver. The third most common movement was fish that ended their detection period upstream or downstream of their position at the beginning of their detection period. Upstream, downstream, and returning to origin note longitudinal movements but return fully or partially back to their origin at the end of the detection period. Upstream only and downstream only movements were noted where fish were detected by other receivers without regressing back to their origin at the beginning of the detection period. Lateral movements are noted when a transmitter is detected by receiver stations directly across the channel from each other. These instances were seen at the RM 173 Upper Peoria Pool River Left and River Right receivers (Figure 1).

Figure 2. *Number of fish detections within each movement category at the end of their detection period across the 2024 field season.*



FUTURE WORK

USFWS Wilmington Substation plans to resume its support of the SEICarP model and redeploy its receiver array in March 2024. The larger array used this season across Peoria and Starved Rock Pools was able to detect two downstream pool-to-pool transitions. Additional detected pool-to-pool movements will assist the SEICarP model estimation of transition probabilities. The 2024 field season array will consist of 18 69-kilohertz receivers instead of 20 due to receiver loss. Changes in receiver deployment design have been made to help reduce the risk of lost receivers in the future. Receiver placement will be based on detections from the 2023 field season and strategic placements suggested by the MRWG Telemetry Work Group. Capturing the movements of fish within the larger array helps reduce the probability that fish are transiting undetected and gives researchers a better idea about individual fish survival. The Wilmington Substation will tag another 150 adult bigheaded carps between Peoria and Starved Rock (100 and 50, respectively) in April 2024. The MRWG Telemetry Work Group will be consulted before tagging and deployment to optimize placement within the IWW.

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REMOVAL WORK GROUP PROJECTS

- Contracted Commercial Fishing Below the Electric Dispersal Barrier
- Invasive Carp Enhanced Contract Removal Program

CONTRACTED COMMERCIAL FISHING BELOW THE ELECTRIC DISPERSAL BARRIER

Participating Agencies: ILDNR (lead); INHS; Allie Lenaerts, Andrew Wieland, Madison Meyers (INHS), Eli Lampo, Justin Widloe, Claire Snyder, Brian Schoenung, Kevin Irons, Mindy Barnett (ILDNR)

MRWG Work Group: Removal

Pools Involved: Dresden Island, Marseilles, Starved Rock

INTRODUCTION AND NEED

This project uses contracted commercial fishers to reduce invasive carp abundance and monitor for changes in range in the Des Plaines River and upper Illinois River downstream of the EDBS. By decreasing invasive carp abundance, we anticipate reduced migration pressure towards the barrier, lessening the chances of invasive carp gaining access to upstream waters in the CAWS and Lake Michigan. Monitoring for upstream expansion of invasive carp should help identify changes in the leading edge, distribution, and relative abundance of invasive carp in the IWW. The "leading edge" is the furthest upstream location where multiple Bighead Carp or Silver Carp have been captured with conventional sampling gears during a single trip or where individuals of either species have been caught in repeated sampling trips to a specific site. Trends in catch data over time may also contribute to understanding invasive carp population abundance and movement between and among pools of the IWW.

OBJECTIVES

- Monitor the presence of invasive carp in the five pools (Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock) below the EDBS in the IWW.
- Reduce invasive carp densities, lessening migration pressure to the EDBS, thus decreasing chances of invasive carp accessing upstream reaches (e.g., CAWS and Lake Michigan).
- Inform other projects (i.e., hydroacoustic verification and calibration, SEICarP model, small fish monitoring, and telemetry master plan) on invasive carp population distribution, dynamics, and movement in the IWW downstream of the EDBS.

PROJECT HIGHLIGHTS

- Since 2010, contracted commercial fishers' effort in the Upper IWW below the EDBS includes 6,014 miles (9,679 kilometers) of gill/trammel net, 22 miles (35 kilometers) of commercial seine, 239 Great Lakes pound net nights, and 4,369 hoop net nights.

- From 2010 to 2024, 106,487 Bighead Carp; 1,783,990 Silver Carp; and 12,550 Grass Carp were removed by contracted fishers. The total estimated weight of invasive carp removed since 2010 is 7,900 tons (15,800,600 pounds).
- No invasive carp have been collected in Lockport or Brandon Road pools since the inception of this project in 2010.
- The leading edge of the invasive carp population remains near Rock Run Rookery in Dresden Island Pool (approximate river mile 281; 452 kilometers from Lake Michigan). No appreciable change has been found in the leading edge over the past 12 years.
- Since 2010, this program has been successful at managing the invasive carp population in the upper Illinois River. Continued implementation of this project will provide the most current data on invasive carp populations at their leading edge and reduce pressure on the EDBS.

METHODS

Contracted commercial netting occurred from February through December in Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools of the IWW. The section of the Kankakee River from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River was included in the Dresden Island Pool (Figure 1). These areas are closed to commercial fishing by Illinois Administrative Rule (*i.e., Part 830: Commercial Fishing and Musseling in Certain Waters of the State, Section 830.10(b): Waters Open to Commercial Harvest of Fish)*; therefore, an agency biologist is required to accompany contracted commercial fishing crews working in this portion of the river. Contracted commercial fishers with assisting agency biologists typically fished four days a week during each week of the field season, except for two weeks in May and October. Sampling occurred upstream of the EDBS for the SIM project.

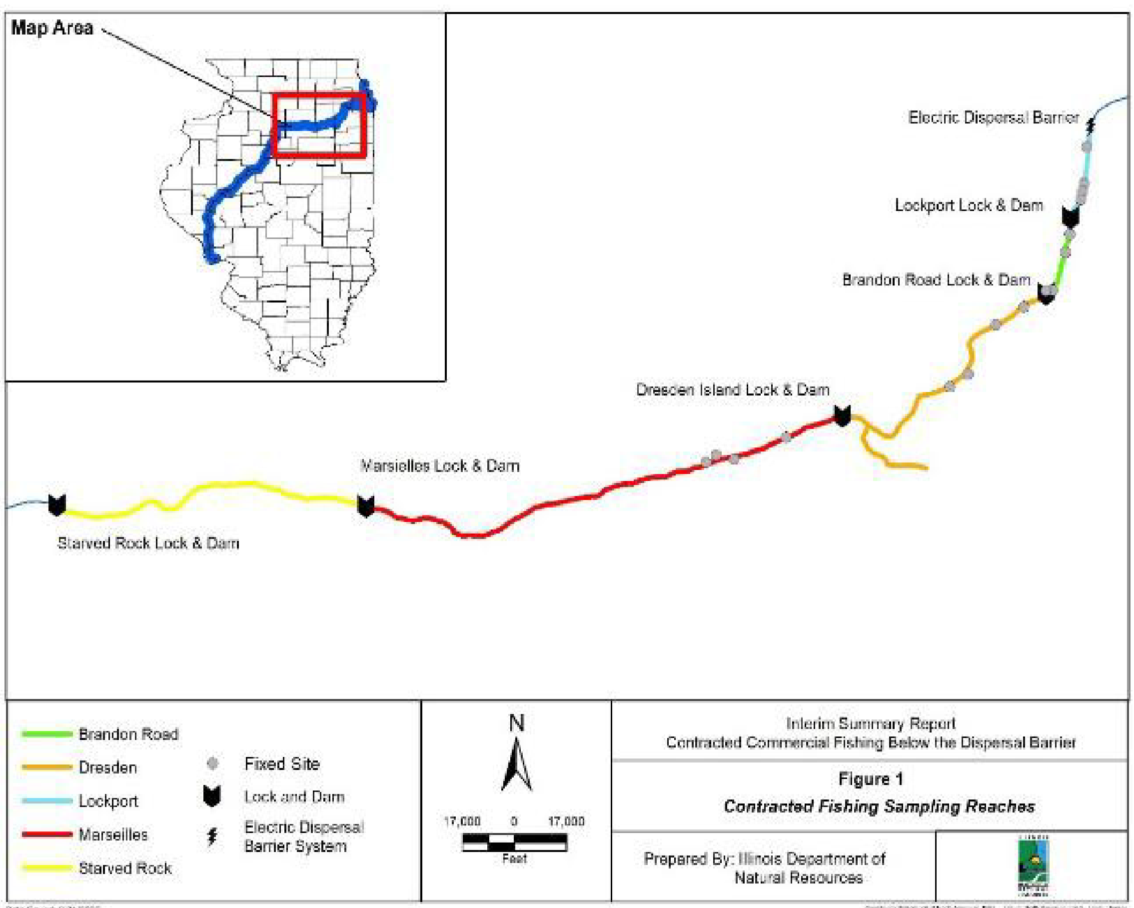
Contract fishing occurred at targeted sites throughout each pool monthly. Four fixed sites each in Lockport, Brandon Road, Dresden Island, and Marseilles pools were also sampled monthly (Figure 1). These data were merged to comprehensively understand invasive carp spatial and temporal abundance below the EDBS, especially at their upper-most extent in Dresden Island Pool. However, because invasive carp abundance and fishing locations are spatially heterogeneous within pools, areas of special interest to MRWG (Rock Run Rockery and Dresden Island above I-55) were analyzed individually. This will make pertinent results more easily interpreted, allowing better relative abundance inferences to be drawn in areas of highest concern (e.g., Dresden Main Channel Above I-55).

Large mesh (2.5 to 5.0 inches; 63.5 mm to 127 mm) gill and trammel nets set in 100- to 1,200- yard segments were used, and fish herding techniques (e.g., pounding on boat hulls, hitting the water surface with plungers, and driving with motors trimmed up) were utilized to drive fish into the net (Butler et al. 2018). Nets were typically set for 20 to 30 minutes. Overnight net sets occasionally occurred in off-channel habitats and non-public backwaters with no boat traffic.

Entangled fish were removed from the net, identified, enumerated, and recorded. All invasive carp and Common Carp were checked for telemetry tags, and all non-tagged invasive carp were harvested and utilized by private industry for purposes other than human consumption (e.g., chum bait, converted to liquid fertilizer, pet treats, food for injured animals, etc.). All tagged invasive carp and all non-invasive carp by-catch were released into the water alive. A representative sample of up to 30 individuals of each invasive carp species (Bighead Carp, Grass Carp, and Silver Carp) from each pool was measured for total length (mm), weighed (grams), and sexed (male or female) 1 to 2 times a week to provide estimates of total weight harvested and gather morphometric data on harvested invasive carp over time.

Unified Fishing Methods were implemented in Dresden Island Pool and the East and West Pits of Hanson Material Services in Marseilles Pool, lasting approximately one week each. Gill and trammel nets were set, and fishers used systematic herding techniques in unison to drive fish into nets. Block nets were used to partition the East and West Pits, and the sections were cleared of invasive carp. Great Lakes pound nets were set to block fish from moving out of areas, and commercial seines were pulled to remove mass amounts of invasive carp. A commercial seine was deployed at Bull's Island (Starved Rock Pool) in December 2024.

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites sampling of the contract fishing below the electric dispersal barrier project.*



RESULTS AND DISCUSSION

Since 2010, 6,025 miles (9,696 kilometers) of gill/trammel net, 23 miles (37 kilometers) of commercial seine, 239 Great Lakes pound net nights, and 4,369 hoop net nights have been deployed in the Upper IWW. The total estimated weight of invasive carp caught and removed from 2010 to 2024 is 15,800,600 pounds. Silver Carp remains the most abundant invasive carp species in the upper Illinois River, in contrast to 2010 when Bighead Carp comprised approximately 93 percent of total invasive carp catch by weight.

The 2024 gill/trammel net CPUE (number of fish per 1,000 yards of net) in Starved Rock Pool was 295, a decrease from 380 in 2023. The gill/trammel net CPUE in Marseilles Pool was 57.11, a decrease from 103.5 in 2023 (Figure 2). The 2024 gill/trammel net CPUE in Dresden Island Pool (leading edge) was 3.6, an increase from 2.1 in 2023 (Figure 2). For details regarding gill/trammel CPUE of invasive carp for all pools combined from other years, see those years' respective ISRs found online at https://icrcc.fws.gov. We attribute much of the decline in CPUE in the Marseilles and Starved Rock pools due to difficult fishing conditions throughout the majority of the 2024 season. The spring was marred by rain and wind, making fishing difficult. Conversely, the fall was very dry and warm and the flow in the river was very low. This caused the Silver carp to remain highly active in the navigation channel for most of the fall, which also made fishing difficult. However, the water temperature dropped in December and contracted commercial fisher and ILDNR biologists were able to deploy a commercial seine at Bull's Island (Starved Rock Pool) and remove 76,049 individual invasive carp over the course of eight days (Figure 3).

Effort and Catch of Invasive Carp within Pools

Dresden Island Pool: Invasive carp abundance is relatively low in Dresden Island Pool compared to downstream pools, and monitoring is essential because the leading edge of the Silver Carp and Bighead Carp population occurs here. In 2024, 1 percent of the total harvested invasive carp came from Dresden Island Pool. Contracted commercial fishing efforts included 156,640 yards (143.2 kilometers) of gill/trammel net. In 2024, 527 Silver Carp and 28 Bighead Carp were harvested from Dresden Island Pool (including Rock Run Rookery, the lower Kankakee River, and the Dresden Nuclear Power Station warm water discharge) (Figure 2).

CPUE estimates for the entire Dresden Island Pool are highly stochastic, likely due to changes in access to fishing hotspots, varying demographics through time (size structure), and environmental and hydrological variation.

Marseilles Pool: In 2024, eight percent of the total harvested invasive carp came from Marseilles Pool. Contracted commercial fishing efforts included 88,704 yards (138.4 kilometers) of gill/trammel net. In 2024, 4,966 Silver Carp, 84 Bighead Carp, and 6 Grass Carp were harvested from Marseilles Pool, amounting to 50.2 tons (100,400 pounds) removed. In 2024, Silver Carp dominated the invasive carp catch in Marseilles Pool (98%), consistent with the past eight years. Prior to 2013, Bighead Carp was the dominant invasive carp species caught in the Marseilles Pool.

Figure 2. *Annual mean CPUE (number of fish per 1,000 yards of gill/trammel net) of invasive carp for Starved Rock, Marseilles, and Dresden Island pools (2010 to 2024).*

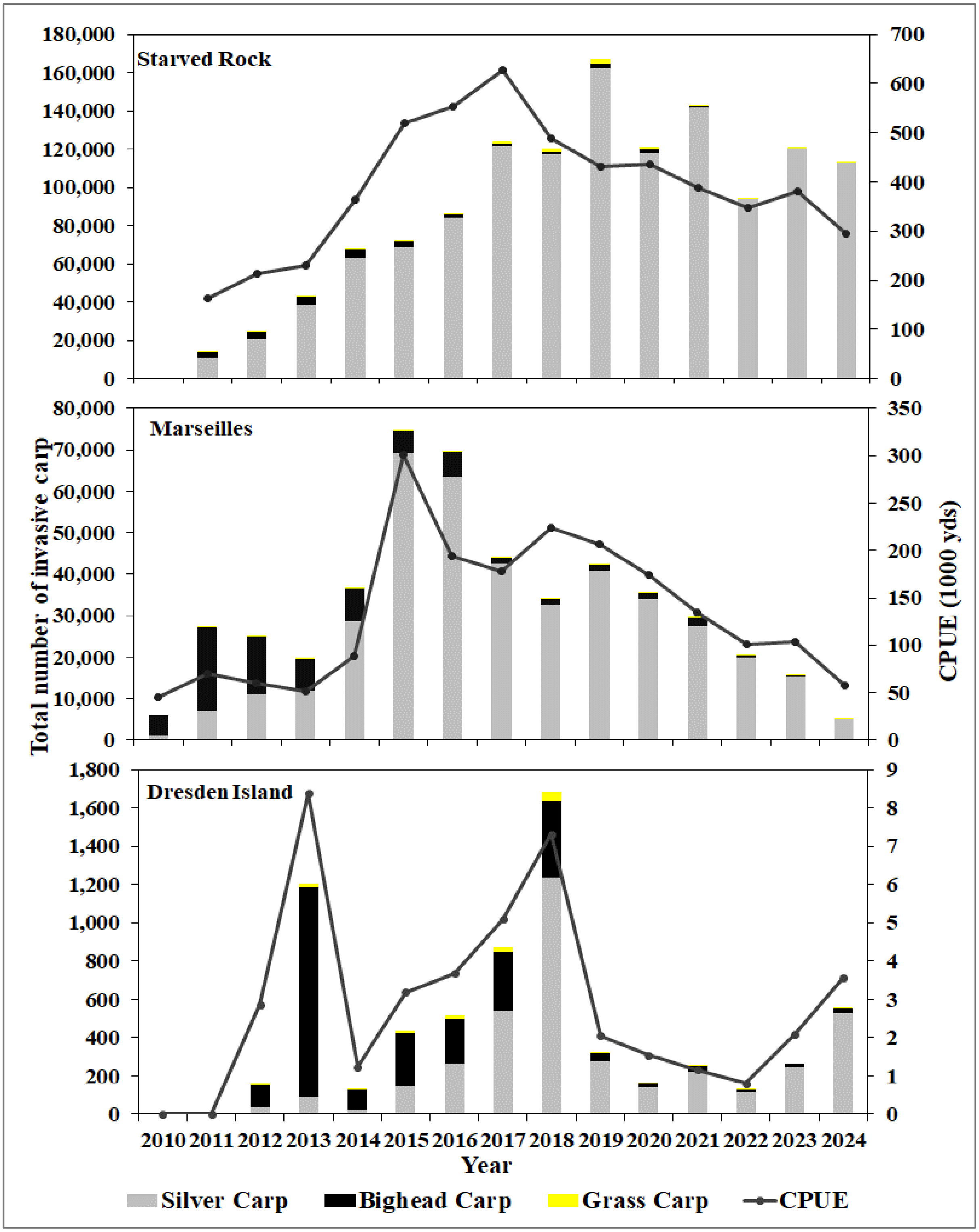
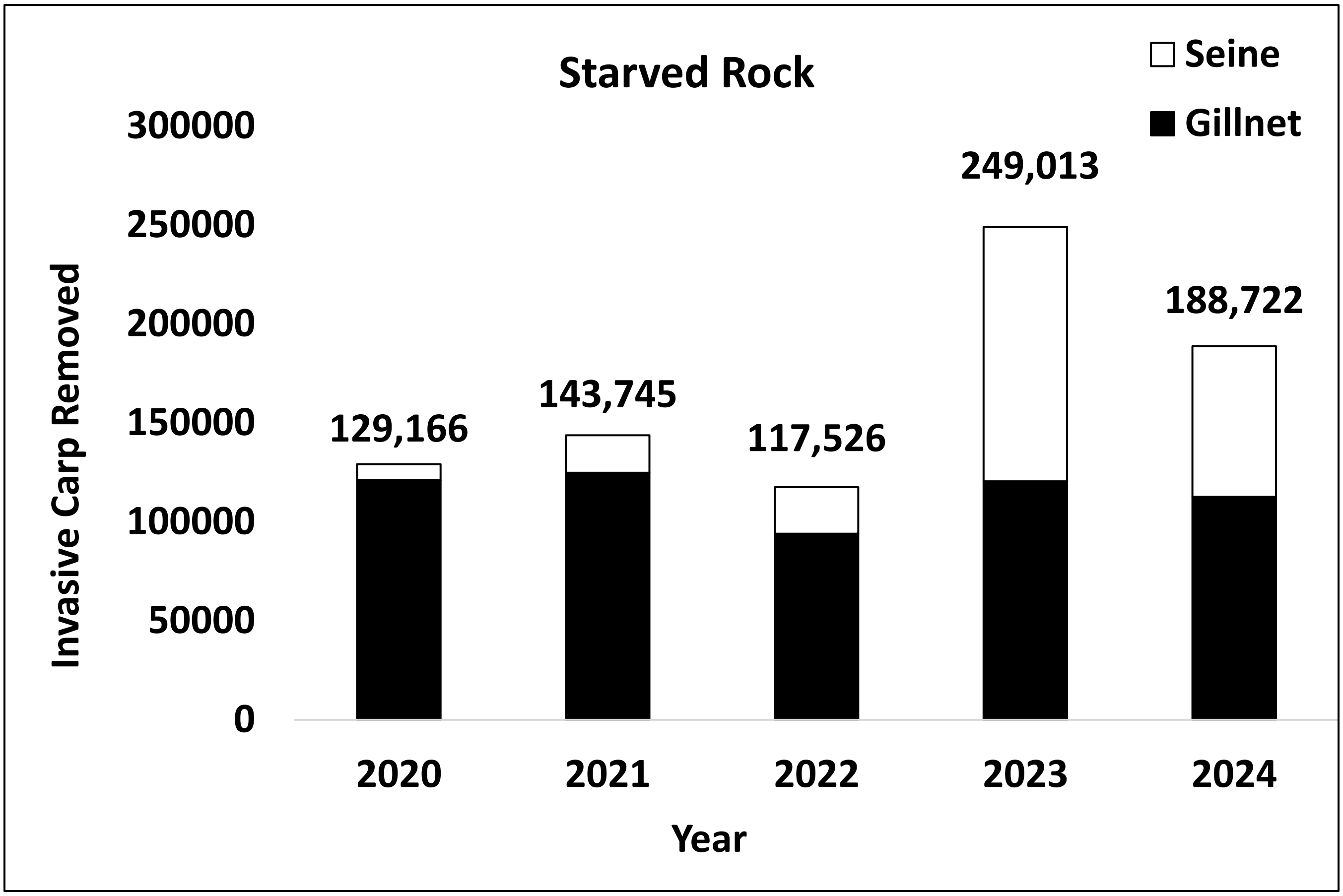


Figure 3. *Number of invasive carp removed using commercial seine and gill net in the Starved Rock Pool (2010 to 2024).*



Starved Rock Pool: In 2024, 91% of the total harvested invasive carp came from Starved Rock Pool. Contracted commercial fishing efforts included 382,272 yards (350 kilometers) of gill/trammel and. In 2024, 111,580 Silver Carp; 450 Bighead Carp; and 662 Grass Carp were harvested from Starved Rock Pool from gill/trammel nets, amounting to 345.3tons (690,660) removed. Silver Carp dominated the catch of invasive carp in Starved Rock Pool in 2024 (99%), consistent with years past.

In December 2024, 41% (475,534 lbs) of the invasive carp biomass removed in the Starved Rock pool was the end result of a seine haul effort at Bull's Island (Ottawa, Illinois). Out of the 188,722 invasive carp removed from the Starved Rock Pool, 76,049 of those individuals were removed via commercial seine (Figure 3). There was minimal bycatch and Silver Carp comprised 99% of the biomass removed. The total weight of this effort and biomass removed via gill and trammel net 1,166,194 pounds. In 2024, a combined total of 1,276,953 pounds of invasive carp were removed from the Dresden Island, Marseilles, and Starved Rock pools.

CPUE estimates for the entire Dresden Island Pool are highly stochastic, likely due to changes in access to fishing hotspots, varying demographics through time (size structure), and environmental and hydrological variation.

Marseilles Pool: In 2023, six percent of the total harvested invasive carp came from Marseilles Pool. Contracted commercial fishing efforts included 151,360 yards (138.4 kilometers) of gill/trammel net. In 2023, 15,362 Silver Carp, 298 Bighead Carp, and 2 Grass Carp were harvested from Marseilles Pool, amounting to 103.4 tons (206,800 pounds) removed (Figure 3). In 2023, Silver Carp dominated the invasive carp catch in Marseilles Pool (98 percent), consistent with the past eight years. Prior to 2013, Bighead Carp was the dominant invasive carp species caught in the Marseilles Pool (greater than 55 percent). In 2023, the catch of Bighead Carp was two percent. The 2023 gill/trammel net CPUE of invasive carp for Marseilles Pool was 103.5, a two percent increase from 2022 (Figure 2).

Starved Rock Pool: In 2023, 93 percent of the total harvested invasive carp came from Starved Rock Pool. Contracted commercial fishing efforts included 316,800 yards (290 kilometers) of gill/trammel and seine net set. In 2023, 249,013 Silver Carp, 354 Bighead Carp, and 401 Grass Carp were harvested from Starved Rock Pool from gill/trammel nets, amounting to 782.7 tons (1,565,400) removed (Figure 3). Silver Carp dominated the catch of invasive carp in Starved Rock Pool in 2023 (99 percent), consistent with years past. The 2023 gill/trammel net CPUE of invasive carp for Starved Rock Pool was 380, a 15 percent decrease from 2022 (Figure 2).

In December of 2023, 48 percent (752,439 pounds) of the invasive carp biomass removed in Starved Rock Pool was the end result of a seine haul effort at Bull's Island (Ottawa, Illinois). The effort was considered a major success from a removal standpoint, with 128,553 Silver Carp and 27 Bighead Carp removed. There was minimal bycatch, and Silver carp comprised 99 percent of the biomass removed. The total weight of this effort is included in the annual pounds removed for the program in 2023.

RECOMMENDATIONS

Since 2010, this program has been successful at managing the invasive carp population in the Upper IWW by significantly decreasing relative biomass near the population front in Dresden Island Pool (Coulter et al. 2018). With these efforts, we hope to further reduce invasive carp abundance at and near the detectable population front and reduce potential propagule pressure on the EDBS. In addition to those core goals, the MRWG Detection and Removal Work Group leads identified several future priorities, including gaining a better understanding of invasive carp abundance and distribution in Dresden Island Pool, assessing how invasive carp species respond to removal at multiple scales, and identifying locations or pools where harvest can have the greatest impact on invasive carp populations. Long-term harvest data provides information necessary to model changes in invasive carp relative abundance and population demographics among pools of the Upper IWW in response to management actions. This project will continue to directly inform multiple MRWG work groups (Detection and Removal), and objectives will continue to be adapted by work group leads to better accomplish overall MRWG priorities. Contracted commercial fishing is a critical tool in managing invasive carp populations, and we recommend this program continue in 2024.

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INVASIVE CARP ENHANCED CONTRACT REMOVAL PROGRAM

Participating Agencies: ILDNR (lead); USEPA and GLFC (project support)

MRWG Work Group: Removal

Pools Involved: Peoria, La Grange, Alton

INTRODUCTION AND NEED

The ICRCC and MRWG recognize the value of increased harvest of invasive carp in the Illinois River, informed by current fishery stock assessment data. Modeling efforts have provided insights, recommending that removal from downstream reaches can heighten the protection of the Great Lakes by preventing fish population growth upstream.

OBJECTIVES

- Aid in reaching a target removal rate of 20 to 50 million pounds of invasive carp per year from the IWW below Starved Rock L&D.
- Remove 6 million pounds of invasive carp under the Enhanced Contract Fishing Program by December 31, 2024, while working toward removing 8 million pounds cumulatively by December 31, 2025.
- Coordinate fishers and processors to increase cooperation with an end goal of increasing the scale of removal operations to satisfy larger orders for harvested invasive carp.
- Leverage other programs, such as the Market Value Program, to continue building increased demand for harvested invasive carp.
- Leverage the new Copi brand launch toward increased removal.

PROJECT HIGHLIGHTS

- Removed more than 6.3 million pounds under this program from the Peoria, La Grange, and Alton pools of the Illinois River in 2024.
- Removed 26.7 million pounds under this program since its inception in 2019.
- Entered into 49 contracts with Illinois-licensed commercial fishers targeting the Peoria, La Grange, and Alton pools.
- Processed over $633,000 in payments to fishers.
- Continued work to support the Copi brand, with increased domestic and international interest and development of new value-added products using the brand.

MODELING WORK GROUP PROJECTS

- USGS Invasive Carp Database Management and Integration Support
- Support for Invasive Carp Population Modeling in the Illinois River

USGS INVASIVE CARP DATABASE MANAGEMENT AND INTEGRATION SUPPORT

Participating Agencies: USGS (lead); ILDNR; INHS; USFWS; USACE; SIU; Aaron Murphy, Marybeth Brey, Matthew Walker (USGS-UMESC)

MRWG Work Group: Modeling

Pools Involved: N/A

INTRODUCTION AND NEED

Invasive carp tracking, monitoring, and contracted removal will continue throughout the Illinois River and upper Mississippi River as part of an adaptive management effort to mitigate, control, and contain invasive carp. To facilitate these actions, a need to compile and analyze invasive carp-related data from all agencies exists. Invasive carp-related data include all data sources that could inform the MRWG objectives or projects. These data, often in disparate formats, must be integrated into a common format that allows all agencies the opportunity to assess invasive carp monitoring, control, and removal efforts. Ensuring the interoperability of these datasets allows for their use in various analyses and modeling efforts. Implementing an interoperable data management framework provides mechanisms for end-users to find and use integrated data. Integrating data for use in modeling and analysis furthers the partnership's collective understanding of invasive carp life history, distribution, and movement and can be used to facilitate adaptive management actions (e.g., directing monitoring, sampling, and removal efforts, assessing invasive carp abundance to support modeling efforts, informing deployment of control actions, etc.). An effective data management strategy will streamline the data update process, providing all agencies with timely data and analyses in support of informed decision-making processes.

OBJECTIVES

- Provide data management, informational products, and decision support tools for scientists and managers to aid and inform the management and removal of invasive carp in the IWW.
- Integrate and transform invasive carp-related datasets into actionable information.
- Develop and maintain the RAFT Network, CarpDAT, Invasive Carp Open Data Hub, and ILRCdb applications to facilitate partner (e.g., Modeling Work Group, Telemetry Work Group, etc.) objectives via data compilation, management, and summarization.
- Support modeling efforts to inform management decisions by making data findable, accessible, interoperable, and reusable.

PROJECT HIGHLIGHTS

Riverine Acoustic Fish Telemetry (RAFT) Network

- Partnered with Ocean Tracking Network as a node. Acquired OTN data schema and QA/QC Python notebooks for data integration.

- Incorporated Login.gov authentication requirements into .NET application framework.
- Developed role-based access for project, personnel, and data management.
- Designed front-end of RAFT, including homepage, transmitter lookup, receiver map, and FAQ. Incorporated US Web Design System components to meet federal requirements.
- Used Python notebooks to QA/QC data from USGS, USACE, and USFWS. Began uploading data to the database. Incorporating all legacy projects and onboarding new projects.
- Completed various bug fixes, optimization, and testing after soft launch in October 2024 and initial round of feedback. Undergoing second round of feedback in March 2025.
- Began developing data download for tags, receivers, and detections summaries as well as process for creating and delivering matched detection extracts.
- Drafted new data policy with the Office of Policy and Analysis to share with partners and users.

CarpDAT (Data, Analysis, Tools)

- Signed MOU with USFWS to continue development of CarpDAT.
- Presented plan for CarpDAT to USFWS Requirements Management Board.
- Designed updated format for CarpDAT using ScienceBase Community.
- Began process of collecting data with USFWS partners.

Invasive Carp Open Data Hub

- Peer review completed and reconciled.
- Hub contains 245 publications, documents, spatial datasets, images, and maps, including bathymetric, benthic, and hydroacoustic data.
- New additions are being cataloged and quarterly updates are planned.
- Hub published at https://geonarrative.usgs.gov/invasivecarpopendatahub/.

ILRCdb

- Maintained access to database.
- Discussed future development needs with Illinois partners.

METHODS

The RAFT Network, formerly FishTracks, is a web-based, centralized location to access, archive, and visualize fish acoustic telemetry data for the Mississippi River Basin. RAFT is an ASP.NET web application linked to a PostgreSQL database. Development of an acoustic telemetry database started at SIU in 2009 using Microsoft Access, and eventually grew into a USGS-managed web application called FishTracks. The FishTracks application was renamed RAFT to avoid infringing on a copyrighted application. In 2024, the application was redesigned to meet updated information technology requirements and support long-term maintenance.

CarpDAT is expected to act as a web-based, centralized location to house data, metadata, and references to facilitate the transfer of knowledge between invasive carp researchers and management agencies. The USGS and USFWS have signed an MOU between agencies to define roles and responsibilities moving forward.

The Invasive Carp Open Data Hub is an ArcGIS Hub to share data and reports from USGS invasive carp research and inform future research and management. The ILRCdb is a database based on the structure of the Long-Term Resource Monitoring database, and developed for invasive carp catch data from ILDNR and INHS.

RESULTS AND DISCUSSION

In 2024, the RAFT web application was upgraded to meet new security (Login.gov) and UI/UX (U.S. Web Design System) requirements. As part of this update, UMESC chose to partner with the OTN as their first riverine node. The OTN supports the development of acoustic telemetry projects internationally with data management and data standardization expertise. Specific features developed include: (1) role-based security access for projects and personnel, (2) a transmitter lookup tool, and (3) an integrated receiver map with filters. Standardized Python notebooks were used to QA/QC data from USGS, USACE, and USFWS prior to uploading to the database. Development was started on tools to allow download of data and delivery of detection extracts.

The CarpDAT system will provide researchers and managers with a centralized location to find invasive carp data and information. During 2024, USGS and USFWS created and revised plans to develop and deploy a metadata catalog and a structured invasive carp demographics database. Work in 2025 will focus on adding entries describing invasive carp data to a metadata catalog structured around a ScienceBase Community with potential linkage to the Invasive Carp Open Data Hub. The creation of a demographics database will begin with a data collection form and the development of the database framework.

The USGS Invasive Carp Open Data Hub was published in 2024 and is available to the public and invasive carp researchers. The GIS lab at UMESC will deploy quarterly updates to add new data, publications, and tools. GIS lab interns will also support the development of new features embedded in the Hub.

Invasive carp monitoring and removal data from the Illinois River continued to be collected by partner agencies in 2024. Data collection protocols similar to the sampling approach used by the LTRM element of the Upper Mississippi River Restoration Program and the FISH app were used. New data will be added to the ILRCdb as appropriate, and discussions about the long-term maintenance and support of the database are ongoing with partners in Illinois and the MRWG.

SUPPORT FOR INVASIVE CARP POPULATION MODELING IN THE ILLINOIS RIVER

Participating Agencies: USFWS Carterville FWCO (lead), USFWS La Crosse FWCO, USGS–UMESC, and ILDNR

MRWG Work Group: Modeling

Pools Involved: Alton, La Grange, Peoria, Starved Rock, Marseilles, Dresden Island, Brandon Road, Lockport; the lower Kankakee and Des Plaines rivers.

INTRODUCTION AND NEED

The goal of this project is to develop objective, data-driven tools in support of the adaptive management process and invasive carp control efforts. To accomplish this goal, this project focuses on developing novel quantitative tools, such as a SCAA model, to address questions regarding the effects of contracted removal efforts on the status of invasive carp populations, as well as maintaining predictive simulation-based models designed to address emerging management questions (i.e., the SEICarP model). These simulation-based and assessment tools can be used in concert to iteratively develop new management targets based on the current assessment of the invasive carp population. In addition to population-level models such as the SCAA and SEICarP models, this project seeks to develop quantitative tools to help inform efficient sampling protocols for understanding invasive carp presence and distribution in areas where they are assumed to be in low abundance (i.e., the Upper Illinois River).

To better understand the effectiveness of removal efforts at reducing the Illinois River invasive carp population, the modeling work group plans to develop a SCAA model following the recommendations of Bence and Brendan (ICRCC 2022). SCAA models are a flexible stock assessment method that can use information from fisheries-dependent catch-at-age and a variety of other data sources (e.g., fishery-independent indices of abundance) to estimate the abundance, biomass, and fishery characteristics of age-structured populations through time. Currently, age data for invasive carps harvested through contracted and commercial fishing are insufficient to support a SCAA model and although this type of model can be used to generate estimates for their biomass and fishing mortality rates, which will allow us to estimate the proportion of invasive carp biomass removed by contracted fishing every year, interim analyses will be necessary while additional data are collected.

A length-based Bayesian analysis is a less robust alternative to a SCAA model that can help the MRWG understand the status of the invasive carp population in the upper Illinois River while data to support the SCAA model are being collected. This model uses only length data from contracted and commercial harvest and a series of fisheries equations to estimate the status of a population by comparing the ratio of exploited to unexploited biomass of the population and the ratio of fishing to natural mortality.

In addition, understanding the sampling effort that is necessary to detect rare species of fish (i.e., invasive carps in the upper portions of the Illinois Waterway) is critical to efficient sampling designs. Occupancy models and rarefaction analyses are two methods of examining the likelihood that a survey may encounter a species of interest. Occupancy models work by using presence/absence data for the species of interest to determine the probability that that species will be detected by survey gears if it is present in the sampling location. Rarefaction analysis, in contrast, uses fish community data to determine sample completeness and species richness and can, therefore, be used to understand if a survey is detecting the majority of species present at a site, or not. These analyses can be used in conjunction with one another to understand if sampling efforts are appropriate, excessive, or insufficient.

OBJECTIVES

- Use the SEICarP model to examine the effects of including a connection between the Mississippi and Illinois rivers on the effectiveness of potential management actions (harvest and deterrent placement) for reducing the Illinois River invasive carp population.
- Begin collecting fisheries-dependent demographic data for invasive carp to support the development of a SCAA model for the Illinois River invasive carp population.
- Develop a length-based Bayesian model to better understand the status of the invasive carp population in the Upper Illinois River.
- Develop an occupancy model and rarefaction analysis to better understand if current early detection efforts for invasive carp in the Upper Illinois River are sufficient, or if additional effort is necessary to better ensure detection of invasive carp.

PROJECT HIGHLIGHTS

SEICarP

- Simulations with low, medium, and high transition probabilities from the Mississippi River to the Illinois River (and vice versa) were developed:
  - Results suggest that harvest of invasive carp from the downstream pools (Alton – Peoria pools; source population) remains more effective than harvest from upstream pools (Starved Rock – Dresden Island pools; sink population) at reducing the Dresden Island population.
- Including a connection to the Mississippi River decreases the efficacy of removal efforts (i.e., a larger proportion of the metapopulation needs to be removed to achieve similar reductions in the Dresden Island invasive carp population when not including a connection to the Mississippi River).

SCAA Model

- Implemented sampling plan for fisheries-dependent demographic data collections (including age structures).
- Demographic data were collected from up to 200 individual Silver Carp captured through contracted and commercial fishing from each pool (Alton – Dresden Island pools) of the Illinois River. The final sample size ranged from N = 89 in Dresden Island pool to N = 197 in both Starved Rock and Alton pools.

Length-Based Bayesian Analysis

- A length-based Bayesian analysis was developed to better understand the status of the Silver Carp population in the Upper Illinois River (Starved Rock – Dresden Island pools) using length data from the contract and commercial harvest of Silver Carp (2012 – 2023).
    - Preliminary model results indicate that the ratio of the exploited biomass to the unexploited biomass is greater than the biomass at maximum sustainable yield indicating that the population is not overfished.
- In addition, the ratio of fishing mortality to natural mortality is less than one, indicating that overfishing is not occurring.

Occupancy Model

- An occupancy model was developed to better understand the sampling focused on the early detection of invasive carps in the Upper IWW (Marseilles L&D – Lower Des Plaines River and the CAWS).
- The results suggest that boat electrofishing and dozer trawl have a high probability of detecting invasive carps when they are present, whereas gill and mini-fyke nets have considerably lower detection probabilities.
- The results also suggest that Marseilles Pool is likely oversampled, whereas the upper areas (Brandon Road and Lockport pools and the Des Plaines River) are likely under sampled.

Rarefraction Analysis

- A rarefaction analysis was developed to better understand sample completeness and species richness in the Upper IWW (Dresden Island – Lockport pools).
- Preliminary results (based on dozer trawl data from 2021) suggest that sampling is sufficient in the Brandon Road Pool and the Kankakee River, but the Dresden Island and Lockport pools were under sampled.

FUTURE WORK

- Following discussions with the Telemetry Work Group, complete additional SEICarP simulations to examine the effects of a Mississippi River connection on the efficacy of management measures.
- Collaborate with the Telemetry Work Group to understand movement to and from the Mississippi River and net movement between the upper and lower portions of the Illinois River.
- QA/QC and harmonization of fisheries-dependent demographic data with harvest data to support the SCAA model.
- Continue collecting fisheries-dependent demographic data in support of the SCAA model.
- Continue discussions within the MRWG to determine the best way to address additional needs of the SCAA model such as understanding temporal variability in:

  - Natural mortality,
  - Stock-recruit relationship, and
  - Net migration between upper and lower Illinois River.
- Examine the sensitivity of the length-based Bayesian model to the maximum theoretical length of an individual (Linf) to determine if manually inputting Linf is feasible and how that might impact the results of the analysis.
- Develop a length-based Bayesian analysis for the lower Illinois River as length data from commercial harvest become available.
- Complete the occupancy models and disseminate the results.
- Continue the rarefaction analysis with additional years of data and gear types.

REFERENCES

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BEHAVIORAL DETERRENTS WORK GROUP

- Field Testing of an Underwater Acoustic Deterrent System in a Marseilles Pool Gravel Pit on the Illinois River

FIELD TESTING OF AN UNDERWATER ACOUSTIC DETERRENT SYSTEM IN A MARSEILLES POOL GRAVEL PIT ON THE ILLINOIS RIVER

Participating Agencies: USGS-UMESC (lead), USACE ERDC (co-lead), ILDNR, USACE – Chicago District, SIU (data-sharing, telemetry support); Mark Roth, Marybeth Brey, William Lamoreux, Todd Johnson, Dan Krause, and Jose Rivera (USGS); Christa Woodley, Aaron Urbanczyk, and Henry Hershey (ERDC)

Location: Heidelberg Materials gravel pits in the Marseilles Pool of the Illinois River near Morris, Illinois.

MRWG Work Group: Behavioral Deterrents

Pools Involved: Marseilles

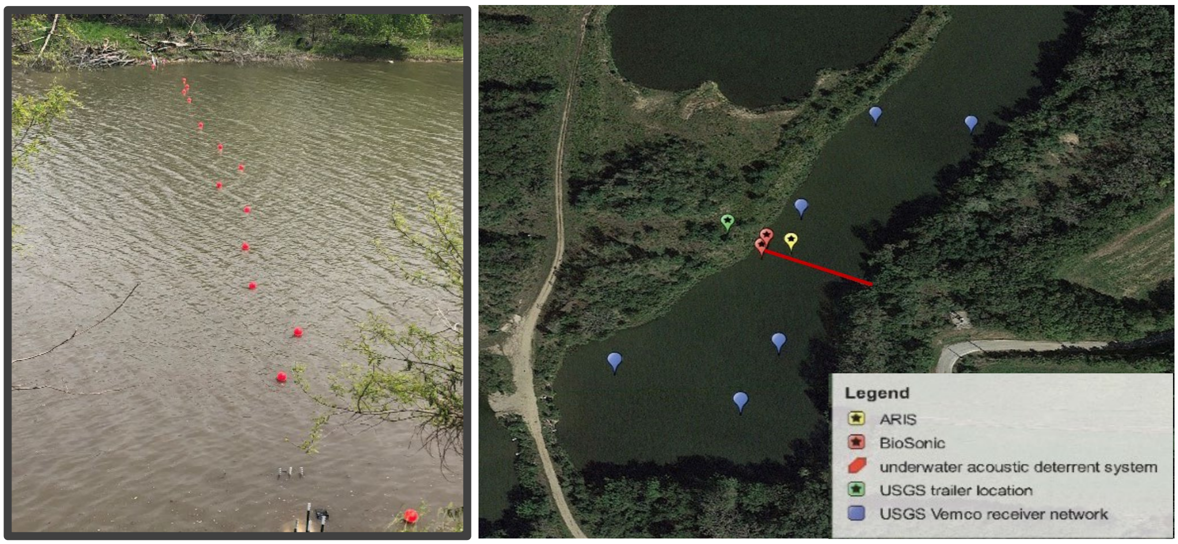
INTRODUCTION AND NEED

Acoustic deterrent technologies are being developed to prevent the spread of invasive carp (Bighead Carp, Silver Carp, Grass Carp, and Black Carp) from the Mississippi River watershed to the Great Lakes. To assess this technology, field testing of the deterrent equipment and newly developed sound stimuli on wild invasive carp populations is essential. Large-scale experimental deployments and testing of uADS are currently installed or proposed at multiple locks and dams. However, there has been limited use or testing of underwater acoustic deterrents in smaller areas where lock infrastructure does not exist (e.g., side channels and backwaters). These more natural areas have important characteristics that differ from hard-structured locks and dams, such as soft substrate, flashy flow conditions, shallow or variable water depth, and inconsistent bathymetry/bottom elevation.

Testing newly developed sound stimuli as deterrents to invasive carp movement should occur at sites where invasive carp are abundant and naturally move. Water depths should generally be greater than 2 meters, and access to electricity should be available to operate the uADS and monitoring equipment to facilitate effective sound propagation. These criteria are met at the Heidelberg Materials, formerly known as Hanson Material Services, gravel pits on the Illinois River near Morris, Illinois. In addition, historical telemetry data and contract catch information are available for this location. Coarse-scale fish behavior (i.e., presence or absence in the Hanson Material pits) has been monitored by SIU, USGS, and the USACE since 2012.

To test an installed uADS on resident Silver Carp and Bighead Carp, the USGS-UMESC and the USACE ERDC deployed an underwater speaker array and acoustic monitoring equipment in mid-2021 (Figure 1). Fish behavior has been monitored with Innovasea (69-kilohertz) acoustic telemetry since April 2021 and with stationary BioSonics DTX split-beam transducers (hereafter, BioSonics) and ARIS 3000 multibeam imaging sonar (hereafter, ARIS) most weeks from mid-April until November in 2021 and 2022.

Figure 1. *Left – Image of* u*ADS with speaker locations marked by buoys. Right – Location of the research site on the Illinois River, including the research trailer (green dot),* u*ADS (red line), ARIS 3000 multibeam imaging sonar (ARIS, yellow dot), BioSonics DTX split-beam transducers (BioSonics; red dots), and the original six Innovasea VR2Tx acoustic telemetry receivers that make up the core VPS array (blue dots).*



OBJECTIVES

- Summarize available telemetry data for the HM gravel pits in collaboration with SIU and other ICRCC MRWG partners to assess the natural movement and distribution of fish around the uADS.
- Experimentally assess Silver Carp and Bighead Carp deterrence or passage during cyclic operation (*on* vs. *off*) of the experimental uADS. The uADS will operate on an 80-hour *on*, 80-hour *off* schedule throughout the year.
- Assess fish passage (i.e., movement across the uADS) relative to uADS operation (i.e., *on*/*off*) and environmental conditions (e.g., water depth, temperature, and discharge).
- Evaluate behavioral responses (e.g., number of fish detections, fish swim direction, probability of approaching and moving through the uADS) of Silver Carp, Bighead Carp, and resident native fish using multiple gears (e.g., acoustic telemetry, underwater cameras, or transducers).
- Evaluate the long-term environmental and operational effects on the performance and function of the uADS (i.e., speaker array) and supporting equipment.

PROJECT HIGHLIGHTS

From 2019 to 2023, 201 Silver Carp and two Bighead Carp were implanted with acoustic telemetry transmitters in the HM pits specifically for this project. These fish contribute to the greater Telemetry Work Group of the ICRCC MRWG objectives and ensure adequate numbers of tagged fish are available to monitor fish behavior and passage across the uADS for this study. The uADS was fully operational from the spring of 2021 through the fall of 2023. In November 2023, the uADS was disassembled and removed from the water. However, the telemetry array will continue to operate during 2024 to monitor the post-deterrent movement of tagged fish in the area.

METHODS

The uADS consists of 16 underwater speakers (LL916C; Lubell Labs Inc., Columbus, Ohio) installed just off the substrate, perpendicular to water flow, across the width of the channel (Figure 2). The uADS operates on an 80-hour *on*, 80-hour *off* loop of ERDC-engineered signals (i.e., plays the same stimuli continuously for 80 hours). The signals and schedule are the same as those operating at Lock 19 on the Mississippi River (Brey et al. 2023). Speaker output is monitored and recorded using underwater hydrophones (SoundTrap ST500; Ocean Instruments, New Zealand). Audio files from these hydrophone recordings will be assessed for signal content, SPL_{rms} (dB re 1 µPa), power spectrum density for the full generated signal, and more specifically to determine if acoustic signals are within the desired range of Silver Carp and Bighead Carp hearing. Hydrophone recordings will also be used to determine ambient and other aberrant signals that occurred near or during the time Silver Carp and Bighead Carp approach and cross over the uADS (e.g., boats or fishing in the area).

Figure 2. *Locations of USGS Innovasea receivers within HM gravel pits near the Illinois River that flows along the top of the image.*

The primary mechanism for assessing changes in fish behavior is with acoustic telemetry, specifically, 13 Innovasea (Innovasea, Inc., Boston, Massachusetts) VR2Tx receivers and two reference tags. Six receivers are deployed within line-of-sight of the uADS and make up the "Vemco Positioning System" (VPS) needed to assess the fine-scale fish movements. An additional seven receivers are stationed outside the original VPS array. These seven receivers are used to detect fish in the area (i.e., presence/absence), but they are not in locations that allow for fine-scale positions to be resolved. The effect of uADS operation (i.e., *on/off*) on fish behavior will be assessed using the VPS data, with additional analysis incorporating possible effects of changing environmental conditions.

Sonar equipment was used to further assess fish behavior and movement of tagged and untagged fish in the proximity of the uADS. An ARIS set to 1.1-megahertz frequency and two BioSonics were deployed seasonally starting in 2021. BioSonics were placed on either side of the uADS looking across the channel from the west bank to the east bank. (Figure 1). The ARIS has a field of view that is much more limited; because of this, it was situated to view across the uADS at an angle between two speakers toward the middle of the channel from northwest to southeast (Figure 1). ARIS and BioSonics data will be post-processed using Echoview (Version 14, Echoview Software Pty. Ltd.) to quantify fish targets, obtain total length estimates, and determine the direction of travel. Potential changes in the number of fish detections, fish swim direction, and fish size distribution will be compared for a subset of times when the UADS is *on* or *off*. BioSonics and an ARIS were only deployed in 2021 and 2022. BioSonics and ARIS systems were not redeployed in 2023 due to persistent equipment failures in both 2021 and 2022.

RESULTS AND DISCUSSION

A total of 201 Silver Carp and two Bighead Carp were surgically implanted with 69-kilohertz acoustic telemetry transmitters by the USGS and ERDC in the HM pits as part of this project between October 22, 2019, and April 12, 2023. Thirty-eight Silver Carp were tagged on October 22, 2019, 40 Silver Carp were tagged on May 23, 2021, and 50 Silver Carp were tagged on April 12, 2022. Seventy-three Silver Carp and two Bighead Carp were tagged on April 11 and 12, 2023. These fish contribute to the greater MRWG Telemetry Work Group objectives by ensuring sufficient fish are tagged to adequately monitor fish behavior and passage across the uADS for this study.

In 2022 and 2023, we achieved consistent uADS operation and fish positions using the VPS array. This project operated through 2023 to add one more complete year of data collection for the analyses. During 2022, a total of 124 fish, of which 83 were tagged by USGS, were detected in the larger USGS Innovasea receiver network within HM gravel pits (Figure 2). In 2023, 164 fish, of which 143 were tagged by USGS, were detected in the larger USGS Innovasea receiver network within HM gravel pits. The VPS will continue to operate during 2024.

In 2022, the Innovasea receivers in the East Pit around the uADS detected 58 individual Silver Carp, of which 49 were tagged by USGS. Of those 58 individuals, fine-scale positioning was achieved for 19 of them. Two additional Innovasea receivers and two reference tags were placed within the VPS array (for a total of six receivers around the UADS) to allow for better fish positioning in 2023. In 2023, 72 individual invasive carp, of which 71 (70 Silver Carp and one Bighead Carp) were tagged by USGS, were detected around the uADS. Of those 72 individuals, fine-scale positioning was achieved for 25 of them. The larger

Innovasea 69-kilohertz receiver array and the VPS array will continue to operate through 2024 to monitor post-deterrent fish movement. Additional data analysis is ongoing.

In 2022, the BioSonics system generated 1,281 hours of data (approximately 54 days). The ARIS system generated 1,650 hours (approximately 65 days) of data. There were approximately 39 days of overlap in 2022, where both the BioSonics and the ARIS were fully operational. In 2023, the BioSonics and the ARIS systems were not deployed. Additional data analysis is ongoing, and a manuscript is expected in 2024.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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BLACK CARP WORK GROUP PROJECTS

- Enhanced Detection of Black Carp in the Lower Illinois River
- Data Collection from Commercial Fishers and Recreational Angler Captures of Black Carp in the Lower Illinois River

ENHANCED DETECTION OF BLACK CARP IN THE LOWER ILLINOIS RIVER

Participating Agencies: INHS (lead), ILDNR

MRWG Work Group: Black Carp

Pools Involved: La Grange, Alton

INTRODUCTION AND NEED

Black Carp have invaded the Illinois River system and have been recently captured in the Alton, La Grange, and Peoria reaches of the lower Illinois River. Currently, the invasion of Black Carp is represented by only a few reported individuals, and little is known about the size of the population or potential scope of ecosystem changes that may result from the invasion. ILDNR has been closely monitoring the range expansion of Black Carp up the Illinois River, despite limited catches reported to date.

Critical to any inferences made about the range expansion of Black Carp is better knowledge of their population levels in invaded reaches. The limited number of Black Carp reported have been from incidental commercial fishermen catches while targeting other species (e.g., Bighead Carp, Silver Carp, Common Carp, Grass Carp, buffalo spp., catfish spp.). These captures and associated data (e.g., length, weight, age, diet) are valuable, but the limited number of reported individuals makes it difficult to assess their prevalence/establishment in the lower Illinois River. More robust estimates of the current population level are essential to manage and potentially control Black Carp in the Illinois River.

Our sampling approach used hoop nets baited and non-baited with experimental baits to assess the population of Black Carp in the lower Illinois River and efficacy of different baits to collect them. In the La Grange and Alton reaches of the Illinois River, we expanded upon the existing Upper Mississippi River Restoration Program's LTRM standardized hoop netting efforts to make comparisons using experimentally baited and non-baited hoop nets to target Black Carp to better detect their presence, abundance, and expansion up the lower Illinois River. This expansion, in conjunction with existing LTRM and MAM hoop netting efforts, allowed for comparisons between standardized hoop nets baited with soybean and hoop netting using clam-based, cottonseed-based baits, and non-baited nets. Additionally, all non-target fishes captured were identified, measured, weighed, and enumerated. All Black Carp captured were measured, weighed, and carcasses distributed to the proper agency(s) for further study of life history (age, diet, origin, etc.).

OBJECTIVES

- Monitor for the presence and abundance of Black Carp in the Alton and La Grange reaches of the Illinois River.
- Improve catchability while minimizing efforts for acquiring Black Carp.
- Determine the most effective bait to capture Black Carp using baited (cottonseed and clam baits) and non-baited hoop nets.
- Provide other projects and agencies (e.g., USGS-CERC, ILDNR, INHS, etc.) with necessary Black Carp abundance and distribution to inform management decisions.

PROJECT HIGHLIGHTS

- In 2024, completed 66 paired hoop nets baited with cottonseed-based baits, 66 baited with clams, and 66 un-baited paired hoop nets within the La Grange and Alton Reaches of the Illinois River.
- No Black Carp were captured during these efforts; three captures were made by commercial fishermen within the Lower Illinois River during 2024.
- Sampling sites were re-stratified using known black carp habitat preferences (e.g., water depth >12 feet, outer bends, within 300m of known mussel beds) to increase the likelihood of capture success.

METHODS

Sampling design was created based on standardized protocols outlined by the LTRMP Procedures (Ratcliff et al. 2014) using paired large and small baited hoop nets. Hoop nets were baited with Atlantic Surf Clams, cottonseed, and no bait. Sampling sites were reclassified for main channel and side channel habitats following a stratification created in conjunction with USGS-UMESC and USGS-CERC) to create a Black Carp sampling design likely to increase probability of capture. Known habitat preference of Black Carp narrowed site selection down to areas with greater than 12 feet water depth, or outer bends within the strata, or within 300 meters of historical mussel beds. Sampling was conducted within the La Grange and Alton Reaches of the Illinois River using this redesigned classification framework following LTRM sampling time periods with bait type per site being randomly chosen with an equal number of sites per period of each bait type.

RESULTS AND DISCUSSION

The total sampling effort included 396 hoop nets (792 hoop net nights) within the La Grange and Alton reaches in 2024. A total of 1,246 fishes were captured representing 27 species and one hybrid species. Channel Catfish represented the largest proportion of catch (27.4 percent; n = 341) with Freshwater Drum following (25.1 percent: n = 313) and Flathead Catfish (10.9 percent: n = 136) as the third most frequent capture. No Black Carp were captured, but Silver Carp (n = 50), Bighead Carp (n = 11), and two hybrid Silver x Bighead Carp were captured. Additionally, there were 250 turtles captured representing six species. Spiny Softshell (64 percent: n = 160) and Red-eared Slider (29.6 percent: n = 74) were the most frequently captured turtles.

Table 1: *Hoop net total fish catch by bait type from Alton and La Grange reaches of Illinois River June 15-October 31, 2024.*

Species	Clam	Cottonseed	No Bait	Total
American Eel	1	0	0	1
Bighead Carp	7	1	3	11
Bigmouth Buffalo	2	1	0	3
Black Buffalo	0	0	1	1
Black Bullhead	0	1	0	1
Black Crappie	9	13	10	32
Blue Catfish	7	1	3	11
Bluegill	3	6	11	20
Channel Catfish	182	90	69	341
Common Carp	10	44	20	74
Flathead Catfish	20	24	92	136
Freshwater Drum	82	117	114	313
Gizzard Shad	3	1	0	4
Grass Carp	5	3	3	11
Longnose Gar	0	1	2	3
Pumpkinseed	0	0	1	1
River Carpsucker	2	3	0	5
Sauger	0	1	0	1
Shorthead Redhorse	5	4	4	13
Shortnose Gar	7	6	4	17
Silver Carp	29	11	10	50
Silver x Bighead Carp	1	0	1	2
Slender Madtom	2	0	0	2
Smallmouth Buffalo	5	87	5	97
Walleye	0	1	0	1
White Bass	14	33	22	69
White Crappie	7	10	5	22
Yellow Bass	1	2	1	4
Total	**404**	**461**	**381**	**1,246**

Table 2: *Hoop net total turtle catch by bait type from Alton and La Grange reaches of Illinois River June 15-October 31, 2024.*

Species	Clam	Cottonseed	No Bait	Total
False Map	2	0	0	2
Northern Map	3	0	0	3
Ouachita Map	9	0	0	9
Red-eared Slider	67	2	5	74
Smooth Softshell	2	0	0	2
Spiny Softshell	142	11	7	160
Total	**225**	**13**	**12**	**250**

RECOMMENDATIONS

We recommend continued sampling to monitor the presence and abundance of Black Carp in the lower Illinois River at their invasion front. This project will continue to directly inform multiple MRWG work groups (Black Carp and Detection) and continue to be adapted to increase catchability and detection of Black Carp in the lower Illinois River to better accomplish management strategies and MRWG priorities.

REFERENCES

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

DATA COLLECTION FROM COMMERCIAL FISHERS AND RECREATIONAL ANGLER CAPTURES OF BLACK CARP IN THE LOWER ILLINOIS RIVER

Participating Agencies: ILDNR (lead), USGS, USFWS, and contributing state resource agencies of the Mississippi River basin

MRWG Work Group: Black Carp

Pools Involved: Entire length of the Illinois River

INTRODUCTION AND NEED

Since the importation of Black Carp to the U.S., escapes into the wild have been documented, and reproducing populations are present in the Mississippi River basin with increasing reports. The greatest concern from Black Carp population expansion is the impact on native mussel and snail fauna, of which many species are already listed as threatened or endangered. In 2015, the state of Illinois initiated a Black Carp Citizen Science Program to encourage reporting of Black Carp captures following initial reports from Illinois and adjacent state waters. Over time, this program developed into the primary mechanism for monitoring the relative rate of incidental Black Carp captures and the species' distribution in the Illinois and Mississippi rivers.

OBJECTIVES

- Coordinate with external partners, including Illinois River and Mississippi River commercial fishers, to document the distribution of Black Carp within the Illinois River, providing up-to-date data on captures to the public and resource managers through the USGS Non-Indigenous Aquatic Species database (USGS-NAS; Nico et al. 2025).
- Gather demographic data such as length, weight, and age to track population status and provide samples that may contribute to later research on subjects such as species longevity and cohort strength.

PROJECT HIGHLIGHTS

- Public engagement (primarily with commercial fishers) through various forms of outreach have occurred since the 2015 initiation of the Illinois Citizen Science Program.
- From 2015-2024, whole Black Carp were reported, captured, and shipped overnight on ice to the USGS-CERC or SIU for collection of biological data paired with the capture data to address research questions such as potential ecological effects of Black Carp through diet (Poulton et al. 2019), the species status (Whitledge et al. 2022), and methods of reported captures (Kroboth et al. 2019; Kroboth et al. 2025).

METHODS

In 2024, the Illinois Black Carp Citizen Science Program transitioned from a research emphasis to monitoring with the desire to continue to receive the capture and demographic data for population monitoring. Prior methods of receiving and documenting captures were continued until September 2024, when a simplified sampling approach was adapted that consisted of documenting each commercial capture with collection of images of the whole fish, total length, weight, sex, location, and calcified structures (lapilli otoliths and/or the anterior dorsal fin rays) for age estimation. The whole Black Carp is no longer shipped for processing. Leadership for the documented receipt of structures, capture data, and species validation for each record transitioned to the USFWS Columbia FWCO in October 2024. All records received throughout the year are still documented and served online to the public and resource managers through the USGS-NAS database.

RESULTS AND DISCUSSION

In 2024, there were 128 total Black Carp records reported to the USGS-NAS representing 132 individual Black Carp. This reporting rate is relative to immediately prior years of 2022 and 2023 (Figure 1). In 2019-2020, there was increased catch and reporting from the earlier years of the program as outreach and word-of-mouth among fishers increased awareness. It should also be noted that in 2017 and 2018, USGS-CERC directly engaged commercial fishers in the lower Mississippi River in Arkansas, Louisiana, and Mississippi to provide samples from the species initial range of research, these years have inflated reporting rates compared to later years. Within Illinois waters, there were 89 Black Carp reported in 2024 with three fish reported from the Alton Pool of the Illinois River near Montezuma, IL (Figure 2). The furthest upstream record in the Illinois River is still the April 2023 record downstream of Hennepin, IL (Nico et al. 2025).

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Whitledge, G. W., Kroboth, P. T., Chapman, D. C., Phelps, Q. E., Sleeper, W., Bailey, J., and Jenkins, J. A. in press. Establishment of Invasive Black Carp (Mylopharyngodon piceus) in the Mississippi River Basin: Identifying Sources and Year Classes Contributing to Recruitment. Biological Invasions 24: 3885–3904.

Figure 1. *The frequency of Black Carp records within the USGS Non-Indigenous Aquatic Species Database from first documented escape and detection until 2024. Note that the first documented escape shown here is representative of the reported escape only and that use during this time was widespread within aquaculture in the lowest extent of the Mississippi River.*

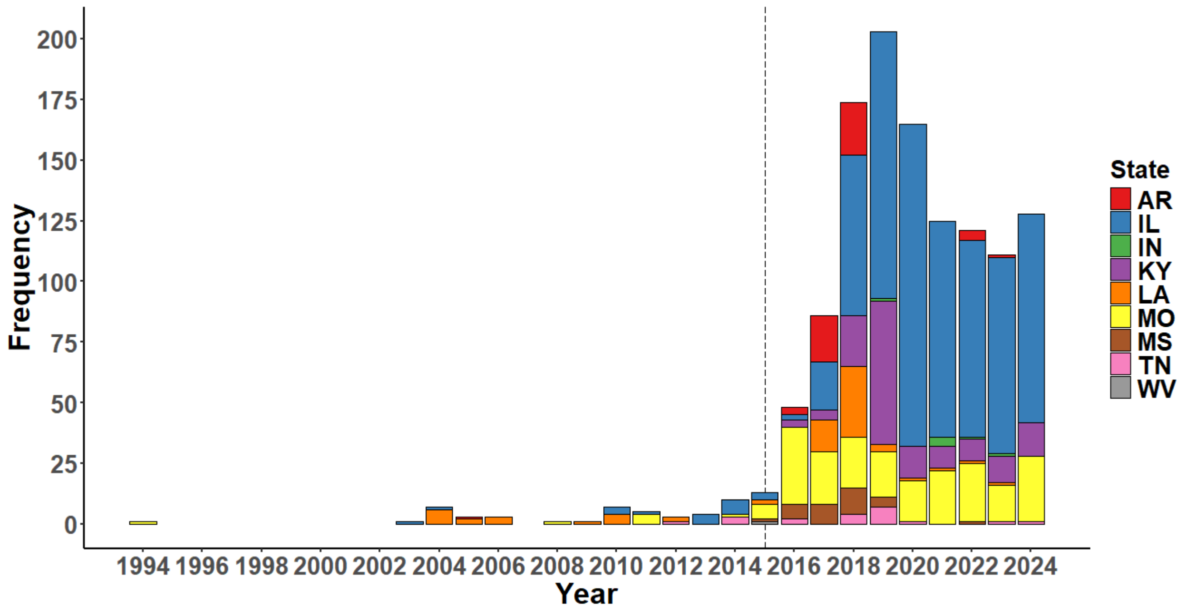
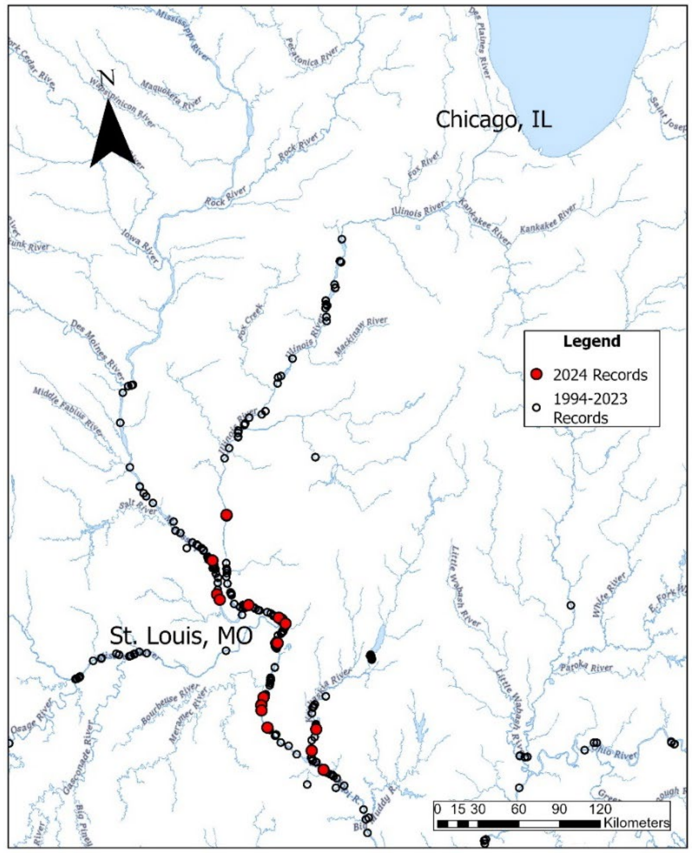


Figure 2. *The distribution of Black Carp in the Illinois River from 1994-2024 records. The subset of records received in 2024 within this range are highlighted in red.*



APPENDIX A
ZOOPLANKTON AS DYNAMIC ASSESSMENT TARGETS FOR INVASIVE CARP REMOVAL

Participating Agencies: INHS (lead); SIUC (field and lab support); Joseph J. Parkos III, Steven E. Butler, Dakota S. Radford, Anthony P. Porreca, Kristopher A. Maxson, Michael J. Spear, Brandon S. Harris, James T. Lamer (INHS), Cameron L. Davis, Joseph L. Mruzek, James E. Garvey (SIUC)

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange

INTRODUCTION AND NEED

Due to their ability to efficiently filter large volumes of water and capture small particle sizes, Bighead Carp and Silver Carp can deplete zooplankton densities and alter zooplankton community composition (Sass et al. 2014; DeBoer et al. 2018; Hochstrasser and Collins 2024), potentially competing with native fishes for food resources (Schrank et al. 2003; Sampson et al. 2009) and altering flows of organic matter (Collins and Wahl 2017; Kramer et al. 2019). The trophic impact of bigheaded carp planktivory is of great concern because of the importance of zooplankton as grazers as well as prey for native planktivores and early life stages of all fishes (Sampson et al. 2009; Pendleton et al. 2017; Fletcher et al. 2019). Introductions of bigheaded carp outside of North America have been related to declines of native filter-feeding fishes and reductions in fish diversity (Spataru and Gophen 1985; De Iongh and Van Zon 1993; Sugunan 1997). In North America, several studies have suggested that bigheaded carp may negatively affect entire fish assemblages, with particularly strong effects on native planktivores (Solomon et al. 2016; Pendleton et al. 2017; Chick et al. 2020).

An aggressive invasive carp removal program has been implemented in the upper navigation pools of the IWW to limit further advances of bigheaded carp toward Lake Michigan (Tsehaye et al. 2013; MacNamara et al. 2016; Bouska et al. 2020). In addition to preventing the expansion of bigheaded carp into the Great Lakes, this removal program may also benefit native communities in the IWW by mitigating some of the ecological impacts that bigheaded carp have had on this system. Although the invasion of bigheaded carp in the Illinois River has caused demonstrable changes to fish communities (Solomon et al. 2016; DeBoer et al. 2018), there is little evidence to date that harvest of bigheaded carp has resulted in subsequent responses from native fishes (Love et al. 2018). However, zooplankton communities have been found to respond to removal of bigheaded carp from backwater habitats over short time scales (Altenritter et al. 2022), although responses at larger spatial scales have been more muted (Chará-Serna and Casper 2021). Due to their short generation times and high productivity rates, zooplankton taxa have the potential to respond quickly to bigheaded carp removal, making them potentially informative performance metrics for assessing the effectiveness of invasive carp control efforts. However, riverine zooplankton abundance and community structure are also known to vary seasonally, longitudinally, among habitats, and in response to hydrologic factors (Thorp et al. 1994; Wahl et al. 2008; Dickerson et al. 2010; Burdis and Hoxmeier 2011). Separating the influence of changing bigheaded carp abundances from the effects of background environmental factors on zooplankton communities is therefore a considerable challenge. Furthermore, zooplankton responses to bigheaded carp harvest have been found to vary among taxa (Altenritter et al. 2022), indicating that the effects of bigheaded carp removals cannot be expected to occur uniformly across the entire zooplankton community. Disentangling the combined influences of bigheaded carp and environmental factors on various zooplankton taxa will help to more thoroughly characterize the true impact of bigheaded carp on large river food webs and identify zooplankton taxa that are most informative for rapidly evaluating ecosystem responses to invasive carp harvest. Development of specific zooplankton-based assessment metrics will help management agencies quantitatively evaluate and define explicit targets for invasive carp control efforts.

OBJECTIVES

Zooplankton are being sampled throughout the IWW to:

- Quantify variation in zooplankton density, body size distribution, biomass, and community composition in the IWW;
- Assess the sensitivity of a range of zooplankton taxa to bigheaded carp density; and
- Use sensitive zooplankton taxa to develop benchmarks for evaluating the impacts of bigheaded carp control and removal efforts.

PROJECT HIGHLIGHTS

- Updated analyses using peak densities of 10 zooplankton taxa and 3 aggregate groupings observed in the IWW during 2012 – 2022 found that 5 taxa were at least moderately and negatively related to bigheaded carp density, and 2 of these were also at least moderately and positively related to native planktivore relative abundance. Comparison of control intervals with target variances suggests that the uppermost navigation pools have experienced diminished impacts of bigheaded carp for longer time periods than downstream pools, and some zooplankton taxa have yet to demonstrate any demonstrable response to changes in bigheaded carp abundances in the lower Illinois River.
- A cumulative stoplight assessment indicates that invasive carp harvest efforts began to have a detectable impact on zooplankton assemblages in the Dresden Island Pool as early as 2014 and the management goal of reducing the impact of bigheaded carp on zooplankton has been met in this pool in all but one year since 2017. Invasive carp harvest efforts have produced some mitigation of impacts to zooplankton in the Marseilles Pool since 2018, but this progress falls short of the management target. Achieving management goals based on zooplankton metrics has remained elusive in all other assessed navigation pools.
- A complete evaluation of zooplankton responses to changes in bigheaded carp density will include a full suite of potential performance metrics (peak and monthly densities and biomass of multiple zooplankton taxa) to identify what metrics prove

most informative for assessing the impact of invasive carp removals. Final evaluation, including model parameterization, metric development, and sensitivity analyses, is expected in 2025.

METHODS

Field sampling for assessing zooplankton trends was completed during 2023. From 2012-2023, zooplankton collections took place biweekly during May to September at established sites to maintain consistency and data comparability. Zooplankton were collected by obtaining vertically integrated water samples using a diaphragmatic pump. At each site, 90 liters of water was filtered through a 55-micrometer mesh to obtain crustacean zooplankton (macrozooplankton), and 10 liters of water was filtered through a 20-micrometer mesh to obtain microzooplankton (rotifers and copepod nauplii). Organisms were transferred to sample jars and preserved in either Lugols solution (4 percent for macrozooplankton) or buffered formalin (10 percent for rotifers). Data on environmental factors known to influence zooplankton communities in large rivers (temperature, dissolved oxygen concentration, turbidity, chlorophyll α concentration, total phosphorus concentration) was also collected on each sampling site visit. In the laboratory, individual organisms were identified to the lowest possible taxonomic unit, counted, and measured using a microscope-mounted camera and measurement software. Zooplankton densities were calculated as the number of individuals per liter of water sampled. Biomass was calculated using standard length-mass regressions for each taxa.

During 2024, we built on our previous analyses of annual peak densities of several dominant zooplankton taxa by updating the assessed models with 2022 zooplankton data, reducing environmental predictor variables into principal components in order to account for potential multicollinearity, and adding native planktivore abundance as a potential explanatory variable. Bigheaded carp co-occur with a number of native planktivore species in the Illinois River, but the extent to which bigheaded carp impact zooplankton abundances alone or in combination with native species has not previously been assessed. Analyses used annual peak densities of 10 zooplankton taxa at the genus or family level, as well as aggregate groupings (all Cladocera, all Copepods, all Rotifers) occurring during the May through September periods from 2012 to 2022 at monitoring sites representative of the Dresden Island (Channahon), Marseilles (Morris), Starved Rock (Ottawa), Peoria (Henry), and La Grange (Havana) navigation pools. Taxa selected for analyses were chosen based on their numerical dominance in the Illinois River zooplankton community or their consistent occurrence in zooplankton samples during the assessed time period.

Estimates of bigheaded carp density in each navigation pool were obtained from annual hydroacoustic surveys conducted each autumn (late September to early November) from 2012 – 2022 by SIUC, with each fall density estimate assumed to represent adult invasive carp density within a navigation pool during the previous several months. Reliable invasive carp density estimates were not available for the Peoria and La Grange pools in 2018, so these pool-year combinations were not used in the analyses. Abundance of native planktivores was estimated from Long Term Resource Monitoring Program (LTRMP; Gutreuter et al. 1995) and Long-Term

Illinois River Fish Population Monitoring Program (LTEF; McClelland et al. 2012, Fritts et al. 2017) pulsed-DC electrofishing sampling of unstructured main-channel border habitats conducted in each navigation pool during 2012 – 2022. Mean catch-per-unit-effort (CPUE) of Bigmouth Buffalo (*Ictiobus cyprinellus*), Emerald Shiner (*Notropis atherinoides*), Gizzard Shad (*Dorosoma cepedianum*), Threadfin Shad (*Dorosoma petenense*), and Skipjack Herring (*Alosa chrysochloris*) across the three LTRM and LTEF sampling periods (Period 1 = June 15 – July 31, Period 2 = August 1 – September 14, Period 3 = September 15 – October 31) were summed to produce a combined estimate of native planktivore CPUE in each navigation pool in each year.

Zooplankton may respond to several environmental factors; therefore, discharge, temperature, chlorophyll *a* concentration, Secchi depth, and dissolved oxygen concentrations were investigated as potential variables influencing zooplankton densities. Discharge data for sites in the upper IWW were obtained from USACE gages located at the Brandon Road, Dresden Island, and Marseilles lock and dams. Discharge measured at the USGS gage at Henry (USGS 5558300) was applied to Peoria Pool observations, and data from the USGS gage at Kingston Mines (USGS 5568500) were used for La Grange Pool flow rates. Discharge values were standardized across sites using Z-transformed values for each site. Mean values of water temperature, dissolved oxygen, Secchi depth, and chlorophyll a concentration in the month prior to the peak density of each zooplankton taxa were calculated to represent environmental conditions potentially affecting zooplankton densities. These variables were natural log-transformed prior to analysis to normalize variances. Due to several correlated environmental variables, principal component analysis was used to reduce these variables into smaller sets of unrelated variables. Only axes with eigenvalues > 1.0 were considered for further analysis.

A reduced maximum likelihood approach was used to model the annual peak density of each indicator taxa within the five navigation pools as a function of environmental variables and pool-scale estimates of bigheaded carp density and native planktivore relative abundance. Repeated-measures models with sampling stations as the repeatedly sampled unit and compound symmetric covariance structure were used to relate peak zooplankton densities to sets of explanatory variables. Candidate models included all linear combinations of bigheaded carp density, native planktivore CPUE, and principal components of environmental variables. Akaike's information criteria corrected for small sample bias (AIC_c; Anderson 2008) was used as the basis for model comparisons, with models within two AIC_c units considered to have similar support. When multiple models had similar levels of support, the most parsimonious model (i.e., the fewest parameters) was chosen. A null model (i.e., intercept only) was also included for comparison to assess whether there was meaningful support for any models in the set. Marginal coefficients of determination (Nakagawa and Schielzeth 2013) were calculated as a measure of the amount of variance accounted for by the fixed effects in each model. Cohen's f^2 (Cohen 1988; Selya et al. 2012) was also calculated to assess the standardized effect size of invasive carp and native planktivores on peak densities of each zooplankton taxa. Models that were the most supported by observed peak zooplankton densities and included bigheaded carp density as a significant explanatory factor with at least a medium effect size (f^2 greater than or equal to 0.15) were then used to evaluate the influence of bigheaded carp density on peak densities of each zooplankton taxa in each navigation pool.

Partial residual plots were used to visualize the relationship between bigheaded carp density, native planktivore abundance, and peak density of each zooplankton taxa while accounting for the effects of environmental variables. Residuals from model-based predictions under observed (i.e., actual bigheaded carp densities) and target conditions (i.e., reduced bigheaded carp densities) were also calculated to assess if declines in bigheaded carp densities have resulted in reduced impacts on zooplankton. A stoplight report card based on the degree of overlap between control intervals and target variances (Trexler and Goss 2009) was produced as a visual summary of the impact of reduced bigheaded carp densities on zooplankton metrics. Control intervals (i.e., residuals ± 1.5 or 2.0 standard errors calculated from predicted zooplankton densities based on observed environmental and bigheaded carp values) represent the uncertainty typically associated with predictions based on simple ecological models. If the target variance (i.e., residuals ± 1.5 standard error calculated from model-based predictions based on target bigheaded carp densities) falls outside the 2.0 standard error control interval, then the management goal of reducing the planktivorous effects of bigheaded carp can be interpreted as having not been met (Red Light; Rank = 3). If target variance falls outside of the 1.5 standard error control interval, but overlaps with the 2.0 standard error interval, then the density of bigheaded carp is considered to be reduced sufficiently to have some impact on their planktivorous effects, but still falls short of management goals (Yellow Light; Rank = 2). If target-based variance overlaps the control interval, then bigheaded carp density can be interpreted to be sufficiently reduced to mitigate their ecosystem effects (Green Light; Rank = 1). For this initial assessment, we used the smallest bigheaded carp density observed during the 2012 – 2022 assessment period (0.003 bigheaded carp/1000 cubic meters; 2019 estimate from Dresden Island Pool) as the management target. We used this observed density as the management target because it is both a desirably low density and does not project model predictions beyond the range of bigheaded carp densities used to parameterize the models. Assessments were only conducted for navigation pool-year combinations that contained all of the information required by the assessment models. The assessment rankings for individual taxa in each navigation pool were averaged for each year (combined taxa groups were excluded to avoid inflating the influence of any zooplankton taxa), rounded to the nearest whole number, and assigned a stoplight category (Red = management goal not met; Yellow = management goal not met, but some progress evident; Green = management goal achieved) to summarize the cumulative impact of bigheaded carp reductions on sensitive zooplankton metrics.

RESULTS AND DISCUSSION

Bigheaded carp densities during the 2012 through 2022 assessment period exhibited a range of values among navigation pools and years (Figure 1), providing the variation needed to test for responses by various zooplankton taxa. In general, bigheaded carp densities in the IWW have been higher in downstream navigation pools than in upstream pools and demonstrated considerable reductions during recent years (2018 through 2021) in most navigation pools relative to the initial years of this study (2012 through 2014). The lowest bigheaded carp densities were observed in most pools during 2019. Some pools have exhibited increased bigheaded carp densities since that time, although remaining below levels observed prior to 2014. Native planktivore CPUE also varied among pools and years during the assessed time. The lowest abundances of native planktivores were observed in the Dresden Island Pool in the majority of years, but native planktivore CPUE was highly variable among other navigation pools over time (Figure 2).

Figure 1. *Annual estimates of bigheaded carp density (number/1000 cubic meters) within five navigation pools of the IWW. Estimates are derived from autumn hydroacoustic surveys and represent the combined density of bigheaded carp species (Silver Carp + Bighead Carp). Density estimates for Peoria and La Grange pools were not available for 2018.*

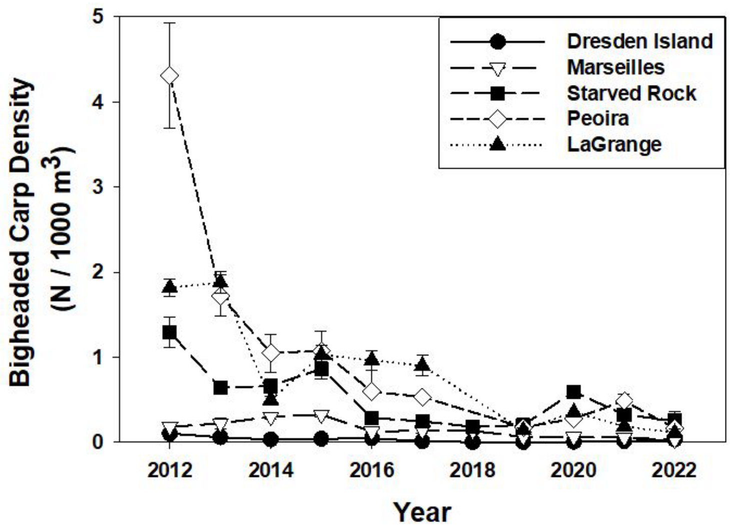
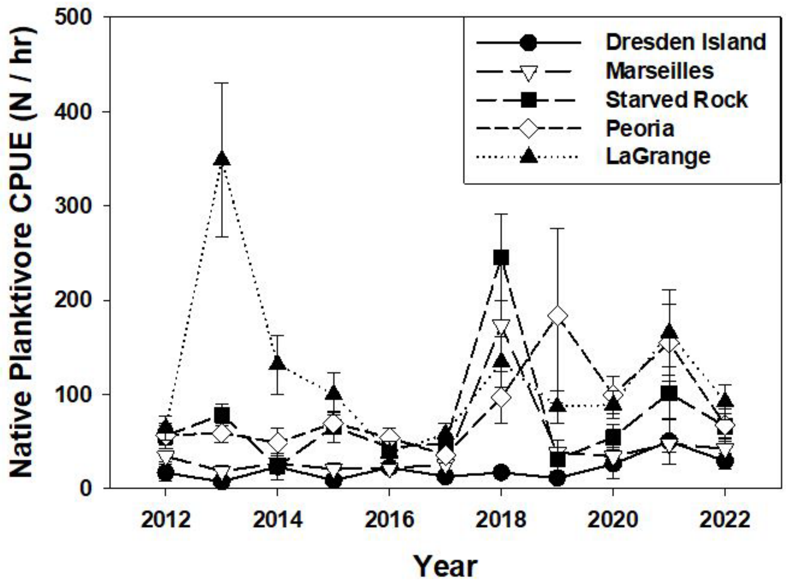


Figure 2. *Annual estimates of native planktivorous fish CPUE (number/hour) within five navigation pools of the IWW. Estimates are derived from Long Term Resource Monitoring Program (LTRMP) and Long-Term Illinois River Fish Population Monitoring (LTEF) pulsed-DC electrofishing sampling of unstructured main-channel border habitats.*



For all zooplankton taxa considered in this assessment, the most supported models contained bigheaded carp density as an explanatory variable, with top-ranked models for 7 of the 13 zooplankton taxa also including native planktivore CPUE (Table 1). Principal components encapsulating environmental conditions associated with peak zooplankton densities were also included in all top-ranked models. Coefficient estimates for bigheaded carp density were negative for all zooplankton metrics, indicating a generally negative influence of bigheaded carp on zooplankton populations, whereas estimates for native planktivore CPUE were positive in all models containing this variable, indicating a positive association between native planktivores and some zooplankton taxa. Best-ranked models for 10 of 13 zooplankton taxa contained bigheaded carp density as a significant effect (all $P \leq 0.05$), and bigheaded carp had at least a medium effect size ($f^2 \geq 0.15$) for 5 of these taxa (*Bosmina* sp., *Keratella* sp., *Polyartha* sp., *Synchaeta* sp., and all rotifers combined). Native planktivore CPUE was also a significant variable with at least a medium effect size for 2 of these taxa (*Keratella* sp. and *Synchaeta* sp.; Table 1).

Table 1. *Coefficients estimates for the top-ranked model for each zooplankton taxa group (as determined by minimum AIC_c score within each candidate set of models), the marginal coefficient of determination ($R^2_{marginal}$) associated with each model, and the standardized effect size for the effect of invasive carp density (f^2_{carp}) and native planktivore CPUE (f^2_{Plank}) on peak annual density of each zooplankton taxa. Explanatory variables considered were annual estimates of bigheaded carp density in each navigation pool (CarpDens), mean electrofishing CPUE of native planktivores in each navigation pool (PlankCPUE), and principal components of hydrologic and physicochemical variables (standardized discharge, water temperature, chlorophyll a concentration, Secchi depth, and dissolved oxygen concentration) measured on and for one*

*month prior to each date of peak density for each zooplankton group. Significant coefficients (P ≤ 0.05) and standardized effect sizes of at least medium effect (f^2 ≥ 0.15) are highlighted with **bold** text.*

-	-	-	Variables	-	-	-	-	-
Taxa	CarpDens	PlankCPUE	PC1	PC2	PC3	$R^2_{marginal}$	f^2_{Carp}	f^2_{Plank}
Bosmina	**-0.489**	-	**0.304**	-	-	0.46	**0.39**	-
Daphnia	-0.137	-	-	0.038	-	0.18	0.08	-
Sididae	-0.125	**0.348**	**0.274**	-	-	0.36	0.02	0.11
All Cladocera	**-0.340**	-	**-0.413**	-	-	0.43	0.13	-
Calanoida	-0.145	-	-0.167	-	-	0.11	0.03	-
Cyclopoida	**-0.198**	**0.313**	-	0.141	-	0.31	0.12	0.12
All Copepoda	**-0.216**	**0.453**	-	0.141	-	0.17	0.11	**0.16**
Brachionus	**-0.364**	**0.477**	-	0.134	-	0.13	0.14	0.11
Keratella	**-0.332**	**0.826**	-	-	0.116	0.41	**0.39**	**0.48**
Polyartha	**-0.503**	-	**0.306**	-	-	0.37	**0.50**	-
Synchaeta	**-0.339**	**0.627**	0.169	-	-	0.47	**0.21**	**0.19**
Trichocerca	**-0.285**	**0.449**	-	-	**-0.327**	0.27	0.13	0.14
All Rotifera	**-0.261**	-	-	-0.145	-	0.30	**0.24**	-

Principal components of environmental variables that were included in these top-ranked models primarily loaded discharge and/or water temperature in PC1, and various combinations of other physicochemical variables in the second and third principle components. Partial residual plots that isolated the effects of invasive carp and native planktivores from environmental conditions further illustrated the negative effect of bigheaded carp density on the five most sensitive zooplankton metrics (example partial residual plot for *Polyartha* sp. shown in Figure 3), and the positive association between native planktivores and the two-rotifer metrics sensitive to this factor (example partial residual plot for *Synchaeta* sp. shown in Figure 4).

Figure 3. *Partial residuals plot of peak Polyartha sp. density in relation to annual bigheaded carp (Silver Carp + Bighead Carp) density in five navigation pools (Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange) of the IWW during 2012 to 2022. Partial residuals were calculated by accounting for principal components of environmental variables measured in the month prior to dates of peak Polyartha sp. density.*

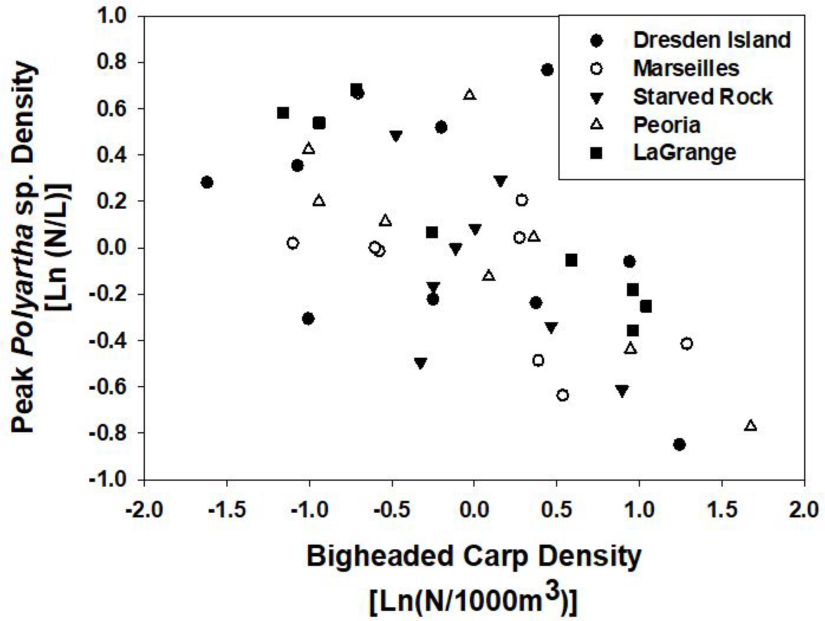
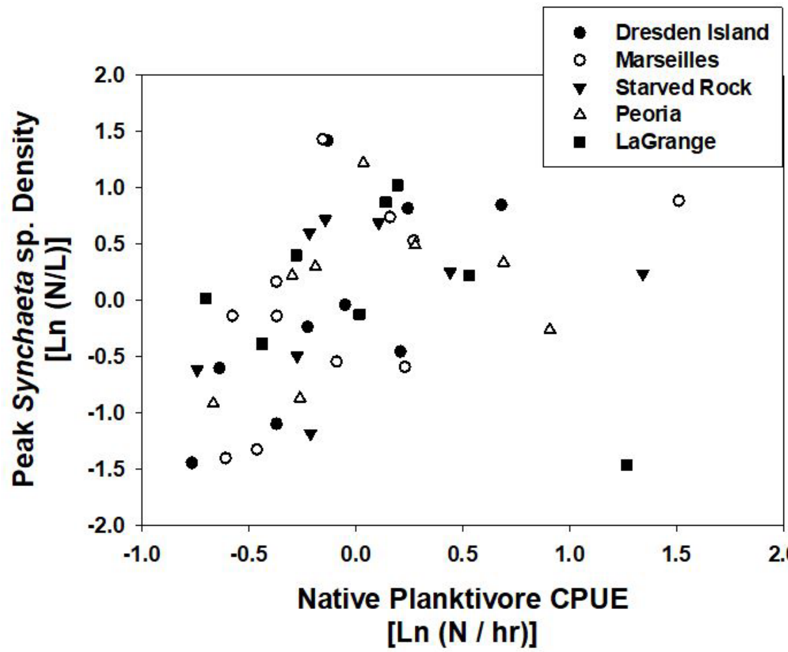


Figure 4. *Partial residuals plot of peak Synchaeta sp. density in relation to annual mean native planktivore CPUE in five navigation pools (Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange) of the IWW during 2012 to 2024. Partial residuals were calculated by accounting for principal components of environmental variables measured in the month prior to dates of peak Synchaeta sp. density.*



Comparisons of control intervals with residuals from updated predictions based on target bigheaded carp densities indicate that the level of reduction in impacts from bigheaded carp on zooplankton populations has varied considerably among zooplankton taxa and among navigation pools. Missing values of some variables resulted in some years where assessment was not possible in some navigation pools. However, the overall pattern of change suggests that the uppermost navigation pools, where bigheaded carp densities have been lowest and have also been subject to the most intense harvest efforts, have experienced diminished impacts of bigheaded carp for longer time periods than downstream pools (example assessment plot for *Synchaeta* sp. shown in Figure 5). In contrast, some zooplankton taxa have exhibited little to no detectable response to changes in bigheaded carp abundances in the lower Illinois River (example assessment plot for *Polyartha* sp. shown in Figure 6). The cumulative stoplight diagnosis for each assessed navigation pool of the Illinois Waterway indicated that invasive carp harvest efforts began to have a detectable impact in the Dresden Island Pool as early as 2014 and the management goal of reducing the impact of bigheaded carp on zooplankton has been met in this pool in all but one year since 2017 (Figure 7). Invasive carp harvest efforts appear to have produced some consistent mitigation of impacts to zooplankton communities in the Marseilles Pool since 2018, but this progress falls short of the management target. Despite some declines in bigheaded carp densities, achieving management goals based on zooplankton benchmarks has remained elusive in all other assessed navigation pools (Figure 7).

Figure 5. *Assessment plots for Synchaeta sp. in Illinois Waterway navigation pools during the 2012 – 2024 assessment period. Residuals from model predictions based on observed environmental conditions and bigheaded carp densities are the control intervals and are plotted as solid back lines with ± 1.5 (dashed lines) or ± 2.0 standard errors (dotted lines). Residuals from model predictions using target bigheaded carp densities are plotted as red, yellow, and green dots with ± 1.5 standard errors. If target variance is outside of control intervals, the assessment point is depicted as red and considered to be a year when the management target of reduced bigheaded carp impacts was not achieved. If target variance falls outside of the 1.5 standard error control interval, but overlaps with the 2.0 standard error interval, then the assessment point is depicted as yellow and the density of bigheaded carp is considered to be reduced sufficiently to have some impact on their planktivorous effects, but still falls short of management goals. If target variance overlaps the control interval, the assessment point is depicted as green and the management target of reduced ecosystem impacts of bigheaded carp was considered to have been achieved.*

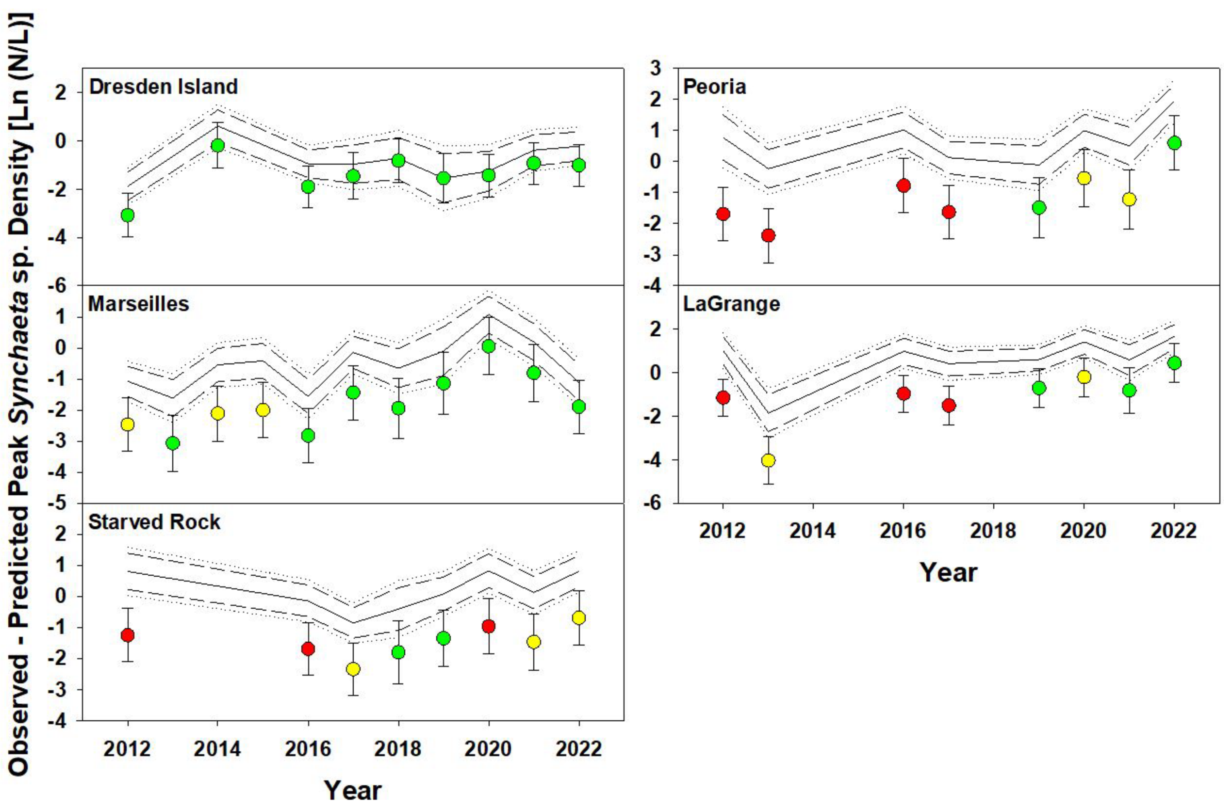


Figure 6. *Assessment plots for Polyartha sp. in Illinois Waterway navigation pools during the 2012 – 2022 assessment period. Residuals from model predictions based on observed environmental conditions and bigheaded carp densities are the control intervals and are plotted as solid back lines with ± 1.5 (dashed lines) or ± 2.0 standard errors (dotted lines). Residuals from model predictions using target bigheaded carp densities are plotted as red, yellow, and green dots with ± 1.5 standard errors. If target variance is outside of control intervals, the assessment point is depicted as red and considered to be a year when the management target of reduced bigheaded carp impacts was not achieved. If target variance falls outside of the 1.5 standard error control interval, but overlaps with the 2.0 standard error interval, then the assessment point is depicted as yellow and the density of bigheaded carp is considered to be reduced sufficiently to have some impact on their planktivorous effects, but still falls short of management goals. If target variance overlaps the control interval, the assessment point is depicted as green and the management target of reduced ecosystem impacts of bigheaded carp was considered to have been achieved.*

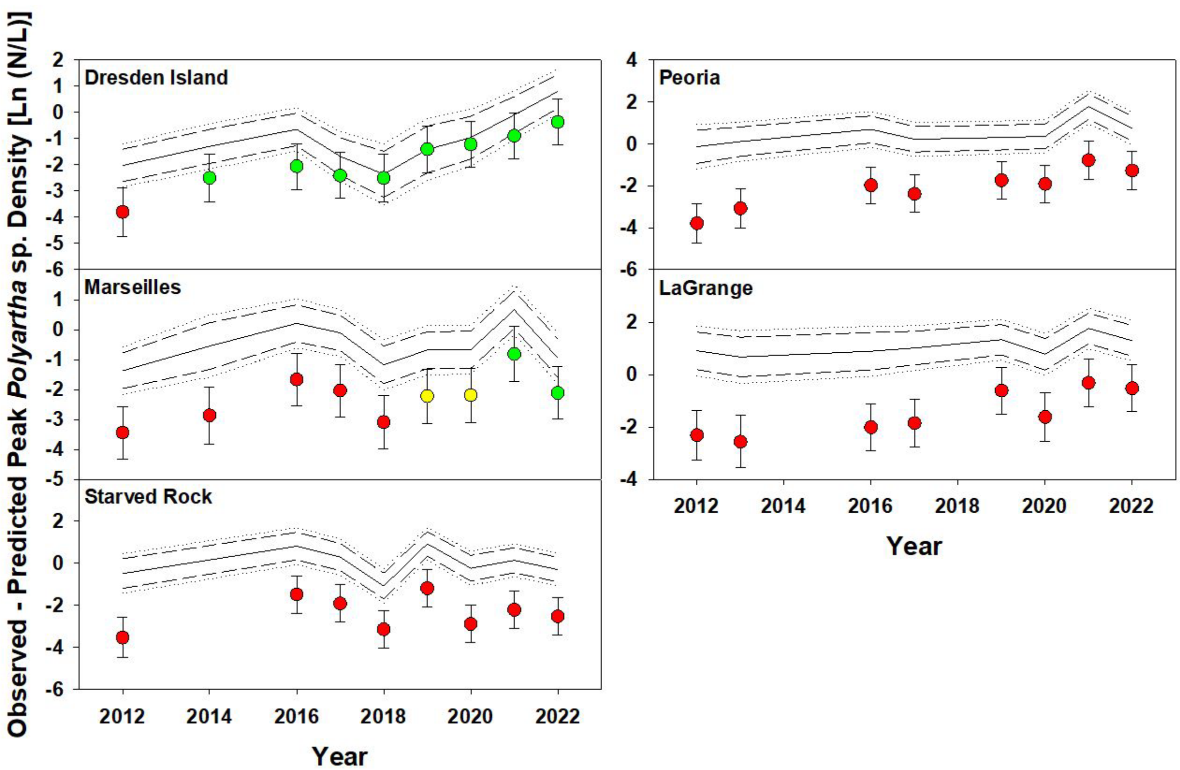


Figure 7. *Stoplight assessment report card for each navigation pool of the Illinois Waterway during 2012 – 2022 based on averaged assessment rankings for the impacts of bigheaded carp planktivory on four zooplankton performance metrics (Bosmina sp., Keratella sp., Polyartha sp., and Synchaeta sp.). Ranks were derived from comparison of residuals from model-based predictions of observed and target bigheaded carp densities (1 = Green Light, meets management goal; 2 = Yellow Light, demonstrates evidence of mitigation of effects of bigheaded carp planktivory, but not sufficient to meet management goal; 3 = Red Light, no evidence of mitigation of impacts of bigheaded carp). Stoplights are only reported for years when all four performance metrics could be assessed. These stoplight assessments are based on peak zooplankton densities and used to illustrate the assessment approach. Final assessments will be based on performance metrics with the highest utility for assessing the impact of changes in invasive carp density.*

Previous observations of zooplankton responses to removal of bigheaded carp have found mixed results (Altenritter et al. 2022). Most previous studies of bigheaded carp effects on zooplankton have pooled different zooplankton taxa into broad taxonomic groups (e.g., cladocerans, copepods, rotifers, etc.), but individual taxa have a wide variety of life histories, tolerances, and adaptations that could lead to variable responses to environmental conditions and the relaxation of predation pressure from bigheaded carp. In this most recent assessment, bigheaded carp density was negatively related to peak densities of all zooplankton taxa. Although most assessed models explained a low amount of variation in the response metrics and the effect size of bigheaded carp density was low, the consistency of this result highlights the generally negative influence of bigheaded carp planktivory on zooplankton populations. Bigheaded carp have frequently been found to have strong effects on large-bodied cladocerans (Sass et al. 2014, DeBoer et al. 2018, Hochstrasser and Collins 2024), and *Bosmina* sp. have been found to be sensitive to variation in bigheaded carp density in every assessment conducted as part of this study. *Bosmina* sp. are among the more common cladoceran taxa found in large rivers (Wahl et al. 2008; Burdis and Hoxmeier 2011) and may therefore be particularly useful for assessment of bigheaded carp impacts. Copepods have also frequently been found to be negatively affected by bigheaded carp abundance (Sass et al. 2014, DeBoer et al. 2018, Hochstrasser and Collins 2024), and cyclopoid copepods have been found to be substantially affected by variation in bigheaded carp density in previous assessments of the current study. However, although bigheaded carp density was a significant explanatory factor affecting both cyclopoid and all copepod taxa, the current analysis did not find that it had more than a medium effect size on any copepod metric. This and earlier assessments have also found that environmental variables have a significant influence on copepod densities (Altenritter et al. 2022). This group may be more strongly affected by abiotic factors, or variation in the responses of the individual species that compose this group may mask the effects of bigheaded carp planktivory.

The strong effect of bigheaded carp on multiple rotifer taxa found here differs from previous assessments conducted as part of this study, and from the findings of previous studies that have found mixed responses of rotifers to bigheaded carp planktivory (Sass et al. 2014, Collins and Wahl 2018, DeBoer et al. 2018, Hochstrasser and Collins 2024). The general dominance of rotifers in large-river zooplankton assemblages (Thorp and Mantovani 2005, Sluss and Jack 2013), their shorter generation times (Lair 2006), the possibility that plankivory by hyperabundant bigheaded carp populations may release rotifers from competition with other zooplankton taxa (Collins et al. 2018) and shift phytoplankton communities towards the smaller taxa favored by rotifer grazers (Miura 1990, Domaizon and Devaux 1999) may explain the neutral or positive effects that bigheaded carp have been found to have on rotifer abundances in some studies. However, rotifers have demonstrated a stronger response to bigheaded carp harvest than larger crustacean zooplankton in some backwaters (Altenritter et al. 2022). The complex relationships of rotifers with other trophic levels (Collins et al. 2018, Chara-Serna and Casper 2021) may complicate our understanding of the mechanisms by which bigheaded carp affect this taxonomic group. However, based on a decade of sampling data, our assessment indicates that there is a negative relationship between rotifer abundances and bigheaded carp density in main channel habitats of the Illinois River, and that declining bigheaded carp densities have contributed to measureable increases in peak densities of several rotifer taxa in some navigation pools.

When included in top-ranked models, native planktivore CPUE was positively related to peak zooplankton densities. Although they consume zooplankton, the positive relationships between the aggregated catch of native planktivores and certain zooplankton taxa may indicate that the relative abundance of both groups are responding similarly to external drivers, including a potential negative effect of bigheaded carp on both native fish and zooplankton. Biomass of invasive carps now equals or exceeds that of native fish species in some pools of the Illinois River (Altenritter et al. 2022), and their consumptive effects on zooplankton communities may therefore exceed that of native planktivores. Native planktivores are known to be negatively affected by bigheaded carp (Irons et al. 2007, Pendleton et al. 2017, Love et al. 2018), likely due to competition for zooplankton resources (Schrank et al. 2003, Sampson et al. 2009, Harris et al. 2022). However, it is unknown at this time if harvest of bigheaded carp has removed sufficient numbers to have a positive effect on abundances of native fish. Nonetheless, while the incorporation of native planktivore abundance does improve the amount of variation in zooplankton densities explained by some models, the effect of this factor appears to be relatively weak for the majority of assessed zooplankton metrics.

The stoplight assessment system employed here allowed us to assess temporal patterns of response by various zooplankton metrics to changes in bigheaded carp density while controlling for the influence of environmental factors. This assessment suggests that individual taxa have responded very differently to bigheaded carp harvest, with some metrics achieving management targets only in the Dresden Island and Marseilles Pools, whereas other metrics show strong responses in all pools. Collectively, it appears that the management goal of reducing the impact of bigheaded carp planktivory on zooplankton assemblages based on these metrics has only been met within the Dresden Island Pool, and although some evidence of mitigation has been detected within the Marseilles Pool, this response falls short of the objective. This evaluation was based on peak densities of the assessed zooplankton taxa, but other metrics may prove more useful for assessment purposes. Because the timing of peak zooplankton densities may vary considerably across years, measuring this variable would require repeated sampling over an extended period. Density or biomass of various zooplankton taxa during specific months requires much less effort to quantify, but identifying time periods when the effects of bigheaded carp planktivory are most apparent or are the most ecologically relevant will require a more complete assessment than that presented here. June densities of several abundant zooplankton taxa were used as potential assessment metrics in previous years and demonstrated some potential to detect changes in the influence of bigheaded carp over time. However, final analyses for this investigation will examine all months of available data before making a final recommendation on specific metrics and time periods for assessing the ecological impact of bigheaded carp removals.

RECOMMENDATIONS

Final evaluation of ecosystem responses to bigheaded carp harvest will account for the influence of environmental factors known to affect zooplankton communities in large rivers (turbidity, chlorophyll *a*, temperature, discharge, etc.), as well as the effect of invasive carp densities in different pools of the IWW. Final evaluation will include multivariate analyses of community-level responses and further analyses of a full suite of performance metrics (peak and monthly densities and biomass of multiple zooplankton taxa) to identify which metrics prove most informative for assessing the impact of invasive carp removals. Future analyses may also benefit from including other management targets for bigheaded carp density that are still within the predictive power of the models. This assessment used the lowest density of bigheaded carp that has been achieved within the Dresden Island Pool as a target, but this may not be a realistic goal for other navigation pools, particularly in the lower Illinois River given the levels of movement of invasive carp among pools and between the Illinois and Mississippi rivers. Changes in bigheaded carp density through time within pools, particularly the substantial declines in the Starved Rock, Marseilles, and Dresden Island pools due to targeted removal efforts in recent years, will be useful for evaluating the utility of any identified performance metrics. Identified performance metrics will provide a simple means of communicating the ecosystem responses to harvest efforts to a general audience (e.g., policymakers and the general public). Complete assessment, including model parameterization, metric development, and sensitivity analyses, are expected in 2025.

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