2023 INVASIVE CARP

MONITORING AND RESPONSE PLAN

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Acronym	Definition
AIS	Aquatic Invasive Species
Cal-Sag	Calumet-Saganashkee
CAWS	Chicago Area Waterway System
CRP	Contingency Response Plan
CSSC	Chicago Sanitary and Ship Canal
EDBS	Electric Dispersal Barrier System
eDNA	Environmental Deoxyribonucleic Acid
FWCO	Fish and Wildlife Conservation Office
ft3	Cubic foot
FY	Fiscal Year
GIS	Geographic Information System
GLFC	Great Lakes Fishery Comission
IAP	Incident Action Plan
ICRCC	Invasive Carp Regional Coordinating Committee
ICS	Incident Comand System
IL DNR	Illinois Department of Natural Resources
ILRCdb	Illinois River Catch Database
IN DNR	Indiana Department of Natural Resources
INHS	Illinois Natural History Survey
ISR	Interim Status Report
ISU	Invasive Species Unit
IWW	Illinois Waterway
LTEF	Long-term Electrofishing
LTRM	Long-term Resource Monitoring
m3	Cubic meter
MAM	Multi-Agency Monitoring
MI DNR	Michigan Department of Natural Resources
mL	Milliliter
MRP	Monitoring and Response Plan
MRWG	Monitoring and Response Work Group
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
qPCR	Quantitative PCR
RM	River Mile
SCAA	Statistical Catch-at-Age
SEICarP	Spatially Explicit Invasive Carp Population
SIM	Seasonal Intensive Monitoring
SIU	Southern Illinois University
SIUC	Southern Illinois University Carbondale
U.S.	United States
USACE	U.S. Army Corps of Engineers
USCG	US. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YOY	Young-of-Year

EXECUTIVE SUMMARY

The Monitoring and Response Work Group (MRWG) prepared this Invasive Carp Monitoring and Response Plan, which was released by the Invasive Carp Regional Coordinating Committee (ICRCC). It acts as an update to previous Monitoring Response Plans (MRPs) and presents up-to-date information and plans 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 20 individual project plans, 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. Each individual plan outlines anticipated actions that will take place in 2023, including project objectives, methodology, and highlights of previous work.

The projects undertaken by the MRWG are designed to address three primary objectives for preventing the spread of invasive carp to Lake Michigan. These objectives are:

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

The plans included in this 2023 MRP build upon considerable work completed since 2010. Selected highlights of past efforts are presented below, grouped by primary objective. For a more detailed accounting of the results and findings of previously completed work, please refer to the 2022 Invasive Carp Interim Summary Report (ISR), presented as a companion document to the 2023 MRP.

HIGHLIGHTS OF PAST EFFORTS

Detection Projects

- A total of 550,706 fish representing 89 species and 9 hybrid groups were collected above the Electric Dispersal Barrier System during 2010-2022.
- Between 2010 to 2022, multi-agency efforts found and removed one Bighead Carp and one Silver Carp upstream of the EDBS. Details of these captures can be found on invasivecarp.us.
- One live Silver Carp was captured in Lake Calumet on August 4, 2022, outside of Seasonal Intensive Monitoring sampling. For more information on this capture and the subsequent response, please see the Response Projects section of the Interim Summary Report.

- Young-of-year (YOY) Gizzard Shad (n=134,136) were examined and no YOY invasive carp were found when sampling from 2010-2022.
- One dead Silver Carp was observed on the banks of the Calumet River during the spring SIM on May 24, 2022. Subsequent sampling did not find any additional bighead or silver carp, alive or dead.
- Observations of eggs, larvae, and juveniles in the upper Illinois River from 2015 to 2022 indicate that some reproduction occurs above Starved Rock Lock and Dam in some years, but the contribution of these fish to the population is likely very low due to the infrequent presence of invasive carp smaller than 6-inches in the Upper Illinois Waterway (IWW). Invasive carp eggs and larvae were abundant during 2022 compared to other recent study years.
- Multi-agency monitoring downstream of the EDBS used standardized, multi-gear sampling approaches to collect 255,810 fish representing 118 species in 2022. In 2022, the leading edge for Bighead Carp and Silver Carp was within the Dresden Island Reach, for Grass Carp the CAWS, and for Black Carp the Peoria Reach.
- No Bighead or Silver Carp have been observed or captured in the Des Plaines River; 10 Grass Carp were captured during sampling since 2011. This spans the collection of 17,058 fish (67 species and 4 hybrid groups) since 2011.
- One Silver Carp and 46 Bighead Carp have been removed from 10 urban ponds since 2011.
- In 2022, two Bighead Carp were captured and removed from Humboldt Park Lagoon.
- At the conclusion of the 2022 field season, there were 170 USACE-tagged fish within the study area near the EDBS.
- In 2022, 20 hydroacoustic surveys at the EDBS were conducted from January 3 to December 19. Mobile hydroacoustic surveys completed in May and June 2022 detected high abundances of large fish targets within the EDBS compared to historical data. Large fish densities in mobile hydroacoustic surveys conducted in Lockport, Brandon Road, and Dresden Island pools were generally low in 2022.

Management and Control Projects

- Through Illinois Department of Natural Resources (ILDNR) and U.S. Fish and Wildlife Service (USFWS) harvest efforts, over 12,798,193 pounds of invasive carp have been removed from the IWW below the EDBS since 2010. This tonnage consists of 104,349 Bighead Carp; 1,327,020 Silver Carp; and 11,473 Grass Carp.
- Telemetry study of tagged fish has observed no upstream passage of live fish past the EDBS. There was one downstream passage of Common Carp through Lockport Lock and three downstream passages of Common Carp through Brandon Road Lock and Dam.
- Invasive carp continue to be detected throughout the Dresden Island Pool, with most detections occurring near the Dresden Island Lock.

- In 2022, 150 invasive carp were tagged with acoustic transmitters throughout the Peoria and Starved Rock pools.
- Law enforcement conservation officers completed inspections of multiple aquaculture facilities and numerous fish trucks. These and other efforts resulted in citations and ongoing multi-agency, cross-jurisdictional investigations into the illegal trade of invasive aquatic species.
- Between September 2019 and March 2023, 13.4 million pounds of invasive carp have been removed from the IWW below Starved Rock Lock and Dam.

Response Projects

- The Upper IWW CRP has been updated. The plan established 2015 as a baseline year for evaluating changes to invasive carp range and population status and describes specific response actions that will be implemented within the five navigation pools of the Upper IWW – Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock based on particular changes to population status on a pool-by-pool basis.

In addition to these highlights, a summary of work anticipated to be completed in 2023 is provided below for each project, grouped by primary objective. For a detailed description of project plans, methods, and objectives, refer to each project's individual plan for 2022.

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

The SIM is a planned intensive surveillance of the CAWS upstream of the EDBS, conducted twice annually. These events are planned for the spring season (weeks of May 15th and 22nd) and the fall season (Weeks of October 2nd and 9th). The SIM deploys fixed and random site monitoring. This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers. Along with maintaining the spatial coverage upstream of the EDBS, each seasonal intensive monitoring event will provide extra sampling focus on a unique location in the CAWS. SIM provides a spatially and temporally adequate assessment of the relative abundance and distribution of invasive carp in the CAWS upstream of the EDBS.

Strategy for eDNA Sampling in the CAWS

In 2023, the CAWS will be sampled for Bighead Carp and Silver Carp environmental deoxyribonucleic acid (eDNA) in Lake Calumet and Marine Services Marina on the Little Calumet River. One sampling event will be conducted prior to the late-spring SIM event and the second will be conducted just prior to the fall SIM event. A control site, Powderhorn Lake, has been added to the sampling regime. The control site is a closed pond with no connectivity to sampled waters but close enough in proximity to assume that bird activity may be similar. This site may then help gauge if birds are substantial secondary vectors of invasive carp eDNA to waterbodies in the area, including the sampling sites. The control site will be sampled in a similar manner and at a similar sampling density to the other monitoring sites.

Telemetry Monitoring Plan

The overall goal of the telemetry monitoring plan is to assess the effect and efficacy of the EDBS on tagged fish in the CAWS and Upper IWW. This project uses ultrasonically tagged invasive carp and surrogate species to assess whether tagged fish challenge and/or penetrate the EDBS and pass through navigation locks in the Upper IWW. An array of stationary acoustic receivers and mobile tracking will be used to collect information on invasive carp and surrogate species' movements. In 2023, 15 tags will be implanted in surrogate species in Lower Lockport Pool to meet the goal of 75 tagged fish in the pool, 10 tags will be implanted in invasive carp in Brandon Road Pool to achieve a target number of 50 tagged fish in the pool, and at least 31 transmitters will be implanted in invasive carp in Dresden Island Pool to meet the goal of 75 tagged fish in the pool.

USGS Telemetry Project

Real-time telemetry receivers are deployed at strategic locations in channel and off-channel areas in the Upper Illinois and Des Plaines River systems and in the CAWS. The associated email alert system alerts key MRWG and ICRCC members of detections of Bigheaded Carp in strategic locations. The email alert system has been revised and alerts will roll out to partners in 2023. The FishTracks DB acts as a centralized database for telemetry receiver and fish transmitter data, and allows project stakeholders to upload, download, and query relevant datasets. The movement probability model estimates the probability of inter-pool movement throughout the Illinois River and has been updated and run with up- to-date data.

Illinois Waterway Hydroacoustics

Since 2016, hydroacoustic surveys have been completed on a biweekly-to-monthly basis to gain greater temporal resolution on fish abundance and distribution dynamics near the EDBS. This project continues to monitor fish abundance and distribution at the EDBS on a fine spatial and temporal scale to evaluate risk and inform contingency response and barrier maintenance scheduling. Information will be disseminated on changes in abundance and distribution near the EDBS and in downstream reaches to guide detection, response, and control efforts for invasive carp. In 2023, the USFWS intends to refocus hydroacoustic sampling to investigate alternative techniques that may benefit surveillance and detection efforts near the EDBS. The utility, applicability, and feasibility of a continuous stationary hydroacoustic monitoring system at the EDBS to increase the temporal resolution of data and provide information to improve understanding of barrier efficacy will be explored in 2023.

Early Detection of Invasive Carp in the Upper Illinois Waterway

The objective of this project is to increase targeted sampling in the Dresden Island and Marseilles pools where large invasive carp are present but small invasive carp are believed to be absent. Targeted sampling for bigheaded carp will occur where bigheaded carp of any size are currently believed to be absent (focus on Brandon Road and Lockport pools) to determine and monitor the geographic location of the upstream invasion front of the population distribution. In 2023, a combination of fixed and random site sampling with habitat stratifications will be conducted using boat electrofishing, electrified dozer trawling, gill netting, and mini-fyke netting. This project is an individual-focused bigheaded carp early detection effort that is intended to complement existing population and assemblage-focused monitoring efforts in the IWW, such as SIM, Multiagency Monitoring (MAM) of the Illinois River for Decision Making, and hydroacoustic monitoring in the vicinity of the EDBS.

Monitoring Invasive Carp Reproduction in the Illinois Waterway

This project monitors for changes in the leading edge of invasive carp reproductive fronts, assesses the impacts of harvest efforts on the reproductive potential of invasive carp populations, monitors for Black Carp reproduction in the IWW, and quantifies relationships between invasive carp adult abundance, reproductive output, and recruitment. Ichthyoplankton monitoring will occur at weekly to biweekly intervals at seven sites located in the Illinois and Des Plaines rivers downstream of the EDBS from late April to October. Additional sampling will occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee rivers to assess potential invasive carp spawning in tributaries of the Illinois River. Sampling may occur more frequently during periods when invasive carp spawning is likely to occur (e.g., May to June, during periods of rising water levels, or shortly after peak flows). Observation of invasive carp eggs or larvae will help to inform the likelihood of capturing YOY invasive carp. Analyses of the spatial and temporal distribution and abundance of invasive carp eggs and larvae will aid in identifying spawning locations, environmental factors associated with successful reproduction, and factors contributing to invasive carp recruitment.

Invasive Carp Stock Assessment in the Illinois River/Management Alternatives

This project continues previous work by Southern Illinois University (SIU) that has intensively monitored movement and density of invasive carp in the Illinois River since 2012. Hydroacoustic and associated sampling surveys will yield information on trends in density, biomass, and population information, such as size structure, catch per unit effort, and length-weight relationships of invasive carp in the Illinois River. Because these surveys have been ongoing since 2012, they provide valuable long-term trends. SIU’s contribution to continued model support will include continued maintenance of the Illinois River stationary telemetry array to document inter-pool movements, deployment of additional acoustic telemetry tags in bigheaded carp, and continued hydroacoustic monitoring of bigheaded carp densities throughout the Illinois River. Work comparing surrogate fish movements to bigheaded carps' movements will continue through 2023.

Des Plaines River and Overflow Monitoring

This project performs monitoring for invasive carp within the Des Plaines River using electrofishing and gill netting. The Des Plaines River runs parallel to the CAWS and represents a possible route for invasive carp to bypass the EDBS during overflow events. To prevent this bypass, a physical barrier was constructed between the Des Plaines River and the CAWS. A minimum of three sampling events will be conducted in 2023, focusing on capturing the pre-spawn to post-spawn time frames.

Alternative Pathway Surveillance – Urban Pond Monitoring

This project provides monitoring and removal efforts for invasive carp that may have been unintentionally stocked in urban fishing ponds in the Chicago Metropolitan Area. Monitoring with eDNA technology and conventional gears (electrofishing and netting) has previously occurred in local fishing ponds and has detected and removed invasive carp (possibly introduced as contaminants in shipments of stocked sport fish). During 2023, urban pond sampling will be based on photographic evidence of invasive carp or reports from credible sources. IDNR also plans to sample all previously sampled urban ponds in 2023 as part of the monitoring response effort.

Multiple Agency Monitoring of the Illinois River for Decision Making

This project began in 2019 and utilizes a standardized, multi-gear sampling approach to (1) effectively monitor invasive carp population demographics (i.e., presence/absence, distribution, and abundance) and (2) assess native fish communities throughout pools of the Illinois River below the EDBS that may be adversely impacted by invasive carp. This project will utilize the Long-Term Resource Monitoring (LTRM) sampling design to provide a more robust and statistically powerful fish population dataset than past monitoring efforts have produced.

MANAGEMENT AND CONTROL PROJECTS

USGS Invasive Carp Database Management and Integration Support

This project uses data compilation and analysis to inform ongoing management and control actions. Continued maintenance and data compilation of the FishTracks Telemetry Database and Illinois River Catch Database of monitoring and removal effort data into a centralized database facilitates data standardization, quality, accessibility, sharing, and analysis to aid in invasive carp removal efforts, evaluations of management actions, and modeling efforts (e.g., Spatially Explicit Invasive Carp Population [SEICarP] model). Data summarization, visualization, and modeling support a better understanding of bigheaded carp life history, behavior, and habitat use. Integrating invasive carp-related data and analyses into decision support tools and products aids in applying control and containment methods in an informed and transparent manner.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Contracted commercial fishing below the EDBS uses contracted commercial fishers to reduce Bighead Carp, Black Carp, Grass Carp, and Silver Carp numbers and monitor for their expansion in the upper Illinois River and lower Des Plaines River downstream of the EDBS. The project aims to decrease invasive carp numbers, resulting in anticipated reduction of migration pressure toward the barrier, lessening the chances of invasive carp gaining access to upstream waters in the CAWS and Lake Michigan. Contracted commercial fishers, with assisting agency biologists, will fish four days a week during each week of the field season, except for two weeks in June and two weeks in September. 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.

Barrier Maintenance and Fish Suppression

U.S. Army Corps of Engineers (USACE) operates three electric dispersal barriers (Barrier 1, Barrier 2A, and Barrier 2B) for aquatic invasive species in the Chicago Sanitary and Ship Canal (CSSC), collectively referred to as the EDBS. Barriers must be shut down for maintenance annually, and the ILDNR has agreed to support maintenance operations by providing fish suppression at the barrier site. This project outlines the monitoring, assessment, and clearing procedures utilized by the MRWG to take necessary precautions to prevent the passage of invasive carp into the Great Lakes. Clearing actions are determined on an as-needed basis when unexpected outages at the EDBS warrant a response action or a planned outage occurs.

Invasive Carp Population Modeling to Support an Adaptive Management Framework

This project will focus on developing novel quantitative tools, such as a statistical catch-at-age (SCAA) model, to address questions regarding the effects of contracted removal efforts on invasive carp populations and continue the development and maintenance of predictive simulation-based models, such as the SEICarP model and the per-capita contribution model, designed to address emerging management questions. This project continues to build on past efforts to develop a SEICarP model that includes spatial components (i.e., river pools) of the Illinois River system. A stock-recruitment relationship will be developed using existing age structures and hydroacoustic data. Statistical catch models will be used to estimate vulnerability to fishing based on fish size, exploitation rates, and immigration to the upper

Illinois River. The model will be used to inform adaptive management efforts to control invasive carp populations in the Illinois River.

Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)

The SEICarP model was developed as a means of assessing invasive carp population status in the IWW. The model functions as an important tool that can be used by fisheries managers to inform harvest and control of adult invasive carp (Silver Carp and Bighead Carp in this study) in the IWW. Because harvest effects, such as changes in fish density and size distributions, are likely to impact movement and will thus influence the ability to predict population responses, continued monitoring of invasive carp movement in the IWW is necessary. This research provides an improved understanding of invasive carp movement in the IWW and its effects on population dynamics. An accurate understanding of invasive carp population status is critical for assessing invasive carp encroachment risk to the Great Lakes. Data gained from tagging additional invasive carp will improve the accuracy of the model.

Invasive Carp Demographics

Detection and monitoring of invasive carp (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) populations in the Illinois River are critical for achieving management goals. To address this important information need, natural resource agencies collaborate to implement a standardized multiple-gear sampling approach. This standardized multiple-gear sampling approach provides an accurate, comparable, and representative understanding of invasive carp distribution and abundance in the Illinois River. Incorporating age data collections into these efforts provides the information needed to implement stock assessment models used to quantify the success of control efforts. The Invasive Carp Demographic project is collaborative with the Multiple Agency Monitoring of the Illinois River for Decision Making project. Starting in 2023, all field sampling, data analysis, and reporting associated with the Invasive Carp Demographics Project will be integrated into the Multiple Agency Monitoring of the Illinois River for Decision-Making framework and reported through that mechanism.

Alternative Pathway Surveillance in Illinois – Law Enforcement

This project created a more robust and effective enforcement component of ILDNR's invasive species program by increasing education and enforcement activities at bait shops, bait and sportfish production/distribution facilities, fish processors, and fish markets/food establishments known to prefer live fish for release or food preparation. Inspection and surveillance efforts will take place in the Chicago Metropolitan Area, including Cook County and the collar counties, with eventual expansion statewide and potentially across state boundaries. In 2023, this project will produce a user-friendly quick reference guide for conservation police officers. Additionally, the project intends to conduct surveillance operations and inspections on industries linked to the invasive carp, coordinate joint forces operations to investigate aquatic invasive species violations, and promote the development of aquatic Organisms in Trade law enforcement units.

Invasive Carp Enhanced Contract Removal Program

This program aims to reduce the abundance of invasive carp in Peoria, LaGrange, and Alton pools through controlled and contracted fishing efforts. This program issues fishing contracts to commercial fishers willing to target invasive carp in these three pools and fulfill contractual obligations of selling, reporting, transporting, and fishing in the identified area. This project also provides critical information about population densities of invasive carp through time in the lower three pools of the Illinois River system to guide management efforts. This project works to identify and employ mechanisms for the use of harvested fish by private industry, including human consumption. Through a cooperative relationship of agencies and fishers, along with end users/markets, advice and support will be provided as necessary to further inform fishers on the delivery of quality and quantity of fish to the end user/markets. In 2023, the project aims to remove 7.55 million pounds of invasive carp from the IWW below Starved Rock Lock and Dam.

RESPONSE PROJECTS

Upper Illinois Waterway Contingency Response Plan

This project has established a set protocol for determining whether detection results merit a direct response action, and laid out a framework for taking response actions, including steps for coordinating between agencies and communicating with the general public. In 2023, relevant agencies will continue developing and refining the response plan, including conducting a tabletop exercise to identify any needed improvements to the plan.

INTRODUCTION AND STRATEGY

The Monitoring and Response Work Group (MRWG) prepared this Invasive Carp Monitoring and Response Plan (MRP), which was released by the Invasive Carp Regional Coordinating Committee (ICRCC). It acts as an update to previous MRPs and presents up-to-date information and plans 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 20 individual project plans, 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. Each individual plan outlines anticipated actions that will take place in 2023, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2023 Invasive Carp Action Plan (Action Plan), which outlines funding and actions taken through the U.S. Environmental Protection Agency's (USEPA) Great Lakes Restoration Initiative. The Fiscal Year 2023 Action Plan contains a portfolio of 51 high-priority strategic activities for implementation in the coming year. The Action Plan serves as a foundation for the work of the ICRCC partnership — a collaboration of 26 United States (U.S.) and Canadian federal, state, provincial, tribal, and local agencies — to achieve its mission of preventing the introduction and establishment of invasive carp in the Great Lakes.

This MRP is a natural extension of the *Illinois State Comprehensive Management Plan for Aquatic Nuisance Species* and further builds upon the *Management and Control Plan for Bighead, Black, Grass, and Silver Carp in the United States*. While the clear and overarching goal of the ICRCC is to prevent the introduction and establishment of invasive carp into the Great Lakes, the work of the MRWG is clearly focused on Bighead Carp and Silver Carp in the IWW. The MRWG believes that techniques showing promise with Bighead Carp and Silver Carp are also techniques that are appropriate for successful surveillance, management/control, and response for Grass Carp and Black Carp.

This MRP builds on prior plans developed for 2011 – 2022. More specifically, it is intended to identify actions to be taken in 2023, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2023 MRP takes advantage of information gathered since 2011 to provide the most robust suite of activities to accomplish MRWG objectives. The MRP is a living document and will be revisited at least annually. All MRPs to date, including the 2023 MRP, have benefitted from the review of technical experts and MRWG members, including, but not limited to, Great Lakes states' natural resource agencies and non-governmental organizations. Contributions to this document have been made by several state and federal agencies.

This 2023 MRP provides information about project plans, which incorporate new information, technologies, and methods as they have been discovered, field-tested, and implemented. A companion document, the 2022 Invasive Carp Interim Summary Report (ISR), has also been completed by the MRWG. The 2022 ISR presents a summary of each individual project's activities, results, findings, and recommendations for future actions. Similar to the MRP, the ISR functions as a living document and will be updated at least annually. Collectively, the 2023 MRP and 2022 ISR present a comprehensive accounting of the projects being conducted to prevent the establishment of invasive carp in the CAWS and Lake Michigan. Through these documents, the reader can obtain a thorough understanding of the most current project results and findings, as well as how these findings will be used to guide future activities.

The projects included in the 2023 MRP have been grouped by core strategic objectives of the MRWG. These core objectives consist of:

1. **Detection**
2. **Management and Control**
3. **Response**

The projects that will address each of these core objectives are presented in the table on the next page. In addition to these project plans that directly address the primary objectives of the MRWG, additional key information is provided in this MRP as appendices. Additional project plans for 2023 are provided in Appendix A. Key background information on invasive carp that may be useful to field crews or the general public is provided in Appendices B through M. The appendices found in the MRP include the following:

- Appendix A: "Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal"
- Appendix B: "Participants of the Monitoring and Response Work Group, Including Roles and Affiliation"
- Appendix C: "Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Invasive Carp Monitoring and Response Field Activities"
- Appendix D: "Detailed Maps of Fixed and Random Site Sampling Locations"
- Appendix E: "Handling Captured Invasive Carp and Maintaining Chain-of-Custody Records"
- Appendix F: "Shipping, Handling, and Data Protocols for Wild Captured Black Carp"
- Appendix G: "List of Invasive Carp Species Codes Arranged in Alphabetical Order by Fish Common Name"
- Appendix H: "Sample Data Sheets"
- Appendix I: "Analysis of Bighead and Silver Carp Spawn Patches"
- Appendix J: "Black and Grass Carp Identification"
- Appendix K: Original Paper, "Bighead carps at the edge of their invaded range: using hydroacoustics to assess population parameters and the efficacy of harvest as a control strategy in a large North American river"

- Appendix L: "Invasive Carp Monitoring and Response Equipment"
- Appendix M: "Invasive Carp Monitoring Sampling Strategy"

Detection
Seasonal Intensive Monitoring in the CAWS
Strategy for eDNA Sampling in the CAWS
Telemetry Monitoring Plan
USGS Telemetry Project: Real-Time Telemetry and Multi-State Modeling
Illinois Waterway Hydroacoustics
Early Detection of Invasive Carp in the Upper Illinois Waterway
Monitoring Invasive Carp Reproduction in the Illinois Waterway
Invasive Carp Stock Assessment in the Illinois River/Management Alternatives
Des Plaines River and Overflow Monitoring
Alternative Pathway Surveillance – Urban Pond Monitoring
Multiple Agency Monitoring of the Illinois River for Decision Making
Management and Control
USGS Invasive Carp Database Management and Integration Support
Contracted Commercial Fishing Below the Electric Dispersal Barrier
Barrier Maintenance Fish Suppression
Invasive Carp Population Modeling to Support an Adaptive Management Framework
Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)
Invasive Carp Demographics
Alternative Pathway Surveillance in Illinois – Law Enforcement
Invasive Carp Enhanced Contract Removal Program
Response
Upper Illinois Waterway Contingency Response Plan

CURRENT STATUS

Detection projects have informed agency actions and development of the 2023 MRP. No invasive carp have been detected in Lake Michigan. On August 4, 2022, an adult Silver Carp was found and collected in Lake Calumet by gill netting and electro-fishing crews. The silver carp capture triggered two additional weeks of intense sampling in the area. No bighead, black, or silver carp were observed or collected during the removal response. Four grass carp were collected and removed upstream of the EDBS.

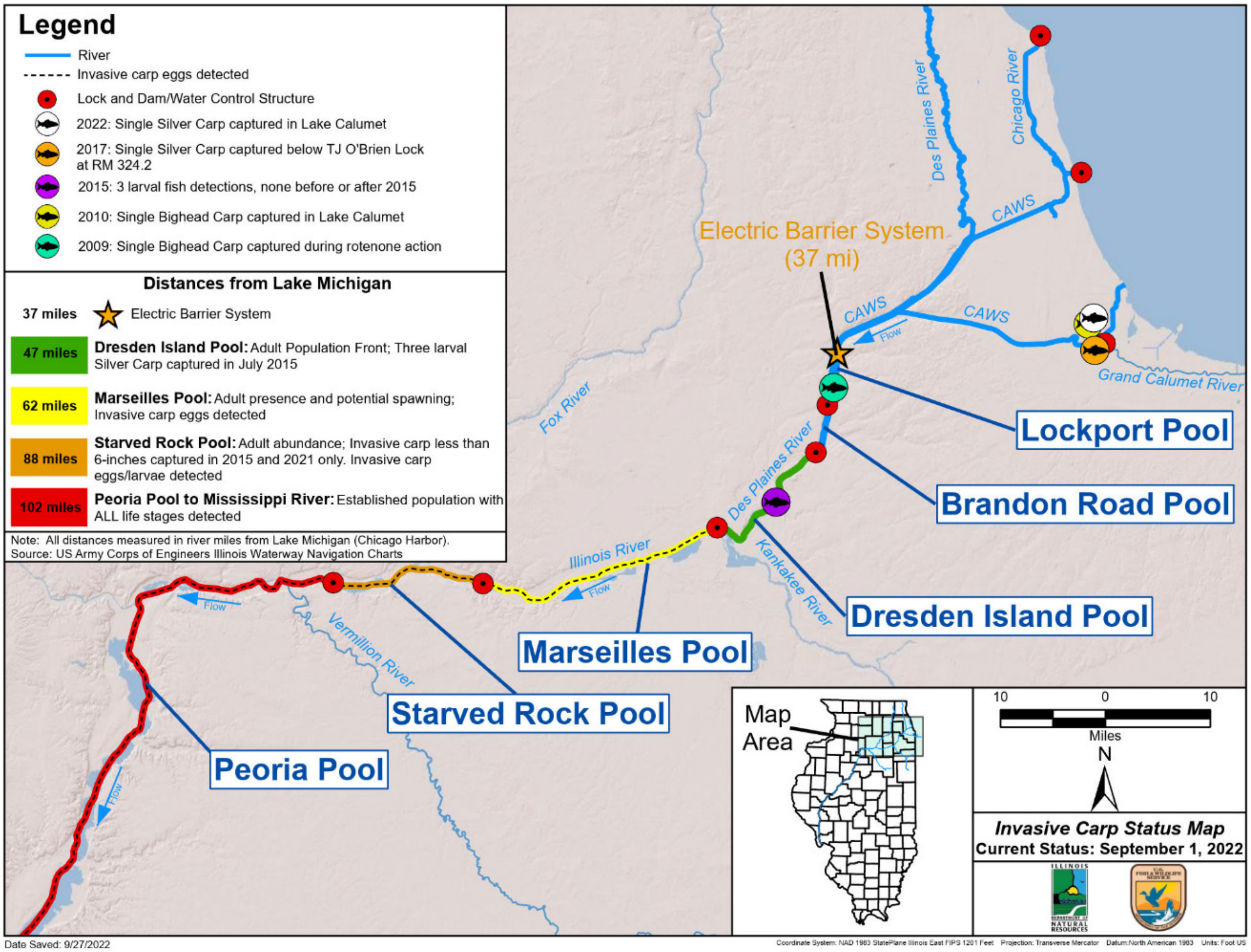
Acoustic-based surveys performed in 2019 suggest relative abundance (measured as mean invasive carp density based on hydroacoustic surveys) has been reduced by an estimated 96.7% in the Dresden Island Pool from 2012 levels. This is an improvement on prior estimates demonstrating relative abundances of adult invasive carp in the Dresden Island Pool decreased between an estimated 59% and 75% from 2012 to 2014 (a 68% average, see MacNamara et al. 2016 contained in Appendix L). This reduction was facilitated, in part, by the mass removal of invasive carp through the strategic use of contract commercial fishing, as well as other factors such as fish migration within the waterway and the degree of reproductive success during those years. These acoustic survey techniques allow for assessment of the invasive carp population on a pool-by-pool basis and evaluation of potential changes of risk of invasive carp approaching the electric barrier system, in addition to traditional techniques.

The management and control aspects of this MRP have also contributed to reduced populations (up to 50% declines as noted by MacNamara et al [Appendix L]) in Marseilles and Starved Rock pools, as well as reduced populations (up to 96% decline) in Dresden Island Pool. While spawning activity has been observed in Marseilles and Starved Rock pools in the past, the resulting eggs travel downstream with prevailing flow direction, away from Lake Michigan. Data suggest that the majority of eggs produced in these pools experience mortality or drift downstream to hatch in the Peoria and La Grange pools, below the Starved Rock Lock and Dam. During 2021, eggs were collected as far upstream as Marseilles Pool, and larvae were collected as far upstream as Starved Rock Pool. No evidence of invasive carp reproduction has been found thus far upstream of Brandon Road Lock and Dam. Overall, the numbers of invasive carp eggs and larvae observed during 2022 were very high compared to other recent study years. Larval and juvenile invasive carp are abundant in some years in the Lower IWW, which acts as the primary source of invasive carp throughout the IWW. The MRWG believes that the vast majority of small invasive carp (< 6 inches) and those larger invasive carp found above the Starved Rock Lock and Dam have immigrated to the Upper IWW from the Lower IWW. Because invasive carp recruit primarily in the Lower Illinois River, the strategy of removal above Starved Rock Lock and Dam has increased efficacy for control until such time as much larger commercial harvest of invasive carp downstream in the Lower Illinois River can be effectively accomplished.

The 2023 Action Plan recognizes management-based contracts that can be issued to increase removal efforts in the lower Illinois River.

Data collected since 2011 have improved knowledge of where fish are and where fish are not in the IWW. The graphic below summarizes our current knowledge of the status of Bighead Carp and Silver Carp developed through ongoing monitoring and historical accounts. This graphic also denotes 2015 as the baseline year to evaluate progress in future years. 2015 was selected as a baseline year for two primary reasons: (1) the MRWG and ICRCC concurred that the establishment of a baseline year would aid in evaluating the status of invasive carp in the Upper IWW; and (2) 2015 was characterized by significant monitoring and detection efforts, which led to a thorough understanding of the invasive carp population status and allowed MRWG to reach a consensus on invasive carp status in 2015. The results of ongoing surveillance and management efforts, including those through September 2022, have been used to establish the current status of invasive carp populations in each pool of the IWW, as described below:

- **Lake Michigan:** No established invasive carp population.
- **CAWS:** No established invasive carp population; However, one adult Silver Carp was captured on August 4, 2022, triggering two additional weeks of intense sampling. Four additional Grass Carp were collected and removed from the CAWS.
- **Lockport Pool:** No established invasive carp population.
- **Brandon Road Pool:** No established invasive carp population.
- **Dresden Island Pool:** Adult Silver Carp and Bighead Carp population front. Larval invasive carp observed in 2015 and have not been observed since (source of larval carp unknown). No Black Carp have been captured.
- **Marseilles Pool:** Adult Silver Carp and Bighead Carp consistently present, and invasive carp eggs have been detected. Spawning has been observed. No Black Carp have been captured.
- **Starved Rock Pool:** Abundance of adult Silver Carp and Bighead Carp, and high densities of their eggs have been detected in some years. Juvenile Silver Carp (less than 6 inches total length) were observed in 2015 and have not been observed since. Early-stage invasive carp larvae were captured in 2020 and 2021. No Black Carp have been captured.
- **Peoria Pool (downstream to confluence with Mississippi River):** Established population with all life stages of invasive carp present. Black Carp over 6 inches have been captured.



Three highlights from the 2022 field season include:

- No invasive carp collected or observed in Lake Michigan or Brandon Road Pool.
- 1.13 million pounds of invasive carp removed from Upper IWW.

In 2023, detection efforts below the EDBS will continue to utilize a standardized, scientifically-based multi-agency monitoring (MAM) framework to provide even more invasive carp and ecologically relevant fisheries data. The methods and protocols that have been adopted are based on a large river monitoring effort. Additional additive measures may be applied for specific purpose, subject to agency and MRWG review. Those standard methods are found within the fisheries portion of the Long Term Resource Monitoring element of Upper Mississippi River Restoration Program, https://www.umesc.usgs.gov/reports_publications/ltrmp/fish/fish_methods.html

Data collected via surveillance and management projects have been used to develop a model that combines the propensity of invasive carp to move, the effects of harvest, and basic biological parameters such as age, growth, and condition of invasive carp. The model serves as a decision support tool to help inform management efforts and strategy over the short term (next 5 years) and long term (> 5 years).

Initial results support the MWRG's existing management strategy that focuses localized and intense invasive carp removal efforts in the Upper Illinois River. However, a long-term strategy bolstered by market-driven forces to remove invasive carp in the lower IWW that could lead to much greater removal than can be accomplished in the Upper IWW and lead to increased risk reduction. Achieving these greater removal levels requires working in concert with economic forces in the Lower IWW. Based on these modeling results, the number of fish required to be removed exceeds funding available to agencies implementing removal projects. Additional commercial fishing pressure is needed to achieve a significant increase in harvest of invasive carp from the Lower Illinois River and other large rivers of the U.S. This increased harvest is necessary to minimize the risk of invasive carp arrival at the EDBS. To that end, ICRCC efforts are evaluating appropriate business models and planning efforts to enable business development. Although the upstream removal strategy may have less impact on the invasive carp population after downstream harvest efforts begin, the MRWG expects that population suppression above Starved Rock Lock and Dam, and detection above Brandon Road Lock and Dam, will continue for at least the next 10 years. This timeline would likely be extended if effective commercial markets for invasive carp cannot be established and sustained in the relatively near future.

Despite current activities, invasive carp populations may respond in unpredictable ways. Based on this realization, this MRP is designed to respond to unforeseen developments in invasive carp detections. The MRWG will continue to characterize the populations in a pool-by-pool fashion in the Upper IWW and identify collections that suggest changes to the invasive carp range. When such new information presents itself, the MRP prescribes a quick and appropriate response utilizing all potential tools to thwart or further characterize the threat. The Upper Illinois River Contingency Plan (CRP) found within this MRP prescribes aggressive actions in response to findings contrary to the baseline (2015) presence of invasive carp in the Upper IWW. The Response Decision Matrix presented below outlines the conditions which trigger response actions on a pool-by-pool basis.

The Upper Illinois River CRP not only provides quick guidance for agencies' actions, but also communication strategies for inter-agency communication as well as outreach and educational communications with partners and public. The contingency plan has proven useful and is suitable to guide other actions and inter-agency activities even when an emergency action is not observed. The CRP was successfully implemented on June 24, 2017, with the capture of a Silver Carp nine miles from Lake Michigan.

Upper Illinois Waterway Invasive Carp Response Decision Matrix*

Direction of flow	Distance from Lake Michigan (miles)		Eggs/Larvae			Small Fish			Large Fish		
			Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
	0 - 37	Chicago Area Waterway System (CAWS)							1		
	37 - 42	Lockport Pool to Electric Barrier System							2		
	42 - 47	Brandon Road Pool							3		
	47 - 62	Dresden Island Pool									
	62 - 88	Marseilles Pool									
	88 - 102	Starved Rock Pool									

Notes:

= Significant change from baseline requiring further response action

= Moderate change from baseline requiring further response action

= No change/Status Quo from baseline. No further action

1 This status is based upon the collection of a single Bighead Carp by contracted fishers in 2010 and a single Silver Carp in 2017.

2 This status is based upon the collection of a signle Bighead Carp during piscicide treatment in 2009.

3 This status is based upon sightings of one (1) Bighead Carp and one (1) Silver Carp by MRWG efforts in 2010-2011. No invasive carp have been collected in this pool.

* Baseline for comparison and determination of response action is the status of invasive carp populations as of December 31, 2015.

The event "Operation Silver Bullet" applied the framework of the CRP, which continued for two weeks until actions ended following the guidelines set forth in the CRP. The CRP was again successfully implemented on September 9, 2019, to address an increased number of positive eDNA results in Bubbly Creek and also in August 2022 to address the capture of a Silver Carp.

The CRP provides a communication framework and response procedure that may be utilized for any planned event or in response to findings that may elevate the risk of invasive carp passage into Lake Michigan. These events may include scheduled or unscheduled maintenance of the EDBS system or the opening of hydraulic connections, which may allow the passage of invasive carp. The same protocols outlined for a response to an unknown event may be applied in advance of these planned events to reduce the risk of a progressing invasion front.

Grass Carp

Grass Carp have been detected in the Upper IWW since 1986, with records in Illinois since 1971. Reproduction was documented in the Lower Illinois River as early as 1991. Grass Carp are not as numerous as Bighead Carp and Silver Carp in the Upper IWW pools of Starved Rock, Marseilles, and Dresden Island, but Grass Carp are found in Brandon Road Pool and the CAWS. Since Grass Carp is a large-bodied cyprinid species similar to Silver Carp and Bighead Carp, MRWG believes methodologies included in this MRP and developed based on past work will also provide sufficient gears, methods for detection, and removal techniques for Grass Carp.

Most of the Grass Carp detected by MRWG efforts in the CAWS are triploid individuals, which means that they are infertile. However, diploid (fertile) Grass Carp have been detected. There is no record of reproducing Grass Carp in Lake Michigan but reproducing populations have been noted in Lake Erie. Grass Carp are removed by monitoring and removal crews when encountered unless tagged and identified for further research. The U.S. Geological Survey (USGS) Nonindigenous Aquatic Species (NAS) website provides a fact sheet and references to supplement this plan and can be found at: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=514

Black Carp

Black Carp have not been detected in the Upper IWW, however through 2022, 52 individual fish have been documented in the Illinois River. Twenty Black Carp were reported captured in the Illinois River in 2020. Reproduction has been documented in the middle-Mississippi River, but little is known about its success or the general distribution of the species. Illinois Department of Natural Resources (IDNR) has imposed a bounty/reward of $100 for Black Carp captured from large rivers of the Midwest in hopes of increasing data on this species, Keep, Cool, Call: What to do if you capture a black carp (invasivecarp.us)

Black Carp are considered rare in the Illinois River but increasing catches in the Mississippi River suggest spawning success and increasing distribution. Since Black Carp is a large-bodied cyprinid species similar to Silver Carp and Bighead Carp, MRWG believes methodologies included in this MRP and developed based on past work will also provide sufficient gears, methods for detection, and removal techniques for Black Carp. Reporting protocols and identification tips for suspected Black Carp are included in the Appendices of this plan.

Results on the USGS NAS website note triploid (infertile) individuals and diploid (fertile) individuals where the data is available. There is no record of Black Carp captures in the Great Lakes Basin. The USGS NAS website provides a factsheet and references beyond this plan and can be found at:
https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=%20573

GOALS AND OBJECTIVES

As discussed above, the 2023 MRP outlines three broad categories of implementing objectives as a guide for both short-term and long-term objectives for preventing the spread of invasive carp to Lake Michigan:

(1) Detection

(2) Management and Control

(3) Response

Specific Objectives for the 2023 MRP

1. Provide aggressive invasive carp detection in each of the pools upstream of Starved Rock to enable effective response to any detection before invaders challenge the EDBS, CAWS, or further threaten the Great Lakes.
2. Provide aggressive invasive carp surveillance in the Des Plaines and Kankakee rivers outside the Upper IWW to enable effective response to any detection before invaders challenge the EDBS, CAWS, or further threaten the Great Lakes.
3. Continue to evaluate and review the CRP to assure efficacy and appropriate response. In 2023, convene at least one table-top exercise with agency and identified natural resource professionals to provide insights into effective response techniques, review technologies available, and incorporate lessons learned into an updated CRP and the 2024 MRP.
4. Manage and control invasive carp populations between Starved Rock Lock and Dam and Brandon Road Lock and Dam, with the goal of removing at least 1.1 million pounds of invasive carp during 2023.
5. Continue implementing discipline-specific work groups to improve coordination within and among agencies and to advise the MRWG about detection technique development, possible efficiencies, acoustic techniques/evaluations, strategy development, or to identify efforts no longer needed.
6. Assess and evaluate data from prior and continued efforts to aid in the development and implementation of new strategies to improve the effectiveness of future management and control efforts.
7. Discipline-specific work groups, agencies, and researchers will recommend findings to MRWG co-chairs. Co-chairs will work with ICRCC representatives to concur and further review potential tools.
8. Encourage business development and enhanced contract fishing to increase the harvest of invasive carp in the Lower IWW from approximately 4.5 million pounds in year one (project started in fall 2019) to 8 million pounds by the conclusion of year four (2024).
9. Establish additional management of the Lower IWW through contract fishing. Through December 2024, an enhanced contracted fishing program will be continued. In 2023/2024, the program aims to remove 7.55 million pounds of invasive carp in Peoria, LaGrange, and Alton pools by contracting with any legally licensed Illinois commercial fisher. The program pays an incentive worth 10 cents per pound after the fisher sells the fish, no caveats for the purpose of those sales will exist save a minimum sale value of 7 cents per pound. This model may be expanded to other Illinois River pools in the future based on success.
10. Remain diligent with outreach and law enforcement activities to discourage other pathways of movement and introduction of invasive carp.

MRWG Work Groups

Discipline-specific work groups assist in developing the most informed MRPs. Work groups may also be useful to focus expertise for further evaluation, assist in decision making, or otherwise provide MRWG Co-chairs, agencies, and ICRCC with insights as technical experts on a range of subjects. Expected work groups for 2023 are listed below with leads identified to assist in communication and structure. Co-leads may also be identified to assist with managing these work groups as appropriate and helpful. Work groups may be added or deleted to serve MRWG and ICRCC needs.

2023 Work Group	Lead/Agency
Contingency Planning	Nick Barkowski/USACE
	Mindy Barnett/ILDNR
Removal	Justin Widloe/ILDNR
	Allie Lenaerts/INHS
Telemetry	Marybeth Brey/USGS
Modeling	Richie Erickson/USGS
	Ben Marcek/USFWS
Behavioral Deterrent Technologies	Aaron Cupp/USGS
Monitoring	Jim Lamer/INHS
	Eli Lampo/ILDNR
Detection	Steve Butler/INHS
	Mindy Barnett/ILDNR

Short-Term (5-year) MRWG Strategic Vision: 2018 – 2022

It is important to note that the short-term strategic vision laid out below is dependent on continued funding at levels similar to 2018 funding received. It is crucial that the necessary funds are available to maintain aggressive removal efforts to reduce the risk of range expansion, as well as to continue focused surveillance to ensure that management agencies have an accurate understanding of changes to invasive carp range, population dynamics, and behavior.

Detection

- Ensure sufficient surveillance effort through standardized MAM deployed throughout the IWW and Des Plaines and Kankakee rivers to inform management and control or response needs. This includes:

  - Adult fish assessment
  - Small fish assessment
  - Larval/egg assessment
  - Population changes and movements

Management and Control

- Remove invasive carp between Starved Rock Lock and Dam and Brandon Road Lockand Dam to reduce upstream migratory pressure at the leading edge of the population.
  - Reduce the estimated biomass of invasive carps in the Dresden Island Pool by an additional 50% from the biomass observed in 2015.
  - Reduce the estimated biomass of invasive carps in the Marseilles Pool by an additional 25% from the biomass observed in 2015.
  - Reduce the estimated biomass of invasive carps in the Starved Rock Pool by an additional 25% from the biomass observed in 2015.
- Prevent the movement into or sustained presence of invasive carp between the Brandon Road Lock and Dam and the Lockport Lock and Dam.
  - Link between detection and response actions
- Use existing and newly developed techniques to maximize annual removal efforts of more than 1 million pounds annually.
  - Contracted harvest
  - Agency efforts
  - Telemetry to enhance removal
  - Strategically deploy the Unified Method
- Utilize technical expertise and recommendations provided by discipline-specific workgroups to determine whether algal attractants, complex noise generation, and use ofcarbon dioxide (CO_2) to herd fish can be effectively incorporated into MRWG actions.
  - If the answer is no or is ambiguous, consider removing techniques that show limited demonstrable effectiveness from future MRPs and MRWG actions.
  - Develop standardized methods for evaluating ongoing research efforts, including set decision points for continuing or stopping research efforts, and recommended timelines for including regulatory input and evaluations.
- Evaluate ongoing management efforts to measure the effectiveness of management actions, adjust activities to improve effectiveness and adapt to future changes.

- Hydroacoustic surveys to provide reliable estimates of abundance in each of the pools of the IWW below Brandon Road Lock and Dam.
- Evaluate new methods for characterizing invasive carp populations based on improving technology and implement where appropriate.

- Assist in developing an enhanced market for invasive carps in the lower three pools of the Illinois River.
    - Use established business development techniques to provide guidance and information to agency, industry, and entrepreneurs to improve ability of business establishment and success.
- This market would build upon the existing commercial fishery in Illinois that can harvest as much as 6 million pounds of invasive carp annually from the Illinois River (4.5 million pounds in Peoria Pool plus additional from downstream pools).
    - Increase total Illinois harvest by expanding the commercial fishery to greater than 4.5 million pounds by 2021 and exceeding 8 million pounds of invasive carp by 2024.

Response

- Ensure that response readiness is maintained and responsive to detected changes as noted in the CRP.
    - Hold annual tabletop exercises
    - Establish contingency steering committee
    - Consider other necessary exercises
    - Identify potential new technologies as practicable, permittable, and available
- Enable rapid deployment of needed assets.
- Review Barrier operations and operational changes with close communication and dialogue between U.S. Army Corps of Engineers (USACE) and MRWG members.

Long-Term (5+-year) MRWG Strategic Vision: 2023 and Beyond

Detection

- Implement an effective, efficient, and sustained standardized detection program to inform ongoing adaptive management and contingency response planning.

Management and Control

- Sustain management and control effort of invasive carp with continued population reduction as baseline 2015 levels in Dresden Island Pool suggest.

- Provide guidance to minimize invasive carp populations in the Upper IWW with no impacts on native fish or mussel populations, human health and safety, recreational use, or industrial uses of the waterway.
- Dynamic economic business strategy in place in the lower IWW to remove 20-50 million pounds of invasive carp annually.
- Support development of management and control strategies in other river basins, as requested.

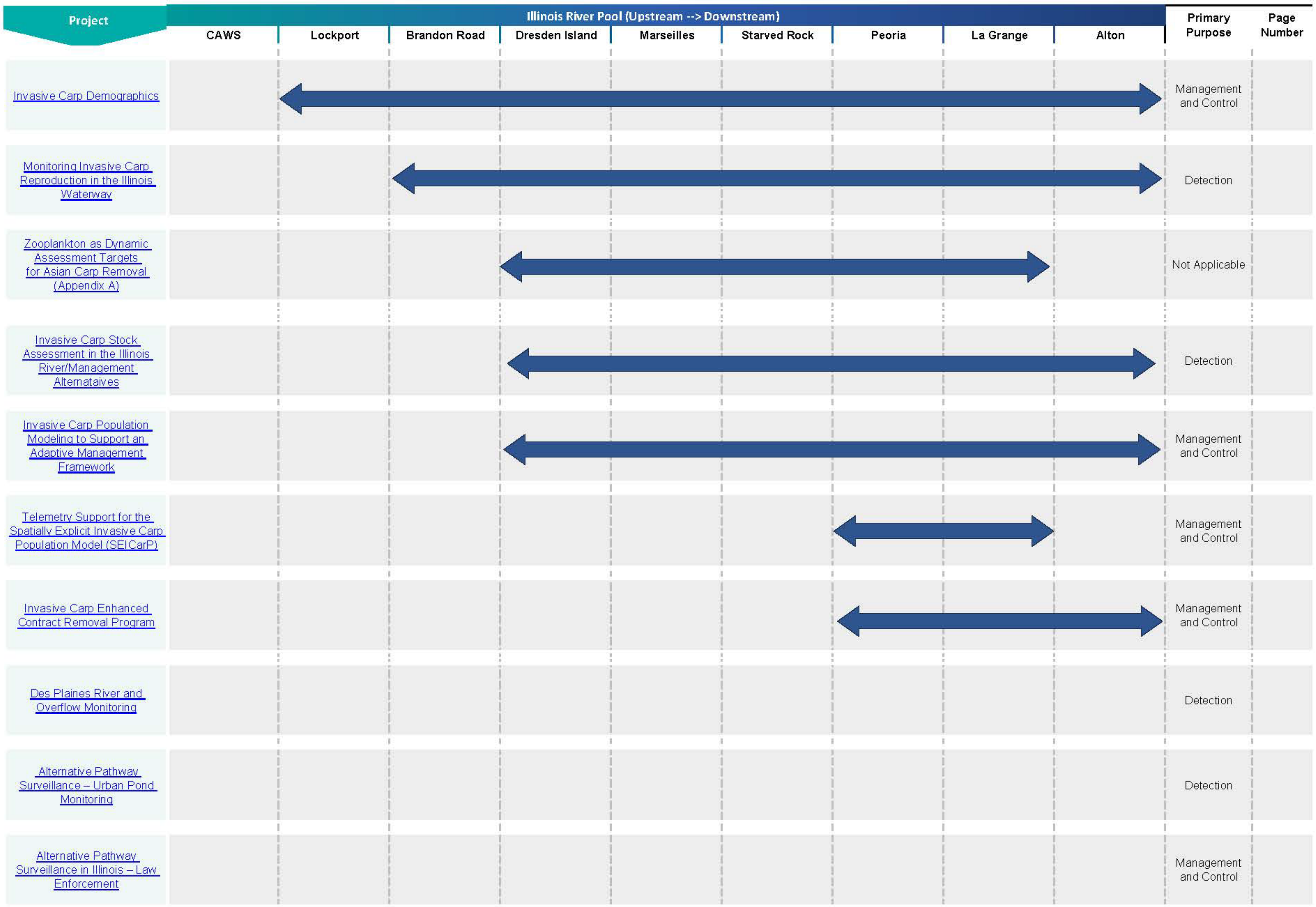
Response

- Provide for Contingency Plan and Response in less than 48 hours for all contingency response measures.

PROJECT LOCATIONS

To more clearly depict the geospatial scale and focus of projects included in the MRP, the MRWG has prepared a project location crosswalk. This crosswalk is intended as a tool to allow readers to quickly understand where a specific project focuses its efforts and quickly discern all projects that are operating in a specific portion of the IWW. The project crosswalk tool includes links to specific project MRPs for readers using a digital version of the MRP and page numbers for readers using a physical version. In that sense, it can also function as an additional table of contents for the document. The project crosswalk tool is presented below.

Project	Illinois River Pool (Upstream --> Downstream)									Primary Purpose	Page Number
	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton		
Seasonal Intensive Monitoring in the CAWS	↔									Detection	
Strategy for eDNA Sampling in the CAWS	↔									Detection	
Telemetry Interim Summary Report	↔	↔	↔	↔						Detection	
USGS Telemetry Project	↔	↔	↔	↔	↔	↔				Detection	
USGS Invasive Carp Database Management and Integration Support	↔	↔	↔	↔	↔	↔	↔	↔	↔	Management and Control	
Barrier Maintenance and Fish Suppression		↔								Management and Control	
Illinois Waterway Hydroacoustics		↔	↔	↔						Detection	
Early Detection of Invasive Carp in the Upper Illinois Waterway		↔	↔	↔	↔					Detection	
Contracted Commercial Fishing Below the Electric Dispersal Barrier		↔	↔	↔	↔	↔				Management and Control	
Upper Illinois Waterway Contingency Response Plan		↔	↔	↔	↔	↔				Response	
Multiple Agency Monitoring of the Illinois River for Decision Making		↔	↔	↔	↔	↔	↔	↔	↔	Detection	


Project
Illinois River Pool (Upstream --> Downstream)
CAWS
Lockport
Brandon Road
Dresden Island
Marseilles
Starved Rock
Peoria
La Grange
Alton
Primary Purpose
Page Number
Invasive Carp Demographics
Management and Control
Monitoring Invasive Carp Reproduction in the Illinois Waterway
Detection
Zooplankton as Dynamic Assessment Targets for Asian Carp Removal (Appendix A)
Not Applicable
Invasive Carp Stock Assessment in the Illinois River/Management Alternataives
Detection
Invasive Carp Population Modeling to Support an Adaptive Management Framework
Management and Control
Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)
Management and Control
Invasive Carp Enhanced Contract Removal Program
Management and Control
Des Plaines River and Overflow Monitoring
Detection
Alternative Pathway Surveillance – Urban Pond Monitoring
Detection
Alternative Pathway Surveillance in Illinois – Law Enforcement
Management and Control

DETECTION PROJECTS

SEASONAL INTENSIVE MONITORING IN THE CAWS

Participating Agencies: IL DNR (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)

Pools Involved: CAWS

INTRODUCTION AND NEED

The CAWS represents a direct connection between the Mississippi River and Great Lakes basins and serves as a potential avenue for invasive carp (Silver Carp and Bighead Carp) to expand into the Great Lakes. The EDBS in the CSSC acts as a final barrier upstream of the current invasive carp population front to prevent the movement of invasive carp between the systems. Downstream of the EDBS, monitoring and removal efforts reduce the risk of invasive carp challenging or bypassing the barrier. However, the threat exists that invasive carp may move through the EDBS undetected or otherwise be introduced upstream of it. Therefore, it is critical to monitor the CAWS for any invasive carp and react accordingly if an individual is detected. Results from the SIM upstream of the EDBS will contribute to our understanding of invasive carp distribution and abundance in the CAWS and guide conventional gear or rapid response actions designed to remove invasive carp from areas where they have been captured or observed. Sampling efforts will continue in 2023 with two seasonal intensive interagency multi-gear sampling efforts in May and October.

OBJECTIVES

- Detect and remove invasive carp from the CAWS upstream of the electric dispersal barrier system when warranted.
- Determine invasive carp abundance and distribution in the CAWS through intense random, fixed, and targeted sampling efforts at locations deemed likely to hold fish.

STATUS

SIM in the CAWS is a modified continuation of the Fixed and Random Site Monitoring Upstream of the EDBS and Planned Intensive Surveillance in the CAWS. This project has been in place since 2014 in its current form. SIM consists of an intensive two-week multi-agency sampling effort in the spring and fall of each year utilizing coordinated netting and electrofishing efforts at fixed, random, and targeted sites in a comprehensive effort to detect the presence of invasive carp in the CAWS upstream of the EDBS. To date, one live Bighead Carp has been collected in Lake Calumet in 2010, and one live Silver Carp has been collected in the Little Calumet River in 2017. An additional live Silver Carp was collected in 2022 in Lake Calumet outside of SIM sampling. Confining effort upstream of the EDBS to short, intensive sampling periods allows for increased detection and removal efforts downstream of the barrier, reducing the risk of individuals moving upstream towards the EDBS and Lake Michigan by way of the CAWS.

METHODS

Sampling Reaches:

The sampling design includes intensive electrofishing and netting at five fixed reaches and four random site reaches (Figure 1). New to 2023, random reaches will include areas of the waterway designated as fixed reaches. Prior to 2023, random site sampling excluded random samples in fixed site areas. This change is happening to increase sampling coverage in the fixed site areas, which have historically received less sampling per mile than the random site areas. Random sample sites will be generated with GIS software from shape files delineating random reaches and will be labeled with latitude-longitude coordinates in decimal degrees.

Upstream Fixed Site Area Descriptions

- Site 1 – Lake Calumet (sampling will be limited to shallower areas north of the Connecting Channel. This avoids deep draft areas with steep walls but includes channel drop-off areas that exist north of the Connecting Channel).
- Site 2 – Calumet/Little Calumet River from T.J. O'Brien Lock and Dam to its confluence with the Little Calumet River South Leg, around 11.3 km (7 miles).
- Site 3 – CSSC and South Branch Chicago River from Western Avenue upstream to Harrison Street, around 6.4 km (4 miles).
- Site 4 – North Branch Chicago River and North Shore Channel from Montrose Avenue north to Peterson Avenue, around 3.2 km (2 miles).
- Site 5 – North Shore Channel from Golf Road north to Wilmette Pumping Station, around 3.2 km (2 miles).

Upstream Random Site Sampling Area Descriptions

- Area 1 – Lake Calumet Connecting Channel, Calumet River, and Fixed Site 1.
- Area 2 – Cal-Sag Channel from its confluence with the CSSC to the Little Calumet River and Fixed Site 2.
- Area 3 – CSSC from Western Avenue downstream to the EDBS and Fixed Site 3.
- Area 4 – North Shore Channel (including Fixed Sites 4 and 5), North Branch Chicago River, and Chicago River.

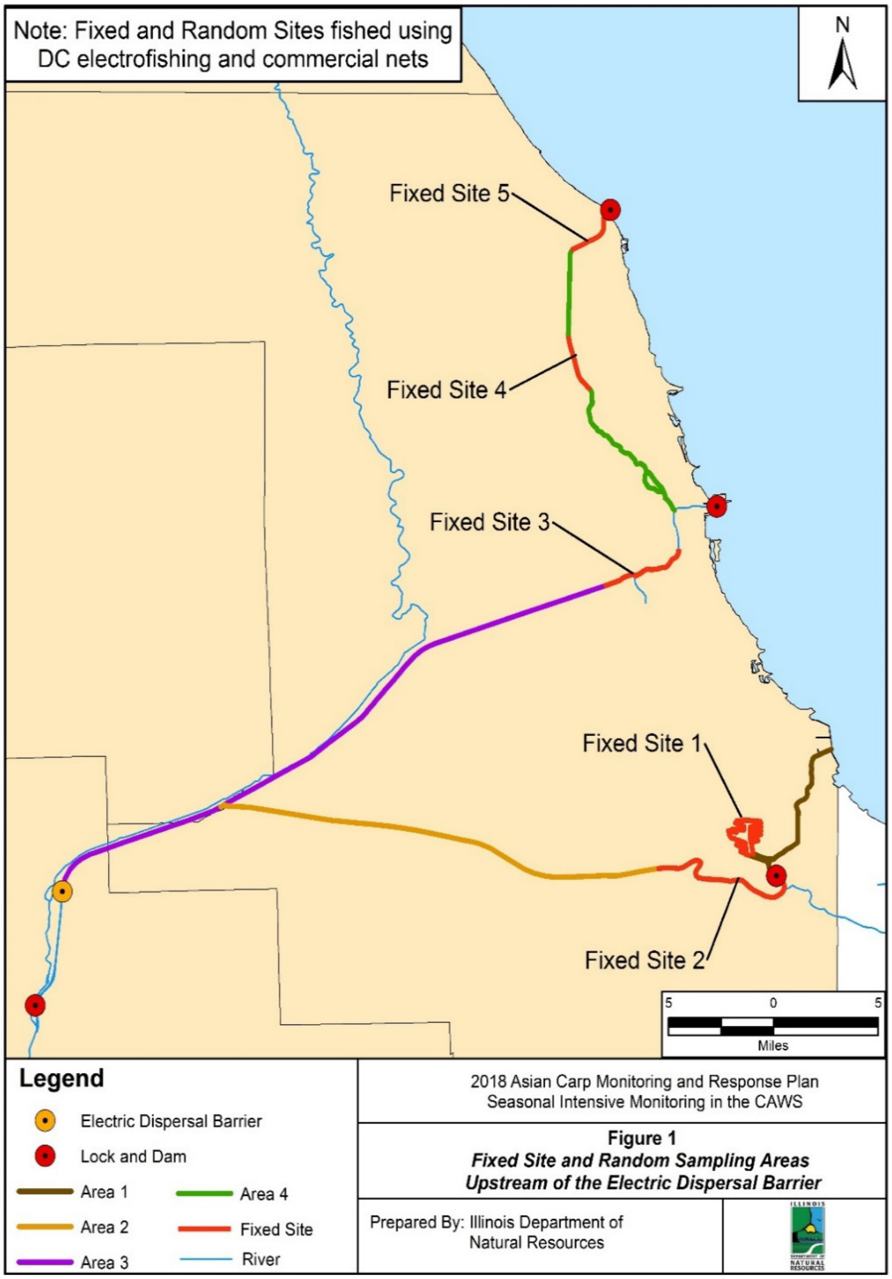


Figure 1. *Fixed site and random site sampling reaches for electrofishing and commercial netting upstream of the EDBS.*

Decontamination Protocol

To prevent contamination of eDNA samples from residual invasive carp genetic material on sampling equipment (boats, netting gear, etc.), hot water pressure washing and chlorine washing (10 percent solution) of boats and potentially contaminated equipment used in the SIM are required (see Appendix C). Additionally, nets specifically for monitoring upstream of the EDBS will be used.

Electrofishing Protocol

Pulsed DC electrofishing will be used at fixed and random sites and include one to two netters (two netters preferred). Random sites are generated with ArcGIS, and locations for each electrofishing transect will be identified with GPS coordinates. Fixed or random electrofishing transects will be sampled for 15 minutes in a downstream direction in waterway main channels (including following shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Electrofishing boat operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat. Electrofishing may also be used in conjunction with commercial fishers to herd fish into nets. Common Carp will be counted without capture, and all other fish will be netted and placed in a tank where they will be identified to species and counted, after which they will be returned live to the water. Schools of YOY Gizzard Shad less than 152.4 mm (6 inches) long will be subsampled by netting as many fish as possible from each encountered school and placing them in a holding tank along with other captured fish. YOY Gizzard Shad will be examined closely for the presence of invasive carp and enumerated due to similarities in appearance and habitat between the species. All fish that are not invasive carp will be returned live to the water after data collection. The goal is to complete 150 electrofishing runs during each two-week event.

Netting Protocol

Contracted commercial fishers will set large mesh gill nets that are 3 meters (10 feet) deep by 182.8 meters (600 feet) long at fixed and random sites per set (Appendix M). Half of the net (91.4 meters) will consist of 88.9 mm (3.5 inches) bar mesh, while the other half will consist of 101.6 mm bar mesh. Deep water gill nets may also be used as appropriate. IL DNR will provide one 9.1-meter (30-foot) deep gill net for each net boat as necessary (Appendix M). Locations for each net set will be identified with GPS coordinates. Net sets will be 15 to 20 minutes long and will incorporate fish herding techniques within 137.2 meters (450 feet) of the net (e.g., plungers on the water surface, pounding on boat hulls, or revving trimmed-up motors) to increase detection probability (Butler et al. 2018). An agency biologist will be assigned to each commercial net boat to monitor operations and record data. All fish that are not invasive carp will be returned live to the water after data collection. The goal is to complete 150 net sets (gill nets and deep-water gill nets) during each two-week event.

Special Protocols

Lake Calumet/Calumet River (week of May 22)

Prior to sampling, crews may set Great Lake pound nets at the entrance to Lake Calumet (if water conditions allow) to prevent fish immigration/emigration (Figure 2). Pound nets will have a single lead, two adjustable length wings, and a 54.9 m^3 (1,938.8 ft^3) mesh cab (catch area) (Appendix M). Pound nets will be checked and emptied each day. Contracted commercial beach seining will occur in the north section of Lake Calumet for two days and in the south section for one day (Figure 2). The 731.5-meter (2,400-foot) seine will be staked to shore on one end, deployed in an arc through the water by boat, and winched up on shore. Gill nets, deep water gill nets, and electrofishing will also be utilized in Lake Calumet, the Calumet Connecting Channel, and the Calumet River, as described above (Figure 2). See Appendix L for a more complete description of invasive carp sampling gears.

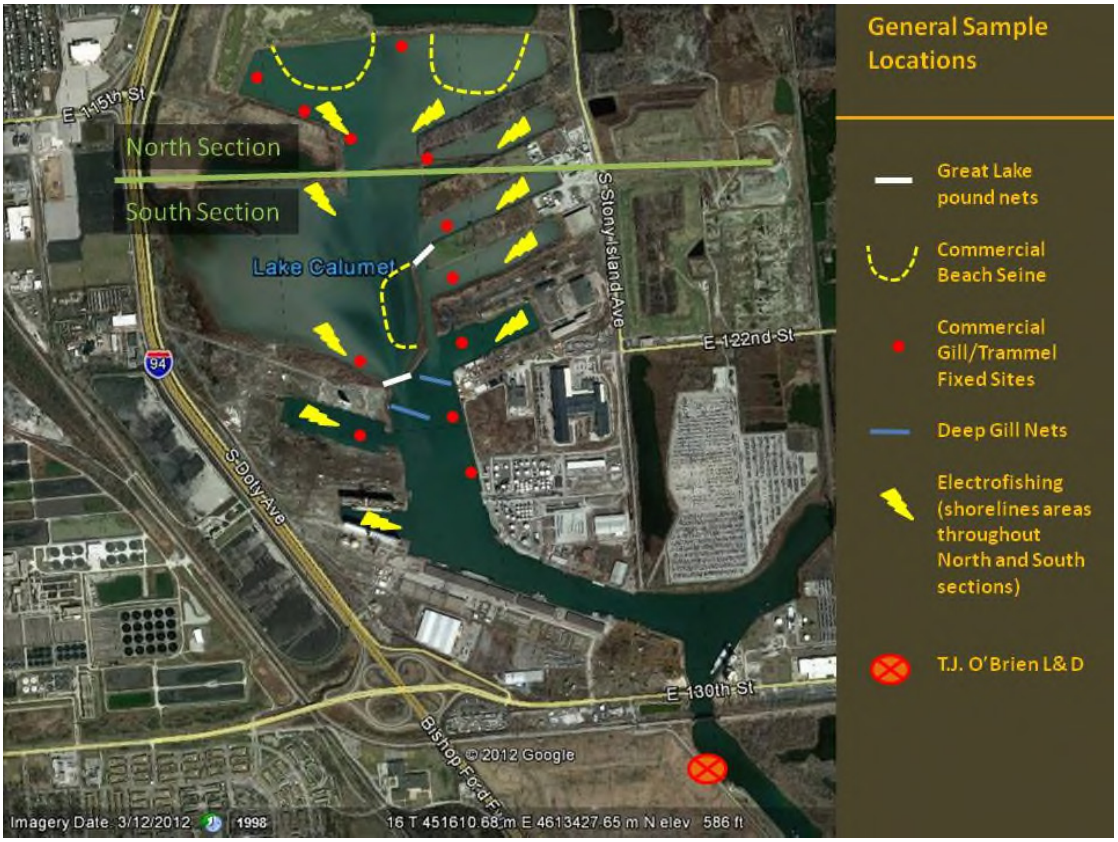


Figure 2. *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

North Shore Channel (week of October 2)

Sampling will occur between the Argyle Street Bridge, located downstream from the North Shore Channel and North Branch Chicago River confluence, and the Wilmette Pumping Station (Figure 3 of Appendix D). Teams of two electrofishing boats and one net boat will begin at the upper and lowermost site boundaries and work toward the middle. Each team will work together to set nets across the channel and drive fish to nets with electrofishing and noise from "pounding" on the hull of boats and revving trimmed-up motors. Each team will set three nets across the channel at intervals of 457.2 to 731.5 meters (500 to 800 yards) apart, after which electrofishing and noise will occur between the nets to drive fish. The net closest to the outer site boundary will then be pulled and reset at 457.2 to 731.5 meters (500 to 800 yards) closer to the site center, and the process will be repeated until the entire reach has been sampled. To maximize sampling time, electrofishing will begin in the area between the remaining nets while the outer net is being moved. The idea is to leapfrog the nets after each electrofishing and fish-driving episode so that each team gradually moves toward the site midpoint.

Chicago River and South Branch Chicago River/Bubbly Creek (week of October 9)

Electrofishing will occur at random sites in the basin between Lake Shore Drive and Chicago Lock and near Wolf Point (confluence of the North Branch Chicago River and Chicago River, Figure 3 of Appendix D). During this time, net boats will set and pull deep water gill nets in areas of the main navigation channel. Once the entire reach is sampled, crews will travel downriver and sample eight barge slips and backwater areas in the South Branch Chicago River near Bubbly Creek (Figure 3 of Appendix D). Barge slip sampling will have a block net or gill net set at the entrance of each slip to prevent fish from leaving the slip. Electrofishing boats will then shock from the back of the slip out toward the main channel, driving fish into the block net while collecting stunned fish along the way. A second block or gill net may be set midway within longer slips to sample them more effectively.

Figure 3. *Sampling locations in the North Shore Channel, Chicago River, and South Branch Chicago River/Bubbly Creek area.*

Data Collection

For all SIM activities, the accurate sampling time will be recorded with all fish enumerated and identified to species. GPS coordinates (decimal degrees) will be taken at the location of all net sets and the beginning of electrofishing runs. Crew leaders should fill in as much information on the data sheets (Appendix H) as possible for each site/transect if not directly recording data in the Microsoft Access Fish App entry application. All field data collected on data sheets will be entered into a Microsoft Access Fish App database.

Detection of Invasive Carp

Any Grass Carp sampled will be kept and put on ice for transfer to USFWS for ploidy analysis. Otoliths will be removed from Grass Carp and sent to Dr. Greg Whitledge (SIU) for microchemistry and origin analysis. Any Bighead Carp or Silver Carp collected will immediately be reported to the Operations Coordinator and Law Enforcement, who will bring a cooler to secure the fish (Appendix E). GPS location, time, and specific gear will be recorded as accurately as possible (mesh size, type, depth). Invasive carp will then be transferred to Dr. John Epifanio, with tissues shared among research agencies (Appendix E). Furthermore, the capture of a Bighead Carp or Silver Carp would initiate a level two rapid response upon conferring with MRWG members; additional effort or time frame could change. See Appendix E for more information on protocols and chain-of-custody instructions in the event of a capture of a Bighead or Silver Carp upstream of the EDBS.

2023 SAMPLING SCHEDULE

Spring Event

Week of May 15: All fixed and random area sites upstream of the EDBS (see netting and electrofishing protocols)

Week of May 22: Lake Calumet/Calumet River (see special protocols) and all random area sites upstream of the EDBS (see netting and electrofishing protocols)

Fall Event

Week of October 2: All fixed and random area sites upstream of the EDBS (see netting and electrofishing protocols)

Week of October 9: North Shore Channel, Chicago River, South Branch Chicago River, and Bubbly Creek (see special protocols) and all random area sites upstream of the EDBS (see netting and electrofishing protocols)

DELIVERABLES

Results for SIM will be reported daily during events and compiled for monthly sampling summaries. Data will be summarized in an annual interim report and the project plan will be updated in annual revisions of the MRP.

STRATEGY FOR eDNA SAMPLING IN THE CAWS

Participating Agencies: UFWS (Green Bay FWCO, Whitney Genetics Lab)

Location: Lake Calumet, Little Calumet River, Powderhorn Lake, Des Plaines River

Pools Involved: CAWS, Des Plaines River

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 used as a surveillance tool to monitor for Bighead Carp and Silver Carp DNA in the CAWS and maintain vigilance above the EDBS. Using multiple detection methods provides a balanced and complete monitoring program in the CAWS because all monitoring methods have difficulty detecting very low-abundance organisms. eDNA sampling offers an additional monitoring method to those used during SIM. Syncing the timing of eDNA sampling with SIM allows eDNA sampling results to complement SIM sampling by monitoring for the genetic presence of invasive carp and providing evidence of areas that may warrant further attention. This also allows SIM efforts to help interpret eDNA results and ensures that, by design, any positive results are already followed up with an intensive physical sampling effort to gauge the likelihood that a positive detection was the result of a live carp threat versus a secondary vector. eDNA sampling events are typically conducted twice per year when conditions allow. Since 2013, eDNA results do not automatically trigger any physical sampling response.

OBJECTIVES

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

STATUS

Since 2013, when the USFWS eDNA Program was formed and all eDNA sampling responsibility in the CAWS, including the methodology, was adopted from the USACE, USFWS has conducted sampling for eDNA in the CAWS above the EDBS. Soon after adoption, USFWS implemented equipment decontamination and separation protocols to reduce potential eDNA loading to the system by contaminated gears. Commercially contracted fishing crews also began using dedicated, clean nets above the EDBS at this time. Several additional improvement steps occurred in subsequent years, including improved DNA markers (Farrington et al. 2015) in 2014, processing methodologies switching from filtering to centrifugation in 2015 (USFWS internal reports), and laboratory analysis changing from conventional PCR to qPCR (Amberg et al. 2015) in 2015. Together, these improvements have made for more sensitive and specific eDNA results. While improvements to the field and lab methods have improved sensitivity, this method should never be expected to find the proverbial “needle in the haystack” or a single fish, but it has been shown to provide detection of rare species when other methods have failed. The low eDNA detection rates observed in the CAWS over the last seven years (0 to 3.8 percent positive detections) reflect that only three live invasive carps have been captured in the CAWS; one Bighead Carp in 2010, one Silver Carp in 2017, and one Silver Carp in 2022. Based on lessons learned deploying eDNA in carp-infested rivers such as the Wabash and Upper Mississippi Rivers, sampling emphasizes targeting slack-water and off-channel areas. In 2019, it became apparent that sewer systems can contribute substantial amounts of DNA to the CAWS in certain areas, likely from fish markets and households consuming invasive carp, so sampling has since been adjusted to avoid these areas of sewer discharge.

METHODS

In 2023, the CAWS will be sampled for Bighead Carp and Silver Carp eDNA in Lake Calumet and Marine Services Marina on the Little Calumet River areas (Figure 1). Sampling will not occur within seven days of any combined sewage overflow events that impact the targeted sampling areas. One sampling event will be conducted prior to the late-spring SIM event, and the second will be conducted just before the fall SIM. During each event, 300 5 by 50 mL water samples will be collected from Lake Calumet, and 100 will be collected from the marina on the Little Calumet River. Field blanks, consisting of one 50 mL tube of distilled water, will occur after every 10 samples for quality assurance purposes (30 in Lake Calumet and 10 in the marina).

A control site, Powderhorn Lake, has been added to the sampling regime. The control site is a closed pond with no connectivity to sampled waters but close enough in proximity to assume that bird activity may be similar. This site may help gauge if birds are substantial secondary vectors of invasive carp eDNA to waterbodies in the area, including the sampling sites. The control site will be sampled in a similar manner and at a similar sampling density to the other monitoring sites (100 5 by 50 mL water samples and 10 field blanks).

The USFWS Wilmington FWCO has requested to add the Des Plaines River to the 2023 sampling schedule (Figure 2). Tentatively, this site will be sampled in early spring in a similar manner and at a similar sampling density to the other monitoring sites (200 5 by 50 mL water samples and 20 field blanks).

Additional events and areas may be added if requested by the MRWG partners. All 2023 eDNA sampling efforts and results will be detailed in the 2023 Interim Summary Report, and a verbal summary will be presented at the annual MRWG meeting. Similar to previous years, sample collection and processing methods will follow the most up-to-date Quality Assurance Project Plan (USFWS 2022). The state of Illinois will be notified of the results from the CAWS following the pre-established Communication Protocols after sample processing is complete, and subsequently, those results will be posted online (USFWS 2022).

2023 SAMPLING SCHEDULE

Week of May 8

- 400 samples, 40 field blanks (CAWS)
- 100 samples, 10 field blanks (Powderhorn Lake)
- 200 samples, 20 field blanks (Des Plaines River)

Week of Sept 25

- 400 samples, 40 field blanks (CAWS)
- 100 samples, 10 field blanks (Powderhorn Lake)

DELIVERABLES

Results of the CAWS sampling event will be reported as positive/negative in sampling summaries for Illinois and then posted online. Data will be summarized for the annual Interim Summary Report, and project plans will be updated for annual revisions to the MRP.

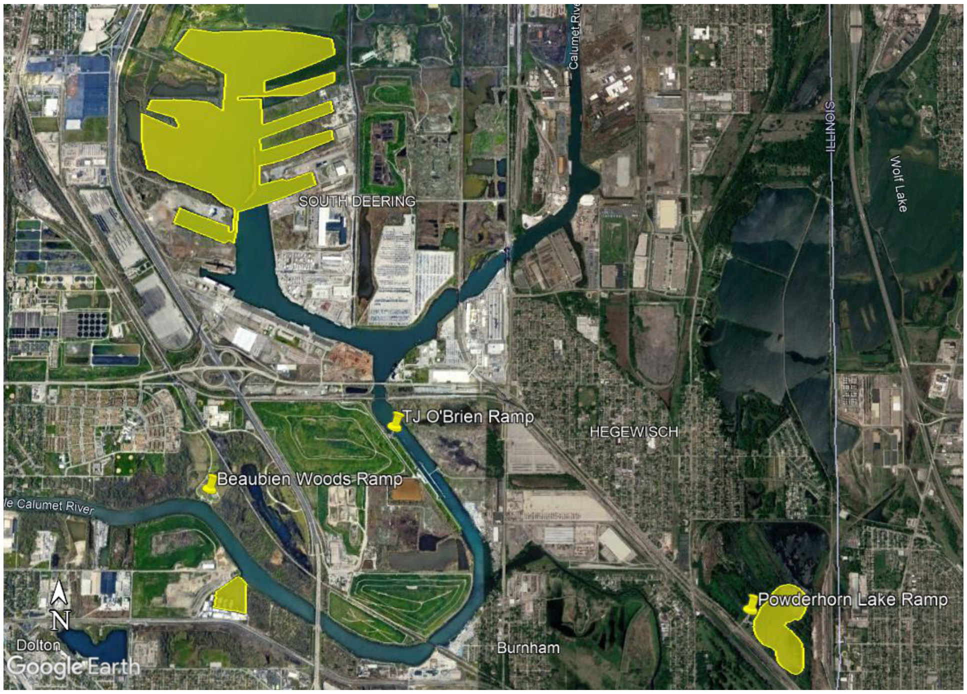


Figure 1. *Locations (yellow shaded areas) of Bighead and Silver Carp eDNA samples to be collected in Lake Calumet, Little Calumet River, and Powderhorn Lake in 2023.*

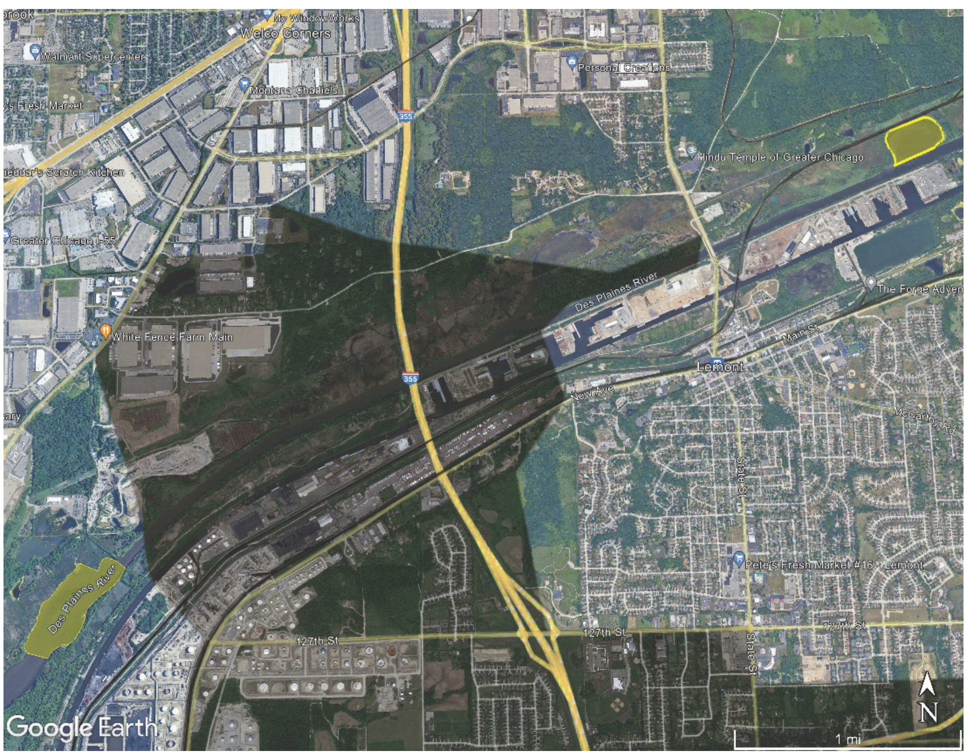


Figure 2. *Locations (yellow shaded areas) of Bighead and Silver Carp eDNA samples to be collected in the Des Plaines River in 2023.*

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US Army Corps of Engineers

TELEMETRY MONITORING PLAN

Participating Agencies: USACE (lead); IL DNR, SIUC, USGS, MWRD of Greater Chicago, and USFWS (support)

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

INTRODUCTION AND NEED

The telemetry monitoring plan includes tagging fish with individually-coded ultrasonic transmitters in the Upper IWW. The proposed acoustic network is comprised of stationary receivers supplemented (when necessary) by a mobile hydrophone unit to collect information from acoustic transmitters (tags) implanted into free-swimming Bighead Carp (*Hypophthalmichthys nobilis)*, Silver Carp (*H. molitrix*), and surrogate species. Some form of the telemetry receiver network that USACE maintains has been in place since 2010. The number of receivers and placement locations have changed over time and have been adapted to improve detection efficiencies, focus on areas of importance, or help identify high-density fish areas. Acoustic receiver coverage within the Upper IWW is primarily focused on the EDBS, with secondary coverage surrounding lock and dams and emigration routes, such as tributaries and backwater areas. As of 2022, USACE operates 29 receivers between the confluence of the Cal-Sag and CSSC and the Dresden Island Lock and Dam. Additionally, over the years, other agencies (SIUC, USGS, and USFWS) have deployed receivers in support of alternative projects within the same area.

This telemetry monitoring project has provided valuable insights to resource managers about fish behavior at the EDBS, movement between navigation pools, and Bighead Carp and Silver Carp movement within the Dresden Island Pool. The telemetry program has demonstrated high efficacy for the EDBS to deter large fish. Telemetry has also helped shed light on barge entrainment risks and fish behavior in response to varying environmental parameters at the EDBS. Tagged fish movements have refined the understanding of how and when fish utilize lock chambers to move between navigation pools within the Upper IWW. Bighead Carp and Silver Carp, as well as surrogate species, have also been studied using acoustic telemetry at the leading edge of the invasion front within the Dresden Island Pool. Telemetry has located several areas where Bighead Carp and Silver Carp activity is greatest in the pool, including the Rock Run Rookery backwater and the confluence of the Kankakee and Des Plaines rivers. Movement patterns at the leading edge have also been analyzed to compare differences between species. All this data has been utilized by resource managers and response agencies to improve harvest efforts and make informed decisions on EDBS operations and maintenance. As more research is conducted on Bighead Carp and Silver Carp in the Upper IWW ecosystem, information gaps are identified, and monitoring plans continue to be refined.

Acoustic telemetry monitoring is the only continuous monitoring project for the EDBS in 2023. Additional barrier efficacy studies have been completed using alternative monitoring tools, such as mark/recapture and hydroacoustic surveys. These studies have helped address the deficiencies of acoustic telemetry but cannot be deployed every day throughout the year. By coupling telemetry with other methodologies, the information gaps can be addressed to better understand the dynamics of the leading edge of the invasion front. The following goals and objectives have been revised from previous years to focus future efforts on the identified knowledge gaps and improving the efficiency of data collection and reporting.

OBJECTIVES

The overall goal of this telemetry monitoring plan is to assess the effect and efficacy of the EDBS on tagged fish in the CAWS and Upper IWW. The goals and objectives for the 2023 season have been identified as:

Goal 1: Determine if the upstream passage of the EDBS by large fishes has occurred and assess the risk of Bighead Carp and Silver Carp presence (Barrier Efficacy).

- **Objective:** Monitor the movements of tagged fish in the vicinity of the EDBS.

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

- **Objective:** 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).
- **Objective:** Review and compare standard operating protocols and vessel lockage statistics for Lockport, Brandon Road, and Dresden Island locks.

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

- **Objective:** Determine if the leading edge of the Bighead Carp and Silver Carp invasion (currently RM 286.0) has changed in either the upstream or downstream direction.
- **Objective:** Describe habitat use and seasonal movement in the areas of the Upper IWW and tributaries where Bighead Carp and Silver Carp have been captured and relay

information to the population reduction program undertaken by IL DNR and commercial fishermen.

Additional objectives of the telemetry monitoring plan:

- **Objective:** Integrate information between agencies conducting related acoustic telemetry studies.
- **Objective:** Download, analyze, and post telemetry data for information sharing/database organization.
- **Objective:** Maintain existing acoustic network and rapidly expand to areas of interest in response to new information.
- **Objective:** Support the modeling efforts by USFWS/USGS with supportive data and adjust the network accordingly in consultation with the telemetry working group.

STATUS

Sample size and distribution – In 2010, the telemetry working group decided that a baseline minimum of 200 transmitters be implanted for telemetry monitoring near the EDBS and that this level of tags be maintained as battery life expires or specimens exit the study area. After the 2022 sampling season, there were 170 USACE-tagged fish within the study area with varying expiration dates, with the nearest expiration date being March 2023 for 24 tags. In the 2022 field season, 60 tags implanted in surrogate fish that were released within the Lower Lockport Pool in previous years will remain active through the end of the field season with no tags expiring. Tag implantations will be required in the spring of 2023 to achieve recommended minimum levels of sample sizes and to replace those that emigrate out of the pool through the lock and dam or the Lockport Control Works. It is anticipated that 15 tags will be implanted in Lockport Pool to meet the goal of 75 tagged fish in the pool (Table 1).

By the end of the 2022 field season, there were 40 active tags implanted in surrogate fish that had been released into the Brandon Road Pool and will remain active until 2027. For the 2023 season, 10 tags are anticipated to be implanted in Brandon Road Pool to achieve a target number of 50 actively tagged fish within the pool (Table 1). Immigration from the Lockport Pool is expected and will assist in maintaining elevated transmitter density in the spring and summer months.

At the end of the 2022 field season, there were 68 USACE transmitters within Dresden Island Pool, of which 24 will be expiring in March 2023. There is an active removal effort underway in this pool, so there is a possibility for tagged individuals to be removed, and emigration is likely to occur to the Marseilles Pool. At least 31 transmitters will be implanted into invasive carp in Dresden Island Pool in the spring and fall of 2023 as the older tags expire to maintain the target goal of 75 USACE tags. Ideally, all 31 tags would be deployed in the spring; however, if resources are limited, the remaining tags will be deployed in the fall. The number of tags and season of deployment in each pool is shown in Table 1.

Table 1: *Recommended transmitter implementation for the 2023 sampling season. Supplemental tags are required to maintain the existing level of coverage within the study area while exact ratios per pool may be changed slightly to account for new focus areas. Tags may be implemented in the fall if the springtime tag density is not met.*

Release Pool/Location	Species	Spring Supplement tags	Fall Supplement tags	Total estimated tag distribution
Upper Lockport/RM300	Common Carp	0	0	0
Lower Lockport/RM292.7	Common Carp	15	0	75
Brandon Road/RM286.5	Common Carp	10	0	50
Dresden Island/RM276	Bighead Carp and Silver Carp	31	0	75
Total	N/A	56	0	200

METHODS

Species Selection (Primary and Surrogate)

Bighead Carp and Silver Carp are the primary species of concern, and their behavioral response to the barriers is of the greatest importance. However, as mentioned previously, populations of both invasive carp species vary and are considered rare to absent near the EDBS. Therefore, to test the direct response of fish and maintain target density levels within all pools, surrogate species have been tagged and monitored within the Dresden Island, Brandon Road, and Lockport pools. Dettmers and Creque (2004) cited the use of Common Carp (*Cyprinus carpio*) as a surrogate species for use in telemetry studies in the CSSC. Common carp are known to migrate relatively long distances, and they grow to large sizes that approximate those achieved by invasive carp. Based on these characteristics, tracking common carp should provide a good indicator of how invasive carp would respond to the dispersal barrier if they were near this deterrent.

Tag Specifications and Implantation Procedure

Tagging efforts will be focused during late spring (April to May) and fall (October to November) and follow the surgical and recovery procedures outlined in the Telemetry Master Plan Summary of Findings by Baerwaldt and Shanks (ACRCC 2012). Adult Bighead Carp and Silver Carp will be collected from Dresden Island Pool (RM 271.5 to 286), and surrogate species will be collected from Lockport Pool and Brandon Road Pool (RM 286 to 304). Fish collected will be weighed and measured, and sex will be identified if possible. API Stress Coat + will be applied to the fish to promote healing of the incision site to reduce fish mortality during or after surgery due to infection at the incision site (Shivappa et al. 2017). Fish in Dresden Island will also be tagged with an external tag (e.g., Jaw tag) to indicate to commercial fishermen and agencies that those fish have an internal acoustic tag. Tagged fish are requested to be released, including Bighead Carp and Silver Carp (if they are suitable for release), otherwise, agencies are to save the fish and return it to USACE to save the transmitter for tagging a replacement fish. No Bighead Carp and Silver Carp caught in Lockport or Brandon Road pools will be tagged and returned, as these areas are upstream of the known invasion front and will be given to IL DNR for species vouchers.

Stationary Receivers

A system of passive, stationary receivers (Vemco VR2W and VR2C) are placed throughout the IWW to monitor the movement of tagged fish. The receivers log data from tagged fish when they swim within the detection range of the receiver (typically within a quarter mile of the receiver). The VR2Ws will be placed from the Dresden Island Lock and Dam (RM 245, IWW) just upstream of the confluence of the Cal-Sag Channel and the CSSC. The confluence is located approximately seven river miles upstream of the EDBS (RM 303.5, IWW). Some receivers may be removed during winter months to prevent damage from ice buildup; however, a majority of the receiver array will remain active.

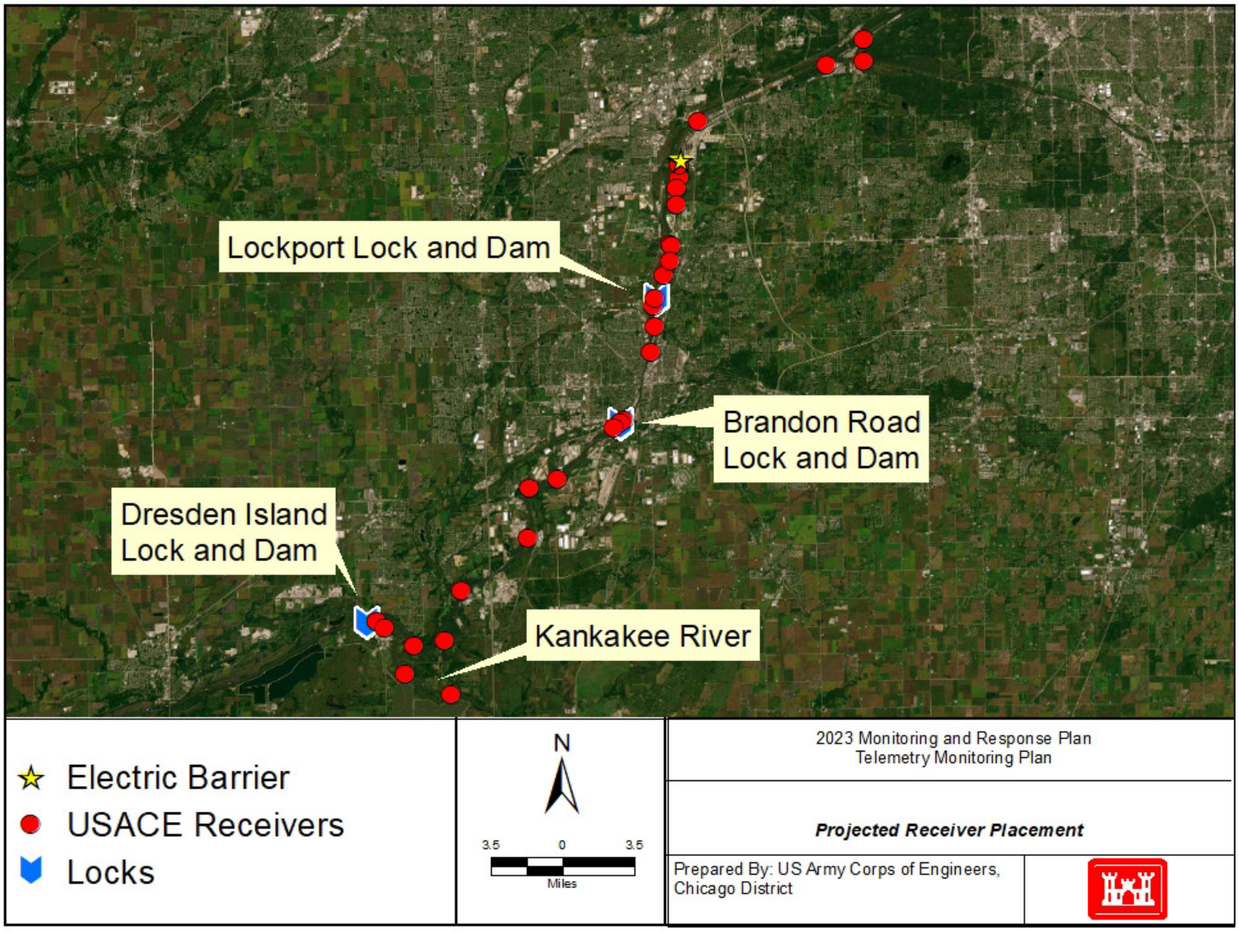

***Figure 1**: Proposed USACE 2023 telemetry network to be deployed throughout the IWW.*

Figure 1 shows the general strategy of VR2W placement for 2023 (N=30 USACE receivers). The priority is to achieve the most coverage (detection capacity) near the EDBS with VR2W receivers. To accomplish this, receivers immediately downstream and upstream of the EDBS will provide a system that will help USACE biologists monitor and track any fish movement through the EDBS. The remaining network throughout the system is used to track overall movement and determine what type of movement occurs from fish navigating lock structures. Receivers will also be deployed at possible escape routes from the telemetry network, such as tributary confluences. Movement through lock structures will be compared to USACE lockage data from Dresden Island, Brandon Road, and Lockport locks. Leading edge movements will be monitored by the receiver network within Dresden Island Pool, Brandon Road Pool, and the Kankakee River. Other significant movement patterns will also be compared to river stage and temperature data.

Receivers will be downloaded bi-monthly, or more frequently if needed, to retrieve data for analysis and maintenance of the acoustic telemetry network (i.e., decrease the risk of vandalism, ensure operation of the device, check battery life, and replace if necessary). All receivers will be downloaded via Bluetooth-USB capability. The software is available online for free from the InnovaSea website (https://support.vemco.com/s/).

Mobile Tracking

In the past, mobile tracking has been used by USACE biologists using a mobile unit (Vemco VR-100 unit with a directional and omnidirectional hydrophone operated out of a boat) that enabled crews to manually locate any tagged fish using the signal emitted from the transmitter inside the fish. The VR-100 can be used as a supplemental tool to help locate any acoustically tagged fish that appear in areas of concern. In addition, the VR-100 will be used to further investigate tags that may cross the EDBS or locks and dams.

Contingency Measures

Tagged fish crossing the EDBS – As described above, any suspicion (indicated by stationary receiver data) of tagged fish crossing the EDBS can be confirmed by the mobile tracking unit. This will enable crews to locate the exact location of a fish rather than approximating the location through detections by a stationary receiver. USACE leadership, agency leads involved with the telemetry plan, and the MRWG will be notified immediately of any suspected barrier breach. In some cases, it may be necessary to implement a 24-hour track to confirm if the fish of interest is indeed viable. This may be done using the mobile tracking device or by placing a temporary stationary receiver near the EDBS.

Tagged Bighead Carp and Silver Carp detected in Brandon Road Pool – Any detection of Bighead or Silver Carp within Brandon Road Pool will be verified immediately. Verification of detections may include a review of stationary receiver network data for patterns of detection and on-site tracking utilizing the VR-100 receiver mobile tracking unit. Verified detections of Bighead Carp and Silver Carp within waterways upstream of the Brandon Road Lock and Dam will trigger immediate notification to USACE leadership, agency leads involved with the telemetry plan, and the MRWG co-chairs.

2023 SAMPLING SCHEDULE

March – April	VR2W network inspected, and new receivers installed and range tested (if needed).
ONGOING	VR2W network maintenance, downloads, and mobile tracking (if needed)
April – May	Acoustic tagging in Lockport, Brandon Road, and Dresden Island pools
December	Prepare receiver array within the IWW and CAWS for winter months

DELIVERABLES

All agency leads involved with the telemetry plan and the MRWG will be notified immediately of any suspected barrier breach or detection of Bighead Carp and Silver Carp above the Brandon Road Lock and Dam. Periodic updates will be given to the MRWG in the form of briefings at regular meetings and monthly summaries. Summarization of all data collected in 2023 will be included in the year-end interim summary report compiled by IL DNR after each field season.

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USGS TELEMETRY PROJECT: REAL-TIME TELEMETRY AND MULTI-STATE MODELING

Participating Agencies: USGS Upper Midwest Environmental Sciences Center (lead), USGS Central Midwest Water Science Center (co-lead), IL DNR, USFWS, USACE – Chicago District, SIU**,** INHS

Location: Upper Illinois River Pools and Upper IWW

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

INTRODUCTION AND NEED

Telemetry of bigheaded carp and surrogate fish species tagged with ultrasonic transmitters has become an invaluable tool in management for these species in the Upper Illinois Waterway and elsewhere. Data collected from detections of these fish can be used to calculate movement probabilities between river pools, estimate fishing mortality, and supplement mark-recapture data for population estimates. These estimates can all be used to parameterize models [e.g., Spatially Explicit Invasive Carp Population (SEICarP) Model] used for adaptive management of the Illinois River. The between-pool 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. Fish removal by contracted fishers has become the primary method of controlling bigheaded carp in the upper Illinois Waterway System. 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 patterns for bigheaded carp through modeling and real-time telemetry applications informs removal efforts and facilitates planning of contingency actions.

To develop a better understanding of bigheaded carp population dynamics to meet management objectives, an existing network of stationary real-time and non-real-time acoustic receivers in the Upper Illinois Waterway, and elsewhere, is collaboratively managed by multiple agencies and universities. A Telemetry Workgroup has been established by the Monitoring and Response Workgroup (MRWG) to ensure that the multi-agency telemetry efforts are coordinated to efficiently and effectively meet MRWG goals. This workgroup plans and executes the placement of receivers, tagging of bigheaded carp with acoustic tags, and data management as needed to meet objectives. Three primary objectives to meet MRWG goals identified by the Telemetry Workgroup included (1) development of a common standardized telemetry database with visualization and analysis tools, (2) transitioning from Program MARK to a custom Bayesian multi-state model for estimating movement probabilities needed for SEICarP and (3) deploying, maintaining, and serving data from real-time acoustic receivers to inform contingency planning and removal. The telemetry database and visualization tools (FishTracks DB) facilitate standardization, archiving, sharing, quality assurance, visualization and analysis of the telemetry data needed for management. In FY2021, the FishTracks DB portion of this work transitioned to a consolidated USGS Database Management and Integration Support Monitoring and Response Plan (MRP) project.

The transition to a custom Bayesian multi-state model to estimate movement probabilities will support more efficient, effective, and robust population modeling with SEICarP by overcoming short comings of Program MARK for this purpose. These shortcomings include lack of customizability, inability to further extend the model, poor model convergence, computer crashes, and limited ability to estimate model uncertainty. The work on the custom Bayesian multi-state model to estimate movement probabilities will conclude this year and reporting to MRWG will be completed in FY2023. In cooperation with the USACE, USGS will continue to maintain and test the five upstream-most, real-time receivers (see Table 1) to ensure reliability and accuracy of the real-time alerts for informing contingency actions and barrier evaluations. The four downstream most receivers including three at Hanson Materials in Marseilles Pool and one below the Starved Rock Dam in Peoria Pool that were being used to assess relation of real-time detections to catch by contract fishers to informing that fishing, have been discontinued.

Finally, continuous monitoring of invasive carp movement dynamics is a goal of the MRWG, and therefore, the Telemetry Work Group of the MRWG. This project links directly with the USFWS, IDNR (through SIU), and USACE projects to monitor invasive carp movement throughout the Illinois River by deploying receivers and tagging fish with acoustic transmitters. These efforts inform modeling work, pool-by-pool tagging goals, optimization of receiver placement in the multi-agency telemetry array, and promotes intra-agency communication and planning to achieve these shared goals.

OBJECTIVES

- Telemetry project in support of SEICarP modeling

    a. *Movement Probability Model:* The Bayesian multi-state model has been completed and parameter estimates shared with the SEICarP Modeling group. The Telemetry and Modeling Workgroups determined that data collection should continue through calendar year 2025 to refine the current transition probability estimates after the telemetry array was bolstered (using the information gained during the modeling process).

b. *Begin feasibility study to estimate fishing mortality from existing telemetry and mark-recapture data from the Illinois River.* USGS, with partners, 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.

c. *Explore the feasibility of including additional parameters and predictor variables into a comprehensive invasive carp movement model.* USGS, in coordination with the developers of the SEICarP model will explore the ability to use existing or collect supplemental telemetry data to paramaterize 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

a. *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.

STATUS

- Telemetry project in support of SEICarP modeling

a. *Movement probability model*: A Bayesian multi-state transition probability model for the Illinois River has been completed and run using telemetry data from 2012 through 2019. Model movement parameters have been shared with the SEICarP team, and a manuscript of this multi-state model is in review.

b. *Feasibility studies*: We will continue to explore the feasibility of using existing telemetry and mark-recapture data from the Illinois River to estimate fishing mortality and population size in the Marseilles and Starved Rock Pools, and we will develop a study plan for gathering additional data to refine these estimates. We will also continue to work with the modeling and telemetry working groups and relevant partners to design a study to explore density-dependent movement throughout the Illinois River. These two projects will continue to be in the development phase in 2023, but they have the potential to provide valuable parameters for the SEICarP model (i.e., better estimates of fishing mortality) and insight into density-dependent effects on fish movement.

- Real-time receiver network:

  a. Five real-time receiver locations (Table 1) will be maintained to support the barrier evaluation study (see USACE Telemetry Monitoring Project) and inform contingency actions. The associated email alert system alerts key MRWG and ICRCC members of detections of bigheaded carp in strategic locations. A revision of that alert system is complete, and the alerts will roll out to partners in 2023.

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

Station	Location
Chicago Sanitary and Ship Canal above the EDBS	Lemont, IL
Chicago Sanitary and Ship Canal below the EDBS	Romeoville, IL
Des Plaines River above Brandon Road Lock and Dam	Rockdale, IL
Des Plaines River below Brandon Road Lock and Dam	Rockdale, IL
Illinois River above Dresden Island Lock and Dam	Minooka, IL

*Note: one additional real-time receivers exist in the Marseilles Pool, supported by another project

METHODS

- Telemetry in support of the SEICarP model

  a. *Movement probability model:* The USGS in collaboration with personnel on the Telemetry Work Group and Population Modelling Work Group of MRWG developed a Bayesian program to estimate interpool movement probabilities needed for SEICarP. Bayesian methods were used to create a model syntax that maximizes user customizability and extensibility, while avoiding the problems of singularities and poor-convergence inherent to the Program MARK. For example, previous multi-state modeling with Program MARK has been fraught with difficulties (computer crashes and parameter exclusion due to the lack of flexibility to specify model inputs in the program) thought to be related to number of states, recapture periods, and specification of random effects to account for individual, and spatial and temporal heterogeneity. As well, Program MARK does not provides limited uncertainty estimates for the desired parameter estimates of of interest; whereas, hierarchical models performed in a Bayesian framework provide a direct expression of uncertainty estimates of parameters feeding into the SEICarP model.

- Real-time receiver network:

    a. The five-year-round, real-time receivers will be maintained and downloaded in 2023. The real-time email alert system will be maintained and updated to alert key MRWG and ICRCC members with invasive carp detections of interest.

2023 SAMPLING SCHEDULE

- Telemetry project in support of SEICarP modeling

    a. Movement probability model:

        - Complete modeling to estimate movement probabilities and associated uncertainty with the new model and present these results to the Population Workgroup for discussion of data adequacy to inform tagging and monitoring network, and for use with SEICarP – *completed October 2021*
        - Present the movement probability model at a conference – *completed May 2022*
        - Submit manuscript detailing the Bayesian movement probability model to a peer-review journal – *to be completed May 2023*
        - Continuously maintain the acoustic array, fish tagging and partner coordination in consultation with Telemetry Work Group – *Ongoing*
        - Prepare data in preporation of rerunning the multi-state model to estimate13-year (2012 – 2024) transition probabilities for Illinois River invasive carp. *Model will be rerun in 2025 with data through 2024*

    b. Feasibility studies:

        - Monthly coordination meetings with the Modeling Work Group and other basin partners to detail and outline the data needs and processes for density-dependent movement models and estimating fishing mortality – *ongoing*

  - Report (or study plan) for estimating additional model parameters and developing a density-dependent movement model – *September 2023*

- Real-time receiver network

  a. Complete annual operation and maintenance of five MRWG-supported real-time receivers in the Upper IWW – *Ongoing.*

  b. Provide email alerts and monthly summaries to managers regarding invasive carp detections on the real-time receivers to inform contingency actions – O*ngoing.*

  c. Summary document of real-time receiver network activity – *completed by September annually.*

DELIVERABLES

- Telemetry project in support of SEICarP modeling

  a. Model: Bayesian multi-state model that estimates movement probabilities and associated uncertainty.

  b. Presentation(s): Presentation to Modeling Work Group on estimated movement probabilities and associated uncertainty with discussion for moving forward with tagging, receiver placement, and SEICarP modeling.

  c. Input for SEICarP: Estimates of movement probabilities and associated uncertainty for parameterizing future SEICarP modeling.

  d. Report: Manuscript for scientific journal article on Bayesian multi-state model for estimating movement probabilities of acoustically tagged bigheaded carp.

- Real-time receiver network

  a. Real-time receiver network with five real-time receivers in the upper Illinois Waterways system.

  b. Email alerts and monthly summaries to managers regarding invasive carp detections on the real-time receivers to inform contingency actions.

  c. Real-time receiver data uploaded to the FishTracks database for use in modeling and visualizations.

USFWS ILLINOIS WATERWAY HYDROACOUSTICS

Participating Agencies: USFWS-Carterville FWCO, Wilmington Substation, Wilmington, IL.

Participating Agencies: USFWS-Carterville FWCO, Wilmington Substation, Wilmington, IL.

Location: Work will take place in the Lockport Pool of the IWW, including at the EDBS. Surveys in Brandon Road and Dresden Island pools may be conducted upon request.

Pools Involved: Lockport, Brandon Road, and Dresden Island.

INTRODUCTION AND NEED

The EDBS, located within the CSSC, operates as the principal barrier in place to deter the movement of invasive fish between the Mississippi River and the Great Lakes basins while maintaining the continuity of this important commercial shipping route. However, the EDBS has been shown to be imperfect at preventing fish passage (Parker et al. 2015, Bryant et al. 2016, Davis et al. 2016). Therefore, numerous projects have been, and continue to be, conducted to reduce pressure on the EDBS (e.g., contracted commercial harvest of invasive carps downriver) and examine the effectiveness of the barriers at deterring fish under a variety of circumstances (e.g., telemetered surrogate fish studies, electric field mapping, barge entrainment, and mitigation analysis [Invasive Carp Action Plan 2022]). As part of this multifaceted detection and control program, regular monitoring of the patterns of abundance and distribution of large fish near the EDBS has been valuable in gauging the level of risk associated with the barriers being challenged by large fish (potentially invasive carp) moving upstream from the IWW toward Lake Michigan. This project will provide this large fish monitoring component by 1) utilizing hydroacoustic technology to survey large volumes of water at the EDBS, allowing for monitoring trends in large fish abundance and distribution near the EDBS and providing information to inform barrier maintenance and 2) exploring the utility and feasibility of a stationary hydroacoustic system to continuously monitor areas of interest adjacent to the EDBS to increase understanding of barrier efficacy. Additional surveys may also be performed to support requests from the MRWG and ICRCC.

OBJECTIVES

- Monitor fish abundance and distribution at the EDBS on a fine spatial and temporal scale to evaluate risk and provide information to guide barrier operations and maintenance.

- Disseminate information on changes in abundance and distribution near the EDBS to inform risk assessment, detection, and response efforts for invasive carp.
- Explore the utility, applicability, and feasibility of a continuous stationary hydroacoustic monitoring system at the EDBS to increase the temporal resolution of data and provide information to improve understanding of barrier efficacy.

STATUS

Since 2016, hydroacoustic surveys have been completed on a biweekly-to-monthly basis to gain greater temporal resolution on fish abundance and distribution dynamics near the EDBS.

In 2022, 20 hydroacoustic surveys at the EDBS were conducted from January 3 to December 19. Mobile hydroacoustic surveys completed in May and June of 2022 detected high abundances of large fish targets within the EDBS compared to historical data (11 targets on May 17 and 8 targets on June 22; both surveys reflect an aggregate number of detections across three replicate passes). In both surveys, most of the fish targets within the EDBS were detected between Barrier IIA and Barrier IIB. Fish abundances directly downstream of the EDBS across surveys remained relatively low throughout the year. Spikes in downstream abundances in mid-January, early summer, and mid-November were observed, but trends were overall similar to previous years.

In 2022, large fish densities in mobile hydroacoustic surveys conducted in Lockport, Brandon Road, and Dresden Island pools were generally low and similar to past years, except for above-average large fish densities in Brandon Road Pool in November and December 2022. Elevated densities in November were primarily due to the observation of two aggregations of large fish just upstream of the confluence of the Des Plaines River and the CSSC. An electrofishing crew was deployed to investigate. No invasive carp were observed.

With the observation of high abundances of large fish targets in mobile hydroacoustic surveys at the EDBS in May and June of 2022, coupled with the capture of a live Silver Carp and recovery of a dead Silver Carp upstream of the EDBS in 2022 (“Invasive Silver Carp Removed from Lake Calumet” 2022), the USFWS intends to refocus hydroacoustic sampling in 2023 to investigate alternative techniques that may benefit surveillance and detection efforts near the EDBS.

METHODS

Mobile Hydroacoustic Fish Surveys – EDBS, Lockport Pool, Brandon Road Pool, Dresden Island Pool

Side-looking split-beam hydroacoustic surveys will be conducted within and downstream of the EDBS to assess fish abundance and distribution patterns on a fine temporal scale. Barrier surveys at the EDBS will take place biweekly-to-monthly throughout 2023, and hydroacoustic results from the survey will be shared with the ICRCC within 48 hours of survey completion. In agreement with internal and external partners, full-pool surveys in Lockport, Brandon Road, and Dresden Island pools will move from monthly to on-request from MRWG and ICRCC partners only. The hydroacoustic equipment utilized for all mobile surveys will consist of a pair of multiplexed Biosonics® 200 kHz split-beam transducers. The two split-beam transducers will be mounted horizontally in parallel on the starboard side of the research vessel 0.4 meters below the water surface on a dual-axis automatic rotator. Surveys will consist of an upstream and downstream transect along the channel border in water depths greater than 2 meters, with the transducers facing outwards towards the middle of the channel. This approach will enable each survey to ensonify a substantial portion of the water column, increasing the ability to detect large fishes that are present in the main channel.

Stationary Hydroacoustic Sampling at the EDBS

In 2023, the USFWS will work with internal and external partners to explore the utility, applicability, and feasibility of implementing a fixed, stationary split-beam hydroacoustic monitoring system to increase temporal coverage of surveillance efforts through continuous monitoring and improve understanding of barrier efficacy. Discussions are ongoing, and specific methodology is currently unavailable. Details will be shared with MRWG members before any potential implementation.

2023 SAMPLING SCHEDULE

- Mobile hydroacoustic fish surveys at the EDBS: biweekly-to-monthly throughout 2023.
- Mobile hydroacoustic fish surveys in Brandon Road, Lockport, and Dresden Island pools: on request of MRWG and/or ICRCC partners.
- Exploration of utility, applicability, and feasibility of stationary hydroacoustic fish surveys at EDBS: conversations with MRWG partners beginning January 2023.

DELIVERABLES

- Report on fish abundance and spatial distribution near the EDBS to the ICRCC and MRWG within 48 hours of completion of a mobile hydroacoustic survey at EDBS to inform risk assessment and provide information to guide barrier operations and maintenance.
- Monthly and annual reports and presentations outlining significant findings of all program study areas.
- Rapid communications to the ICRCC on moderate or significant changes in fish abundance or distribution at the EDBS or in uninvaded pool.

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Report: Carbondale, IL.

EARLY DETECTION OF INVASIVE CARP IN THE UPPER ILLINOIS WATERWAY

Lead Agency: USFWS-Carterville FWCO, Wilmington Substation, Wilmington, Illinois

Pools Involved: Lockport, Brandon Road, Dresden Island, and Marseilles pools

Location: Targeted sampling of small (less than or equal to 153 millimeters total length), 'juvenile,' invasive carp will occur where juvenile bigheaded carp are currently believed to be absent. Sampling efforts will be focused in the Dresden Island and Marseilles pools, where large invasive carp are present, but small invasive carp are believed to be absent.

Targeted sampling for bigheaded carp will occur where bigheaded carp of any size are currently believed to be absent (Brandon Road and Lockport pools) to determine and monitor the geographic location of the upstream invasion front of the population distribution.

INTRODUCTION AND NEED

Globally, biological invasion by non-native aquatic species is an issue that can result in both ecological and economic impacts on the affected and connected ecosystems (Lodge et al. 1998; Hoffman et al. 2011). The primary management strategies for reducing the impacts of invasive species on ecosystems are control and eradication (Hulme 2006; Lodge et al. 2006). Early detection of invasive species is crucial to the success of these strategies because it allows control and eradication efforts to be implemented when abundance is low and individuals are more likely to be spatially restricted (Myers et al. 2000; Mehta et al. 2007). Since the 1970s, invasive Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*Hypophthalmichthys nobilis*) populations have invaded the Mississippi River basin, expanded upstream, and become established in the Illinois River (Chick and Pegg 2001; Sass et al. 2010). Silver Carp and Bighead Carp (collectively known as bigheaded carp) pose a significant threat to economically and recreationally valuable fisheries in the Great Lakes through competition for limited plankton forage resources (Cooke and Hill 2010). Bigheaded carp also pose a threat to lake users and their properties (Kolar et al. 2007). The most probable invasion pathway for Silver Carp and Bighead Carp to enter the Great Lakes is through the connection of the Upper IWW, which includes the CAWS, to Lake Michigan (Kolar et al. 2007).

An EDBS, operated by USACE, in Lockport Pool is intended to block the upstream passage of Silver Carp and Bighead Carp through the IWW pathway. Laboratory tests have shown the EDBS is sufficient at stopping large-bodied fish from passage; however, tests with small Bighead Carp

(51 to 76 millimeters total length) have indicated that the operational parameters of the EDBS may be inadequate for blocking the passage of small-bodied fishes (Holliman 2011). Studies have also shown that small fish can become entrained in barge junction gaps and transported through the EDBS (Davis et al. 2016). Furthermore, research using Dual Frequency Identification Sonar indicated that small fishes (unknown species) can be transported upstream through the EDBS by return water current created during downstream barge movement. These studies illustrate a vulnerability in the EDBS and some potential mechanisms by which small-bodied Silver Carp and Bighead Carp could pass upstream through the EDBS.

Currently, the bigheaded carp population front in the IWW resides in the Dresden Island Pool, approximately 20 kilometers from the EDBS and 70 kilometers from Lake Michigan. While a large effort is underway to reduce potential upstream movements of invasive carp to uninvaded habitats through proposed modifications to Brandon Road Lock, currently no deterrents exist between the invasion front and the EDBS, and invasive carp have been shown to pass through lock chambers regularly. Therefore, routine efforts designed to detect any invasive carp that may be present in those systems and could pressure the EDBS are warranted. Similarly, small invasive carp (less than or equal to 153 millimeters) are considered absent upstream of Marseilles Lock and Dam, approximately 83 kilometers from the EDBS and 153 kilometers from Lake Michigan (ICRCC 2022). However, due to the risk associated with fish of this size potentially being able to bypass the EDBS uninhibited or be entrained and transported upstream of the EDBS by barges, increased effort to detect any small invasive carps that may be present between Marseilles Lock and Dam and the EDBS are imperative.

The overall objective of this project is to increase focused, species-specific, early detection sampling for small (less than or equal to 153 millimeters total length) and large (greater than 153 millimeters total length) Silver Carp and Bighead Carp in the Upper IWW to increase certainty in the derived species distributions by reducing the potential for concluding carp are absent from areas where they are present. The information provided by this bigheaded carp-focused sampling is intended to aid ICRCC and MRWG agencies in evaluating the current invasion risk of bigheaded carp to the Great Lakes via the CAWS and provide information that may trigger CRP response actions when warranted. This project is an individual-focused bigheaded carp early detection effort that is intended to complement existing population and assemblage-focused monitoring efforts in the IWW, such as SIM, MAM of the Illinois River for Decision Making, and hydroacoustic monitoring near the EDBS.

OBJECTIVES

- Conduct monthly fixed and randomized electrofishing and gill net sampling targeted for large bigheaded carp in Brandon Road and Lockport pools from March to November.

- Conduct monthly fixed and randomized electrofishing, dozer trawling, and mini-fyke netting sampling targeted for small bigheaded carp in Dresden Island Pool, Marseilles Pool, and the Kankakee River from March to November.
- Remove any bigheaded carp captured across all pools and immediately report any captures upstream of known invasion fronts.

STATUS

This early detection project continues the USFWS efforts toward early detection of bigheaded carp in the IWW, which builds on the work done by the Distribution and Movement of Small Invasive Carp in the IWW project, the Habitat Use, Early Detection of Bigheaded Carp in the Upper IWW project, and Movement of Juvenile Invasive Carp in the IWW using Telemetry project. The total sampling effort will provide focused early detection efforts for both small and large invasive carp life stages from Marseilles Lock and Dam through Lockport Pool. Sampling conducted in 2023 will consist of boat electrofishing, electrified dozer trawling, gill netting, and mini-fyke netting.

METHODS

Sampling site selection will be supplemental to the stratified-random approach of the MAM project and will employ a target analysis-informed sampling design with the intent of improving the probability of detecting invasive carp in the Upper IWW. Target analysis is a strategic approach aimed at detecting specific invasive species at a defined locality and time using focused methods or technologies (Morisette et al. 2020). When target species are known (e.g., invasive carp), target analysis enables more effective and cost-efficient invasive species surveillance than programs that are broadly focused on detecting the presence of unknown, non-target, invasive species (Hoffman et al. 2016; Morisette et al. 2020). In practice, target analysis is a form of meta-analysis that integrates raw data with modeling and mapping to inform when, where, and how to look for the target species (Morisette et al. 2020).

In 2023, a combination of fixed and random site sampling with habitat stratifications will be conducted in pools depending on gear and habitat suitability. Initial sampling sites were selected using target analysis of data previously collected during this project in 2022, the Distribution and Movement of Small Invasive Carp in the IWW project, the Habitat Use and Movement of Juvenile Invasive Carp in the IWW using Telemetry project, and the MAM project. Target analysis and site selection focus on habitats both small and large bigheaded carp life stages are vulnerable to capture in, the gear types that most effectively capture invasive carp in those habitats, and the most effective times to sample. Notable areas to target or avoid will be incorporated in 2023 site selections based on field experiences from the 2021 to 2022 sampling years. Fixed sites are located where invasive carp had previously been captured or in similar habitats across the pools and are selected to provide pool-wide spatial sampling coverage. Random sites are stratified by habitat type (main channel border, side channel, and backwater) and habitat area, excluding zones that were not useable for each gear type deployed. Fixed and random site sampling include the use of boat-mounted electrofishing, electrified dozer trawling, gill netting, and mini-fyke netting.

During 2023, the sampling effort will include 2 to 5 days of sampling per gear per pool per month. Boat-mounted electrofishing will be conducted along habitat borders and consist of a 15-minute sampling period. Electrified dozer trawling will consist of a single 5-minute transect traveling in an upstream direction per site (Hammen et al. 2019). Mini-fyke netting will be conducted in appropriate habitats (shallow side channels and backwaters) within Marseilles and Dresden Island pools and Kankakee River sites. Mini-fyke netting will consist of approximately 24-hour net sets at each sampling site. Gill netting will be conducted within the Lockport and Brandon Road pools and will consist of short-term pounded or electrified sets. Early season sampling efforts will begin when water conditions become appropriate for invasive carp spawning (generally when the water temperature is above 17 to 18°C). Coordination with other agencies will be necessary to monitor for spawning behaviors, which might alter how, where, and when this project is conducted.

Physical characteristics and water quality measurements will be measured and recorded at each collection site and will include depth, substrate type (i.e., boulder, cobble, gravel, sand, silt, and clay), temperature, specific conductivity, and dissolved oxygen. Water quality measurements will be taken using a YSI Professional Series multi-meter. These metrics will be used to parameterize future target analysis and adaptively increase invasive carp detection probability through continued sampling. Additionally, GPS coordinates and time stamps will be recorded at the start and end of each electrofishing event, trawl run, gill net set, and mini-fyke net set.

During this targeted sampling effort, all Bighead Carp, Silver Carp, Black Carp (*Mylopharyngodon piceus*), and Grass Carp (*Ctenopharyngodon idella*) will be measured for total length (millimeters) and mass (grams); all other species will be identified to species, recorded, and released to increase processing speed. All threatened and endangered species will be photographed prior to release. Any fish not easily identified in the field will be preserved in 70 percent ethanol for laboratory identification to the lowest possible taxonomic level. Effort will be quantified as net nights (mini-fykes), meters of gill net, and minutes of electrofishing (boat electrofishing and dozer trawl).

Early detection programs are inherently challenged by and focused on detecting the presence of rare non-native species (Rew et al. 2006; Mehta et al. 2007; Harvey et al. 2009). Fortunately, the challenges of early detection are analogous to the challenges of threatened and endangered species assessment, which focuses on detecting the presence of rare native species. Therefore, many sampling techniques and analytical tools developed for threatened and endangered species are transferable to an invasive species early detection context (Trebitz et al. 2009; Jerde et al. 2011). Species richness estimators are one such tool that can be used to assess the thoroughness of sampling efforts at capturing rare species that are present in the ecosystem (Cao et al. 1998; Cao et al. 2001; Kanno et al. 2009). Rarefaction analyses were used to evaluate the thoroughness of sampling at the applied level of sampling effort in the study areas by estimating species richness using the Mao Tau method for species accumulation and the Chao2 estimator via 1000 Monte Carlo resamples in each study area. All analyses were performed in R 4.1.2.

Individual Gear Descriptions for 2023

Electrofishing – Pulsed DC daytime boat electrofishing will be conducted using two dippers for 15-minute sampling periods. Nets have 3/16-inch bar mesh, 1-foot-deep bags, and 9-foot handles.

Mini-fyke net – Wisconsin-type mini-fyke nets set overnight in both single and tandem configurations, depending on site characteristics. Single nets will be set with the lead end staked against the shoreline or another obstruction to fish movement. Tandem nets (with leads attached end to end) will be fished in open water areas. All mini-fyke nets have a 24-foot lead and 1/8-inch mesh.

Gill net – A 100-yard (91.4-meter) net will be anchored and buoyed at both ends and set in a J-hook fashion, with the curved end anchored and set near the shoreline. Several nets may be tied together to cover larger areas of interest. Depending on site characteristics, nets may be 8 feet or 12 feet deep and consist of 3.25- to 5-inch bar mesh. The area inside the net will be pounded or electrified to drive fish into the net while the net is soaking. Sets will only be short-term, and nets will be monitored by staff.

Dozer trawl – A 35 millimeters mesh net at the mouth reducing to 4 millimeters mesh at the cod end tied to a 2- by 1-meter rigid frame mechanically raised and lowered to fish depths from 0 to 1 meter. The net extends approximately 2.5 meters back as it is pulled forward. The target habitat is open water greater than 0.6 meter deep. The trawl is mounted to an electrofishing boat with anodes extending 1.5 meters in front of the trawl and the trawl acting as the cathode. Trawl sampling duration will be 5-minute transects.

2023 SAMPLING SCHEDULE

January – February: Gear preparation, planning field logistics, and crew scheduling.

March – November: Fish sampling, identification, and data entry.

November – December: Complete fish identification (preserved specimens), data entry, and verification.

December – January 2024: Analyze data, prepare a report, and present findings.

DELIVERABLES

Any small invasive carp captured upstream of Marseilles Lock and Dam and any size invasive carp captured above Brandon Road Lock and Dam will be reported immediately via approved live fish communication and response protocols. An annual MRWG report and presentation will be provided during winter 2023/2024. Invasive carp capture data from sampling will be used to define future sampling sites. Length and mass data will be provided for the SEIcarP model development project and hydroacoustics monitoring projects.

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MONITORING INVASIVE CARP REPRODUCTION IN THE ILLINOIS WATERWAY

Participating Agencies: INHS (lead), Eastern Illinois University, SIUC, USGS – Central Midwest Water Science Center, USFWS – Whitney Genetics Lab (field and lab support)

Pools Involved: Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton pools; Illinois River tributaries (Kankakee, Fox, Mackinaw, Spoon, and Sangamon rivers)

Location: Ichthyoplankton (i.e., fish embryo and larval life stages) sampling will take place at 10 sites in the Illinois and Des Plaines rivers downstream of the EDBS (Figure 1). Sampling for fish eggs and larvae will also occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee rivers to monitor for invasive carp spawning in Illinois River tributaries. Sites may be dropped or additional sites added as needed to complete study objectives.

INTRODUCTION AND NEED

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. An evaluation of invasive carp reproduction and the distribution of early life stages in the IWW and its tributaries is needed to monitor changes in the reproductive front of bigheaded carp in this system, monitor potential reproduction by the newly expanding Black Carp population in Illinois, and better understand the impacts of removal efforts on the reproductive potential of invasive carp populations. Reproduction and recruitment of invasive carps in the IWW have been highly variable across years, and multiyear efforts are necessary to assess the conditions affecting the magnitude, location, and timing of reproduction and 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. Observations of eggs and larvae in the upper Illinois River indicate invasive carp reproduction occurs above Starved Rock Lock and Dam in some years (Zhu et al. 2018; Parkos et al 2021). Due to egg and larval drift, reproduction in upper river pools may be an important source for recruits in downstream pools, particularly the Peoria Pool. However, recruitment may vary considerably for a given magnitude of reproductive output, and factors affecting recruitment variability and the life stages at which recruitment bottlenecks occur are not well understood for invasive carp species. Invasive carp spawning also appears to occur in some years in smaller tributary rivers. 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 tributaries (Schaick et al. 2021). The contribution of tributaries to the abundance of invasive carp eggs and larvae in the mainstem Illinois River is unknown but may be an important source of early life stages to some navigation pools in some years. This project will evaluate the spatial and temporal extent and magnitude of invasive carp reproduction in the IWW and its tributaries, monitor spawning occurring upstream of the known reproductive front, provide early detection of Black Carp reproduction, and quantify relationships between invasive carp adult abundance, reproductive output, and recruitment.

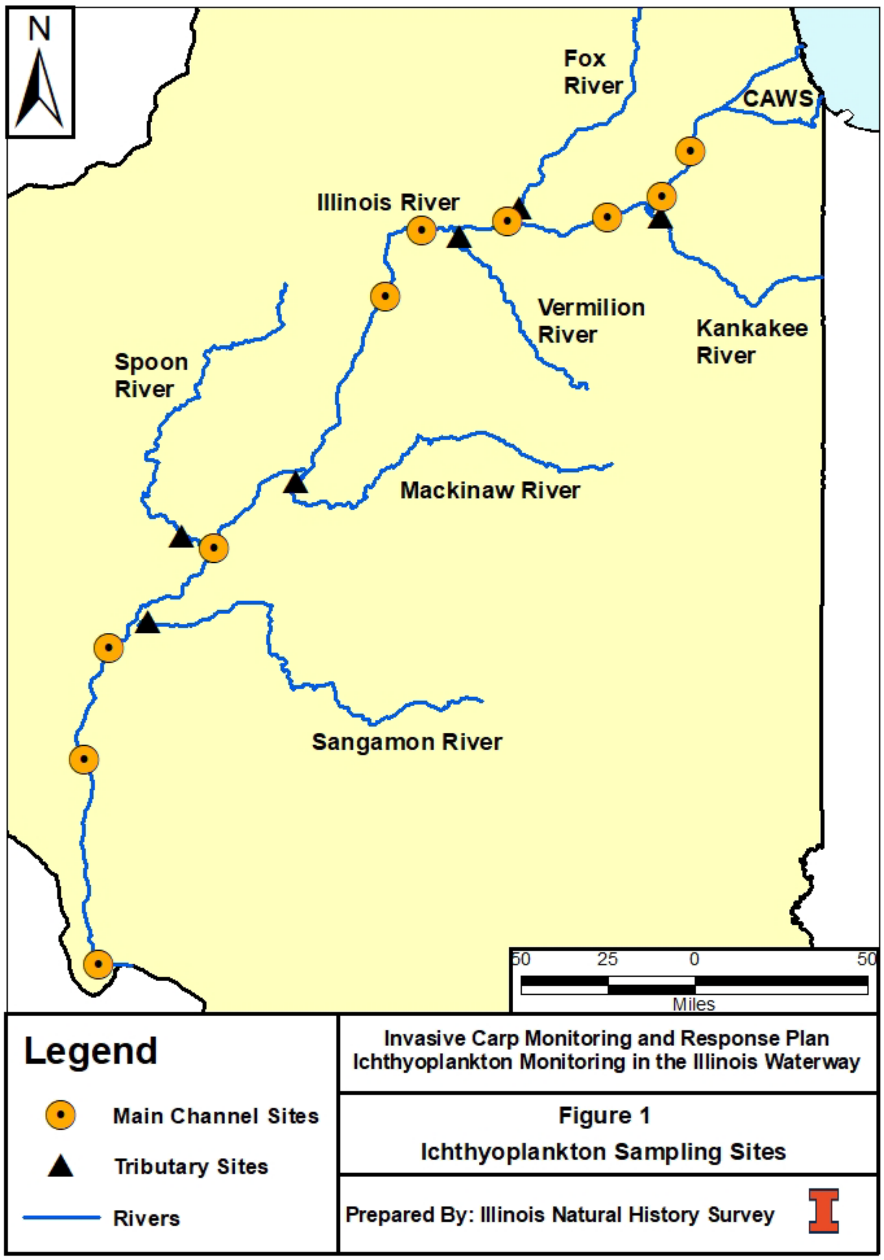

Figure 1. *Map of ichthyoplankton sampling sites in the IWW (circles) and in tributary rivers (triangles).*

OBJECTIVES

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

STATUS

Ichthyoplankton monitoring has occurred in the IWW since 2010. In the initial years of this project, invasive carp eggs and larvae were only collected in low numbers from the LaGrange and Peoria pools but not from any upstream navigation pools. However, invasive carp eggs were collected from the Starved Rock and Marseilles pools from 2015 through 2018 and 2020 through 2021, larvae were collected in the Starved Rock Pool in 2020 and 2021, and three Silver Carp larvae were collected in the Dresden Island Pool in 2015. No evidence of invasive carp reproduction has been found thus far upstream of Brandon Road Lock and Dam. Hydrodynamic modeling of egg drift through the Illinois River (FluEgg model) combined with a reverse-time particle tracking algorithm has indicated tailwater areas below the locks and dams on the IWW are likely important spawning areas for invasive carp (Zhu et al. 2018). Tributary sampling has revealed invasive carp spawning also occurs in Illinois River tributaries in some years. No evidence of invasive carp reproduction has been found in the Kankakee River to date, but invasive carp eggs were collected in the Fox River in 2016, and larvae were captured from this river in 2021. Tributaries of the LaGrange and Peoria pools have produced highly variable numbers of invasive carp eggs and larvae across study years. Tributaries with larger watersheds, higher discharge, greater turbidity, and higher temperatures have been found to produce higher abundances of invasive carp eggs (Schaick et al. 2021).

The densities of invasive carp eggs and larvae that have been collected from the main channel of the IWW have been highly variable over the years, with seemingly low reproductive output from 2010 through 2013 but moderate to high levels of reproduction evident from 2014 through 2022.

Juvenile abundances have also been extremely variable. Low numbers of Silver Carp juveniles were produced during years with low production of egg and larval stages but high levels of reproductive output were not a guarantee of high recruitment, likely due to prevailing environmental conditions. Reproductive activity has commonly occurred in May and June, with the magnitude of reproductive output in June greatly exceeding that in other months. The highest egg abundances have been found in the upper Peoria Pool, whereas the highest larval abundances have occurred in the lower Peoria and LaGrange pools. The relationship between invasive carp spawning stock density and the magnitude of reproduction provides evidence of both diminished reproductive output at low adult abundances as well as density-limitation of reproductive output at very high adult densities (Parkos et al. 2021). Egg production was also found to be higher during years with higher seasonal fluctuations in discharge and higher water temperatures during May and June. Reproductive output was either absent or too low to detect once the combined density of adult invasive carp in the Marseilles and Dresden Island pools was less than or equal to 0.268 adult carp/2000 m^3 (Parkos et al. 2021).

Collaborative efforts using samples collected from the Illinois River and elsewhere have produced a qPCR screening procedure for identifying ichthyoplankton samples that are likely to contain invasive carp eggs or larvae (Fritts et al. 2019). The number of invasive carp DNA copies present within a sample has been found to be a significant predictor of the presence of invasive carp eggs or larvae in the sample and is positively related to the number of invasive carp eggs and larvae present in the sample. Ichthyoplankton sampling may help to differentiate low-density reproductive events by each individual invasive carp species and hold promise as an early detection tool for monitoring Black Carp reproduction.

METHODS

Ichthyoplankton sampling will occur weekly from late April through mid-July and biweekly from mid-July to October. Additional sampling will be conducted as necessary during periods when invasive carp spawning is likely (e.g., during periods of rising water levels or shortly after peak flows when water temperatures are sufficiently high to allow for invasive carp spawning).

At all IWW sampling sites, samples will be collected using a 0.5-meter diameter ichthyoplankton push net with 500-micrometer mesh. To obtain each sample, the net will be pushed upstream using an aluminum frame mounted to the front of the boat. Boat speeds will be adjusted to obtain 1.0 to 1.5 meters per second water velocity through the net. The flow will be measured using a flow meter mounted in the center of the net mouth and will be used to calculate the volume of water sampled. Fish eggs and larvae will be collected in a meshed tube at the tail end of the net, transferred to sample jars, and preserved in 90 percent ethanol. A minimum of four ichthyoplankton samples will be collected at each mainstem site on each sampling date. Sampling transects will be located on each side of the navigation channel, parallel to the bank, and at both upstream and downstream locations within each study site.

At tributary sites (Sangamon, Spoon, Mackinaw, Vermilion, Fox, and Kankakee rivers), a minimum of three samples will be collected at each site on each sampling date, one near each bank and another in the center of the channel. Sampling will be conducted far enough upstream of the confluence of each tributary with the mainstem Illinois River to ensure any fish eggs or larvae collected are derived from the tributary itself rather than originating in the Illinois River. Tributary sampling will be conducted similarly to main channel sampling (i.e., boat-mounted push nets).

IWW ichthyoplankton samples collected from May to mid-July will be assessed for the presence of species-specific invasive carp DNA derived from eggs or larvae. Potential presence of adult carp DNA will be removed by exchanging sample ethanol with fresh molecular-grade ethanol. Samples will be gently inverted in the refreshed ethanol, and aliquots of sample preservative will be removed to screen for the presence of DNA derived from invasive carp eggs or larvae. Following DNA extraction, assays for the four taxa of invasive carp will be run in multiplex reactions, following qPCR methodology (Fritts et al. 2019; Guan et al. 2019). Samples will be run in triplicate with a dilution series and no-template controls. The number of DNA copies from each taxon present in each extraction replicate will be quantified and used to assess the probability that eggs or larvae of each species of invasive carp are present in the sample. Samples with higher likelihoods of containing invasive carp eggs or larvae, particularly from upstream of Starved Rock Lock and Dam, will be prioritized for immediate processing. Specimens from samples found to contain high quantities of Black Carp DNA will be subjected to further genetic analyses to confirm incidences of Black Carp reproduction.

In the laboratory, fish eggs and larvae will be separated from other materials, and all larval fish will be identified to the lowest possible taxonomic unit. Fish eggs will be 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 analysis. Larval fish and egg density estimates will be calculated as the number of individuals per cubic meter of water. Spatial and temporal patterns in the densities of invasive carp eggs and larvae will be described, and all observations of invasive carp reproduction upstream of Starved Rock Lock and Dam, as well as any evidence of Black Carp reproduction from the IWW, will be immediately reported. Invasive carp stock densities will be obtained from hydroacoustic surveys conducted by collaborators at SIUC. Data on juvenile invasive carp abundances will be obtained from collaborators at the INHS Illinois River Biological Station and other partner agencies. Relationships between environmental variables (temperature, discharge, etc.) and abundances of invasive carp eggs, larvae, and juveniles among years will be examined to determine conditions that contribute to successful reproduction and recruitment and to identify recruitment bottlenecks, factors that influence stock-recruitment relationships, and life stages where compensatory mechanisms could hinder management goals. Developmental stages of invasive carp eggs and larvae will be determined to provide input for FluEgg modeling being conducted with collaborators at the USGS Central Midwest Water Science Center to identify spawning locations and zones of larval settlement.

2023 SAMPLING SCHEDULE

- Weekly sampling at all sites from late April to mid-July.
- Bi-weekly sampling from mid-July to October.
- Additional opportunistic sampling, as necessary, during periods when invasive carp spawning is likely (e.g., during rising water levels or shortly after peak flows).
- qPCR screening of samples collected from May to mid-July for species-level identification of potential spawning events.

DELIVERABLES

Results of 2023 sampling activities and ongoing analyses of previous years' data will be reported to MRWG partners as relevant findings are identified. All observations of invasive carp spawning activities upstream of Starved Rock Lock and Dam will be reported as soon as they are detected. Any detection of Black Carp reproduction at any location in the IWW will also be immediately reported to MRWG. Data will be summarized for an annual interim report, and project plans will be updated for annual revisions of the MRP.

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SIU
CARBONDALE

INVASIVE CARP STOCK ASSESSMENT IN THE ILLINOIS RIVER/MANAGEMENT ALTERNATIVES

Participating Agencies: SIUC (lead), additional assistance/collaboration with USACE, USGS, IL DNR, INHS, USFWS

Location: Illinois and Des Plaines rivers from Dresden Island Pool (Brandon Road Lock and Dam) to Alton Pool, along with associated backwaters, side channels, and tributaries

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton pools

INTRODUCTION AND NEED

Management goals for Silver Carp and Bighead Carp (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 both seasonally and annually; therefore, 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 (e.g., SEICarP) that can help evaluate potential effects of management options.

Monitoring of bigheaded carp densities via hydroacoustic sampling throughout the Illinois River (Alton to Dresden Island pools) by SIU has been ongoing since 2012 and is 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. Annual densities, particularly in the Lower Illinois River, have displayed relatively large annual fluctuations over the years, necessitating the need for continued assessments of bigheaded carp densities throughout the river (Coulter et al. 2016). This will identify whether the population size in the lower river has increased from previous years and help determine whether harvest or surveillance in the upper river should be altered in anticipation of increased immigration from downstream pools. It is currently unclear whether, or 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 help quantify these patterns, which will better inform management decisions 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. Repeated hydroacoustic surveys of bigheaded carp densities in these pools will identify locations where bigheaded carp aggregate to inform and direct harvest throughout the year.

The SEICarP model for bigheaded carp in the Illinois River assesses how bigheaded carp populations respond to a variety of management actions (e.g., location and intensity of harvest and location and effectiveness of deterrent technologies). This model draws on a wide variety of data, including bigheaded carp densities and movement data. Collaborations between MRWG and the modeling, telemetry, and hydroacoustic working groups have identified several additional data needs in addition to the maintenance of current monitoring efforts. SIU's contribution to continued model support will include continued maintenance of the Illinois River stationary telemetry array to document inter-pool movements, deployment of additional acoustic telemetry tags in bigheaded carp (numbers set based on telemetry working group determinations), and continued hydroacoustic monitoring of bigheaded carp densities throughout the Illinois River. Movement information from telemetry efforts will also be critical for maintaining surveillance to detect potential changes in bigheaded carp spatial distributions (e.g., movements among pools), especially in supporting surveillance efforts with real-time acoustic telemetry receivers.

OBJECTIVES

- Quantify bigheaded carp densities every other month in Dresden Island and Marseilles pools in 2023 using mobile hydroacoustic surveys to pinpoint high-density areas that can be targeted during contracted removal.
- Conduct hydroacoustic surveys at standardized sites in the fall of 2023 from Alton through Dresden Island pools to assess long-term trends in density and biomass.
- Maintain SIU's acoustic telemetry array currently in place in the Illinois River used to collect movement and dam passage information. Collected data will be shared with the telemetry and modeling work groups.

STATUS

Continue previous work by SIU that has intensively monitored the movement and density of bigheaded carp in the Illinois River since 2012. Hydroacoustic and associated sampling surveys will yield information on trends in density, biomass, and size structure of bigheaded carp in the Illinois River. Because these surveys have been ongoing since 2012, they provide valuable long-term trends.

METHODS

Spatial and Temporal Variation in Bigheaded Carp Densities in Marseilles and Dresden Island Pools

Mobile hydroacoustic surveys will occur in main channels, tributaries, side channels, and connected backwater lakes using horizontally oriented split-beam transducers. Surveys will be conducted every other month in Dresden Island and Marseilles pools from March to October, given appropriate sampling conditions. To inform hydroacoustic data, catch from ongoing efforts (e.g., contracted removal) in the Dresden Island and Marseilles pools will be sampled throughout the year for species' relative abundance and measured for length and weight.

Density Estimates of Bigheaded Carp in the Illinois River

Hydroacoustic surveys will be conducted in the fall of 2023 throughout the Illinois River (Alton through Dresden Island pools) following the same protocol outlined above for the bi-monthly surveys of Marseilles and Dresden Island pools. Survey sites will be the same locations sampled previously by SIU to add to the existing long-term (11 years as of 2022) dataset. Such data are essential to fully understand population dynamics, especially when biotic (e.g., annual variability in recruitment success) and abiotic (e.g., drought, flood years) processes fluctuate through time.

Telemetry Data to Identify Bigheaded Carp Passage through Illinois River Lock and Dams

The existing acoustic telemetry array of 65-plus stationary receivers will be maintained and downloaded on two occasions in 2023. Twenty-six additional stationary receivers will be placed throughout the lower reaches to increase detection ability within these larger pools. Additional acoustic telemetry tags (194 total tags) will be deployed in La Grange (97 tags) and Alton (97 tags) pools to replace expiring tags. Bigheaded carp in other Illinois River pools will be tagged by USFWS and USACE such that numbers of tagged bigheaded carp remain high in all pools within the telemetry array. Stands holding receivers and hardware will be replaced as necessary. Data from the telemetry array will provide information on the numbers of tagged bigheaded carp moving upstream or downstream through each lock and dam, which provides an indication of the relative numbers of individuals in the population that may be moving among pools. Replacing expiring telemetry tags also maintains sufficient numbers of tagged individuals at-large in each pool for adult surveillance and early detection efforts (e.g., monitoring for movements past real-time receivers).

2023 SAMPLING SCHEDULE

- Bi-monthly hydroacoustic surveys will be conducted in the Marseilles and Dresden Island pools every other month from March through August 2023.
- Telemetry stationary receivers will be downloaded twice during 2023 (April and November), and acoustic transmitters will be implanted into fish from March through April 2023.
- Annual hydroacoustic surveys will occur in the Alton, LaGrange, Peoria, Starved Rock, Marseilles, and Dresden Island pools during October of 2023.

DELIVERABLES

Hydroacoustic bigheaded carp information will reveal how density varies spatially and temporally at the edge of their invasion front. Results will consist of heat maps that visually display bigheaded carp densities in the Marseilles and Dresden Island pools throughout the year. These maps will be shared with partners in the removal working group to inform harvest efforts. Fall hydroacoustic sampling will provide a long-term assessment of bigheaded carp densities throughout the Illinois River (Alton through Dresden Island pools) by comparing 2023 pool-wide densities to densities from previous years.

Telemetry data will be used to determine the passage route (number of passages through locks versus dam gates) as well as the environmental conditions and timing associated with upstream passages. These results will provide a spatial and temporal context for the deployment of control measures which will increase the efficiency (both in costs and in preventing movement) of the control measures.

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DES PLAINES RIVER AND OVERFLOW MONITORING

Participating Agencies: USFWS-Carterville FWCO Wilmington Substation (lead), and USACE Chicago District

Location: Des Plaines River above the confluence with the CSSC

Pools Involved: Not applicable

INTRODUCTION AND NEED

The upper Des Plaines River rises in southeast Wisconsin and joins the CSSC in the Brandon Road Pool immediately below the Lockport Lock and Dam. Invasive Bighead Carp and Silver Carp (bigheaded carp) have been observed in Brandon Road Pool up to the confluence with the Des Plaines River and have free access to the upper Des Plaines River. In 2010 and 2011, invasive carp eDNA was detected in the upper Des Plaines River. No invasive carp eDNA sampling has been conducted in the Des Plaines River since 2011. It is possible that during high water events when water flows laterally from the Des Plaines River into the CSSC, invasive carp present in the upper Des Plaines River could gain access to the CSSC upstream of the EDBS. To reduce the likelihood of fish transfer during high flows, a physical barrier was constructed by the USACE in 2010. The physical barrier consists of concrete barriers and 0.25-inch mesh fencing built along 13.5 miles of the upper Des Plaines River, where it runs adjacent to the CSSC. It is designed to stop adult and juvenile invasive carp from infiltrating the CSSC but likely allows invasive carp eggs and fry in the drift to pass. Opportunities for fish to pass occurred during high discharge events in 2011 and 2013, when water breached the physical barrier. USACE reinforced these and other low-lying areas to prevent scouring during future lateral water transfers. These reinforcements withstood high-flow events in 2017 and 2019. A high discharge event in 2020 allowed for a few inches of water to pass through and under the barrier between the Des Plaines River and the CSSC and allowed for the passage of eggs and larvae. Gear deployed by the USACE did not capture any fish moving between the systems. Scour holes and fence damage were repaired for 2021. Due to the continued risk of invasive carp longitudinal expansion in the Des Plaines River and the potential for overflow events, it remains important to understand the status of invasive carp in the Des Plaines River, monitor for potential spawning events, and determine the effectiveness of the physical barrier.

OBJECTIVES

- Monitor the presence of invasive carp populations in the Des Plaines River above the confluence with the CSSC.
- Monitor breaches of the barrier and passage of fish during high-flow events when water moves laterally from the Des Plaines River into the CSSC.
- Monitor for invasive carp eggs and larvae around the physical barrier when water moves laterally from the Des Plaines River into the CSSC.

STATUS

This project began in 2011 and is ongoing. Between 2011 and 2022, 17,059 fish have been collected via electrofishing (91.75 hours) and gill netting (159 sets; 22,571.1 meters). No Bighead Carp or Silver Carp have been collected or observed. Ten Grass Carp (*Ctenopharyngodon idella*) have been collected. Six of these were submitted for ploidy analysis, and all six were determined to be triploid (sterile).

METHODS

Population Monitoring

Population monitoring will include electrofishing, fyke netting, and gill netting. The project will utilize pulsed-DC electrofishing. One or two netters will attempt to dip all visible fish except for Common Carp (*Cyprinus carpio*). The number of Common Carp observed to be incapacitated in the electrical field will be recorded. All non-invasive carp will be identified and released. Any Bighead Carp or Silver Carp collected will be kept for further study, and MRWG will be notified. Grass Carp will be tested for ploidy at the USFWS Midwest Fish Health Center. A minimum of three sampling events are currently planned for 2023 that will span from pre-spawn to post-spawn periods. Three backwater areas will be considered fixed sites and will be sampled during each sampling event if accessible (Figure 1). All accessible shorelines in the backwaters will be sampled with electrofishing gear. Each fixed site will also be sampled with 200 yards of gill net during the spring, summer, and fall events. In addition to the fixed backwater sites, main channel habitats will be targeted with electrofishing as time and access allow.

Sampling Gear Descriptions

Gill nets – Nets will consist of 100-yard (91.4-meter) monofilament panel mesh and be set as short-term, top to bottom sets. Mesh sizes will be 3- to 4-inch bar mesh or experimental sets where mesh decreases between panels ranging in size from 5- to 0.5-inch bar mesh. Backwater areas will be blocked off with the nets, and fish will be driven toward the nets via pounding or electrofishing.

Electrofishing – Pulsed DC daytime boat electrofishing will be conducted using two dippers for 15-minute sampling periods. Nets will have 3/16-inch bar mesh, 1-foot-deep bags, and 9-foot handles.

Fyke net – LTRM Program style nets that are set overnight. Single nets will be set with the lead end staked against the shoreline or another obstruction to fish movement. All fyke nets are constructed of 3/4-inch mesh.

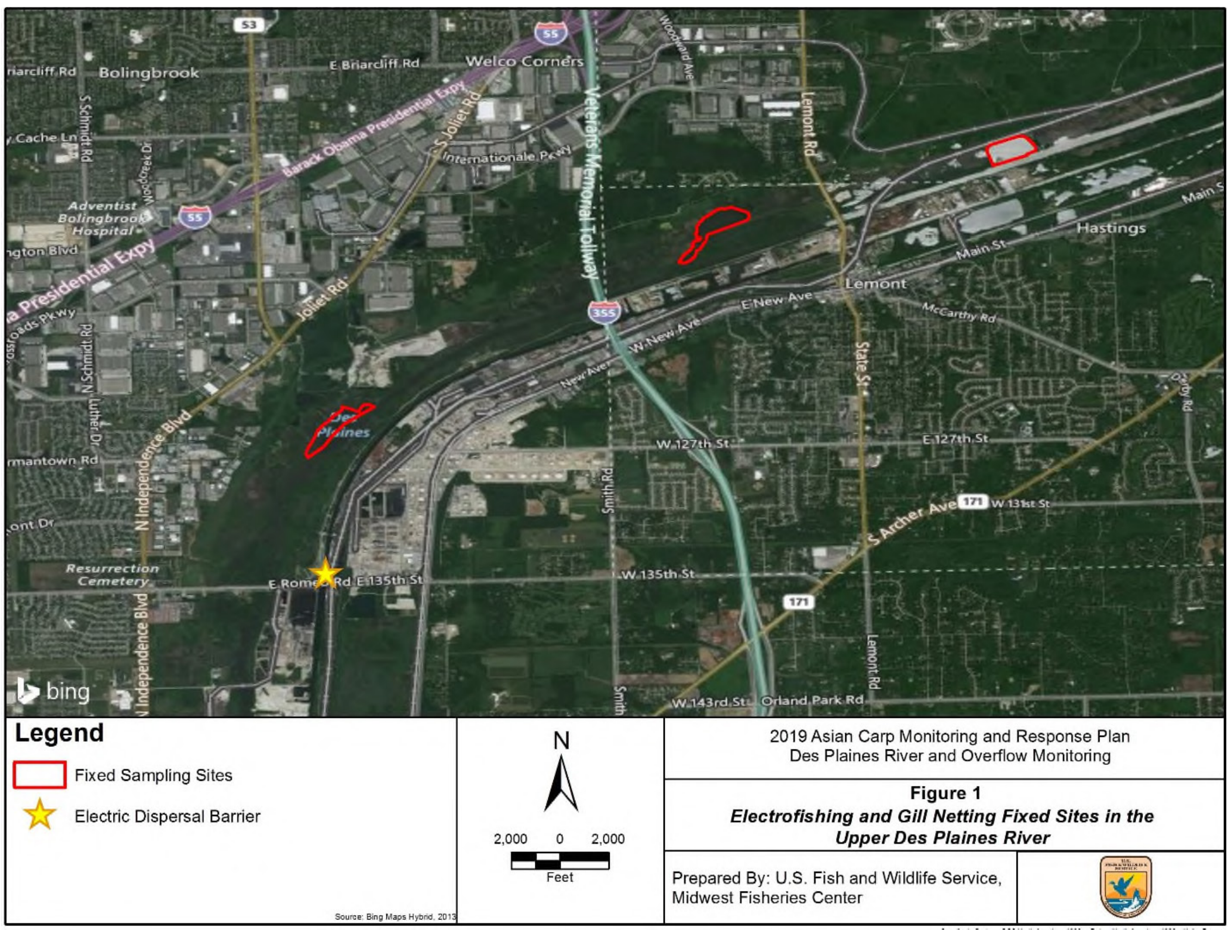

Figure 1. *Fixed sampling site areas of interest are outlined in the above map for electrofishing and gill netting in the upper Des Plaines River*

ALTERNATIVE PATHWAY SURVEILLANCE – URBAN POND MONITORING

Participating Agencies: IL DNR (lead), SIUC (otolith chemistry analysis)

Pools Involved: N/A

Location: Monitoring will occur in Chicago area fishing ponds supported by the IL DNR Urban Fishing Program.

INTRODUCTION AND NEED

IL DNR fields many public reports of observed or captured invasive carp. All reports are taken seriously and investigated by corresponding with individuals making a report via phone/email, 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. Typically, no Bighead Carp or Silver Carp are captured during sampling responses. However, this pattern changed in 2011 when 20 Bighead Carp (greater than 21.8 kilograms [48 pounds]) were captured by electrofishing and netting in Flatfoot Lake and Schiller Pond, both fishing ponds located in Cook County once supported by the IL DNR Urban Fishing Program.

As a further response to the Bighead Carp in Flatfoot Lake and Schiller Pond, IL DNR reviewed invasive carp captures in all fishing ponds included in the IL DNR Urban Fishing Program located in the Chicago Metropolitan area. To date, 10 of the 21 urban fishing ponds in the program have verified captures of invasive carp either from sampling, pond rehabilitation with piscicide, natural die-offs, or incidental take. One pond had reported sightings of invasive carp that were not confirmed by sampling (McKinley Park). The distance from Chicago area fishing ponds to Lake Michigan ranges from 0.2 to 41.4 kilometers (0.1 to 25.7 miles). The distance from these ponds to the CAWS upstream of the EDBS ranges from 0.02 to 23.3 kilometers (0.01 to 14.5 miles). Although some ponds are located near Lake Michigan or the CAWS, most are isolated and have no surface water connection to the lake or CAWS upstream of the EDBS. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively. Gompers Park never had a report of invasive carp, nor have any been captured or observed during past sampling events. Nevertheless, examining all urban fishing ponds close to the CAWS or Lake Michigan continues to be of importance due to the potential for human transfer of invasive carp between waters near one another, the CAWS, and Lake Michigan.

In addition to Chicago area ponds once supported by the IL DNR Urban Fishing Program, ponds with positive detections for invasive carp eDNA were also reviewed. Eight of the 40 ponds sampled for eDNA by the University of Notre Dame resulted in positive detections for invasive carp, two of which are also IL DNR urban fishing ponds (Jackson Park and Flatfoot Lake). Invasive carp have been captured and removed from two of the eight ponds yielding positive eDNA detections. The distance from ponds with positive eDNA detections to Lake Michigan ranges from 4.8 to 31.4 kilometers (3 to 19.5 miles). The distance from these ponds to the CAWS upstream of the EDBS ranges from 0.05 to 7.6 kilometers (0.03 to 4.7 miles). The lake at Harborside International Golf Course has surface water connectivity to the CAWS. However, no invasive carp have been reported, observed, or captured. Though positive eDNA detections do not necessarily represent the presence of live fish (e.g., may represent live or dead fish or result from sources other than live fish, such as DNA from the guano of piscivorous birds), all ponds with positive detections were examined for the presence of live invasive carp given the proximity to the CAWS.

OBJECTIVES

- Monitor the presence of invasive carp in Chicago area fishing ponds supported by the IL DNR Urban Fishing Program.
- Obtain life history, age, and otolith microchemistry information from captured invasive carp.

STATUS

This project began in 2011 and is ongoing. A total of 46 Bighead Carp and one Silver Carp have been removed from 10 ponds. Eighty-four hours of electrofishing and 19 miles of gill/trammel net were utilized to sample 29 Chicago area fishing ponds, resulting in 35 Bighead Carp removed from five ponds since 2011. Additionally, eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. Lastly, one Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have both had Bighead Carp removed following natural die-offs and sampling. All ponds yielding positive eDNA detections and 18 of the 21 IL DNR urban fishing ponds have been sampled. Lincoln Park South was not sampled because it was drained in 2008, resulting in three Bighead Carp being removed, and is no longer a source of invasive carp. Auburn Park was too shallow for boat access but had extremely high visibility. Therefore, the pond was visually inspected, with no large-bodied fish observed. Lastly, Jackson Park and Garfield Park were drained in 2015 and, like Lincoln Park South, are no longer a source of invasive carp. 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. For more detailed results, see the 2021 Interim Summary Report document (MRWG 2018).

During the 2021 season, one Bighead Carp was caught by fisherman Jarrett Knize in the Humboldt Park Lagoon (41.906881, -87.699607). This Bighead Carp weighed in at 72 pounds 8 ounces, with a length of 52 inches and a girth of 34 ½ inches. This beats the previous state record rod and reel catch of 69 pounds caught in 2010. Humboldt Park Lagoon is approximately 4 miles from Lake Michigan but does not directly connect to Lake Michigan, the Des Plaines River, or the DuPage River. There is an approximately 20-foot change in elevation from the lagoon to Lake Michigan and its tributaries, so the risk of connection through flooding is low. In 2022, IL DNR biologists and contracted commercial fishers responded by setting 2000 yards of gill and trammel net and conducting four hours of pulsed-DC electrofishing. During this effort, two additional Bighead Carp were captured and removed from Humboldt Park Lagoon. The heads of the Bighead Carp were kept to determine age and analyzed by otolith microchemistry to determine the source of each specimen. The IL DNR is currently awaiting results on both facets.

METHODS

Sampling Protocol

Trammel and gill nets used are approximately 3 meters (10 feet) deep by 91.4 meters (300 feet) long in bar mesh sizes ranging from 88.9 to 108 millimeters (3.5 to 4.25 inches). Multiple nets will be set simultaneously to increase the likelihood of capturing fish. Pulsed-DC electrofishing, along with pounding on boats and revving trimmed-up motors, will be used to drive fish from both shoreline and open water habitats into the nets. Upon capture, invasive carp will be removed from the pond, and the length in millimeters and weight in grams of each fish will be recorded.

Otolith Microchemistry and Aging

Invasive carp captured in urban fishing ponds will have heads, vertebrae, and post-cleithra removed and sent to SIUC for otolith microchemistry analysis and age estimation.

2023 SAMPLING SCHEDULE

We will investigate reports of invasive carp sightings or captures in other Chicago area ponds solely based on photographic evidence or reports from credible sources. IL DNR also plans to sample all previously sampled urban ponds as part of the monitoring response effort.

DELIVERABLES

The results of each sampling event will be reported for monthly sampling summaries. An annual report summarizing sampling results will be provided to the MRWG, agency partners, and any other interested parties.

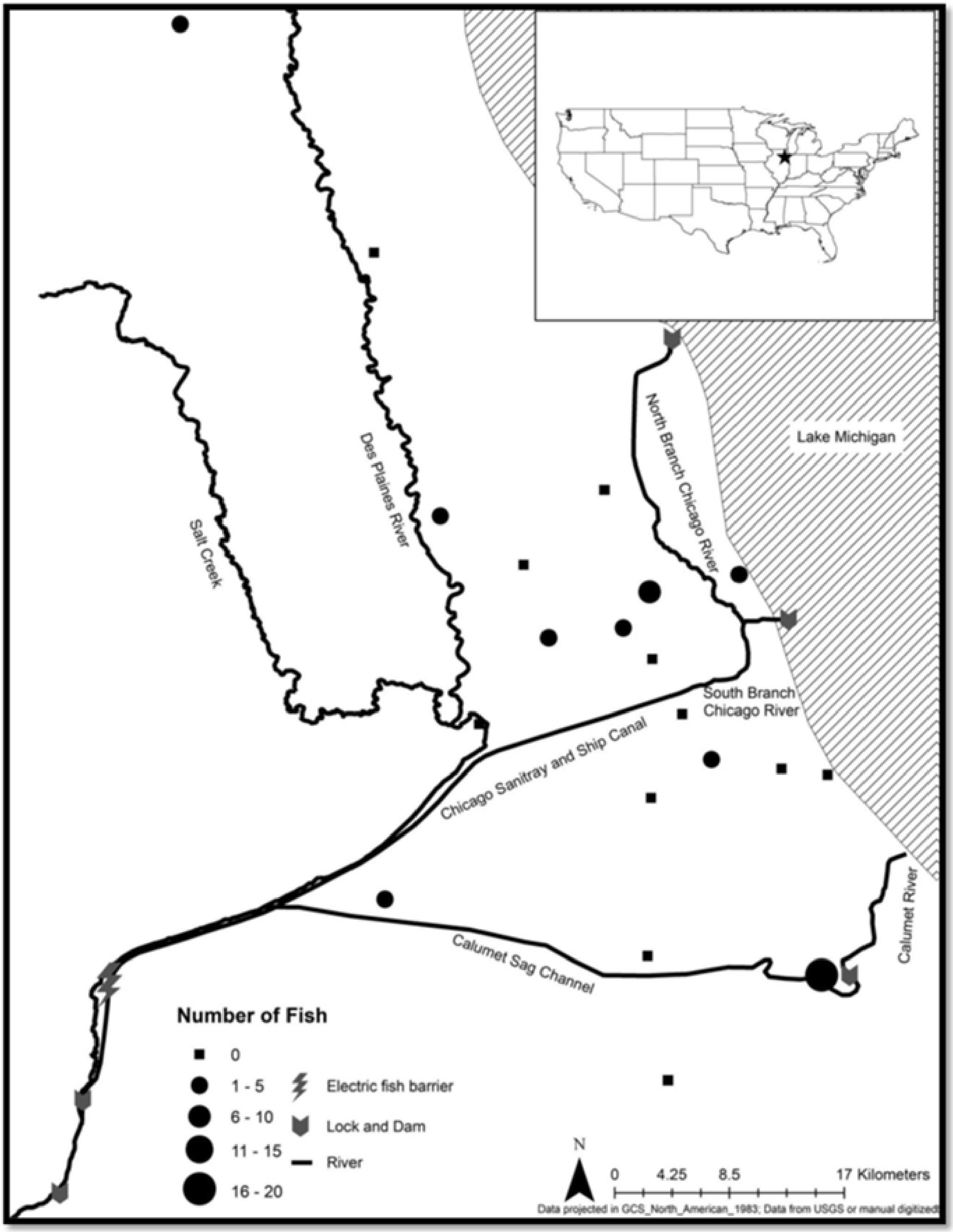

Figure 1. *Chicago area fishing ponds that were sampled or inspected.*

MULTIPLE AGENCY MONITORING OF THE ILLINOIS RIVER FOR DECISION MAKING

Participating Agencies: IL DNR, INHS (co-leads), USFWS (supporting agency), and USACE Chicago District (supporting agency).

Location: The MAM of the Illinois River for Decision Making will include data from Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, and Alton pools of the Illinois River below the EDBS (Figure 1).

INTRODUCTION AND NEED

Detection of and monitoring of invasive carp (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) below the EDBS are pertinent to understanding the threat of expansion into Lake Michigan and effectively controlling their spread. Surveillance is particularly important in reaches deemed the most upstream expanse for each invasive carp species. The leading edge for Bighead Carp and Silver Carp in 2022 was within the Dresden Island Reach, for Grass Carp the CAWS, and for Black Carp the Peoria Reach (MRWG 2020). Utilizing a standardized, multiple-gear approach has been critical in determining the geographic expanse of invasive carp and monitoring their relative abundance (Ickes et al. 2005; Irons et al. 2011). This multiple-gear approach also provided critical information on non-target species, such as abundance, condition (Love et al. 2017; Irons et al. 2007), recruitment (DeBoer et al. 2018), and fish community structure (Solomon et al. 2016), providing additional lines of evidence toward the presence and impact of invasive carp and management actions being taken (e.g., removal). Therefore, there is value in monitoring reaches downstream of the EDBS (Lockport through Alton reaches) using a standardized, multiple-gear sampling approach. Doing so will allow for an accurate, comparable, and representative understanding of invasive carp distribution and abundance in the Illinois River between the EDBS and the Alton Reach. A standardized, multiple-gear sampling protocol will also allow researchers to further evaluate the impacts of invasive carp management and their impacts on the native fish community.

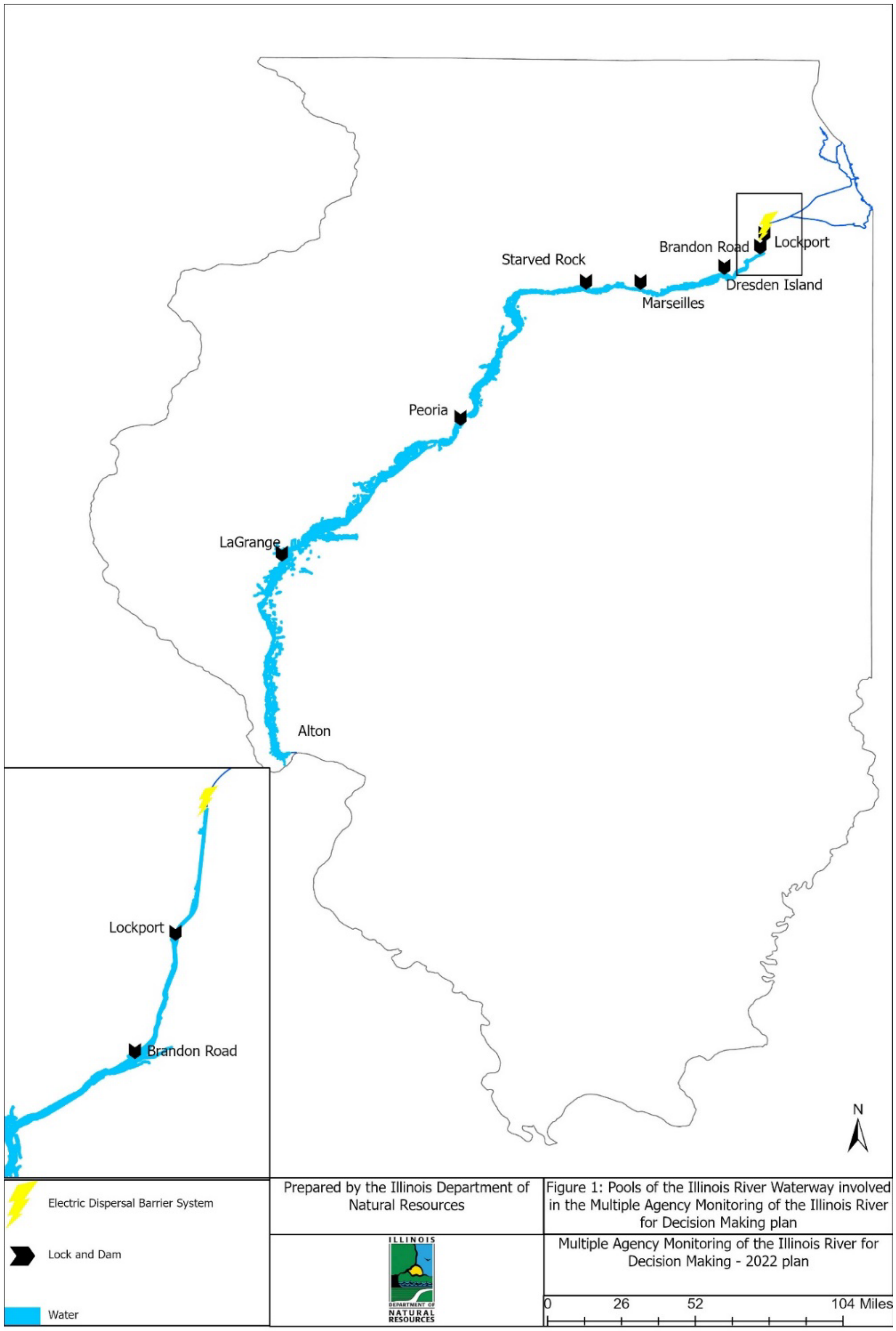

Figure 1. *Map of the sampling reaches of the Illinois River below the EDBS to the confluence of the Upper Mississippi River involved in the MAM of the Illinois River for Decision Making plan.*

OBJECTIVES

- Monitor the geographic distribution and relative abundance of adult and juvenile invasive carp populations in reaches below the EDBS downstream to Alton Reach.
- Provide data capable of detecting spatial and temporal changes in the invasive carp population and native fish community throughout the Illinois River between the EDBS and Peoria Reach.
- Inform other projects (i.e., contracted invasive carp removal, hydroacoustic surveys, invasive carp demographics, telemetry monitoring, SEIcarP model, etc.) with necessary invasive carp and fish community data to make management decisions.

STATUS

The MAM of the Illinois River for Decision Making will follow a standardized sampling protocol that has been used to monitor the Illinois River for decades. The USACE's Upper Mississippi River Restoration Program (Ratcliff *et al.* 2014) has monitored the La Grange Reach of the Illinois River using a standardized, multiple-gear monitoring approach since 1994. The Long-term Survey and Assessment of Large-River Fishes in Illinois, formerly the LTEF Project, has sampled the main channel of the Dresden Island, Marseilles, Starved Rock, Peoria, and Alton reaches since 1959. The LTEF transitioned to the LTRM electrofishing protocol in 2009 (Fritts *et al.* 2017). The Invasive Carp Demographics Project (ICRCC-MRWG 2022) has conducted standardized monitoring of the lower six pools of the Illinois River utilizing the electrified dozer trawl. The electrified dozer trawl has been shown to increase catch rates of invasive carp in relation to traditional boat electrofishing (Hammen et al. 2019) and sample unique strata in relation to standardized LTRM gears (ICRCC-MRWG 2022). The addition of the electrified dozer trawl to an LTRM-style standardized monitoring approach will help provide unique habitat strata sampled and increased invasive carp catches. This standardized protocol will create a comprehensive picture of the spatial and temporal distribution of invasive carp populations within Lockport to Alton reaches of the Illinois River.

METHODS

Sampling will utilize several gear types, including boat pulsed-DC electrofishing (Table 1), fyke netting (Table 2), minnow fyke netting (Table 3), paired large and small hoop netting (Table 4), and electrified dozer trawl sampling (Tables 5 and 6) in a stratified random approach targeting all life stages of invasive carps. Sampling will occur at random sites stratified among the various aquatic strata (main-channel-border, side-channel-border, backwater, impounded, tailwater zone, and tributaries) within each river reach (Lockport through Alton) during spring (June 15 to

July 31), summer (August 1 to September 15), and fall (September 16 to October 31). Detailed descriptions of gear specifications and sampling protocol can be found in Ratcliff *et al.* (2014), Hammen et al. (2019), and Appendix L.

Collected fish will be identified to species, measured, and categorized into 10-millimeter-length bins signified by their lower length boundary. Sampled invasive carp will be measured to total length (nearest millimeter), their sex assigned, and maturity status determined. In addition to length measurements and weight data from all invasive carp individuals greater than or equal to 100 millimeters and at least three individuals per 10-millimeter-length group greater than or equal to 100 millimeters from all other species will be collected during fall sampling. Aging structures (Lapilli otoliths) will be collected from the first 200 invasive carp sampled in each pool during fall sampling. Otoliths will be transferred and processed by the USFWS Columbia field station.

Specimens not identified to species in the field will be placed in vials, preserved with 10 percent formalin or 95 percent alcohol, and labeled with location code, reach, start date and time, gear code, and stratum code. Preserved specimens will be identified, measured, enumerated, and recorded in the laboratory as time permits. Any specimen identified to a species that has not been found previously within the Illinois River or is recognized as state-threatened or endangered will be photographed or vouchered (IL DNR 2018).

Historically sampled fixed sites upstream of the known invasive carp invasion front (Dresden Island Reach) within Brandon Road Reach and Lockport Reach will also be sampled with pulsed-DC electrofishing. Fixed sites will be sampled every other week from March through November, providing a higher frequency and lengthier temporal range than the randomized sampling design. This fixed and random approach provides additional opportunities to detect whether invasive carp are present near the EDBS in periods outside of the standard sampling window and maintains the collection of historical trend data.

Table 1. *Electrofishing effort by agency and project type among each 6-week time period across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include main channel border (MCB), side channel border (SCB), and backwater (BWC). Participating agencies and projects include IL DNR Yorkville (IL DNR-Y), INHS Illinois River Biological Station invasive carp (IRBS-BSH), INHS Illinois River Biological Station Black Carp (IRBS-BC), INHS Illinois River Biological Station Long Term Survey and Assessment of Large River Fishes In Illinois (IRBS-LTEF), and the USACE.*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria
MCB						
IRBS-LTEF	0	0	3	6	3	15
IRBS- BSH	0	0	0	5	8	0
IL DNR-Y	4	4	9	0	0	0
USACE	8	8	0	0	0	0
Total	12	12	12	11	11	15
SCB						
IRBS-BC	0	0	0	6	12	15
IL DNR-Y	0	0	4	6	0	0
Total	0	0	4	12	12	15
BWC						
IRBS-BC	0	0	0	0	0	15
USFWS	0	0	0	0	12	0
IDNR-Y	3	0	8	8	0	0
Total	3	0	8	8	12	15

Table 2. *Fyke net effort by agency and project type among each 6-week time period across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include backwater (BWC). Participating agencies include INHS Illinois River Biological Station Invasive carp (IRBS-BSH) and INHS Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria
BWC						
IRBS-	0	0	0	0	0	9
IRBS-	0	0	5	5	0	0
Total	0	0	5	5	0	9

Table 3. *Minnow fyke net effort by agency and project type among each 6-week time period across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include main channel border (MCB), side channel border (SCB), and backwater (BWC). Participating agencies include IL DNR Yorkville (IL DNR-Y) and INHS Illinois River Biological Station Invasive carp (IRBS-BSH).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria
MCB						
IL DNR-Y	8	8	8	8	0	0
IRBS-BSH	0	0	0	0	8	8
Total	8	8	8	8	8	8
SCB						
IL DNR-Y	0	0	6	6	0	0
IRBS-BSH	0	0	0	0	6	6
Total	0	0	6	6	6	6
BWC						
IL DNR-Y	0	0	10	10	0	0
IRBS-BSH	0	0	0	0	10	10
Total	0	0	10	10	10	10

Table 4. *Paired hoop net effort by agency and project type among each 6-week time period across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include main channel border (MCB) and side channel border (SCB). Participating agencies include IL DNR Yorkville (IL DNR-Y) and the INHS Illinois River Biological Station Black Carp (IRBS-BC).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria
MCB						
IL DNR-Y	14	14	8	8	0	0
IRBS-BC	0	0	0	0	8	8
Total	14	14	8	8	8	8
SCB						
IL DNR-Y	0	0	6	6	0	0
IRBS-BC	0	0	0	0	6	6
Total	0	0	6	6	6	6

Table 5. *Electrified Dozer Trawl effort by agency and project type among the first two 6-week time periods across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include main channel border (MCB), side channel border (SCB), backwater (BWC), and tributary (TRIB). Participating agencies and projects include USFWS and Columbia FWCO (CFWCO).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	LaGrange
MCB							
CFWCO	0	0	12	11	11	15	15
Total	0	0	12	11	11	15	15
SCB							
CFWCO	0	0	4	12	12	15	15
Total	0	0	4	12	12	15	15
BWC							
CFWCO	0	0	8	8	12	15	15
Total	0	0	8	8	12	15	15
TRIB							

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	LaGrange
CFWCO	0	0	5	0	5	0	0
Total	0	0	5	0	5	0	0

Table 6. *Electrified Dozer Trawl effort by agency and project type among the third 6-week time periods across habitat strata within the reaches of the Illinois River below the EDBS. Strata sampled include main channel border (MCB), side channel border (SCB), backwater (BWC), and tributary (TRIB). Participating agencies and projects include, USFWS and Columbia FWCO (CFWCO).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	LaGrange	Alton
MCB								
CFWCO	0	0	20	24	19	15	18	40
Total	0	0	20	24	19	15	18	40
SCB								
CFWCO	0	0	10	12	13	15	17	10
Total	0	0	10	12	13	15	17	10
BWC								
CFWCO	0	0	15	14	18	20	17	0
Total	0	0	15	14	18	20	17	0
TRIB								
CFWCO	0	0	5	0	5	0	0	0
Total	0	0	5	0	5	0	0	0

2023 SAMPLING SCHEDULE

- Sampling coordination: January 1 to June 14
- Sampling techniques workshop: May 1
- Period 1 sampling: June 15 to July 31
- Period 2 sampling: August 1 to September 15

- Period 3 sampling: September 16 to October 31
- Data quality assurance and lab identifications: November 1 to December 31 (tentative)
- Data upload: Before the 2024 sampling season

DELIVERABLES

Collected data will be recorded in a standardized Microsoft Access data entry application. Catch and effort data will be preliminarily summarized by each participating agency following the completion of each 6-week period and sent to the MRWG Monthly Summary assembler to be posted to https://invasivecarp.us/PartnerResources.html. Finalized sampling and fish data collected by each agency will be submitted to the USGS Upper Midwest Environmental Sciences Center before the next sampling season using the online portal. Following submission, data will be appended into a single database, summarized for an annual interim report, and made accessible to MRWG members upon request from the database curator.

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MANAGEMENT AND CONTROL PROJECTS

USGS INVASIVE CARP DATABASE MANAGEMENT AND INTEGRATION SUPPORT

Participating Agencies: USGS, IL DNR, INHS, USFWS, USACE, and SIU

Location: Illinois River Waterway System

Pools Involved: CAWS, Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, and Alton pools

INTRODUCTION AND NEED

Invasive carp tracking, monitoring, and contracted removal will continue throughout the Upper IWW system as part of an adaptive management effort to mitigate, control, and contain invasive carp. To help facilitate these actions, there is a need to compile and analyze data from the multitude of partner agencies that are collecting invasive carp-related data throughout the Illinois River system. These data are often in disparate formats, and integrating these data into a common format allows both researchers and managers to assess invasive carp monitoring, control, and removal efforts at several scales is necessary. Ensuring the interoperability of these data sets allows for their use in various analyses and modeling efforts. Implementing an interoperable data management framework also provides mechanisms for end users to find and use existing data. Integrating data for use in modeling and analysis furthers the MRWG 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). An effective data management strategy will streamline the database update process, providing partners with timely, well-organized, uniformly formatted data and analyses in support of informed decision-making processes.

OBJECTIVES

Provide data management, informational products, and decision support tools to aid and inform the management and removal of invasive carp in the Illinois River system. Integrating and transforming invasive carp-related data sets into actionable information includes the following objectives:

- Continued maintenance of the FishTracks Telemetry Database (FishTracks) and ILRCdb applications to facilitate objectives 2 and 3 via data standards, compilation, management, and summarization.
- Further the understanding of invasive carp life history and other factors that might influence the efficacy and efficiency of contract removal or other control approaches (such as deterrents) and facilitate risk assessments.
- Incorporate findings from objective 2 into analyses, informational products, and decision support tools to inform modeling efforts and management decisions to control invasive carp.

STATUS

The FishTracks and ILRCdb applications, which contain query-able, downloadable telemetry and catch data (respectively), have been developed, deployed, and released to partners. Standardized data requirements are utilized during the data collection process, and data quality assurance checks are implemented during the data upload process. Automated monthly reporting features have been updated for FishTracks and shared with partners to help inform management utilizing real-time receivers.

An access-controlled API has been developed for end users (such as modelers) to directly access invasive carp telemetry data stored in FishTracks with agency data-sharing agreements in place. This API is available to the MRWG partners to further enable efficient data integration and analysis. Demographic-related data being compiled and utilized by the monitoring working group for population modeling efforts will be used to establish core data standards, similar to telemetry and catch data, for easier integration into analysis-ready workflows.

High-resolution hydroacoustic bathymetric survey data (from multibeam and side scan sonar) have been collected, validated, and processed into benthic classification layers from priority removal areas of the Illinois River system (Brandon Road, Dresden Island, Marseilles, Starved Rock, and select areas of Peoria pools). These data sets, along with other invasive carp-related data sets, are complete and publicly available but exist in disparate digital data repositories and oftentimes require specialized software to visualize and use (for example, proprietary GIS software). Integrating these data sets into an online, easy-to-use data hub will reduce access barriers for the multi-agency partnership.

METHODS

FishTracks, a Microsoft SQL Server application, and the ILRCdb application, developed in open-source relational database PostgreSQL (open-source relational database management system), are actively maintained, which involves performing routine database maintenance (such as ensuring data backups, performing internal consistency checks, rebuilding indexes as needed, etc.) to keep the applications online and available to users. New telemetry and catch data collected by partner agencies are loaded into the database applications after passing quality assurance checks for data consistency (for example, standardized formatting of data, ensuring complete and within-bounds fields, etc.). Updates and additions are made to the applications based on partner requests and sponsor requirements (such as customized monthly, quarterly, or annual reports based on specific monitoring or management needs, updating security and software protocols, etc.).

An API has been developed to allow direct programmatic access to FishTracks, enabling end users (such as modelers) to integrate and analyze partnership data into modeling software programs, such as R. In addition, population demographic-related data requirements from monitoring data collections have been determined. Establishing core data standards for this type of data will allow for the integration of data from multiple agencies with minimal data post-processing required.

Existing invasive carp-related data sets and analytical tools that have been collected, processed, and developed by the multi-agency partnership are being converted to web mapping and geoprocessing services and integrated into an online Mississippi River Basin invasive carp data hub for researchers and managers to access these data sets and tools. Data set examples include high-resolution hydroacoustic bathymetric survey data (from multibeam and side scan sonar), benthic classification layers (such as landform and substrate classifications), and other relevant environmental data layers (such as water temperature, discharge, etc.). An online, user-friendly interface (ArcGIS Hub) will allow for improved discoverability and usability of existing data sets without the need for specialized software or advanced technical skills. Incorporating existing data sets into analyses and decision support tools aims to further the understanding of invasive carp life history, behavior, and distribution.

2023 SCHEDULE

- Add new data to FishTracks Telemetry Database – annual basis (post-field season)
- Add new data to the ILRCdb – June and December (bi-annually)

- Finalize demographics-related data template to support population modeling objectives – May 2023
- Deploy online hub of invasive carp data sets and tools – September 2023

DELIVERABLES

- A continually maintained database applications for invasive carp-related telemetry, monitoring, and removal data in the Upper Mississippi and Ohio River subbasins (FishTracks Telemetry Database and ILRCdb applications), with customized data reports, upload functionality for data sharing among partner agencies, and query-able data access for end users through an access-controlled API.
- A database application for demographics-related data collected by the partnership (beginning with the Upper Mississippi River, as supported by USGS funding) to facilitate population modeling efforts. Includes standardized, core data elements to integrate demographics data sets based on end-user needs (for example, modeling working group of the MRWG).
- An online Mississippi River Basin invasive carp data hub with an end-user interface for the discoverability and usability of existing invasive carp-related data sets and analytical tools that have been collected, processed, and developed by the partnership (such as web mapping and geoprocessing services). Deployment of a web mapping tool that integrates existing bathymetric and benthic classification spatial data layers with environmental variables, telemetry, and catch data to analyze bigheaded carp distribution and inform the deployment of control and removal efforts.

CONTRACTED COMMERCIAL FISHING BELOW THE ELECTRIC DISPERSAL BARRIER SYSTEM

Participating Agencies: IL DNR (lead), INHS (field support)

Location: Contracted Commercial Fishing Below the EDBS will target the area between the EDBS at Romeoville, IL (approximately 37 miles [60 kilometers] from Lake Michigan), downstream to Starved Rock Lock and Dam, and includes the Lockport Pool, Brandon Road Pool, Dresden Island Pool, Marseilles Pool, and Starved Rock Pool (Figure 1).

INTRODUCTION AND NEED

The Contracted Commercial Fishing Below the EDBS project uses contracted commercial fishers to reduce invasive carp (Bighead Carp, Silver Carp, Grass Carp, and Black Carp) relative abundance and monitor for their expansion in the upper Illinois River and lower Des Plaines River downstream of the EDBS. Decreasing invasive carp relative abundance reduces migration pressure toward 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 defined as the furthest upstream location where multiple Bighead Carp or Silver Carp have been captured using 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 the understanding of invasive carp population abundance, distribution, and movement between and among pools of the IWW and can be utilized in conjunction with other MRWG projects to better understand population dynamics in areas of concern.

OBJECTIVES

- Monitor for 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, SEACarP model, small fish monitoring, telemetry master plan) with invasive carp population distribution, dynamics, and movement in the IWW downstream of the EDBS.

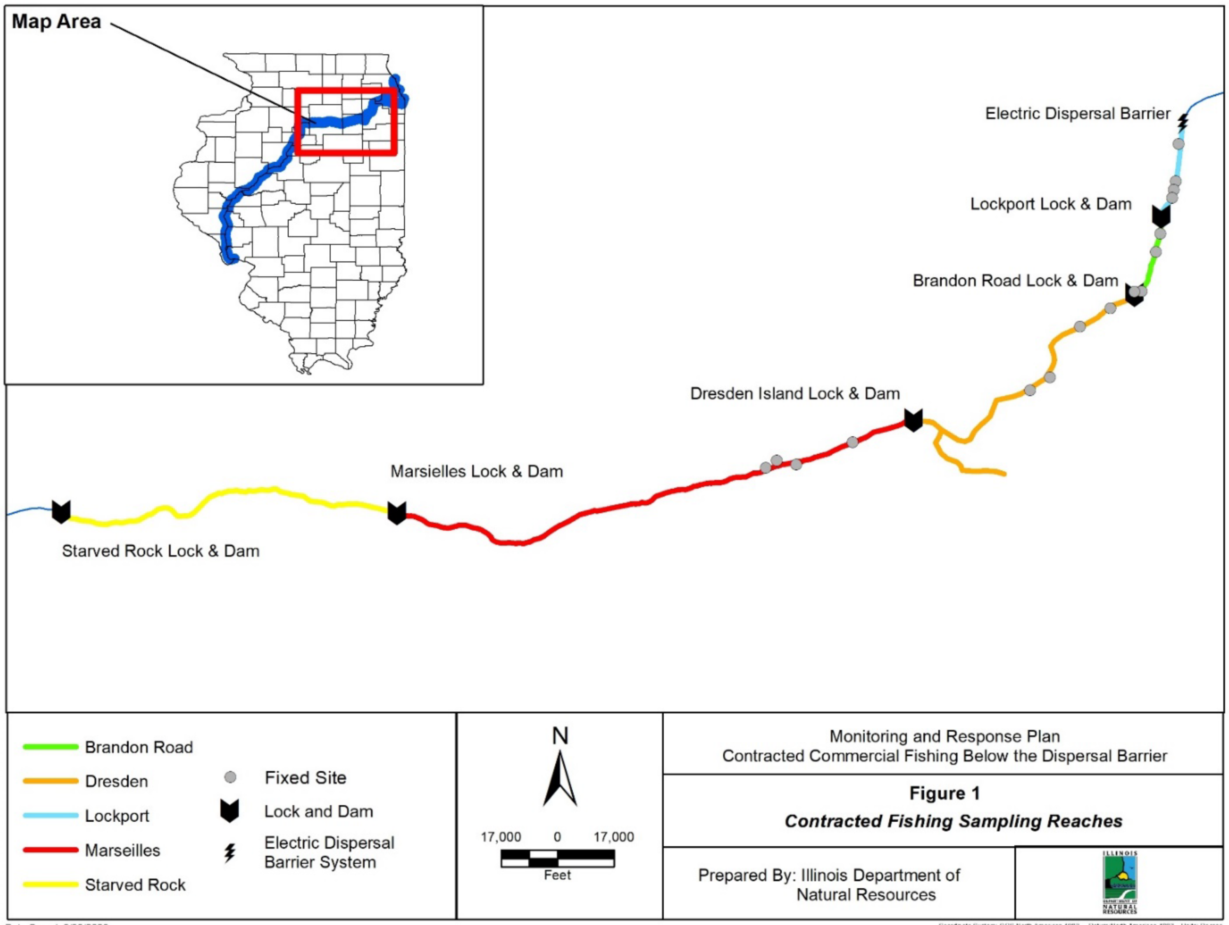

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites below the EDBS.*

STATUS

Contracted commercial fishers have been used in the Monitoring Efforts Downstream of the Electric Dispersal Barrier System Project and the Barrier Defense Invasive Carp Removal Project (2010 to 2018). In 2019, the two projects were combined into a single project to provide a more comprehensive picture of the ongoing contracted commercial fishing effort and results. Since 2010, contracted commercial fishers' effort in the upper IWW below the EDBS includes 4,800 miles (7,741 kilometers) of gill/trammel net, 19 miles (31 kilometers) of commercial seine, 239-pound net nights, and 4,369 hoop net nights. A total of 104,349 Bighead Carp, 1,327,020 Silver Carp, and 11,473 Grass Carp have been removed. The estimated total weight of invasive carp removed is 5,714.5 tons (11,429,000 pounds). Contracted commercial fishing efforts indicate a decreasing abundance trend of invasive carp as you progress upriver from Starved Rock Pool to Dresden Island Pool, with no invasive carp captured in Lockport or Brandon Road pools during contracted commercial fishing. One adult Bighead Carp was observed in Brandon Road Pool by a netting crew in October 2011. For more detailed results, consult the 2021 Interim Summary Report.

METHODS

Contracted commercial netting will occur from March 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 will be 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 will be required to accompany contracted commercial fishing crews working in this portion of the river. Contracted commercial fishers, with assisting agency biologists, will fish four days a week during each week of the field season, except for two weeks in June and two weeks in September when contracted commercial fishers will be sampling upstream of the EDBS for the SIM project (Table 1).

Contract fishing with observing IL DNR biologists will occur monthly at targeted sites throughout each pool. Four fixed sites each in Lockport, Brandon Road, Dresden Island, and Marseilles pools will also be sampled monthly (Figure 1). Fixed and targeted site data will be merged to gain a comprehensive understanding of invasive carp spatial and temporal abundance below the EDBS, especially at their upper-most extent in the Dresden Island Pool. This will allow a more thorough understanding of invasive carp relative abundance through time at a pool-wide scale. However, because invasive carp abundance and fishing locations are spatially heterogeneous, areas of special interest to the monitoring and response working group (Rock Run Rookery and Dresden Island Pool above I-55) will be 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 Island Pool Main Channel Above I-55).

Large mesh (2.5- to 5.0-inch; 63.5- to 127-millimeter) gill and trammel nets set in 100 to 1,200-yard segments will be used, and commercial fishers will utilize fish herding (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors trimmed up) to drive fish into the net. Nets will typically be set for 20 to 30 minutes, with overnight net sets occasionally occurring in off-channel habitats and in non-public backwaters with no boat traffic. Entangled fish will be removed from the net, identified, enumerated, and recorded. All invasive carp and Common Carp will be checked for telemetry tags, and all non-tagged invasive carp will be harvested and utilized by private industry for purposes other than human consumption (e.g., chum bait, converted to liquid fertilizer, pet treats, food for wildlife rehabilitation centers, etc.). All tagged invasive carp and all non-invasive carp bycatch will be released into the water alive. A representative sample of up to 30 individuals of each invasive carp species from each pool will be measured for total length, weighed, and sexed each week to gather morphometric data on harvested carp over time. Invasive carp will be placed in totes, and all totes will be weighed with a pallet jack scale to determine the total weight of invasive carp harvested.

Suggested Boat Launches for Contracted Commercial Fishing Sampling:

Lockport Pool: Cargill Launch in Romeoville off W 9th St. (Inform Martin Castro (312) 401-9328)

Brandon Road Pool: Ruby Street Launch (767 N Bluff St., Joliet, IL 60435)

Joliet Boat Store Launch (724 Railroad St., Joliet, IL 60436)

Dresden Island Pool: Big Basin Marina under the I-55 Bridge (24045 W Front St., Channahon, IL 60410)

Marseilles Pool: William G. Stratton State Park Launch (Griggs Dr., Morris, IL 60450)

LST Memorial Public Boat Launch (E. South St., Seneca, IL 61360)

llini State Park Launch (2660 E. 2350th Rd., Marseilles, IL 61341)

Starved Rock Pool: Allen Park Launch off Route 71 (400 Courtney St., Ottawa, IL 61350)

Starved Rock Marina off Dee Bennett Road (1130 N 27th Rd., Ottawa, IL 61350)

2023 SAMPLING SCHEDULE

Sampling will occur from March 14 to December 16, 2023.

DELIVERABLES

Results of each sampling event (e.g., each week) will be reported in monthly sampling summaries. Data will also be summarized in an annual interim summary report, and project plans will be updated for annual revisions of the MRP.

BARRIER MAINTENANCE AND FISH SUPPRESSION

Project Title: Barrier Maintenance Fish Suppression

Participating Agencies: IL-DNR (lead), USFWS, USACE, MWRDGC, and USCG

Location: Romeoville, Illinois near the EDBS

Pools Involved: Lockport Pool

INTRODUCTION AND NEED

The USACE operates three Electric Dispersal Barriers (Barrier 1, Barrier 2A, and Barrier 2B) for aquatic invasive species in the CSSC, collectively referred to as the EDBS. Barriers must be shut down for annual maintenance, and the IL DNR agreed to support maintenance operations by providing fish suppression at the barrier site. Fish suppression can vary widely in scope and may include the application of piscicide (rotenone) to keep fish from moving upstream past the barriers when they are shut down. This project outlines the monitoring, assessment, and clearing procedures utilized by the MRWG to take necessary precautions to prevent the passage of invasive carp into the Great Lakes.

Sampling to assess the abundance of invasive carp may take place in the Lockport Pool of the CSSC between Lockport Lock and Power Station and the EDBS (RM 291.0-296.1). Surveillance methods utilizing both hydroacoustic and sonar-based surveys will occur between the Demonstration Barrier and Barrier 2A to assess initial abundances between the EDBS. Traditional and novel techniques will then be deployed in cooperation with or after the surveillance technologies to clear fish from between the barriers, as determined by the MRWG co-chairs. The work area will be extended about 0.25 miles (0.4 kilometers) in both upstream and downstream directions if a backup rotenone action is necessary to allow for chemical application and detoxification stations.

OBJECTIVES

- Remove fish greater than 300 millimeters (12 inches) in total length present between two active barriers before maintenance operations are initiated or after maintenance is completed by collecting or driving fish from the area with mechanical technologies (surface noise, surface pulsed-DC electrofishing or, if needed, a small-scale rotenone action).

- Assess fish assemblage less than 300 millimeters (12 inches) in total length at the EDBS for species composition to ensure juvenile or YOY Bighead Carp and Silver Carp are not present. Physical capture gears focused on small-bodied fish, such as electrified Paupier surface trawls and surface pulsed-DC electrofishing, could be utilized in support of this effort.

- Assess the results of fish clearing operations by reviewing the physical captures and surveying the EDBS with remote sensing gear (split-beam hydroacoustic and side-scan sonar) and initiate further clearing actions as necessary until the MRWG has identified the remaining risk of Invasive carp presence to be low.

STATUS

The project is ongoing. Clearing actions are determined on an as-needed basis, and few clearing actions have been required over the last few years due to the very low risk of invasive carp in the Lockport pool.

METHODS

The methods used for fish suppression can vary dramatically depending on the risk level at the time of the clearing action. Methods may include a combination of hydroacoustic surveys, electrofishing, gillnetting, additional commercial harvest, underwater acoustic sound deterrence, and rotenone application. When a need for a clearing/suppression action arises, the MRWG co-chairs will meet to determine the necessary actions based on the current risk of invasive carp and the safety of personnel.

2023 SAMPLING SCHEDULE

Fish suppression occurs on an as-needed basis when unexpected outages at the EDBS warrant a response action. In addition, clearing actions may be required for planned outages. The current maintenance operations that are tentatively scheduled for 2023 and may require a fish-clearing action are:

- Barrier 1 annual maintenance – January 9 through 27, 2023
- 2A and 2B annual maintenance – February 6 through 24, 2023
- Barrier 1 South array pulser installation and activation – Fall 2023

DELIVERABLES

Updates on planned and unexpected outages will occur via email notification and will be briefed in monthly summaries. A summary of outages and any necessary clearing actions will be outlined in the annual Interim Summary Report.

INVASIVE CARP POPULATION MODELING TO SUPPORT AN ADAPTIVE MANAGEMENT FRAMEWORK

Participating Agencies: USFWS, Carterville FWCO; USGS Upper Midwest Environmental Sciences Center

Collaborators: INHS, IL DNR, SIU, USGS Columbia Environmental Research Center, USFWS, La Crosse FWCO, USFWS, Columbia FWCO, Michigan State University

Location: Dresen Island, Marseilles, Starved Rock, Peoria, La Grange, and Alton pools, Illinois River

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 will focus on the development of novel quantitative tools, such as an SCAA model, to address questions regarding the effects of contracted removal efforts on invasive carp populations and continue the development and maintenance of predictive simulation-based models designed to address emerging management questions (i.e., the SEICarP model and the per-capita contribution model). These simulation-based and assessment tools can be used in conjunction with one another to iteratively develop new management targets based on the current assessment of the invasive carp population.

The SEICarP and per-capita contribution models are simulation-based mathematical representations of Silver and Bighead Carp population dynamics. These models inform management by providing estimates of the effects of the spatial allocation and magnitude of harvest and the location and effectiveness of barriers to upstream movement of invasive carp in the Illinois River invasive carp population (SEICarP) or individual contributions of invasive carps to the Dresden Island population (per-capita contribution). Additionally, the results of these models can be used to understand critical model assumptions and uncertainties and can be used to provide recommendations concerning data collection and research in the Illinois River, guiding ongoing model development aimed at extending model capabilities and reducing uncertainty.

There are currently three limitations that limit our confidence in the predictions made by the SEICarP model. While the model is largely complete, it can be iteratively improved by addressing these limitations, and we can increase our confidence in the model outputs and management recommendations. The first limitation is the assumption that invasive carp neither leave nor enter the Illinois River. Currently, the SEICarP model treats the Illinois River as a closed system, despite considerable fish movement between the Illinois River and Upper Mississippi River basins. Second, the current version of the SEICarP model cannot provide pool-specific recommendations for fish removals because of the limitations in the movement model discussed above. Improving this movement model will allow modelers to improve the spatial resolution of management recommendations, such as the proportion of the carp population that should be removed from each pool. Third, we do not understand the relationship between the parental fish stock and resulting recruitment (i.e., the stock-recruit relationship) for Illinois River invasive carp. Understanding this relationship is critical to the management of invasive carp in the Illinois River because the stock-recruitment relationship determines how recruitment rates will respond to control-induced reductions in adult biomass. To address the first two limitations, this project will coordinate with the MRWG telemetry working group to determine the feasibility of expanding data collections into the Mississippi River and incorporating the updated movement model with finer spatial resolution into the SEICarP model. Additionally, developing a stock-recruitment model leveraging data from the MRWG hydroacoustics working group and age-structure data from field collections is underway and will address the third limitation. Furthermore, to improve the utility of the SEICarP model to managers, this project will develop a user interface that will allow managers to independently explore various harvest and barrier scenarios prior to more in-depth modeling efforts to understand the uncertainty of any recommendations derived from those scenarios.

Lastly, this project will develop an SCAA model following the recommendations of Bence and Brendan (2022). SCAA models are a flexible stock assessment method that can use information from a variety of data sources (e.g., fishery-dependent catch-at-age and fishery-independent indices of abundance) to estimate the abundance, biomass, and fishery characteristics of age-structured populations through time. An SCAA model of invasive carp in the Illinois River 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. This information will directly help managers assess the effectiveness of contract removal programs.

OBJECTIVES

- Collaborate with the MRWG telemetry working group to incorporate updated pool-to-pool movement probabilities into SEICarP.
- Develop a stock-recruitment relationship using existing age structure and hydroacoustics data.

- Develop a graphical user interface to allow managers to directly interact with the SEICarP model and to improve communication between managers and the modeling working group.
- Work with MRWG co-chairs and working group leads to apply per-capita contribution modeling to invasive carp management.
- Begin developing an SCAA model following the recommendations of Bence and Brendan (2022).
- Begin discussions with the removals and monitoring working groups regarding the collection of additional demographic information from harvested invasive carp to support the SCAA model.

STATUS

This is a continuing project from 2022.

- Updated results were presented at the annual January 2023 MRWG meeting and in the 2021 ISR submission.
- Submitted the SEICarP model manuscript for peer review in the *Journal of Applied Ecology* in December 2022.
- Coordinated with MRWG sub-working groups (i.e., telemetry and monitoring) to address identified data needs and knowledge gaps.
- Published the per-capita contribution model manuscript in *Ecosphere* in December 2022.
- Submitted the per-capita barrier scenarios manuscript for review by coauthors.
- Received report from the SCAA feasibility study (Bence and Brendan 2022).

METHODS

Objectives 1 and 2 of this project will address critical limitations in our understanding of invasive carp population dynamics, including support for updated movement modeling (Objective 1) and the development of an invasive carp-specific stock-recruitment model (Objective 2). To address limitations associated with the movement model, the MRWG modeling working group will coordinate with the MRWG telemetry working group to incorporate an updated movement model with greater spatial coverage and finer spatial resolution into SEICarP. To parameterize the stock-recruitment model (Ricker 1954) age-length keys (Ailloud et al. 2019) will be developed from age-structure data. Age-length keys will be paired with existing hydroacoustics data to quantify and determine the relationship between recruitment (fall age-1 abundance) and spawning stock biomass.

Objective 3 of this project is to develop a SEICarP geographic user interface to allow managers to directly interact with the SEICarP model and promote discussion of the assumptions and uncertainties of various management scenarios.

Objective 4 of this project is to work with the MRWG co-chairs and working group leads (e.g., telemetry and deterrents) to determine the best applications of the per-capita contribution modeling to support invasive carp management.

Objective 5 of this project is to begin developing an SCAA model following the recommendations of Bence and Brendan (2022). This will begin with a USFWS modeler receiving training in stock assessment modeling and the software used to develop these models (i.e., template model builder). Following training, the modeler will work with data managers within IL DNR and USFWS to begin data harmonization and with Michigan State University's Quantitative Fisheries Center to begin model development.

Objective 6 of this project is to begin discussions with the removals and monitoring working groups to determine a path forward for additional collections of demographic information from harvested invasive carp. These data will support the development of the SCAA model.

2023 SAMPLING SCHEDULE

February through March

- Prepare and submit per-capita barrier scenarios manuscript to the MRWG co-chairs and the USGS review process.
- Begin collaboration with Michigan State University's Quantitative Fisheries Center to receive training in stock assessment modeling.

April through September

- Begin development of an SCAA model using data provided by the removals and monitoring working groups.

January through September

- Apply per-capita contribution modeling scope to address management questions.

February through September

- Develop a stock-recruit relationship for the lower three pools of the Illinois River using previously collected age structure and hydroacoustics data (2012 through present).
- Develop SEICarP geographic user interface, identify a web-hosting platform, complete USGS review process, and distribute to partners.

DELIVERABLES

- Stock-recruit relationship for the lower three pools of the Illinois River derived from age-structure and hydroacoustics data (2012 through present).
- Per-capita barrier scenarios manuscript.
- SEICarP geographic user interface.

REFERENCES

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Bence, J., and T. Brendan. 2022. Review of Contemporary Approaches to Fishery Stock Assessment with Special Reference to their Applicability to Bigheaded Carp in the Illinois River. Page 19 pp.

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

Lead Agency: USFWS Carterville FWCO, Wilmington Substation, Wilmington, IL.

Location: Peoria and Starved Rock pools within the IWW.

Pools Involved: Starved Rock and Peoria pools

INTRODUCTION AND NEED

The SEICarP model was developed as a means of assessing the invasive carp population status in the IWW. Movement is the backbone of the SEICarP model and is the primary source of information about how researchers expect the population to respond to management strategies. Therefore, the model functions as an important tool that can be used by fisheries managers to inform the harvest and control of adult invasive carp (Silver Carp and Bighead Carp in this study) in the IWW. Because harvest effects, such as changes in fish density and size distributions, are likely to impact movement and will thus influence our ability to predict population responses, continued monitoring of invasive carp movement in the IWW is necessary. Furthermore, the telemetry data collected in support of SEICarP complements telemetry data being collected throughout the IWW describing interpool transfer of adult invasive carp and is used to parameterize the transition probability component of the SEICarP model. This research provides an improved understanding of the invasive carp movement in the IWW and its effects on population dynamics. An accurate understanding of invasive carp population status is critical for assessing invasive carp encroachment risk to the Great Lakes. Data gained from tagging additional invasive carp will improve the accuracy of the model.

OBJECTIVES

- Quantify movement frequency and distance of invasive carp in the IWW.
- Refine transition probabilities across locks and dams.
- Address limitations regarding the movement aspect of the SEIcarP model by tagging additional adult carp and placing additional receivers to increase the accuracy and precision of pool-to-pool estimates of movement in the IWW.

STATUS

This project was started in 2018 and will continue in 2023. During 2018, 130 invasive carp were tagged throughout Peoria Pool. The total length of tagged fish ranged from 391 to 635 millimeters. During 2019, 161 Silver Carp were tagged throughout Peoria Pool. The total lengths of tagged fish ranged from 374 to 776 millimeters. No invasive carp were tagged in 2020 due to COVID-19 working restrictions. In 2021, 100 invasive carp were tagged throughout Peoria Pool, with an additional 49 invasive carp tagged in Alton Pool by SIU staff. The total lengths of tagged fish ranged from 419 to 748 millimeters in Peoria Pool and 509 to 856 millimeters in Alton Pool. In 2022, 150 transmitters were used to tag invasive carp throughout the Peoria and Starved Rock pools, with half going into each pool. Total lengths of tagged fish ranged from 411 to 707 millimeters in the Peoria Pool and 540 to 949 millimeters in Starved Rock Pool. All fish were collected using standard boat electrofishing and an electrified dozer trawl. Locations of released fish were distributed throughout the pool, as was discussed with the MRWG telemetry working group.

METHODS

In 2023, USFWS staff will tag an additional 150 adult invasive carp with Vemco V-9 or V-13 tags, which are on the 69-kilohertz frequency. Invasive carp will be captured using boat electrofishing and electrified dozer trawl from the Illinois River in Peoria and Starved Rock pools. Immediately after capture, fish will be held for no more than 1 hour in an aerated 100-gallon holding tank covered with ¼-inch mesh. To maintain as close to sterile conditions as possible, one crew member, as the dedicated "surgeon," will wear gloves and only handle fish for the process of the incision, tag implantation, and suturing. Another crew member will be responsible for weighing and measuring the fish and recording data. All surgical tools, fish tags, and sutures will be soaked in 70 percent isopropyl alcohol between surgeries. All acoustic tags will be tested for functionality with an active receiver (VR100, Innovasea, Halifax, or Canada) prior to their use in use in surgery. Only active, healthy-looking fish will be selected for surgery. Each fish will be measured for total length (millimeters) and weight (grams), assigned a number, then placed into a V-notched board for surgery. A surgical rubber hose connected to a slow siphon of fresh aerated river water will be placed in the mouth of fish to allow them to breathe during surgery. A wet microfiber towel will be placed over the head of the fish to keep them calm.

The surgery site will be descaled to slightly beyond the length of the incision (approximately 3.5 centimeters) and wide enough (approximately 1.5 centimeters) for the suture to properly close the wound. The site will then be gently washed with several drops of betadine prior to making an incision. Using a #10 scalpel, a 2.5-centimeter incision will be made in the ventral side of the body, just behind the pelvic fins, anterior to the anus, taking care not to damage the intestines. Next, the tag will be inserted through the incision and gently pushed toward the anterior of the body cavity. At least two non-absorbable nylon sutures will be used to close the incision site for acoustic tags. Immediately following suture closure, the incision site will be washed with povidone-iodine a second time and rinsed using deionized water. The fish will then be placed into an aerated, salted holding tank for recovery. Once fish equilibrium has been re-established, fish will be returned to the river in proximity to their capture location. The total holding time for fish will generally be less than 2 hours.

Fish will be tracked using the current acoustic array within the IWW. Additional receivers will be placed in areas with reduced coverage, and the MRWG telemetry working group will be consulted prior to deployment.

Passive acoustic receivers (VR2W, 69khz, Innovsea, Halifax, or Canada) will be tethered to trees and set perpendicular to the shore. They will be placed a minimum of five river kilometers away from known partner agency receivers in the main channel to capture larger movements if they occur. An array of 20 receivers will be maintained in 2023. Active tracking with an active VR100 receiver may occur periodically to assess mortality and get real-time locations of tagged invasive carp.

For more information on the SEICarP model, please refer to the SEICarP Modeling Monitoring and Response Plan.

2023 SAMPLING SCHEDULE

- January through March: Gear preparation, fieldwork planning, crew scheduling
- March through April: Fish tagging, gear deployment
- April through November: Data download, gear maintenance and relocation, range testing, active tracking
- November through December: Receiver removal, final data downloads
- December through February 2024: Data analyses, prepare report and presentation

DELIVERABLES

Results from this project will be used to support the SEICarP model via regular uploads to the FishTracks database. Data will be analyzed, and results will be summarized into an MWRG summary report/presentation for the winter of 2023-2024.

INVASIVE CARP DEMOGRAPHICS – MULTIPLE AGENCY MONITORING SUPPORT

Participating Agencies: USFWS, MAM-IL DNR, INHS

Location: Invasive carp demographics will include data from Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, La Grange, and Alton pools of the Illinois River.

INTRODUCTION AND NEED

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

The USFWS's Invasive Carp Demographic Project is collaborative with the MAM of the Illinois River for Decision Making Project. Please see MAM of the Illinois River for Decision Making MRP for field sampling details associated with this project. Herein contains details not covered by the collaborative MRP.

OBJECTIVES

In addition to the MAM 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, 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.

STATUS

This is a continuing project from 2018. Starting in 2023, all field sampling, data analysis, and reporting associated with the Invasive Carp Demographics Project will be integrated into the MAM of the Illinois River for Decision Making framework and reported through that mechanism. Please see MAM of the Illinois River for Decision Making MRP for full details.

METHODS

Please see project MAM of the Illinois River for Decision Making MRP for full details.

2023 SAMPLING SCHEDULE

See the MAM of the Illinois River for Decision Making Project MRP for additional details. See below for the population age structure sample processing timeline.

- Age structure lab analysis: November 1 to January 15
- Data upload: No later than February 15

DELIVERABLES

Please see MAM of the Illinois River for Decision Making Project MRP for full details concerning field sampling deliverables, timelines, and reporting platforms. Additionally, this project will provide population age structure results. Age results will be made available to the USGS Upper Midwest Environmental Sciences Center.

ALTERNATIVE PATHWAY SURVEILLANCE IN ILLINOIS – LAW ENFORCEMENT

Participating Agencies: IL DNR (lead)

Location: Surveillance and enforcement activities will be conducted throughout Illinois; however, some Joint Forces Operations and investigations will require actions outside of Illinois.

Pools Involved: This project is not assigned to a specific pool or area.

INTRODUCTION AND NEED

It is an unquestioned fact today that the economic cost to federal, state, and local governments in mitigating damage from the introduction and spread of invasive species is tallied in the billions of dollars per year. In 2010, international, federal, state, and municipal agencies created an ICRCC to combat the spread of invasive carp into the Great Lakes. Two years later, the IL DNR, Office of Law Enforcement established its own ISU as an enforcement component to ICRCC efforts in Illinois. ISU specializes in more closely regulating those water-related industries that are likely to facilitate future introductions or expansion of invasive species into state waters. Such industries include commercial and sport fishing, aquaculture, bait, pet, aquarium, fish transportation, fish stocking, and live fish markets. ISU efforts to date have identified substantial violations in each of the above-listed industries, with many violators demonstrating a blatant disregard for regulations. Though monetary gain remains the top motive of offenders, recidivism rates appear to be significantly lower than with other crimes due to the substantial penalties first-time offenders face. Unfortunately, industry newcomers hoping to make quick money too often fill the void. Therefore, a substantial risk to the state's natural resources remains for the foreseeable future, mitigated only by the efforts of specialized organisms in trade law enforcement units.

ISU accomplishments have inspired other natural resource agencies to develop similar specialized units, and efforts are underway to develop Organisms in Trade law enforcement units throughout the Great Lakes Basin. Law Enforcement-backed Organisms in Trade units provide three benefits to taxpayers - future violations of aquatic invasive species laws will be addressed by experienced and well-trained personnel; the public's topic-related questions and complaints will be addressed by experts in the field; and other government entities will have a go-to person for aquatic invasive species law enforcement matters.

Training curriculums specifically designed to teach all conservation police officers the skills necessary to identify and address aquatic invasive species violations are essential to natural resource agencies adapting to the ever-changing threats posed by invasive species. Developing and administering this training remains a top priority for this project. ISU serves as a positive example of how changing perceptions on what effective resource protection looks like in the future.

OBJECTIVES

To detect, dissuade, prevent and/or apprehend those involved with activities that can spread aquatic invasive species, this project proposes to:

- Create a user-friendly quick reference guide for conservation police officers that provides guidelines and tools to address the most frequent aquatic invasive species violations.
- Conduct surveillance operations and inspections on industries linked to the invasive carp trade where the highest likelihood for regulatory violations has been identified.
- Coordinate joint forces operations to investigate aquatic invasive species violations occurring in multiple jurisdictions.
- Promote the development of aquatic Organisms in Trade law enforcement units in each Great Lakes Basin jurisdiction.

STATUS

This project is ongoing and has been extended into 2023. ISU is actively pursuing leads and conducting relevant investigations.

METHODS

Intelligence gathering and Surveillance - ISU utilizes law enforcement databases, Internet search tools, surveillance, inspections, information sharing, and street-level intelligence sources to successfully meet objectives.

2023 SAMPLING SCHEDULE

Surveillance and enforcement activities will take place at yet-to-be-determined times and locations throughout the year.

DELIVERABLES

Results will be summarized and reported to the MRWG as they become available. Data will be summarized for an annual interim report, and project plans will be updated for annual revisions of the MRP.

INVASIVE CARP ENHANCED CONTRACT FISHING REMOVAL PROGRAM

Participating Agencies: IL DNR (lead); US EPA and Great Lakes Fishery Commission (project support).

Pools Involved: The Enhanced Contract Removal Program evaluates actions throughout the Illinois River and IWW. Enhanced removal efforts are currently focused in Peoria, LaGrange, and Alton pools.

INTRODUCTION AND NEED

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

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 Lock and Dam.
- Remove a goal of 7.55 million pounds (cumulative from 2019 of 16-plus million pounds) of invasive carp under the Enhanced Contract Fishing Program for 2023/2024.
- 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 new brand implementation and the Market Value Program, to continue building increased demand for harvested invasive carp.

STATUS

Enhanced removal efforts, which began in September of 2019, focused efforts in the Peoria Pool and were expanded in 2022 to include LaGrange and Alton pools. As of March 2023, nearly 13.4 million pounds have been removed under this program. The use of targeted contract fishing in the Illinois River is a key component of the multipronged strategy. Since its inception in late 2019, 49 cumulative contracts were entered into with Illinois-licensed commercial fishing. Initial contracts targeted Peoria Pool but have since expanded to also include contracts targeting LaGrange and Alton pools.

RESPONSE PROJECTS

UPPER ILLINOIS WATERWAY CONTINGENCY RESPONSE PLAN

Participating agencies: USACE, IL DNR, USFWS, USGS, INHS, USEPA, Great Lakes Fishery Commission, MWRDGC

Location: The IWW is a series of rivers and canals running from Lake Michigan near Chicago, Illinois, to the Mississippi River near St. Louis, Missouri. This waterway contains approximately 336 miles of canal and navigable rivers, including the Chicago, Calumet, Des Plaines, and Illinois rivers and connecting canals. The five pools of the upper IWW (upstream toward Lake Michigan) are covered by this document, including Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools, RM 231 to 327 (Figure 1). Each pool is defined as the body of water between two structures, lock and dams, and any tributaries connected to that pool. For instance, the Brandon Road Pool is the body of water upstream of the Brandon Road Lock and Dam and downstream of the Lockport Lock and Dam. The distances from the upstream structure of a given pool to the EDBS are as follows: Lockport – 0 miles, Brandon Road – 5.5 miles, Dresden Island – 10.5 miles, Marseilles – 26 miles, and Starved Rock – 49.5 miles. While the LaGrange and Peoria pools and the Alton Reach of the Lower IWW are not covered by this CRP, the status and trends of invasive carp populations in these pools are monitored by the MRWG to elevate awareness of potential changes in the upper pools.

The reaches upstream of the EDBS are sampled in the spring and fall each year through the SIM event. Given that invasive carp are absent to rare in these areas, response actions have been triggered through the CRP in the past.

MRWG activities and the CRP do not extend into Lake Michigan. However, a variety of detection sampling programs are in place in Lake Michigan and its tributaries for numerous aquatic invasive species. IL DNR annually conducts AIS sampling, including for invasive carp, in nearshore waters of Lake Michigan and Illinois harbors. The USFWS Green Bay FWCO AIS team samples harbors within southern Lake Michigan every year as a surveillance tool. Targeted efforts to remove invasive Grass Carp are currently being led by the USFWS and MI DNR in southwestern Lake Michigan harbors and tributaries. Should a response in Lake Michigan become necessary, that decision would be led by the Lake Michigan Committee, comprised of the fishery management agencies involved in Lake Michigan fishery decisions. During discussions with MRWG partners, it is anticipated that the MRWG would consider assisting with a response if an invasive carp was captured within Illinois portions of Lake Michigan. The request for assistance will occur through the Lake Michigan Committee, which the MRWG Co-chair John Dettmers is a participant in, and the Great Lakes Fishery Commission facilitates.

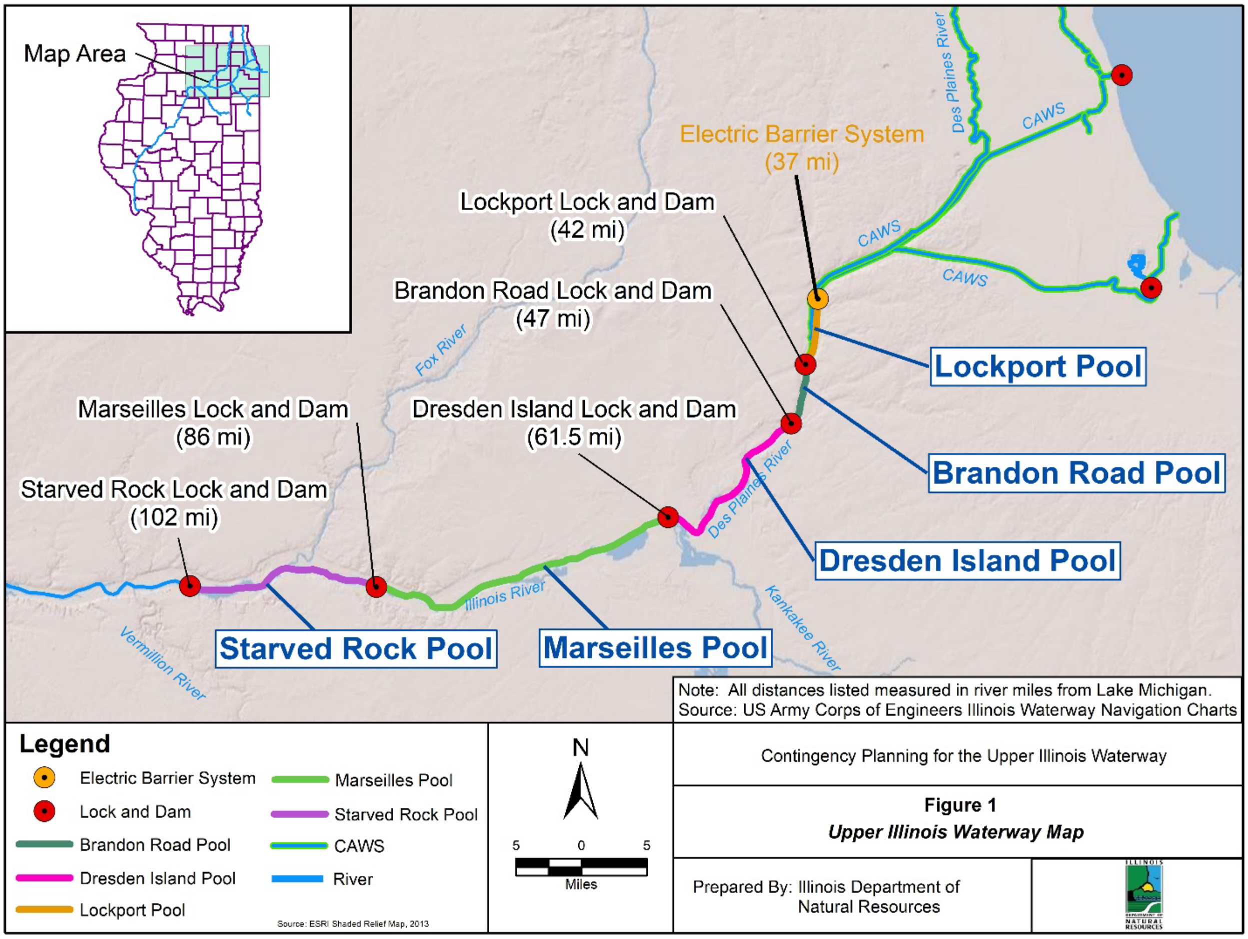


Figure 1. *IWW map and profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.*

INTRODUCTION AND NEED

This CRP describes specific response actions that will be implemented within the five navigation pools of the IWW - Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools (RM 231 to 327) if a change is detected in the status of invasive carp in those pools, indicating an increase in risk level (Figure 1). The interagency MRWG has maintained a robust and comprehensive invasive carp monitoring program in the CRP area and will continue these efforts as the foundation for early detection capability in the IWW. Annual interim summary reports describing these efforts can be found at www.invasivecarp.us. Based on this experience, the MRWG is confident in its ability to detect changes to invasive carp status in the navigation pools in the upper IWW.

The MRWG and ICRCC member agencies acknowledge that any actions recommended by the MRWG or ICRCC would be considered for implementation by member agencies in a manner consistent with their authorities, policies, and available resources and subject to the decision-making processes of that particular member agency. Nothing in this plan is meant to supplement or supersede the authorities of the state or federal agencies regarding their jurisdictions. For instance, no other state has the authority to direct or approve actions affecting the IWW aquatic resources other than the state of Illinois (Illinois Wildlife and Natural Resource Law [515 ILCS 5/1-150; from Ch. 56, par. 1-150]).

Communication

Communicating captures of various invasive carp life stages is a critical component of the CRP. While it is recognized that several monitoring strategies require in-depth analyses in both the field and laboratory setting, potential changes must be immediately forwarded to the MRWG co-chairs, John Dettmers and Brian Schoenung. Each agency should follow its respective chain of command to ensure the MRWG co-chairs are notified in a quick and timely manner. Quick and efficient communication allows for appropriate dissemination and rapid implementation of a response action if needed. Not only should new occurrences of invasive carp of any life stage be communicated to the co-chairs, but potential population changes in areas where invasive carp are known and rare occurrences of specific life stages within the Upper Illinois River should be reported. Recognizing and establishing a baseline as to where all life stages of invasive have been captured is necessary, but it is important to prevent this from convoluting what information needs to be communicated to the co-chairs. For example, if significant changes in the abundance of a specific life stage occur within an area they are known to exist, that data should be reported. In general, it is best to be proactive in the information communicated to the MRWG co-chairs, and if you are not sure, send the data to the co-chairs for consideration.

Outside of communicating captures and changes to invasive carp populations, it is also important to note the capture of other uncommon invasive species to the IL DNR. The MRWG has a robust monitoring plan, and MRWG partner agencies may encounter other invasive species that may pose a threat to aquatic resources in the region. If a novel or uncommon invasive species is captured during the MRWG monitoring activities, please report those findings to IL DNR immediately so it can make a risk-based decision about the need for additional actions outside of the CRP and MRWG MRP.

For a detailed list of definitions to accurately determine any changes in invasive carp populations and size classes, please review Attachment 3 at the end of this CRP.

Background

Existing plans for responding to the collection of invasive carp or changing barrier operations have been in place since 2011 and provide guidance focused on actions that could be undertaken in and around the USACE EDBS and CAWS upstream of the Lockport Lock and Dam

(RM 291). The ICRCC relies on the EDBS within the CSSC at Romeoville, Illinois, as a key tool to prevent the establishment of invasive carp in the Laurentian Great Lakes Basin. In support of the current EDBS and to prevent the establishment of invasive carp, this CRP seeks to ensure invasive carp populations in the upper IWW remain low and that the probability of invasive carp arrival at the EDBS is as low as practicable.

Previous response operations have been successfully conducted by the MRWG in response to detections of invasive carp above the EDBS. The most recent response action occurred in 2022 when a physical capture of a Silver Carp occurred in Lake Calumet (Details provided in 2022 ISR). Prior to 2022, an interagency response in 2017 was initiated after a Silver Carp was captured in the Little Calumet River and a 2010 response in the Little Calumet River where piscicide was applied to over 2 miles of waterway. In 2009, a response was conducted downstream of the EDBS to prevent fish passage during a scheduled maintenance outage in which 5 miles of the CSSC were treated with a piscicide.

This enhanced CRP expands the geographic scope of contingency planning efforts prior to 2017 and the range of potential tools that are available if a response action is needed. This plan also considers the operations and status of the EDBS and related fish suppression considerations, which are detailed in Appendix A of this document.

Finally, this CRP provides a communication framework and response procedure that may be utilized for any planned event to mitigate the risk of invasive carp passage into Lake Michigan. These events may include scheduled maintenance of the EDBS or the opening of hydraulic connections that may allow the passage of invasive carp. The same protocols outlined for a response to an unplanned event may be applied in advance of these planned events to reduce the risk of a progressing invasion front. An operationalized application of the contingency response process for planned EDBS outages is detailed in Appendix A of this document.

Invasive carp distribution has not changed significantly in the upper IWW since individuals were discovered in the Dresden Island Pool in 2006. However, densities of adult invasive carp have declined in the Upper IWW from 2012 to 2019 based on hydroacoustic scans. The 2021 MRP ISR highlights a significant amount of monitoring efforts from the Starved Rock Lock and Dam upstream through the CAWS with no evidence of an established population of any life stage above the Dresden Island Pool (MRWG 2021). Lack of range expansion and decreased densities may be due to intensive contracted fishing efforts, lack of suitable habitat upstream, water quality conditions, or a combination of other factors not yet fully understood. Despite no evidence of range expansion or increasing abundance of the invasive carp population in the upper IWW in recent years, it is generally recognized that invasive fish populations may expand their range and abundance. Examples of introduced fish exhibiting this phenomenon are available from other locations.

Small invasive carp (less than 6 inches in length) are of special concern when considering response actions because of the risk that smaller fish may not be effectively repelled by electric barriers or small invasive carp may become inadvertently entrained by barge tows and propelled through locks. In 2017, biologists from the USFWS Carterville FWCO conducted a study in the LaGrange and Peoria pools of the Illinois River specifically focused on invasive carp entrainment. Biologists found that small Silver Carp (less than 60 millimeters) released into a barge junction gap can be transported upstream while entrained in commercial tow junction gaps over distances of up to 4 miles (Davis and Neeley 2017). However, such entrainment has not been observed to occur naturally for either Bighead Carp or Silver Carp outside of these studies. Observations of small fish in advance of adult population fronts have not been reported in either the IWW or other large navigable rivers of the U.S.

While the focus of the CRP is related to the status of the more abundant Silver Carp and Bighead Carp in the Upper IWW, the plan is also applicable and adaptable to Black Carp. Black Carp have become a greater concern in the Upper Illinois River over the past several years. Black Carp's diet of mollusks, which includes native freshwater mussels, is of special concern due to the imperiled status of many mussel species throughout North America. As of January 2021, the closest known capture of Black Carp occurred within the Peoria Pool. While more data is needed to fully understand the population dynamics of Black Carp in the Illinois River, captures of Black Carp may result in a response action by the MRWG. In addition, while Grass Carp have been established within the region for several decades, the MRWG continues to monitor and record information on population trends throughout the Upper IWW and the CAWS.

OBJECTIVES

The purpose of this CRP is to outline the process and procedures the MRWG and ICRCC member agencies will follow in response to detected changes in invasive carp distribution or abundance of life stages in any given pool of the upper IWW.

Mission and Goals

The MRWG convened a panel of experts to evaluate invasive carp population status and waterway conditions, forecast invasive carp risk scenarios, and develop a plan to direct appropriate and prudent contingency response actions as needed in the upper IWW. Current and/or expected regulatory or other required actions are noted for each contingency measure as practical. The goal of the panel was to develop contingency plans to meet the ICRCC mission as stated:

> *The purpose of the ICRCC is to coordinate the planning and execution of efforts of its members to prevent the introduction, establishment, and spread of Bighead, Black, Grass, and Silver Carp populations in the Great Lakes.*

In support of this mission statement, the goal of the CRP is to provide a process to consider appropriate response actions that account for available tools and the authorities of member agencies to implement actions. The intent is for the plan to be clear and easy to understand while allowing the flexibility needed to ensure response actions fully address situation-specific issues. This plan ensures open and transparent communication with the public and stakeholder groups while providing consistent terminology as defined by the MRWG panel of experts in relation to the invasive carp population, ecology, and invasion front dynamics.

The CRP is a living document that will evolve over time as information changes and additional technologies/tools are developed, e.g., ozone, thermal, or carbon dioxide barriers; attractants, such as pheromones, audio cues, or feeding stimulants; or other unspecified tools that may be developed at a future time.

ADDITIONAL RESOURCES FOR CONSIDERATION

This CRP allows for deploying monitoring or control tools deemed most appropriate by the MRWG, the ICRCC, and the governmental agencies holding locational or operational jurisdictional authority. For example, one of the most aggressive responses for invasive carp prevention occurred in 2009, when approximately 5 miles of the CSSC were treated with a fish piscicide (Rotenone) in support of an EDBS maintenance operation. This control action occurred at a time when invasive carp abundance patterns and the risk of a barrier breach were less understood. The IL DNR remains the sole entity with legal authority to apply piscicide to the waters of the state of Illinois and has previously made decisions to do so in close consultation with many local, state, and federal partners. Illinois retains the authority, ability, and responsibility to facilitate similar actions but has already determined that this tool is not appropriate for most of the rivers and locations included in this plan. While not listed as a tool in this CRP for the MRWG to consider, the IL DNR reserves the right to authorize the use of piscicide or other developing technologies as appropriate and/or permitted in cooperation with other regulatory agencies in the CSSC.

Temporary modification of lock operations may be used under existing USACE authorities when necessary to support other control measures within the CRP. The duration of the modified operation would be limited to the time necessary to carry out the supported control measures.

Such modifications have supported previous barrier-clearing events when electrofishing, water cannons, and/or nets were used to sample fish in and around the barrier system. In some instances, restriction of navigation traffic in the waterway may be necessary to safely execute a control measure. Such restrictions fall under the authority of the USCG. As with temporary modifying lock operations, the duration of the restriction would be limited to the time necessary to carry out the control measure. The USACE and USCG have processes in place to provide timely evaluation and decisions in response to requests for temporary modified operations to support control actions by other entities and fulfill other necessary posting and communication requirements.

STATUS

This CRP was placed into operation in the spring of 2016, building upon existing and complementary response plans, and has been updated annually based on new scientific information and available technical capacity for invasive carp control.

Data collected since 2011 have further clarified where invasive carp are in the IWW. Figure 2 summarizes the current knowledge of the status of Bighead Carp and Silver Carp through ongoing monitoring efforts. This graphic was originally established in 2015 as the benchmark year from which to evaluate progress in future years. The MRWG concurred that establishing a point of reference would aid in evaluating the status of invasive carp in the Upper IWW, and 2015 was characterized by significant monitoring and detection efforts that led to a thorough understanding of the invasive carp population status. Due to these increased efforts, the MRWG reached a consensus on invasive carp status in 2015. The results of ongoing surveillance and management efforts have been used to establish the current status of invasive carp populations in each pool of the IWW, as described below:

- **Lake Michigan:** No established invasive carp population.
- **CAWS:** No established invasive carp population. Three individual fish have been captured since 2010 (Figure 2).
- **Lockport Pool:** No established invasive carp population. One fish was captured in 2009 (Figure 2).
- **Brandon Road Pool:** No established invasive carp population.
- **Dresden Island Pool:** Adult Silver Carp and Bighead Carp population front. In 2015, larval invasive carp were observed for the first time but have not been observed since. No Black Carp have been captured.

- **Marseilles Pool:** Adult Silver Carp and Bighead Carp are consistently present, and their eggs have been detected. Spawning has been observed. No Black Carp have been captured.
- **Starved Rock Pool:** An abundance of adult Silver Carp and Bighead Carp are present, and high densities of their eggs have been detected in some years. In 2015, juvenile Silver Carp (less than 6 inches in total length) were observed and have not been observed since. In 2020 and 2021, early-stage invasive carp larvae were captured in Starved Rock Pool at RM 238.5 and 240.5. These larvae were pre-gas bladder inflation (See definitions in Appendix A). In 2021, post-gas bladder inflation larvae were captured in the Fox River for the first time. No Black Carp have been captured.
- **Peoria Pool (downstream to the confluence with the Mississippi River):** Established population with all life stages of Silver Carp and Bighead Carp have been observed. Black Carp over 6 inches have been captured.

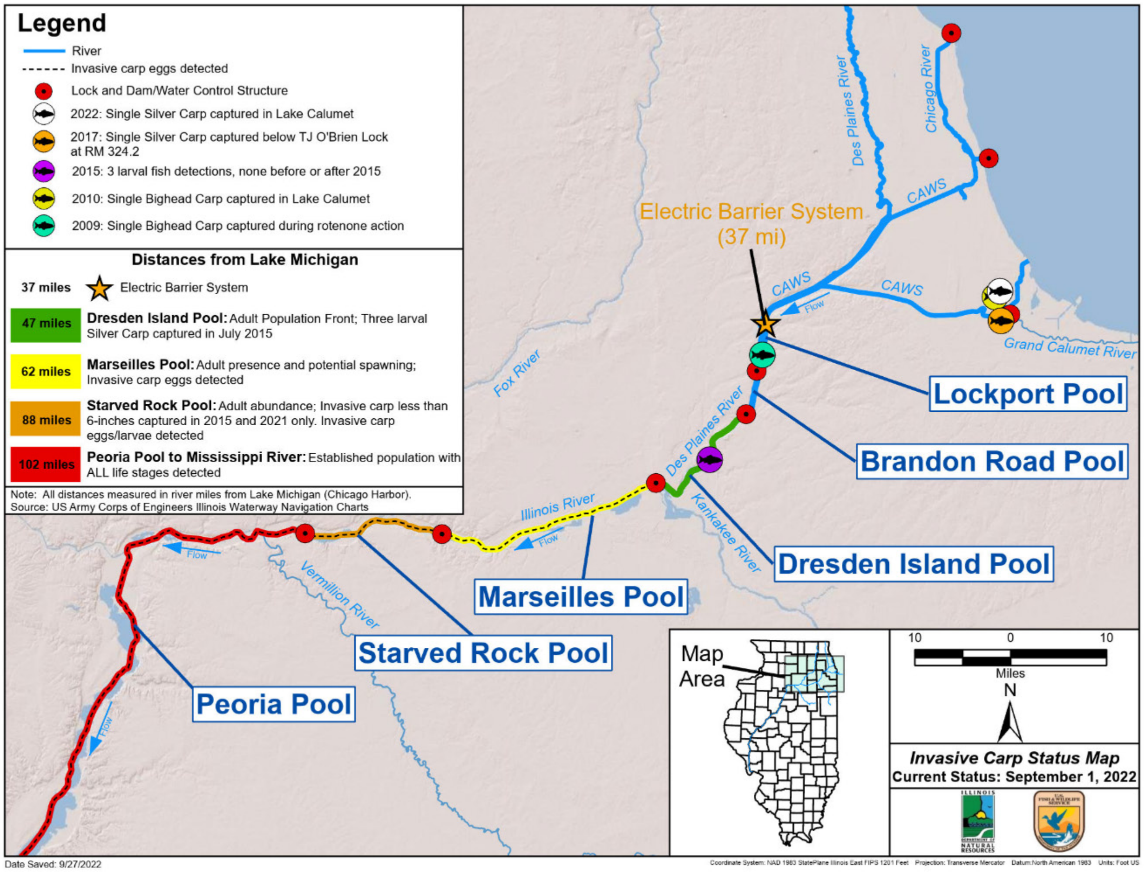


Figure 2. *Invasive carp status map as of January 1, 2022.*

[1] Invasive carp larvae (pre-gas bladder inflation) were captured in the Starved Rock Pool for the first time in 2020. The furthest upstream post-gas bladder inflation larvae (outside of the three captured in Dresden Island in 2015) were captured in the Fox River near RM 240 in the Starved Rock Pool in 2021.

[2] Black Carp over 6 inches have been captured in Peoria Pool. Review definitions in Attachment 3 for any clarification on terminology used within the map.

Planning Assumptions

These planning assumptions anticipate potential realistic situations and constraints on the ICRCC, other stakeholder agencies, and partners. The following assumptions pertain to all responding agencies and their resources, as well as the response situation, and are relevant to this planning initiative:

Situation Assumptions

- Response actions will be selected based on waterway conditions, the time and geographic location of invasive carp detection, and other factors.
- Response actions will be located within the designated area of the upper IWW described in the CRP (from Starved Rock Pool to the Lockport Pool, as depicted in Figure 1).
- For planning purposes, under this CRP, invasive carp primarily refers to Bighead Carp and Silver Carp. However, this CRP may also serve to inform potential response actions if a Black Carp is captured above Starved Rock Lock and Dam.

Command, Control, and Coordination Assumptions

- All response operations will be conducted under ICS or unified command as mandated under Presidential Policy Directive 8.
- Actions recommended by the ICRCC are dependent on agency authority to act at their discretion.

Logistics and Resources Assumptions

- The MRWG may request ICRCC support to leverage additional resources needed to conduct appropriate contingency response actions.
- Illinois as signatory to the Mutual Aid Agreement of the Conference of Great Lakes & St. Lawrence Governors and Premiers, may request assistance if deemed necessary. ais-mutual-aid-agreement-signed-3-26-15.pdf (gsgp.org)
- The need for mobilizing personnel and resources from outside coordinating agencies may affect the response time and should be planned for accordingly.

CONCEPT OF OPERATIONS FOR RESPONSE

The following sections present the implementation options for the local response and coordination with the MRWG and the ICRCC stakeholders. If conditions continue to warrant response, the number of coordinating entities could increase along with the need for additional response operations. This expansion will trigger additional command, control, and coordination elements. The overall incident complexity and ICS span of control principles should guide the incident management organization.

Methods

Subject matter experts from participating agencies discussed the importance of many factors within the IWW that could cause invasive carp populations to change and result in an increased potential for invasion of the Great Lakes. The subject matter experts independently evaluated the abundance and distribution of each invasive carp life stage across each pool within the IWW. The group then met to discuss and develop a consistent opinion about the changes and determine the risk associated with each scenario. Individuals then made independent assessments as to what type and level of response they would choose under the varying conditions within the decision support trees. These responses were then discussed and agreed upon by the group, which resulted in the contingency table presented in Attachment 1 of Appendix A.

Direct Considerations for Response

Data collected in the field considers the location of invasive carp populations (at the pool scale), life history stages (eggs/larvae, small fish [less than 6 inches], and large fish), and abundance (rare, common, and abundant). The data is then cross-referenced with the contingency table and identifies whether a change (moderate or significant) in management or monitoring actions is needed.

Pool

Since pools are delimited by locks and dams that could at least partially restrict movements of fish, the navigation pool was determined to be the most appropriate scale of reference for contingency planning purposes.

Life History

Fish life history relates to the age, size, and reproductive status of fish, which affects their vulnerability to monitoring and control tools (i.e., smaller fish are less susceptible to electricity while larger fish are more susceptible to electricity; management actions may be size-specific) and indicates the occurrence of spawning and recruitment.

Abundance

Increased abundance of any life stage signifies a change in the population structure at a given location and increases concern of upstream population expansion. Generally, larval invasive carp have not been found in the Upper IWW. Finding invasive carp larvae would represent a potential change in the population dynamics in the Upper IWW. As larvae are not a life stage that effective management action can be directed toward, responses related to the detection of larval invasive carp would likely be directed at adult or juvenile life stages. Similarly, changes in juvenile populations may signify evidence of spawning success and recruitment for the area, while changes in adult populations may indicate increases in immigration rates or indicate the previous year's recruitment success.

Electric Barrier Functionality

The operational status of the EDBS (barrier functionality) directly impacts the ability of invasive carp to potentially breach the barriers and move upstream of the Lockport Pool. Decreased barrier function increases the probability of invasive carp passage. Barrier operational status will inform actions considered when planning responses. Meetings of the MRWG and ICRCC will be convened in the event of a complete barrier outage and may lead to response actions. Incomplete outage events at one or more barrier arrays that may allow for upstream passage to the next barrier array have a separate process called barrier maintenance fish suppression. This process, outlined in Appendix A, uses the same decision-making structure as the CRP in a more routine and operationalized manner.

Considerations for Actions and Decision-Making Process

This process includes a recommended set of response actions for decision-makers to consider when a change to the baseline condition is identified. Factors that may affect decision-making may include changes in fish population abundance, life stage presence, new geographical positions in upstream and/or downstream pools, the ongoing rate of change in invasive carp population characteristics, season and/or water temperature, the habitat where fish are sighted or collected, flow conditions, the amount of available data, and whether multiple lines of evidence exist to support changing conditions. The validity of evidence that a response trigger has been met will also be taken into consideration. Evidence of invasive carp presence in new locations within the IWW may come from physical captures, confirmed sightings by trained biologists, or via detections of telemetered specimens on active or passive receivers. These observations may be reported by any activity within the MRP or external work conducted by other groups. The MRWG will evaluate the validity of each reported observation and discuss whether an actionable trigger has been met. A dead invasive carp found in a location where live fish are rare or absent should be collected and communicated with the MRWG co-chairs for consideration.

The status of invasive carp populations is continuously monitored by the MRWG, and communication of important findings occurs rapidly. Consensus on the current population status on a pool-by-pool basis is made annually with a holistic review of data collected by all MRWG agencies. Quarterly meetings of the MRWG serve as a checkpoint to discuss potential population changes through each sampling season as new data is collected. The group recognized that identified response options are recommendations only. An action(s) could be more or less intense based on the nature (e.g., magnitude/life stage) and location (e.g., close or far from Lake Michigan/Electric Barrier) of the change. One example scenario is illustrated in Attachment 1. The scenario is based on a change in conditions in Brandon Road Pool and is one example of when a contingency plan is called into action. Attachment 2 provides the decision-making process and flow of likely activities in such an event. This scenario and decision process illustrates what could occur should a change be identified from this decision support framework.

Command, Control, and Coordination

Command and control of an invasive carp response in the IWW will be implemented under the MRWG. The ICS is a management system designed to enable effective and efficient incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. The MRWG will utilize the ICS to manage response operations to maximize efficiency and ensure a standard approach across all participating agencies. Area command, unified command, or single incident commander, depending on the needs, will be maintained to determine the overarching response objectives and implement individual tactics necessary to accomplish each objective. Local command and control involve directing resources to achieve objectives for eradication, control, or identification of invasive carp during a response operation.

Figure 3 shows the basic unified command organization structure that will be utilized for any response that requires the mobilization of resources and multi-agency personnel and provides a visual representation of the basic command, control, and coordination relationships for invasive carp response personnel during an event.

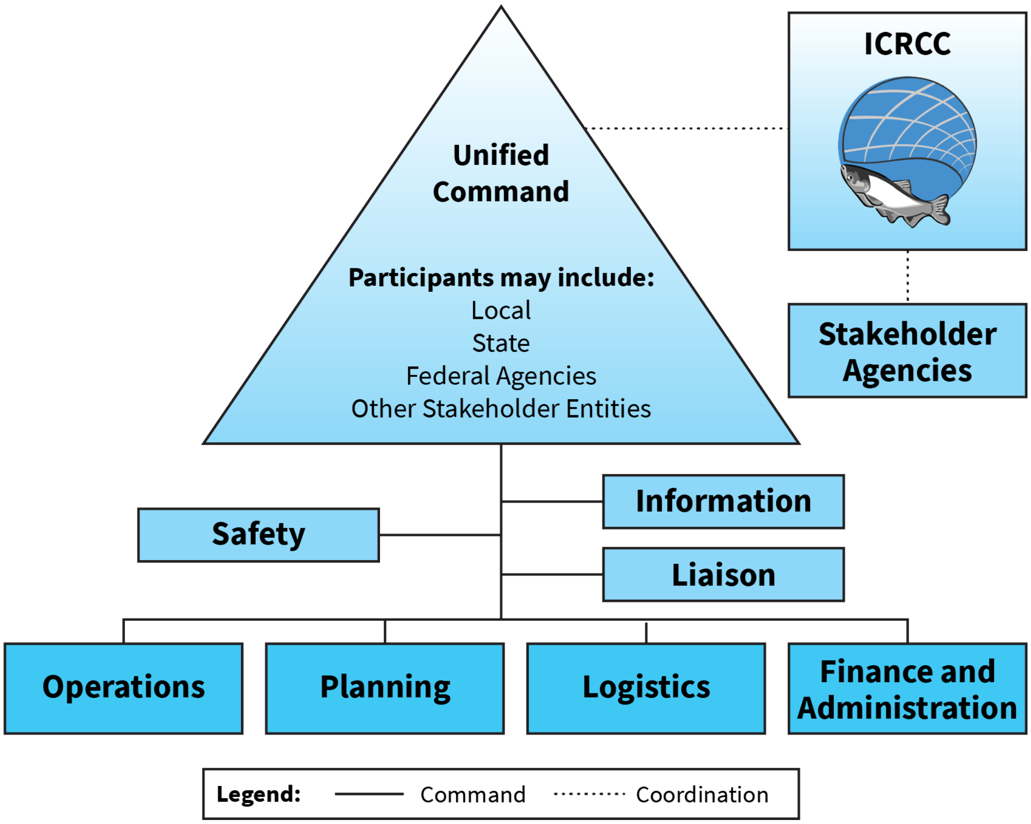


Figure 3. *Unified command organization structure.*

Incident Action Planning

An IAP is a standard means of documenting and communicating objectives, strategies, and tactics utilized to address issues resulting from an incident. At the core of a functional IAP are well-written objectives. The standard acronym is "SMART" objectives—objectives that are (1) Specific, (2) Measurable, (3) Achievable, (4) Realistic, and (5) Time-bound. Objectives can then be inserted into an IAP template. Each response is unique, but the basic concepts of operations and objectives can be the building blocks for a solid IAP that communicates, internally and externally, the jurisdiction's plans for managing an incident. An example of an IAP is provided in Attachment 4. The example outlines pertinent sections and considerations that were used in a recent response. Attachment 5 is meant to provide a template, and various sections may be added based on the objectives of the IAP.

> **SMART Objective Example**
>
> State agency X will contain 2 miles of the river using block nets within 8 hours of notification.

Incident action planning extends further than just preparing and distributing the IAP. This planning includes the routine activities during each operational period of an incident response that provides a steady tempo and routine structure to incident management. The ICS Planning

"P" is a guide to the steps, relative chronology, and basic elements for managing an incident. By incorporating the Planning "P" into planning efforts, overlaying anticipated daily operational and logistical chronologies, a local jurisdiction can establish a framework for incident management that provides a rough playbook for local, state, federal, and outside resources to respond to invasive carp under emergency incident conditions.

Figure 4 depicts the ICS Planning "P" and further describes agencies that may be involved at various steps in the process, what actions may be taken, and when actions will be implemented.

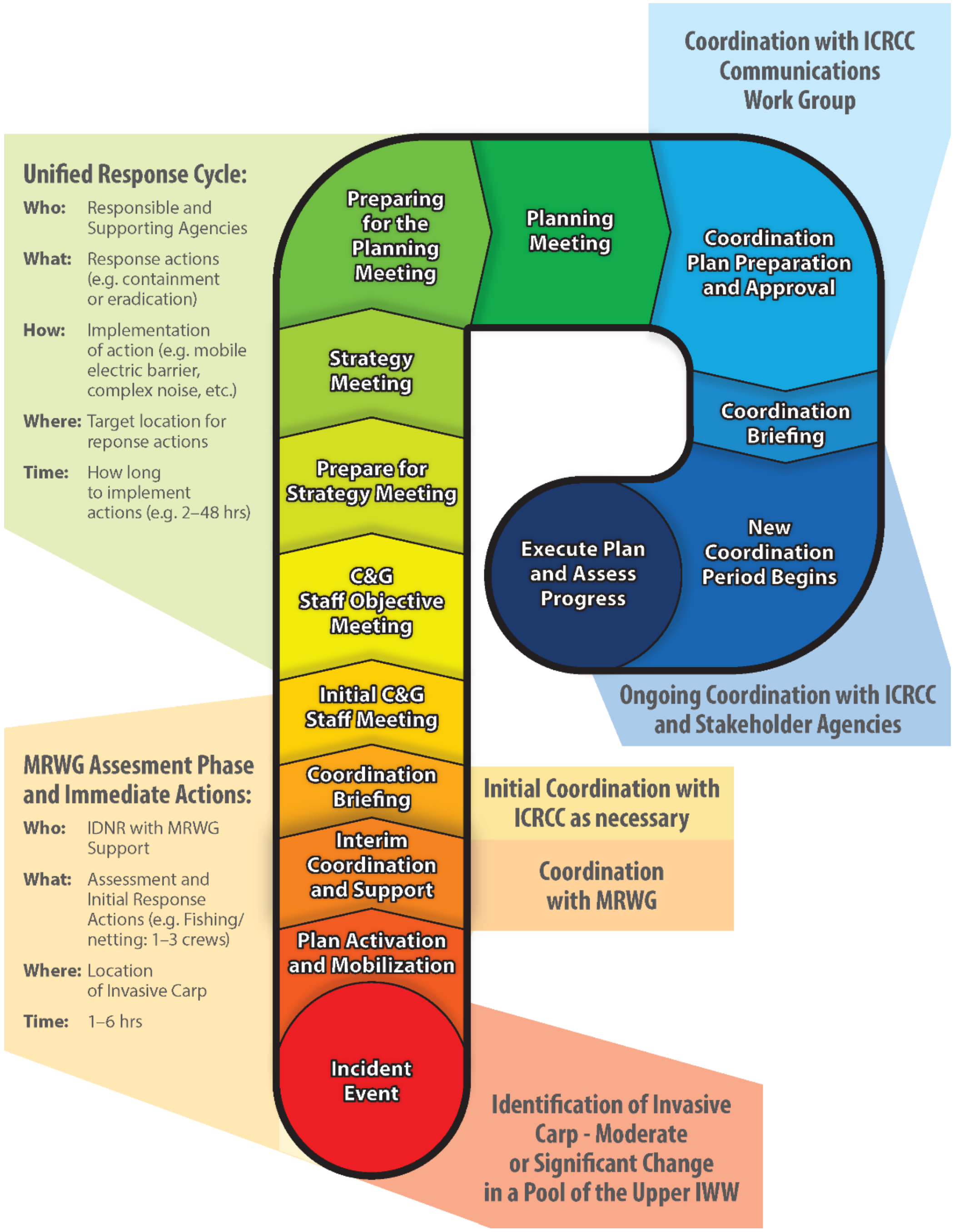


Figure 4. *ICS Planning "P"*

Notes:

C&G	Command and General Staff
IWW	Illinois Water Way
MRWG	Monitoring and Response Workgroup
ICRCC	Invasive carp Regional Coordinating Committee

Response Decision Matrix

To inform contingency response planning in the upper IWW, MRWG developed a "response decision matrix" that will aid the MRWG in determining the need for a contingency response action. This decision-support guide uses common, agreed-upon definitions (Attachment 3). The process consists of 1) identifying the pool of interest, 2) identifying the proper life stage of invasive carp captured, observed, or detected (verified physical observations by agency personnel or confirmed telemetry-based detections), and 3) identifying whether the sampling result is rare, common, or abundant relative to 2015 reference conditions.

Once all determinations have been made, the decision response matrix (Figure 5) will funnel the user to an action response level. This action response level will identify actions that could occur. Response actions may be determined by new findings in one pool but occur in a different pool. Each pool has an agreed-upon set of response actions that can be taken. If change is apparent and a response is warranted, the proper agencies will be notified and can then discuss how best to proceed based on the options available. A chart of the potential response actions to be considered is provided in Table 1. An example is also provided in Attachment 1 for illustrative purposes.

Figure 6 describes the entire contingency response process for all ICRCC stakeholder agencies. The response decision matrix is utilized in steps 3 through 7 to assess the need for further response actions.

Upper Illinois Waterway Invasive Carp Response Decision Matrix*

	Distance from Lake Michigan (miles)		Eggs/Larvae			Small Fish			Large Fish		
			Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
of flow	0 - 37	**Chicago Area Waterway System (CAWS)**									
	37 - 42	**Lockport Pool to Electric Barrier System**									
	42 - 47	**Brandon Road Pool**									

= Significant change from baseline requiring further response action

= Moderate change from baseline requiring further response action

= No change/Status Quo from baseline. No further action

Figure 5. *Upper IWW invasive carp Response Decision*

1 This status is based on the collection of a single Bighead Carp by contracted fishers in 2010 and a single Silver Carp in 2017.

2 This status is based on the collection of a single Bighead Carp during piscicides treatment in 2009.

3 This status is based on sightings of one Bighead Carp and one Silver Carp by MRWG efforts in 2010-2011. No invasive carp have been collected in this pool.

*Baseline for comparison and determination of response action is the status of invasive carp populations as of December 31, 2015. At that time, the total monitoring effort was the highest it ever was. Since 2015, efforts have varied by gear times across pools, but overall effort increased dramatically compared to 2015. A total of 5,463 samples across gear types occurred in 2021 compared to 3,857 in 2015, resulting in over 285,380 more yards of net and over 14,396 **additional** hours of monitoring. After collecting data for several years, the statuses for large fish were reevaluated in 2023, and it was determined that large fish are abundant in both Marseilles and Starved Rock pools.

Definitions are available in Attachment 3 at the end of this CRP.

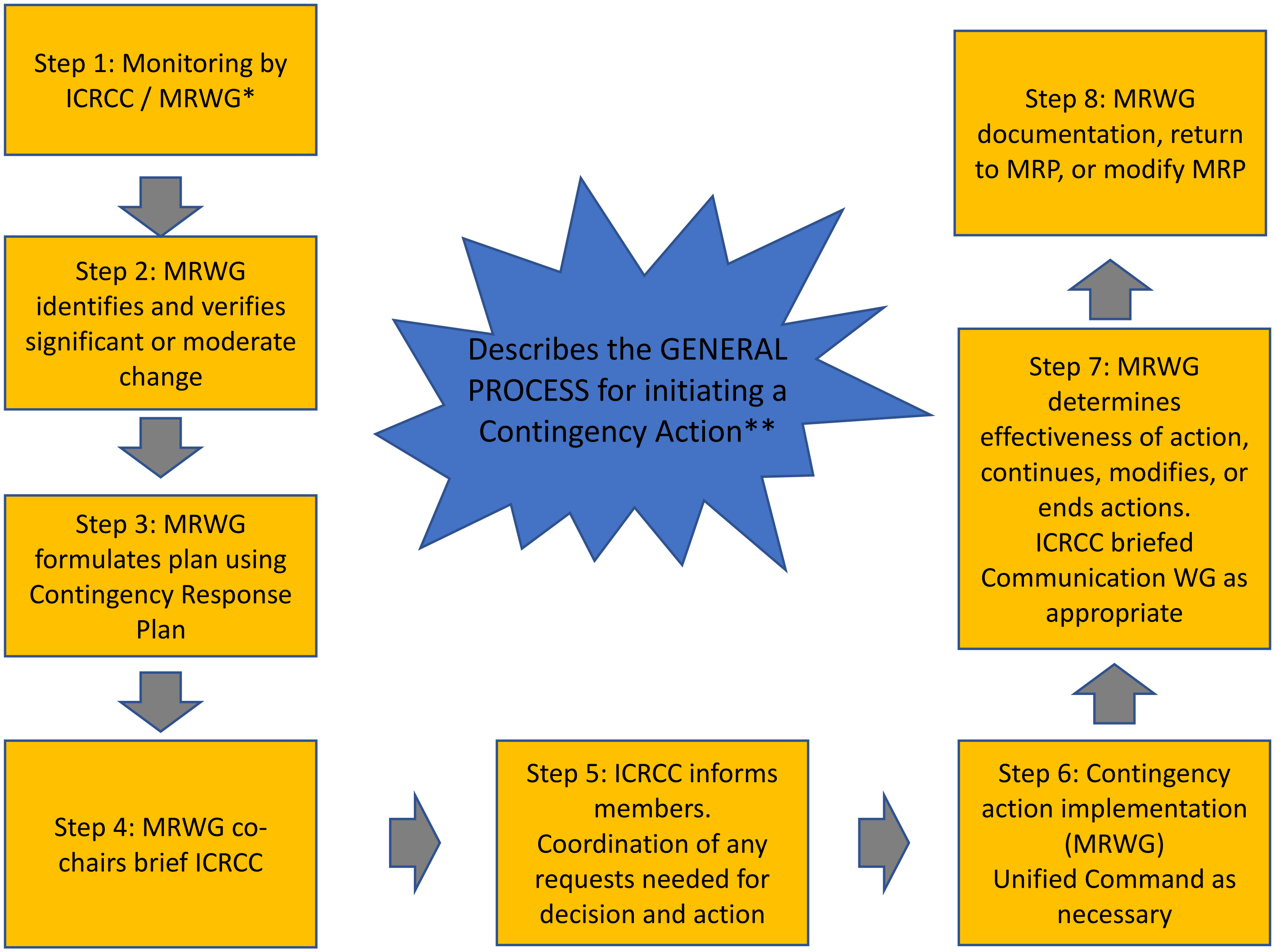


Figure 6. *Simplified Process Flow Chart for a Contingency Response*
*MRWG is the working-level body of the ICRCC. The MRWG implements the annual MRP and contingency actions subject to agency authorities and approvals by their individual agency.
** In this general process, multiple steps may happen concurrently to facilitate the most effective and efficient action implemented.

Table 1. Contingency Response Action Matrix*[1]

Level of Urgency (Action Response Level)	Potential Actions[2]	Applicable Locations	Responsible Agencies	Estimated Time to Implement	Regulatory or Other Requirements	Relative Cost ($-$$$$)
Significant Change						($$)
	Modify Barrier Operations	LP, BR	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents-Staionary[4]	All	USGS/USACE	1-7 days	Coordinate with local stakeholders	($$)
	Acoustic Deterrents-Mobile[4]	All	USGS/USFWS	1 day	None	($)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS/SIU/USGS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
	Temporary Flow Control	LP, BR	MWRD	1 day	Notice to navigation	($)

Level of Urgency (Action Response Level)	Potential Actions[2]	Applicable Locations	Responsible Agencies	Estimated Time to Implement	Regulatory or Other Requirements	Relative Cost ($-$$$$)
						($$$)
Moderate Change	Increased Sampling Efforts	All	IDNR/USFWS	1-7 days	Sampling permits	($$)
	Modify Barrier Operations	All	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents-Staionary[4]	All	USGS/USACE	1-7 days	Coordinate with stakeholders	($$)
	Acoustic Deterrents-Mobile[4]	All	USGS/USFWS	1 day	None	($)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
No Change	Maintain Current Level of Effort	N/A	All	Ongoing	N/A	($)

LP Lockport

BR Brandon Road

* The implementation of some of these actions may require temporary lock closures or navigation restrictions, which fall under the authority of USACE and the USCG, respectively. Temporary lock closures and navigation restrictions would be limited to the time necessary to carry out the supported measures. Such lock closures have supported previous barrier clearing events when electrofishing, water cannons, and/or nets were used to sample fish in and around the barrier system.

1 Additional Resource Considerations (page J-4) describes other measures that may be implemented as necessary and aligned with agency authorities.

2 The current monitoring and response activities are covered under existing federal budgets.

3 Response techniques encompassed by increased sampling efforts under Potential Actions in above table.

4 Acoustic deterrents can be deployed in various ways. A stationary system may include the deployment of speakers at a fixed location or structure to strategically deter fish while a mobile system may be used from a boat to help heard/push fish to a point of interest.

Technique	*Participating Agencies*
Electrofishing	USFWS, IDNR, INHS, USACE
Netting (Gill, Trammel, Pound, ichthyoplankton)	USFWS, IDNR, INHS
Fyke Netting	IDNR, USFWS, USACE
Dozer Trawl	USFWS
Telemetry	USGS, USACE, SIU, USFWS

INFORMATION AND DATA MANAGEMENT

The ICRCC communications working group will be the primary conduit for ensuring open and transparent communication with both the public and other stakeholder agencies during an invasive carp contingency response operation. The public and stakeholder groups will be notified as early as possible in the process and according to messaging protocols established by the ICRCC communications working group.

Essential Elements of Information

At all points of the incident management process, essential elements of information should be collected and managed in a standard format. Paper forms, when power and electronic systems are not available, and electronic data should be collected with end usage in mind. For instance, if data on how various waterways' conditions are used as the basis for logistical requests and response decisions, these data should be separated and properly analyzed to ensure acquisition of adequate supplies for selected response. For response personnel, simple numerical counts of each fish species, and all other critical data must be communicated up the chain early and often. Additionally, routine recording and reporting of staffing levels, available resources, and capability gaps are all important for managing overall response under a specific scenario.

REFERENCES

Davis, J. J. and R. N. Neeley. (2017). Dynamics of Silver Carp Entrainment and Transport by Commercial Tows on the Illinois Waterway- Preliminary Results 2017 Field Studies. Internal US Fish and Wildlife Service - Midwest Region Fisheries report: unpublished.

Appendix A

APPENDIX A: BARRIER MAINTENANCE AND FISH SUPRESSION

The USACE operates three Electric Dispersal Barriers (Barrier 1 [1D array, 1N array, and eventually 1S array], Barrier 2A, and Barrier 2B) for aquatic invasive species in the CSSC at approximately RM 296.1 near Romeoville, Illinois. These three separate barriers are operated together in what is referred to as the EDBS (Figure A-1). Barrier 1 includes two narrow arrays (1N and 1S; 1S is scheduled to operate in fall 2023) and the 1D array. The 1D array was the Demonstration Barrier and is the farthest upstream array operating at a setting that has been shown to repel adult fish (1 volt/inch). The Barrier 1N and 1S arrays are downstream of the 1D array. Barriers 2A and 2B are located 200 meters and 310 meters downstream of Barrier 1, respectively. Barriers 2A and 2B operate at parameters (approximately 2.3 volts/inch) that have been shown to repel fish as small as 3.0 inches (76.2 millimeters) long in the laboratory. The 1N and 1S arrays of Barrier 1 are capable of higher voltage outputs, but additional testing is required before they can be operated at higher levels. Each of the barriers must be shut down for annual maintenance, and the IL DNR has agreed to support maintenance operations by providing fish suppression at the barrier site. Fish suppression can vary widely in scope and may include application of piscicide (Rotenone) to keep fish from moving upstream past the barriers when they are shut down. This was the scenario for a December 2009 Rotenone operation completed in support of Barrier 2A maintenance before Barrier 2B was constructed. With all three barriers now operational, fish suppression actions may be smaller in scope because one barrier can remain on while the other is taken down for maintenance. However, fish passage opportunities may occur when the furthest downstream active barrier experiences a loss of power in the water, allowing fish to move upstream to the next active barrier. Those fish may then be entrained between two electric fields until the next upstream barrier allows passage during an outage, or they are flushed downstream. This creates an increased level of risk that invasive carp could gain access to the upper CAWS and Lake Michigan and reduces the redundancy that is considered an essential feature of the entire barrier system. The intent is to drive fish below the barrier system after repairs and/or maintenance have been completed, and normal operations have been resumed.

Appendix A

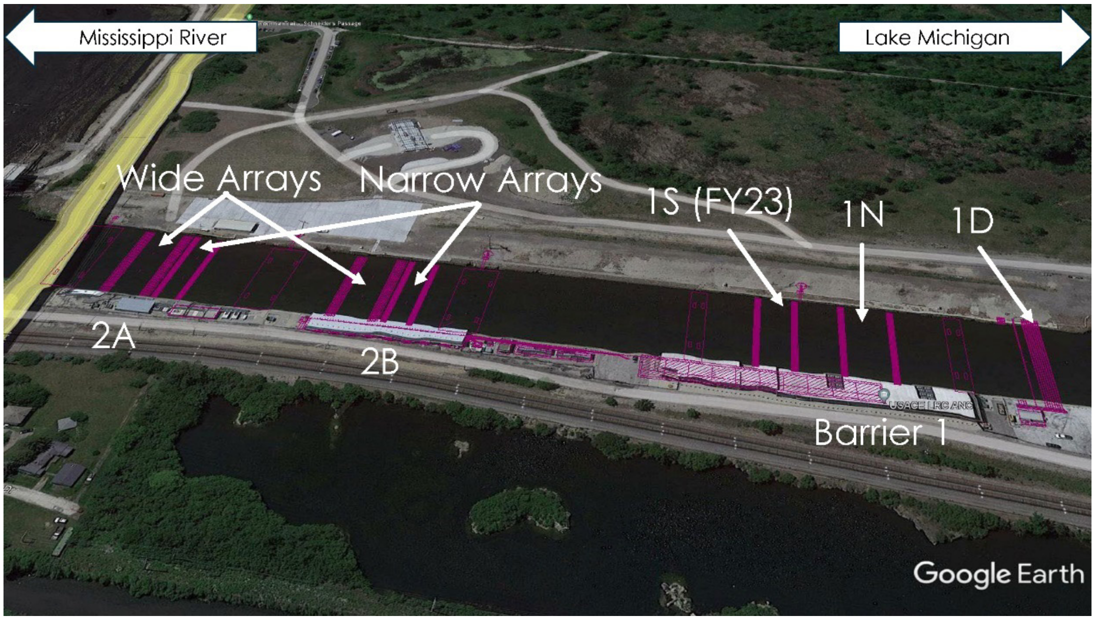


Figure A-1: *Diagram of the EDBS. Flow of water moves from the right (from Lake Michigan) to the left (toward Mississippi River) in the diagram.*

A more specific plan of action has been described in previous MRPs to address outages at the EDBS and was previously included as an independent project titled "Barrier Maintenance Fish Suppression." The MRWG resource agency partners have agreed to support future maintenance operations by providing enhanced monitoring and, if required, fish suppression at the EDBS site. This task is now integrated into the MRP and the CRP as a continuous operation as opposed to an annual project. The project is now included as an appendix of the CRP and is used for both planned and unplanned outages at one or more barrier arrays within the EDBS. For each planned or unplanned outage at the EDBS, a protocol is established for notification of the outage, an MRWG review of the current level of risk for invasive carp presence is documented, and a decision on actionable responses is implemented.

The current approach to fish suppression at the EDBS is to first survey the area with remote sensing gears to assess the need for fish clearing operations either in support of planned barrier maintenance or after an unplanned power loss. If any number of fish over 300 millimeters in total length are present, additional surveillance to further inform the risk invasive carp pose at this location will guide possible capture methods or driving techniques that will be used to move fish downstream out of the target area. Additional actions may utilize physical capture techniques (electrofishing, netting, trapping, etc.). Remote sensing techniques (hydroacoustics, telemetry downloads, or mobile tracking) may also be directed by the MRWG to gain up-to-date data to make more informed decisions on fish-clearing actions. Fish-clearing actions within the regulated navigation area of the EDBS are considered high risk to the safety of staff involved. Water-borne electric fields pose a major obstacle to traditional fish driving and collection techniques. The decision to implement a fish-clearing action is always done with extreme caution and is considered by MRWG participating agencies in the context of all available data.

In recent years, additional deterrents have been implemented to help mitigate the risk of invasive carp movement during winter annual maintenance activities. In the winter of 2017-2018 and 2018-2019, an acoustic deterrent system was deployed by USGS with assistance from USACE, Engineer Research and Development Center and Chicago District personnel. Up to five underwater speakers were temporarily welded to a moored tugboat approximately 0.8 miles downstream of the EDBS at the Hanson Material Service barge slip in Romeoville, Illinois. A recording of a 100-horsepower boat motor sound, shown to deter invasive carp in previous lab studies, was played on loop during the maintenance operations. At the discretion of the MRWG and dependent on available resources, the deployment of an acoustic deterrent system will be discussed prior to any future winter barrier maintenance activities. Additional deterrent technologies will also be considered as they are developed, tested, and determined to be feasible for field applications.

Fish suppression decisions should be made each time there is a planned or unplanned outage at the EDBS that allows an opportunity for fish passage in the upstream direction. The below tables indicate the various operational scenarios that may be experienced at the EDBS with corresponding decision points (Table A-1) and anticipated operational changes between March 2023 and March 2024 (Table A-2). All operational changes of the EDBS require notification to the MRWG. Notification of operational changes that require a clearing decision will be flagged appropriately, with pertinent details included in the notification to clarify the reason for the change in operations. Table A-1 outlines those scenarios where an immediate assessment and clearing decision should be made by action agencies. The ICRCC stakeholders or MRWG resource agencies may request additional clearing decisions as necessary.

Appendix A

Table A-1. *Potential operational scenarios at the EDBS and recommended responses**

Barrier Operational Status			Clearing Decision Required
Barrier 2A	Barrier 2B	Demonstration/Barrier I North**	
On	On	On	No
Off	On	On	Yes
On	Off	On	No
On	On	Off	No
Off	Off	On	Yes
On	Off	Off	No
Off	Off	Off	Yes
Off	On	Off	Yes

*This table assumes all three barriers are operational at the time of the outages. Responses may vary, and each scenario should be individually analyzed with considerations of which barriers are operational.

**The Demonstration Barrier is integrated completely with Barrier I. Barrier I will consist of three parts: Demo Barrier, Barrier I North and Barrier I South (Construction set for 2023).

Appendix A

Table A-2. *Operational changes anticipated from March 2023 to March 2024*

Barrier Operational Status			Clearing Decision	Activity	Season
Barrier 2A	Barrier 2B	Barrier 1 (1D and 1N Array)			
Off	ON	On	Yes	IIA Raceway Enclosure	April 2023 through September 2023
Off	Off	On	Yes	ROV Electrode Inspection	April 2023*
Off	On	Off	Yes	ROV Electrode Inspection	April 2023*
On	On	Off	No	Annual Maintenance	Winter 2023/2024
On	Off	On	No	Annual Maintenance	Winter 2023/2024
Off	On	On	Yes	Annual Maintenance	Winter 2023/2024

*Weather conditions and discussions with the MRWG will determine when ROV inspections will occur.

Attachment 1

ATTACHMENT 1: HYPOTHETICAL SCENARIO

Small invasive carp are collected in Brandon Road Pool, while the barrier is operating normally. The location is first identified in the matrix, then barrier efficacy function, then fish life history, and finally the abundance. Based on this scenario, a significant change in actions should be considered.

Upper Illinois Waterway Invasive Carp Response Decision Matrix*

Fish Life History

	Distance from Lake Michigan (miles)		Eggs/Larvae			Small Fish			Large Fish		
			Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of flow	0 - 37	Chicago Area Waterway System (CAWS)							1		
	37 - 42	Lockport Pool to Electric Barrier System							2		
	42 - 47	Location → Brandon Road Pool							3		
	47 - 62	Dresden Island Pool									
	62 - 88	Marseilles Pool									
	88 - 102	Starved Rock Pool									

Abundance

Significant Change; Action Implemented

Notes:
= Significant change from baseline requiring further response action
= Moderate change from baseline requiring further response action
= No change/Status Quo from baseline. No further action

1 This status is based on the collection of a single Bighead Carp by contracted fishers in 2010 and a single Silver Carp in 2017.

2 This status is based on the collection of a single Bighead Carp during piscicides treatment in 2009.

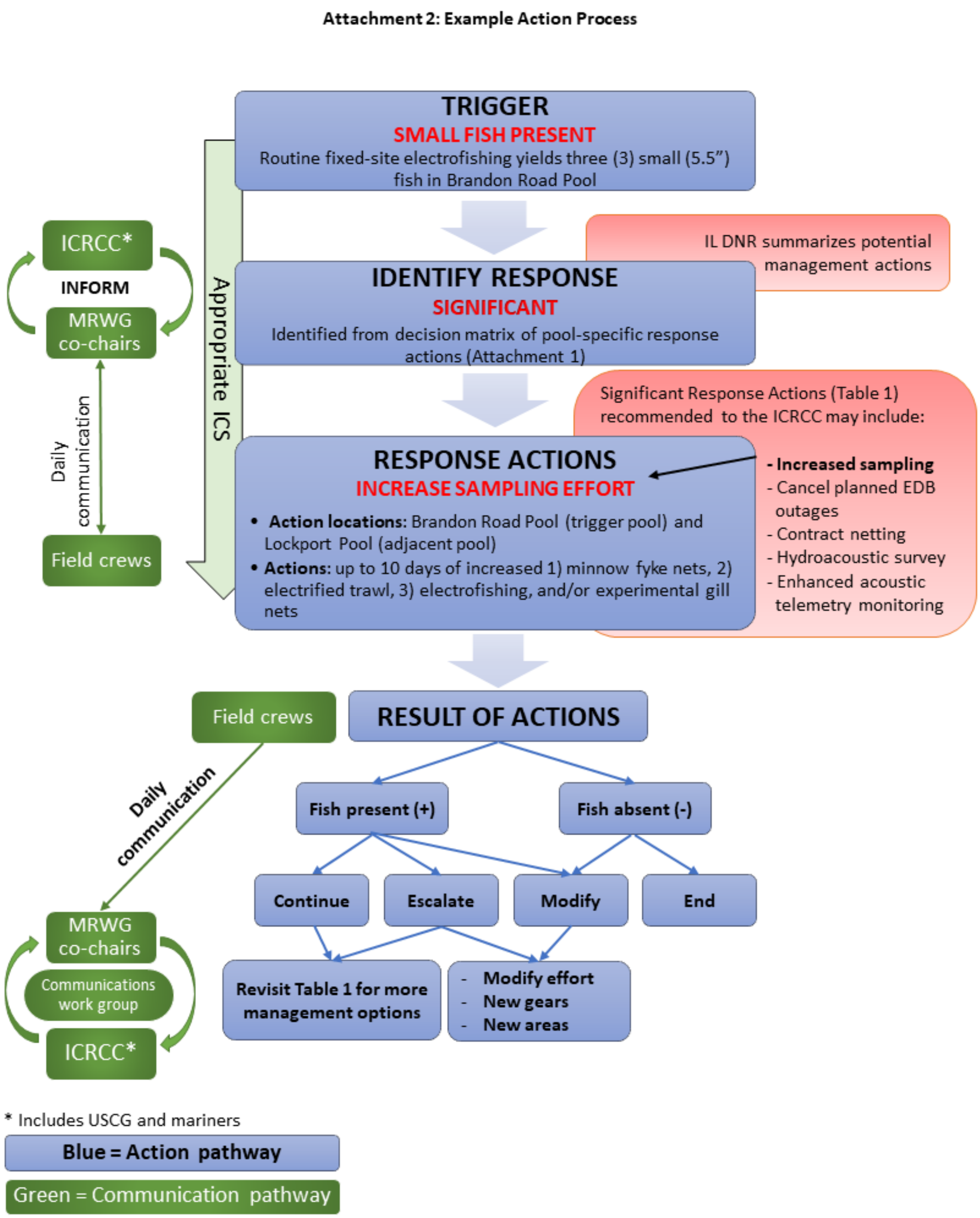
3 This status is based on sightings of one Bighead Carp and one Silver Carp by MRWG efforts in 2010-2011. No invasive carp have been collected in this pool.

*Baseline for comparison and determination of response action is the status of invasive carp populations as of December 31, 2015. At that time, the total monitoring effort was the highest it ever was. Since 2015, efforts have varied by gear types across pools but overall effort increased dramatically compared to 2015. A total of 5,463 samples across gear types occurred in 2021 compared to 3,857 in 2015, resulting in over 285,380 more yards of net and over 14,396 **additional** hours of monitoring. After collecting data for several years, the statuses for large fish were reevaluated in 2023, and it was determined that large fish are abundant in both Marseilles and Starved Rock pools.

Definitions are available in Attachment 3 at the end of this CRP.

Attachment 2

ATTACHMENT 2: EXAMPLE ACTION PROCESS



This example illustrates the process should three small invasive carp be collected in Brandon Road Pool.

Attachment 3

ATTACHMENT 3: DEFINITIONS

Life Stage	
Egg	The rounded reproductive body produced by females.
Larvae	A distinct juvenile form of fish before fins and scales are fully developed. Larvae are further separated into two separate categories (Pre- and Post-Gas Bladder Inflation) as they pose different risks.
Larvae- Pre-Gas Bladder Inflation	Any larval stage from the time of hatching until the time that the gas bladder appears. Bigheaded carp larvae at these stages are generally capable of vertical swimming but are not able to swim horizontally or maintain position in the water column without active swimming and generally do not feed.
Larvae- Post-Gas Bladder Inflation	Any larval stage from the time the gas bladder appears until fins and scales are fully developed (juvenile stage). Bigheaded carp larvae at these stages are capable of horizontal swimming and maintaining their position in the water column without actively swimming. They begin feeding shortly after gas bladder appearance and are thought to be more capable of actively exiting main channel habitats and selecting nursery areas. Besides the three larvae captured in Dresden Island, post-gas bladder inflation larvae have been captured as far upstream as RM 197 near Henry, IL, prior to 2021. Two post-gas bladder inflation larvae were captured in the Fox River near River mile 240 in 2021.
Young of Year (YOY)	Fish hatched that calendar year. Also known as age 0 fish.
Juvenile	A post-larval individual that has not yet reached its adult form, sexual maturity, or size. A juvenile fish may range in size from 1 inch to over 12 inches long or approximately age 0 to 5, depending on the species.
Adult	A sexually mature organism.

Attachment 3

Size	
Small	Fish that are less than 6 inches (a conservative length designation to inform actions in which the Electric Dispersal Barrier may be challenged by fish found to be less susceptible to electrical deterrence, identified in USACE Efficacy reports).
Large	Fish that are greater than 6 inches.
Populations	
Adult Population Front	The most upstream pool where detection/presence of adult fish is common (see below) and either repeated immigration or recruitment has been verified.
Capture Record	Capture of an adult, juvenile, larvae, and egg verified by agency efforts/personnel, does not notate any qualification of population size/establishment.
Small Fish Population Front	The most upstream pool where detection/presence of small fish is repeatedly recorded and either repeated immigration or recruitment has been verified.
Established	Inter-breeding individuals of Bighead Carp and/or Silver Carp, as well as the presence of eggs, larvae, YOY and juveniles that leads to a self-sustaining population.
Range Expansion	Verified population front upstream of the previously identified pool.
Reproduction	
Recruitment	Juveniles survive to be added to an adult population by successful spawning.
Observed Spawning	Visually documented spawning activity.
Successful Spawning	Spawning that has been confirmed by the collection of eggs or larvae.

Attachment 3

Captures	
New Record/ Single Occurrence	When a single fish/egg/larva is collected in a location it was not previously found. Also referred to as a novel occurrence.
Sighting	A visual confirmation with high likelihood (experience/professional opinion) that the item seen was in fact a Bighead Carp or Silver Carp at the noted life stage/activity (spawning behavior could be a sighting; Silver Carp in an electrofishing field but not netted would be a sighting.
Sampling Occurrences	
Rare	One sample containing the targeted species or size group where the species or size group is not expected to occur; invasive carp collections are not predictable and may take multiple sampling trips to collect just one individual.
Common	Consistent catches within a pool; invasive carp collection is predictable with one or multiple individuals being collected in a given day/week of sampling.
Abundant	Consistent catches within a pool in large quantities e.g., invasive carp collection is predictable with multiple fish being collected with nearly every deployment of gear, numerous individuals collected often and daily/weekly. However, some seasonality or environmental conditions may play an important role in specific life stages (i.e., eggs/larvae) when they are captured and should be accounted for when determining occurrences across pools.
Action Response Level	
No Change/ Current Level	Maintain current levels of sampling effort.
Moderate Change	Heightened level of response may occur along with maintaining current levels of sampling effort. Prior to any moderate change response, the MRWG will convene to evaluate the data and situation and recommend a suite of responses to the ICRCC for implementation. Strategies will

	then be determined for the best course of action and tools available based on the status change and concurrence with jurisdictional authorities and abilities
Significant Change	Substantial or heightened levels of response may occur along with maintaining current levels of sampling effort. All tools from “moderate change” are available during a significant change response, as are additional robust tools along with “maintaining current levels of sampling effort” for consideration. Prior to any moderate change response, the MRWG will convene to evaluate the data and situation and recommend a suite of responses to the ICRCC. The ICRCC, after reviewing MRWG recommendations, may concur or offer opinions regarding the appropriate response(s) to implement. Prior to any significant change response, the MRWG will convene to evaluate the data and situation, then strategies will be made on the best course of action and tools available based on the status change and concurrence with jurisdictional authorities and abilities
Potential Response Actions	
Increased Sampling Efforts	Modified or increased number of samples using fish sampling/detection methods currently used by MRWG in Monitoring.
Electrofishing	Standard fish sampling method to sample small and adult invasive carp currently used by MRWG in Fixed and Targeted Sampling.
Hoop Netting	Standard fish sampling method to sample adult invasive carp currently used by MRWG in Fixed and Targeted Sampling.
Minnow Fyke Netting	Standard fish sampling method to sample small invasive carp currently used by MRWG in Fixed and Targeted Sampling.
Electrofied Dozier Trawl	Experimental fish sampling method to sample small and adult invasive carp currently used by MRWG.

Attachment 3

Ichthyoplankton Tows	Standard fish sampling method to sample larvae and eggs of invasive carp currently used by MRWG in Fixed and Targeted Sampling.
Pound Nets	Experimental fish sampling method to adult invasive carp currently used by MRWG.
Modify Barrier Operations	MRWG and USACE will coordinate upon potential postponements and operations of planned Barrier outages.
Acoustic Deterrent	Noise methods to drive/herd/deter fish including revving of outboard boat motors, banging on boats in the waterway, and deployment of speakers with developed sounds.
Commercial Contract Netting	Mobilizing contracted commercial fisherman and using commercial fishing methods used currently by MRWG in sampling/detection and removal including gill netting, trammel netting, large mesh seine, small mesh seine, and hoop netting.
Hydroacoustics	Electronic Fish survey and locating techniques used currently by MRWG including side-scan sonar, and DIDSON sonar to evaluate the number and density of large or small invasive carp in a given area.
Temporary Flow Control	MWRD authority and ability to reduce flow velocities to complete response actions.
Block Netting	Large nets that can block the waterway or contain selected areas from small and adult invasive carp movement used currently by MRWG for removal.
Mobile Electric Array	Experimental electric array that can be used as temporary barrier or drive/herd and deter small and adult invasive carp.
Other	
Pool	The water between two successive locks or barriers within the river system.

Attachment 3

Developing Technologies	Technologies and methodologies currently being investigated that show promise in deterring invasive carp or increases harvest efficiency which are not currently approved for use in the field by the applicable regulatory agencies.

Attachment 4

ATTACHMENT 4: INCIDENT RESPONSE PLAN EXAMPLE

*******EXAMPLE*******
OPERATION BUBBLY CREEK
INCIDENT ACTION PLAN
WEEK OF NOV 18, 2019

Unified Command/Operations Chief – IL DNR

Agency Representative – USACE

Agency Representative – USFWS

Agency Representative – Brian Schoenung, IL DNR

Agency Representative – John Dettmers, GLFC

Liaison –IL DNR

Industry liaison/USCG –

Industry liaison/ICRCC Co-Chair –Mike Wiemer

Onsite support – Tetra Tech

BACKGROUND

The USFWS Whitney Genetics Lab presented the results of their eDNA sampling of the CAWS above the electric fish dispersal barrier that occurred from October 8 to 10, 2019. Collected water samples indicated that of the 414 samples, 49 were found to be positive for Silver Carp eDNA, and 27 were found to be positive for Bighead Carp eDNA (Figure 1).

These detections followed an extensive multiple-agency assessment of the CAWS looking for Bighead Carp and Silver Carp from September 9 to 20, 2019. While no Bighead Carp or Silver Carp were found during that assessment, out of an abundance of caution, the IL DNR is leading the ICRCC agencies in two weeks of intense sampling in the waters around Bubbly Creek. Effort will be similar to if live fish had been captured as outlined in the ICRCC's Contingency Response Plan.

It is important to note that these positive eDNA findings do not confirm the presence of Bighead Carp or Silver Carp, nor that a reproducing population of these species exist above the EDBS or within the Great Lakes. In 10 consecutive years of intensive fish monitoring in the CAWS that included 1,425 hours of electrofishing, 701 miles of gill/trammel net, 11 miles of seine, 13 net pound net nights, 18 hoop net nights, and 175 fyke net nights, only one Bighead Carp and one Silver Carp have been captured.

DESCRIPTION

Agency personnel and contracted commercial fishing crews will intensively sample areas where positive eDNA detections occurred in a coordinated and unified fashion. Areas directly upstream and downstream of those locations deemed as potentially suitable habitats for invasive carp will also be sampled.

Commercial netting boats will be paired with an electrofishing boat forming a sampling crew. Sampling crews will deploy a variety of sampling methods (e.g., gill/trammel net and electrofishing) and employ various fish driving strategies, such as banging, block net, underwater sound, electricity, and revving boat motors. Following net deployment, crews will start driving the deployed net utilizing the driving methods described above. Commercial boats will lead driving of the net, followed by electrofishing boats. After electrofishing boats have completed their run, the commercial boat will begin to retrieve the net. This net will then be "hopscotched" ahead of the crews and the second net and deployed at a strategic location. All boats will maintain the same driving pace toward the previously set gill nets. As boats approach the net, crews will coordinate the next drive in a unified manner. This incident action plan will serve as a tracking device for personnel throughout the nine-day operation.

Attachment 4

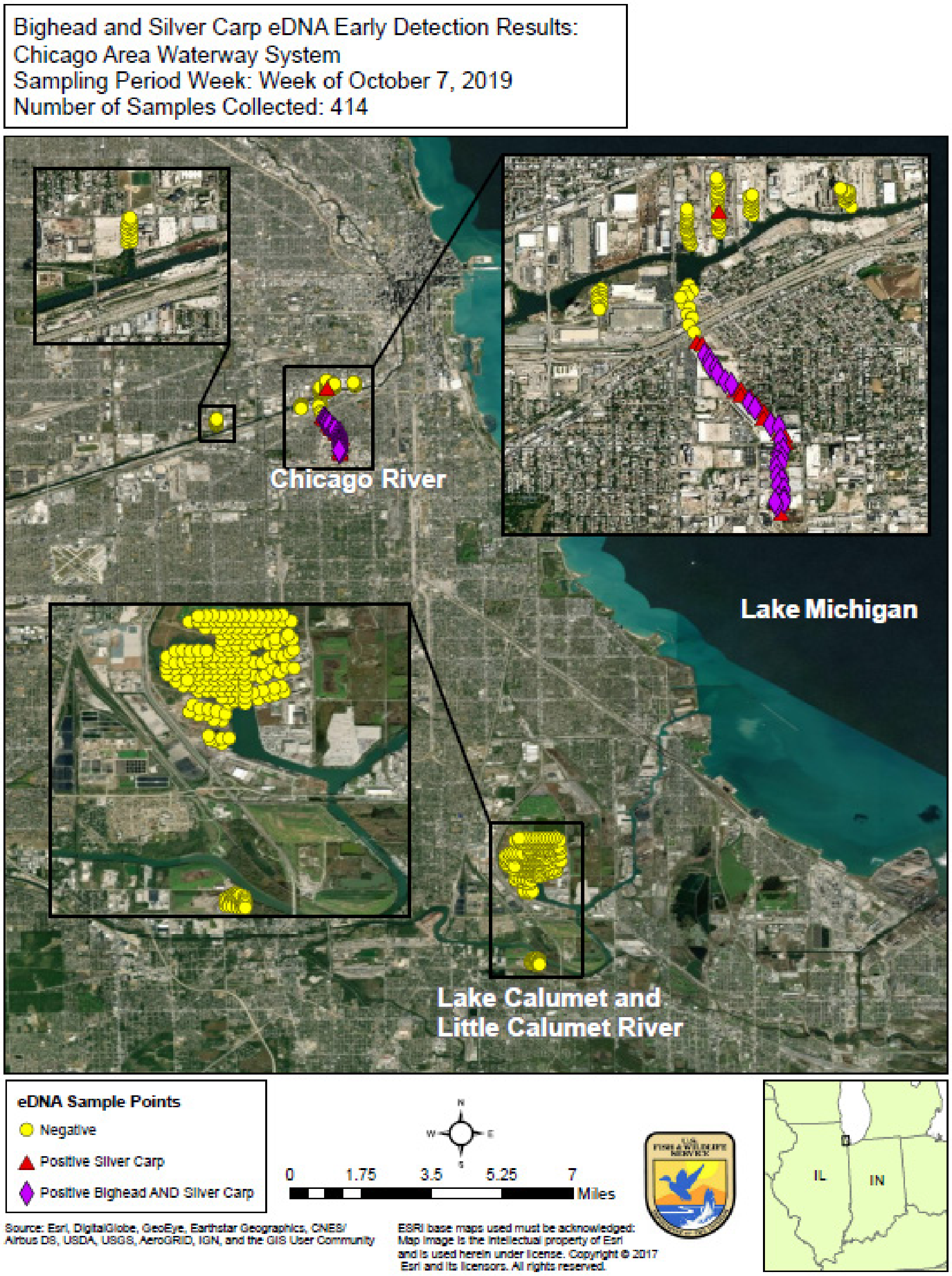


Figure 1. *Geographic locations of water collections and results of ensuing Bighead Carp and Silver Carp eDNA analysis.*

Operation briefing:

Monday, November 18, Richard J. Daley Park (0900). Richard J. Daley Park boat ramp will serve as the incident management team command area throughout the event. Incident command will brief out crews on sampling goals, weather, safety, communications, check-in and check-out procedures, and event tracking each day. This is an appropriate time for questions, but it is important to always keep communication open. **During the event, all**

boats will be utilizing Marine Radio Channel 72A. Crew leaders are responsible for keeping crew names updated and immediately confirming changes to Nathan Lederman or Justin Widloe via Phone/Radio/in person. At the end of the day, crew leaders are to confirm all personnel are accounted for and off the water by calling or texting the operations chief. Datasheets from that day are to be turned in to operations chief/unified command following the completion of each day.

If you are approached by the public or a reporter, indicate the agency you are work for, explain the operation objective (e.g., monitoring for the presence of Bighead Carp and Silver Carp), and provide basic/general information on what is occurring. If other questions are asked, direct them to MRWG co-chairs for additional information.

Daily briefings:

Tuesday-Friday. Prior to launch each day, a daily briefing will be held at the incident management team command area (Richard J. Daley Park). The operations chief will update and give each crew assignments for each day. This briefing will serve as a guide for personnel and provide updates on weather, findings, and safety. At the end of day, crew leaders are to hand their datasheets to Nathan Lederman.

Designated boat numbers and crews and sample area with crew leaders (Point of Contacts [POC] for each)

Electrofishing Boats:

Electro Boat 1: *USFWS Wilmington*

POC:

Electro Boat 2: *IL DNR*

POC:

Electro Boat 3: *IL DNR*

POC:

Netting Boats:

Commercial Net Boat 1: POC:

POC:

Commercial Net Boat 2: POC:

Attachment 4

POC:

Safety Boat:

Safety Boat 1: *IL DNR*

POC:

Schedule:

Monday – Richard J. Daley Park (Western Ave) 9:00 am to 4:00 pm

Electro Boat 1 – Pair up with net boat 1; Fish from north end of Bubbly Creek down and back

Electro Boat 2 – Pair up with net boat 2; Fish from south end of Bubbly Creek up and back

Electro Boat 3 – 10 random sites on North Branch Chicago River

Net Boat 1 – Pair up with electro boat 1; Fish from north end of Bubbly Creek down and back

Net Boat 2 – Pair up with electro boat 2; Fish from south end of Bubbly Creek up and back

IL DNR Boat – Set block net across channel on downstream end of Bubbly Creek

Tuesday – Richard J. Daley Park (Western Ave) 8:00 am to 4:00 pm

Electro Boat 1 – Pair up with net boat 1; Fish upstream end of Goose Island down the east side

Electro Boat 2 – 10 random sites near Downtown Chicago

Electro Boat 3 – Pair up with net boat 2; Fish upstream end of Goose Island down the west side

Net Boat 1 – Pair up with electro boat 1; Fish upstream end of Goose Island down the east side

Net Boat 2 – Pair up with electro boat 3; Fish upstream end of Goose Island down the west side

Wednesday – Richard J. Daley Park (Western Ave) 8:00 am to 4:00 pm

Electro Boat 1 – 10 random sites in North Branch Chicago River

Electro Boat 2 – Pair up with net boat 2; Fish from south end of Bubbly Creek up and back

Electro Boat 3 – Pair up with net boat 1; Fish from north end of Bubbly Creek down and back

Net Boat 1 – Pair up with Electro boat 3; Fish from north end of Bubbly Creek down and back

Net Boat 2 – Pair up with Electro boat 2; Fish from south end of Bubbly Creek up and back

IL DNR Boat – Set block net across channel on downstream end of Bubbly Creek, pull when done for the day

Attachment 4

Thursday – Richard J. Daley Park (Western Ave) 8:00 am to 4:00 pm

Electro Boat 1 – Pair up with net boat 1; Fish downtown Chicago Lock Area

Electro Boat 2 – Pair up with net boat 2; Fish downstream end of Goose Island up

Electro Boat 3 – 10 random sites in Chicago Lock Area; RM 317 in CSSC to Bubbly Creek

Net Boat 1 – Pair up with electro boat 1; Fish downtown Chicago Lock Area

Net Boat 2 – Pair up with electro boat 2; Fish downstream end of Goose Island up

Friday – Richard J. Daley Park (Western Ave) 8:00am to 1:00 pm

Electro Boat 1 – 8 targeted sites upstream of Bubbly Creek (toward downtown Chicago)

Electro Boat 2 – 8 targeted sites downstream of Bubbly Creek (toward CSSC)

Electro Boat 3 – 8 targeted sites downstream of downtown Chicago

Net Boat 1 – 8 targeted sites in and around Bubbly Creek

Net Boat 2 – 8 targeted sites downstream of Bubbly Creek (toward CSSC)

IL DNR Boat – Pull block net

BEST MANAGEMENT PRACTICES

BOAT DECONTAMINATION

The MRWG recommends the use of best management practices prior to and after the event. Please use the provided power washer that will be kept at the Silver Springs field office if your boat needs to be decontaminated. Best management practices to prevent the spread of aquatic nuisance species during invasive carp monitoring and response field activities are outlined in the 2018 Monitoring and Response Plan for Invasive Carp in the Upper Illinois River and Chicago Area Waterway. We appreciate your diligence in this matter.

SAFETY

ALL boats will be equipped with required safety equipment and floatation devices, including a basic first aid kit to treat any minor injury. Operators and crews will **wear** personal flotation devices while working on the water. To avoid dehydration, each crew should carry water and take adequate breaks. Be aware of your crew members and identify health and safety concerns. **Health and safety of all working on the water is the highest concern.**

Temperatures may be cold, and proper field gear is essential. If participants get cold/wet and need to get warm, a warming station and hypothermia kit will be located at the incident management team command area. It is recommended each crew has dry clothes stored in a vehicle on site.

Communication among boats, staff, security, and shore command will be by marine radio or cell phone. A briefing before any crew enters the water will be held at Richard J. Daley Park (3150 S Western Blvd, Chicago, IL 60680) on Monday, November 4, at 9:00 am, and will assure all staff has a copy of this IAP, which contains all critical contact information. This IAP includes a map of the sample area. All boats will be equipped with marine radios, hand-held marine radios monitoring Channel 16A for the operation, and cell phones. Communication with USCG and to initiate communication with other vessels, please use VHF Marine radio channel 16A. **Crews may have interactions with commercial vessels traveling to and from operations site and should have marine radios (VHF-16).** Crew leaders see Nathan Lederman for a handheld marine radio if one is not on your boat.

Emergency contact numbers (local ambulance, fire/rescue service, USGC contact info, Port Authority) will be included on the handout if needed for unforeseen reasons, yet the primary communicator to these services will be the operations coordinator. If the operations coordinator is not the first call for emergencies, notify at the earliest possible time.

NAVIGATION SAFETY ZONE

No safety zone closure has been requested for this operation. Sampling will take place between RM 317 of the CSSC and RM 326 of the North Branch of the Chicago River. VHF-16 would be the call channel to hail any vessel in the waterway. USCG will issue broadcast to mariners as notification of our activities/operation.

NOTICE TO COAST GUARD

Over the next week, November 18 through November 22, 2019 (Monday-Friday), the IL DNR, along with USFWS and the USACE, will have increased presence on the CAWS as part of the ICRCC CRP. During this time, mariners should be aware of these crews and additional agency boats. All boaters should be aware of possible fishing nets in the water, as all nets will be marked with floats and always attended by agencies. The activity will be between RM 329.0 on the North Branch of the Chicago River to RM 314.0 on the Cal-Sag, with emphasis being placed between RM 321.0 and RM 322.0 (Figure 2). All crews will be monitoring VHF channel 16A. Gears utilized will include pulsed DC-electrofishing, trammel net and gill net, deep water gill nets, and block net to capture and remove any invasive carp present.

There will be two IL DNR contracted commercial fishing boats (20 to 26 feet in length), three agency electrofishing boats, and one safety boat during this intensive sampling. If more details are needed, please contact Nathan Lederman or Kevin Irons of IL DNR. An IAP, daily schedule, and maps will be provided, and any changes to the schedule will be posted.

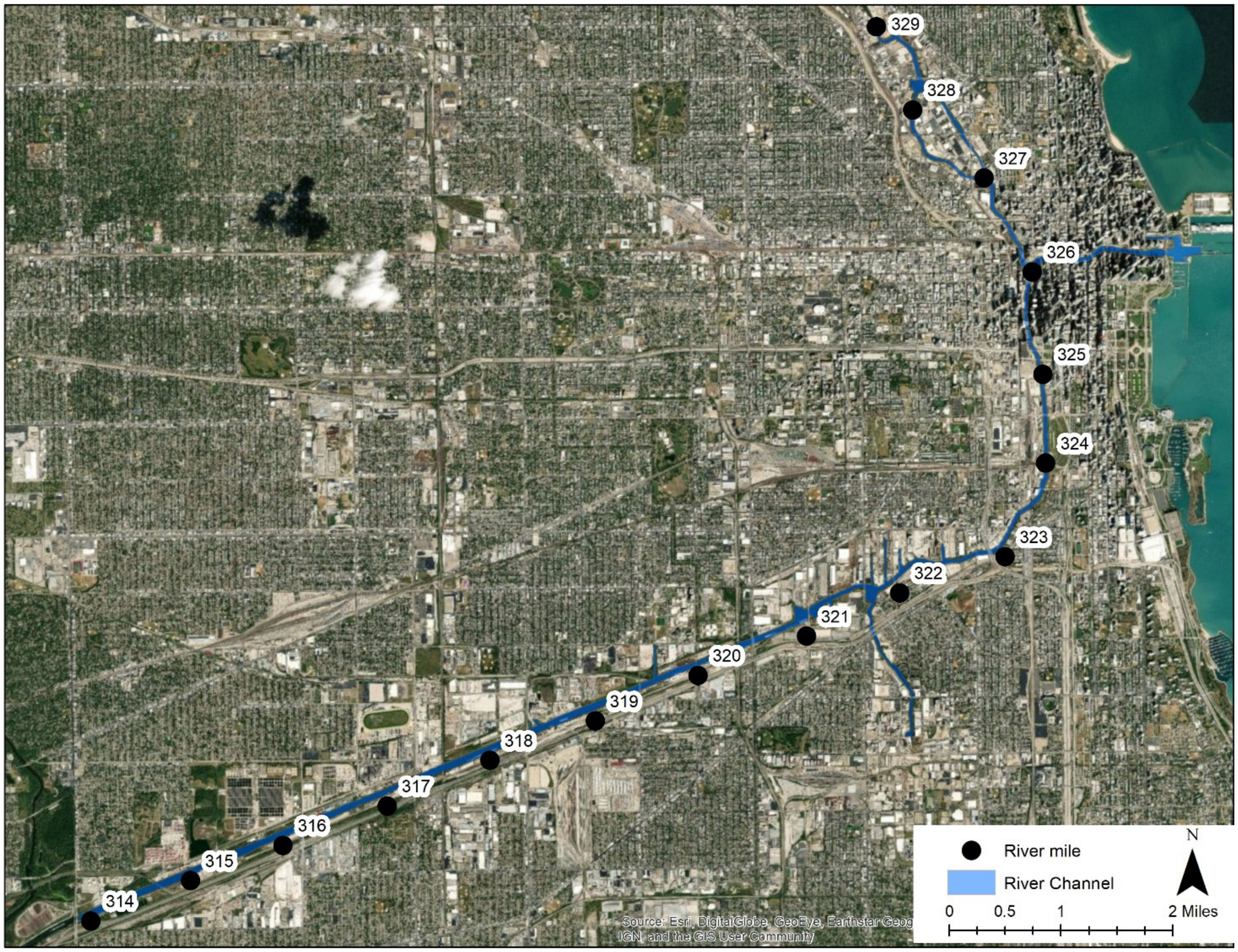


Figure 2. *Incident action spatial extent.*

CAPTURE OF SILVER CARP, BIGHEAD CARP OR GRASS CARP

If a boat crew believes they have captured a Bighead Carp or Silver Carp, they should cease further collection and take a GPS reading of the location at which the fish was found. An onboard fish biologist should confirm the identification of fish species, euthanize the individual, put the individual on ice, and take it to the staging area (Richard J. Daley Park). The boat crew leader should notify unified command upon confirmation, and the unified command will immediately notify the agency representatives, MRWG superiors, ICRCC co-chairs, and the conservation police commander.

Attachment 4

At the staging area, the fish is to have a unique identifying fish tag created, a picture taken, and the total length (millimeters) and weight (grams) measured. The fish should be placed in a plastic bag and sealed in a cooler with wet ice, with evidence tape placed across the opening of the cooler. Captured fish are to not be frozen or preserved with chemicals, as these techniques distort the DNA, but the individual should be kept chilled. The evidence cooler with the fish in is to be transferred to the Illinois conservation police commander. The conservation police commander will deliver the sealed fish to the sampling laboratory on-site or arrange for transport to the genetics laboratory at the University of Illinois (contact: Dr. John Epifanio). Soft tissue for genetic testing and hard tissue for aging and/or chemical analysis will be removed at the University of Illinois Chicago laboratory. Only authorized IL DNR tissue samplers or persons designated by an operations coordinator or chief will unseal the fish and remove the tissue samples from the fish for preservation and delivery to the lab. The lab samples will maintain the same sample ID as the subject fish but will also include an additional sequential letter (IC 001a, IC001b, IC002a, IC002b, etc.) for multiple samples from one fish. While soft tissue and hard tissue extraction occur, the fish and samples will remain under supervision of the IL DNR conservation police officer, who will maintain the chain-of-custody form. Additional soft tissue samples will be collected for other cooperating genetics laboratories (e.g., ERDC), as needed. Hard tissue will be transported to SIUC for analysis (contact: Dr. Greg Whitledge).

A chain-of-custody system will be used in case any Bighead Carp, Grass Carp, or Silver Carp are captured. Chain-of-custody is a legal term that refers to the ability to guarantee the identity and integrity of a sample from collection through reporting of the test results. During each transfer of the fish from one person to another, a chain-of-custody form is to be filled out legibly with permanent ink. Chain-of-custody is to be maintained when transporting hard tissue between university laboratories.

If a Grass Carp is captured, use the same procedure as described above, except for contacting the Illinois conservation police commander, and the use of evidence tape is unnecessary. Additionally, the crew is to continue sampling.

Additional Contacts and Emergency Phone numbers

USCG

No on-scene representative will be present during this sampling operation. If needed, the USCG can be contacted by phone at 630-336-0296 or VHF-16. They will have a Broadcast Notice to Mariners for information purposes on VHF. D09-DG-MSUChicago-Waterways@uscg.mil

USEPA

Attachment 4

POC:

MWRD

No on-scene representative, not affected in operation

POC:

O'Brien Lock and Dam

Phone: (773) 646-2183

Coordinates: 41°39'5"N 87°34'1"W

1615 E 130th St.
Chicago, IL
United States

POC at O'Brien:

International Port Authority (IPA)

No on-scene representative will be present during this sampling operation. If needed, the POC for IPA is:

Local Emergency

Chicago Police: (Emergency): 911 or 312-746-6000; (Non-emergency): 312-747-8205

Chicago Fire: (Emergency): 911 or 312-746-6000

Chicago Police: 2255 E 103rd St., Chicago, IL

Ingalls Memorial

1 Ingalls Dr., Harvey, IL 60426

Phone: (708) 333-2300

Roseland Community Hospital

Address: 45 W. 111th St., Chicago, IL 60628

Phone: (773) 995-3000

Attachment 5

ATTACHMENT 5: AUTHORITIES

Key authorities linked to response actions are listed below. The list may not include all federal, state, and local authorities tied to ongoing operation and maintenance activities.

Illinois

Other Illinois agencies authorities may apply, e.g., Illinois Environmental Protection Agency (Illinois EPA) and IL Department of Agriculture, but key IDNR authorities are below:

Illinois Department of Natural Resources (from Illinois Compiled Statutes http://www.ilga.gov/legislation/ilcs/ilcs.asp)

20 ILCS 801/1-15; 20 ILCS 805/805-100; 515 ILCS 5/1-135; 515 ILCS 5/10-80

Illinois Administrative Rules (17 ILCS Part 890 Fish Removal with Chemicals)

Section 890.30 Treatment of the Water Area

Authority for 17 ILCS Part 890 Fish Removal with Chemicals (found in statute below):

515 ILCS 5/1-135

515 ILCS 5/1-150

ARTICLE 5. FISH PROTECTION

515 ILCS 5/5-5

USACE

Water Resources Development Act of 2007 Section 3061(b) - Chicago Sanitary and Ship Canal Dispersal Barriers Project, Illinois; Authorization.

Water Resources Reform and Development Act of 2014. Section 1039(c) – Invasive Species; Prevention, Great Lakes and Mississippi River Basin.

USFWS

H.R. 3080 Water Resources Reform and Development Act of 2014

Attachment 5

Fish and Wildlife Coordination Act (16 U.S.C. 661-667e; the Act of March 10, 1934; Ch. 55; 48 Stat. 401), as amended by the Act of June 24, 1936, Ch. 764, 49 Stat. 913; the Act of August 14, 1946, Ch. 965, 60 Stat. 1080; the Act of August 5, 1947, Ch. 489, 61 Stat. 770; the Act of May 19, 1948, Ch. 310, 62 Stat. 240; P.L. 325, October 6, 1949, 63 Stat. 708; P.L. 85-624, August 12, 1958, 72 Stat. 563; and P.L. 89-72, 79 Stat. 216, July 9, 1965.

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990

Lacey Act (16 U.S.C. §§ 3371–3378)

Executive Order 13112 of February 3, 1999 - Invasive Species

H.R.223 - Great Lakes Restoration Initiative Act of 2016

APPENDICES

ZOOPLANKTON AS DYNAMIC ASSESSMENT TARGETS FOR INVASIVE CARP REMOVAL

Participating Agencies: INHS (lead), SIUC (field and lab support)

Location: Zooplankton and water chemistry sampling will take place throughout the IWW from the Dresden Island Pool to the lower LaGrange Pool (Figure 1).

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, and LaGrange pools

INTRODUCTION AND NEED

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; Love et al. 2018). One challenge associated with the removal program has been assessing whether harvest efforts have caused ecologically meaningful changes in bigheaded carp abundance. In addition to preventing the expansion of bigheaded carp into the Great Lakes, this removal program may benefit native communities in the IWW by mitigating some of the ecological impacts that bigheaded carp have had on this system. Bighead Carp and Silver Carp (collectively bigheaded carp) can deplete zooplankton densities and alter zooplankton community composition (Sass et al. 2014; DeBoer et al. 2018), 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) due to their ability to efficiently filter large volumes of water and capture small particle sizes. The trophic impact of bigheaded carp is of great concern because of the importance of zooplankton as grazers and prey for native planktivores and early life stages of all fishes (Cushing 1990; Carpenter et al. 1985; Sampson et al. 2009). In the Illinois River, densities of large-bodied crustacean zooplankton have been substantially reduced since the establishment of bigheaded carp (Sass et al. 2014; DeBoer et al. 2018). However, the extent and pace of ecosystem responses to the removals of bigheaded carp are uncertain. Due to their short generation times and high productivity rates, zooplankton taxa have the potential to quickly respond to bigheaded carp removal, making them potentially favorable performance metrics for assessing the effectiveness of invasive carp control efforts and whether sufficient numbers of fish have been removed to allow for ecosystem recovery. This project will investigate whether zooplankton-based assessment metrics can be used to quantitatively evaluate the extent to which the removal strategy is working to reverse ecosystem impacts of bigheaded carp in the IWW. This work will help inform management agencies regarding ecosystem responses to bigheaded carp removals and define ecosystem-based benchmarks for bigheaded carp control efforts.

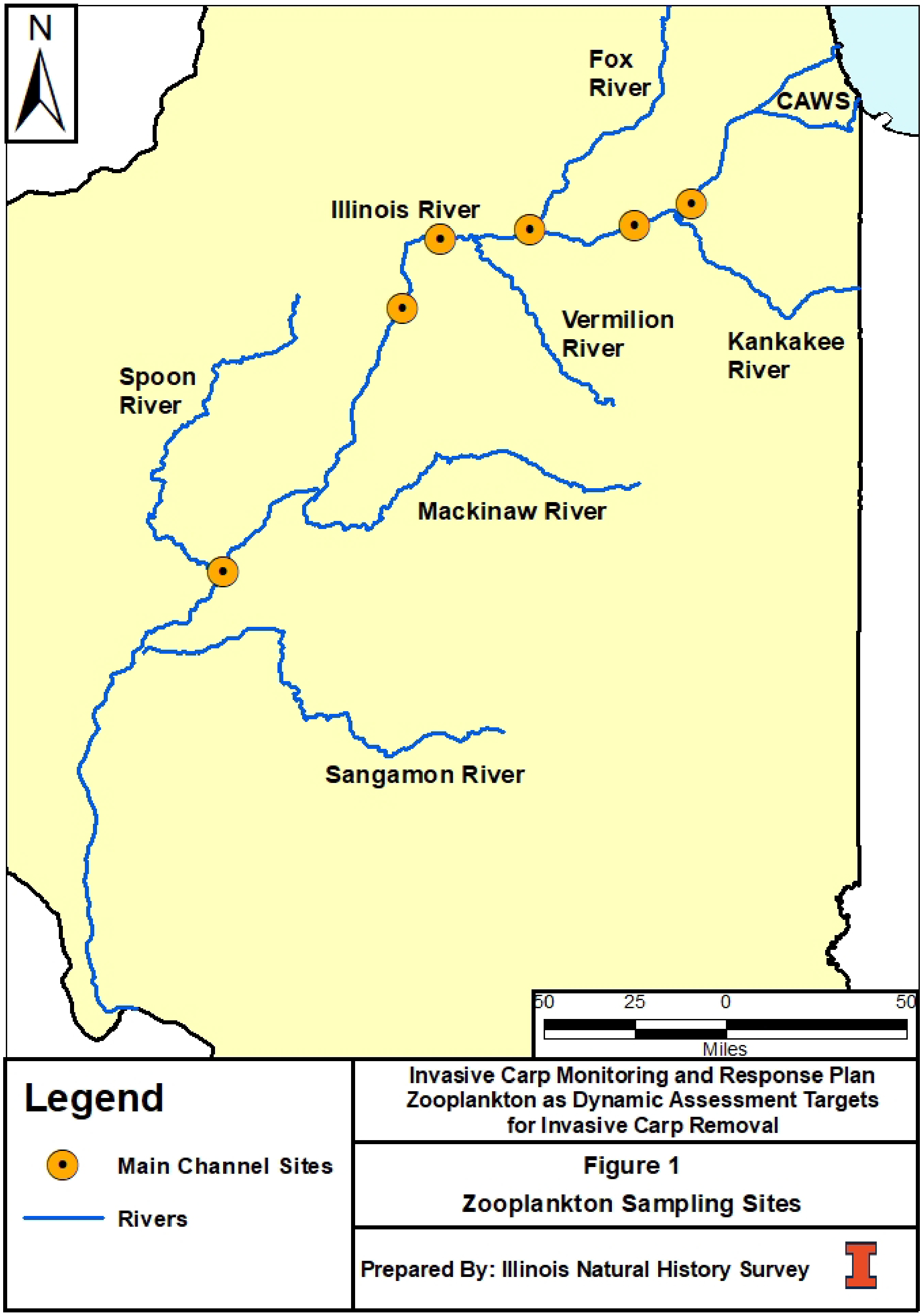


Figure 1. *Map of zooplankton sampling sites in the IWW.*

OBJECTIVES

- Quantify 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.
- Use sensitive zooplankton taxa to develop benchmarks for evaluating the outcome of bigheaded carp control and removal efforts.

STATUS

Zooplankton have been sampled from sites throughout the IWW from 2011 to 2022. Comparison of zooplankton data collected during recent years with pre-invasion zooplankton collections indicates that zooplankton assemblages in the Illinois River have been substantially altered since the establishment of bigheaded carp, with large declines in macrozooplankton, such as cladocerans. Zooplankton communities also exhibit considerable seasonal, longitudinal, and habitat-specific variation. Underlying environmentally driven variability in zooplankton metrics must therefore be accounted for in any analyses evaluating relationships between zooplankton and bigheaded carp abundance. Previous analyses examined June densities of several zooplankton taxa and identified June *Bosmina* densities as a more sensitive performance metric than other assessed taxa. More recent analyses using updated data from 2012 through 2020 collections examined the influence of bigheaded carp density and hydrologic and water chemistry variables on annual peak densities of select cladoceran, copepod, and rotifer taxa. None of the models of peak densities of various rotifer taxa that included bigheaded carp density as an explanatory factor were found to have strong support from the data. However, bigheaded carp density was included in the most supported models for peak cyclopoid copepod and *Bosmina* densities. During 2023, final zooplankton collections will be conducted and further analyses of a broad range of potential performance metrics, including both monthly and peak density and biomass estimates for several zooplankton taxa, will be conducted to identify metrics that are most informative for assessing the impacts of bigheaded carp removals. Complete assessment, including model parameterization, metric development, and sensitivity analyses, are expected by 2024.

METHODS

Field sampling for assessing zooplankton trends will occur biweekly between late April and October of 2023 at established sites to maintain consistency and data comparability with past years (Figure 1). Zooplankton will be collected by obtaining vertically integrated water samples using a diaphragmatic pump. At each site, 90 liters of water will be filtered through a 55-

micrometer mesh to obtain crustacean zooplankton (macrozooplankton), whereas 10 liters of water will be filtered through a 20-micrometer mesh to obtain rotifers. Organisms will be transferred to sample jars and preserved in either Lugol's solution (4 percent for macrozooplankton) or buffered formalin (10 percent for rotifers). In the laboratory, individual organisms will be identified to the lowest possible taxonomic unit, counted, and measured using a microscope-mounted camera and measurement software. The densities of each zooplankton taxa will be calculated as the number of individuals per liter of water sampled. Density and body size measurements will be used to estimate zooplankton biomass. During zooplankton sampling, data on environmental factors known to influence zooplankton communities in large rivers (turbidity, chlorophyll *a*, total phosphorus, dissolved oxygen, temperature, etc.) will also be collected. Discharge data will be acquired from USGS gages on the IWW. Estimates of invasive carp density in each navigation pool will be obtained from hydroacoustic surveys conducted by SIUC.

Targets for ecosystem response to bigheaded carp removals will be developed using monitoring data to model zooplankton indicators as a function of bigheaded carp density and the seasonal environmental variation influencing their spatiotemporal dynamics (e.g., discharge, dissolved oxygen, temperature, total phosphorus, chlorophyll *a*, etc.). Models of zooplankton indicators will be parameterized across a range of bigheaded carp densities, including navigation pools where invasive carp removal efforts have substantially reduced bigheaded carp densities during the assessment period. The influence of environmental variables on the relationships between bigheaded carp density and each zooplankton metric will be assessed, and metrics that demonstrate the highest sensitivity to bigheaded carp density will be considered further as potential tools for evaluating the impacts of bigheaded carp harvest. The most informative performance metrics will be modeled using observed environmental conditions and bigheaded carp densities in each pool to calculate the difference between the observed and expected values of each metric. The same models and environmental conditions will then be used to predict what the target metric value would be if bigheaded carp had been reduced to a specified density (e.g., lowest densities observed in the time series of hydroacoustic surveys), and the difference between the target predictions and observed metric values will be compared to the residuals obtained from the model that used observed bigheaded carp density. If the target interval (i.e., prediction residuals ± 1.5 SE from bigheaded carp density goal) overlaps the limits based on the observed carp density, bigheaded carp removal at this site would be concluded to have met the management target for zooplankton recovery. 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.

2023 SAMPLING SCHEDULE

- Bi-weekly sampling at all sites from late April to October.
- Updated assessment of potential performance metrics and evaluation of ecosystem impacts of harvest efforts in each navigation pool by the end of 2023.
- Project completion, including final model parameterizations and metric development expected in 2024.

DELIVERABLES

Results of 2023 sampling and on-going evaluations of zooplankton response metrics to assess annual variation in bigheaded carp densities and harvest operations will be provided to MRWG partners as relevant findings are produced. Data will be summarized for an annual interim report, and project plans will be updated for annual revisions of the MRP.

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Appendix B: Participants of the Monitoring and Response Work Group, Including Roles and Affiliation

Affiliation acronyms are EA: Engineering, Science and Technology, EPA: U.S. Environmental Protection Agency, GLFC: Great Lakes Fishery Commission, IDNR: Illinois Department of Natural Resources, INHS: Illinois Natural History Survey, UI: University of Illinois, USACE: U.S. Army Corps of Engineers, USCG: U.S. Coast Guard, USGS: U.S. Geological Survey, USFWS: U.S. Fish and Wildlife Service, SIU: Southern Illinois University.

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Appendix C

Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring and Response Field Activities

The activities of the Asian Carp Monitoring and Response Plan (MRP) pose a risk of transporting and introducing aquatic nuisance species (ANS), including fish, plants, invertebrates, and pathogens. To slow their spread, it is best to take ANS into consideration during all stages of field work, including planning, while field work is in progress, and cleanup. The best management practices (BMPs) outlined below are designed to be effective, easy to implement, and realistic; when followed correctly, their use should reduce or potentially eliminate the risk of ANS being spread by MRP activities. These BMPs, combined with diligent record keeping, can also benefit the organizations participating in MRP activities by demonstrating that they are taking deliberate action to prevent the spread of ANS.

For the purposes of these BMPs, all equipment utilized in field work that comes into contact with Illinois waters, including but not limited to boats and trailers, personal gear, nets, and specialized gear for electrofishing and hydroacoustics, will be referred to as "gear."

Field activities that use location-specific gear may require less effort to ensure that they are not transporting ANS. Examples include boats, electrofishing gear, nets, or personal gear that are used in sampling only one location. If potentially contaminated gear does not travel, the possibility of that equipment transporting ANS may be eliminated. Maintaining duplicate gear for use in contaminated vs. non-contaminated locations or sampling all non-contaminated locations before moving to contaminated locations may also reduce or eliminate the possibility of ANS spread.

BEST MANAGEMENT PRACTICES

BEFORE TRAVELING TO A SAMPLING LOCATION:

- ***CHECK*** gear and determine if it was previously cleaned.

  Accurate record-keeping can eliminate the need for inspecting or re-cleaning before equipment is used. If it is unknown whether the gear was cleaned after its last use, inspect and remove any plant fragments, animals, mud, and debris, and drain any standing water. If necessary, follow the appropriate decontamination steps listed below.

- ***PLAN*** sampling trips to progress from the least to the most likely-to-be-contaminated areas when working within the same waterbody.

  When feasible, plan on decontaminating whenever equipment crosses a barrier (such as a lock and dam or the Electric Dispersal Barrier) while going upstream.

WHILE ON A WATERBODY:

- ***INSPECT*** and clean gear while working.
- ***OBSERVE*** any ANS that may not have been previously recorded.

  Adjust decontamination plans when new occurrences are observed. Report new infestations at www.usgs.gov/STOPANS, by sending an email to dnr.ans@illinois.gov, and also include in monthly reports to the Monitoring and Response Workgroup.

Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring and Response Field Activities

AFTER FIELD WORK ON WATERBODY IS COMPLETE:

- ***REMOVE*** plants, animals, and mud from all gear.

  This step can reduce the amount of macrophytes on a boat by 88 percent.[A] *It should occur before gear is transported away from the waterbody to be compliant with Illinois' Public Act 097-0850, which prevents transport of aquatic plants and animals by boats, trailers, and vehicles on Illinois' roadways.*

- ***DRAIN*** all water from your boat and gear.

  Drain all water before gear is transported away from the waterbody to be compliant with Administrative Code Title 17 Section 875.50, which makes it unlawful to transport the natural waters of the state without permission.

- ***DISPOSE*** of unwanted plants and animals appropriately.

- ***DECONTAMINATE*** using a recommended method before using gear at another location.

  Decontaminate whenever there is the potential for gear to transfer ANS. The best method for decontamination varies; see Attachment A for more information about various decontamination methods and gear-specific tips, and Attachment B to inform decisions as to which decontamination method is best for each ANS.

- ***KEEP RECORDS.***

  Develop and follow a Standard Operating Procedure (SOP) and checklist for cleaning equipment. This checklist makes the ANS prevention steps easy to follow and documentable. Complete the SOP and checklist for each sampling event with date, location, recorder's name, and what was done.

  It may be beneficial to develop a lock and tag system to ensure that potentially infested (dirty) gear is not reused before it is decontaminated. Examples could include flagging dirty gear in a particular color (such as red, indicating stop) to designate that it should not be used in the field and flagging decontaminated gear in a different color (green, indicating go) to designate that it is ready for reuse. Alternatively, a colored carabiner could be used to flag boat keys; keys without the appropriate colored carabiner would designate that gear as dirty and therefore unable to be used without being decontaminated.

  Developing a system and keeping records over time demonstrates a solid commitment to ANS prevention, helps build a standard cleaning protocol, and eliminates wasted time spent re-checking or re-cleaning equipment. An appropriate SOP with lock and tag system, color coding, or rotation of gear as described above is minimally expected.

[A] Rothlisberger, J.D., W.L. Chadderton, J. McNulty, and D.M. Lodge. 2010. Aquatic invasive species transport via trailered boats: what is being moved, who is moving it, and what can be done. Fisheries. 35(3):121-132.

Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring and Response Field Activities

ATTACHMENT A
DECONTAMINATION METHODS AND GEAR-SPECIFIC TIPS

While simple hand removal can reduce the majority of ANS found on gear and equipment[B], additional decontamination methods are recommended to eliminate (kill) any elements that may not be seen. The methods presented here outline a range of effective methods for decontaminating equipment and allow the user to select the most practical option for a specific situation. Successful decontamination depends on a multitude of factors, including the type and life stage of ANS infestation, decontamination method, contact time, and (if necessary) concentration of chemical used. For information on the effectiveness of each method for specific species, see Attachment B.

High-pressure washing is a commonly recommended method of removing organic material, although it is not considered a means of decontamination as defined above. If high-pressure washing is not possible, scrub equipment with a stiff-bristled brush or wash with soapy water to aid in the removal of small organisms and seeds, as well as remove organic material that makes decontamination less effective. Scrubbing could damage the anti-fouling paint and coating of some boat hulls, so check the manufacturer's recommendations. When brushing fabric, be careful to brush with the nap, as brushing against the nap could cause small seeds to become embedded.[B] Brushing should be followed by a rinse with clean water. If these methods of organic material removal are conducted in the absence of decontamination, it is necessary to ensure that wastewater runoff does not contaminate surface waters, as there is potential for live ANS to be removed from gear and carried in wastewater.

Decontamination Methods

1. *Drying*
   Accepted as effective: Dry for five consecutive days after cleaning with soap and water or high-pressure water;[C] dry in the sun for 3 days.[D]

   - Make sure equipment and gear is completely dried after the drying period. Surfaces may appear dry while the interior is still wet. Waders, boots, wetsuits, fabric, and wood may be difficult to dry thoroughly.
   - If using shared equipment, it is recommended to keep a log of when things are used to ensure the minimum drying period has been met. If there is any possibility that another individual will use the shared equipment before the recommended drying period is reached, it is safer to disinfect via other means.

2. *Steam Cleaning*
   Accepted as effective: Steam cleaning (washing with 212°F water)[D]

   - Heated water is effective in killing a wide range of organisms and fish pathogens (see Attachment B); although the efficacy of steam cleaning is commonly shared knowledge, its effectiveness is not necessarily supported by references.[F]
   - Steam cleaners can work well in small spaces and on items such as small boat hulls, clothing, and heavy equipment. To be the most effective, all sides, as well as the inside, of all

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[B] DiVittorio, J., M. Grodowitz, and J. Snow. 2010. Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species [2010 Edition]. U.S. Department of the Interior Bureau of Reclamation. Technical Memorandum No. 86-68220-07-05.
[C] Wisconsin Department of Natural Resources. 2015. Boat, Gear, and Equipment Decontamination Protocol. Manual Code #9183.1.
[D] United States Geological Survey. Movement of field equipment (boats, trucks, nets, seines, etc.) between two separate waterbodies for field sampling. Columbia Environmental Research Center. HACCP Plan. Accessed 4 Nov 2015.

equipment being treated should be sprayed.[E]

- Be careful when steaming over items held together with adhesives because high temperatures can melt bonds. Inflatable PFDs can also be melted by the use of steam.
- The use of personal protective equipment is recommended when working with heated water. Most adults will suffer third-degree burns with a 2-second exposure to 150°F water.[F]

3. *Hot Water*
   Accepted as effective: Washing with high pressure, hot (≥140°F) water for 30 seconds at 90 psi;[E] washing with hot (≥140°F) water for a 10 second contact time.[G]

- It is recommended to use pressure washing in conjunction with hot water; otherwise, it can aid in the spread of ANS because it removes organisms, but does not kill them.[F]
- Heated water is effective in killing a wide range of organisms and fish pathogens (see Attachment B).
- While some species are killed at lower temperatures, hot water should be at least 140°F to kill the most species. This method becomes more effective when applied with high pressure, which removes ANS.[F]
- It is important to note that some self-serve car washes do not reach 140°F; however, studies have demonstrated some ANS mortality at temperatures lower than 140°F with an increase in contact time.[H]
- To verify that the hot water spray is effectively heating the contact area, a non-contact infrared thermometer can be purchased at a home supply store.
- When carpeted bunks are present on boat trailers, it is recommended to slowly flush for at least 70 seconds to allow capillary action to draw the hot water through the carpet.[H]
- The use of personal protective equipment is recommended when working with heated water. Most adults will suffer burns with a 6-second exposure to 140°F water.[G]

5. *Virkon® Aquatic*
   Accepted as effective: Applying a 2 percent (2:100) solution of Virkon® Aquatic for 20-minute contact time,[C] or 10-minute contact time.[D] Contact time is species-specific; see Attachment B for more information.

- Virkon® Aquatic is a powder, oxygen-based disinfectant that is biodegradable and not classified as persistent in the environment.[I]
- As shown in Apendix B-2, Virkon® Aquatic is the best method to use on equipment that has been used in areas that are known to have New Zealand mudsnail (*Potamopytrgus*

[E] Perdrock, A. 2015. Best Management Practices for Boat, Gear, and Equipment Decontamination. State of Wisconsin Department of Natural Resources, Bureau of Water Quality.
[F] U.S. Consumer Product Safety Commission. 2011. Avoiding Tap Water Scalds. Publication 5098. http://www.cpsc.gov/PageFiles/121522/5098.pdf.
[G] Zook, B. and S. Phillips. 2012. Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States (UMPS II). Pacific States Marine Fisheries Commission.
[H] Comeau, S., S. Rainville, W. Baldwin, E. Austin, S. Gerstenberger, C. Cross, and W. Wong. 2011. Sucsceptibility of quagga mussels (*Dreissena rostiformis bugensis*) to hot-water sprays as a means of watercraft decontamination. Biofouling. 27(3):267-274.
[I] Baldry, M.G.C. Biodegradability of Virkon® Aquatic. Accessed 23 November 2015. http://www.wchemical.com/downloads/dl/file/id/68/biodegradability_of_virkon_aquatic.pdf.

antipodarum, NZMS) populations or might be vulnerable to NZMS.[F,J]

- Virkon® Aquatic should not be used on items made of wood. Because the solution soaks into the wood, it may carry residues that could be harmful to fish. Negative impacts of Virkon® Aquatic can be reduced by rinsing equipment with clean water (municipal, bottled, and well) after decontamination is complete.[F]
- Labeling for Virkon® Aquatic indicates it is not corrosive at the recommended dilution; however, solutions have been shown to cause degradation to gear and equipment when used repeatedly.[K]
- Always wear personal protective gear when mixing solutions of Virkon® Aquatic.

6. *Chlorine*
   Accepted as effective: Applying a 500 ppm chlorine solution[C] or a 200 mg/L chlorine solution[D] for a 10-minute contact time.

- As shown in Attachment B, chlorine solutions are not effective on spiny waterflea (*Bythotrephes longimanus*, SWF) resting eggs or NZMS. For this reason, it is recommended to follow chlorine solution treatments with an additional decontamination method or select another decontamination method if SWF or NZMS transport is a concern.
- Note that the chlorine concentration of solutions deteriorates with time, exposure to light and heat, and on contact with air, metals, metallic ions, and organic materials.[K]
- There are no differences in decontamination abilities between solutions using tap water or sterile water to make the chlorine solution. The cleaning and decontamination abilities of chlorine solutions are not impacted by the temperature of the water used.[L]
- Chlorine solutions will begin to lose disinfecting properties after 24 hours, and the more dilute the chlorine solution, the more quickly it will deteriorate. Therefore, it is important to use bleach solutions that are less than 24 hours old.[F]
- When household bleach is used as a chlorine source, be aware of bleach shelf life. If stored at a temperature between 50 and 70°F, household bleach retains its decontamination properties for about 6 months, after which it degrades into salt and water at a rate of 20 percent each year.[M]
- Chlorine solutions may have corrosive effects on certain articles of equipment, but these effects can be reduced by rinsing equipment with clean water after decontamination is complete.[F]
- Because different brands of household bleach vary in the amount of sodium hypochlorite used, differing quantities will need to be used to create the appropriate concentration (Table 1).

[J] Stockton, K.A. and C.M. Moffitt. 2013. Disinfection of three wading boot surfaces infested with New Zealand mudsnails. North American Journal of Fisheries Management. 33:529-538.

[K] Clarkson, R.M., A.J. Moule, and H.M. Podlich. 2001. The shelf-life of sodium hypochlorite irrigating solutions. Australian Dental Journal. 46(4):269-276.

[L]Johnson, B.R. and N.A. Remeik. 1993. Effective shelf-life of prepared sodium hypochlorite solution. Journal of Endodontics. 19(1):40-43.

[M] Brylinski, M. 2003. How long does diluted bleach last? Email from clorox@casupport.com to the Director of WCMC EHS Dated February 6, 2003. http://weill.cornell.edu/ehs/forms_and_resources/faq/biological_safety.html

Table 1. *Converting household bleach to 500 or 200 parts per million (mg/L) of chlorine solution.*

Sodium hypochlorite concentration of household bleach	Ounces of household bleach per gallon water		Tablespoons of household bleach per gallon water	
	200 ppm	500 ppm	200 ppm	500 ppm
5.0	0.51	1.28	1.02	2.56
5.25	0.49	1.22	0.98	2.44
8.25	0.31	0.78	0.62	1.55

7. *Freezing*

- As a result of the threat posed by fish pathogens and the ability of many pathogens to survive freezing temperatures, it is recommended to utilize freezing in conjunction with other decontamination methods.
- See Attachment B for recommendations regarding the efficacy of freezing for various ANS.

Gear-Specific Tips for Decontamination

To ensure success, organic debris should be removed prior to decontamination. Organic debris can be removed by hand, by scrubbing with a stiff-bristled brush, or by rinsing/power washing with clean municipal, well, or non-surface water.

Nets

- The most effective way to remove organic debris from nets is by rinsing with clean municipal, well, or non-surface water. Power washing is not required, but nets could be sprayed with a garden hose or rinsed in a tub of water to remove debris.
- Nets can be steam cleaned, washed, and dried thoroughly for 5 days, or washed and treated with a decontamination solution. Nets should be placed in the decontamination solution for the appropriate contact time for the solution being used. After rinsing, the nets can be used immediately or hung to dry.
- If nets are rinsed or decontaminated in a tub of water, be sure to thoroughly clean and disinfect the tub.

Personal Gear and Clothing

- Remove organic debris prior to decontamination to ensure success.
- An adhesive roller can be used on clothing to remove seeds and plant materials.
- Note that hot water and steam may damage the seams of rain gear, waders, and boots.[F]
- Waders may take more than 48 hours to dry completely.[F]
- Whenever possible, use a dedicated or completely new set of gear for each waterbody during the work day and disinfect all gear at the end of the day.
- Consider purchase of wading gear and boots with the fewest places for organisms and debris to become attached. One-piece systems with full rubber material and open cleat soles are recommended to reduce likelihood of ANS spread. Mud/rock guards used with stocking-foot waders may minimize contamination on inside surfaces.

Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring and Response Field Activities

Dip nets, measuring boards, and other gear

- Remove any organic material prior to decontamination.
- Because dissolved oxygen probes and other sensitive electronic gear may be damaged by hand decontamination methods, they should only be rinsed with clean water and allowed to dry. See manufacturer's instructions for further directions on the cleaning of sensitive gear (Sondes, Hydrolabs, and dataloggers).
- For other gear, use steam, hot water, chlorine solution, or Virkon® Aquatic solution to disinfect equipment.
- If using chlorine or Virkon® Aquatic solution, fill a tub with the decontamination solution and place all equipment in the tub for the appropriate contact time. Alternatively, spray with a decontamination solution so that a wet surface is maintained for the appropriate contact time. All gear should be rinsed with clean water before reuse.
- Whenever possible, use a completely new set of gear for each waterbody visited and disinfect all gear at the end of the day.

Boats, trailers, and live wells

- Remove organic material from boats, trailers, and live wells prior to decontamination. Note that scrubbing could damage the anti-fouling paint/coating of some boat hulls, so check manufacturer recommendations.
- Drain water from live wells, bilges, and pumps.
- Whenever possible, foam rubber or carpet trailer pads should be removed when working in ANS infested waters.[C]
- All surfaces (inside and out) should be steam cleaned or sprayed with a decontamination solution and left wet for the appropriate contact time.
- Run pumps so that they take in the decontamination solution and make sure that the solution comes in contact with all parts of the pump and hose.
- If chlorine or Virkon® Aquatic is used, the boat, trailer, bilges, live well, and pumps should be rinsed with clean water after the appropriate contact time.
- Every effort should be made to keep the decontamination solution and rinse water out of surface waters. Pull the boat and trailer off the ramp and onto a level area where infiltration can occur and away from street drains to minimize potential runoff into surface waters.

Motors

- Scrub sediments off the exterior of the motor and then tip the motor down and allow water to drain from engine.
- Running a chemical solution through the engine may void the warranty or damage the engine. Always follow the manufacturer's recommendations as to the appropriate decontamination method.

ATTACHMENT B
LITERATURE REVIEW ON EFFICACY OF DECONTAMINATION METHODS BY SPECIES[N]

The following tables outline the effectiveness of various decontamination methods for eliminating (killing) common ANS and include citations for determinations.

Key:

√ = Effective
⊗ = Not Effective
Ⓡ = Additional Research Needed
? = Literature Review Needed

Supporting references are enumerated in superscript and can be found in the References section that follows Tables 1-3. Symbols shown without references depict commonly shared knowledge wherein references or studies that validate the information may exist, but have not yet been found.

Table 1. *Efficacy of treatment methods for macrophytes and algae.*

ANS	Steam Cleaning (212°F)	Hot Water (140°F)	Drying (5 days)	Chlorine (500 ppm)	Virkon® (2:100 solution)	Freezing (-3°C)
Curlyleaf Pondweed	Ⓡ	Ⓡ	√[3,55]	Ⓡ	Ⓡ	⊗[52]
Curlyleaf Pondweed (Turion)	√	√[53]	⊗[3]	Ⓡ	Ⓡ	?
Eurasian Watermilfoil	√	√[15]	√[12,55]	Ⓡ[57]	Ⓡ	⊗[58]
Eurasian Watermilfoil (Seed)	?	?	⊗[56]	?	?	?
Hydrilla	?	?	√[55,59,60,61]	?	?	?
Yellow Floating Heart	?	?	⊗[62]	?	?	?
Starry Stonewort	?	?	?	?	?	?
Didymo	√	√[13,70]	√[13,70]	√[13,48,49,50,51]	√[1]	√[70]

[N] These tables and the literature review contained within were reproduced from: Perdrock, A. 2015. Best Management Practices for Boat, Gear, and Equipment Contamination. State of Wisconsin, Department of Natural Resources, Bureau of Water Quality.

Table 2. *Efficacy of treatment methods for invertebrates.*

ANS	Steam Cleaning (212°F)	Hot Water (140°F)	Drying (5 days)	Chlorine (500 ppm)	Virkon® (2:100 solution)	Freezing (-3°C)
Faucet Snail	√	√[18]	⊗[18,35]	⊗[18]	Ⓡ[18]	√
New Zealand Mudsnail	√	√[4,65]	√[6,66]	⊗[21]	√[10,76]	√[4,6]
Quagga Mussel (Adults)	√[77]	√[7,16]	√[14,67]	√	√[9]	√
Quagga Mussel (Veligers)	√[77]	√[4,17]	√[69]	√	√[9]	√
Zebra Mussel (Adult)	√[77]	√[7,8,54,67]	√[14,25,67]	√[11,19,22]	Ⓡ	√[25,27,67,68]
Zebra Mussel (Veligers)	√[77]	√[4]	Ⓡ	√	Ⓡ	√
Asian Clam	√	√[4,37,41,42,43]	⊗[4,44,45]	⊗[36,37,38,39,40]	√[23]	√[46]
Spiny Waterflea (Adult)	√	√[7,47]	√[4]	Ⓡ	Ⓡ	Ⓡ
Spiny Waterflea (Resting Eggs)	√	√[2]	√[2]	⊗[2]	Ⓡ	√[2]
Bloody Red Shrimp	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ
Rusty Crayfish	?	?	?	?	?	?

Table 3. *Efficacy of treatment methods for viruses and diseases.*

ANS	Steam Cleaning (212°F)	Hot Water (140°F)	Drying (5 days)	Chlorine (500 ppm)	Virkon® (2:100 solution)	Freezing (-3°C)
Spring Viremia of Carp Virus (SVCv)	√	√[29,30,31,64]	⊗[4*]	√[28,29,30,64]	√[28]	⊗[29]
Largemouth Bass Virus (LMBv)	Ⓡ	Ⓡ	Ⓡ	√[24,28]	√[24,28]	⊗[32]
Viral Hemorrhagic Septicemia Virus (VHSv)	√	√[4,72,73]	√[4,72,74]	√[28]	√[28,72]	√[26,29,63] ⊗[75]
Lymphosarcoma	Ⓡ	Ⓡ	Ⓡ	√	Ⓡ	Ⓡ
Whirling Disease	√[33]	⊗[20,33,71]	√[5,33]	√[5,20,28,33]	Ⓡ	√[5,33]
Heterosporis	Ⓡ	Ⓡ	√[34]	√[34]	Ⓡ	√[34]

References

1. Root, S. and C.M. O'Reilly. 2012. Didymo control: increasing the effectiveness of decontamination strategies and reducing spread. Fisheries. 37(10):440-448.

   Tested the effectiveness of liquid dish detergent, bleach, Virkon®, and salt in killing Didymo. Found that longer submersion times did not significantly increase mortality and a one minute submersion time would be sufficient for all treatments. Exact mortality rates are not listed for each treatment, however, a graph shows the *effectiveness for 1% Virkon® solution at around 80% and the effectiveness for 2% bleach around 95%.*

2. Branstrator, D.K., L.J. Shannon, M.E. Brown, and M.T. Kitson. 2013. Effects of chemical and physical conditions on hatching success of *Bythotrephes longimanus* resting eggs. Limnology and Oceanography. 58(6):2171-2184.

   Frozen in water, not just in air; Hot water: 50°C (122°F) for >5 min (or 1 min at >50°C); Drying: ≥ 6 hr @ 17°C 63°F). Chlorine solutions of 3400 mg L-1 had no impact on hatching success when exposed for up to 5 min.

3. Bruckerhoff, L., J. Havel, and S. Knight. 2013. Survival of invasive aquatic plants after air exposure and implication for dispersal by recreation boats. Unpublished data.

   Studied the impacts of drying on the viability of Eurasian watermilfoil and curlyleaf pondweeds. For Eurasian watermilfoil, single stems were viable for up to 24hrs while coiled strands were viable for up to 72hrs. For curlyleaf pondweed, single stems were viable for 18hrs, and turions were still viable after 28 days of drying.

4. United States Forest Service. 2014. Preventing spread of aquatic invasive organisms common to the Intermountain Region. Intermountain Region Technical Guidance. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5373422.pdf.

   Outlines guidance to avoid spread of ANS during fire management and suppression activities. Recommends treatments for various species based on a literature review; references are outlined in this guidance. For quagga and zebra mussel adults and larvae: ≥140°F (60°C) hot water spray for 5 to 10 seconds, or hot water immersion of ≥120°F (50°C) for 1 minute. Freeze at 0°C for adults. Dry for 5 days. 0.5% bleach solution rinse. 2% Virkon® Aquatic solution for 10 minutes. Drying of >28 days at 70°F needed.

5. Hedrick, R.P., T.S. McDowell, K. Mukkatira, E. MacConnell, and B. Petri. 2008. Effects of freezing, drying, ultraviolet irradiation, chlorine, and quaternary ammonium treatments on the infectivity of myxospores of *Myxobolus cerebralis* for *Tubifex tubifex*. Journal of Aquatic Animal Health. 20(2):116-125.

   Chlorine concentrations of 500 mg/L for >15 minutes; freezing at either -20°C or -80°C for 7 days or 2 months.

6. Richards, D.C., P. O'Connell, and D. Cazier Shinn. 2004. Simple control method to limit the spread of the New Zealand mudsnail *Potamopyrgus antipodarum*. North American Journal of Fisheries Management. 24(1):114-117.

   Drying: Must ensure hot and dry environment (>84°F (~29°C) for 24 hours; ≥104°F (40°C) for >2 hours). Freezing: ≤27°F (-3°C) for 1 to 2 hours.

7. Beyer, J., P. Moy, and B. De Stasio. 2011. Acute upper thermal limits of three aquatic invasive invertebrates: hot water treatment to prevent upstream transport of invasive species. Environmental Management. 47(1):67-76.

   Recommends >43°C (110°F) for 5 to 10 minutes.

8. Morse, J.T. 2009. Assessing the effects of application time and temperature on the efficacy of hot-water sprays to mitigate fouling by *Dreissena polymorpha* (zebra mussels Pallas). Biofouling. 25(7):605-610.

   Recommends a minimum of ≥140°F (60°C) for >10 seconds.

9. Stockton, K.A. 2011. Methods to assess, control, and manage risks for two invasive mollusks in fish hatcheries. M.S. Thesis, University of Idaho.

10. Stockton, K.A. and C.M. Moffitt. 2013. Disinfection of three wading boot surfaces infested with New Zealand mudsnails. North American Journal of Fisheries Management. 33(3):529-538.

    Found that a 2% solution (77 grams/1 gallon water) for 15-20 minutes was effective at killing all NZMS.

11. Cope, W.G., T.J. Newton, and C.M. Gatenby. 2003. Review of techniques to prevent introduction of zebra mussels (*Dreissena polymorpha*) during native mussel (Unionoidea) conservation activities. Journal of Shellfish Research. 22(1):177-184.

    Literature review recommends use of chlorine solutions with concentrations ranging from 25-250 mg/L for disinfecting equipment and supplies.

12. Jerde, C.L., M.A. Barnes, E.K. DeBuysser, A. Noveroske, W.L. Chadderton, and D.M. Lodge. 2012. Eurasian

watermilfoil fitness loss and invasion potential following desiccation during simulated overland transport. Aquatic Invasions. 7(1):135-142.

13. Kilroy, C. 2005. Tests to determine the effectiveness of methods for decontaminating materials that have been in contact with *Didymosphenia geminata*. Christchurch: National Institute of Water & Atmospheric Research Ltd. Client Report CHC 2005-005.

    1% bleach solution resulted in 100% mortality after 30 seconds.

14. Ricciardi, A., R. Serrouya, and F.G. Whoriskey. 1995. Aerial exposure tolerance of zebra and quagga mussels (Bivalvia, Dressenidae) – implications for overland dispersal. Canadian Journal of Fisheries and Aquatic Sciences. 52(3):470-477.

    Adult Dreissena may survive overland transport for 3-5 days.

15. Blumer, D.L., R.M. Newman, and F.K. Gleason. Can hot water be used to kill Eurasian watermilfoil? Journal of Aquatic Plant Management. 47:122-127.

    Submerged at ≥60°C (140°F) for at 2-10 minutes.

16. Comeau, S., S. Rainville, W. Baldwin, E. Austin, S. Gerstenberger, C. Cross, and W.H. Wong. 2011. Susceptibility of quagga mussels (*Dreissena rostriformis bugensis*) to hot-water sprays as a means of watercraft decontamination. Biofouling. 27(3):267-274.

    Recommends a ≥140°F (60°C) spray for 5-10 seconds to mitigate fouling by quagga mussels.

17. Craft, C.D., and C.A. Myrick. 2011. Evaluation of quagga mussel veliger thermal tolerance. Colorado Division of Wildlife Task Order # CSU1003.

18. Mitchell, A.J. and R.A. Cole. 2008. Survival of the faucet snail after chemical disinfection, pH extremes, and heated water bath treatments. North American Journal of Fisheries Management. 28(5):1597-1600.

    Exposed faucet snails to various chemicals, temperatures and pH levels. Virkon® was only tested at a 0.16 and 0.21% solution. 100% of Snails exposed to a 1% solution of household bleach for 24hrs survived.

19. Harrington, D.K., J.E. VanBenschoten, J.N. Jensen, D.P. Lewis, and E.F. Neuhauser. 1997. Combined use of heat and oxidants for controlling adult zebra mussels. Water Research. 31(11):2783-2791.

20. Wagner, E.J. 2002. Whirling disease prevention, control, management: a review. American Fisheries Society. 29:217-225.

    This is a literature review of different chemical and physical control methods of the parasite that causes whirling disease. Studies identified in this review indicate that 5,000 ppm chlorine for 10 min killed the intermediate spores that infect tubifex worms that lead to whirling disease in fish. 130-260 ppm chlorine was recommended in treatment of the direct spores that infect fish. Temperature is effective treatment at 75°C for 10 minutes, but 70°C for 100 minutes was not effective. Recommended heat of 90°C for 10 minutes; bleach at 1600 ppm for 24 hours, or 5000 ppm for 10 minutes.

21. Hosea, R.C. and B. Finlayson. 2005. Controlling the spread of New Zealand mud snails on wading gear. State of California Department of Fish and Game, Office of Spill Prevention and Response, Administrative Report 2005-02.

    NZMS exposed to various dilutions of household bleach for 5 minutes. The only concentration to show an impact was undiluted bleach.

22. Sprecher, S.L., and K.D. Getsinger. 2000. Zebra mussel chemical control guide. United States Army Corps of Engineers – Engineer Research and Development Center. ERDC/EL TR-00-1.

23. Barbour, J.H., S. McMenamin, J.T.A. Dick, M.E. Alexander, and J. Caffrey. 2013. Biosecurity measures to reduce secondary spread of the invasive freshwater Asian clam, *Corbicula fluminea* (Müller, 1774). Management of Biological Invasions. 4(3):219-230.

24. Kipp, R.M., A.K. Bogdanoff, and A. Fusaro. 2014. Ranavirus. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Revision Date: 8/17/2012. http://nas.er.usgs.gov/queries/GreatLakes/SpeciesInfo.asp?NoCache=5%2F6%2F2011+6%3A17%3A25+PM&SpeciesID=2657&State=&HUCNumber=DGreatLakes>.

Recommends 10% bleach/water solution.

25. Boelman, S.F., F.M. Neilson, E.A. Dardeau Jr., and T. Cross. 1997. Zebra mussel (*Dreissena polymorpha*) control handbook for facility operators, First Edition. US Army Corps of Engineers, Zebra Mussel Research Program. Miscellaneous Paper EL-97-1.

    Must ensure hot and dry environment: >25°C for at least 2 days, or 5 days when humidity is high.

26. Batts, W.N. and J.R. Winton. 2012. Viral hemorrhagic septicemia. USGS Western Fisheries Research Center. http://afs-fhs.org/perch/resources/14069231582.2.7vhsv2014.pdf.

27. McMahon, R.F., T.A. Ussery, and M. Clarke. 1993. Use of emersion as a zebra mussel control method. US Army Corps of Engineers Contract Report EL-93-1. http://el.erdc.usace.army.mil/elpubs/pdf/crel93-1.pdf.

28. Yanong, R.P.E. and C. Erlacher-Reid. 2012. Biosecurity in aquaculture, part 1: an overview. Southern Regional Aquaculture Center, SRAC Pub. No. 4707.

    This publication provides an overview of major concepts in biosecurity for aquaculture and is not a scientific study. Based on research (Bowker et al. 2011), recommends chlorine 500 mg/L for 15 minutes or Virkon® Aquatic 0.5 to 1% for 10 minutes to disinfect whirling disease virus, VHS, LMBv, and SVCv. Specifically, for SVCv: bleach = 500 mg/L for 10 minutes, Virkon® = 0.5-1% for 10 minutes or 0.1% for 30 minutes; for VHS: bleach = 200-500 mg/L for 5 minutes, Virkon® = 0.5-1% for 10 minutes; for Whirling Disease: bleach = 500 mg/L for 10-15 minutes, Virkon® = 0.5-1% for 5 minutes; for LMBv: bleach = 500 mg/L for 15 minutes, Virkon® = 0.5-1% for 1 minute.

29. World Organization for Animal Health. 2012. Manual of Diagnostic Tests for Aquatic Animals. http://www.oie.int/international-standard-setting/aquatic-manual/access-online/.

    Direct quotes:

    "The virus is inactivated at 56°C for 30 minutes, at pH 12 for 10 minutes and pH 3 for 2 hours (Ahne,1986)."

    "The following disinfectants are also effective for inactivation… 540 mg litre–1 chlorine for 20 minutes, 200–250 ppm (parts per million… (Ahne, 1982; Ahne & Held, 1980; Kiryu et al., 2007)."

    "The virus is most stable at lower temperatures, with little loss of titre for when stored for 1 month at -20°C, or for 6 months at -30 or -74°C (Ahne, 1976; Kinkelin & Le Berre, 1974)."

    VHSv reference in the above source was quote from another study Arkush, et. Al 2006, this reference has been added. (75)

30. Iowa State University: College of Veterinary Medicine. 2007. Spring Viremia of Carp. http://www.cfsph.iastate.edu/Factsheets/pdfs/spring_viremia_of_carp.pdf.

    Direct Quote:

    "It can be inactivated with…chlorine (500 ppm)… SVCv can also be inactivated by heating to 60°C (140°F) for 30 minutes…" No contact time was given for the bleach solution.

31. Kiryu, I., T. Sakai, J. Kurita, and T. Iida. 2007. Virucidal effect of disinfectants on spring viremia of carp virus. Fish Pathology. 42(2):111-113.

    This study reviewed past literature and displayed the following results: using a Bleach concentration of 7.6ppm for a contact time of 20 min. resulted in 99-99.9% inactivation of SVCv and a concentration of 540 ppm for a 20 minute contact time resulted in >99.9% inactivation of SVCv. This paper also reveals that 45°C heat treatments for 10 minutes have been found SVCv to be 99-99.9% inactivated, while 60°C heat treatments for 30 minutes was recommended for sterilization.

32. Plumb, J.A. and D. Zilberg. 1999. Survival of largemouth bass iridovirus in frozen fish. Journal of Aquatic Animal Health. 11(1):94-96.

    This study found LMBv to be very stable when frozen at -10°C in fresh fish tissue. Infectious doses were still found after freezing for 155 days in fish tissue.

33. Wagner, E.J., M. Smith, R. Arndt, and D.W. Roberts. 2003. Physical and chemical effects on viability of the *Myxobolus cerebralis* triactinomyxon. Diseases of Aquatic Organisms 53(2):133-142.

Various chemical and physical methods for destroying the triactinomyxon (TAM) stage of the myxozoan parasite Myxobolus cerebralis were tested at different exposure/doses. Freezing for 105 minutes at -20°C or drying for 1 hour at 19-21°C, chlorine concentrations of 130 ppm for 10 min, immersion in 75°C water bath for 5 minutes all produced 0% viability of the parasite which causes whirling disease. However at 58°C water bath for 5 minutes, as much as 10% remain possibly viable.

34. DNR/GLFC guidance. 2005. http://dnr.wi.gov/topic/fishing/documents/fishhealth/heterosporis_factsheet.pdf.

    Direct Quote:

    "Immerse gear in a chlorine bleach solution for five minutes (3 cups of household bleach in 5 gallons of water). Freezing at -4 °F for 24 hours (home freezer) will also kill the spores….completely dry for a minimum of 24 hours for dessication to effectively kill the spores."

35. Wood, A.M., C.R. Haro, R.J. Haro, and G.J. Sandland. 2011. Effects of desiccation on two life stages of an invasive snail and its native cohabitant. Hydrobiologia. 675:167-174.

    Compared the effects of desiccation on adults and egg viability on faucet snails and a native snail. Results found desiccation for 7 days produced 73% mortality in faucet snail eggs, and only 62% mortality in adult faucet snails.

36. Ramsay, G.G., J.H. Tackett, and D.W. Morris. 1988. Effect of low-level continuous chlorination on *Corbicula fluminea*. Environmental Toxicology and Chemistry. 7:855-856.

    Evaluated long exposure times (2-28 days) at low concentrations (0.2-40 mg/L) of chlorine.

37. Mattice, J.S., R.B. McLean, and M.B. Burch. 1982. Evaluation of short-term exposure to heated water and chlorine for control of the Asiatic clam (*Corbicula fluminea*). Technical Report ORNL/TM-7808. Oak Ridge National Lab., TN (USA).

    Evaluated short exposure times (30 minutes) at low concentrations (0, 5, 7.5, and 10 mg/L) of chlorine. Found mortality at 35-43°C (95-110°F) water.

38. Belanger, S.E., D.S. Cherry, J.L. Farris, K.G. Sappington, J. Cairns Jr. 1991. Sensitivity of the Asiatic clam to various biocidal control agents. Journal of the American Water Works Association. 83(10):79-87.

    Long exposure time (14-28 days) to low rates (0.25-.04 mg/L) of chlorination.

39. Doherty, F.G., J.L. Farris, D.S. Cherry, and J. Cairns Jr. 1986. Control of the freshwater fouling bivalve *Corbicula fluminea* by halogenation. Archives of Environmental Contamination and Toxicology. 15(5):535-542.

    Long exposure time (28-32 days) to low rates (0.2-1 mg/L) of chlorination.

40. Chandler, J.H. and L.L. Marking. 1979. Toxicity of fishery chemicals to the Asiatic clam, *Corbicula manilensis*. Progressive Fish-Culturist. 41:148-51.

    Tested concentrations of various chemicals on Asiatic clam. Clorine solutions derived from Calcium hypochlorite had a 96-hr LC_{50} of 1450mg/L.

41. Habel, M.L. 1970. Oxygen consumption, temperature tolerance, filtration rate of introduced Asiatic clam *Corbicula manilensis* from the Tennessee River. MS Thesis, Auburn University, Auburn, Alabama, 66 pp.

    Found mortality at 35-43°C (95-110°F) water.

42. Coldiron, D.R. 1975. Some aspects of the biology of the exotic mollusk *Corbicula* (Bivalvia: Corhiculidae). MS Thesis, Texas Christian University, Fort Worth, Texas, 92 pp.

    Found mortality at 35-43°C (95-110°F) water.

43. Cherry, D.S., J.H. Rodgers Jr., R.L. Graney, and J. Cairns Jr. 1980. Dynamics and control of the Asiatic clam in the New River, Virginia. Bulletin 123, Virginia Water Resources Research Center, Virginia Polytechnic Institute & State University, 72 pp.

    Found mortality at 35-43°C (95-110°F) water.

44. McMahon, R.F. 1979. Tolerance of aerial exposure in the Asiatic freshwater clam *Corbicula fluminea* (Muller). In Proceedings, First International Corbicula Symposium, ed. by J. C. Britton, 22741, Texas Christian University Research Foundation.

    Two weeks needed for mortality.

45. Dudgcon, D. 1982. Aspects of the dessication tolerance of four species of benthic Mollusca from Plover Cove Reservoir, Hong Kong. Veliger. 24:267-271.

46. Müller, O. and B. Baur. 2011. Survival of the invasive clam *Corbicula fluminea* (Müller) in response to winter water temperature. Malacologia. 53(2):367-371.

    Lethal temperature reorted at 0°C; freezing is possible control method that warrants research.

47. Garton, D.W., D.L. Berg, and R.J. Fletcher. 1990. Thermal tolerances of the predatory cladocerans *Bythotrephes cederstroemi* and *Leptodora kindti*: relationship to seasonal abundance in Western Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences. 47:731-738.

    >38°C (100°F) for 12 hours.

48. Kilroy, C., A. Lagerstedt, A. Davey, and K. Robinson. 2006. Studies on the survivability of the invasive diatom *Didymosphenia geminata* under a range of environmental and chemical conditions. Christchurch: National Institute of Water & Atmospheric Research.

49. Jellyman, P.G, S.J. Clearwater, B.J.F. Biggs, N. Blair, D.C. Bremner, J.S. Clayton, A. Davey, M.R. Gretz, C. Hickey, and C. Kilroy. 2006. *Didymosphenia geminata* experimental control trials: stage one (screening of biocides and stalk disruption agents) and stage two phase one (biocide testing). Christchurch: National Institute of Water & Atmospheric Research Ltd.

50. Beeby, J. 2012. Water quality and survivability of *Didymosphenia geminata*. Colorado State University, Master's Thesis Dissertation.

    Tested the impact of chlorine solutions at the doses of 1.3, 2.5, 5.0, and 10 mg/L.

51. Jellyman, P.G., S.J. Clearwater, J.S. Clayton, C. Kilroy, C.W. Hickey, N. Blair, and B.J.F. Biggs. 2010. Rapid screening of multiple compounds for control of the invasive diatom *Didymosphenia geminata*. Journal of Aquatic Plant Management. 48:63-71.

52. USDA-NRCS, 2009. Curly-leaf pondweed. The PLANTS Database Version 3.5. Baton Rouge, USA: National Plant Data Center. http://plants.usda.gov.

    Minimum temp of -33°F; freezing unlikely to cause mortality.

53. Barr, T.C. III. 2013. Integrative control of curly leaf pondweed propagules employing benthic bottom barriers: physical, chemical and thermal approaches. University of California – Davis. Ph.D Dissertation.

    Study tested the pumping of heated water under bottom barriers to inhibit turion sprouting. Turions were exposed to treatments and then given recovery period. Those that did not sprout were believed to be unviable. Water of temperatures between 60-80°C (140-176°F) for 30 seconds was sufficient to inhibit growth.

54. Rajagopal, S., G. Van Der Velde, M. Van Der Gaag, and H.A. Jenner. 2005. Factors influencing the upper temperature tolerances of three mussel species in a brackish water canal: size, season and laboratory protocols. Biofouling. 21:87-97.

55. Barnes, M.A., C.L. Jerde, D. Keller, W.L. Chadderton, J.G. Howeth, D.M. Lodge. 2013. Viability of aquatic plant fragments following desiccation. Invasive Plant Science and Management. 6(2):320-325.

    Hydrilla reported as "fastest drying plant" of 10 species tested; however, additional viability testing not done due to state transport laws.

56. Standifer, N.E. and J.D. Madsen. 1997. The effect of drying period on the germination of Eurasian watermilfoil seeds. Journal of Aquatic Plant Management. 35:35-36.

    EWM seeds are viable to excessive periods of desiccation.

57. Watkins, C. H. and R. S. Hammerschlag. 1984. The toxicity of chlorine to a common vascular aquatic plant. Water Research. 18(8):1037-1043.

Study looked at impact of low chlorine concentrations (0.02, 0.05, 0.1, 0.3,0.5, and 1.0mgL-1) on Eurasian watermilfoil growth over 96-hr period. Rate reductions ranged from 16.2% for plants grown with chlorine concentrations of .05 mgL-1 to 88.2% reduction in growth in a chlorine concentration of 1.0 mg-1.

58. Patten Jr., B.C. 1955. Germination of the seed of *Myriophyllum spicatum L.* in a New Jersey lake. Bulletin of the Torrey Botanical Club. 82(1):50-56.

EWM seeds likely experience increased viability after freezing.

59. Silveira, M.J., S.M. Thomaz, P.R. Mormul, and F.P. Camacho. 2009. Effects of desiccation and sediment type on early regeneration of plant fragments of three species of aquatic macrophytes. International Review of Hydrobiology. 94(2):169-178.

Fragments of Hydrilla was left on trays of sand and clay for 1-4 days inside a greenhouse. Samples left in clay were still viable after 1-4 days of desiccation, however, not sprouts were produced in the sand treatment after one day of drying.

60. Kar, R.K. and M.A. Choudhuri. 1982. Effect of desiccation on internal changes with respect to survival of *Hydrilla verticillata*. Hydrobiological Bulletin. 16(2-3):213-221.

Twigs of Hydrilla verticillata were dried for periods of up to 24hrs and then analyzed for signs of life. Respiration continued for at least 20hrs.

61. Basiouny, F.M., W.T. Haller, and L.A. Garrard. 1978. Survival of Hydrilla (*Hydrilla verticillata*) plants and propagules after removal from the aquatic habitat. Weed Science. 26:502–504.

Hydrilla plants and propagules were dried for up to 7 days, and then replanted. 16hrs of drying resulted in no regeneration of plant fragments, while drying tubers 120 hours and turions for 32 hours resulted in no new sprouting.

62. Smits, A. J.M., R. Van Ruremonde, and G. Van der Velde. 1989. Seed dispersal of three nymphaeid macrophytes. Aquatic Botany. 35:167-180

N. peltata seeds show high tolerance to desiccation.

63. Arkush, K.D., H.L. Mendonca, A.M. McBride, S. Yun, T. S. McDowell, and R. P. Hedrick. 2006. Effects of temperature on infectivity and of commercial freezing on survival of the North American strain of viral hemorrhagic septicemia virus (VHSV). Diseases of Aquatic Organisms. 69:145-151.

Freezing will not completely kill the virus but will reduce infectivity of virus titres by 90%.

64. Ahne, W., H.V. Bjorklund, S. Essbauer, N. Fijan, G. Kurath, J. R. Winton. 2002. Spring viremia of carp (SVC). Diseases of Aquatic Organisms. 52:261-272.

65. Dwyer, W., B. Kerans, and M. Gangloff. 2003. Effects of acute exposure to chlorine, copper sulfate, and heat on survival of New Zealand mudsnails. Intermountain Journal of Sciences. 9:53-58.

>50°C (122°F) for 15 seconds

66. Alonso, A. and P. Castro-Diez. 2012. Tolerance to air exposure of the New Zealand mudsnail *Potamopyrgus antipodarum* (Hydrobiidae, Mollusca) as a prerequisite to survival in overland translocations. NeoBiota. 14:67-74.

Dry in full sunlight for >50 hours.

67. McMahon, R.F. 1996. The physiological ecology of the zebra mussel, *Dreissena polymorpha*, in North America and Europe. American Zoologist. 36(3):339-363.

68. Clarke, M. 1993. Freeze sensitivity of the zebra mussel (*Dreissena polymorpha*) with reference to dewatering during freezing conditions as a mitigation strategy. M.S.Thesis. The University of Texas at Arlington, Arlington, Texas.

69. Choi, W.J., S. Gerstenberger, R.F. McMahon, and W.H. Wong. 2013. Estimating survival rates of quagga mussel (*Dreissena rostriformis bugensis*) veliger larvae under summer and autumn temperature regimes in residual water of trailered watercraft at Lake Mead, USA. Management of Biological Invasions. 4(1):61-69.

Veligers experienced 100% mortality after 5 days under summer temperature conditions, and after approximately 27 days under autumn conditions.

70. Kilroy, C., A. Lagerstedt, A. Davey, and K. Robinson. 2007. Studies on the survivability of the invasive diatom *Didymosphenia geminata* under a range of environmental and chemical conditions. Biosecurity New Zealand NIWA Client Report: CHC2006-116. National Institute of Water and Atmospheric Research LTD. Christchurch, New Zealand.

Studied the survivability of D. geminata to determine optimum growing conditions. Then tested the use of disinfection methods on D. geminata being grown in optimum conditions. 100% Cell mortality occurred after 20 min with 40^{o}C water, but 60^{o}C for at least one minute is recommended for rapid treatment. Freezing is stated to be effective at killing D. geminata, however, this study does not list treatment times. A 1% chlorine solution was effective after 1 minute, and a 0.5% solution took 100 minutes to kill ~90% of specimens.

71. Hoffman, G.L. and M. E. Marliw. 1977. Control of whirling disease (*Myxosoma cerebralis*): use of methylene blue staining as a possible indicator of effect of heat on spores. Journal of Fish Biology. 10:181-183.

72. Bovo, G., B. Hill, A. Husby, T. Hästein, C. Michel, N. Olesen, A. Storset, and P. Midtlyng. 2005. Work Package 3 Report: Pathogen survival outside the host, and susceptibility to disinfection. Report QLK2-Ct-2002-01546: Fish Egg Trade. Veterinary Science Opportunities (VESO). Oslo, Norway.

73. Jørgensen, P. 1974. A study of viral diseases in Danish rainbow trout: their diagnosis and control. Thesis, Royal Veterinary and Agricultural University, Copenhagen. 101pp.

122°F (50°C) for 10 minutes or 122°F (50°C)

74. Pietsch, J., D. Amend, and C. Miller.1977. Survival of infectious hematopoietic necrosis virus held under various conditions. Journal of Fisheries Research Board of Canada. 34:1360-1364.

Study done on IHNH virus (similar to VHSv); dry gear for 4 days at 21°C (70°F).

75. Arkush K.D., H.L. Mendonca, A.M. McBride, S. Yun, T.S. McDowell, and R.P Hedrick. 2006. Effects of temperature on infectivity and of commercial freezing on survival of the North American strain of viral hemorrhagic septicemia virus (VHSV). Dis Aquat Organ. 69(2-3):145-51.

In 2006, Arkush et al. found that commercial freezing (held at -20^{o}C for 2 weeks after blast freezing at-40^{o}C) of in vitro VHSv shown a significant 99.9% reduction of the active virus post thaw.

76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

Virkon® was found to be effective after trials of 1, 5, and 10 minute exposures to a 2% solution. Bleach and 409 were also tested. Bleach was found to be effective at 5, 10, and 20 minute exposures to a 400 ppm solution.

77. DiVittorio, J., M. Grodowitz, and J. Snow. 2010. Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species [2010 Edition]. U.S. Department of the Interior Bureau of Reclamation. Technical Memorandum No. 86-68220-07-05.

Mentioned steam cleaning as effective, however, no reference or study provided to validate claim.

Appendix D: Detailed Maps of Fixed and Random Site Sampling Locations

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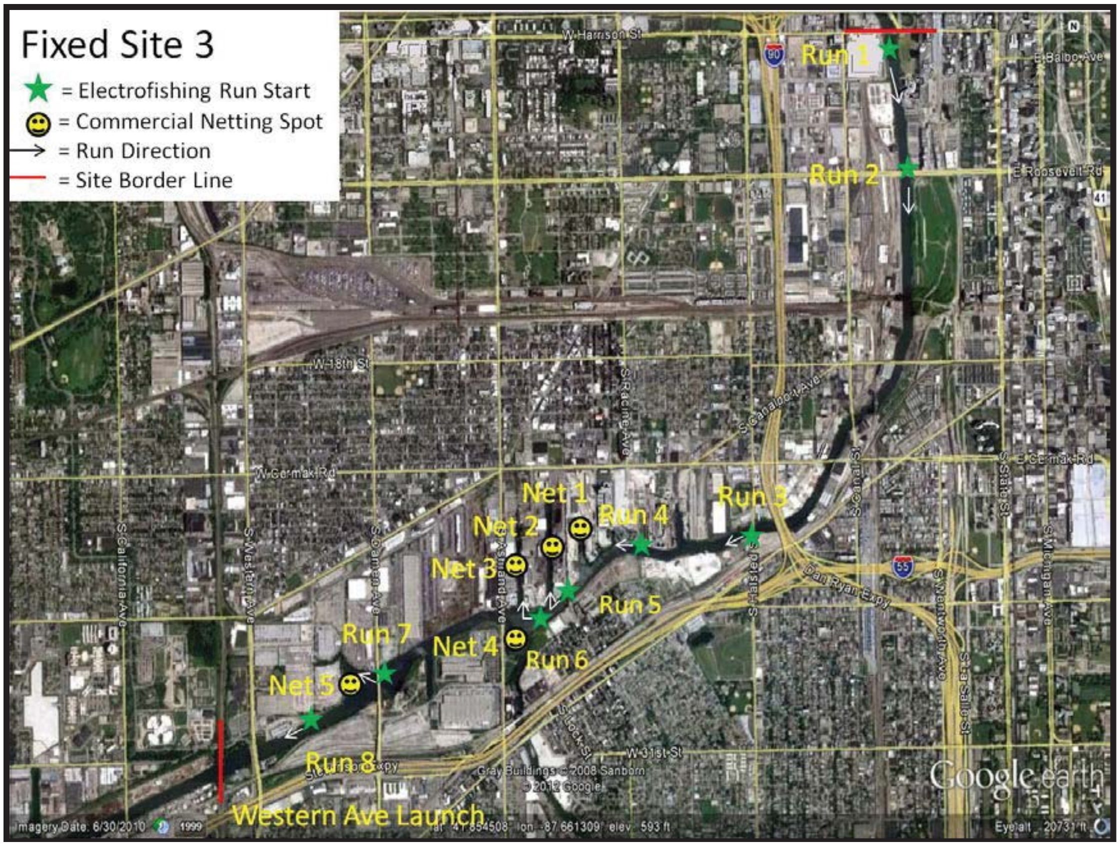

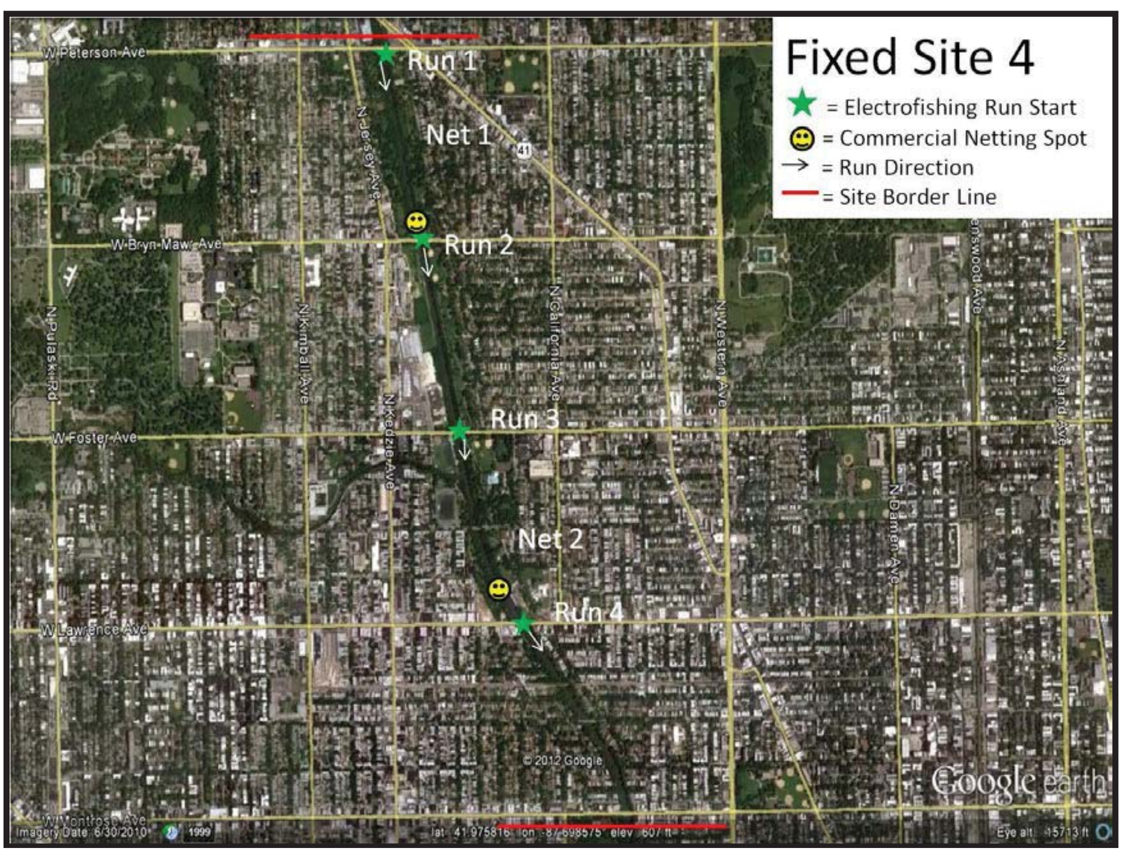

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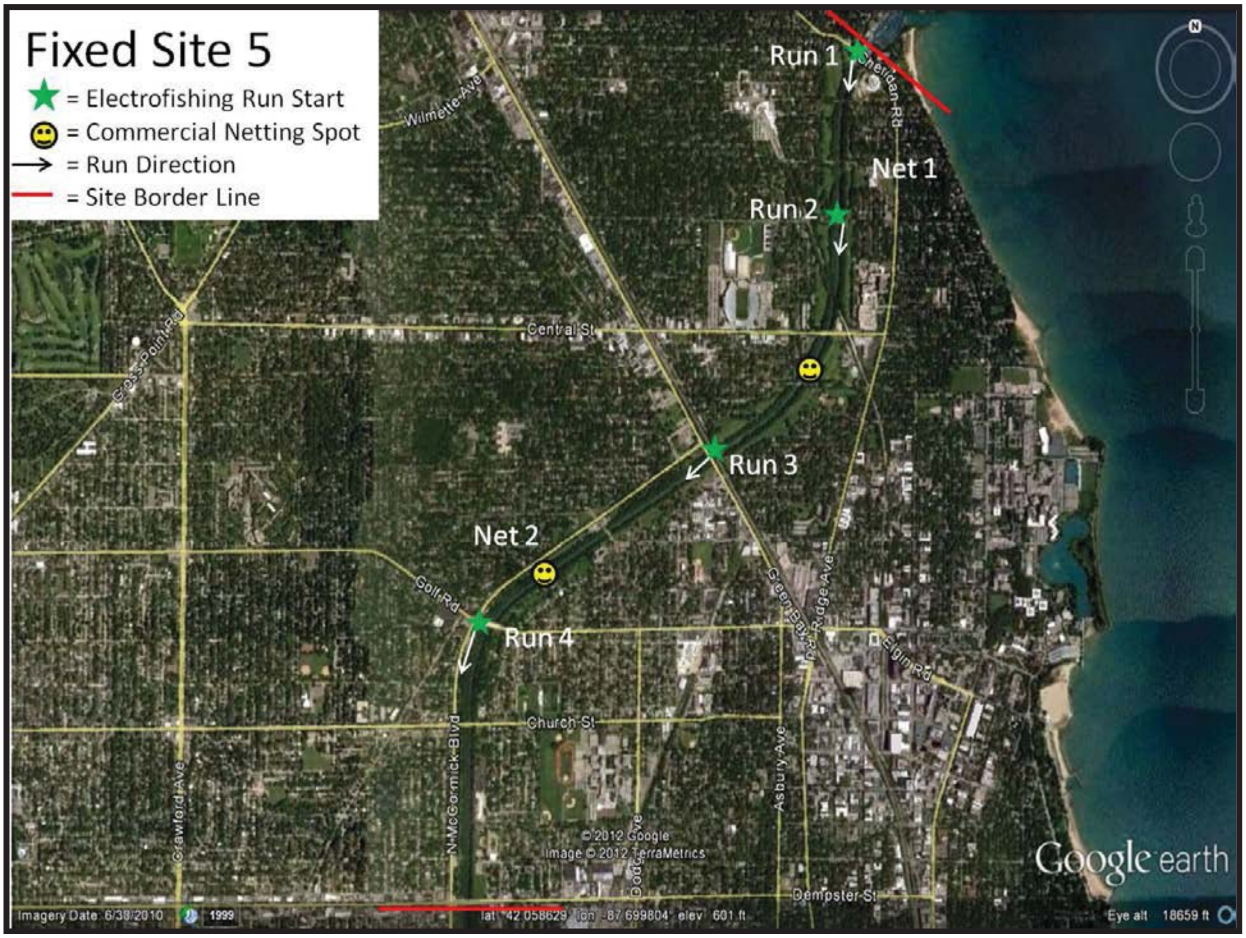

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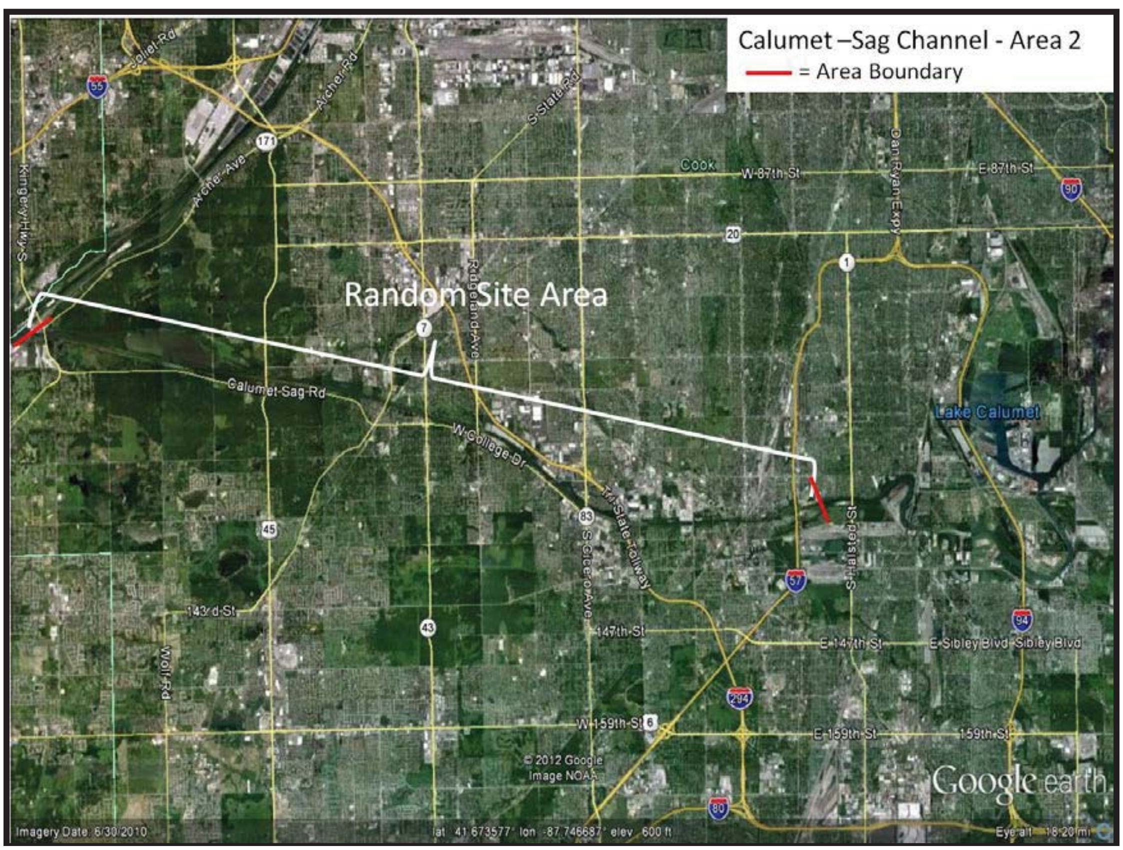

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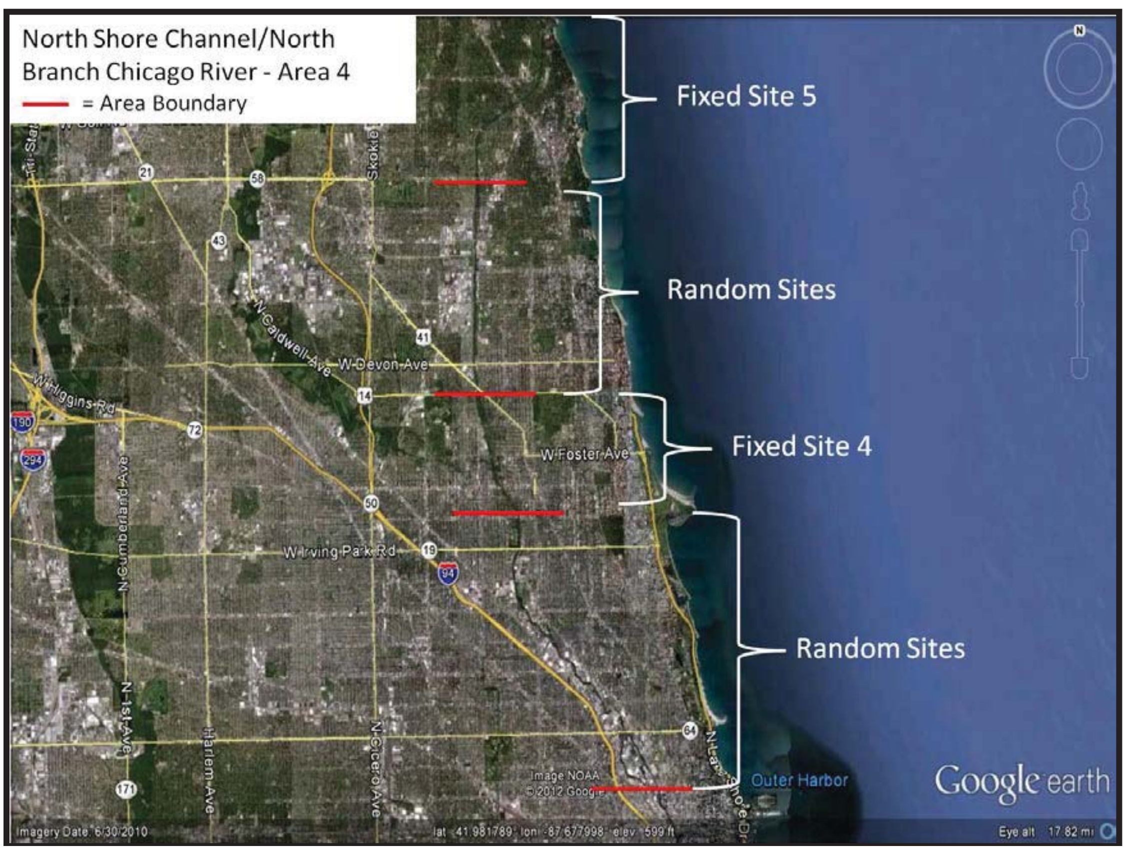

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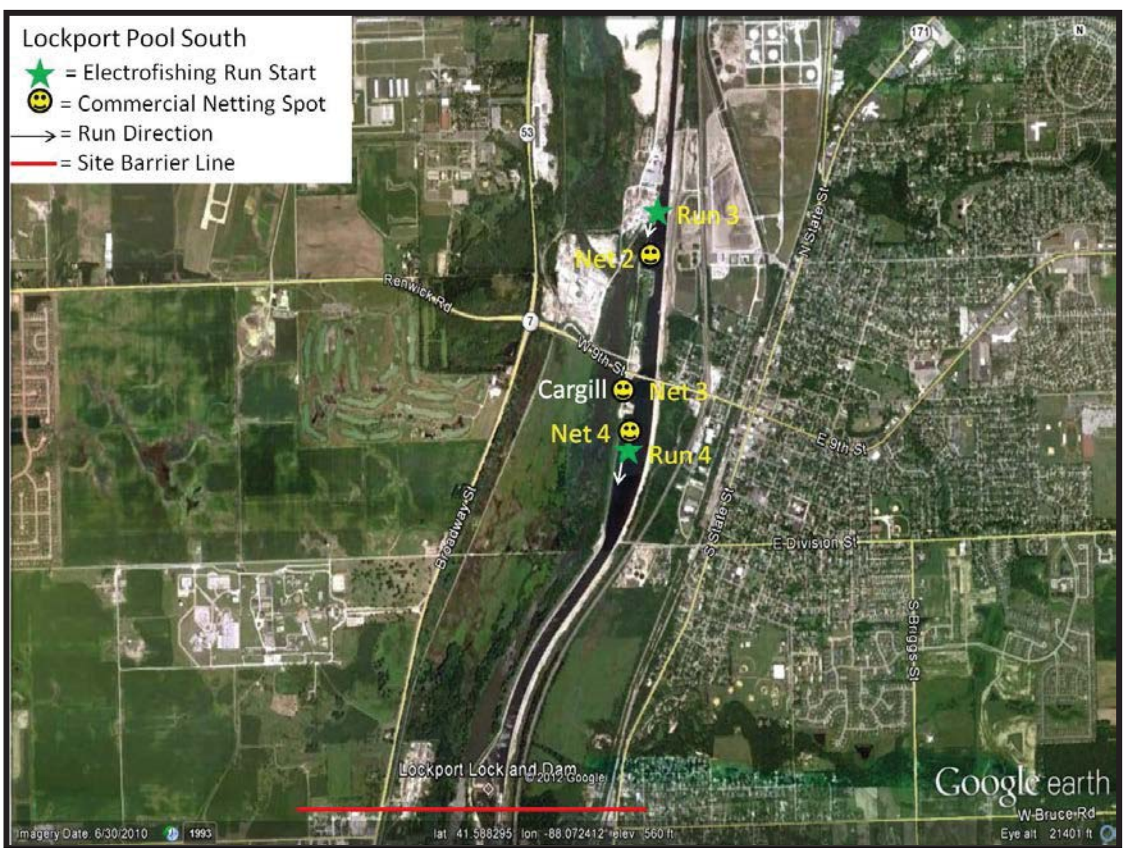

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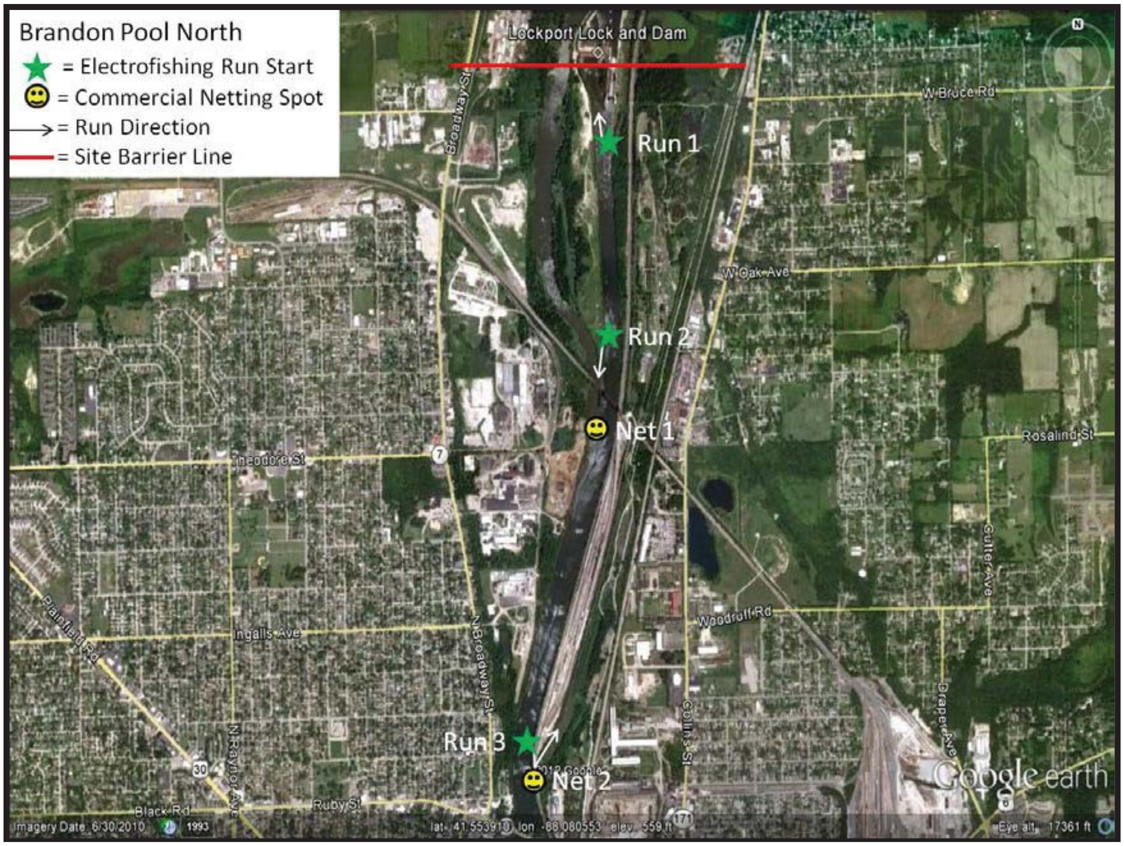

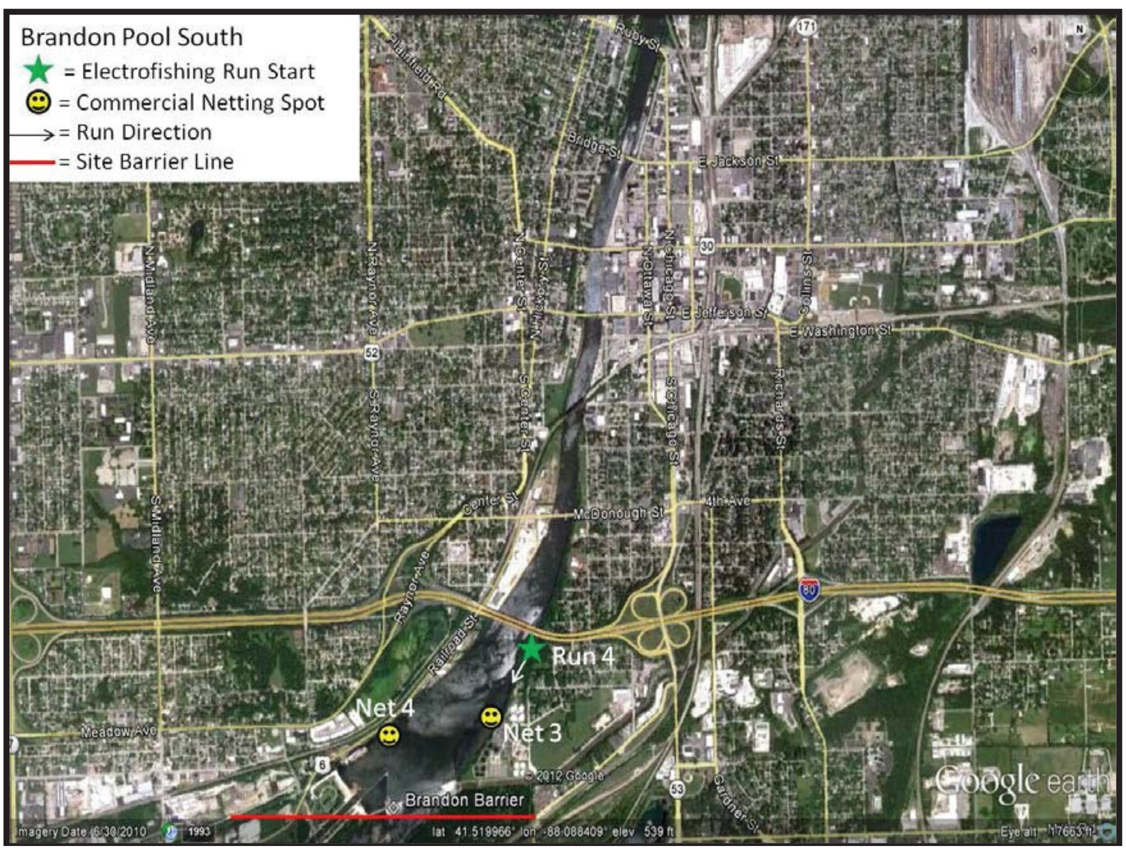

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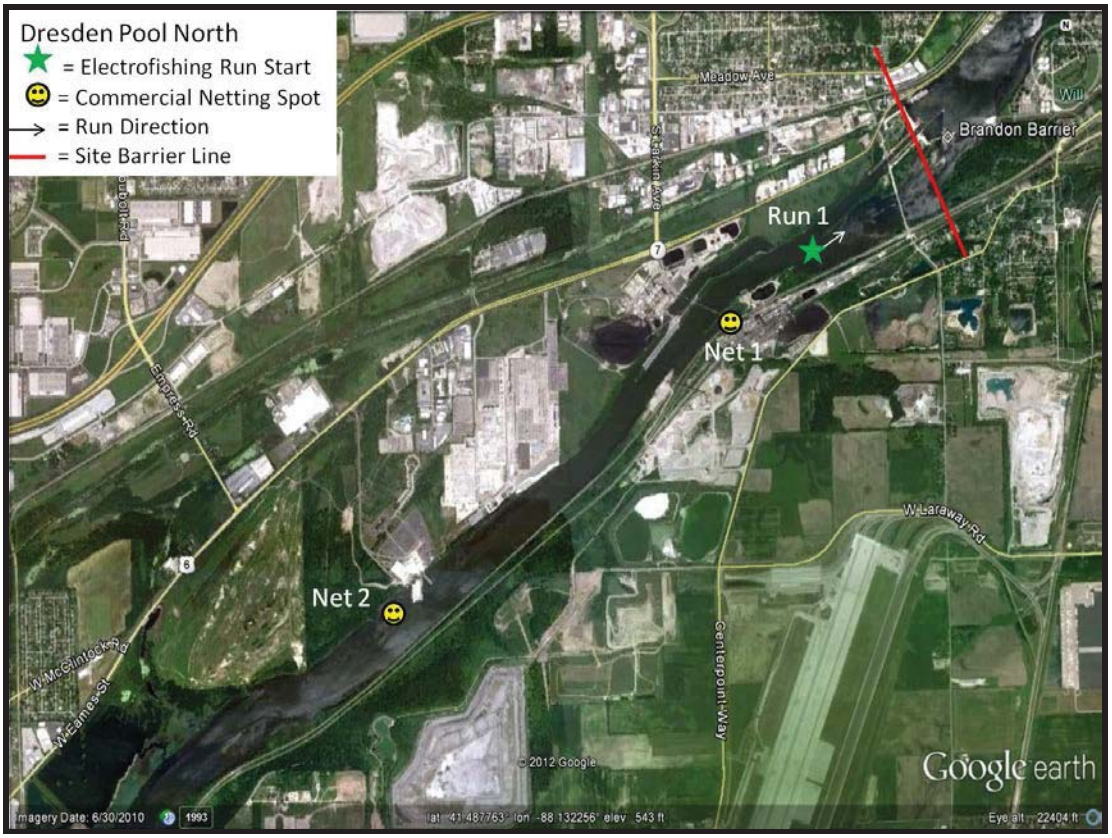

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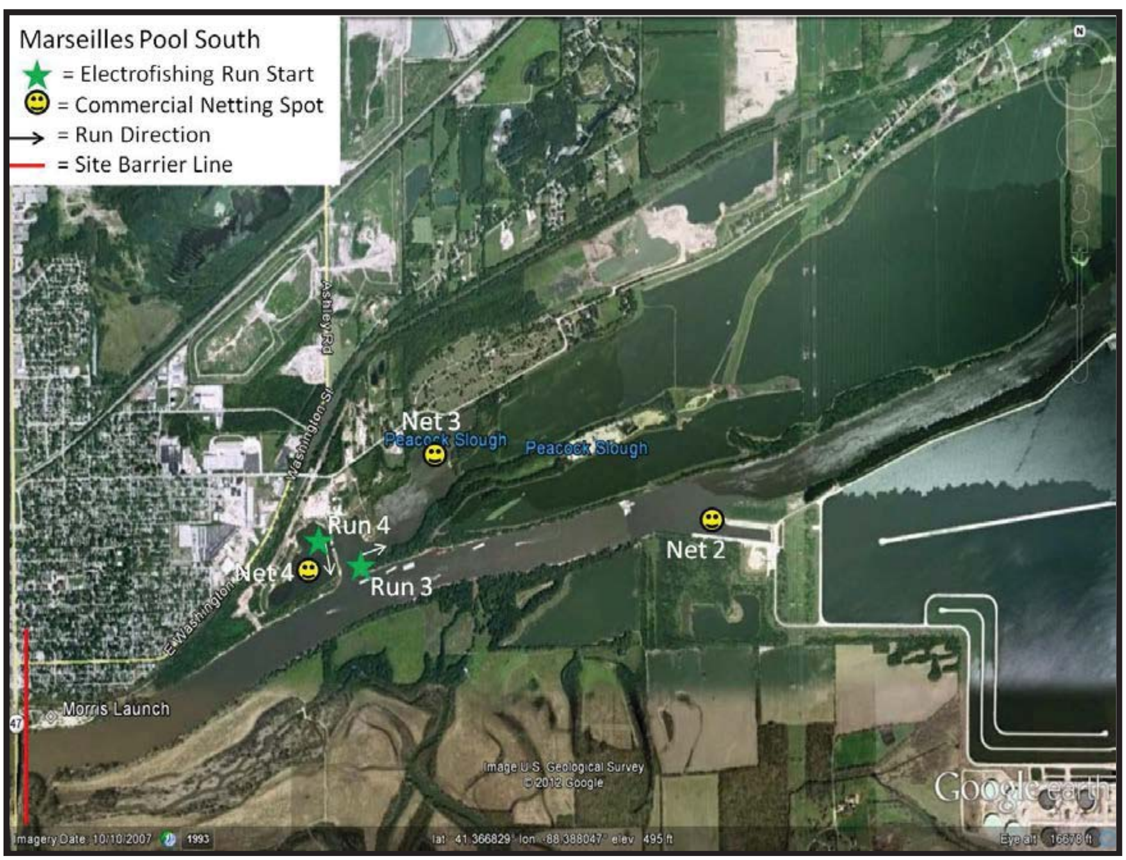

Appendix E: Handling Captured Asian Carp and Maintaining Chain-of-Custody Records

Chain-of-custody is a legal term that refers to the ability to guarantee the identity and integrity of a sample from collection through reporting of the test results. The following are general guidelines to keep chain-of-custody intact throughout the fish collection process.

These procedures should be followed when any Bighead or Silver carp is collected in the Chicago Area Waterway (from Lockport Lock and Dam to Lake Michigan, but also areas where they have not previously been collected (e.g. Brandon Road Pool, Des Plaines River, or Lake Michigan).

1. Keep the number of people involved in collecting and handling samples and data to a minimum.

2. Only allow authorized people associated with the project to handle samples and data. Always document the transfer of samples and data from one person to another on chain-of-custody forms. No one who has signed the chain-of-custody form shall relinquish custody without first having the chain-of-custody form signed by the next recipient.

3. Always accompany samples and data with their chain-of-custody forms. The chain-of - custody form must accompany the sample.

4. Ensure that sample identification and data collected are legible and written with permanent ink.

Specific Instructions for Handling Asian Carp:

1. A. If the boat crew believes they have collected an Asian carp, they should cease further collection and take a GPS reading of the location at which the Asian carp was found or mark the location on a map provided.

   B. The boat crew leader should immediately notify a lead operations coordinator or chief, who will immediately notify the Incident Commander and the Conservation Police Commander, if present. If a command structure is not in place, then immediately contact an Illinois Conservation Police Officer (CPO) by contacting the IDNR Region 2 law office at 847-608-3100 x 2056.

   C. The boat crew will then take the fish to a staging area for identification by the fish biologist stationed at the site. If a staging area has not been designated, the boat crew should proceed to a predetermined meeting location and await the arrival of the CPO. The boat crew will not leave until the CPO arrives and they have recorded the GPS reading on a chain-of-custody form and signed the form over to the CPO. The CPO is to remain with the fish at all times.

   D. Once a fish biologist at the staging area makes a positive visual identification, he/she will identify the fish with a fish tag; take pictures of the tagged fish (See spawn patch preservation and analysis appendix for photo request, Appendix H); measure its total length (mm) and weight (g); determine the fish's gender; identify reproductive status and gonad development as immature, mature – green, mature – ripe, mature - running ripe, and mature – spent; place the fish in a plastic bag; and seal the fish in a cooler with wet ice. The fish biologist at the staging area will place evidence tape across the opening of the cooler and initial it. The fish biologist at the staging area or when no staging area has been designated, the boat crew leader will give the sealed cooler to the IDNR CPO. The fish is to remain under IDNR control at all times.

E. The CPO will then deliver the sealed fish and chain-of-custody form to the sampling laboratory on site or make arrangements for transport to the genetics laboratory at the University of Illinois (contact: Dr. John Epifanio). Soft tissue for genetic testing and hard tissue for aging and/or chemical analysis will be removed at the UIUC laboratory. Additional soft tissue samples will be collected for other cooperating genetics laboratories (e.g., ERDC), as needed. Hard tissue will be transported to SIUC for analysis (contact: Dr. Jim Garvey). Chain-of-custody will be maintained when transporting hard tissue between university laboratories.

2. Only authorized IDNR tissue samplers or persons designated by an operations coordinator or chief will unseal the fish and remove the tissue samples from the fish for preservation and delivery to the lab. The lab samples will maintain the same sample ID as the subject fish but will also include an additional sequential letter (AC 001a, AC001b, AC002a, AC002b, etc) for multiple tissue samples from one fish. While sampling is occurring, the fish and samples will remain under supervision of the IDNR CPO who will maintain the chain-of-custody form.

3. All Asian carp captured during rapid response actions should be treated with care, handled minimally (no photo ops prior to tissue sampling), and transported to the staging area where they will be stored on ice in a cooler (no plastic bags). Captured fish cannot be frozen or preserved with chemicals, as these techniques distort the DNA. The USACE Engineer Research and Development Center (ERDC) has been designated to obtain a tissue sample from any Bighead Carp or Silver Carp collected during a rapid response action. The preferred tissue for DNA analysis is a pectoral fin (the entire fin) removed with a deep cut in order to include flesh and tissue of the fin base. The fin and tissue sample will be stored in a vial containing ethanol preservative (USACE will provide vials and preservative). Samples will be transported to ERDC for sequencing and comparison to the eDNA found in the pool.

CHAIN OF CUSTODY RECORD

File No.
Inv.

Date and Time of Collection:	**River Reach:**	**Collected By:**

Notes:

Collection No.	**Description of Collection (include river reach, river mileage (if known), and any serial numbers):**

Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**
Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**
Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**
Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**
Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**
Collection No.	**From: (Print Name, Agency)** **To: (Print Name, Agency)**	**Release Signature:**	**Release Date:**	**Delivered Via:** ☐ **U.S. Mail** ☐ **In Person** ☐ **Other:**

Appendix F: Shipping, Handling, and Data Protocols for Wild Captured Black Carp

Any suspect black carp collected in the wild in the United States, should be immediately reported to the appropriate resource management agency in the state where the fish was collected [Keep, Cool, Call: What to do if you capture a black carp (invasivecarp.us)]. Do ***not*** release any suspect black carp, unless instructed to do so by the resource management agency.

Differentiating black carp from grass carp using diagnostic external characteristics can be very challenging, especially when the two species are not being compared side-by-side. An identification fact sheet is available online for your reference [BlackGrassCarpIdentification.PDF (invasivecarp.us)]. Careful attention should be given in waters where grass carp are known to occur to confirm that captured individuals are indeed grass carp and not black carp. If you are not positive of the species identification you should report the collection to the appropriate resource management agency to get assistance and further instructions.

Collection information, basic biological data, and digital images should be collected for any suspect black as soon as possible after capture. In addition to collection and basic biological data, we are interested in collecting multiple structures and tissues from each fish for management and research purposes.

Protocols are provided for:

1. collection of capture information, basic biological data, and digital images
2. removal, preparation, and shipment of eyes or blood for ploidy analysis
3. preparation and shipment of black carp carcasses

These protocols are intended to provide resource management agencies, or authorized personnel, with complete instructions for the proper collection, preparation, and shipping of data, samples, and carcasses for the collection of as much biological information as possible. It is important that all collections of black are immediately reported to the appropriate resource management agency in the state where the fish was collected. Ploidy results and field collection data from wild-caught black carp will be incorporated into the USGS Nonindigenous Aquatic Species publicly searchable database: http://nas.er.usgs.gov/. Please contact Wesley Daniel (wdaniel@usgs.gov) for questions regarding this database.

Step 1: Capture Data Collection

1. Fill out BLCP Field Data Collection Form (Attached).
2. Record GPS Location (if available, otherwise a description of collection location);
3. Record date of capture, method of capture, and collecting individual or agency. Record fish weight, girth (Figure 1), total and fork lengths, and species (label samples if necessary);
4. Take high resolution digital pictures:
   a. Lateral view of fish's entire left side (Figure 1)
   b. Close-up lateral view of head (Figure 2)
   c. Dorsal view of head with mouth ***fully*** closed taken from directly above the fish's head (Figure 3)
5. Record name, telephone number, and/or email address for point of agency contact or collector.
6. E-mail data and digital images to Kroboth, Patrick T pkroboth@usgs.gov and Carlson, Cayla L clcarlson@usgs.gov
7. Proceed to Step 2.

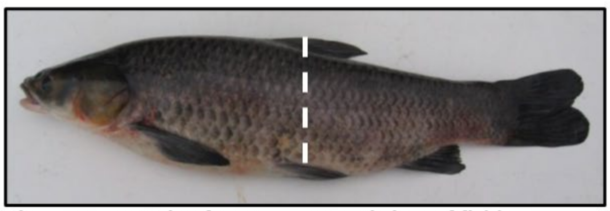

Figure 1. Example of step 4.a: Lateral view of fish's entire left side. Dashed white line indicates location for girth measurement.

Figure 2. Example of step 4.b: Close-up lateral view of head.

Figure 3. Example of step 4.c: Dorsal view of head with mouth fully closed.

Step 2: Sample Preparation, and Shipping Procedures for Ploidy Analysis (Eyeballs or Blood Samples)

Materials for eyeball collection:

- Forceps; scalpel; blunt or curved scissors
- Permanent marking pen
- 50-100 ml plastic containers with leak-proof screw top cap
- Sealable plastic bags to fit several 50-100 ml containers
- Contact lens solution or saline (0.8-1.0% NaCl in DI water)(1 g NaCl per 100 ml of DI water)
- MS-222 or other means of euthanasia

- Cooler or insulated container with ice packs, packing tape to seal cooler

NOTE: Contact the La Crosse Fish Health Center if you have questions regarding the materials needed or to request assistance with preparing a kit for sample preparation and shipment.

Eyeball Sample Preparation for Overnight Shipment – **Do Not Freeze**: This is the most commonly used method. Eyes can be collected from live or dead fish.

1. Label a small, plastic container with collection date, species, and sample number (e.g. 25MAR13, black carp, #12).
2. Use forceps to hold the eyeball steady. Taking care not to puncture the eyeball, insert scalpel blade between the eyeball and socket wall with the blade pointed outward toward the socket wall. Cut around the circumference of the eyeball until the eyeball moves freely in the socket.
3. Use the blunt or curved scissors to reach behind the eyeball and cut the optic nerve. Once the optic nerve is cut, you should be able remove the eyeball and trim off any excess tissue.
4. Remove the other eyeball and place both eyeballs in the labeled container.
5. Pour contact lens solution or saline into the labeled container until full. Both eyeballs should be completely immersed. Close lid tightly. Maintain at 4 to 8°C. **Do Not Freeze.**

Blood Sample Preparation for Overnight Shipment – **Do Not Freeze**: Only for live fish. A blood sample may be collected instead of eyes. This is good for non-lethal sampling, or for scheduled sampling events when live fish will be collected. Collection of blood samples may streamline sample collection and reduce supplies. Consider collection of blood samples when working with live fish or when large numbers of fish are expected. Contact La Crosse Fish Health Center staff for blood collection kits.

1. Anesthetize fish appropriately for handling or euthanize.
2. Using a 3 ml syringe with a 21G needle attached, insert needle through ACD stopper and draw up a few drops of Acid Citrate Dextrose into the syringe. Set blood collection tube aside.
3. Holding the plunger, insert the needle into the caudal vein or just below the lateral line until you find the vein (you will see blood enter the syringe). If you hit the spine, pull the needle out slightly (about 1mm) and reinsert just below that spot. The vein lies directly below the spine.
4. Watch the base of the needle, when you see blood entering the syringe, stop moving and allow the blood to collect in the syringe until you have 1/2-2 ml. You may pull on the plunger with gentle pressure.
5. Remove the needle. If taking a non-lethal sample, put pressure on the spot to encourage clotting.
6. Re-insert the needle through the rubber stopper of a vacutainer.
7. Depress the plunger to dispense. Keep cool (4-8C). **Do Not Freeze.**

Shipping Eye or Blood Samples: Contact Laboratory Staff to make Overnight Shipping arrangements

1. Pack samples in a Ziploc bag to prevent leakage and then enclose in a sealed, insulated cooler with ice packs to maintain 4 to 8°C. **Include a copy of the collection data form with package.** Tape lid securely.

2. Ship priority overnight to La Crosse Fish Health Center

La Crosse Fish Health Center
U.S. Fish and Wildlife Service
555 Lester Ave, Onalaska, WI 54650

Please address shipments to the attention of Jennifer Bailey Jennifer_Bailey@fws.gov **or Sara Dziki** sara_dziki@fws.gov

3. Email confirmation of shipment and tracking numbers to the laboratory

Step 3: Gonad removal and preparation for shipping

If the fish is less than 18" long, gonads need not be collected. For very large samples, ship the anterior portion of the specimen with tail section remove to reduce weight for shipping. If gonad samples can be shipped overnight and it is logistically possible to ship or deliver the fish without freezing, it is not necessary to remove the gonads. Whole fish may be shipped, refrigerated, not frozen, to the Columbia Environmental Research Center, address:

U.S. Geological Survey
Columbia Environmental Research Center
4200 E. New Haven Rd.
Columbia, MO 65201

Please address shipments to the attention of Patrick Kroboth (573) 540-8434 (cell), pkroboth@usgs.gov or Cayla Carlson (573) 875-5399, clcarlson@usgs.gov.

If the fish is too large to easily ship or shipping must be delayed, follow the below protocol to provide the gonad samples. Note gonad samples **cannot be frozen**.

Instructions for Gonad Histology Sampling – **Do Not Freeze:**

1. Remove complete gonad from body cavity.
2. Lay out on dissection area. Assess the tissue to identify gonad tissue from fat. Carefully remove excess fat (The fat tissue is smooth and yellow to white in color, the ovaries will be grainy, eggy or lattice-like, and the testes will be smooth and almost white in color and will usually have been closest to where the gonad was adhered to the inside of the body cavity.)
3. Weigh the whole gonad. Record gonad weight on bottle and on data sheet. (Note: do not enclose in the same sample bottle with the eyes).
   Is total weight of the gonad > 20 g?
   Yes: Proceed to #4 below.
   No: Place entire gonad in sample bottle, skip to #5 below.

4. Are the two gonad branches mirror images?

   YES, gonad branches are mirror images:
      From the left gonad, take 5 samples along the length, at least 2 g each and place in a histology cassette. Weigh and record mass of the 5 samples combined on the datasheet and label the bottle.

NO, gonad branches are not mirror images:

Make note of the difference; weigh the halves and record weights. Take 5 samples at least 2 g each along the “normal” side of the gonad, weigh and record data as above. Take 2 samples from the abnormal section of the gonad, weigh, and record data. Store in a separate bottle, and label appropriately.

5. Fill sample bottles with saline or contact solution. Maintain at 4 to 8°C. **Do Not Freeze.**
6. Ship sample bottles to Columbia Environmental Research Center, Columbia, Missouri.
7. Email confirmation of shipment and tracking numbers to the laboratory.

Step 4: Carcass and Digestive Tract Preparation and Shipping Procedures

Several external and internal samples will be analyzed from black carp collections, including the contents of the digestive tract, otoliths, fin rays, vertebrae, and genetics. Fish should be shipped whole to the USGS lab for processing, however for large specimens it is only necessary to ship the anterior 1/3 (Figure 4). If shipping the anterior 1/3 please include the anterior dorsal fin ray for aging. The entire digestive tract from all black carp should accompany shipments. If you must remove the digestive tract to ship, first squeeze both ends roughly 2 cm near the esophagus and anus to condense contents away from your cut. Place the whole digestive tract in a zip lock bag or whirl pack and refrigerate until shipped. **Do not freeze the digestive tract.** This can damage diet items rendering them unidentifiable. The anterior 1/3 of the fish should be frozen and shipped along with the digestive tract on ice packs. Consider adding packaging materials to the shipment to cushion.

Note: The USGS lab may be contacted to discuss shipping options, instructions for the collection of gut or gonad samples, and payment of shipping fees as needed.

Carcass Sample Preparation for Overnight Shipment:

If possible, *ship samples on ice or ice packs within 36 hours of catch*. Otherwise, freeze the carcass before shipping. *Note: Prior to freezing, follow gonad and eyeball removal and preparation protocol.*

1. First wrap the entire carcass or anterior 1/3 in a plastic trash bag to keep the package from leaking.
2. Pack entire specimen (with eyes extracted) in an insulated container with plenty of ice packs, frozen water bottles (soda bottles work well), or ice. Do ***NOT*** use dry ice for shipping. Include a copy of collection data (and sample number if necessary) in ziplock bag in container.
3. Seal container to contain leaks. If using a styrofoam cooler within a box, make sure the interior lid is taped and sealed securely.
4. Ship immediately or keep frozen until Overnight Priority shipping arrangements are made.

Carcass Shipping Procedures:

1. Contact Columbia Environmental Research Center personnel to make Overnight Priority (for morning delivery) shipping arrangements (contact information below). Do ***NOT*** ship samples until arrangements have been made for receipt of package. Samples can not be received by the lab on weekends, thus Friday shipments should be retained until Monday to ensure samples are stored at the appropriate temperature until delivery.
2. Ship specimen in sealed, insulated container (see sample preparation instructions above) priority overnight to the attention of the recipients previously listed (step 3).
3. Email confirmation of shipment and tracking numbers to recipients.

BLACK CARP REPORTING FORM

Data Collection Form - Include with Shipment: **Do Not Freeze** eyes blood gonads **OK** to freeze carcasses

Capture information

Unique ID assignment: ________________ - __________ - ________________________
(month day year e.g. 031419) (fish #, e.g. 01, 02, etc.) (initials or program acronym, e.g. JWB or LFHC)

Alternate ID(s) if assigned: __________________________

Species: ______________________________________ Date of Capture: ____________________

GPS Location (decimal degrees): N: ___________________ W: ____________________

Water body: ____

Collector: ______________________________ State: ______ Agency: __________________

Capture Method: _________________________________

Water Temp (or estimate): _________________ Depth (ft): _____________________________

Habitat description: ____

Sample dimensions and dissemination

Weight (g): ______________ Girth (mm): ___________ Ploidy sample type: **Eyeballs Blood** (circle)

Total Length (mm): _______ Fork Length (mm): ________ Ploidy sample shipped(Y/N): ________

Sex: ________________ Gonad weight (g): ____________ Gonad subsample wt. (g): __________

Carcass shipped(Y/N): ______ Destination: __________

Gonads shipped(Y/N): ______ Destination: __________

Contact Person (Agency and phone or email): ____

Shipping

Email a copy of this form to Wesley Daniel for entry into the USGS NAS database: wdaniel@usgs.gov
Include a copy of this form with any sample (carcass, gonad, eye, blood, etc.) shipments

Call, email, or text to make shipping arrangements (no shipments on Friday) text or email tracking to:

Ploidy samples and gonads – Jennifer Bailey, 608-783-8451, 608-518-0128 (cell), jennifer_bailey@fws.gov
Sara Erickson, 608-783-8418, sara_dziki@fws.gov
Ship Overnight: La Crosse Fish Health Center, 555 Lester Ave, Onalaska, WI 54650

Mississippi River Carcasses - Patrick Kroboth, 573-875-5399, 573-540-8434 (cell), pkroboth@usgs.gov
Cayla Carlson, 573-875-5399, clcarlson@usgs.gov
Ship Overnight: Columbia Environmental Research Center, 4200 New Haven Rd, Columbia, MO 65201

GREAT LAKES GRASS CARP REPORTING FORM

***Data Collection Form - Include with Shipment*:** **Do Not Freeze** eyes, blood, or gonads **OK** to freeze carcasses

Capture information

Barcode ID: ______________________________

Barcode label here

Lab ID assignment: ___________________

Floy, jaw, or cattle tag #: ___________________

Great Lake basin: __________________________________ Date of capture: ___________________

GPS location (decimal degrees): N: ________________________ W: __________________

Water body: _____________________________________

Collector: _________________________________ State: ______ Agency: _________

Capture method: __________________________________

Water temp (or estimate): ___________________ Depth (ft): ______________________________

Habitat description: ____

Sample dimensions and dissemination

Is this capture sensitive information? YES or NO (circle one)

Weight (g): ________________ Girth (mm): ____________ Ploidy sample type: **Eyeballs Blood** (circle)

Total length (mm): ____________Fork length (mm): ____________ Ploidy sample shipped (Y/N): ________

Sex: ____ Gonad weight (g): _____________ Gonad subsample wt. (g): __________

Carcass shipped (Y/N): ______ Destination: __________

Gonads shipped (Y/N): ______ Destination: __________

Contact person (Agency and phone or email): ____

Shipping

- Include a copy of this form with any sample (carcass, gonad, eye, blood, etc.) shipments. All Grass Carp captures will be reported at the end of the field season to the USGS NAS database: https://nas.er.usgs.gov/
- **Call, email, or text to make shipping arrangements (no shipments on Friday) text or email tracking to:**
    - **Ploidy samples and gonads** – Store and maintain at 4ºC (refrigeration temp or cooler with ice)
        - Jennifer Bailey, jennifer_bailey@fws.gov
        - Sara Dziki, sara_dziki@fws.gov
        - Ship overnight (on ice): La Crosse Fish Health Center, 555 Lester Ave, Onalaska, WI 54650
    - **Grass Carp carcasses** - Dillon Weik, 937-681-5403 (cell), dillon.weik@utoledo.edu
        - Ship overnight (on ice): Lake Erie Center 6200 Bayshore Rd. Oregon, OH 43616
    - **Ploidy results** - Ryan Young, 248-891-6433 (cell), ryan_young@fws.gov
        - U.S. Fish and Wildlife Service, Alpena FWCO Detroit River Sub-station, 28403 Old North Gibraltar Rd., Gibraltar, MI 48173

Appendix G: List of Asian Carp fish species codes arranged in alphabetical order by fish common name. Four-digit species codes are the same as codes used by the Long Term Resource Monitoring Program (Ratcliff et al. 2014). Nomenclature follows the American Fisheries Society standard naming conventions (Nelson et al. 2004).

Common name	Scientific name	Code
Age-0 fish (young-of-the-year)	Age-0 fish	YOYF
American brook lamprey	Lampetra appendix	ABLP
American eel	*Anguilla rostrata*	AMEL
Banded darter	*Etheostoma zonale*	BDDR
Bigeye chub	*Hybopsis amblops*	BECB
Bigeye shiner	*Notropis boops*	BESN
Bighead carp	*Hypophthalmichthys nobilis*	BHCP
Bigmouth buffalo	*Ictiobus cyprinellus*	BMBF
Bigmouth shiner	*Notropis dorsalis*	BMSN
Black buffalo	*Ictiobus niger*	BKBF
Black bullhead	*Ameiurus melas*	BKBH
Black crappie	*Pomoxis nigromaculatus*	BKCP
Black crappie x white crappie hybrid	*P. nigromaculatus x P. annularis*	BCWC
Blackside darter	*Percina maculata*	BSDR
Blackspotted topminnow	*Fundulus olivaceus*	BPTM
Blackstripe topminnow	*Fundulus notatus*	BTTM
Blacktail shiner	*Cyprinella venusta*	BTSN
Bleeding shiner	*Luxilus zonatus*	BDSN
Blue catfish	*Ictalurus furcatus*	BLCF
Blue sucker	*Cycleptus elongatus*	BUSK
Bluegill	*Lepomis macrochirus*	BLGL
Bluegill x longear sunfish hybrid	*L. macrochirus x L. megalotis*	BGLE
Bluegill x orangespotted sunfish hybrid	*L. macrochirus x L. humilis*	BGOS
Bluegill x redear sunfish hybrid	*L. macrochirus x L. microlophus*	BGRS
Bluegill x warmouth hybrid	*L. macrochirus x L. gulosus*	BGWM
Bluntnose darter	*Etheostoma chlorosoma*	BNDR
Bluntnose minnow	*Pimephales notatus*	BNMW
Bowfin	*Amia calva*	BWFN
Brassy minnow	*Hybognathus hankinsoni*	BSMW
Brook silverside	*Labidesthes sicculus*	BKSS
Brook stickleback	*Culaea inconstans*	BKSB
Brown bullhead	*Ameiurus nebulosus*	BNBH
Brown trout	*Salmo trutta*	BNTT
Bullhead minnow	*Pimephales vigilax*	BHMW
Burbot	*Lota lota*	BRBT
Central mudminnow	*Umbra limi*	CMMW
Central stoneroller	*Campostoma anomalum*	CLSR
Channel catfish	*Ictalurus punctatus*	CNCF
Channel shiner	*Notropis wickliffi*	CNSN
Chestnut lamprey	*Ichthyomyzon castaneus*	CNLP
Common carp	*Cyprinus carpio*	CARP

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Common name	Scientific name	Code
Common carp x goldfish hybrid	*C. carpio x Carassius auratus*	CCGF
Common shiner	*Luxilus cornutus*	CMSN
Creek chub	*Semotilus atromaculatus*	CKCB
Creek chubsucker	*Erimyzon oblongus*	CKCS
Crystal darter	*Crystallaria asprella*	CLDR
Dusky darter	*Percina sciera*	DYDR
Emerald shiner	*Notropis atherinoides*	ERSN
Fantail darter	*Etheostoma flabellare*	FTDR
Fathead minnow	*Pimephales promelas*	FHMW
Flathead catfish	*Pylodictis olivaris*	FHCF
Flier	*Centrarchus macropterus*	FLER
Freckled madtom	*Noturus nocturnus*	FKMT
Freshwater drum	*Aplodinotus grunniens*	FWDM
Ghost shiner	*Notropis buchanani*	GTSN
Gizzard shad	*Dorosoma cepedianum*	GZSD
Golden redhorse	*Moxostoma erythrurum*	GDRH
Golden shiner	*Notemigonus crysoleucas*	GDSN
Goldeye	*Hiodon alosoides*	GDEY
Goldfish	*Carassius auratus*	GDFH
Grass carp	*Ctenopharyngodon idella*	GSCP
Grass pickerel	*Esox americanus vermiculatus*	GSPK
Green sunfish	*Lepomis cyanellus*	GNSF
Green sunfish x bluegill hybrid	*L. cyanellus x L. macrochirus*	GSBG
Green sunfish x orangespotted sunfish hybrid	*L. cyanellus x L. humilis*	GSOS
Green sunfish x pumpkinseed hybrid	*L. cyanellus x L. gibbosus*	GSPS
Green sunfish x redear hybrid	*L. cyanellus x L. microlophus*	GSRS
Green sunfish x warmouth hybrid	*L. cyanellus x L. gulosus*	GSWM
Greenside darter	*Etheostoma blennioides*	GSDR
Highfin carpsucker	*Carpiodes velifer*	HFCS
Hornyhead chub	*Nocomis biguttatus*	HHCB
Inland silverside	*Menidia beryllina*	IDSS
Iowa darter	*Etheostoma exile*	IODR
Johnny darter	*Etheostoma nigrum*	JYDR
Lake sturgeon	*Acipenser fulvescens*	LKSG
Largemouth bass	*Micropterus salmoides*	LMBS
Largescale stoneroller	*Campostoma oligolepis*	LSSR
Larval fish	Larval fish	LRVL
Least brook lamprey	*Lampetra aepyptera*	LBLP
Logperch	*Percina caprodes*	LGPH
Longear sunfish	*Lepomis megalotis*	LESF
Longnose gar	*Lepisosteus osseus*	LNGR
Longnose gar x spotted gar hybrid	*L. osseus x L. oculatus*	LNST

Appendix G: List of Asian Carp fish species codes arranged in alphabetical order by fish common name. Four-digit species codes are the same as codes used by the Long Term Resource Monitoring Program (Ratcliff et al. 2014). Nomenclature follows the American Fisheries Society standard naming conventions (Nelson et al. 2004).

Common name	Scientific name	Code
Mimic shiner	*Notropis volucellus*	MMSN
Mississippi silvery minnow	*Hybognathus nuchalis*	SVMW
Mooneye	*Hiodon tergisus*	MNEY
Mud darter	*Etheostoma asprigene*	MDDR
Muskellunge	*Esox masquinongy*	MSKG
New species	New species	NWSP
No fish caught	No fish caught	NFSH
Northern hog sucker	*Hypentelium nigricans*	NHSK
Northern pike	*Esox lucius*	NTPK
Northern studfish	*Fundulus catenatus*	NTSF
Orangespotted sunfish	*Lepomis humilis*	OSSF
Orangespotted sunfish x longear sunfish hybrid	*L. humilis x L. megalotis*	OSLE
Orangethroat darter	*Etheostoma spectabile*	OTDR
Ozark minnow	*Notropis nubilus*	OZMW
Paddlefish	*Polyodon spathula*	PDFH
Pallid shiner	*Hybopsis amnis*	PDSN
Pirate perch	*Aphredoderus sayanus*	PRPH
Plains minnow	*Hybognathus placitus*	PNMW
Pugnose minnow	*Opsopoeodus emiliae*	PGMW
Pumpkinseed	*Lepomis gibbosus*	PNSD
Pumpkinseed x bluegill hybrid	*L. gibbosus x L. macrochirus*	PSBG
Pumpkinseed x orangespotted sunfish hybrid	*L. gibbosus x L. humilis*	PSOS
Pumpkinseed x warmouth hybrid	*L. gibbosus x L. gulosus*	PSWM
Quillback	*Carpiodes cyprinus*	QLBK
Rainbow smelt	*Osmerus mordax*	RBST
Red shiner	*Cyprinella lutrensis*	RDSN
Redear sunfish	*Lepomis microlophus*	RESF
Redfin shiner	*Lythrurus umbratilis*	RFSN
Redspotted sunfish	*Lepomis miniatus*	RSSF
River carpsucker	*Carpiodes carpio*	RVCS
River chub	*Nocomis micropogon*	RVCB
River darter	*Percina shumardi*	RRDR
River redhorse	*Moxostoma carinatum*	RVRH
River shiner	*Notropis blennius*	RVSN
Rock bass	*Ambloplites rupestris*	RKBS
Round goby	*Neogobius melanostomus*	RDGY
Rudd	*Scardinius erythrophthalmus*	RUDD
Sand shiner	*Notropis stramineus*	SNSN
Sauger	*Sander canadensis*	SGER
Sauger x walleye hybrid	*S. canadensis x S. vitreus*	SGWE
Shorthead redhorse	*Moxostoma macrolepidotum*	SHRH

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Common name	Scientific name	Code
Shortnose gar	*Lepisosteus platostomus*	SNGR
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	SNSG
Shovelnose sturgeon x pallid sturgeon hybrid	*S. platorynchus x S. albus*	SNPD
Sicklefin chub	*Macrhybopsis meeki*	SFCB
Silver carp	*Hypophthalmichthys molitrix*	SVCP
Silver carp x bighead carp hybrid	*H. molitrix x H. nobilis*	SCBC
Silver chub	*Macrhybopsis storeriana*	SVCB
Silver lamprey	*Ichthyomyzon unicuspis*	SVLP
Silver redhorse	*Moxostoma anisurum*	SVRH
Silverband shiner	*Notropis shumardi*	SBSN
Skipjack herring	*Alosa chrysochloris*	SJHR
Slenderhead darter	*Percina phoxocephala*	SHDR
Slough darter	*Etheostoma gracile*	SLDR
Smallmouth bass	*Micropterus dolomieu*	SMBS
Smallmouth buffalo	*Ictiobus bubalus*	SMBF
Southern redbelly dace	*Phoxinus erythrogaster*	SRBD
Speckled chub	*Macrhybopsis aestivalis*	SKCB
Spotfin shiner	*Cyprinella spiloptera*	SFSN
Spottail shiner	*Notropis hudsonius*	STSN
Spotted bass	*Micropterus punctulatus*	STBS
Spotted gar	*Lepisosteus oculatus*	STGR
Spotted sucker	*Minytrema melanops*	SPSK
Starhead topminnow	*Fundulus dispar*	SHTM
Stonecat	*Noturus flavus*	STCT
Striped bass	*Morone saxatilis*	SDBS
Striped bass x white bass hybrid	*M. saxatilis x M. chrysops*	SBWB
Striped mullet	*Mugil cephalus*	SPMT
Striped shiner	*Luxilus chrysocephalus*	SPSN
Sturgeon chub	*Macrhybopsis gelida*	SGCB
Suckermouth minnow	*Phenacobius mirabilis*	SMMW
Tadpole madtom	*Noturus gyrinus*	TPMT
Threadfin shad	*Dorosoma petenense*	TFSD
Tiger muskellunge	*Esox masquinongy x E. lucius*	MGNP
Trout-perch	*Percopsis omiscomaycus*	TTPH
Unidentified	Unidentified	UNID
Unidentified sturgeons	Acipenseridae	U-SG
Unidentified suckers	Catostomidae	U-CT
Unidentified sunfishes	Centrarchidae	U-CN
Unidentified shads	Clupeidae	U-CL
Unidentified minnows	Cyprinidae	U-CY
Unidentified mooneyes	Hiodontidae	U-HI
Unidentified catfishes	Ictaluridae	U-IL

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Common name	Scientific name	Code
Unidentified perches	Percidae	U-PC
Unidentified lampreys	Petromyzontidae	U-LY
Walleye	*Sander vitreus*	WLYE
Warmouth	*Lepomis gulosus*	WRMH
Wedgespot shiner	*Notropis greenei*	WSSN
Weed shiner	*Notropis texanus*	WDSN
Western blacknose dace	*Rhinichthys obtusus*	BNDC
Western mosquitofish	*Gambusia affinis*	MQTF
Western sand darter	*Ammocrypta clara*	WSDR
Western silvery minnow	*Hybognathus argyritis*	WSMW
White bass	*Morone chrysops*	WTBS
White crappie	*Pomoxis annularis*	WTCP
White perch	*Morone americana*	WTPH
White perch x yellow bass hybrid	*M. americana x M. mississippiensis*	WPYB
White sucker	*Catostomus commersonii*	WTSK
Yellow bass	*Morone mississippiensis*	YWBS
Yellow bullhead	*Ameiurus natalis*	YLBH
Yellow perch	*Perca flavescens*	YWPH

Common name	Scientific name	code
Alligator snapping turtle	*Macrochelys temminckii*	ASNT
Blanding's turtle*	*Emydoidea blandingii*	BLDT
Chinese Mystery Snails	*Cipangopaludina chinensis*	CMSN
Eastern musk turtle (formerly common musk turtle)	*Sternotherus odoratus*	CMKT
Eastern snapping turtle (formerly common snapping turtle)	*Chelydra serpentina*	CSNT
False map turtle	*Graptemys pseudogeographica*	FMPT
Midland painted turtle	*Chrysemys picta marginata*	MPTT
Midland smooth softshell	*Apalone mutica mutica*	SMSS
Mississippi map turtle	*Graptemys pseudogeographica kohnii*	MMPT
Northern map turtle (formerly common map turtle)	*Graptemys geographica*	CMPT
Ouachita map turtle	*Graptemys ouachitensis ouachitensis*	OMPT
Red Swamp Crayfish	*Procambarus clarkii*	RSCF
Red-eared slider	*Trachemys scripta elegans*	RESL
River cooter	*Pseudemys concinna*	RCOT
Rusty Crayfish	Orconectes rusticus	RUCF
Spiny softshell	*Apalone spinifera*	SPSS
Western painted turtle	*Chrysemys picta belli*	WPTT
Wood turtle*	*Glyptemys insculpta*	WODT
Yellow mud turtle* (formerly Illinois mud turtle)	*Kinosternon flavescens*	IMDT
Zebra Mussels	*Dreissena polymorpha*	ZEBR

*Rare species. Should be reported to respective state agencies if captured

Asian Carp Monitoring Project - Electro

Date: ____________________

Area Surveyed: ____________________________ Biologist (Crew): ________________________________

Wisc Unit DC: Rate: ______ Duty:______ Range: High or Low Volts:_____ Amps:_________

Smith Root DC: Percent of Setting:________Pulse Per Second Setting:________Amps:________

Other (Describe): ____

Rate Gear Efficency (circle one): Good Moderate Poor

Air Temp: ________ Water Temp: _________ Conductivity: _________ Others: _________________

	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total No. Fish
Gizzard shad >6 in.				
Gizzard shad juv.<6 in.				
Alewife				
Common carp				
Goldfish				
Carp x Goldfish hybrid				
Freshwater drum				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
White sucker				
Channel catfish				
Yellow bullhead				
Black bullhead				
Largemouth bass				
Smallmouth bass				
Bluegill				
Green sunfish				
Pumpkinseed				
Hybrid sunfish				
Rock bass				
White crappie				
Black crappie				
Golden shiner				
Bluntnose minnow				
Fathead minnow				
Spotfin shiner				
Emerald shiner				
Spottail shiner				
Round goby				
White perch				
White bass				
Yellow bass				

Asian Carp Monitoring Project - Nets

Date: ____________________

Area Surveyed: ____________________________ Biologist (Crew): _________________________________

Air Temp: ________ Water Temp: _________ Conductivity: _________ Others: _________________

Set No.___________ Lat.________________ Lon.______________ Total Yds.__________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total
Gizzard shad >6.0 in.				
Common carp				
Goldfish				
Carp x goldfish hybrid				
Freshwater drum				
Bighead carp				
Silver carp				
Grass carp				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
Channel catfish				

Set No.___________ Lat.________________ Lon.______________ Total Yds.__________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total
Gizzard shad >6.0 in.				
Common carp				
Goldfish				
Carp x goldfish hybrid				
Freshwater drum				
Bighead carp				
Silver carp				
Grass carp				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
Channel catfish				

Asian Carp Monitoring Project

Date: ___________________

Area Surveyed: ____________________ **Biologist (Crew):** ________________________________

Gear Type (circle one): DC, AC, Nets

Nets (Describe Nets): ____

Fish Species	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm
Gizzard shad >6 in.										
Gizzard shad juv.<6 in.										
Alewife										
Common carp										
Goldfish										
Carp x Goldfish hybrid										
Freshwater drum										
Smallmouth buffalo										
Bigmouth buffalo										
Black buffalo										
Quillback										
White sucker										
Channel catfish										
Yellow bullhead										
Black bullhead										
Largemouth bass										
Smallmouth bass										
Bluegill										
Green sunfish										
Pumpkinseed										
Hybrid sunfish										
Rock bass										
White crappie										
Black crappie										
Golden shiner										
Bluntnose minnow										
Fathead minnow										
Spotfin shiner										
Emerald shiner										
Round goby										
White perch										
Yellow Bass										

eDNA Field Data Sheet

DATE______________ NAME________________________________ START TIME____________ SHEET ____of______

ID	Volume	Latitude	Longitude	Temp	Depth	Habitat	Collect Time	Filter Time

Notes/Comments:

Appendix I: Analysis of Bighead and Silver Carp Spawn Patches

Spawn Patch Preservation/Analysis:

Bighead and Silver Carp males use their pectoral fins to irritate the vental margin of females during the spawning season (Figure 1). Recent spawning or prespawning interactions between males and females will leave an irritated patch on the breast of the female fish, and scales are often lost. Presence of regenerated scales is evidence that a female fish may have been courted by a male fish (although it is impossible to tell from this feature if spawning actually occurred). The number of annuli in regenerated scales may also be useful in determining the number of years since spawning activity occurred. It is as yet unclear how many scales are lost on average or if scales are lost each time the fish spawns. However, in order to preserve potential information on spawning activity or presence of male fish where a female fish is captured, it is prudent to preserve the breast of Bighead and Silver Carp caught from areas where the presence of Asian carps caught is being investigated if allowable by the state and regulatory bodies. For the 2013 Monitoring and Response Plan participants, fish collected in the CAWS or the Great Lakes should follow the chain of command and custody protocols is of primary importance with biological data being collected after securing the fish. Fish collected in Brandon Road Pool require a voucher per the 2013 MRP. Additional biological data will be processed after those protocols have been followed and likely in a lab setting. For fish collected below Brandon Road Lock and Dam, it is permissible to follow the procedures as long as it would not interfere with ongoing tracking/telemetry.

Figure 1. Spawn patch of a female Bighead Carp, located on the breast of the fish between the pelvic and pectoral fins.

If a Bighead or Silver Carp is caught from the Great Lakes or the CAWS, FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL; See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records**. If there is no conflict with existing protocol, the portion of the fish illustrated in Figure 2 should be photographed as soon as possible after capture, to document abrasions from recent sexual activity. In areas outside of the CAWS and the Great Lakes sections should be preserved from damage to ensure scale regeneration can be analyzed if required by state and regulatory agencies.

Protocols for analysis of scale regeneration in this area are not yet prepared, but care should be taken to preserve the scales and skin in this area. This technique is only useful when employed on female Bighead and Silver Carp. Although external features are useful in identifying the sex of a captured Bighead or Silver Carp, none of these features are 100% reliable in identification of sex. Therefore this portion of the fish should be preserved at least until the sex is determined by the examination of the gonads. When the gonads are examined, care should be taken to avoid cutting through the area of the spawn patch. Note that histological examination of gonads may also be useful in evaluating recent spawning activity.

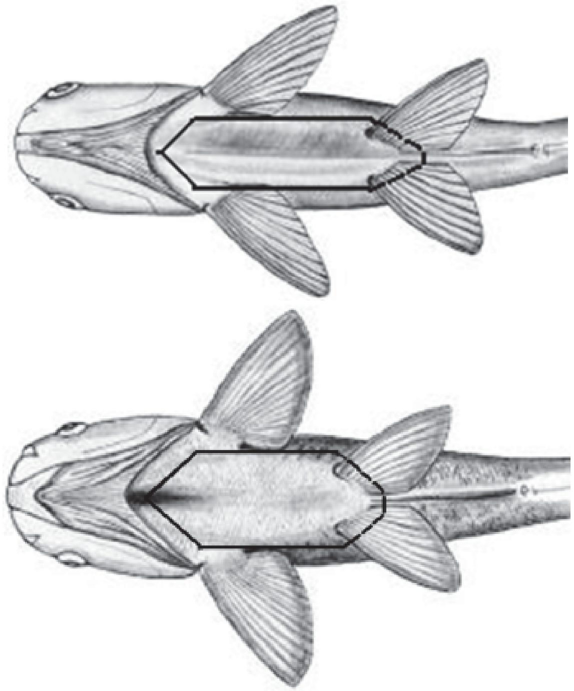


Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection of fish collected in these areas and need to be consulted about any physical samples being taken**).

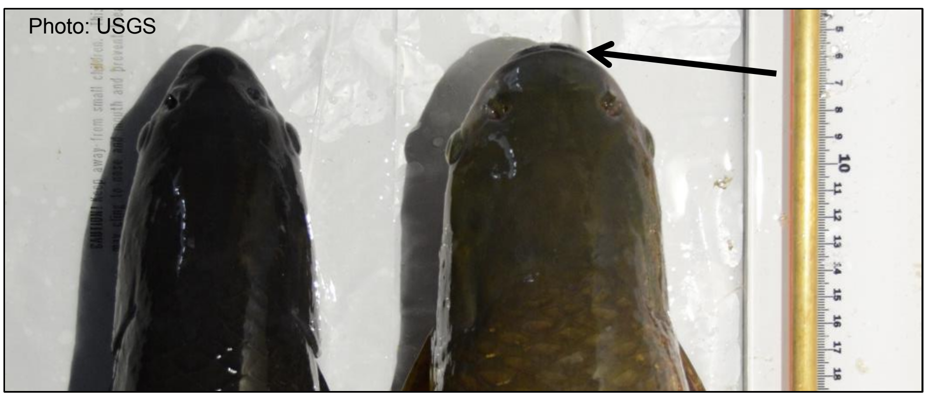
Appendix J: Black and Grass Carp Identification

Black and grass carp are very similar in appearance. We do not have a reliable method to tell them apart based on external characteristics, but these photos and general characteristics might help. When in doubt, report the fish to the appropriate resource management agency.

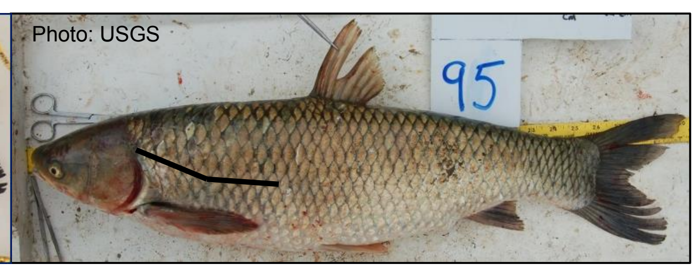
Black carp

Grass Carp

The mouth of **adult** black carp is more subterminal and the operculum is longer than in grass carp. The black carp's head is generally narrower, more cone-shaped, whereas the grass carp's tends to be rounder, blunter. However, the difference can be subtle.



The upper lip of a grass carp is visible from above **when the mouth is fully closed.** Young black carp may also exhibit this feature, so it is only useful for **adults**.



If the carcass is in good condition, you might be able to use the angle of the lateral line to ID the fish. "The lateral line of a black carp remains relatively straight moving from the operculum posterior, with a slight dip around the dorsal fin. On grass carp the lateral line takes an initial ventral dip for the first 6-8 scales (about 10°)" (Patrick Kroboth, USGS).

Black carp

Photo: Greg Whitledge, SIU

Photo: USGS

Photo: USFWS

Photo: USGS

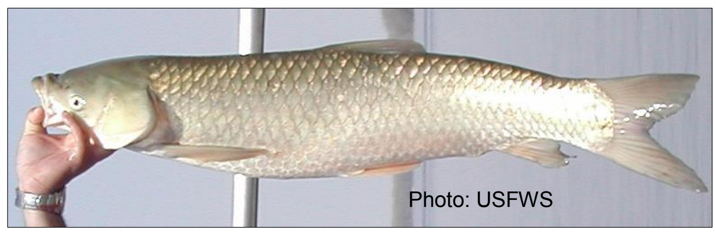
Photo: Greg Whitledge, SIU

Grass Carp

Photo: USFWS

Photo: USGS

Photo: USGS



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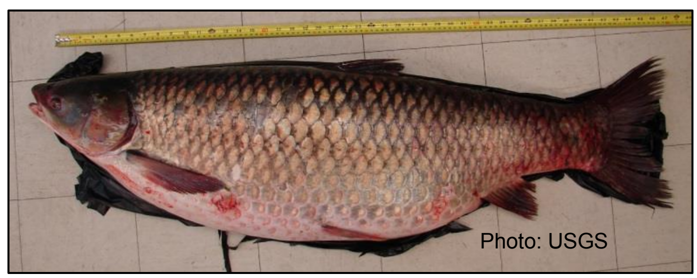

Photo: USGS

Photo: USGS

Black carp tend to have longer pectoral fins than grass carp. The coloration of black carp is described as, “Black, blue gray, or dark brown and the fins in particular are darkly pigmented. In contrast, coloration of grass carp is often described as olivaceous or silvery white, or as olive-brown above and silvery below, and most fins are dusky. Nevertheless, color may not always be reliable” (Nico et al. 2005).

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ORIGINAL PAPER

Bigheaded carps (*Hypophthalmichthys* spp.) at the edge of their invaded range: using hydroacoustics to assess population parameters and the efficacy of harvest as a control strategy in a large North American river

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Abstract The threat posed by bigheaded carps (*Hypophthalmichthys* spp.) to novel ecosystems has focused efforts on preventing further range expansion; upstream progression in the Illinois River is a major concern due to its connection with the uninvaded Great Lakes. In addition to an electric barrier system, commercial harvest of silver carp (*H. molitrix*) and bighead carp (*H. nobilis*) in the upper river is intended to reduce propagule pressure and prevent range expansion. To quantify demographics and evaluate harvest efficacy, the upper river was sampled between 2012 and 2015 using mobile hydroacoustic methods. Reach-specific densities, size structures and species compositions varied interannually but the advancing population was characterized longitudinally as small-bodied, silver carp-dominated at the highest densities downstream, shifting to large-bodied, bighead carp-dominated at the low-density population front. The use of hydroacoustic sampling for harvest evaluation was validated in backwater lakes; there was a significant positive correlation between density estimates and the corresponding harvest catch-per-unit-effort of bigheaded carps. Localized densities of bigheaded carps were reduced by up to 64.4 % immediately post-harvest but generally rebounded within weeks. However, annual sampling of the entire upper river indicated that density of bigheaded carps decreased by over 40 % (between 2012 and 2013) and subsequently remained stable (between 2013 and 2014). The annual harvest of bigheaded carps increased during this period (from 45,192 to 102,453 individuals), in years of contrasting discharge conditions. At this spatiotemporal scale, harvest appears to have contributed to initial reduction, and subsequent maintenance of, bigheaded carps density levels, but discharge likely plays an important role (e.g., through immigration) in determining the extent of its impact. Mobile hydroacoustic sampling enabled robust quantification of the population over varying spatial scales and density gradients, highlighting the potential of this approach as an assessment tool for invasive fishes in riverine environments.

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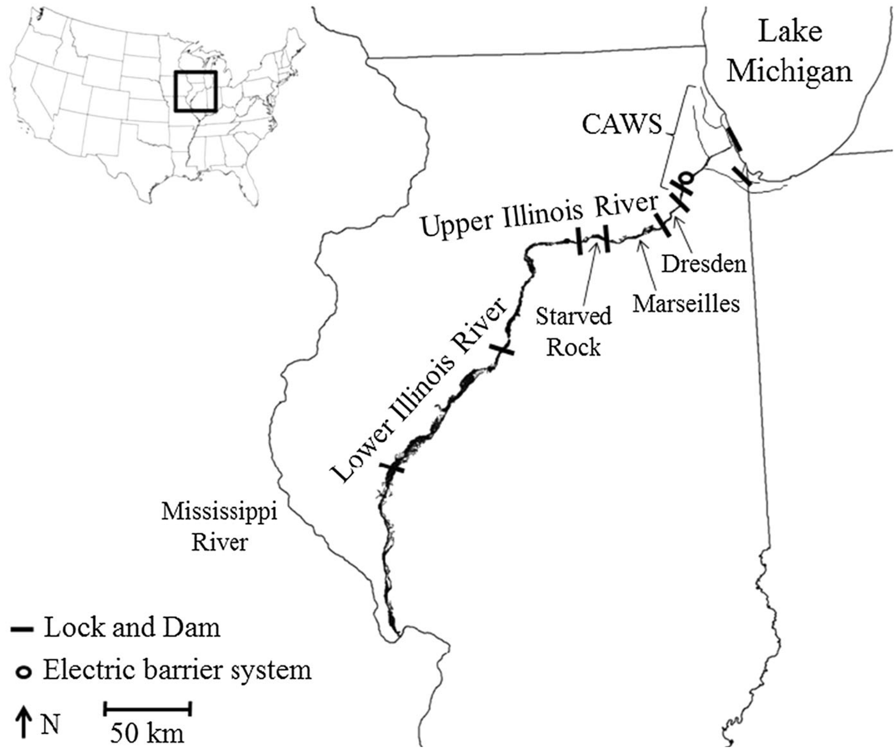
Introduction

Aquatic invasive species can have negative ecological and socio-economic impacts in freshwater ecosystems where they are introduced (Vitule et al. 2009). As our understanding of these adverse effects increases, so too does vigilance regarding potential invaders (Van-der Zanden et al. 2010). In the central United States, preventing interbasin movement of non-native species between the Mississippi and Great Lakes is a key management objective (USACE 2014). Bigheaded carps (silver carp *Hypopthalmichthys molitrix* and bighead carp *H. nobilis*), large planktivores native to east Asia (Kolar et al. 2007; Garvey 2012), are among the fish species of highest concern. Since the early 2000s, many studies have focused on the ecology of bigheaded carps at the core of their North American range, specifically in the Middle Mississippi, Lower Missouri and Lower Illinois Rivers (e.g., Schrank and Guy 2002; Williamson and Garvey 2005; Sass et al. 2010; Cudmore et al 2012; Garvey et al. 2012; Norman and Whitledge 2015). Theoretical work has also examined the potential threat posed by the species to the uninvaded Great Lakes (Kocovsky et al. 2012; Cuddington et al. 2014; Zhang et al. 2016; see review by Cooke 2016). However, critical information on bigheaded carps adjacent to novel ecosystems is limited (see Hayer et al. 2014; Stuck et al. 2015; Coulter et al. 2016). These are the propagules most likely to be successful new invaders and, thus, their presence corresponds to locations at which immediate control measures need to be implemented.

The Illinois River is a major Mississippi River tributary that is hydrologically connected to the Great Lakes basin (Lake Michigan) via a network of canals and heavily modified rivers called the Chicago-Area Waterway System (CAWS). Bigheaded carps are established in the lower reaches of this river at high densities (Sass et al 2010; Garvey et al. 2012). In the upper river, the ‘last line of defense’ preventing dispersal into Lake Michigan is an electric barrier system located in the CAWS (Moy et al. 2011), although concerns exist about its effectiveness under certain conditions (Parker et al. 2015). Management agencies aim to reduce the population of bigheaded carps (and hence the likelihood of bigheaded carps reaching and challenging the barrier system) through contracted commercial harvest in the Starved Rock (river km (RKM) 372–394), Marseilles (RKM 394–437) and Dresden (RKM 437–460) reaches of the upper river (Fig. 1). The population front has remained in the Dresden reach for several years (ACRCC 2015), *c*. 17 RKM downstream of the electric barrier system.

As bigheaded carps in the Upper Illinois River represent an immediate threat to Lake Michigan, collection of accurate empirical data on this advancing population is needed to understand range expansion dynamics and develop effective management strategies (Cooke 2016). However, many sampling challenges exist: silver carp and bighead carp occupy a variety of habitat types (e.g., main channel, backwater lakes, side channels) over a relatively large spatial scale (three river reaches extending 88 RKM); both species may respond differently to capture sampling gears like electrofishing or netting (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014; Collins et al. 2015); and it is likely that a density gradient exists over the 88 RKM occupied by the advancing population, so sampling would have to be equally effective at a variety of densities. Mobile hydroacoustic sampling has begun to feature more prominently in fisheries research in riverine environments (e.g., Lucas and Baras 2000; CEN 2014) and, considering the constraints outlined above, this technology may represent the optimal approach in terms of spatial coverage and unbiased representation of the target species. We therefore initiated a program of mobile hydroacoustic surveys in the Upper Illinois River in 2012 with the objectives of (1) quantifying key demographics (density, size structure and species composition) of the advancing population of bigheaded carps, (2) ground-truthing hydroacoustic density estimates by reference to localized harvest metrics, and (3) evaluating the efficacy of harvest at suppressing overall population levels. We outline a unique sampling framework that can be applied in a variety of contexts (e.g., population assessment, control strategy evaluation, early detection) for management of invasive fish species.

Fig. 1 The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM 372 and RKM 460. Also shown is the electric barrier system (RKM 477) located in the Chicago-Area Waterway System (CAWS)



Methods and materials

Harvest program

Commercial fishing is prohibited in the Upper Illinois River but fishing crews have been specially contracted by the Illinois Department of Natural Resources (IDNR) to harvest Asian carps (silver carp, bighead carp and grass carp *Ctenopharyngodon idella*) in the Marseilles and Dresden reaches since 2010 and in Starved Rock reach since 2011. Grass carp accounted for <1 % of the total harvest annually so were not considered further in this study. Each crew consisted of an experienced two-person team whose fishing location, effort, and catch was recorded by an onboard IDNR biologist. Suitable locations in the upper river were fished by up to five crews per day during the season, which extended from March to December (*c.* 340 crew-days per year). All bycatch was returned alive, while Asian carps were donated to a processor for conversion to liquid fertilizer (ACRCC 2015). The program goal was to maximize harvest, so a variety of gear types (e.g., gill and trammel nets, hoop nets, seine hauls) and fishing strategies (e.g. short-set, overnight set) were used, depending on river conditions and location. However, the mainstay of the harvest program has been the use of short-set (20–30 min), large-mesh (7.6–10.2 cm) gill and trammel nets. These accounted for 93.6–98.5 % of crew-days annually. As it was not possible to quantify effort for all gear types combined, we used gill and trammel net catch-per-unit-effort (CPUE; bigheaded carps/1000 m of net) as a relative indicator of harvest intensity and for comparison with hydroacoustic density estimates (see below).

Research vessel, hydroacoustic equipment and settings

The mobile hydroacoustic system (BioSonics DT-X) consisted of two horizontal-orientated split-beam transducers positioned on a stable, 9 m research vessel. The upper acoustic beam extended parallel to the water surface, and the lower beam was offset to ensonify the water column directly below the first beam (Fig. 2). Transducer pitch and horizontal plane was maintained by automatically adjusting dual-axis rotators. Data were collected out to a maximum distance of 50 m, at a ping rate of 5 pings/s and pulse duration of 0.40 ms. Transducers of frequencies

70 kHz (5° beam angle) and 200 kHz (6.6° beam angle) were deployed in various combinations (i.e. two 70 kHz, two 200 kHz, or 70 and 200 kHz) and each transducer was individually calibrated on-axis with the appropriate tungsten carbide sphere (Foote et al. 1987). This involved mooring the research vessel to a fixed object, in sufficiently deep water, with the transducers deployed as shown in Fig. 2 and aimed outward from the shore. The calibration sphere was attached to a 3 m pole using nylon fishing line and suspended in each acoustic beam.

Hydroacoustic sampling throughout the Upper Illinois River

As much boat-accessible habitat (>1–1.5 m depth) as possible within each reach was sampled annually (2012–2014) during September and October. The upper river consists of main channel (typically 150–250 m wide with a minimum depth of 2.7 m maintained over the thalweg for navigation) and connected backwaters. Backwater sites suitable for hydroacoustic sampling included backwater lakes ($N = 3$), side channels ($N = 5$), tributaries ($N = 2$), harbors ($N = 2$) and bays ($N = 1$) of varying size (0.1–1.8 km^2). In the main channel, transects consisted of a nearshore loop following the *c.* 1 m depth contour and a mid-channel loop. Only a single nearshore transect loop was generally required in side channels, bays, harbors and tributaries (Fig. 3). In the typically larger backwater lakes, transect loops were repeated progressively closer to the center, at intervals that would limit beam overlap while ensuring maximum possible coverage (Fig. 3). The acoustic beams were aimed outward from the nearest shoreline for all transects. Vessel speed was kept constant at approximately 6.5 km/h, and transects were as similar as possible to the previous year with some exceptions (e.g., allowing for boat traffic, debris, changes in water levels). River discharge data were obtained from a main channel gaging station at Seneca, IL in the Marseilles reach (http://waterdata.usgs.gov/nwis).

Hydroacoustic sampling of harvest events (ground-truthing of density estimates)

To test whether a relationship existed between localized hydroacoustic density estimates and harvest CPUE, three backwater lakes were sampled during summer 2014 and 2015, independent of the fall sampling outlined above. These lakes were created as gravel quarries that are now either active (East Pit, 1.8 km^2 surface area, 2.7 m mean depth, located at approx. RKM 422 in the Marseilles reach), inactive (West Pit, 1.3 km^2, 2.4 m, RKM 418 in the Marseilles reach), or converted to a nature preserve (Rock Run, 0.3 km^2, 4.4 m, RKM 453 in the Dresden reach) (Fig. 3). Hydroacoustic sampling was undertaken directly before and after harvest events (i.e. within a <24 h period), and subsample length and weight

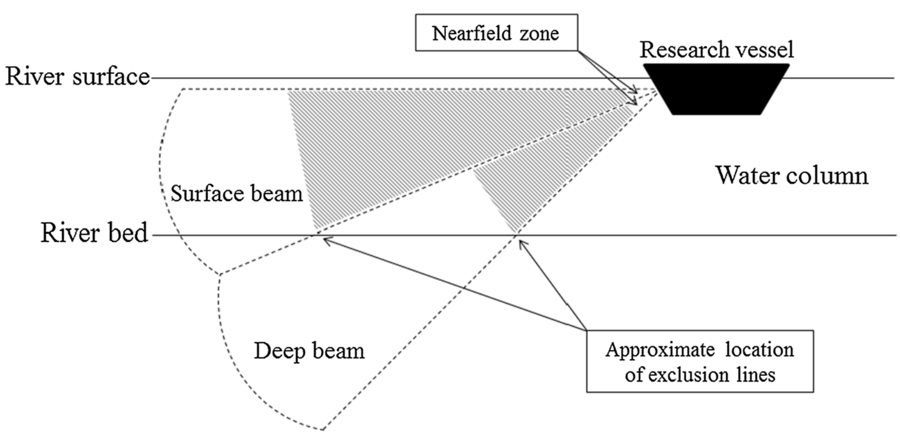


Fig. 2 Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in which acoustic targets were analyzed are indicated by the *gray shading* (no data analyzed in the nearfield zone or beyond the exclusion *line*). The surface beam typically accounted for *c.* 75 % of the volume of water sampled

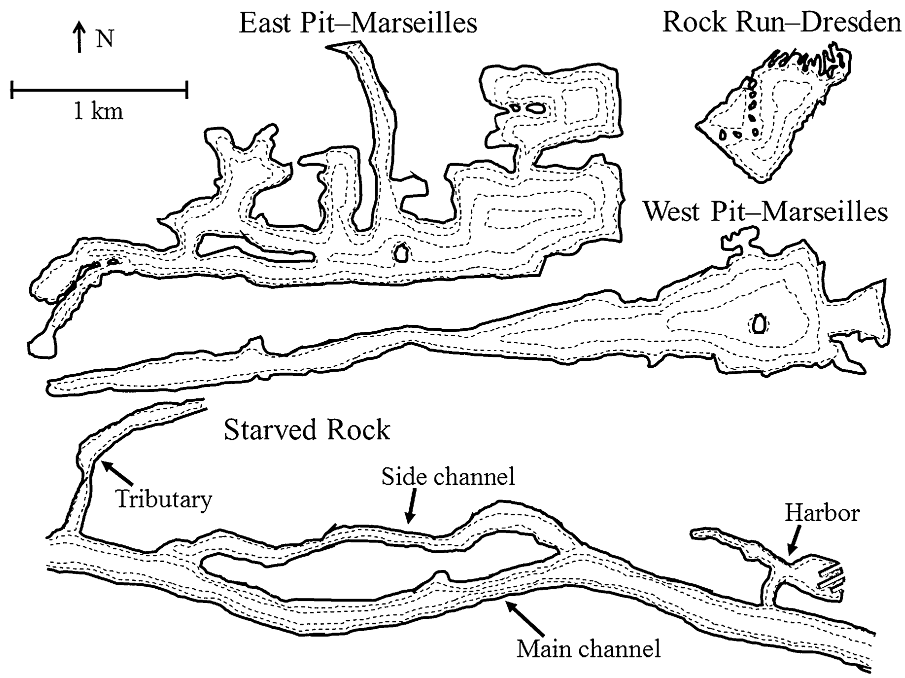


Fig. 3 Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after harvest events in the three backwater lakes consisted of a single nearshore loop only, rather the multiple loops undertaken as part of the river-wide surveys (as shown). For all surveys, the acoustic beams were aimed outward from the nearest shoreline

measurements of all species captured were taken. To minimize the time interval between hydroacoustic sampling and the harvest event (and thus the possibility of fish movement between the main channel), transects consisted of a single nearshore loop only (i.e. the area where harvest netting is focused) rather than multiple loops.

Hydroacoustic post-processing

Hydroacoustic data were processed using Echoview 5.4 software. An exclusion line was manually drawn at the point where the acoustic beams intersected the river bed (Fig. 2). Only data in the water column >1 m from the transducers (i.e. two times the near-field zone; Simmonds and MacLennan 2005; Rudstam et al. 2009) and before the exclusion line were analyzed. Areas of high interference (e.g., caused by passing boats or wind-generated waves) where acoustic targets could not be reliably distinguished were also excluded. Background noise was filtered by removing acoustic signals less than −60 decibels (dB). The volume of water sampled was calculated between the near-field and exclusion lines (Fig. 2) using the 'wedge volume sampled' method in Echoview.

Fish targets were identified using Echoview's 'split-beam single target detection (method 2)' algorithm following Parker-Stetter et al. (2009). Echoview's 'fish track detection' algorithm was then used to group targets originating from a single fish (Table 1). All fish tracks were manually inspected and edited to ensure accuracy. The mean compensated target strength (TS; in dB) of each fish track was then converted to fish total length (TL) using the side-aspect TL–TS equation given by Love (1971). Unlike most TL–TS equations, this multi-species equation is not frequency-specific and hence could be applied to the various transducer frequencies used. One shortcoming of using Love's (1971) equation is that it relates to maximum side-aspect target strength; this assumes that fish targets are ensonified near-perpendicular to the acoustic beam axis. Though likely in the main channel due to fish orientation relative to river flow and our parallel transect design, fish orientation may not be as uniform in lentic backwaters (i.e. acoustic ensonification may not always be exactly side-aspect). Adopting a TL–TS equation developed at multiple body aspects, for example 360° (Kubecka and Duncan 1998) could reduce this potential source of bias but, to our knowledge, such studies are all frequency-specific. Thus, for consistency across habitats and transducer frequencies, we opted to use the Love (1971) TL–TS equation and believe that using the mean TS of a fish track for conversion to TL

Table 1 Single target and fish track algorithm properties used for hydroacoustic post-processing

Split-beam single target detection (method 2)	
Min. and max. TS threshold (dB)	Dependent on transducer frequency used (Love 1971); corresponded to fish TL range of 30–120 cm
Pulse length determination level (dB)	6
Min. and max. normalized pulse length	0.6 and 1.5
Max. beam compensation	6
Max. standard deviations of minor and major axis angles	0.6
Fish track detection	
Min. number of single targets	1
Min. number of pings in track	1
Max. gap between single targets	3

adequately accounts for fish targets that may not have been ensonified exactly in the side aspect.

To further improve the accuracy of the fish track algorithms and manual editing, only acoustic targets corresponding to >30 cm TL were included in the analysis (the smallest silver carp or bighead carp captured in any year of the study was 48.8 cm).

Paired sampling

To interpret the acoustic data, we used information gathered annually in each reach during late summer/early autumn from a random site pulsed-DC electrofishing program (The Long-term Illinois, Mississippi, Ohio, and Wabash Rivers Fish Population Monitoring Program; http://wwx.inhs.illinois.edu/fieldstations/irbs/research/ltef-website/; see also McClelland et al. 2012) and the Asian carps harvest program (subsampling of target and bycatch species captured using short-set gill and trammel nets). Fish collected were identified, measured (TL; mm) and weighed (g). Both capture methods were combined to reduce selectivity biases (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014) and all fish >30 cm TL were separated into three categories (i.e. silver carp, bighead carp, and other fish species). For each reach, proportional abundance of silver carp, bighead carp and other fish species was determined for each 2 cm TL-class (i.e. 30–32, 32–34 cm…) and then linearly interpolated for each 0.1 cm TL increment, up to a maximum of 120 cm TL; if the largest fish captured was less than this cut-off point, a 1.0 bighead carp proportion was assumed for the remaining length increments, which was corroborated with field observations.

Estimating bigheaded carps demographic parameters

Surveys were analyzed following the protocols developed by Scheaffer et al. (1996) and Parker-Stetter et al. (2009). Main channel transects were separated into two strata, the first stratum consisting of the nearshore loop and the second stratum consisting of the mid-channel loop (Fig. 3). Each 0.926 km (0.5 nautical mile) sampled along these strata represented replicates. Backwaters had one to four strata (depending on whether single or multiple transect loops were undertaken) (Fig. 3) and 0.463 km replicates were used. Initial density calculations were made based on all fish detected (i.e. converted acoustic targets equating to fish of 30–120 cm TL). Stratum-specific fish density $\bar{\rho}_h$ and within-stratum variance $Var(\bar{\rho}_h)$ were calculated as:

$$\bar{\rho}_h = \frac{1}{n_h}\sum_{i=1}^{n_h} \rho_{h,i} \tag{1}$$

$$Var(\bar{\rho}_h) = \frac{1}{n_h - 1}\sum_{i=1}^{n_h} \left(\rho_{h,i} - \bar{\rho}_h\right)^2 \tag{2}$$

where n_h = number of replicates in stratum h and $\rho_{h,i}$ = mean fish density of replicate i within stratum h. For single stratum backwaters, this was the final mean fish density. For multi-strata survey sites, final mean fish density $\bar{\rho}$ and standard error ($SE(\bar{\rho})$) were calculated as:

$$\bar{\rho} = \frac{1}{A}\sum_{h=1}^{L} A_h \cdot \bar{\rho}_h \quad (3)$$

$$SE(\bar{\rho}) = \sqrt{\sum_{h=1}^{L}\left(\frac{A_h}{A}\right)^2\left(\frac{Var(\bar{\rho}_h)}{n_h}\right)} \quad (4)$$

where L = total number of strata, A = volume of water sampled for all strata combined, and A_h = volume of water sampled for stratum h (such that estimates were weighted by the sampled volume in each strata).

Silver carp and bighead carp densities (fish/1000 m^3 of sampled water) and associated 95 % confidence intervals were then calculated for each survey site by assigning the paired sampling proportional abundances to the size-specific densities. To obtain representative reach-specific and upper river density estimates, sampling sites were combined and calculated as above in Eqs. (3) and (4), except strata were substituted by sampling site.

To determine approximate size structure and numerical species composition of bigheaded carps, acoustic targets corresponding to fish TL with a >0.5 silver carp or bighead carp proportional abundance were classified accordingly.

Statistical analysis

Differences between annual hydroacoustic density estimates were assessed by pairwise interval estimation (i.e. whether the 95 % confidence interval of the difference in means contained zero). Changes in size structure were assessed using a non-parametric Kruskal–Wallis H-test, followed by Dunn's post hoc test. A χ^2 test of independence was used to determine whether species composition (silver carp vs. bighead carp) changed. Due to error in both the X and Y variables, the relationship between harvest CPUE and hydroacoustic density estimates of bigheaded carps was examined using reduced major axis (RMA) regression (Sokal and Rohlf 1995). A non-parametric repeated-measures approach (Wilcoxon signed-rank test) was used to determine if hydroacoustic density estimates differed between sampling undertaken before and after harvest events (i.e. for each identical 0.463 km replicate). The critical level of significance was set at $P = 0.05$. All statistical analyses were performed using IBM SPSS Statistics 21, except for RMA regressions performed using RMA for JAVA v. 1.21: Reduced Major Axis Regression software (Bohonak and van der Linde 2004).

Results

Characterizing the advancing population

Main channel and backwater sampling sites in the Upper Illinois River differed in terms of bigheaded carps density. Of the 45 total sampling occasions (15 sites × 3 years), six backwaters had lower densities than the corresponding main channel, whereas, the remaining backwater densities were on average 9.3 times (range = 1.5–23.3 times) higher than the main channel. However, to give a representative overall measure of the bigheaded carps population, and to account for the different number and type of backwaters within each reach, the advancing population was examined by combining main channel and backwater estimates for each reach.

Regardless of year, a significant decreasing bigheaded carps density gradient was apparent from the lowermost Starved Rock reach upstream to the population front (Dresden reach) (Fig. 4). Overall density was highest in Starved Rock, occurring in the range *c.* 0.4–1.6 bigheaded carps/1000 m^3. Annual mean densities of either species were consistently significantly higher in Starved Rock than Marseilles (*c.* 0.15–0.4 bigheaded carps/1000 m^3) and Dresden (<0.15 bigheaded carps/1000 m^3). Silver carp density followed this observed gradient each year (i.e. Starved Rock > Marseilles > Dresden). Bighead carp density was always highest in Starved Rock, while its density was comparable in Marseilles and Dresden during 2012 and 2013, but not 2014 (Fig. 4). Silver carp mean density in Dresden was <0.02/1000 m^3 in all years.

Significant longitudinal shifts in the size structure (H = 501–1319, all $P < 0.001$ (post hoc, all $P < 0.001$)) and species composition (χ^2 = 116–937, all $P < 0.001$) of bigheaded carps were observed from downstream to upstream in the Upper Illinois River during each year (Fig. 5). Within the highest density Starved Rock reach, bigheaded carps were significantly smaller and dominated by silver carp (71.6–83.8 % silver carp). In the lower density Marseilles reach, bigheaded carps were larger, and

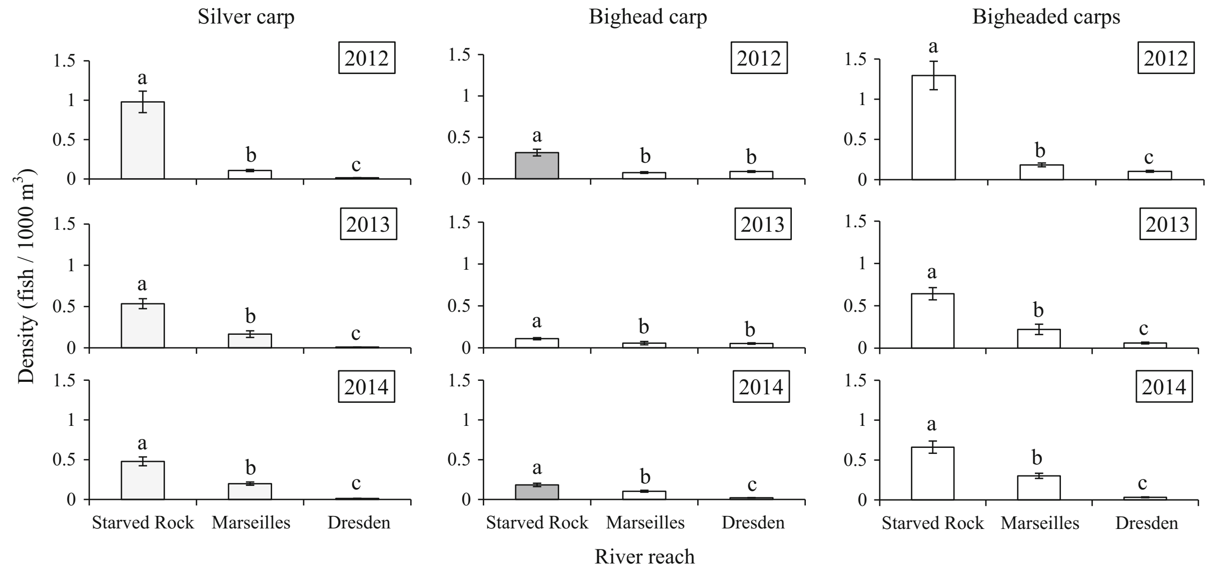


Fig. 4 Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated by *different letters*

though the proportion of bighead carp increased, there was still a silver carp predominance (59.4–74.2 % silver carp). At lowest density, in the Dresden reach (i.e. the population front), bigheaded carps were largest and species composition shifted in favor of bighead carp (15.1–38.2 % silver carp) (Fig. 5).

Validating hydroacoustic density estimates for harvest evaluation

Hydroacoustic sampling of backwater lakes was undertaken on ten occasions before harvest events, and on eight occasions after harvest events. Depending on the lake, one to five fishing crews operated, with effort (total m of net) ranging from 1829 to 14,905 m (mean ± SD = 6963 ± 4325 m). Harvest events captured 1–1301 bigheaded carps (mean ± SD = 589 ± 483 individuals). Hydroacoustic estimates of bigheaded carps density before harvest were significantly correlated with bigheaded carps harvest CPUE ($R^2 = 0.744$; Fig. 6a; Table 2). The density equivalent of harvested bigheaded carps (i.e. the difference in before–after hydroacoustic estimates) was also significantly correlated with bigheaded carps harvest CPUE ($R^2 = 0.823$; Fig. 6b; Table 2).

In nearly all cases, harvest significantly reduced bigheaded carps densities in the short term (i.e. within a <24 h period) by 32.0–64.4 % on average (Table 3). However, at backwater lakes with more than one before–after sequence, densities rebounded to initial levels (Rock Run 2014, East Pit 2015), or exceeded initial levels (East Pit 2014), in as little as 2 weeks (Table 3).

Bigheaded carps population changes throughout the upper Illinois River

Discharge conditions during the surveyed period in 2012 (mean ± SD = 70 ± 25 m^3/s) and 2013 (77 ± 24 m^3/s) were considerably lower than in 2014 (313 ± 142 m^3/s) but, in terms of the overall hydrograph, prolonged high discharge conditions occurred during 2013 and 2014 compared to the lower discharge in 2012, a drought year (Fig. 7 top). The total number of bigheaded carps harvested March–December increased annually from 45,192 in 2012, to 58,374 in 2013 and 102,453 in 2014. Monthly harvest (all gear types) of bigheaded carps within each reach was variable (Fig. 7) and, to a certain extent, harvested quantity (all gear types) and CPUE (gill and trammel nets) of bigheaded carps broadly reflected the advancing populations' density gradient (as described above).

Based on the annual hydroacoustic surveys, bigheaded carps density in the entire upper river (i.e. all

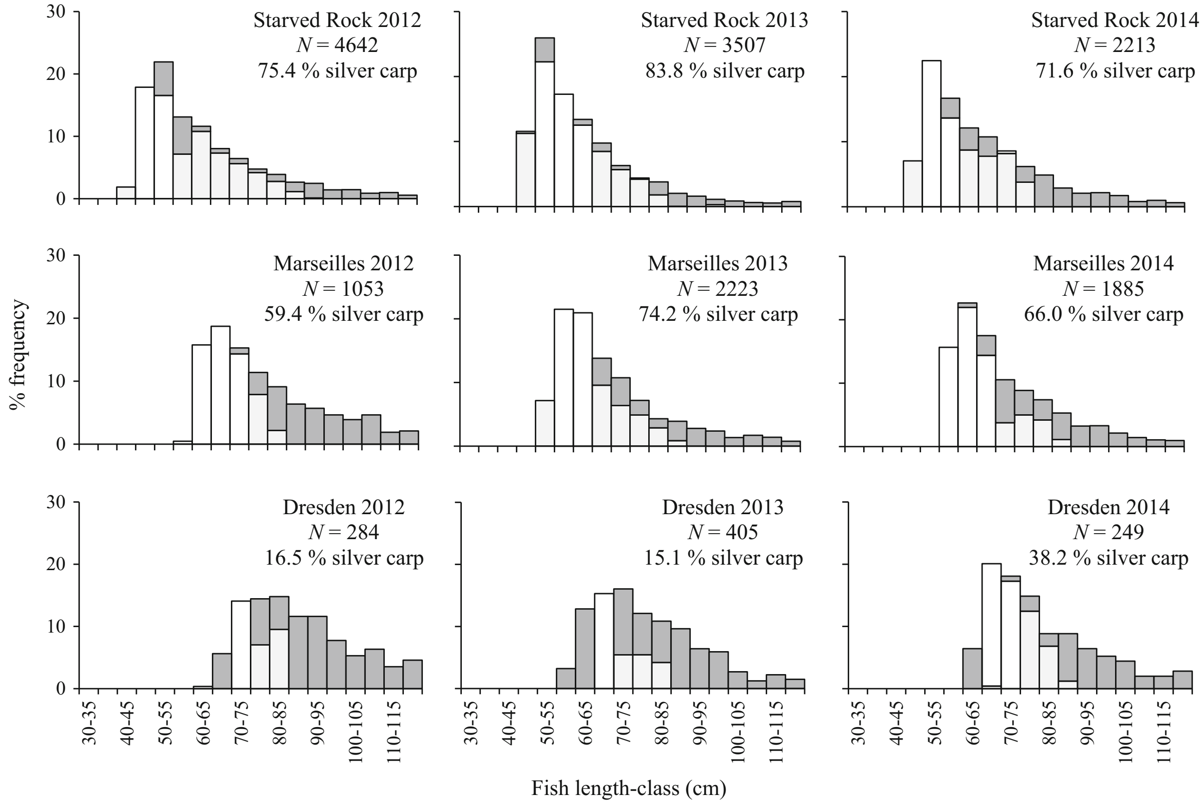


Fig. 5 Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding to each size distribution are shown

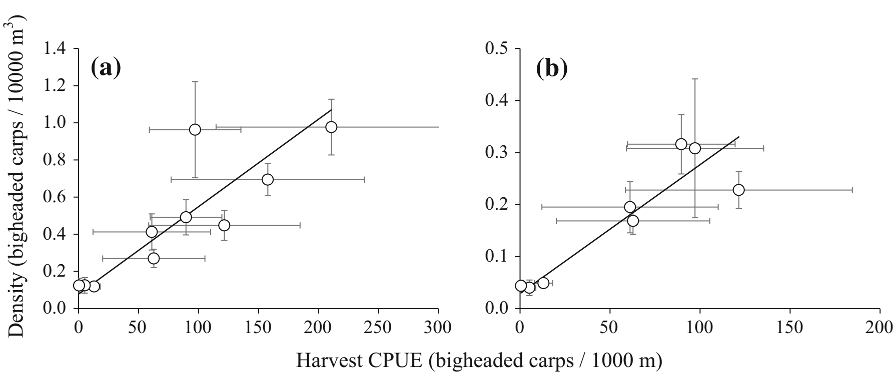


Fig. 6 Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence intervals

reaches combined) declined significantly, from $0.492 \pm 0.053/1000\ m^3$ in 2012 to $0.278 \pm 0.034/1000\ m^3$ in 2013, but remained stable between 2013 and 2014 ($0.254 \pm 0.024/1000\ m^3$). Annual density in Starved Rock mirrored that of the entire river, in contrast to Marseilles (where density did not change

Table 2 Reduced major axis regression estimates for (a) bigheaded carps density (before), and (b) before–after difference in bigheaded carps density, versus bigheaded carps harvest CPUE. Note that the primary statistics (*F* values and *P* values) are from linear least-squares regressions

Variable	Intercept ± SE	Slope ± SE (95 % CIs)	*F*	*df*	*P*	R^2
(a) Bigheaded carps density (before)	0.073 ± 0.090	0.005 ± 0.001 (0.003–0.007)	23.291	1, 8	0.001	0.744
(b) Before–after difference in bigheaded carps density	0.028 ± 0.030	0.003 ± 0.0004 (0.001–0.004)	27.807	1, 6	0.002	0.823

Table 3 Hydroacoustic estimates of bigheaded carps density (mean ± 95 % confidence intervals) before and after harvest events in three backwater lakes of the Upper Illinois River during 2014 and 2015. Bigheaded carps harvest metrics (CPUE and total number of individuals harvested) for the corresponding harvest event are given in parentheses under each pair of density estimates

2014						
East Pit (Marseilles)	6 May → 7 May		19 May → 20 May		7 July → 8 July	
	0.270 ± 0.049[a]	0.101 ± 0.023[b]	0.491 ± 0.095[a]	0.175 ± 0.037[b]	0.963 ± 0.259[a]	0.655 ± 0.126[b]
	(62.5 and 812)		(83.1 and 855)		(87.3 and 1301)	
West Pit (Marseilles)	20 May → 21 May					
	0.119 ± 0.020[a]	0.070 ± 0.023[b]				
	(13.4 and 66)					
Rock Run (Dresden)	8 July → 9 July		24 July → 25 July			
	0.125 ± 0.042[a]	0.078 ± 0.037[a]	0.124 ± 0.039[a]	0.069 ± 0.029[b]		
	(5.1 and 26)		(0.5 and 1)			
2015						
East Pit (Marseilles)	6 Aug → 7 Aug		7 Sep → 8 Sep			
	0.420 ± 0.099[a]	0.217 ± 0.048[b]	0.448 ± 0.081[a]	0.220 ± 0.045[b]		
	(56.6 and 150)		(116.2 and 701)			

Different superscript letters indicate a significant difference ($P < 0.01$) for each before and after sequence

year to year, but did increase significantly between 2012 and 2014) and Dresden (where consecutive annual declines in density occurred) (Fig. 7). At the scale of the entire upper river, the population response appears closely linked with the prevailing seasonal/annual discharge regime, as increasing annual harvest elicited an apparent 43.5 % decline after a drought year, but only maintenance of the reduced density levels following a flood year.

Discussion

The Upper Illinois River, as the conduit that links two major hydrological basins (one invaded and one not), is a critical location at which to investigate bigheaded carps invasion dynamics and the population response to control efforts (Cooke 2016). We adapted marine and large lake hydroacoustic protocols (Simmonds and MacLennan 2005; Parker-Stetter et al. 2009; Rudstam et al. 2009) for use in this shallow riverine environment, to estimate key demographic parameters of the advancing population at the edge of their range and, thus, by extension evaluate the efficacy of harvest in the Upper Illinois River.

Advancing population characteristics

Density of bigheaded carps was assessed on a volumetric basis, on the assumption that it is the most representative measure of population status (i.e. direct measurement rather than extrapolation). Annual fall surveys of the advancing populations' continuous longitudinal distribution confirmed that bigheaded carps were more prevalent downstream than upstream. The advancing population in each reach was

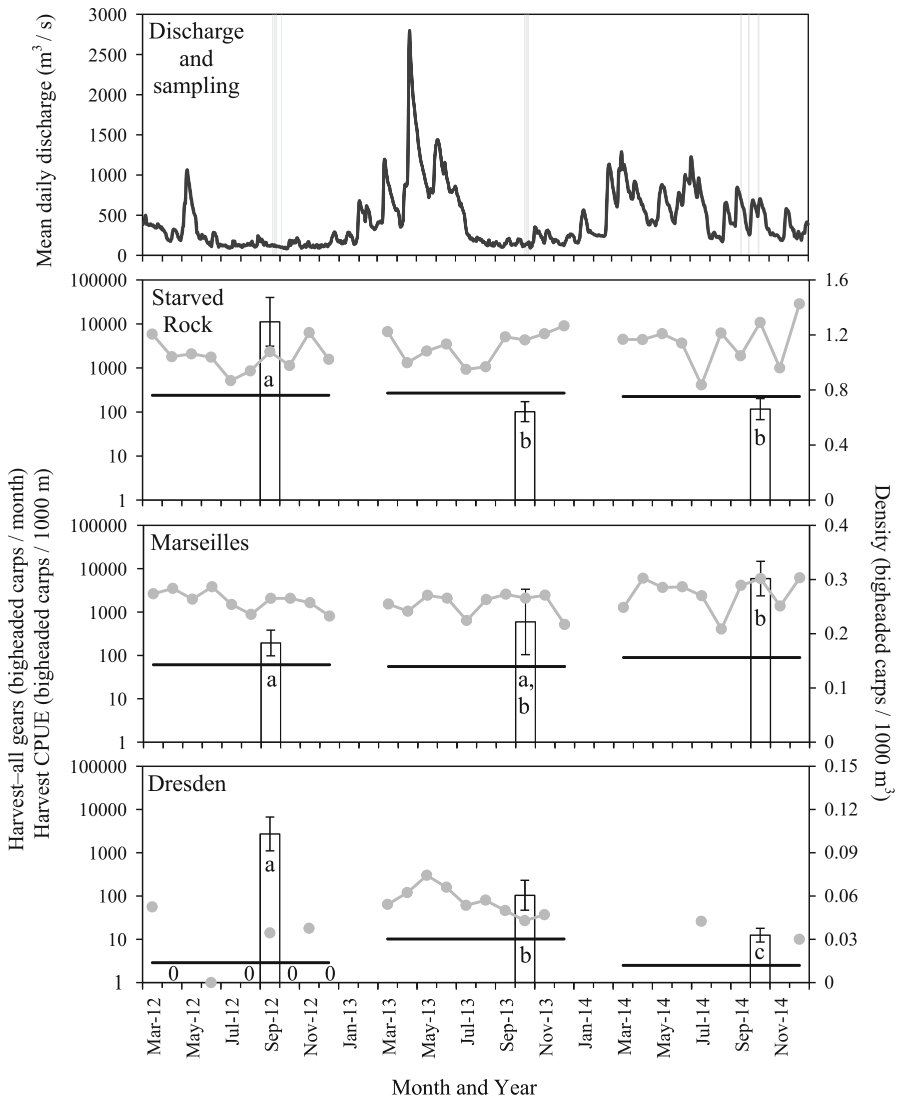


Fig. 7 *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks* indicate no fishing), annual bigheaded carps gill/trammel net CPUE (*horizontal black lines*) and bigheaded carps mean density ±95 % confidence intervals (*white bars*). Note y-axis logarithmic scale for harvest and CPUE, and the different scales for density in each reach. Significant differences ($P < 0.05$) in densities within a reach are indicated by *different letters*

categorized into distinct density components, ranging from the highest levels in Starved Rock to the lowest in Dresden. Site-specific densities within a reach may lie outside the observed ranges (reflecting habitat preferences of bigheaded carps e.g., DeGrandchamp et al. 2008), but these overall classifications provide an indication of the density gradient of this advancing population. Such information is useful where bigheaded carps are expanding their range, so as to quantify the invasion process and set appropriate removal targets (e.g., Tsehaye et al. 2013; Green et al. 2014).

Size structure and species composition also appear linked with each bigheaded carps density component, as body size (both species) and proportion of bighead carp increased from downstream to upstream. To what extent this is attributable to species-specific upstream dispersal or other density-dependent mechanisms is not clear. It also remains to be seen if the interannual variability in size structure and species composition observed within a particular reach reflects natural trends (e.g., a strong year-class) or is harvest-induced through gear selection for a particular species or size-class (Irons et al. 2011; Tsehaye et al. 2013).

Harvest evaluation (short-term, local scale)

The series of before–after harvest experiments in backwater lakes showed that in nearly all cases, density of bigheaded carps was reduced immediately post-harvest. It is probable that the large quantities of bigheaded carps removed by harvest caused most of the observed declines, but fish actively moving from the backwater to the main channel in response to the disturbance of the harvest event may also have contributed. This is especially likely in the smallest lake, Rock Run, which would help explain the somewhat less consistent results there.

Regardless of initial densities, recolonization of the backwater lakes occurred in as little as two weeks. Rebound rate is an important metric for evaluating targeted harvest (Frazer et al. 2012) and it appears that, in these locations at least, some features and/or conditions are continually re-attracting bigheaded carps (e.g. Cuddington et al. 2015). An integrated pest management approach (Koehn et al. 2000; ACRCC 2015), involving removal of individuals present (i.e. by harvest) and prevention of recolonization by new individuals (e.g., by behavioral barriers at strategic locations or manipulation of water levels), may be a rational approach to pursue, but the potential for altering upstream dispersal must also be carefully considered.

Hydroacoustic and capture gear comparisons can be highly variable, with the level of accuracy depending on the environment, gear type and characteristics of the species under consideration (e.g., Mehner and Schulz 2002; Dennerline et al. 2012; Guillard et al. 2012). Though the use of mobile hydroacoustic methods in shallow environments is increasing (e.g., Lucas and Baras 2000; CEN 2014), few studies have verified estimates against known relative abundance indices. The positive density–CPUE relationships obtained during the backwater lake experiments provided the basis upon which to use our river-wide hydroacoustic surveys as a tool to evaluate harvest on a broader spatiotemporal scale (i.e. throughout the upper river over three consecutive years).

Harvest evaluation (long-term, river-wide)

The river-wide fall surveys were not intended to directly correspond with harvest events, as sampling occurred during alternate weeks to harvest. Instead, we aimed to provide 'snapshots' of the population status in the entire upper river, at a comparable stage of each year (i.e. during suitable hydrological conditions, and when the harvest season had been underway for *c.* 6 months). Therefore, while harvested quantities and CPUE of bigheaded carps broadly reflected the density components estimated from the hydroacoustic surveys, they appear to lack the resolution of the hydroacoustic surveys to map fluctuations within these ranges (see Dennerline et al. 2012). The complexity of these reach-specific density trends likely reflects between-reach movement and differential harvest rates. Biases associated with the unstandardized, catch-maximizing approach of the harvest program further confound the interpretation of the capture statistics and highlight the need for the present fishery-independent evaluation.

Despite the large quantities of bigheaded carps removed from the Upper Illinois River annually, harvest alone is clearly not the only factor regulating population dynamics in the river (see also Tsehaye et al. 2013). Total harvest increased annually, yet density did not decline between 2013 and 2014. Instead, the prevailing discharge regime may play a key role. In situ reproduction is currently a negligible source of bigheaded carps in the upstream portion of the river (ACRCC 2015), thus Starved Rock Lock and Dam is the only immigration pathway to the Upper Illinois River from the high density reaches farther downstream (Sass et al. 2010; Garvey et al. 2012). Discharge is important for upstream fish passage at low-head dam structures (Zigler et al. 2004; Tripp et al. 2014) and it is likely that population densities were sustained by high immigration via Starved Rock Lock and Dam to the upper river in the latter two study years due to 'open-river' conditions (i.e. dam gates open to varying degrees to prevent flooding during high discharge). Both silver carp and bighead carp have shown increased movement rates during periods of high water levels (DeGrandchamp et al. 2008; Coulter et al. 2016).

The observed decline in bigheaded carps density in the Dresden reach (*c.* 68 % cumulative decline between 2012 and 2014) is interesting to note, suggesting that continued harvest at the low density population front may be effective (likely aided somewhat by the spatial isolation from higher densities downstream). From an invasion biology perspective, the ability to suppress at such low density has important management implications, both at the

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Conclusions

When viewed in the context of other removal efforts in large rivers (Mueller 2005; Coggins et al. 2011; Franssen et al. 2014), the Asian carps harvest program in the Upper Illinois River compares quite favorably. During the 3 years of sampling, overall density declined to and remained at the lower level, and the population front has not expanded. However, hydrological variability (and possibly other environmental conditions) likely determine the extent of the population response in a particular year. Years with coinciding high discharge, strong year-class and/or successful recruitment are likely to put harvest resources under considerable pressure.

While there are still certain technological limitations associated with the use of hydroacoustic methods in shallow riverine environments (e.g., minimum depth and fish size, appropriate TL–TS equation relative to fish aspect, paired sampling required for species identification), this study nonetheless outlines a fishery-independent sampling framework that will be a valuable addition to management of invasive fishes in the Mississippi River basin and elsewhere. Integration of existing population estimates (Sass et al. 2010; Garvey et al. 2012; this study) with movement ecology (DeGrandchamp et al. 2008; Norman and Whitledge 2015) and simulation modeling (Tsehaye et al. 2013) is an important next step that will help disentangle the complex invasion processes and enable optimum control strategies to be developed.

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APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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Introduction:

Various agencies (e.g., Illinois Department of Natural Resource, U.S. Army Core of Engineers, Illinois Natural History Survey, U.S. Fish and Wildlife), universities (e.g., Eastern Illinois University, Southern Illinois University, Western Illinois University) and personnel (e.g., contracted fisherman, volunteers) collaboratively monitor, remove, and research Invasive Carp (e.g., Bighead Carp [*Hypophthalmichthys nobilis*], Black Carp [*Mylopharyngodon piceus*], Grass Carp [*Ctenopharyngodon Idella*] and Silver Carp [*H. molitrix*]) in the Illinois River. Since numerous entities and personnel actively manage Invasive Carp populations in the Illinois River, standardizing sampling methods among groups and workers is critical. Standardized sampling efforts and methods ensure data collected by these entities and personnel can provide statistically valid interpretations that are comparable among agencies, locations and years. Long term comparisons of standardized sampling data will also allow managers to assess trends in Asian carp dynamics over time and the response of the Asian carp population to management actions.

Objective:

(1) Create a living document (i.e., a continually updated as new data becomes available) describing specifications of sampling gears utilized to deplete, detect, or monitor adult, juvenile, and larval Invasive Carp populations in the Illinois River watershed.

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Adult and juvenile fish capture gears

Active capture gears

Electrofishing (Figure 1):

Flat bottomed aluminum boats, 5.5 to 6.1 m (18.0 to 20.0 ft.) in length powered with 90-horsepower or greater outboard motors served as the boat for electrofishing. One, 3.4 m (11.0 ft.) fiberglass boom was attached to the port rail and starboard rail of the bow of the boat. Each fiberglass boom was created of hollow 3.8 cm (1.5 in.) outer-diameter, and 0.6 cm (0.3 in.) thick walled fiberglass poles and were spaced 3.1 m (10.0 ft.) apart (center to center at ends of booms). Each boom had a 0.9 m (3.0 ft.) diameter round stainless steel anode ring attached to the end of the pole. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode droppers cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 7,000-watt generator produced the electrical charge through an electrofishing box. Electrofishing boxes were either a MBS-1D "Wisconsin" style control box or Type VI-A smith-root control box with on foot pedal safety switch. Pulse rate of electrofishing boxes could be adjusted from 10 to 1,000 Hertz and duty cycles from 1% to 100%. Output voltage was adjustable from approximately 100 to 600 volts peak DC, depending on generator watt capacity and water conductivity. Electrofishers used a standardized pulse rate of 60 Hz with 25% duty with a uniform base power goal of 3,000 watts. Power goals (in watts) were calculated based off specific conductivity (micro siemens per centimeter) and temperature (in degrees Celsius) to ensure potential transfer of watt from water to fish was 3,000 watts. When operating at 3,000-watt power goal, an effective voltage gradient varying from 0.1 to 1.0 volts/centimeter was produced out to approximately 1.0 m from the boat hull and 2.0 m from the anode arrays. Dip nets used during electrofishing to capture stunned fish were 30.0 cm (12 in.) deep by 45.0 cm (17.6 in.) wide stitched to an approximately square frame mounted to a 2.4 m (8.0 ft.) fiberglass handle. Bar-measured mesh size in dip nets was 3.0 mm (0.1 in.).

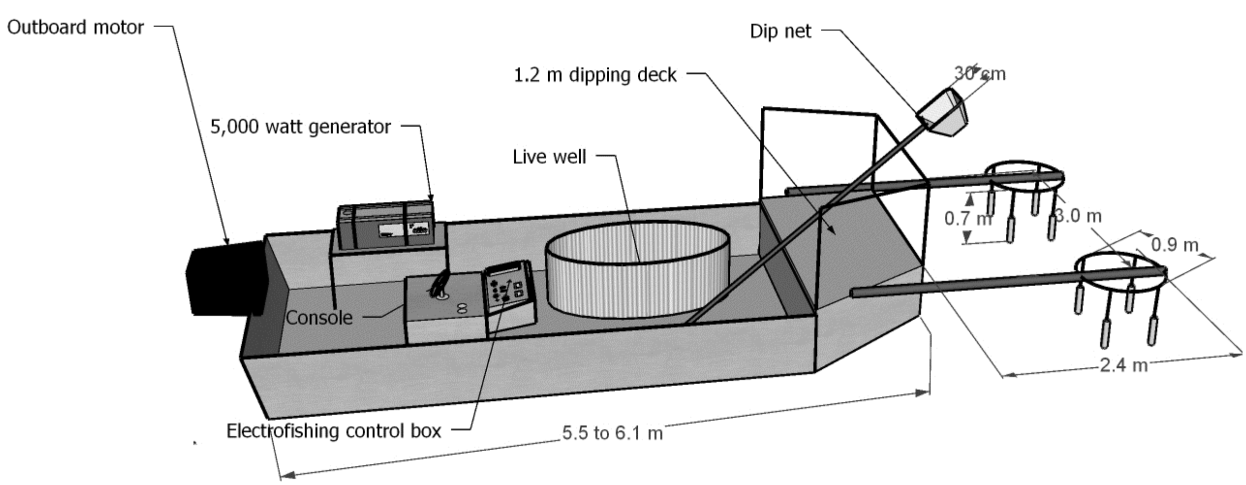

Figure 1. *Schematic of electrofishing boat.*

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Shallow drive electrofishing boat (Figure 2):
A flat-bottomed aluminum boat, 6.1 m (20.0 ft.) in length powered with two 37-horsepower EFI Gator Tail motors served as the shallow drive boat for electrofishing. One, 3.4 m (11.0 ft.) fiberglass boom was attached to the port rail and starboard rail of the bow of the boat. Hollow 3.8 cm (1.5 in.) outer-diameter by 0.6 cm (0.3 in.) thick walled fiberglass booms extended 2.4 m (8.0 ft.) in front of the boat and were spaced 2.7 m (9.0 ft.) apart (center to center at ends of booms) on the port and starboard sides of the bow. Each boom had a 0.8 m (2.5 ft.) diameter round anode ring attached to the end of the pole. Anode rings were constructed of a 1.3 cm (0.5 in.) stainless-steel rod bent and welded into a 76.2 cm (30 in.) outer-diameter circle. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode dropper cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 7,000-watt generator produced the electrical charge through an electrofishing box. Electrofishing box was a ETS 82A wave pulse DC (ETS Electrofishing Systems) control box with two dead man mat style safety switches. Pulse rate of electrofishing box could be adjusted from 10 to 1,000 Hertz and duty cycles from 1% to 100%. Output voltage was adjustable from approximately 100 to 600 volts peak DC, depending on generator watt capacity and water conductivity. Electrofishers used a standardized pulse rate of 60 Hz with 25% duty (15% - 20% duty if specific conductivity is over 900) with a uniform base power goal. A dedicated power goal strategy is currently being developed. Power goals (in watts) were calculated based off specific conductivity (micro siemens per centimeter) and temperature (in degrees Celsius) to ensure potential power transfer was great enough to achieve fish immobilization (narcosis) and electrotaxis but avoid tetany (full rigid, non-breathing) of small bodied (15.2 cm [6.0 in]) native species. Dip nets used during electrofishing to capture stunned fish were 30.0 cm (12 in.) deep by 45.0 cm (17.6 in.) wide stitched to an approximately square frame mounted to a 2.4 m (8.0 ft.) fiberglass handle. Bar-measured mesh size in dip nets was 3.0 mm (0.1 in.).

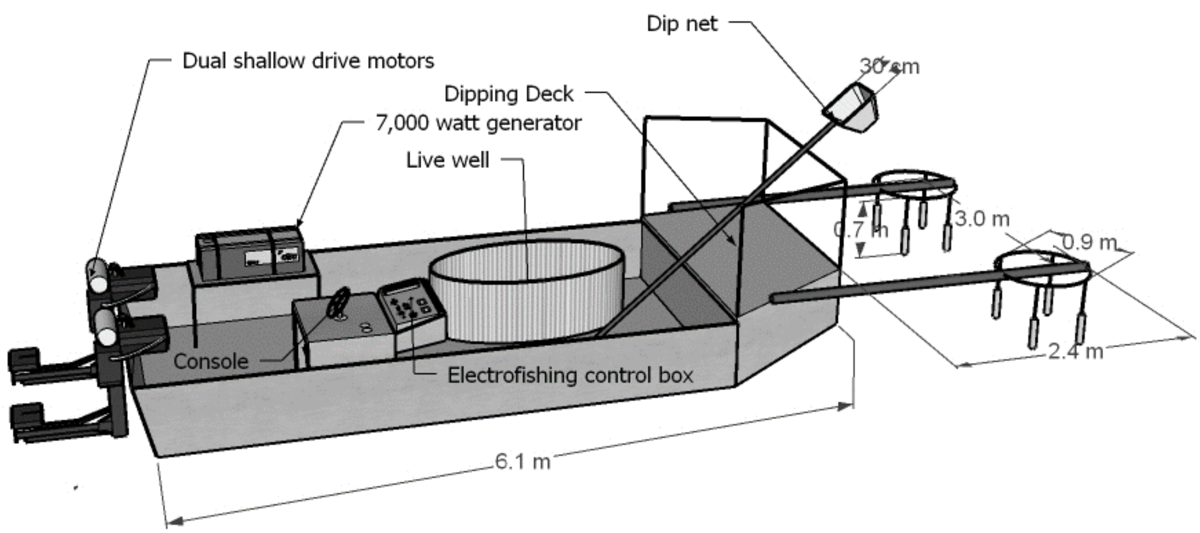

Figure 2. *Schematic of the shallow drive electrofishing boat.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Electrified dozer trawl (Figure 3):

A shallow drafting flat bottom aluminum boat 5.5 m (18.0 ft.) or 5.8 m (19.0 ft.) long, 2.4 m (8.0 ft.) wide with a semi-v bow, powered by a 105-horsepower outboard jet drive connected to a jack plate or a 36-horsepower tiller-steer outboard motor served as the boat for the dozer trawl. A 3.8 cm (1.5 in.) powered coated square steel tubing 2.1 m (7.0 ft) wide and 0.9 m (3.0 ft.) tall frame was secured to two 1.2 (4.0 ft.) booms that were attached to the port and starboard side of the bow with 1.3 cm (0.5 in.) a hinge pin. The net of attached to the frame was 1.83 m (6.0 ft.) or 4.6 m (15.0 ft.) long net was stitched to the frame with a combination of zip-ties and nylon cordage. The net was 4.6 m (15.0 ft.) long with a 3.7 m (12.0 ft.) long front portion was made of 35.0 mm (1.4 in.) bar measured mesh which tapered back in a funnel shape to a 0.9 m (3.0 ft.) cod end made of 4.0 mm (0.3 in.) bar measured mesh. The cod end of the net was tied securely closed using 10.2 mm (0.4 in.) nylon rope. The net-frame was held in fishing position (90 degrees to water surface with net opening forward) by double braided kevlar rope attached from the bottom of the frame to 90.7 kg (200.0 lb.) break away nylon cord at the top. Additionally, heavy duty 3.2 mm (0.1 in.) cord mesh with 5.8 cm (2.0 in.) bar measured netting was tied along the bottom of the fishing net to protect the fishing net from snagging on debris during shallow water fishing. A 1,360 kg (3,000.0 lb.) 12v electric winch fed with 4.8 mm (0.2 in.) steel cable was mounted to the deck of the boat. The steel cable was fed through pulleys on the boom arms to lift the boom-arms and subsequently the net-frame from the water when fishing was complete. A three-anode dropper configuration made of a polyvinyl chloride pipe frame was aligned 2.4 m (8.0 ft.) in front of the trawl frame with anode droppers spaced 457.2 mm (18.0 in.) apart. Alternatively, two anode booms space 1.8 m (6 ft.) apart each with an anode ring and four droppers were used occasionally. Anode rings of the booms were constructed of a 1.3 cm (0.5 in.) stainless-steel rod bent welded into a circle. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode droppers cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 42-amp Infinity control box produced by Midwest Lake Electrofishing System with a 7,000-watt or a 5,500-watt generator produced the electrical charge. A more detailed version of the electrified dozer trawl design is described in Hammen et al. (in review, USFWS-Columbia).

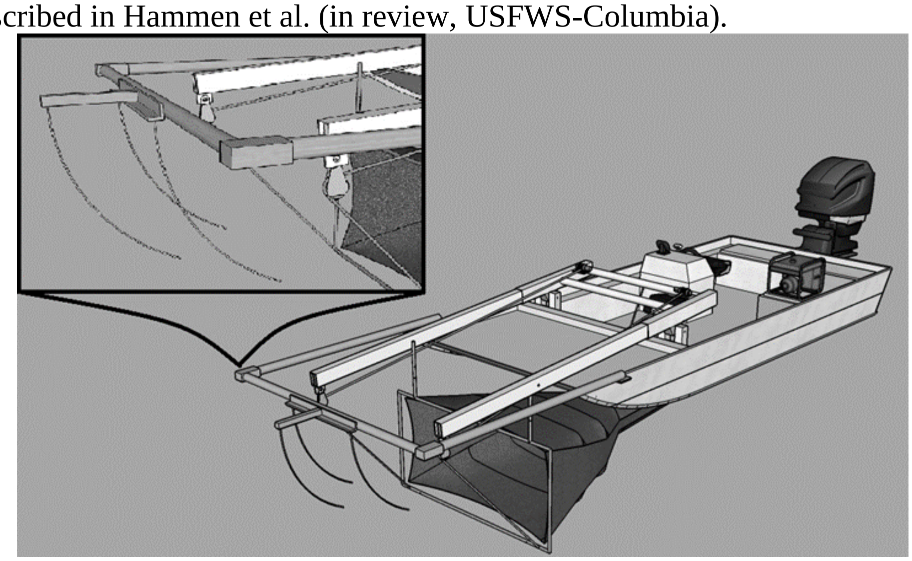

Figure 3. *Generalized schematic of the electrified dozer trawl.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Paupier trawl (Figure 4):

The paupier boat was a 7.3 m (24.0 ft.) long, 1.8 m (6.0 ft.) wide, semi-v bow, flat bottom boat powered with a 175-horsepower outboard motor. The bottom of the paupier was coated with a non-conductive abrasion resistant paint. A 4.0 m (13.0 ft.) wide by 1.5 m (5.0 ft.) deep rigid cathodic frame with a net consisting of 38.0 mm (1.5 in.) mesh in the body reducing to 6.0 mm (0.3 in.) mesh in the cod was attached on both sides of the hull of the boat. Three cable anodes droppers were affixed to booms 3.0-4.0m (10.0-13.0 ft.) in front of each frame. An 18.0 cm (7.0 in.) hemisphere anode was suspended in each frame approximately 1.0 m (3.3 ft.) back from the net opening. Cathodic frames were attached to an aluminum gantry which contained an electric winch allowing the frames to be raised and lowered within the water column during sampling. A Wisconsin ETS MBS-1D 72 amp high-output electrofishing box with 7,000-watt generator was used to produce the electrical charge. A more detailed version of the paupier design is described in Doyle et al. (in review, USFWS-Columbia).

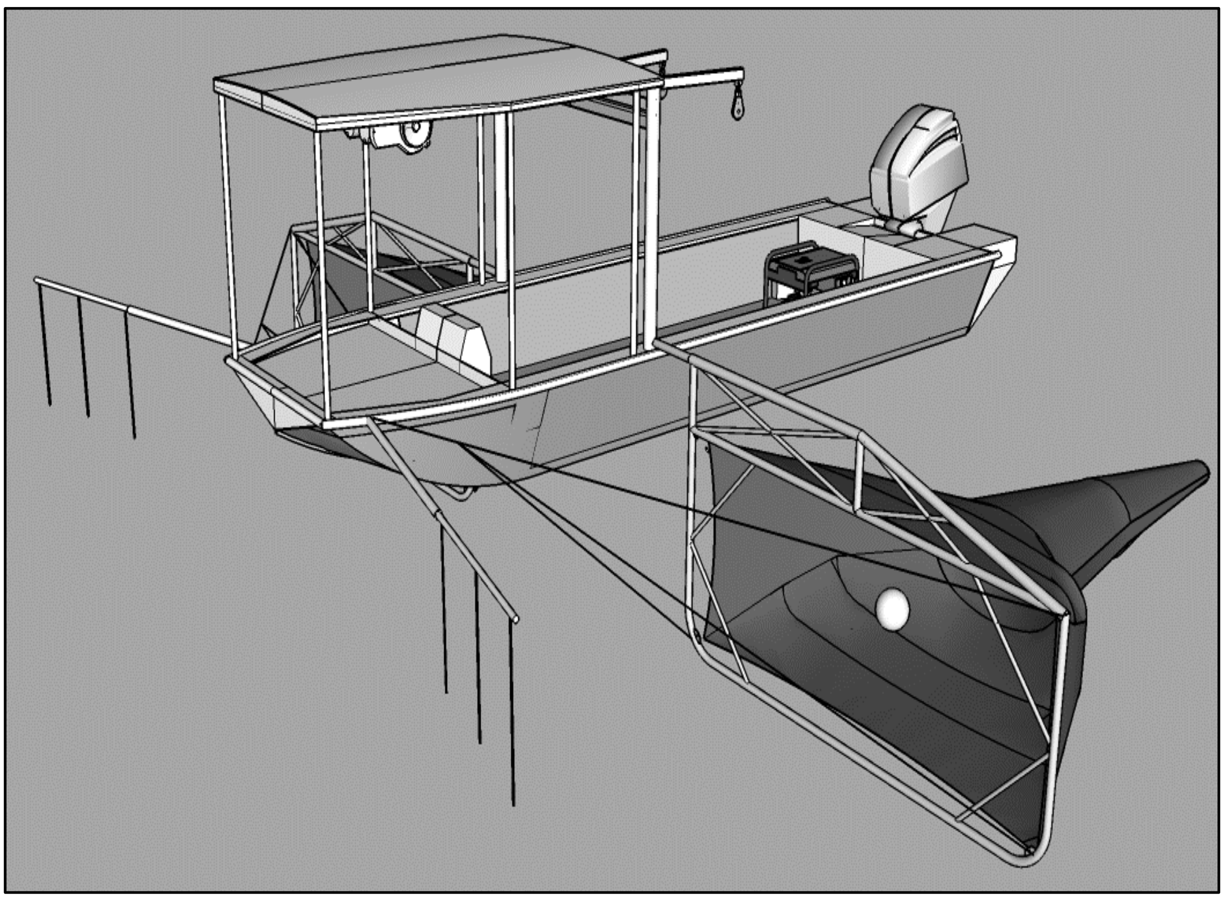

Figure 4. *Schematic of electrified Paupier trawl*

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Seine (Figure 5):

Seines consisted of two wings and a bunt section or a bag (extra material in the middle of the seine concentrating fish) secured to a float line and lead line. Floats were attached every 25.4 cm (10.0 in.) on the float line and a solid core lead line was used as the lead line. Floats were 41.3 mm x 111.0 mm (1.6 in. x 4.4 in.) hard orange foam that produced 85.0 g (3.0 oz.) of buoyancy. Bar measure of mesh was uniform within a seine, but two different mesh sizes of seines were used. The large mesh seine was 50.8 mm (2.0 in.) black asphalt coated bar-measured mesh and the small mesh seine was 1.6 cm (0.6 in.) black asphalt coated bar-measured mesh. Wings had a height of 3.2 m (10.0 ft.) tapering down to the bunt or bag section with a height of 9.1 m (30.0 ft.) for large mesh seines and 6.1 m (20.0 ft.) for small mesh seines. Total length of large mesh seines varied from 274.3 m (900.0 ft.) to 731.5 m (2400.0 ft.). Total length of the small mesh seine was 182.8 m (600.0 ft.).

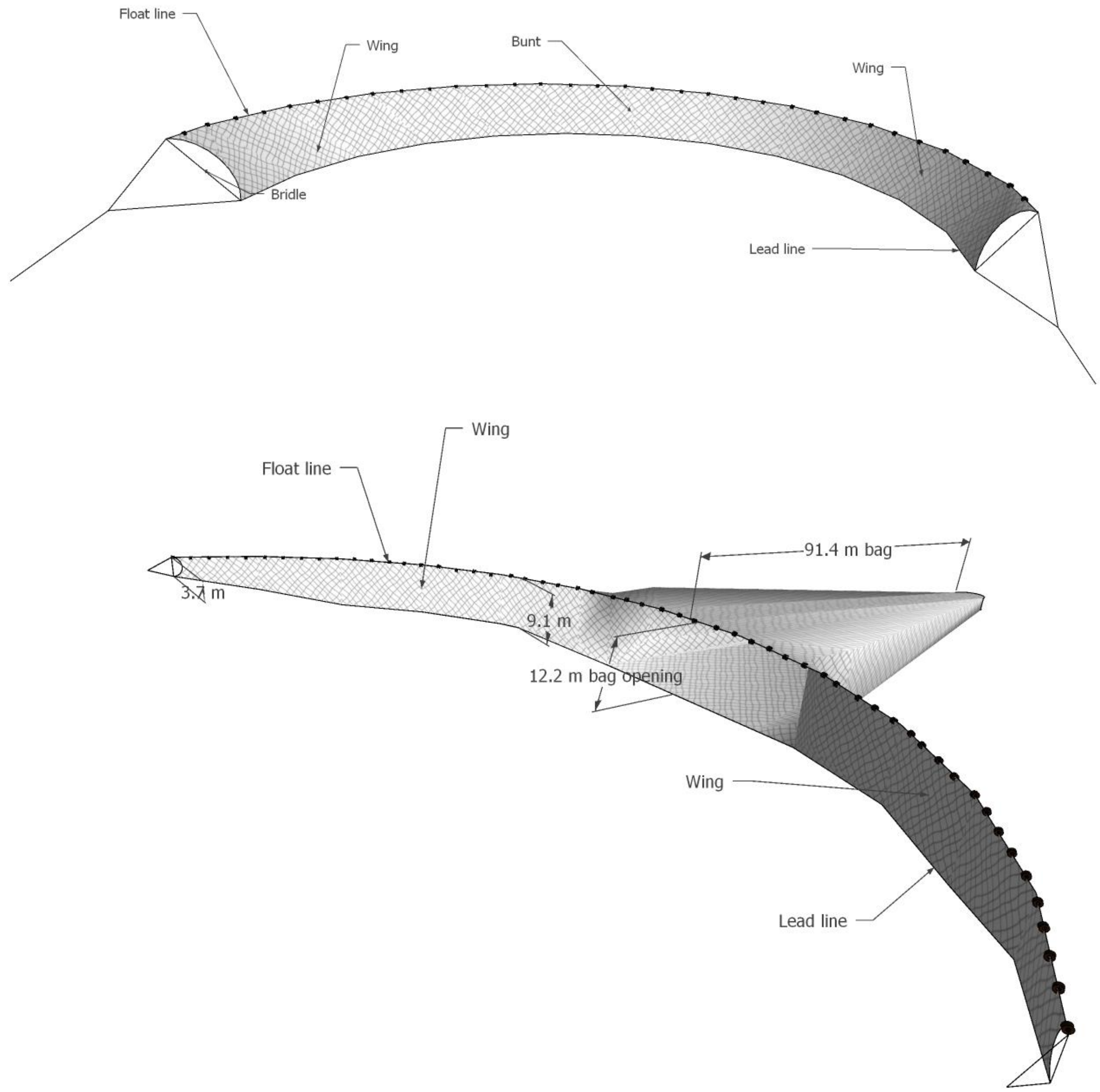

Figure 5. *Generalized schematic of a commercial seine without a bag (top) and with a bag (bottom).*

Trawl (Figure 6):

The trawl was a two-seam balloon style trawl covered with 4.4 cm (1.8 in.) heavy delta-style bar measured mesh. The headrope was 19.8 m (65.0 ft.) long with floats spaced every 30.5 cm (12.0 in.). Floats were 41.3 mm by 111.0 mm (1.6 in. by 4.4 in.) orange hard foam which produced 85.0 g (3.0 oz) of buoyancy. The footrope was 22.3 m (73.0 ft) long with a 7.9 mm (0.3 in.) proof coil low carbon steel chain sewn to it. The mouth opening of the trawl tapered down from 1.8 m (6.0 ft.) at the brail ends to 3.7 m (12.0 ft.) at the mid-section. The 4.4 cm heavy delta-style asphalt coated mesh was attached to the headrope with 1.0 mm #72 black diameter nylon twine. The cod end of the trawl was 12.2 m (40.0 ft.) tarping down to a 2.1 m (7.0 ft.) stretched circumference catch area. Brail ends (sides of the trawl) of the trawl were 1.8 m (6.0 ft.) deep. Each bridle was attached to a 24.4 m (80.0 ft.) towrope that was securely fastened the stern of one of the towboats.

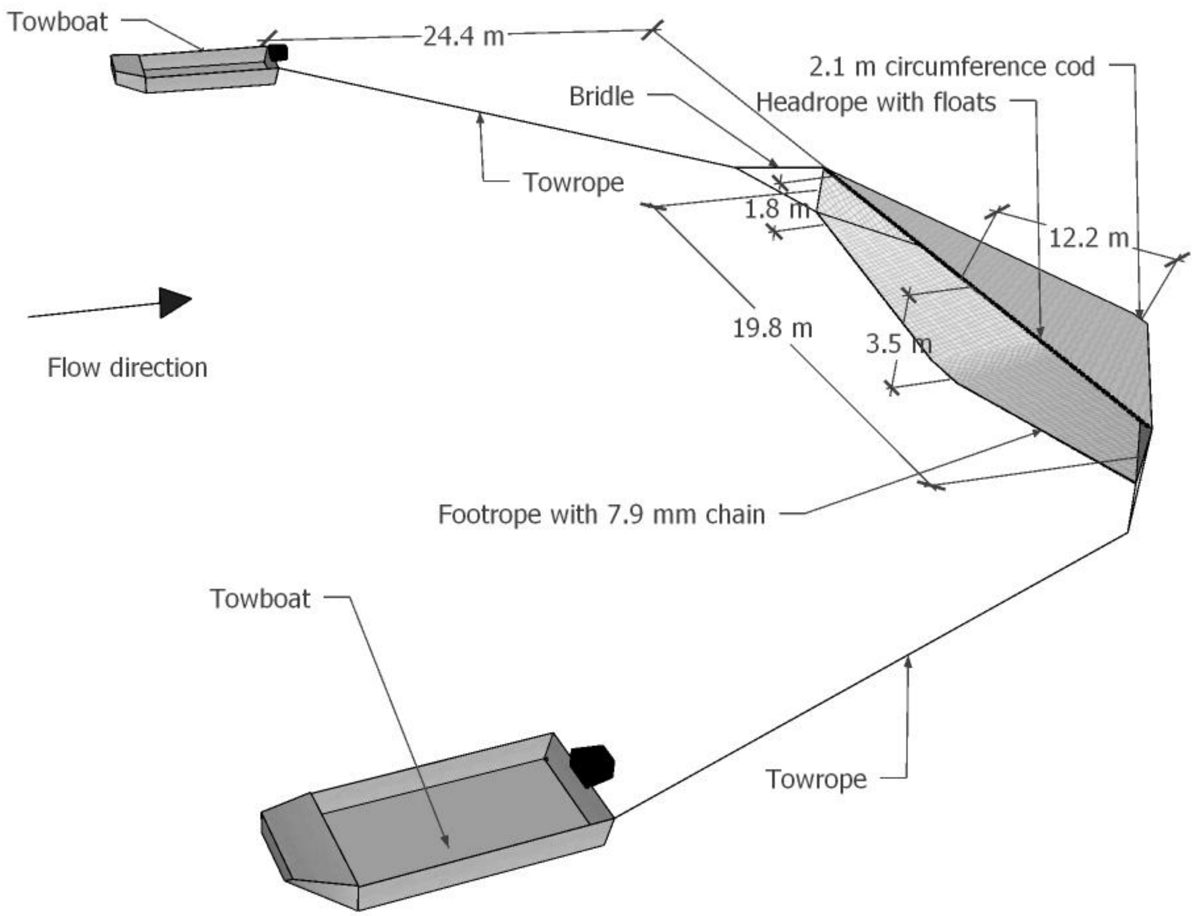

Figure 6. *Generalized schematic of a trawl.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Passive capture gears

Deep-water gill net (Figure 7):

Deep-water gill nets were constructed of three single walled panels made of clear monofilament webbing panels stitched vertically together. Each panel was 3.0 m (10.0 ft.) deep and 91.4 m (300 ft.) long. Stitched panels produced a 9.1 m (30.0 ft.) deep net. The multi-paneled net was tied to a single float line and single lead line. Float line was created from 127.0 mm (0.5 in.) foamcore float line producing 9071.0 g (320.0 oz.) of buoyancy. Lead line was created from #30 leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale; lower number meaning more webbing length per foot of float line) of each panel was 0.5. The bag created (depth of webbing versus the depth of the net) was 0.6 m (2.0 ft.). Bar-measured mesh size of webbing for each panel was 69.9 (2.8 in.), 82.6 mm (3.3) or 88.9 (3.5 in.) attached in a quasi-random experimental fashion (panels of different mesh size attached together to reduce effects of size selectivity). Two multi-panel deep-water gill nets were tied together increasing the total length of the net to 183.0 m (600.0 ft.).

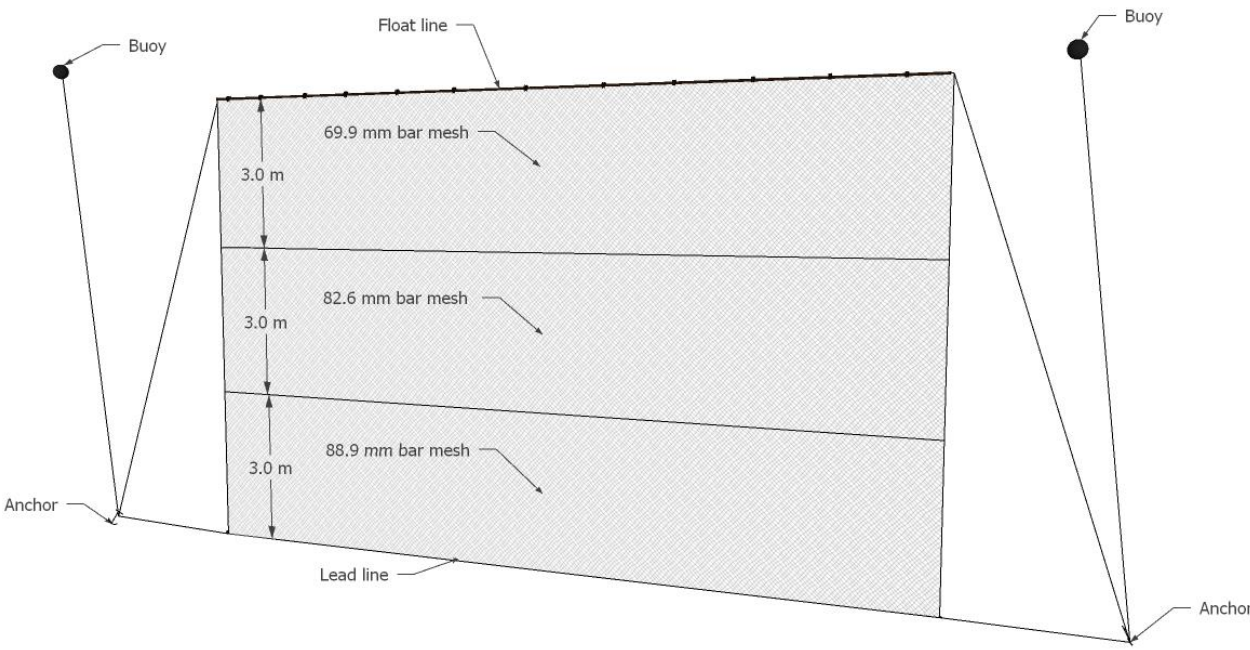

Figure 7. *Generalized schematic of a deep-water gill net.*

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Shallow gill net (Figure 8):

Shallow gill nets were constructed of a panel of single walled monofilament, multi-strand monofilament or multifilament webbing stitched to a float line and a lead line in 91.4 m (300.0 ft.) increments. The float line was created from 95.0 mm (0.4 in.) or 127.0 mm (0.5 in.) foamcore float line producing 4,536.0 g (160.0 oz.) or 9,071.0 g (320.0 oz.) of buoyancy, respectfully. Lead line was created from #30 solid leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale with lower number meaning more webbing length per foot of float line) of each panel varied between 0.5 to 0.2. The bag created (depth of webbing versus the depth of the net) varied between 3.7 m (12.0 ft.) to 1.2 m (4.0 ft.). Color of panel webbing was black, clear, green, purple, red, or white depending on the net. Bar-measured mesh size of webbing varied from 63.5 mm to 127 mm (2.5 - 5.0-in.) depending on the panel. Depth of panel walling varied from 2.4 m (8.0 ft.) to 4.3 m (14.0 ft.) depending on the net. Multiple 91.4 m (300.0 ft.) panels could be tied together increasing the total length of a net to over 914.0 m (3,000.0 ft.).

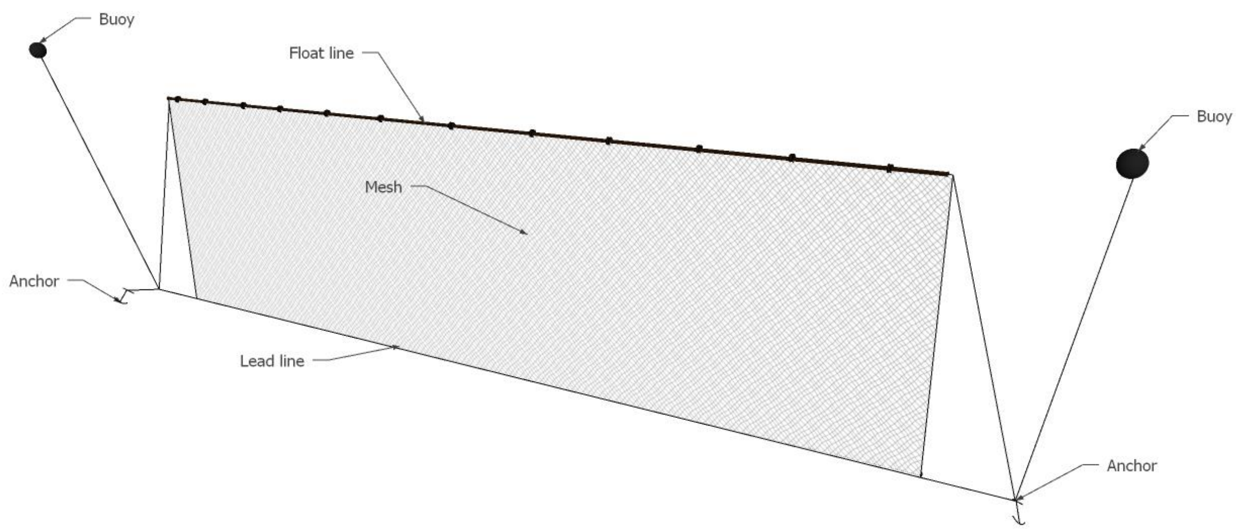

Figure 8. *Generalized schematic of a commercial shallow gill net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Trammel net (Figure 9):

Trammel nets were constructed of three parallel mesh panels of monofilament, multi-strand monofilament or multifilament webbing stitched to a float line and a lead line in 91.4 m (300.0 ft.) increments. Float line was created from 95.0 mm (0.4 in.) or 127.0 mm (0.5 in.) foamcore float line producing 4,536.0 g (160.0 oz.) and 9,071.0 g (320.0 oz.) of buoyancy, respectfully. Lead line was created from #30 leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale with lower number meaning more webbing length per foot of float line) of each panel varied between 0.5 to 0.2. The bag created (depth of webbing versus the depth of the net) was 1.2 m (4.0 ft.). Color of webbing included clear, green, red, and white depending on the panel. Bar-measured mesh webbing size of the outer panels were 457.0 mm (18.0 in.) with inner panel bar-measured mesh varying in size from 63.5 mm to 127.0 mm (2.5 to 5.0 in.) depending on the panel. Depth of panel walling varied from 2.4 m (8.0 ft.) to 3.7 m (12.0 ft.) depending on the net. Multiple 91.4 m (300.0 ft.) panels could be tied together increasing the total length of a net to over 914.0 m (3,000.0 ft.).

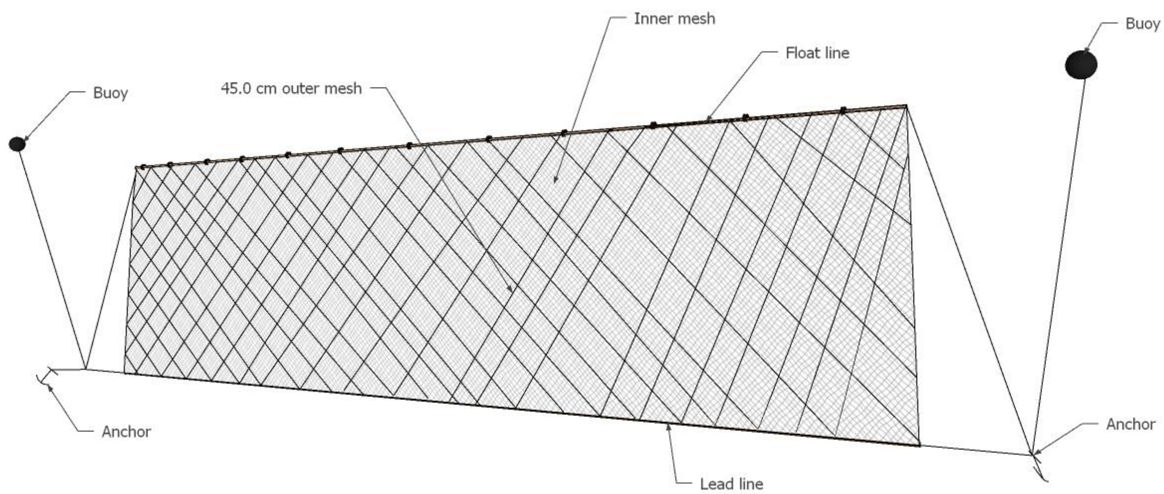

Figure 9. *Generalized schematic of a commercial trammel net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Hoop net (Figure 10):

Hoop nets were constructed of a series of six, 1.8 m (6.0 ft.) fiberglass or spring metal hoops covered in #15 nylon black asphalt coated mesh. Mesh was hung on each hoop with # 21 nylon twine. The first three sections from the mouth between hoops were covered in 8.9 cm (3.5 in.) bar measured mesh and spaced 44.5 cm (17.5 in.) or 5 meshes apart. The last two sections from the mouth between hoops were covered in 6.4 cm (2.5 in.) bar measured mesh and spaced 63.5 cm (25.0 in.) or 10 meshes apart. The cod end was covered in 6.4 cm (2.5 in.) bar measured mesh and 69.8 cm (27.5 in.) or 11 meshes in length. A sand anchor was attached was to tension strings of the cod and a weight plate secured the bridle with a rope 4.0 m to 6.0 m in length tied to the bridle on one end and a buoy on the other ensuring the net remained taught at a length of 6.7 m (22.0 ft.). The weight plate was 1.3 cm (0.5 in.) thick steel plate 30.5 cm (12.0 in.) in length by 20.3 cm (8.0 in.) weighing approximately 6.1 kg (13.6 lbs.). A finger style throat was directed inward from the second and fourth hoop from the mouth of the net and shaped with finger lines. The front finger-style throat hand tapered down to a 61.0 cm (24.0 in.) diameter opening (at rear) and was 53.3 cm (21.0 in.) long. The rear finger-style throat hand tapered down to a 17.8 cm (7.0 in.) diameter opening (at rear) and was 85.9 cm (33.3 in.) long. The front throat had two tension strings secured to the finger lines and tied to the fifth hoop from the mouth of the net. The rear throat had two tensions strings also attached to finger lines secured to the cod-end drawstring. Tension strings were made of #72 black nylon twine.

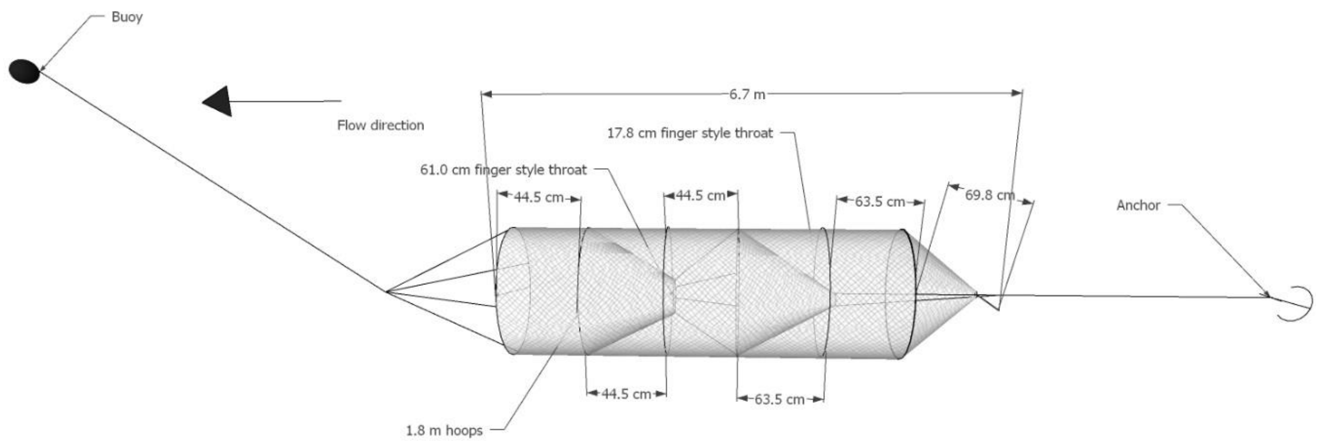

Figure 10. *Schematic of commercial hoop net*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Great lakes style pound net (Figure 11):

Pound nets had a single 100.0 m (328.0 ft.) long by 3.0 m (9.8 ft.) deep lead and two adjustable length wings that were longer than 150.0 m and 3.0 m (9.8 ft.) deep. Floats were attached every 91.4 cm (36.0 in.) on the float line of the lead and wings. Lead line of the lead and adjustable wings were created of solid core lead line. Floats were hard black plastic 127.0 mm (5.0 in.) in length by 51.0 mm (2.0 in.) in diameter which produced about 147.0 g (5.2 oz.) of buoyancy. The lead and adjustable wings were stitched to the heart joining the lead and wings to the mesh cab. The mesh cab or catch area, was a 6.1 m long by 3.0 m wide by 3.0 m deep (19.6 x 9.8 x 9.8 ft.) mesh square. The cab had two, 3.0 m (9.8 ft.) long by 2.5 cm (1.0 in.) diameter steel pipes sewn to the bottom of the horizontal panels of the cab as weights and one 3.0 m (9.8 ft.) long by 7.6 cm (3.0 in.) diameter capped polyvinyl chloride pipe stitched to the top of the rear horizontal cab panel for a float. Inner wings (wall throats) of the mesh cab, created a tunnel that extended from the outer corners of the heart to the middle of the rear rectangle mesh panel of the cab, with a 38.0 cm (15.0 in.) vertical gap between wings and either side of lead. Bar measured mesh size of webbing in pounds nets were either 3.8 cm (1.5 in.) or 6.4 cm (2.5 in.) black asphalt coated web depending on the pound net being used.

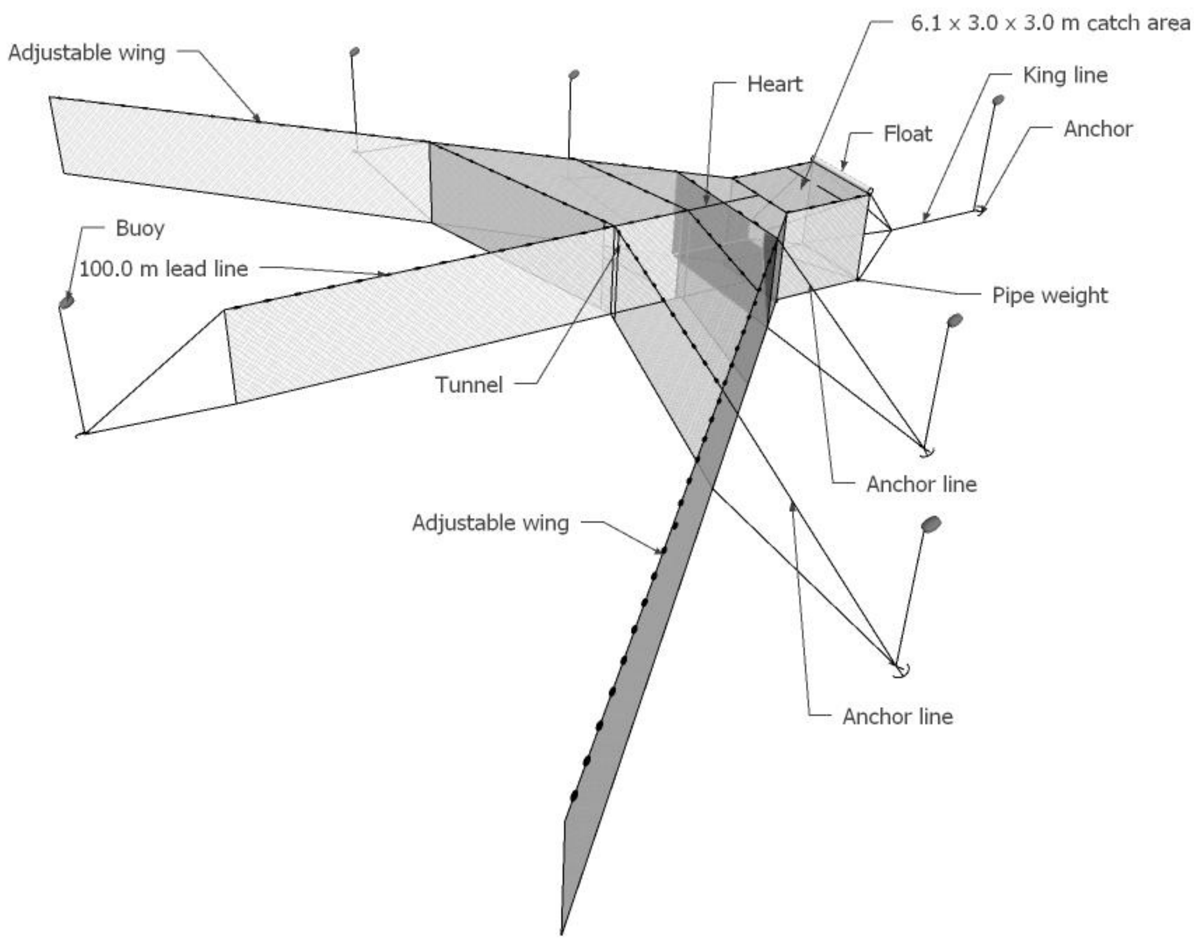

Figure 11. *Schematic of the great lakes style pound net*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Mini modified fyke net (Figure 12):

Mini modified fyke nets had a single, 5.0 m (16.4 ft.) long by 0.6 meter (2.0 ft.) deep lead. Floats were attached to the float line of the lead every 91.4 cm (36.0 in.) and lead weights attached every 45.7 cm (18.0 in.) along the lead line. Floats were made of 41.3 mm x 111.0 mm (1.6 in. by 4.4 in.) black hard foam that produced 85.0 g (3.0 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long, made from lead weighing approximately 28.3 g (1.0 oz.). The lead continued to the rear of the rectangular frame and was sewn to the vertical crossbar stitching the frame and lead together. The frame of the net was constructed of two, 0.6 m by 1.2 m (2.0 ft. by 4.0 ft.) rectangular bars made of 8.0 mm (0.3 in) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extend from outer corners of the front rectangle to middle of the rear rectangle. A 5.1 cm (2.0 in.) vertical gap existed between wings and either side of the lead at middle of rear rectangle. A 0.76 m (2.5 ft.) webbing covered gap connected the cab and frame together. The cab was constructed of two, 8 mm (0.3 in.) spring steel hoops that were 0.6 m (2.0 ft.) in diameter, spaced 0.6 m (2.0 ft.) apart. Cab and frame combined created a net that was 2.7 m (9.0 ft.) in total length. A single throat in the cab was attached to the first hoop from the mouth and tapered down to a 50.0 mm (2.0 in.) diameter hole at the rear. The throat was created with a 50.0 mm (2.0 in.) inner diameter by 6.4 mm thick (2.0 x 0.3 in.) stainless steel or nickel-plated ring sewn in the mesh. Four tension strings tied to the ring were secured to the rear hoop. A 1.8 m (6.0 ft.) long by 5.0 mm (0.2 in.) diameter braided nylon drawstring was sewn in a casing on the cod end secured the cod end closed. All webbing for the net was 3.0 mm (0.1 in.) ace type nylon netting coated with green latex type dip.

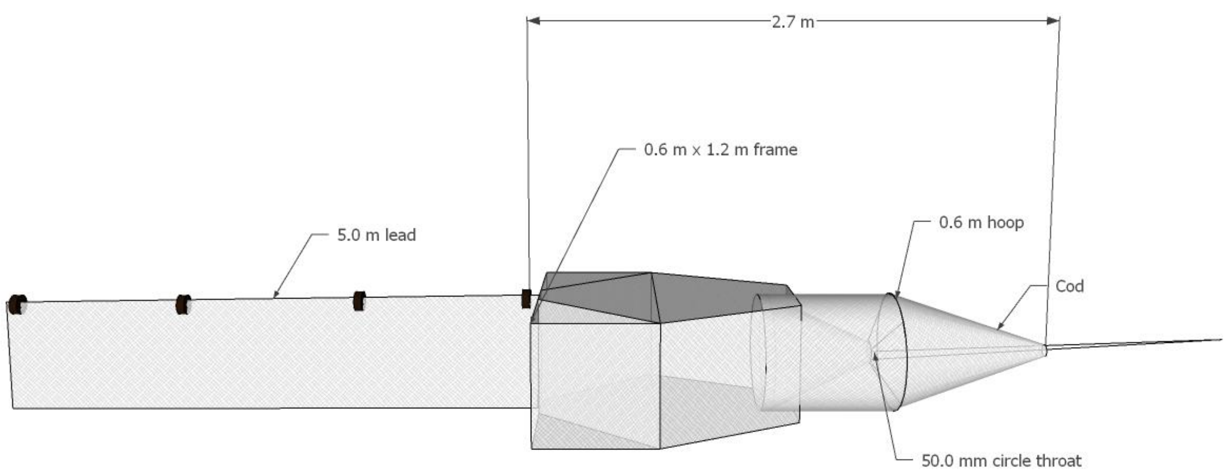

Figure 12. *Schematic of mini modified fyke net*

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Modified fyke net (Figure 13):

Modified fyke nets had a single 15.2 m (50.0 ft.) long by 1.4 m (4.5 ft.) deep lead. Floats were attached every 91.4 cm (36.0 in.) on the float line of the lead, and lead weights every 30.5 cm (12.0 in.) along lead line of the lead. Floats were made from 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge producing about 156.0 g (5.5 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long lead weighing approximately 28.3 g (1.0 oz.). Lead continued into the rear of the net frame and was sewn to the vertical crossbar joining the frame and lead. The frame of the net was constructed of two, 1.2 m (4.0 ft.) by 1.8 m (5.0 ft.) rectangular bars made of 8.0 mm (0.3 in.) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extended from outer corners of the front rectangle to the middle of the rear rectangle. A 76.0 mm (3.0 in.) vertical gap existed on either side of lead at middle of rear rectangle. A 1.2 m (4.0 ft.) mesh covered gap connected the cab and frame together. The cab was constructed of six, 0.9 m (3.0 ft.) diameter spring steel hoops spaced 61.0 cm (24.0 in.) apart from each other and covered in webbing. Cab and frame together were 6.0 m (20.0 ft.) in total length. The front throat of the cab began at the first hoop from the mouth and was a 203.0 mm (8.0 in.) square style throat, 20 meshes long, and knitted to 40 meshes around (10 per side) at rear. The rear end of the front throat was attached to the third hoop with 4 tension strings. The rear throat of the cab began at the third hoop from the mouth and was a 102.0 mm (4.0 in.) crowfoot style throat 28 meshes long, knitted to 32 meshes around at rear. The rear end of the second throat was attached to cod end drawstring with 2 tension strings. A 2.4 m (8.0 ft.) long, 6.0 mm (0.3 in.) diameter asphalt coated braided nylon drawstring secured the cod end closed. All finger lines were made of #15 black nylon twine and tension strings were made of #72 black nylon twine. Webbing for the modified fyke net was 18.0 mm (0.8 in.) bar measured mesh coated with a black asphalt coating.

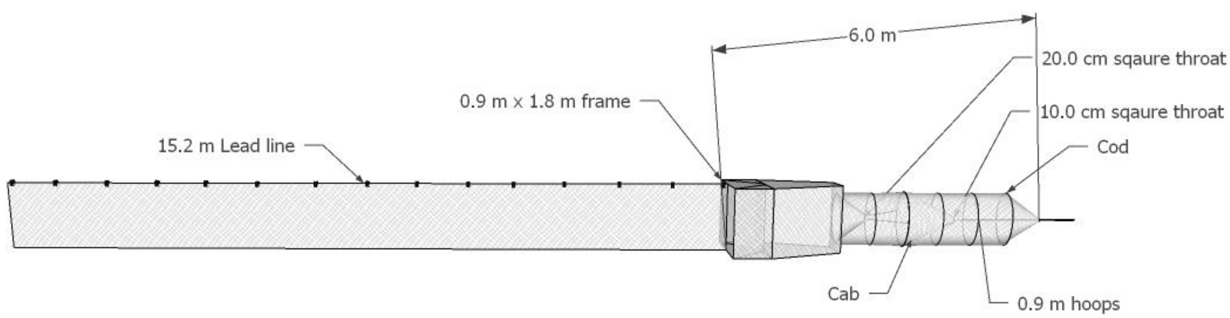

Figure 13. *Schematic of modified fyke net*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Larval fish capture gears

Active capture gears

Larval pushnet (Figure 14):

Larval pushnets were created from a nylon-mesh cone stitched to a steel rod cylinder secured to an aluminum frame. The nylon mesh cone was 500 µm mesh and was 3.0 m (9.8 ft.) in total length that tapered down to an 8.9 cm (3.5 in.) diameter circle at the distal end. The steel rod cylinder was made of 3.2 mm (0.1 in.) stainless steel rod bent and welded into a 0.5 (1.6 ft.) diameter circle. The distal end of the nylon mesh cone had an 8.9 cm (3.5 in.) adapter secured to it allowing a 1,000 ml hard-plastic plankton bucket to be attached. The plankton bucket had multiple rectangular sections removed and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. A flow meter or flow rocket was secured one-fourth the distance of the diameter of the steel cylinder in the net mouth (approximately the middle of the mouth) to estimate volume of water filtered. The pushnet was attached to an aluminum hexagon frame with industrial strength zip ties. The hexagonal frame was secured to the bow of the boat with 2.8 m (9.2 ft.) long aluminum bars.

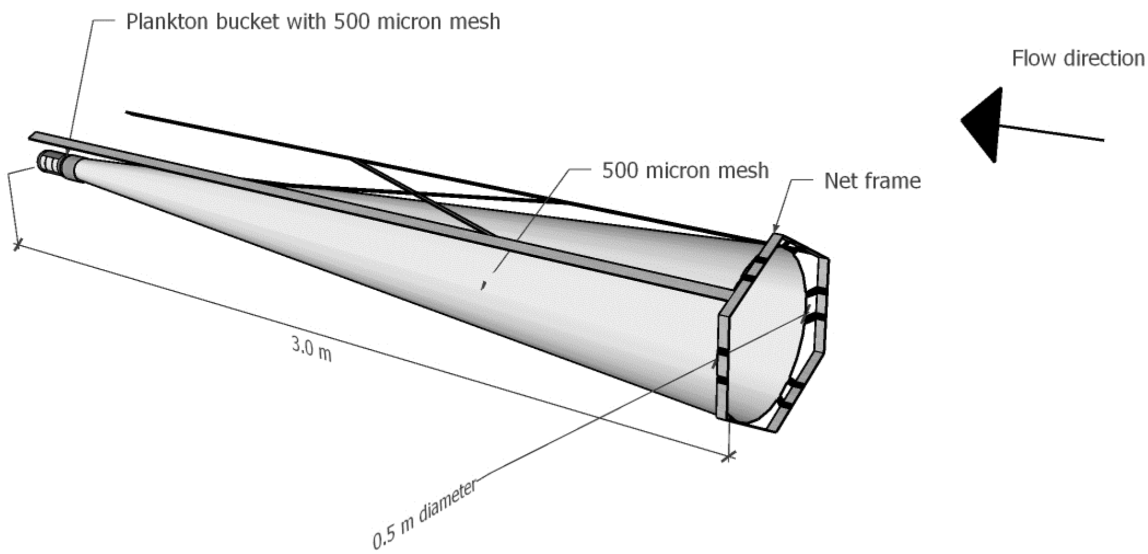

Figure 14. *Generalized schematic of a pushnet.*

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Passive capture gears

Larval driftnet (Figure 15):

Larval driftnets were created from 1.0 m (3.3 ft.) long plankton net stitched to a 0.3 m (0.8 ft.) by 0.5 m (1.5 ft.) rectangular made from 3.2 mm (0.1 in.) aluminum rod stock. Mesh pores of the plankton net were 500 µm. The plankton net tapered down to an 8.9 cm (3.5 in.) circumference circle on the distal end. An adapter was secured to the distal end of the plankton net allowing a 1,000 ml hard-plastic plankton bucket to be attached. The driftnet bucket had multiple sections cut out from the sides and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. Flow was recorded prior to setting a driftnet with a flow meter for an estimate of the volume of water sampled. Drift nets were anchored to the river bottom using rebar stakes.

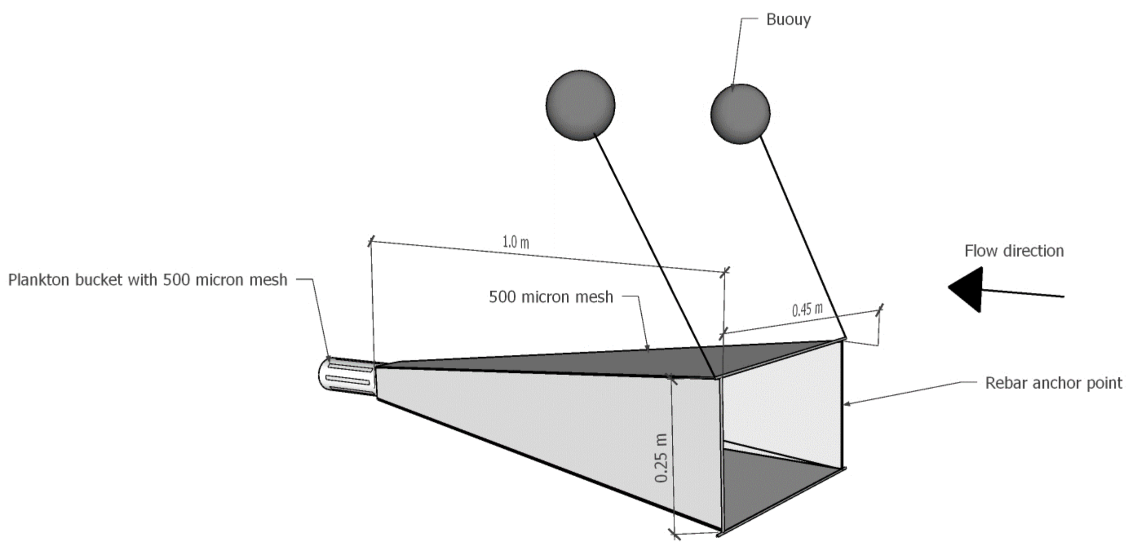

Figure 15. *Generalized schematic of a drift net.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Larval quadrafoil light trap (Figure 16):
Quadrafoil light traps consisted of a collection pan, a cloverleaf array and a closed cell floatation block. Collection pans were constructed of a 30.0 cm (11.8 in.) diameter aluminum pan with 5.1 cm (2.0 in.) tall sides. Six, 3.8 cm (1.5 in.) diameter drain holes were drilled into side of the collection pan and covered with 250 µm mesh allowing water to drained from the trap while retaining captured organisms upon retrieval. The cloverleaf array was created from four half circle polycarbonate tubes 10.2 cm (4.0 in.) in diameter with 6.4 mm (0.25 in.) thick polycarbonate cemented to a top and bottom 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick clear polycarbonate circles. The top polycarbonate circle of the cloverleaf array was secured to the closed cell floatation block with four, 4.8 mm (0.2 in.) by 25.4 mm (1.0 in.) stainless steel eye bolts. The closed cell floatation block consisted of the top polycarbonate circle of the cloverleaf array, a 30.0 cm (11.8 in.) diameter by 10.0 cm (3.9 in.) thick Styrofoam middle and a 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick polyvinyl chloride top. The bottom polycarbonate circle was secured to aluminum collection pan with two paracord straps using four 3.2 mm (0.1 in.) zinc plated spring snap link carabiners on each end which were clipped to one of the rigging point eyebolts. A 20.0 mm diameter by 25.0 cm long capped central light tube at the center of the cloverleaf array stored the light source for light traps. Light sources for light traps were green photochemical light sticks. Rigging point eyebolts served as a point to tether the trap to a tree, the bank, or anchor at each sampling location.

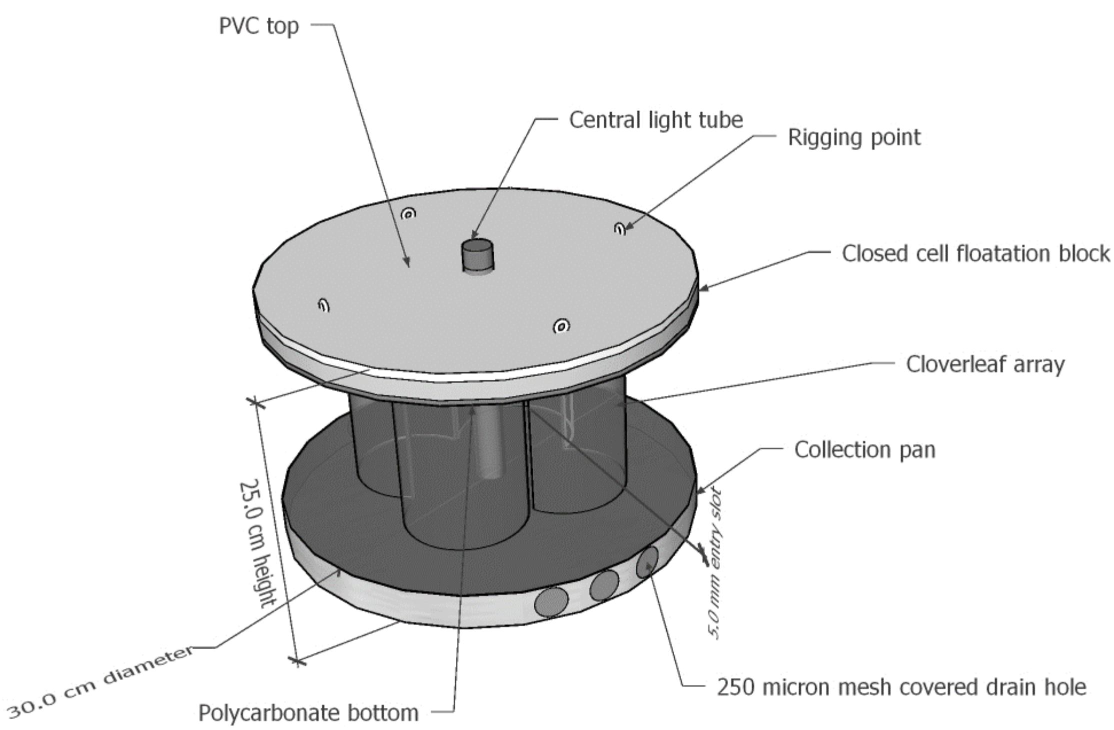

Figure 16. *Schematic of Quadrafoil light trap*

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Non-capture gears

Nets

Block net (Figure 17):

Block nets consisted of nylon mesh webbing sewn to a float line and a lead line. Float lines had 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge floats attached every 30.5 cm (12.0 in.). Each float produced about 156.0 g (5.5 oz.) of buoyancy. Lead lines were 95.3 mm (0.3 in.) braided solid leadcore rope. Webbing of block nets was 7.9 mm (0.3 in.) bar measured nylon mesh covered in a black asphalt coating. Depth of block nets where either 9.1 m (30.0 ft.) or 6.1 (20.0 ft.) with webbing depths of 9.8 m (32.0 ft.) or 6.7 m (22.0 ft.), respectfully. Total lengths of block nets were either 152.4 m (500.0 ft.), 304.8 m (1,000.0 ft.) or 762.0 m (2,500.0 ft) with the webbing fully stretched to the same length as the total length of the block net (hanging ratio: 1.0 [measure of how tightly webbing is stretched along float and lead lines]). Block nets were used in conjunction with other sampling gears (e.g., electrofishing, gill/trammel nets) as they did not directly sample fish but prevented fish movement out of or into a new area.

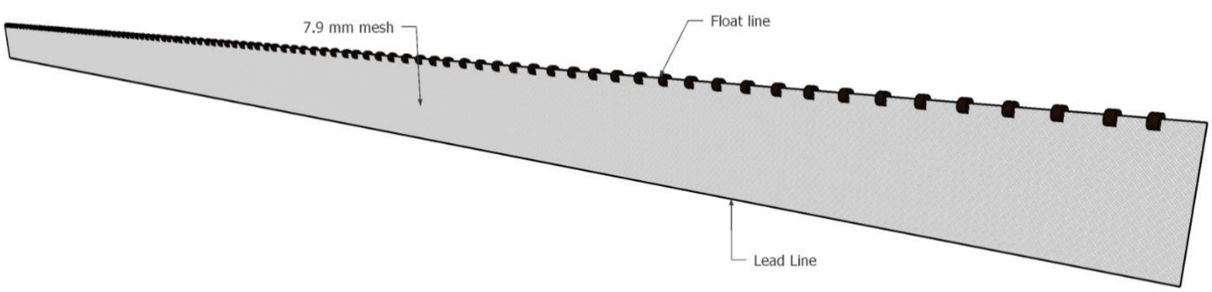

Figure 17. *Generalized schematic of a block net.*

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Sampling boats

Netting boat (Figure 18):

Flat bottomed aluminum boats, 4.9 m to 8.7 m (16.0 ft. to 28.0 ft.) in length powered with 90-horsepower or greater counsil or tiller controlled outboard motor set various active and passive capture gears. Outboard motors were controlled with a tiller handle or steering counsel. Netting boats had 2.3 m (7.5 ft.) wide hull with sides around 66.0 cm (25.0 in.) tall. Netting boats were made of 3.2 mm (0.1 in.) thick aluminum. A front 1.5 m to 2.3 m (5 ft. to 7.4 ft.) aluminum deck created a front platform with larger netting boats having a 1.0 m (3.2 ft) long step up to the deck. Under the step in larger netting boats was a 94.6-liter (25.0 gallon) fuel cell while smaller boats had a removable gas tank toward the stern. Two, 91.4 cm (36.0 in.) by 75.0 cm (29.5 in.) by 40.0 cm (16.0 in.) deep dry storage boxes were on the port and starboard freeboards in the stern of both the larger and smaller netting boats. Coupled with the outboard motor was a 3-blade stainless steel propeller.

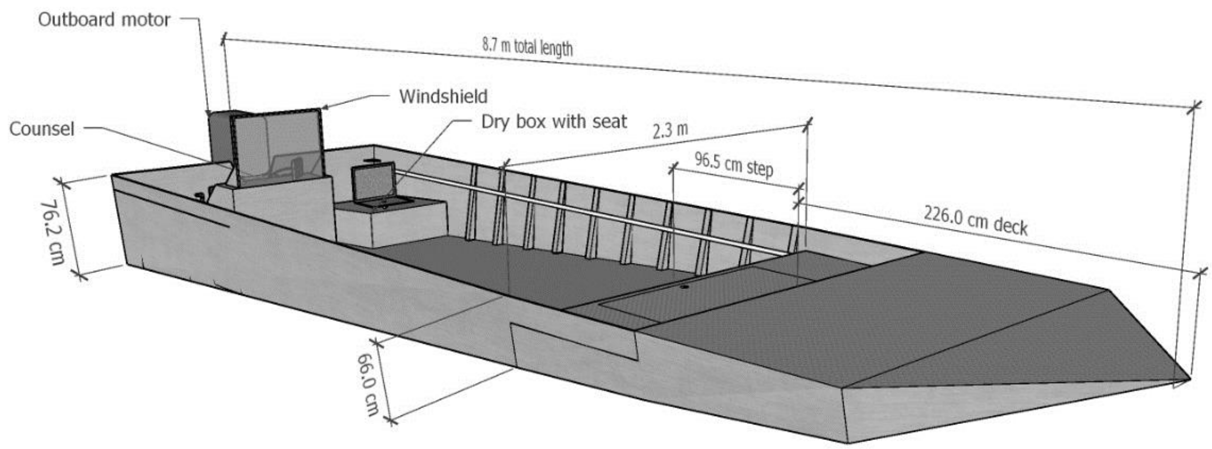

Figure 18. *Generalized schematic of netting boat.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Shallow drive boat (Figure 19):

The shallow drive boat used to drive fish and set gill/trammel net in shallow water was 5.5 m (18.0 ft.) long by 1.5 m (5.0 ft.) wide semi-v bottom with 61.0 cm (24.0 in.) tall sides of 3.2 mm (0.1 in.) thick aluminum. A front 1.4 m (4.6 ft.) aluminum deck coated in non-skid rubber created a front platform. Under the front deck was a 45.4-liter (12.0 gallon) fuel cell. The floor of the shallow drive boat was coated with non-skid rubber. Two, 91.0 cm (36.0 in.) by 73.6 cm (29.0 in.) dry storage boxes were on the port and starboard freeboards in the stern. A 38.1 cm by 58.4 cm by 38.1 cm (15.0 in. by 23.0 in. by 15.0 in.) aluminum float pod was welded to the starboard and port side of the transom. The hull of the shallow drive boat was coated with Gator Gilde. A 2017 Mudd Buddy HDR 44 tbd reverset power trim shallow drive motor with a V twin motor and 42 mm (16.5 in.) Mikuni carburetor was attached to the transom of the shallow drive boat. The shallow drive motor was made from cast aluminum and stainless steel with a 9.7 cm (3.8 in.) thick outdrive casting cover, an aluminum transmission cover and a stainless steel lower drive tube. An electric shift controller, allowed shifting of the shallow drive motor. A standard BPS "Q" performance muffler was attached to the shallow drive motor as well as a capacitor discharge ignition automatic advanced ignition with a 4650-rev limiter and a 50-amp charger. Coupled with the shallow drive motor was a 2-blade stainless steel hammer propeller.

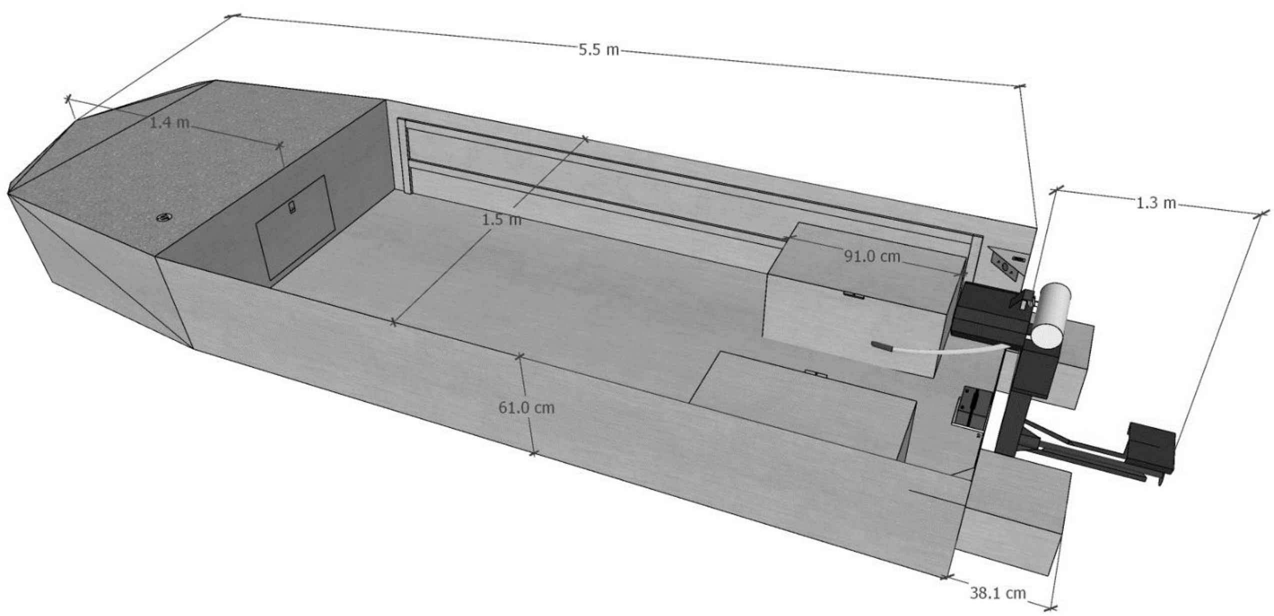

Figure 19. *Schematic of the shallow drive boat.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Table 1. *List of equipment vendors used during Asian Carp monitoring and response sampling. Use of trade names is for descriptive purpose and does not imply endorsement by an agency.*

Description	Vendor	Vendor contact
	Boats and Motors	
Electrofishing boat (aluminum, 5.5 + m)	Oquawka	www.oquawkaboats.com
Electrofishing boat trailer	Oquawka	www.oquawkaboats.com
Net boat (aluminum 5.5 + m)	Blue Ridge Custom boats, Oquawka, Kann, or AAD welding	https://www.facebook.com/pg/Blue-Ridge-Custom-Boats-1547565388875733/about/ www.oquawkaboats.com http://www.kannmfg.com/products/marine/ http://www.aadcustomboats.com/
Net boat trailer	Blue Ridge Custom boats, Oquawka, or Kann or AAD welding	https://www.facebook.com/pg/Blue-Ridge-Custom-Boats-1547565388875733/about/ www.oquawkaboats.com http://www.kannmfg.com/products/marine/ http://www.aadcustomboats.com/
Shallow drive boat (aluminum)	AAD welding	http://www.aadcustomboats.com/
Shallow drive boat trailer	AAD welding	http://www.aadcustomboats.com/
90 + HP outboard motors	Evinrude, Mercury, Yamaha	http://www.evinrude.com/en-US?redirect=false https://www.mercurymarine.com/en/de/engines/outboard/ https://yamahaoutboards.com/en-us/
Shallow drive motor	MudBuddy	http://www.mudbuddy.com/hdsport.htm
Miscellaneous: anchor, batteries, bilge pump, lights fuel tanks, rope, safety equipment		
	Electrofishing components	
MBS-1D Electrofishing control box	ETS Electrofishing	http://etselectrofishing.com/
Type VI-A Electrofishing control box	Smith-Root	https://store.smith-root.com/type-via-electrofisher-system-p-9.html
5,000 watt generator	Honda	http://powerequipment.honda.com/
Electrofishing boat booms	WS Hampshire	http://www.wshampshire.com/index.html
Electrofishing dip nets	Duraframe	http://www.duraframedipnet.com/
Holding tank fill pump	Rule	http://www.xylemflowcontrol.com/rule/
Holding tank (~379 liters)	Various suppliers	——
Miscellaneous: boots, gloves, life jacket, raingear, safety equipment, tank aeration, tank dip net		
	Net gear	
Mini Fyke net	Miller Net Company	http://www.millernets.com/
Fyke net	Duluth Nets Miller Net Company	http://duluthfishnets.com/ http://www.millernets.com/
Hoop net	Brown Fisheries Miller Net Company Memphis net	ronbrown.brownfisheries@gmail.com http://www.millernets.com/ http://www.memphisnet.net/
Gill/trammel nets	Brown Fisheries Memphis net	ronbrown.brownfisheries@gmail.com http://www.memphisnet.net/
Pushnet	Wildco	http://wildco.com/
Driftnet	Wildco	http://wildco.com/
Quadrafoil light trap	Aquatic Research Instruments	http://www.aquaticresearch.com/default.htm http://www.forestry-suppliers.com/

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Description	Vendor	Vendor contact
	Forestry Suppliers	
	Net get	
Pound net	Stuth Fishing	stuthfishing@charter.net
Seine	Commercial fisherman	——
Trawl	Commercial fisherman	——
Miscellaneous: anchors, floats, grapple, net preservative, rebar/stakes, rope, twine, webbing,		

Appendix M: Asian Carp Monitoring Sampling Strategy

Participating Agencies: Illinois Department of Natural Resources, Illinois Natural History Survey, U.S. Fish and Wildlife, U.S Army Corps of Engineers

Introduction:

The Monitoring and Response Working Group (MRWG) has detected, managed and controlled, and responded to Asian Carp (Bighead Carp, Silver Carp, Grass Carp, and Black Carp) within the Illinois River Waterway since 2010. Data collected during these efforts index Asian carp abundance, determine their geographic expanse, describe their demographics in each of the upper Illinois River Waterway pools triggering response actions as needed. The goals of these efforts are to reduce the likelihood of Asian carp becoming establishing within the Chicago Area Waterway System (CAWS) and Lake Michigan.

Collection of meaningful, interpretable, and insightful data from such a large and diverse system like the Upper Illinois River requires an appropriately and comprehensively designed approach. A variety of sampling protocols, utilizing numerous gear types (traditional and novel) and site selection methodologies (probabilistic and nonprobabilistic) has been used within the Upper Illinois River Waterway since 2010. These multiple projects using differing sampling approaches allowed for single year inferences to be drawn but created difficulties drawing across years inferences due to differing effort levels and gears being used. A standardized mixed sampling design began in 2019 across all the pools of the upper Illinois River. Standardization should increase efficiency within the Monitoring and Response Work Group (MWRG) by reducing redundancy among project objectives and increase capabilities for trend analysis. The sampling approach was modeled off of the Long Term Resource Monitoring Program of the Upper Mississippi River Restoration Program (Ickes et al. 2014). The objective of this section is to detail the sampling frame and sampling design differences within the upper Illinois River Waterway by the MRWG from the model.

Sampling Frame:

The U.S. Geological Survey's Upper Midwest Environmental Sciences Center created sampling frames of all Illinois River pools in 1989 (UMESC 1991). Aquatic areas were generated by generalizing land cover/use data from 1 : 15,000-scale color infrared aerial photos collected in 1989 or 1991 into a land/water data set. Areas classified as water within aerial photography were further classified as specific aquatic areas. Aquatic areas were defined by permanent geomorphic conditions of backwater, impounded areas, main channel, side channel, and tailwater zones (Wilcox 1993). Backwater and main channel area were further delineated to include a "shoreline" portion facilitating sampling gears deployment only along the shoreline.

Field validations of the initial 1989 strata designations were obtained during 2019. Adjustments to the original GIS-based strata were made to better align with ground truthed observations

(Figure 1-6). Changes centralized around defining barge slips as backwaters, removing or reclassifying miscategorized side channels, and removing unsampleable areas from the sampling frame (Table 1). Aquatic areas were then converted into 50 x 50 meter grids. Due to the size of Lockport, a smaller grid size of 25 x 25 meter grid was used. Density of strata within each pool was summarized and used to allocate effort (Table 2).

Table 1. *Pool and locations of aquatic area changes in the original 1989 classification for the 2019 Monitoring and Response Working Group sampling frame.*

Pool	Location	1989 stratum	2019 stratum
Lockport	Barge Slips	Side Channel	Backwater
	Right descending bank flat downstream of Cargill ramp	Side Channel	Main Channel
	Des Plaines River	Side Channel	Non-sampled area
Brandon	Des Plaines River Confluence	Side Channel	Non-sampled area
Dresden Island	Left descending bank of treats island	Backwater	Side Channel
	NRG Joliet Generating Station	Backwater	Non-sampled area
	Moose Island	Side Channel	Backwater
	Illinois and Michigan Canal	Backwater	Non-sampled area
	Exelon Nuclear Plant cooling ponds	Backwater	Non-sampled area
Marseilles	First 500 meters below Dresden Island Lock and Dam	Side Channel	Tailwater
	Illinois and Michigan Canal	Backwater	Non-sampled area
Starved Rock	First 500 meters below Marseilles Dam	Side Channel	Tailwater
	Flat upriver of Peoria lock and dam on left descending bank	Backwater	Side Channel
Peoria	Split Rock Lake	Backwater	Non-sampled area

Sample Selection:

Units of effort are gear and strata specific (Table 3). Effort level is dependent on the size of the pool and the proportion of each strata within each pool (Table 4). A specified number of points were randomly selected from the sampling grid within each sampling strata for each gear type within each pool using a reselection is procedure in the statistical software package (SAS). Sites were selected at the intersections of the sampling grid, as opposed to the center of the cells.

Appendix M: Asian Carp Monitoring Sampling Strategy

Table 2. *Strata population sizes by study reach and stratum in the Upper Illinois River Waterway. The number of sampling frame elements composing each stratum in each study reach is denoted.*

Classification	Lockport	Brandon	Dresden	Marseilles	Starved Rock	Peoria
Main channel, off-shore	315	159	1,548	1,573	1,300	7,537
Main channel, shoreline	619	295	915	1,577	745	3,784
Side channel	-	-	239	143	2,189	487
backwater, off-shore	-	-	470	393	70	31,195
backwater, shoreline	29	-	322	521	207	5,009
Total	**963**	**454**	**3,494**	**4,207**	**4,511**	**48,012**

Sampling intensity by gear type among pools meets those of the Long Term Resource Monitoring Program of the Upper Mississippi River Restoration Program effort within the LaGrange Reach of the Illinois River at a minimum (Ickes and Burkhardt 2002). Effort intensity was increased from the LaGrange Reach model in pools closer to the electric dispersal barrier (e.g., Lockport and Brandon) when effort was not deemed sufficient for management needs. Current effort level also is consistent with the effort amount put forth during baseline establishment in 2016 for the contingency response plan (MRWG 2016).

Table 3. *List of sampling gears used to collect Asian Carp in Upper Illinois River Waterway sampling areas (SRS). X indicates that the particular gear is used in the sampling area and a blank indicates it is not used. [L, Lockport pool, B, Brandon Road Pool, D, Dresden Island pool, M, Marseilles Pool, S, Starved Rock, P, Peoria. [MCB-O, main channel border-open water; MCB-S, main channel border shoreline, SCB, side channel border; BWC-S, backwater, contiguous-shoreline; MCB-M, main channel border-mourning cell]*

Sampling gear	**Sampling area**				
	SRS strata				**Engineered Structures**
	MCB-O	**MCB-S**	**SCB**	**BWC-S**	**MCB-M**
Day electrofishing		X	X	X	X
Fyke netting				X	
Mini fyke netting		X	X	X	
Large hoop netting	X		X		
Small hoop netting	X		X		
Pools	**L,B,D,M,S,P**	**L,B,D,M,S,P**	**L,B,D,M,S,P**	**L,B,D,M,S,P**	**L,B,D**

A number of nonrandom ("fixed") sites will also be sampled regularly. Main channel mourning cells are a predominant engineered structure in Lockport, Brandon Road Pools, and Dresden Island Pools. These features cannot be sampled effectively using the random sampling procedures as they have no area-based weight to incorporate into the larger sampling frame. Since these areas have been sampled previously as fixed sites, these sites will continue to be sampled with daytime electrofishing uninterrupted (Table 3). This combined design allows for statistically valid inferences within sampled strata across the entire study to be generated overtime.

Table 4. *Sampling allocations by gear type within each pool in Upper Illinois River each year. Sample allotments within a gear are proportional to the area that strata represents within the entire pool.*

Gear	Lockport	Brandon	Dresden	Marseilles	Starved Rock	Peoria
Day electrofishing	57	48	72	93	105	135
Fyke netting	0	0	15	15	15	30
Large hoop net	42	42	42	42	42	36
Small hoop net	42	42	42	42	42	36
Minnow fyke net	24	24	42	42	42	42
Total	**165**	**156**	**213**	**234**	**246**	**279**

References:

Asian Carp Monitoring and Response Working Group (ACMRWG). 2016. 2016 Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System. Illinois, Chicago.

Ickes, B. S., R. W. Burkhardt. 2002. Evaluation and proposed refinement of the sampling design for the long term resource monitoring program's fish component. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, October 2002. LTRMP 2002-T001. 17 pp., https://www.umesc.usgs.gov/documents/reports/2002/02t001.pdf

Ickes, B.S., Sauer, J.S., and Rogala, J.T., 2014, Monitoring rationale, strategy, issues, and methods: UMRR-EMP LTRMP Fish Component. A program report submitted to the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program, Program Report LTRMP 2014–P001a, 29 p., *http://pubs.usgs.gov/mis/ltrmp2014-p001a/*

Upper Midwest Environmental Sciences Center (UMESC). 1991. 1989-1991 Aquatic Habitats – Upper Mississippi River System. La Crosse, Wisconsin.

Appendix M: Asian Carp Monitoring Sampling Strategy

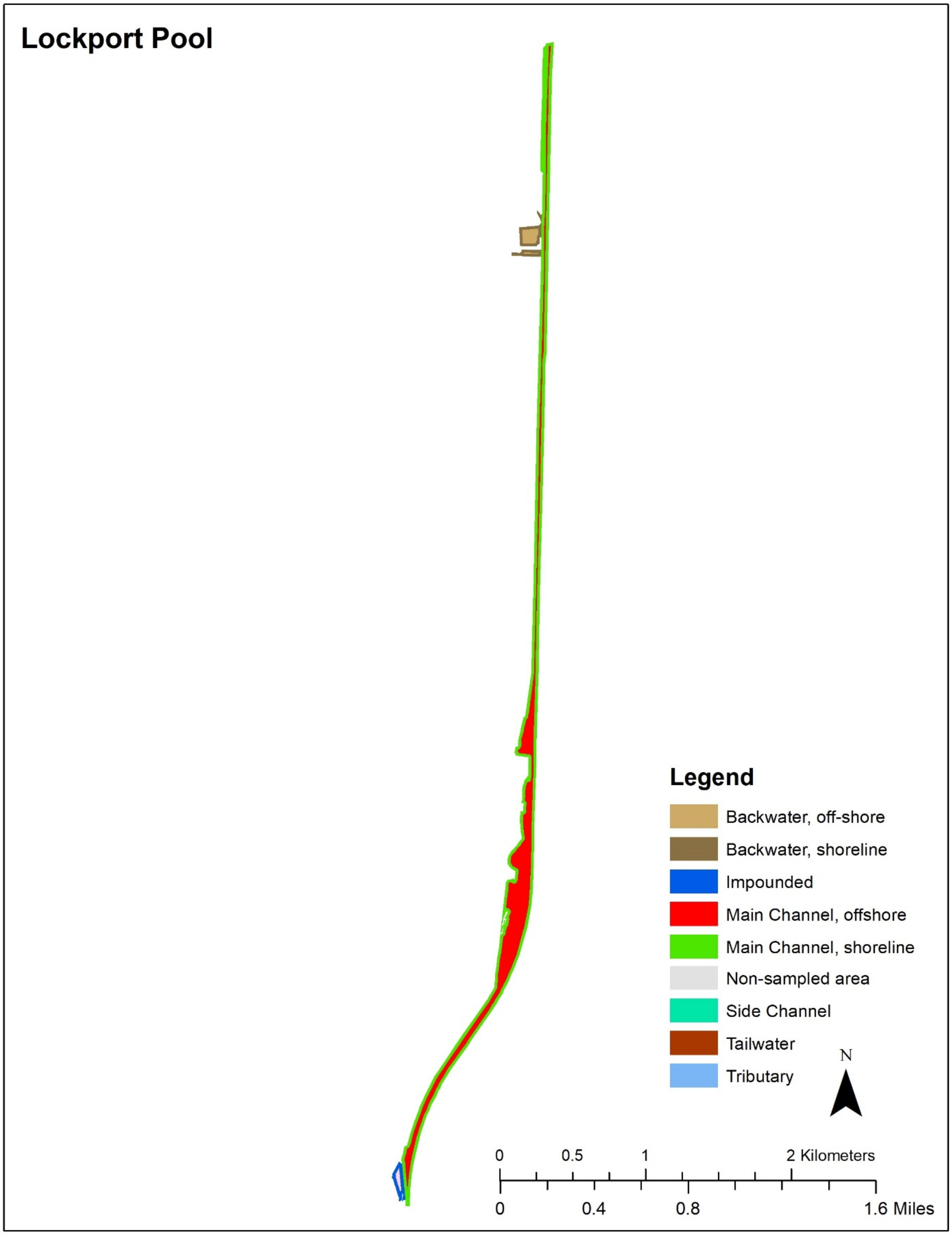

Figure 1. *Lockport Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

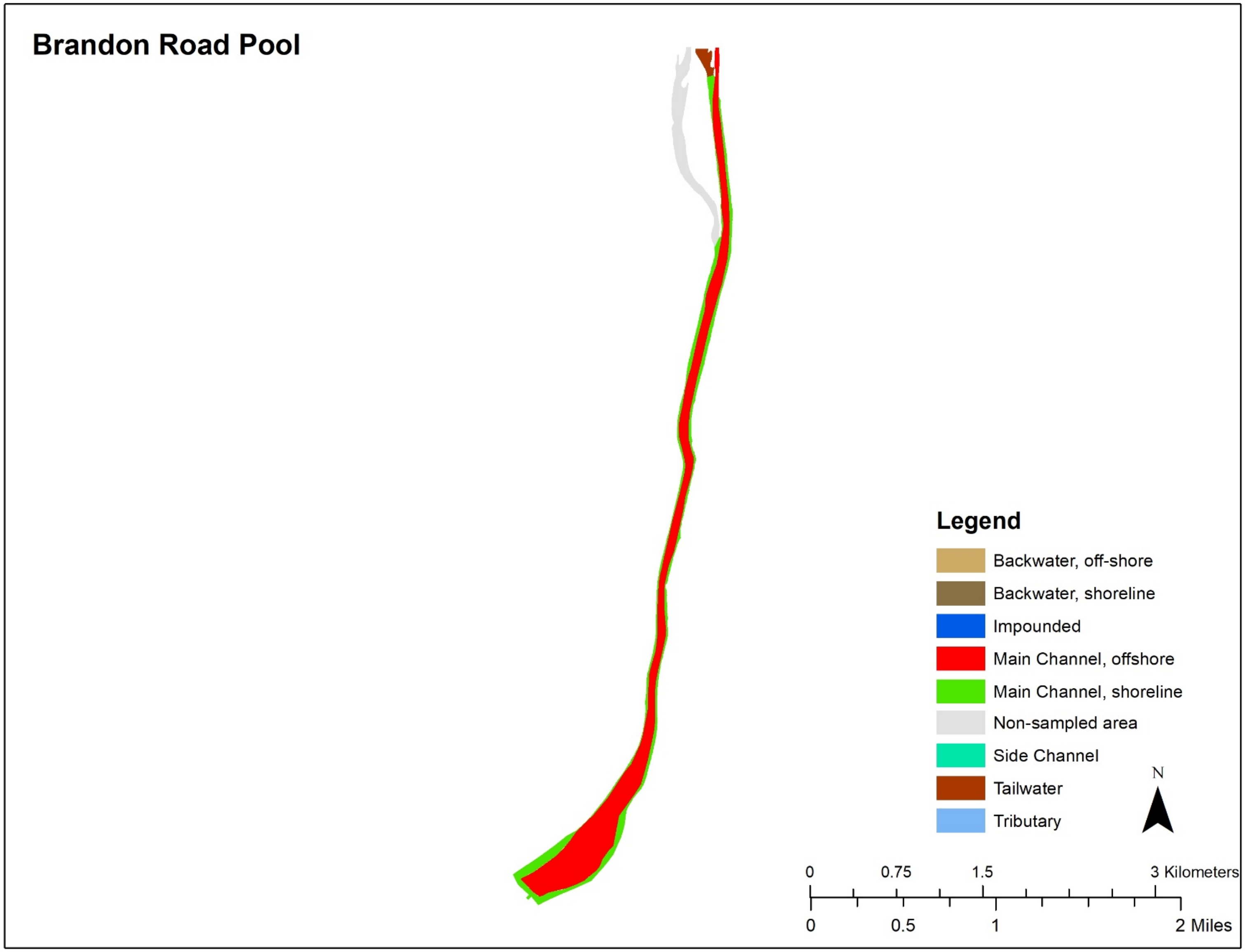

Figure 2. *Brandon Road Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

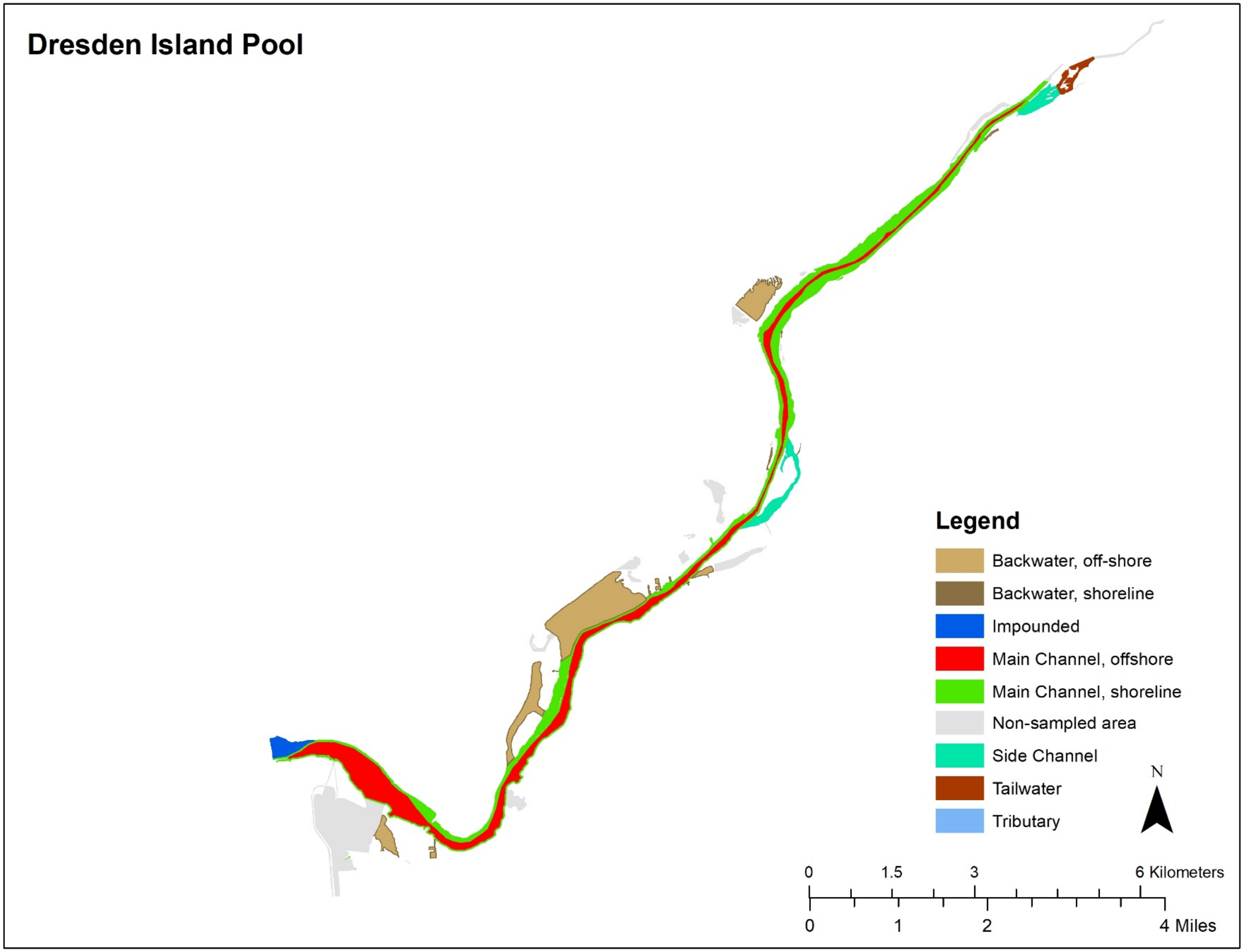

Figure 3. *Dresden Island Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

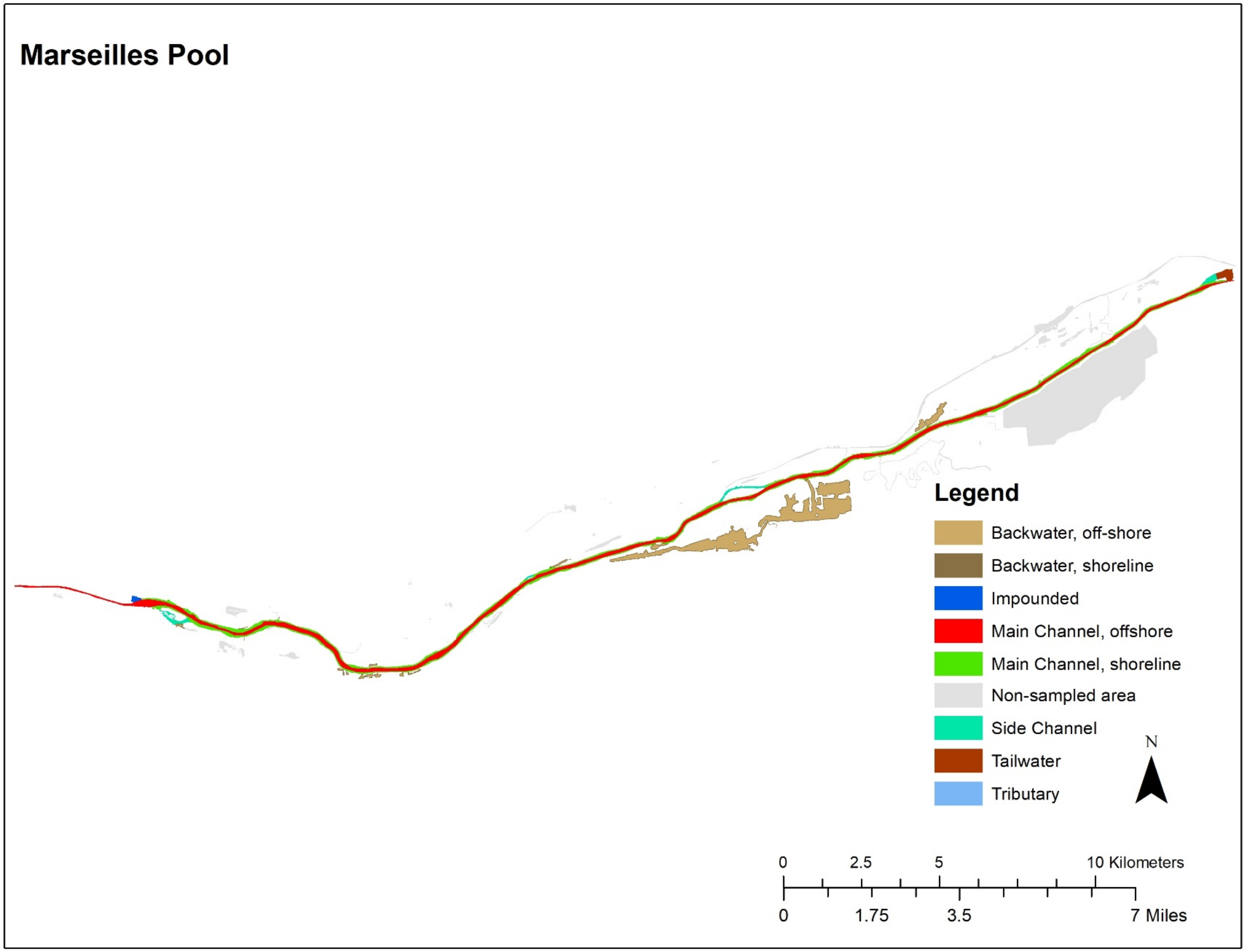

Figure 4. *Marseilles Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

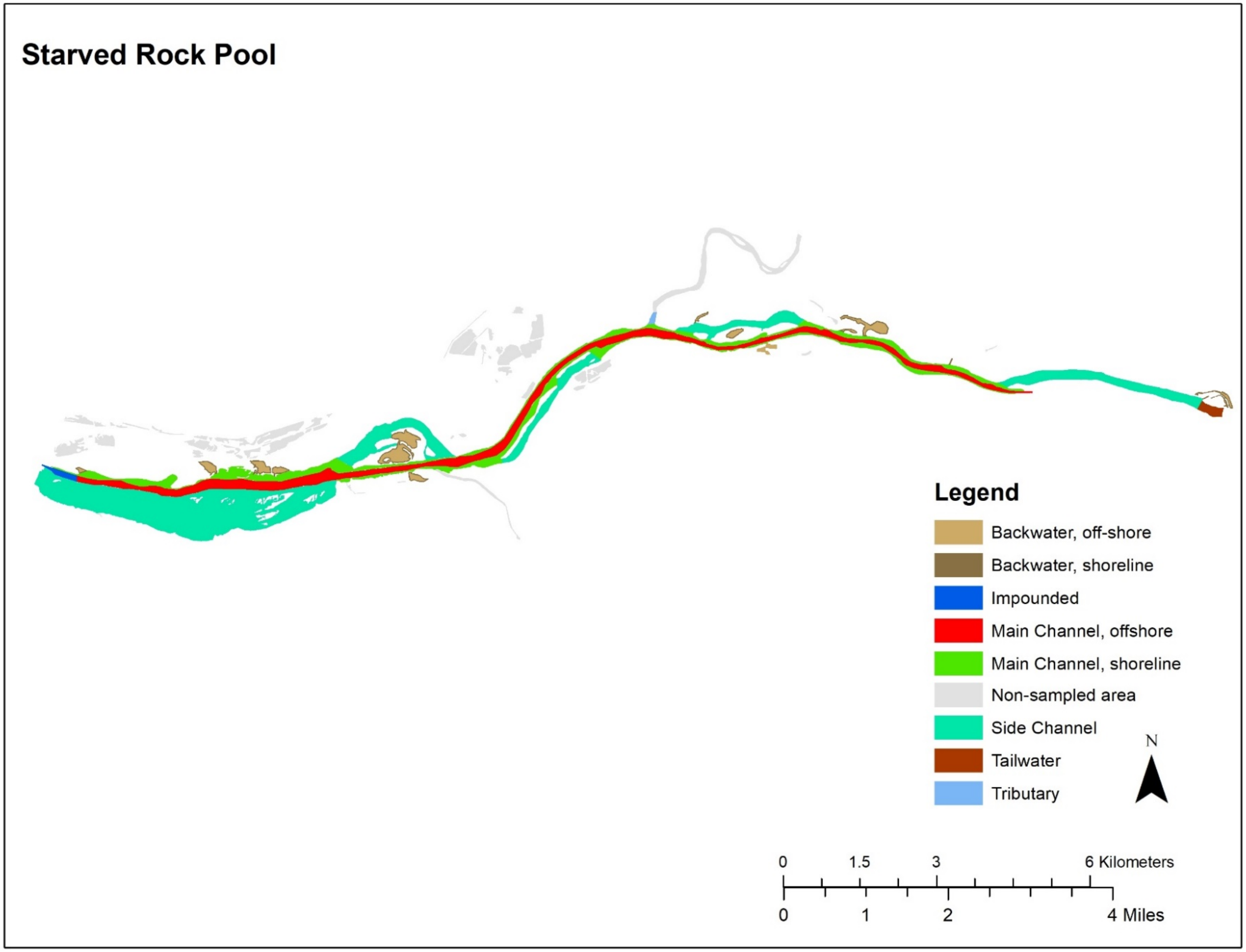

Figure 5. *Starved Rock Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

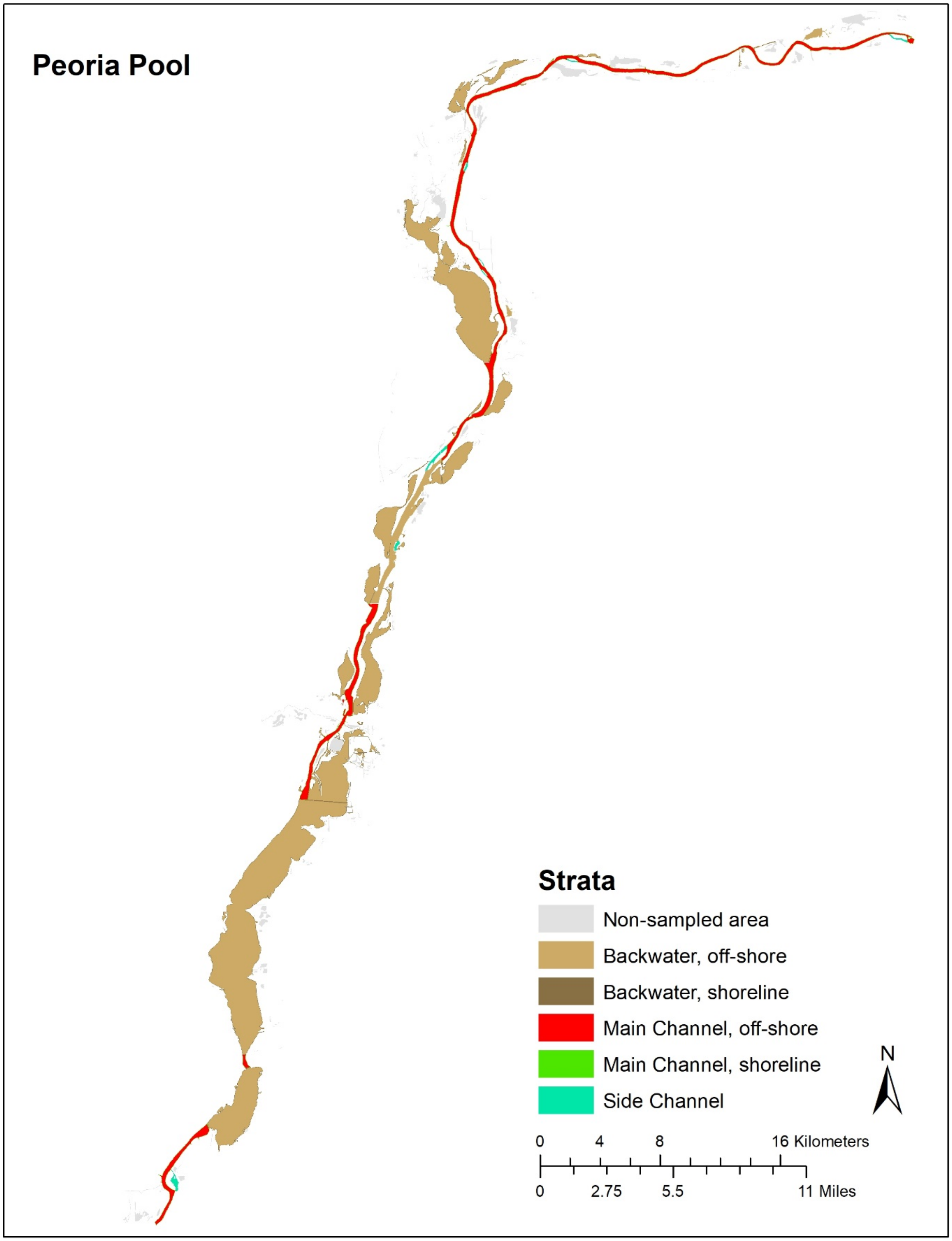

Figure 6. *Peoria Pool sampling strata from the 1989 coverages modified with 2019 field observations.*