2022

INVASIVE CARP MONITORING AND RESPONSE PLAN

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EXECUTIVE SUMMARY

> **A Terminology Change**
> For the purpose of this MRP, the term 'invasive carp' refers to Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (H. *molitrix*), exclusive of Grass Carp (*Ctenopharyngodon idella*) and Black Carp (*Mylopharyngodon piceus*). Where individual projects address Grass Carp and Black Carp, they will be referenced specifically by name, and without using the generic 'invasive carp' moniker.

This Invasive Carp Monitoring and Response Plan (MRP) was prepared by the Monitoring and Response Work Group (MRWG) and 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 21 individual project plans, each of which plays an important role in preventing the expansion of the range of invasive carp, and in 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 2022, including project objectives, methodology, and highlights of previous work.

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

(1) **Detection:** Determine the distribution and abundance of invasive carp to guide response and control actions.

(2) **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.

(3) **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 2022 MRP build upon considerable work completed since 2010. Selected highlights of past efforts are presented below, grouped by primary objective. For a moredetailed accounting of the results and findings of previously completed work, please refer to the 2021 Invasive Carp Interim Summary Report, presented as a companion document to the 2022 MRP.

HIGHLIGHTS OF PAST EFFORTS

Detection Projects

- A total of 513,609 fish representing 89 species and 9 hybrid groups have been sampledabove the Electric Dispersal Barrier System (EDBS) during 2010-2021.
- During 2009-2020 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.
- Thirteen Silver Carp were captured in Starved Rock Pool in 2021.

- Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2021 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 2021 compared to other recent study years.
- Multi-agency monitoring downstream of the EDBS used standardized sampling approaches to collect 489,104 fish representing 128 species during 2021. The leading edge of the Bighead Carp and Silver Carp populations remained around river mile 281 (north of I-55 Bridge within the Dresden Island Pool near the Rock Run Rookery) in 2021.
- No invasive carp have been captured during sampling in the Des Plaines River. This spans the collection of 15,499 fish since 2011.
- 35 Bighead Carp have been removed from urban ponds since 2011.

Management and Control Projects

- Through ILDNR and USFWS harvest efforts, over 11,429,000 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 past the EDBS. There were two upstream and two downstream passages of Common Carp through the Lockport Lock and Dam and there was one upstream passage of a Common Carp through the Lockport Control Works.
- Invasive carp continue to be detected throughout the Dresden Island Pool with most detections occurring near the Dresden Island Lock.
- Law enforcement conservation officers have completed inspections of multiple aquaculture facilities and numerous fish trucks. These and other efforts have resulted incitations and ongoing multi-agency, cross-jurisdictional investigations into the illegal trade of invasive aquatic species.

Response Projects

- A contingency response plan for the Upper IWW has been established. The plan established 2015 as a baseline year for evaluating changes to invasive carp range and population status and prescribes appropriate response actions based on particular changesto population status on a pool-by-pool basis.

In addition to these highlights, a brief summary of work anticipated to be completed in 2022 isprovided 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

Seasonal Intensive Monitoring (SIM) is a modified continuation of Fixed and Random Site Monitoring Upstream of the EDBS and Planned Intensive Surveillance in the Chicago-Area Waterway System (CAWS). These events will be planned for the spring season (Weeks of May 16th and 23rd) and the fall season (Weeks of October 3rd and 10th). This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers at sites in the CAWS upstream of the EDBS. Monitoring also will include five fixed sites with additional random electrofishing transects and net sets at locations outside of fixed sites to maintain spatial coverage of the waterway. 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. The two-week event in the spring will focus on the Lake Calumet/Cal-Sag area of the CAWS. In 2017 one Silver Carp was captured in this area, leading to a successful response operation knownas Operation Silver Bullet. The two-week event in the fall will focus on the North Shore Channel/Chicago River. SIM provides a spatially and temporally adequate assessment of relative abundance and distribution of invasive carp in the CAWS upstreamof the EDBS.

Strategy for eDNA Sampling in the CAWS

In 2022, 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.

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 taggedfish 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.

USGS Telemetry Project

This project uses an existing network of real-time and non-real-time acoustic telemetry receivers for detecting bigheaded carp (Silver Carp and Bighead Carp) and surrogate fishes, and also provides supplementary support to telemetry projects, including development and maintenance of the FishTracks DB database, development of a common standardized telemetry database with visualization and analysis tools, and transitioning from Program MARK to a custom Bayesian multi-state model for estimating movement probabilities needed for SEICarP. 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 with the intent to support decisions on directing (1) removal efforts by contracted fishing and (2) contingency actions. Location information of tagged bigheaded carp from real-time detections at these receivers are available online to biologists directing day-to-day removal efforts, and as email or text alerts to managers responsible for executing contingency actions. 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 runwith 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.

Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools

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.

Larval Fish Monitoring 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, and monitors for Black Carp reproduction in the Illinois Waterway. 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 - June, during periods of rising water levels, or shortly after peak flows). Observation of invasive carp eggs or larvae will help to inform other agencies of the upcoming likelihood of capturing young-of-year 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 (CPUE), and length-weight relationships of invasive carp in the Illinois River. Because these surveys have been ongoing since2012, they provide valuable long-term trends. Work comparing surrogate fish movements to bigheaded carps' movement will continue through 2022.

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 representsa 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. This project continues to monitor for invasive carp in the Des Plaines River to determine the threat posed to the CAWS by invasive carp populations within the Des Plaines River. A minimum of three sampling events will be conducted in 2022, focusing on capturing the spawn and 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 andremoved invasive carp (possibly introduced as contaminants in shipments of stocked sport fish). During 2022, urban pond sampling will be based upon photographic evidence of invasive carp or reports from credible sources.

Multiple Agency Monitoring of the Illinois River for Decision Making
This project began in 2019 and utilizes a standardized 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 belowthe EDBS that may be adversely impacted by invasive carp. This project will utilize 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 compiling data of the FishTracks Telemetry Database and Illinois River Catch Database (ILRCdb) to compile data from monitoring and removal efforts 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 supports 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 (e.g., improved efficiencies in implementation of the UnifiedMethod, inform targeted removal efforts or deterrent deployments in key locations based on preferential benthic characteristics and environmental conditions).

Contracted Commercial Fishing Below the Electric Dispersal Barrier
Contracted commercial fishing below the EDBS uses contracted commercial fishers to reduceBighead 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 towards the barrier, lessening the chances of invasive carp gaining access to upstream waters in the CAWS and Lake Michigan. Monitoring for upstream expansion of invasive carp should help identify changes in the leading edge, distribution, and relative abundance of invasive carp in the IWW.

Barrier Maintenance Fish Suppression

The USACE operates four electric dispersal barriers (Demonstration Barrier, Barrier 1N, 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.

Invasive Carp Population Modeling to Support an Adaptive Management Framework

This project continues to build upon past efforts to develop a SEICarP model that includes spatial components (i.e., river pools) of the Illinois River system. During 2022, the model will be submitted to for publication in a peer reviewed journal to gather additional feedback. A stock-recruitment relationship will be developed using existing age structure and hydroacousticdata. 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 informadaptive 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 impact movement and will thus influence our 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

Management of invasive carp in the IWW calls for an adaptive management approach (Walters 1986). Data driven tools are integral parts of the adaptive management framework. They describe existing understanding using systems models that include key assumptions and predictions, which form the basis for further learning and decision making. Providing standardized invasive carp demographic data over time and space will support managing and monitoring efforts of these species within the Illinois River. During 2022 the USFWS ColumbiaFWCO will collect fisheries-independent data including age, size, and sex structure, length at maturity, and relative abundance during spring (May – June) and fall (September – November)in each of the lower six pools of the Illinois River (Figure 1) using a random design stratified byhabitat type.

Experimental Field Testing of Longitudinal Bubbler Arrays for Barge EntrainmentMitigation

This project is a continuation of previous studies that investigated small fish entrainment, retainment, and upstream transport by commercial barge tows. The USFWS and partner agencies have conducted several years of barge entrainment studies that demonstrate small fish can become entrained and retained in the box-to-rake junction of commercial tows. These previous studies illustrate the need for mitigation technologies capable of removing entrained small fish and, therefore, reducing the risk of upstream transport in the IWW. In 2022, USFWS, USACE, and USGS plan to carry out a full-scale barge study to test the efficacy of a longitudinal bubble array at mitigating retainment and transport of invasive carp by commercial barge tows.

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 have a preference for 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.

Invasive Carp Enhanced Contract Removal Program

This program aims to reduce the abundance of invasive carp in Peoria Pool through controlled and contracted fishing efforts. This program issues fishing contracts to those commercial fishers willing to target invasive carp in Peoria Pool 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 Peoria Pool as well as the Illinois River system to guide management efforts. This project also works to identify and employ mechanisms for use of the harvested fish by private industry for purposes including human consumption. Through a cooperative relationship of agency and fishers along with end users/markets, advice and support will be provided as necessary to further inform fishers on thedelivery of quality and quantity of fish to the end user/markets through this interaction.

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 forcoordinating between agencies and communicating with the general public. In 2022, 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

A Terminology Change
For the purpose of this MRP, the term 'invasive carp' refers to Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (H. *molitrix*), exclusive of Grass Carp (*Ctenopharyngodon idella*) and Black Carp (*Mylopharyngodon piceus*). Where individual projects address Grass Carp and Black Carp, they will be referenced specifically by name, and without using the generic 'invasive carp' moniker.

This Invasive Carp Monitoring and Response Plan (MRP) was prepared by the Monitoring and Response Work Group (MRWG) and released by the Invasive Carp Regional Coordinating Committee (ICRCC). It builds upon previous MRPs and presents plans for an integrated suite of projects dedicated to preventing invasive carp from establishing populations in the Chicago AreaWaterway System (CAWS) and Lake Michigan. The MRP also seeks to reduce the impact of invasive carp in the Upper Illinois Waterway (IWW) and further reduce the risk of spread toward Lake Michigan. Specifically, this document is a compilation of 21 individual project plans, eachof which plays an important role in preventing expansion of the range of invasive carp, and in furthering the understanding of invasive carp location, population dynamics, behavior, and the efficacy of control and capture methods. Each project outlines anticipated actions that will take place in 2021, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2022 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 2022 Action Plan contains a portfolio of more than 61 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 28 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 Carps 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 Carpin the Illinois Waterway (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 – 2021. More specifically, it is intended to identify actions to be taken in 2022, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2022 MRP takes advantage of information gathered since 2011 to provide the most robust suite of activities to accomplish MRWG objectives. The MRP is a livingdocument and will be revisited at least annually. All MRPs to date, including the 2022 MRP, have benefitted from the review of technical experts and MRWG members, including, but notlimited 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 2022 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 2021 Invasive Carp Interim Summary Report (ISR), has also been completed by the MRWG. The 2021 ISR presents a summary of each individual project's activities, results, findings, and recommendations for future actions. Similar to the MRP, the ISRfunctions as a living document, and will be updated at least annually. Collectively, the 2022 MRPand 2021 ISR present a comprehensive accounting of the projects being conducted to prevent 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 2022 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 nextpage. 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 for2022 are provided in the following locations:

- Appendix A: "Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal"

Key background information on invasive carp that may be useful to field crews or the general public is provided in Appendices B through M. Appendix L provides descriptions and pictorialdisplays of common fishing gears that are used during invasive carp field projects. Appendix M provides a summary of the sampling frames established for the Illinois River pools below the EDBS.

Detection
Seasonal Intensive Monitoring in the CAWS
Strategy for environmental deoxyribonucleic acid eDNA Sampling in the CAWS
Telemetry Monitoring Plan
USGS Telemetry Project: Real-Time Telemetry and Multi-State Modeling
Illinois Waterway Hydroacoustics
Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools
Larval Fish Monitoring in the Illinois Waterway
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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 2022 MRP. No invasive carp have been detected in Lake Michigan, and no invasive carp have been collected between Brandon Road Lock and Dam and the EDBS since detection efforts were intensified in 2010.

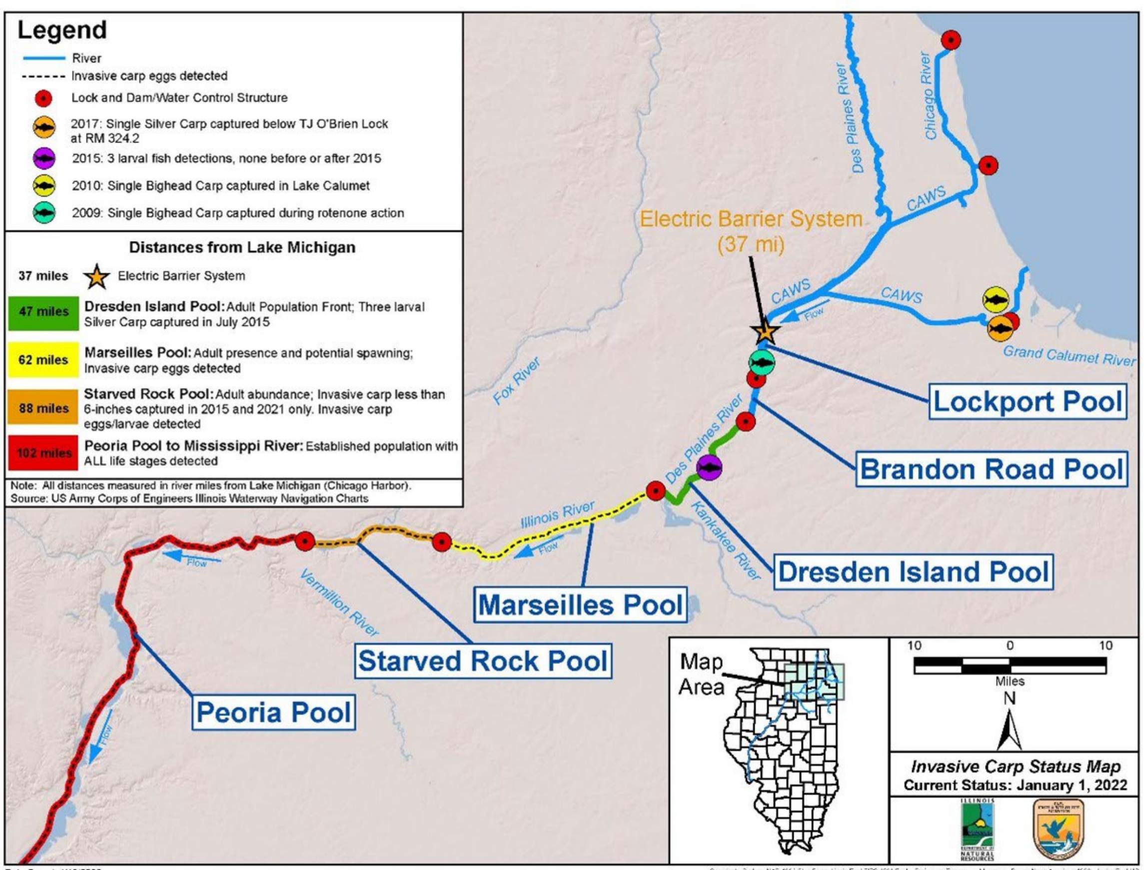
Acoustic-based surveys performed in 2019 suggest relative abundance (measured as mean invasive carp density based on hydroacoustic surveys) has been reduced by an estimated 96.7% in the Dresden Island Pool from 2012 levels. This is an improvement on prior estimates demonstrating relative abundances of 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 change 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 fromLake 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. Overall, numbers of invasive carp eggs and larvae observed during 2021 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 2022 Invasive Carp 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 inthe 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 asa 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 ledto 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 January 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.
- **Lockport Pool:** No established invasive carp population.
- **Brandon Road Pool:** No established invasive carp population.
- **Dresden Island Pool:** Adult invasive carp population front. Larval invasive carp observed in 2015 and have not been observed since (source of larval carp unknown).
- **Marseilles Pool:** Adult invasive carp consistently present, and invasive carp eggs have been detected. Spawning has been observed.
- **Starved Rock Pool:** Abundant invasive carp present, and invasive carp eggs have been detected. Early life-stage invasive carp (<6 inches total length) were observed in 2015 and again in 2021. Larvae have also been detected.
- **Peoria Pool (downstream to confluence with Mississippi River):** Establishedpopulation with all life stages of invasive carp present.



Two highlights from the 2021 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 2022, detection efforts below the EDBS will continue to utilize a standardized, scientifically- based multi-agency monitoring framework to provide even more invasive carp and ecologically relevant fisheries data. The methods and protocols that have been adopted are based upon a largeriver 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 havebeen 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 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 amount of fish required to be removed exceeds funding available to agencies implementing removal projects. Additional commercial fishing pressure is needed toachieve 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 UpperIWW and identify collections that suggest changes to 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 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-poolbasis.

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
Direction of Flow	0 - 37	Chicago Area Waterway System							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 Silver Carp in 2017.

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

3 This status is based upon sightings of 1 Bighead Carp and 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 Upper Illinois River Contingency Plan 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 emergencyaction is not observed. The contingency plan was successfully implemented on June 24, 2017, with the capture of a Silver Carp nine miles from Lake Michigan. The event "Operation Silver Bullet" applied the framework of the contingency plan, which continued for two weeks until actions ended following the guidelines set forth in the Contingency Response Plan (CRP).The CRP was again successfully implemented on September 9, 2019, to address an increased number of positive eDNA results in Bubbly Creek.

The CRP provides a communication framework and response procedure that may be utilized forany 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 encounteredunless tagged and identified for further research. The 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 2021, 44 individual fishhave been documented in the Illinois River. Twenty Black Carp were reported captured in the Illinois River during 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 Departmentof Natural Resources (ILDNR) 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, http://www.asiancarp.us/documents/KeepCoolCallHandout.pdf. 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 2022 MRP outlines three broad categories of implementing objectives asa 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 2022 MRP

1. Provide aggressive invasive carp **detection** in each of the pools upstream of Starved Rockto 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 of

the Upper IWW to enable effective response to any detection before invaderschallenge the EDBS, CAWS, or further threaten the Great Lakes.

3. Continue to evaluate and review the CRP to assure efficacy and appropriate response. In2022, convene at least one table-top exercise with agency and identified natural resourceprofessionals to provide insights into effective response techniques, review technologies available, and incorporate lessons learned into an updated CRP and the 2023 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 ofinvasive carp during 2022.
5. Continue implementing discipline-specific work groups to improve coordination withinand among agencies, and to advise the MRWG about detection technique development,possible efficiencies, acoustic techniques/evaluations, strategy development, or to identify effort 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 workgroups, agencies, and researchers will recommend findings to MRWG co-chairs. Co-chairs will work withICRCC representatives for concurrence and further review of potential tools.
8. Encourage business development and enhanced contract fishing to increase harvest ofinvasive carp in the Lower IWW from approximately 4.5 million pounds in year one (project started in fall 2019) to 8 million pounds by conclusion of year four (2024).
9. Establish additional management of the Lower IWW through contract fishing. Through December 2023, an enhanced contracted fishing program will be continued. The program has a goal of removing 15 million pounds of invasive carp through 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 purposeof those sales will exist save a minimum sale value of 7 cents per pound. This model maybe expanded to other Illinois River pools in the future based upon success, with a four-year goal to remove 8 million pounds of invasive carp from Peoria Pool.
10. Remain diligent with outreach and law enforcement activities to discourage otherpathways of movement and introduction of invasive carp.

MRWG Work Groups

Discipline-specific work groups assist in developing the most informed Monitoring and Response Plans. 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 2020 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. Workgroups may be added or deleted to serve MRWG and ICRCC needs.

2022 Work Group	Lead/Agency
Contingency Planning	Nick Barkowski/USACE Mindy Barnett/ILDNR
Removal	Justin Widloe/ILDNR Nathan Lederman/ILDNR
Hydroacoustic Assessments	Dave Coulter/SIU
Telemetry	Marybeth Brey/USGS
Modeling	Richie Erickson/USGS Ben Marcek/USFWS
Behavioral Deterrent Technologies	Aaron Cupp/USGS
Monitoring	Jim Lamer/INHS Nathan Lederman/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 fundsare 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 multi-agency monitoring deployed throughout the IWW, Des Plaines and Kankakee rivers to inform managementand 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 from 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 anadditional 25% from the biomass observed in 2015.
  - Reduce the estimated biomass of invasive carps in the Starved Rock Pool by anadditional 25% from the biomass observed in 2015.

- Prevent the movement into or sustained presence of invasive carp between the BrandonRoad 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 ofmore 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 showlimited demonstrable effectiveness from future MRPs and MRWG actions.
  - Develop standardized methods for evaluating ongoing research efforts, includingset decision points for continuing or stopping research efforts, and recommendedtimelines for including regulatory input and evaluations.
- Evaluate ongoing management efforts to measure the effectiveness of managementactions, adjust activities to improve effectiveness and adapt to future changes.
  - Hydroacoustic surveys to provide reliable estimates of abundance in each of thepools of the IWW below Brandon Road Lock and Dam.
  - Evaluate new methods for characterizing invasive carp populations based onimproving 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 businessestablishment 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 fromthe 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 notedin 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 anddialogue between 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 millionpounds of invasive carp annually.
- Support development of management and control strategies in other river basins, asrequested.

Response

- Provide for Contingency Plan and Response in less than 48 hours for all contingencyresponse 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 cross-walk. This cross-walk is intended as a tool to allow readers to quickly understand where a specific project focuses its efforts,and also to quickly discern all projects that are operating in a specific portion of the Illinois Waterway. The project cross-walk 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 cross-walk tool is presented below.

Project	Illinois River Pool (Upstream --> Downstream)									Primary Purpose	Page Number	Lead Agency
	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton			
Seasonal Intensive Monitoring in the CAWS										Detection		ILDNR
Strategy for eDNA Sampling in the CAWS										Detection		USFWS LaCrosse FWCO, Whitney Genetics Lab, Green Bay FWCO
Telemetry Interim Summary Report										Detection		USACE
USGS Telemetry Project										Detection		USGS Upper Midwest Environmental Sciences Center, Central Midwest Water Science Center
USGS Invasive Carp Database Management and Integration Support										Management and Control		USGS
Illinois Waterway Hydroacoustics										Detection		USFWS, Carterville FWCO, Wilmington Substation
Combined Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools										Detection		USFWS, Carterville FWCO, Wilmington Substation
Contracted Commercial Fishing Below the Electric Dispersal Barrier										Management and Control		ILDNR, INHS
Upper Illinois Waterway Contingency Response Plan										Response		ILDNR, USFWS, USACE, USGS, INHS, GLFC, MWRDGC
Multiple Agency Monitoring of the Illinois River for Decision Making										Detection		ILDNR, INHS
Larval Fish Monitoring in the Illinois Waterway										Detection		INHS
Zooplankton as Dynamic Assessment Targets for Asian Carp Removal (Appendix A)										Not Applicable		INHS

Project	Illinois River Pool (Upstream --> Downstream)									Primary Purpose	Page Number	Lead Agency
	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton			
Invasive Carp Stock Assessment in the Illinois River/Management Alternataives										Detection		SIU
Invasive Carp Population Modeling to Support an Adaptive Management Framework										Management and Control		USFWS Carterville FWCO Wilmington Substation
Invasive Carp Demographics										Management and Control		USFWS Carterville FWCO Wilmington Substation and USGS Upper Midwest Environmental Sciences Center
Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)										Management and Control		USFWS Carterville FWCO Wilmington Substation
Invasive Carp Enhanced Contract Removal Program										Management and Control		ILDNR
Experimental Field Testing of Longitudinal Bubbler Arrays for Barge Entrainment Mitigation										Management and Control		USFWS Carterville FWCO Wilmington Substation
Des Plaines River and Overflow Monitoring										Detection		USFWS Carterville FWCO Wilmington Substation
Alternative Pathway Surveillance – Urban Pond Monitoring										Detection		ILDNR
Alternative Pathway Surveillance in Illinois – Law Enforcement										Management and Control		ILDNR

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS
2022 Plan

Participating Agencies: ILDNR (lead); INHS, USFWS, USACE, and SIU (field support); USCG (waterway closures when needed); USGS (flow monitoring when needed); MWRDGC (waterway flow management and access); and USEPA and GLFC (project support).

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 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 the presence of any invasive carp and to 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 2022 with two seasonal intensive interagency multi-gear sampling efforts in May and October.

Objectives:

(1) Detect and remove invasive carp from the CAWS upstream of the electric dispersal barrier system when warranted.
(2) 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. In its current form, this project has been in place since 2014. SIM consists of an intensive two-week multi-agency sampling effort in the spring and fall of each year utilizing coordinated netting and electrofishing effort 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 Bighead Carp was collected in Lake Calumet in 2010, and one Silver Carp was collected in the Little Calumet River in 2017. Confining effort upstream of the EDBS to short, intensive sampling periods allows for increased detection and removal efforts downstream of the barrier, which reduces 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). Random reaches exclude areas of the waterway designated as fixed reaches. Random sample sites will be generated with GIS software from shape files delineating random reaches and will be labeled with Lat-Lon 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 ~11.3 km (7 mi).
- **Site 3** – CSSC and South Branch Chicago River from Western Avenue upstream to Harrison Street ~6.4 km (4 mi).
- **Site 4** – North Branch Chicago River and North Shore Channel from Montrose Avenue north to Peterson Avenue ~3.2 km (2 mi).
- **Site 5** – North Shore Channel from Golf Road north to Wilmette Pumping Station ~3.2 km (2 mi).

Upstream Random Site Sampling Area Descriptions

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

Decontamination Protocol:

To prevent contamination of eDNA samples from of residual invasive carp genetic material on sampling equipment (boats, netting gear, etc.), hot water pressure washing and chlorine washing (10% solution) of boats and potentially contaminated equipment used in the SIM is 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 1-2 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

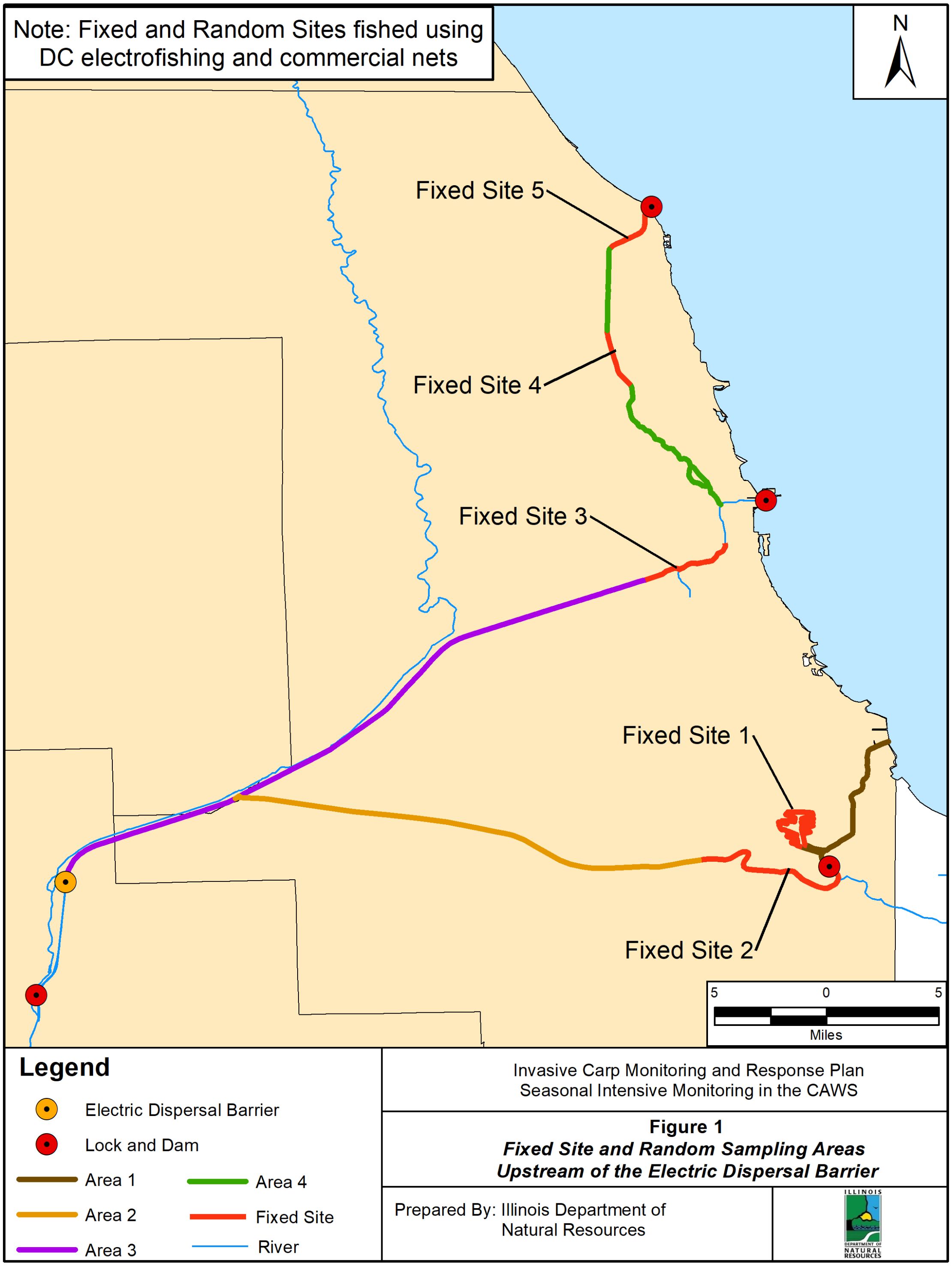


Figure 1. *Fixed site and random site sampling reaches for electrofishing and commercial.*

sampled for 15 minutes in a downstream direction in waterway main channels (including and off at times to prevent pushing following shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Electrofishing boat operators may switch the safety pedal on 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 < 152.4 mm (6 in) 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 m (10 ft) deep x 182.8 m (600 ft) long in bar mesh sizes ranging from 88.9-108 mm (3.5-4.25 in) at fixed and random sites per set (Appendix M). Deep water gill nets may also be used as appropriate. One 9.1 m (30 ft) deep gill net for each net boat will be provided by the ILDNR as necessary (Appendix M). Locations for each net set will be identified with GPS coordinates. Net sets will be 15-20 minutes long and will incorporate fish herding techniques within 137.2 m (450 ft) 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 23):

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 (1938.8 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, then in the south section for one day (Figure 2). The 731.5 m (2400 ft) 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 M for a more complete description of invasive carp sampling gears.

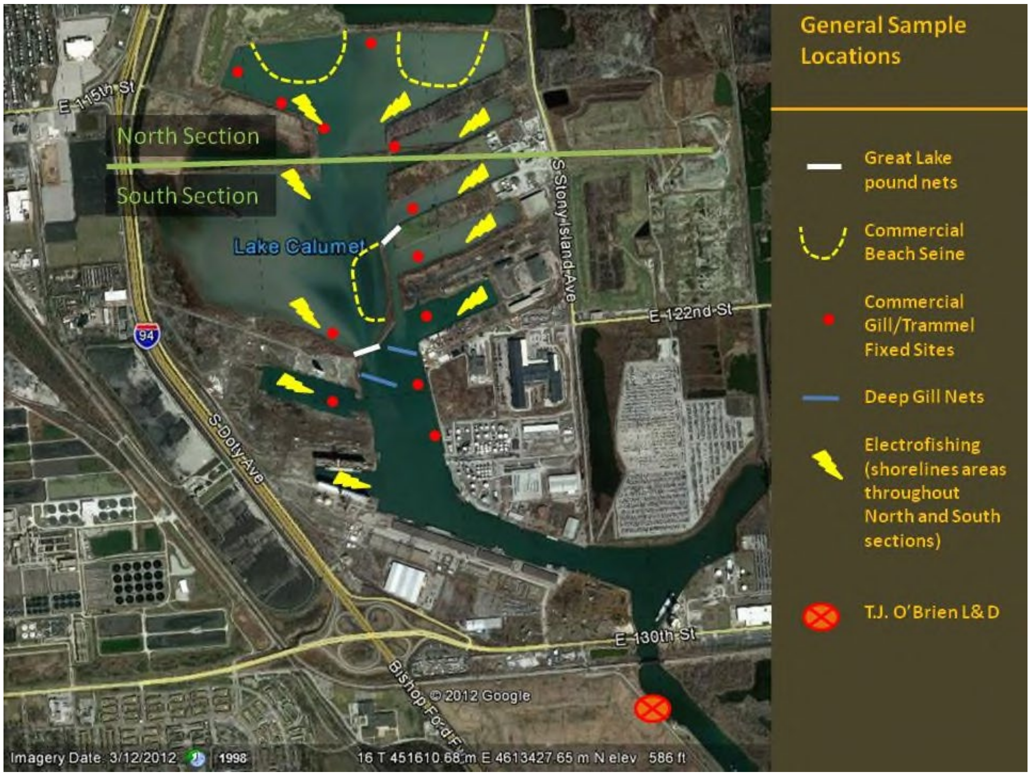


Figure 2. *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

North Shore Channel (week of October 10):

Sampling will occur between the Argyle Street Bridge, located just downstream from the North Shore Channel and North Branch Chicago River confluence, and the Wilmette Pumping Station (Figure 3; 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 m (500 to 800 yds) 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 457.2 to 731.5 m (500 to 800 yds) closer to the site center and the process 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 10):

Electrofishing will occur around the entire shoreline of 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; Appendix D). During this time net boats will set and pull deep water gill nets in areas off of the main navigation channel. Once the entire reach is sampled, crews will travel down river and sample eight barge slips and backwater areas in the South Branch Chicago River near Bubbly Creek (Figure 3; 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 towards 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.

Data Collection:

For all SIM activities 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 at 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 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, 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 capture of a Bighead Carp or Silver Carp upstream of the EDBS.

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

2022 Sampling Schedule:

Spring Event

- Week of May 16: All fixed and random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols).
- Week of May 23: Lake Calumet/Calumet River (see special protocols) and all random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols).

Fall Event

- Week of October 3: All fixed and random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols).
- Week of October 10: North Shore Channel/Chicago River/South Branch Chicago River/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 for an annual interim report and project plan updated for annual revisions of the MRP.

Strategy for eDNA Sampling in the CAWS
2022 Plan

Participating Agencies: USFWS (La Crosse FWCO, Whitney Genetics Lab, Green Bay FWCO)

Location: Lake Calumet and Little Calumet River

Pools Involved: CAWS

Introduction and Need:

Monitoring with multiple gears in the CAWS has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of invasive carp from establishing in the Great Lakes. Since 2009, eDNA sampling has been used as a surveillance tool to monitor for Bighead Carp and Silver Carp DNA in the CAWS and maintain vigilence 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 compliment SIM sampling by monitoring for the genetic presence of invasive carp and providing evidence to areas that may warrant further attention. This also allows SIM efforts to help interpret eDNA results and ensures that, by design, any highly positive results are already followed up with an intensive physical sampling effort to gage the likelihood that positivity was the result of a live carp threat versus a secondary vector. eDNA sampling events are typically conducted twice per year when conditions allow eDNA results are transmitted from the USFWS promptly to ILDNR to determine the appropriate follow up actions and communications. Positive eDNA results do not automatically trigger any kind of physical sampling response per the CRP.

Objectives:

(1) Sample for Bighead Carp and Silver Carp DNA in targeted areas of the CAWS to maintain vigilence.
(2) Compliment other ongoing monitoring efforts above the EDBS.

Status:

USFWS has conducted sampling for eDNA in the CAWS above the EDBS since 2013, when the USFWS eDNA Program was formed and all eDNA sampling responsibility in the CAWS, including the methodology, were adopted from the USACE. 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) were deployed in 2014, processing methodologies switching from filtering to centrifugation in 2015 (USFWS internal reports), and laboratory analysis changing from conventional PCR to qPCR in (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 five years (0-3.8% positive detections) reflect that only one Silver Carp was captured alive in 2017, and one Bighead Carp was captured alive in the CAWS in 2010. 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 going forward.

Methods:

In 2022, 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 CSO 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 prior to the fall SIM. During each event 300, 5 x 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).

Ancilary to the two regular monitoring sites, USFWS may seek to add a control site to the sampling regime. This control site will be a closed pond with no connectivity to sampled waters, but will be close enough in proximity to assume that bird activity may be similar. This site may then help gage if birds are substantial secondary vectors of invasive carp eDNA to waterbodies in the area, including the sampling sites. The control site would be sampled in a similar manner and at a similar sampling density to the actual monitoring sites.

Additional events and areas may be added if requested by MRWG partners. All eDNA sampling efforts and results in 2022 will be detailed in the 2022 ISR 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 QAPP (QAPP; USFWS 2022; http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf). The state of Illinois will be notified of the results from the CAWS following the pre-established Communication Protocol (see USFWS 2022) after sample processing is complete, and then those results will then be posted online.

2022 Schedule:

- Week of May 9 400 samples, 40 field blanks (monitoring sites)
  100 samples, 10 field blanks (control site, tentative)
- Week of Sept 26 400 samples, 40 field blanks (monitoring sites)
  100 samples, 10 field blanks (control site, tentative)

Deliverables:

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

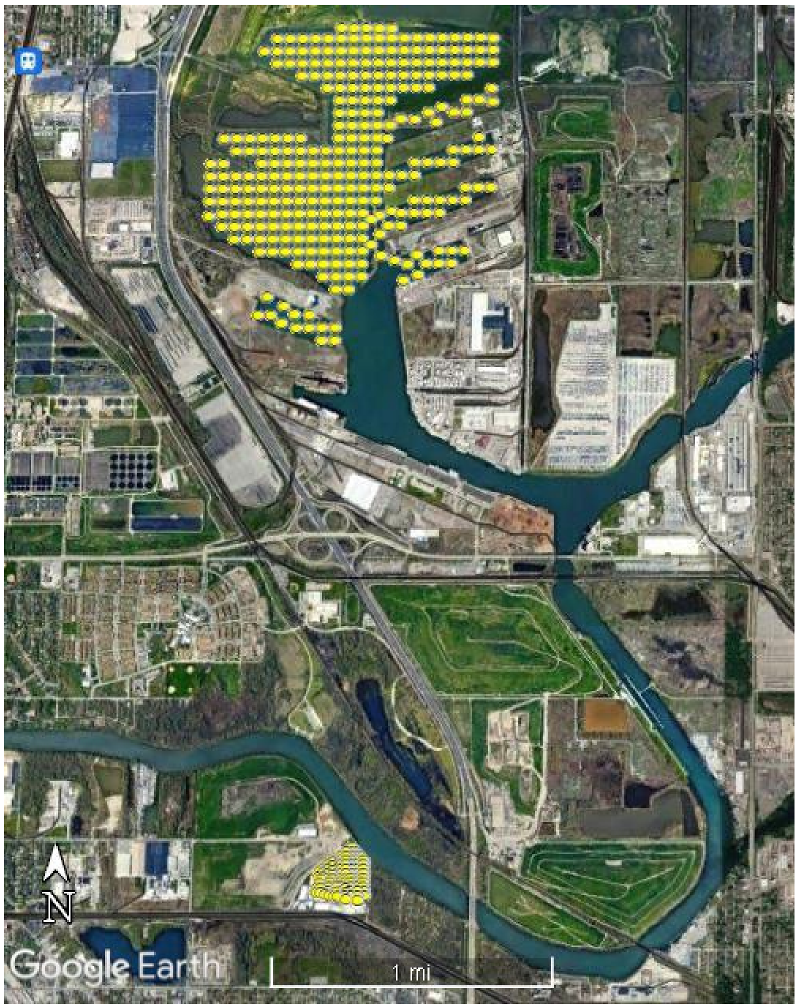


Figure 1. *Distribution of Bighead and Silver Carp eDNA samples (yellow dots) to be collected in Lake Calumet and the Little Calumet River in 2022.*

References:

Amberg, J.J., S.G. McCalla, E. Monroe, R. Lance, K. Baerwaldt, and M.P. Gaikowski. 2015. Improving efficiency and reliability of environmental DNA nalysis for silver carp. Journal of Great Lakes Research. 41(2): 367-373. DOI:10.1016/j.jglr.2015.02.009.

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U.S. Fish and Wildlife Service (USFWS). 2022. Quality Assurance Project Plan (QAPP) eDNA monitoring of bighead and silver carps. Midwest Region Bloomington, MN. Available:http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf.

Participating Agencies: USACE (lead); ILDNR, SIU, USGS, MWRDGC, USFWS (support)

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

Introduction and Need:

The telemetry monitoring plan includes the tagging of fish with individually coded ultrasonic transmitters in the Upper IWW. The acoustic network proposed is comprised of stationary receivers and supplemented when necessary by a mobile hydrophone unit to collect information from acoustic transmitters (tags) implanted into free-swimming Bighead Carp, Silver Carp, 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 of those receivers has changed and been adapted to improve detection efficiencies and focus on areas of importance or likely high-density fish areas. Acoustic receiver coverage within the Upper IWW is primarily focused at the EDBS with secondary coverage surrounding lock and dams and emigration routes such as tributaries and backwater areas. As of 2021, USACE operates 28 receivers between the confluence of the Cal-Sag and CSSC and Dresden Island Lock and Dam. Additionally, over the years, other agencies (SIU, 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 a high efficacy for the EDBS to deter large fishes. 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 in which Bighead Carp and Silver Carp activity is greatest within the pool including the Rock Run Rookery backwater and the Kankakee River confluence. 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 the EDBS operations and maintenance. As more research is conducted on Bighead Carp and Silver Carp in the Upper IWW ecosystem, information gaps are being identified and monitoring plans continue to be refined. For instance, in 2021 an additional receiver was placed in the I&M Canal to better understand fish movements in or out of the side channel of the Des Plaines River.

Acoustic telemetry monitoring is the only continuous monitoring project for the EDBS in 2021. Additional barrier efficacy studies have been completed using alternative monitoring tools such as mark/release and hydroacoustic surveys. These studies have helped to address the deficiencies of acoustic telemetry but cannot be deployed every day throughout the year and can be used to address several information gaps that have been identified at the leading edge of the invasion front. The following goals and objectives have been revised from previous years to focus future efforts on identified knowledge gaps and improving the efficiency of data collection and reporting.

Goals and 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 2022 season have been identified as:

Goal 1: Determine if upstream passage of EDBS by large fishes has occurred and assess 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) and within Brandon Road lock (N=1).
- **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 and Silver Carp invasion (currently RM 286.0) has changed in either the up 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 ILDNR 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.
- **Objective:** Maintain existing acoustic network and rapidly expand to areas of interest in response to new information.
- **Objective:** Support the modeling efforts by USFWS with supportive data and adjust network accordingly in consultation with telemetry working group.

Status:

Sample size and distribution – In 2010, the workgroup decided that a baseline minimum of 200 transmitters be implanted for telemetry monitoring in the vicinity of the EDBS and that this level of tags be maintained as battery life expires or specimens exit the study area. At the conclusion of the 2021 sampling season there were 155 USACE tagged fish within the study area with varying expiration dates, in which the nearest expiration date will be March 2023 for 25 tags. In the 2022 field season, 63 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 2022 to achieve recommended minimum levels of the sampling size and to replace those that emigrate out of the pool through the Lock and Dam or the Lockport Control Works. It is anticipated that 12 tags will be implemented in Lockport Pool to meet the goal of 75 tagged fish in the pool (Table 1).

At the start of the 2021 field season, all of the Brandon Road tags from previous years were expired, and 42 tags were implanted in Common Carp in the spring and fall. For the 2022 season, 8 tags are anticipated to be implanted in Brandon Road Pool to achieve a target number of 50 active 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. Immigration from Dresden Island is possible, though it is not as frequent as from Lockport.

As of November 2021, there are 58 USACE transmitters within Dresden Island Pool that will remain active through at least 2023 and none are set to expire during the 2022 sampling season. There is an active removal effort underway in this pool so there is possibility for tagged individuals to be removed and immigration is likely to occur to the Marseilles pool. To maintain the target goal of 75 USACE tags, at least 17 transmitters (V13TP-1x-069k-0017m) will be implanted into invasive carp in Dresden Island Pool in 2022. The number of tags and season of deployment in each pool is shown in Table 1 on the next page.

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 carps. Based on these characteristics, tracking of Common Carp should provide a good indicator of how invasive carps would respond to the dispersal barrier if they were near this deterrent.

Table 1*: Recommended transmitter implementation for the 2022 sampling season. Supplemental tags are required to maintain 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 spring time 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	12	0	75
Brandon Road/ RM286.5	Common Carp	8	0	50
Dresden Island/RM276	Bighead Carp and Silver Carp	17	0	75
Total	-	37	0	200

Tag specifications and Implantation procedure – Tagging efforts will be focused during late spring (April - May) and fall (October – November) and will follow the surgical and recovery procedures outlined in *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, measured, and sex will be identified if possible. To reduce fish mortality during or after surgery due to infection at the incision site, API Stress Coat + will be applied to the fish to promote healing of the incision site (Shivappa et al. 2017). Fish will also be tagged with an external 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 so we can save the transmitter and tag 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. Any Bighead Carp and Silver Carp captured in Lockport or Brandon Road will be turned over to ILDNR for species voucher.

Stationary Receivers – A system of passive, stationary receivers (Vemco VR2W and VR2C) are placed throughout the IWW to monitor movement of tagged fishes. 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). VR2W's will be placed from the Dresden Island Lock and Dam (RM 245, Illinois Waterway) to 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, Illinois Waterway). At the conclusion of each field season (late November to early December) a minimized network of receivers is left in place at strategic choke points throughout the study area while the remaining receivers are removed to prevent damage from winter conditions. These will be placed directly above and below the EDBS; above and below Lockport Lock; above, below and within Brandon Road Lock; and above Dresden Island Lock. The receiver network is re-established to its full capacity at the commencement of the following season, typically late March.

Figure 1 shows the general strategy of VR2W placement for 2022 (N=28 USACE receivers). The priority is to achieve the most coverage (detection capacity) in the immediate vicinity of 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 to 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 for maintenance of the acoustic telemetry network (i.e., decrease risk of vandalism, ensure operation of device, check battery life, and replacement if necessary). All receivers will be downloaded via Bluetooth-USB capability. The software is available for free online 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 portable directional and omni-directional 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 mobile tracking unit will be used as a supplemental tool to help locate congregations of Bighead Carp and Silver Carp in coordination with IDNR contracted commercial fishermen. In doing so, increased harvest of Bighead Carp and Silver Carp may occur. 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 EDBS – As described above, any suspicion (indicated by stationary receiver data) of any 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, as well as 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 in the vicinity.

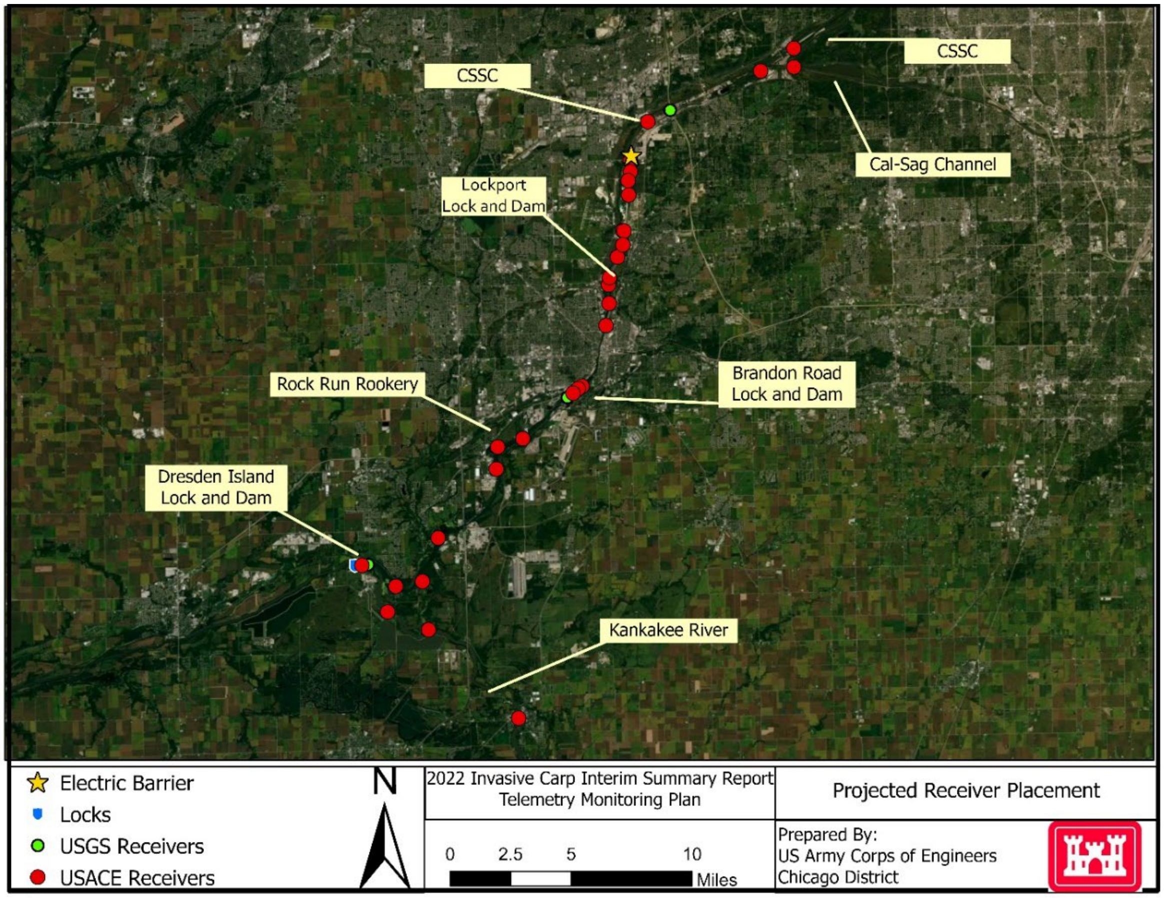

Figure 1. *Proposed USACE 2022 telemetry network to be deployed throughout the IWW.*

Tagged Bighead Carp and Silver Carp detected in Brandon Road Pool – Any detection of Bighead Carp or Silver Carp within Brandon Road Pool will be verified immediately. Verification of detections may include review of stationary receiver network data for patterns of detection and on-site tracking utilizing the VR-100 receiver mobile tracking unit. Verified detection 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, as well as the MRWG co-chairs.

Sampling Schedule: A tentative work schedule is presented below.

March – April 2022	VR2W network inspected, and new receivers installed, and range tested.
ONGOING	VR2W network maintenance, downloads and mobile tracking.
April – May 2022	Tagging of surrogate fish in Brandon Road and Dresden Island pools.
December 2022	Prepare receiver array within the IWW and CAWS for winter months.

Deliverables:

All agency leads involved with the telemetry plan, as well as 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. A summarization of all data collected in 2022 will be included in the year-end interim summary report compiled by ILDNR after each field season.

References:

Asian Carp Regional Coordinating Committee (ACRCC) Monitoring and Rapid Response Workgroup. 2012. 2011 Asian Carp monitoring and rapid response plan interim summary report.

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Shivappa, R.B., L.S. Christian, J.M. Law, G.A. Lewbart. 2017. Laboratory evaluation of different formulation of Stress Coat® for slime production in goldfish (*Carassius auratus*) and koi (*Cyprinus carpio*) PeerJ 5:e3759 https://doi.org/10.7717/peerj.3759.

USGS Telemetry Project: Real-Time Telemetry and Multi-State Modeling 2022 Plan

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

Location: Upper Illinois River Pools and Upper Illinois Waterway

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 IWW and elsewhere. Data collected from detections of these fish can be used to calculate movement probabilities between river pools, estimate fishing mortality (F), and supplement mark-recapture data for population estimates. These estimates can all be used to parameterize models (e.g., 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 IWW 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 IWW, and elsewhere, is collaboratively managed by multiple agencies and universities. A Telemetry Work Group has been established by the 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 Work Group 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 MRP project (USGS Invasive Carp Database Management and Integration Support). 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 customizability, extension of the model, ,poor model convergence, computer crashes, lack of movement probability estimates, and inability 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 FY 2022. 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. Analysis and reporting from these assessments will be finalized and shared with MRWG in FY 2022.

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:

(1) Telemetry project in support of SEICarP modeling

- *Publish Movement Probability Model:* The Bayesian multi-state model has been completed and parameter estimates shared with the SEICarP Modeling group. The goal is to publish this model in FY2022.
- *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.
- *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).

(2) Real-time telemetry in support of barrier evaluations and contingency planning

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

Status:

- Telemetry project in support of SEICarP modeling

- *Movement probability model*: A Bayesian multi-state transition probability model for the Illinois River has been completed and run using telemetry data from 2012 - 2019. Model movement parameters have been shared with the SEICarP team, and a manuscript of this multi-state model is in preparation.
- *Feasibility studies*: Two new aspects of this project are planned for 2022. First, we will 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. Second, we will work with the modeling and telemetry workgroups, and relevant partners, to design a study to explore density-dependent movement throughout the Illinois River. These two projects will be in the development phase in 2022, 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:* 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 will be completed in early 2022.

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

Station	Location
Chicago Sanitary and Ship Canal above the EDB	Lemont, IL
Chicago Sanitary and Ship Canal below the EDB	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: two additional real-time receivers exist in the Marseilles Pool, supported by another project

Methods:

- Telemetry in support of the SEICarP model
  - *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, automatically excluding parameters from the model, and not providing estimates) 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 provide uncertainty estimates for the estimated parameters; 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:* The five year-round, real-time receivers will be maintained and downloaded in 2022. The real-time email alert system will be maintained and updated to alert key MRWG and ICRCC members with invasive carp detections of interest to members.

2022 Schedule:

- Telemetry project in support of SEICarP modeling
    - Movement probability model:
- Complete modeling to estimate movement probabilities and associated uncertainty with the new model and present these results to the Population Work Group for discussion of data adequacy to inform tagging and monitoring network, and for use with SEICarP – *completed October 2021*
- Submit manuscript detailing the Bayesian movement probability model to a peer-review journal – Se*ptember 2022*
- Present the movement probability model at a conference – *May 2022*
    - Feasibility studies
- Monthly coordination meetings with the Modeling Work Group and other Basin partners to detail outline the data needs and process for density dependent movement models and estimating fishing mortality.
- Report (or study plan) for estimating additional model parameters and developing a density-dependent movement model – *September 2022*
- Real-time receiver network
    - Complete annual operation and maintenance of five MRWG supported real-time receivers in the upper Illinois Waterway – *ongoing 2022*
    - Provide email alerts and monthly summaries to managers regarding invasive carp detections on the real-time receivers to inform contingency actions – *ongoing 2022*
    - Summary document of real-time receiver network activity – *completed by September 2022*

Deliverables:

- Telemetry project in support of SEICarP modeling

- Model: Bayesian multi-state model that estimates movement probabilities and associated uncertainty.
- 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. Presentation at a professional society meeting.
- Input for SEICarP: Estimates of movement probabilities and associated uncertainty for parameterizing future SEICarP modeling.
- Report: Manuscript for scientific journal article on Bayesian multi-state model for estimating movement probabilities of acoustically tagged bigheaded carp.

- Real-time receiver network
  - Real-timer receiver network with five real-time receivers in the upper Illinois Waterways system.
  - Email alerts and monthly summaries to managers regarding invasive carp detections on the real-time receivers to inform contingency actions.
  - Real-time receiver data uploaded to the FishTracks database for use in modeling and visualizations.

Illinois Waterway Hydroacoustics
2022 Plan

Participating Agencies: USFWS-Carterville FWCO, Wilmington Substation

Location: Brandon Road, Dresden Island, and Lockport reaches of the IWW including at the EDBS

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 movement of invasive fishes between the Mississippi River and the Great Lakes basins while maintaining 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 in effort to reduce propagule 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 [2021 Invasive Carp Action Plan]). As part of this multifaceted detection and control program, regular monitoring of the patterns of abundance and distribution of large fishes in the immediate vicinity of the EDBS and in the downstream pools has been valuable in gauging the level of risk of the barriers being challenged by large fish (potentially invasive carps) moving upstream through the IWW towards Lake Michigan. This project will provide this large fish monitoring component by utilizing hydroacoustic technology to survey large volumes of water at the EDBS and in the uninvaded and low-density pools downstream, allowing for detection of, and rapid response to, changes in large fish abundance and distribution and informed barrier maintenance scheduling. Additional surveys may also be performed as necessary to support requests from the ICRCC.

Objectives:

(1) 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.

(2) Disseminate information on changes in abundance and distribution near the EDBS, and in downstream reaches, to guide detection, response, and control efforts for invasive carp.

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 2021, due to the COVID-19 pandemic, only seven hydroacoustic surveys at the EDBS were conducted from August 30 – December 14 (compared to roughly 25 surveys in a typical year). Fish targets were detected within the EDBS in four of seven surveys, but abundances were low with an overall mean of 1.0 large fish targets detected per survey (min = 0, max = 2 individual large fish targets, n = 7). Fish abundance directly downstream of the EDBS remained relatively low from August – December with a mean of 3.7 large fish targets detected per survey (min = 0, max = 7 individual large fish targets, n = 7).

Hydroacoustic surveys were conducted monthly in Lockport, Brandon Road, and Dresden Island, pools from September – December 2021 (none from January – August due to COVID-19 pandemic restrictions). Highest abundance of large fish targets occurred in Dresden Island Pool in September (187 large fish targets) but was considerably lower by November (42 large fish targets) and December (24 large fish targets). Notably, a modified unified method harvest event for invasive carps was conducted in Dresden Island Pool in October. This event removed 75 invasive carps from the mainstem Des Plaines and Kankakee rivers and may have contributed to the reductions large fish density observed in Dresden Island Pool in November and December. It is also possible that lateral movements of large fishes to unsampleable nearshore habitats such as shallow backwaters for overwintering may have occurred (Sheehan et al. 1994; Coulter et al. 2017), thus reducing the number of fish able to be encountered by the hydroacoustic gear. Large fish abundance in Lockport and Brandon Road pools generally remained similar and relatively low between pools and across months, with means of 6.25 large fish targets per survey in Lockport Pool (SD = 4.1, n = 4) and 8.5 large fish targets per survey in Brandon Road Pool (SD = 6.1, n = 4).

Methods:

Mobile hydroacoustic fish surveys- Dresden Island Pool, Brandon Road Pool, Lockport Pool, and at the Electric Dispersal Barrier System

Side-looking split beam hydroacoustic and side scan sonar surveys will be conducted within and downstream of the Electric Dispersal Barrier System to assess fish abundance and distribution patterns on a fine temporal scale. Barrier surveys at the EDBS will take place every two weeks and hydroacoustic results from the survey will be shared with the ICRCC within 48 hours of survey completion. Pool surveys with split-beam hydroacoustics will take place every month beginning in January 2022, except in Dresden Island Pool during months when SIU conducts hydroacoustic surveys to avoid duplicating effort. The hydroacoustic equipment utilized for these surveys will consist of a pair of Biosonics® 200 kHz split-beam transducers and a 4125 Edge Tech ultra-high resolution side scan unit. The two split-beam transducers will be mounted horizontally in parallel on the starboard side of the research vessel 0.4 m below the water surface on a dual axis automatic rotator. The side scan unit will be attached to a port-side davit on the research vessel and is lowered approximately a meter into the water. Surveys will consist of an upstream and downstream transect along the channel border in water depths > 2m, 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.

2022 Schedule:

- Mobile hydroacoustic fish surveys at the EDBS: Biweekly throughout 2022, depending on COVID-19 conditions.
- Mobile hydroacoustic fish surveys in Brandon Road, Lockport, Dresden Island pools: Monthly throughout 2022, depending on COVID-19 conditions.

Deliverables:

- Biweekly report on fish abundance and spatial distribution near the EDBS to the ICRCC and MRWG to inform contingency response and guide barrier maintenance scheduling.
- 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 pools.

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Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools 2022 Plan

Participating Agencies: USFWS-Carterville FWCO, Wilmington Substation

Pools Involved: *Upper IWW Small Invasive Carp Distribution Monitoring*

Dresden Island and Marseilles pools

Early Detection Monitoring in the Upper Pools

Lockport and Brandon Road pools

Location:

Upper IWW Small Invasive Carp Distribution Monitoring

Targeted sampling of small (≤ 153 mm TL), 'juvenile', invasive carp will occur where juvenile bigheaded carp are currently believed to be absent. Sampling effort 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.

Early Detection Monitoring in the Upper Pools

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:

The success of management strategies to control or eradicate aquatic invasive species is closely linked to how early the novel species is detected and subsequently how fast management action is taken. Early detection is crucial to management successes because the propagule pressure is lower and the individuals are more likely to be spatial restricted (Myers et al. 2000, Mehta et al. 2007). Therefore, 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 of the 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). For example, both early detection and endangered species assessment sampling designs often take into consideration habitat preferences and life-history traits of the species to improve detection probability (e.g., Rew et al. 2006, Hoffman et al. 2011, Lintermans 2016). Likewise, species richness estimators 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).

Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools 2022 Plan

Since the 1970s, invasive Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*Hypophthalmichthys nobilis*) populations have invaded the Mississippi River Basin, subsequently expanding upstream and becoming established in the Illinois River (Chick and Pegg 2001, Sass et al. 2010). Silver Carp and Bighead 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) and threat of harm to lake users and their property (Kolar et al. 2007). The most probable invasion pathway for Silver Carp and Bighead Carp to enter the Great Lakes is through connection of the upper IWW, which includes the CAWS, to Lake Michigan (Kolar et al. 2007).

An EDBS, operated by the USACE in the 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 fishes from passage (Holliman 2011). However, tests with small Bighead Carp (51-76 mm total length [TL]) have indicated that the operational parameters of the EDBS may be inadequate for blocking passage of small-bodied fishes (Holliman 2011). Moreover, research using Golden Shiners (*Notemigonus crysoleucas*) as a non-invasive surrogate species for juvenile Silver Carp, indicated that small fish can become entrained in barge junction gaps and transported through the EDBS (Davis et al. 2016). Furthermore, research using DIDSON indicated that small fishes (unknown species) can be transported upstream through the EDBS by return water currents created during downstream barge movement. These studies illustrate a potential vulnerability in the EDBS and some potential mechanisms by which small-bodied Silver Carp and Bighead Carp, if present in the vicinity, could pass upstream through the EDBS. For this reason, as well as the potential for established mature invasive carp present in Dresden Island Pool to advance the invasion front upstream via successful reproduction, there is a need for high spatial- and temporal-resolution monitoring focused on the detection of invasive carp in the IWW both upstream and downstream of the EDBS.

The overall objective of these sampling efforts is to increase targeted early detection sampling of Silver Carp and Bighead Carp in the upper IWW for the purpose of increasing certainty in the derived species distributions by reducing the potential for type II error. The information provided by this invasive carp-focused sampling will aid ICRCC and MRWG agencies in evaluating the invasion risk of invasive carp to the Great Lake via the CAWS and will provide additional information on any changes to invasive carp distribution that would be relevant to the interagency CRP.

The small fish distribution sampling effort conducted in Marseilles and Dresden Island pools is focused on small invasive carp early detection and is intended to complement existing population and assemblage-focused monitoring actions in the IWW such as SIM, Multiagency Monitoring of the Illinois River for Decision Making (MAM), Early Detection of Bigheaded Carp in the Upper IWW, and hydroacoustic monitoring in the vicinity of the EDBS.

Upper Illinois Waterway Small Invasive Carp Distribution Monitoring and Early Detection Monitoring in the Upper Pools 2022 Plan

Objectives:

The objective of the *Upper IWW Small Invasive Carp Distribution Monitoring* activity is to detect small (≤ 153 mm TL) bigheaded carp that may be present in areas where they are not known to occur above Marseilles Lock and Dam.

The objective of the *Early Detection Monitoring in the Upper Pools* activity is to detect bigheaded carp of any size that may be present in areas where they are not known to occur above Brandon Road Lock and Dam.

Status:

This is an updated project for 2022 consisting of two sampling activity components. This MRP project overview combines the *Upper IWW Small Invasive Carp Distribution Monitoring* and the *Early Detection Monitoring in the Upper Pools*. They are distinct projects supported in the ICRCC FY 2022 Action Plan, but for the purposes of the MRP document they both describe targeted invasive carp sampling, conducted in an early detection fashion using similar gears. The difference being the size fish targeted and the location (pool) of sampling.

This early detection project updates the USFWS efforts towards the Distribution and Movement of Small Invasive Carp in the IWW project as well as the Habitat Use, Early Detection of Bigheaded Carp in the Upper IWW, and Movement of Juvenile Asian Carp in the Illinois Waterway 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 2022 will consist of boat electrofishing, electrified dozer trawling, 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 for 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 2022, IWW early detection sampling will be conducted via a combination of fixed and random site sampling. Initial sampling sites will be selected using target analysis of data previously collected through MRWG-supported projects such as 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, Fixed and Random Site Sampling downstream of the EDBS, and MAM. Target analysis will focus on determining the habitats both small invasive 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. Site selection will be targeted towards detecting small Silver Carp and Bighead Carp. In general, fixed sites will be based on areas where small invasive carp have previously been detected in the IWW (Peoria and Starved Rock pools). Data from these fixed sites will be used for trend analyses as well as to provide information on habitat preferences that will be used to stratify random site selection. Random sites will be stratified by habitat type (MCB, SC, BW) and habitat area and exclude certain zones that are not useable for each gear type deployed. Floodplain lakes will be sampled following high-water events which could have resulted in spawning activity or movement of juvenile carp into the area. Where depth is sufficient, sampling at both fixed and random of sites will include boat-mounted electrofishing, electrified dozer trawling, and mini-fyke netting. During 2022, sampling effort will 2-5 days of sampling per gear per pool per month (approximately 20 electrofishing sites, 20-30 electrified-dozer trawl sites, and 8-15 mini-fyke net sets). Boat-mounted electrofishing will be conducted via the methods described in Bouska et al. (2017) where the boat is maneuvered in a scalloped pattern along the shoreline and the pedal operator applies power to the water at the peak of the loop to drive fish back towards the shore. 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 channel and backwaters) within Marseilles and Dresden Island pools and will consist of 24-hour net sets at each sampling site. Early season sampling efforts will begin when water conditions become appropriate for invasive carp spawning (generally when water temperature ≥17-18°C). Coordination with other agencies will be necessary to monitor for spawning behaviors, which might alter how, where, and when this project conducted.

Physical characteristics and water quality measurements will be measured and recorded at each collection site and will include pH, 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, 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 TL (mm) and mass (g); 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 ExCell Plus fixative or 70% ethanol for laboratory identification to the lowest possible taxonomic level. Effort will be quantified as net nights (mini-fykes) and minutes of electrofishing (boat electrofishing and dozer trawl).

***Individual gear descriptions for 2021*:**

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

The methods described in Bouska et al. (2017), have the pedal being intermittently activated to drive fish into shore, so runs are longer spatially and temporally compared to LTRM style methods, described in Ratcliff et al. (2014), in which the pedal is constantly activated to capture fish along the entire run. However, the seconds that electricity is applied to the water is the same in both methods.

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.

Dozer trawl – A 35 mm mesh net at the mouth reducing to 4 mm mesh at the cod end tied to a 2- meter 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 >0.6 meter deep. The trawl is mounted to an electrofishing boat with anodes extending 1.5 m in front of the trawl and the trawl acting as the cathode. Trawl sampling duration will be 5-minute transects.

2021 Schedule:

January – February 2022:	Gear preparation, planning field logistics, and crew scheduling
March – November 2022:	Fish sampling, identification, and data entry
November – December 2022:	Complete fish identification (preserved specimens), data entry, and verification
December 2022 – January 2023:	Data analyses, prepare report, and presentation

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 the winter of 2022 – 2023. 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 to hydroacoustics monitoring projects.

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Larval Fish Monitoring in the Illinois Waterway 2022 Plan

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

Location: Ichthyoplankton (i.e., fish embryo and larval life stages) sampling will take place at seven 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 in order to complete study objectives.

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

Introduction and Need:

Understanding the spatial and temporal dynamics of reproduction by invasive fishes 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 different sections of the IWW and its tributaries is needed to monitor for changes in the reproductive front of invasive carp populations in this system and to better understand the impacts of removal efforts on the reproductive potential of these populations. These data are used for monitoring the upstream expansion or contraction of Bighead Carp and Silver Carp populations and potential reproduction by the newly expanding Black Carp population in Illinois, as well as to assess the relationship between invasive carp stock abundance and reproductive output to assess if removal efforts are reducing invasive carp densities enough to degrade their ability to perpetuate themselves through reproduction.

Reproduction and recruitment of invasive carps in the IWW have been highly variable across years and multiyear efforts are necessary to assess the magnitude, location, and timing of reproduction, evaluate conditions affecting reproduction, and monitor for changes in the invasive carp reproductive front. Observations of eggs and larvae in the upper Illinois River indicate that some reproduction occurs above Starved Rock Lock and Dam in some years. 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. Monitoring for any changes to these patterns can help to evaluate the risk for further population growth in the upper Illinois River or the prospects for fishery-induced declines. Invasive carp spawning also appears to occur in some years in smaller tributary rivers. These systems may provide sources of recruits to basin-wide invasive carp populations and may offer insight for the suitability of Great Lakes basin tributaries were invasive carp to become established there. Combining annual assessments of invasive carp reproductive output with stock density also provides data needed to evaluate the impact of invasive carp removal efforts on the reproductive potential of these populations.

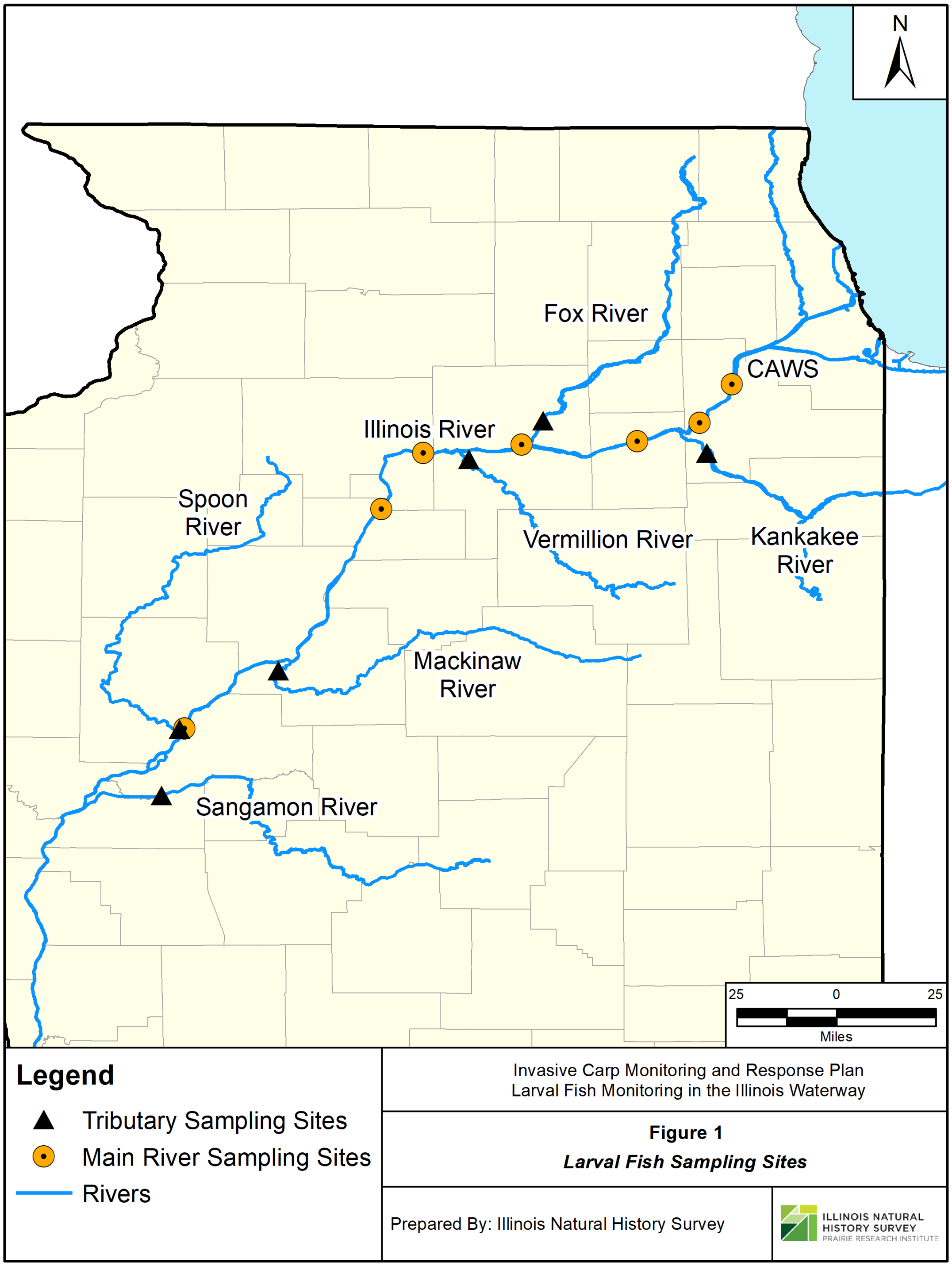

Figure 1. *Map of ichthyoplankton sampling sites in the IWW (circles) and in tributary rivers (triangles).*

Larval Fish Monitoring in the Illinois Waterway 2022 Plan

Objectives:

(1) Monitor for potential changes in the reproductive front of invasive carp populations.
(2) Monitor for Black Carp reproduction in the IWW.
(3) Quantify relationships between invasive carp adult abundance, reproductive output, and recruitment.

Status:

Ichthyoplankton monitoring has occurred in the IWW from 2010 to 2021. In the initial years of this study, invasive carp eggs and larvae were only collected from the LaGrange and Peoria pools of the Illinois River, but not from any upstream navigation pools. However, invasive carp eggs and larvae collected from the Starved Rock and Marseilles pools in recent years have indicated that invasive carps are indeed spawning in the upper Illinois River. Hydrodynamic modelling of egg drift through the Illinois River (FluEgg model) combined with a reverse-time particle tracking algorithm has indicated that 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 that invasive carp spawning also occurs in smaller tributary rivers 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 (Schaik et al. 2020).

The densities of invasive carp eggs and larvae that have been collected from the main channel of the IWW have been highly variable among years. 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 no guarantee of high juvenile abundances, likely due to prevailing environmental conditions. Reproductive activity has most 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; Figure 2). 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 were ≤ 0.268 adult carp/2000 m^3.

Quantitative PCR analyses showed potential for more rapidly identifying the presence of invasive carp early life stages in different areas of the IWW than is possible with traditional processing methods. The number of invasive carp DNA copies present in a sample was found to be a significant predictor of the probability that a sample contained invasive carp eggs or larvae." Continued assessment of this procedure is necessary to identify and control potential sources of error and ensure that this tool is able to provide useful information about invasive carp spawning activity. Microscopy-based identification of eggs and larvae can take weeks to months to complete, whereas qPCR methods could potentially be able to identify reproductive events within days of sample collection.

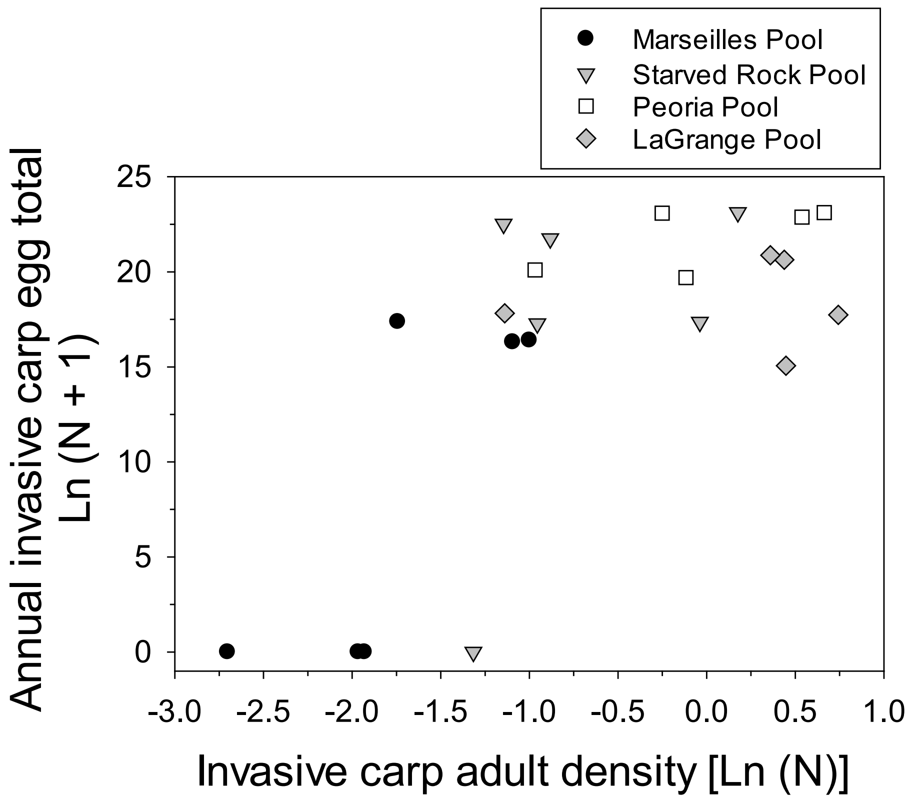

Figure 2. *Observed index of total annual invasive carp egg drift measured at sites within each navigation pool (coded by symbol) and associated adult invasive carp density. Index of total egg drift was estimated by summing observed egg densities standardized by site-specific discharge and scaled up over 24-hr intervals. Adult invasive carp density was estimated with autumn (late September – early November) hydroacoustic surveys.*

Larval Fish Monitoring in the Illinois Waterway 2022 Plan

Methods:

Ichthyoplankton sampling will occur weekly during late April through early July, and biweekly from mid-July to October. At all IWW sampling sites, samples will be collected using a 0.5 m-diameter ichthyoplankton push net with 500 µm mesh. To obtain each sample, the net will be pushed upstream using an aluminum frame mounted to the front of the boat. Boat speed will be adjusted to obtain 1.0 – 1.5 m/s water velocity through the net. 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% ethanol. 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, at both upstream and downstream locations within each study site.

At tributary sites (Sangamon, Spoon, Mackinaw, Vermilion, Fox, and Kankakee rivers), 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 that any fish eggs or larvae collected are derived from the tributary itself rather than originating in the Illinois River. Tributary sampling will be conducted in a similar manner to main channel sampling (i.e., boat-mounted push nets).

IWW ichthyoplankton samples collected from May to early 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, DNA assays for the four taxa of invasive carps will be run in multiplex reactions, following quantitative PCR (qPCR) methodology. Samples will be run in triplicate with a dilution series and no-template controls. The lowest concentration of DNA distinguishable from the control and at which coefficient of variation of estimated copy number is 20% or less will be quantified. Samples with species-specific DNA copy numbers above a given threshold (Fritts et al. 2019) will be considered to have a high probability of containing eggs or larvae of that species of invasive carp and will be prioritized for immediate processing. The relationship between DNA copy number and the number of invasive carp eggs and larvae in a sample will also be further assessed following microscopic identification of all specimens.

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 densities will be calculated as the number of individuals per cubic meter of water sampled. Spatial and temporal patterns in the densities of various larval fish taxa will be described, and locations where invasive carp larvae are captured will be reported. Invasive carp stock density will be obtained from hydroacoustic surveys conducted by collaborators at Southern

Illinois University – Carbondale. Data on juvenile 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. Developmental stages of invasive carp eggs and larvae will be determined in order 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.

2022 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 periods of rising water levels or shortly after peak flows).
- qPCR screening of samples collected from May to early July for rapid species-level identification of potential spawning events.

Deliverables:

Results of 2022 sampling activities 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 updated for annual revisions of the MRP.

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SIU CARBONDALE

Invasive Carp Stock Assessment in the Illinois River/Management Alternatives 2022 Plan

Participating Agencies: SIU – Carbondale (lead), additional assistance/collaboration with USACE, USGS, ILDNR, 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

Introduction and Need:

Management goals for bigheaded carp (Silver Carp and Bighead 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 among years (Coulter et al. 2016), necessitating the need for continued assessments of bigheaded carp densities throughout the river. This will identify whether 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 young-of-year 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 of 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; 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 modeling, telemetry, and hydroacoustic work groups have identified several additional data needs in addition to maintenance of current monitoring efforts. SIU's contribution to continued model support and development 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:

(1) Quantify bigheaded carp densities every other month in Dresden Island and Marseilles pools in 2022 using mobile hydroacoustic surveys to pinpoint high density areas that can be targeted during contracted removal.
(2) Conduct hydroacoustic surveys at standardized sites in fall 2022 from Alton – Dresden Island pools to assess long-term trends in density and biomass.
(3) 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 working group and those working on the SEICarP population model.

Status:

Continues previous work by SIU that has intensively monitored 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 channel, 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. In order 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 2022 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 in order to add to the existing long-term (10 years as of 2021) 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+ stationary receivers will be maintained and downloaded on two occasions in 2022. Thirty additional stationary receivers will be placed throughout the lower reaches to increase detection ability in these larger pools. Additional acoustic telemetry tags (255 total tags) will be deployed in La Grange (128 tags) and Alton (127 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 carps 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 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).

2022 Schedule:

- Bi-monthly hydroacoustic surveys will be conducted in the Marseilles and Dresden Island pools every other month from March through August 2022.
- Telemetry stationary receivers will be downloaded twice during 2022 (April and November), and acoustic transmitters will be implanted into fish in March – April of 2022.
- Annual hydroacoustic surveys will occur in the Alton, LaGrange, Peoria, Starved Rock, Marseilles, and Dresden Island pools during October of 2022.

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 work 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 2022 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 costs and in preventing movement) of the control measures.

References:

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Des Plaines River and Overflowing Monitoring 2022 Plan

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

Location: Des Plaines River above the confluence with the CSSC

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 bigheaded carp (Bighead Carp [*Hypophthalmichthys nobilis*] and Silver Carp [*Hypophthalmichthys molitrix*]) have been observed in Brandon Road Pool up to the confluence with the Des Plaines River and have free access to enter 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 allow for 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 as well as 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:

(1) Monitor for the presence of invasive carp populations in the Des Plaines River above the confluence with the CSSC.

(2) Monitor for breaches of the barrier and passage of fish during high flow events when water moves laterally from the Des Plaines River into the CSSC.

(3) 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 2021, 15,499 fish have been collected via electrofishing (89.25 hours) and gill netting (155 sets; 22,205.3 m). 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 and gill netting. The project will utilize pulsed- DC electrofishing. One or two netters will attempt to dip all visible fish, with the exception of Common Carp (*Cyprinus carpio*). The number of Common Carp observed to be incapacitated in the electrical field will be recorded. Gill netting will consist of short-term top to bottom sets. Mesh sizes will be 3- to 4-inch bar mesh. Backwater areas will be blocked off with the net and fish will be driven towards the net via pounding or electrofishing. 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 2022 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 shoreline in the backwaters will be sampled with electrofishing gear. Each fixed site will also be sampled with 600 yards of gill net during the spring and fall events. In addition to the fixed backwater sites, main channel habitats will be targeted with electrofishing as time and access allow. With the continuation of the COVID-19 pandemic into 2022, some of these sampling procedures may have to be modified to ensure the safety of staff members.

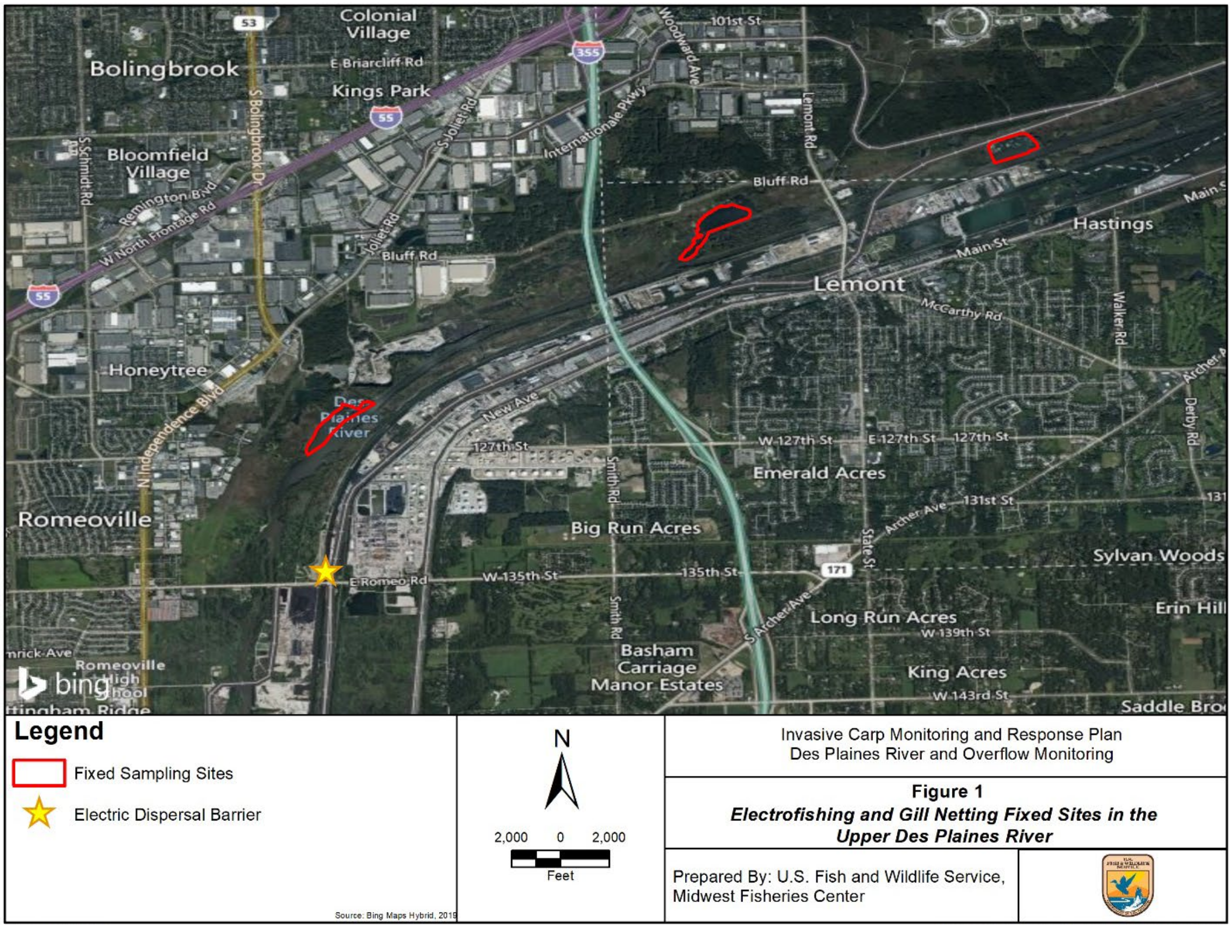

Figure 1. *Fixed sampling site areas of interest are outlined in the above map for electrofishing and gill netting in the upper Des Plaines River*

Alternative Pathway Surveillance – Urban Pond Monitoring 2022 Plan

Participating Agencies: ILDNR (lead), SIU (otolith chemistry analysis)

Location: Chicago area fishing ponds

Introduction and Need:

The ILDNR fields many public reports of observed or captured invasive carp. All reports are taken seriously and investigated through phone/email correspondence with individuals making a report, requesting and viewing pictures of suspect fish, and visiting locations where fish are being held or reported to have been observed. In most instances, reports of invasive carp prove to be native Gizzard Shad or stocked non-natives, such as trout, salmon, or Grass Carp. Reports of Bighead Carp or Silver Carp from valid sources and locations where these species are not known to previously exist elicit a sampling response with boat electrofishing and trammel or gill nets. Typically, no Bighead Carp or Silver Carp are captured during sampling responses. However, this pattern changed in 2011 when 20 Bighead Carp (> 21.8 kg [48 lbs]) were captured by electrofishing and netting in Flatfoot Lake and Schiller Pond, both fishing ponds located in Cook County once supported by the ILDNR Urban Fishing Program.

As a further response to the Bighead Carp in Flatfoot Lake and Schiller Pond, ILDNR reviewed invasive carp captures in all fishing ponds included in the ILDNR 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 km (0.1 to 25.7 mi). The distance from these ponds to the Chicago Area Waterway System (CAWS) upstream of the Electric Dispersal Barrier ranges from 0.02 to 23.3 km (0.01 to 14.5 mi). 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 Electric Dispersal Barrier. 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 of human transfer of invasive carp between waters within close proximity to one another, the CAWs, and Lake Michigan.

In addition to Chicago area ponds once supported by the ILDNR 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 ILDNR 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 km (3 to 19.5 mi). The distance from these ponds to the CAWS upstream of the Electric Dispersal Barrier ranges from 0.05 to 7.6 km (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:

(1) Monitor for the presence of invasive carp in Chicago area fishing ponds supported by the ILDNR Urban Fishing Program.

(2) Obtain life history, age and otolith microchemistry information from captured invasive carp.

Status:

This project began in 2011 and is on-going. A total of 44 Bighead Carp and one Silver Carp have been removed from 10 ponds. Fifty-eight hours of electrofishing and 13 miles of gill/trammel net were utilized to sample 24 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 ILDNR 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 as a result. 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, similar to 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 2019 ISR document (MRWG 2018).

During 2020 our sampling efforts were mitigated due to Covid-19. One call was reported to our agency. A report of a leaping fish within the pond behind the Cancer of Center of America

(42.449339 -87.828856) was made on April 4, 2020 by Ellin Jaffe. A fisher at the park indicated to her that it was 'a carp'. Ellin had seen videos of the invasive carp leaping into boats and was suspicious it wasn't the type of carp.

With the stay-at-home order that was put in place by the Governor of Illinois, the agency did not directly respond to this report with a site visit. The system was assessed remotely to the best of our abilities and reported the findings to Ellin.

The pond was ~ 1 mile from Lake Michigan, but did not directly connect to Lake Michigan, the Des Plaines River, or the DuPage River. A ~65 ft change in elevation existed between Lake Michigan and the pond so direct connection through a flood is highly unlikely. It was felt that there was an extremely low chance of potential transfer into Lake Michigan if the sighting was an invasive carp.

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 out the previous state record rod and reel catch of 69 pounds caught in 2010.

Humboldt Park Lagoon is ~ 4 miles from Lake Michigan, but does not directly connect to Lake Michigan, the Des Plaines River, or the DuPage River. There is a ~ 20-foot change in elevation from the lagoon to Lake Michigan and its tributaries so risk of connection through flooding is low. No additional sightings or captures were reported, and no additional effort was conducted.

The head of the Bighead Carp was kept to determine age, as well as Otolith Microchemistry analysis to determine source, the ILDNR is currently awaiting results on both facets.

Methods:

Sampling Protocol

Trammel and gill nets used are approximately 3 m (10 feet) deep x 91.4 m (300 feet) long in bar mesh sizes ranging from 88.9 – 108 mm (3.5 – 4.25 inches). Multiple nets will be set simultaneously to increase the likelihood of capturing fish. 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 head, vertebrae, and post-cleithra removed and sent to SIU for otolith microchemistry analysis and age estimation.

2022 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. ILDNR also plans to sample all previously sampled urban ponds as part of the monitoring response effort.

Deliverables:

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.

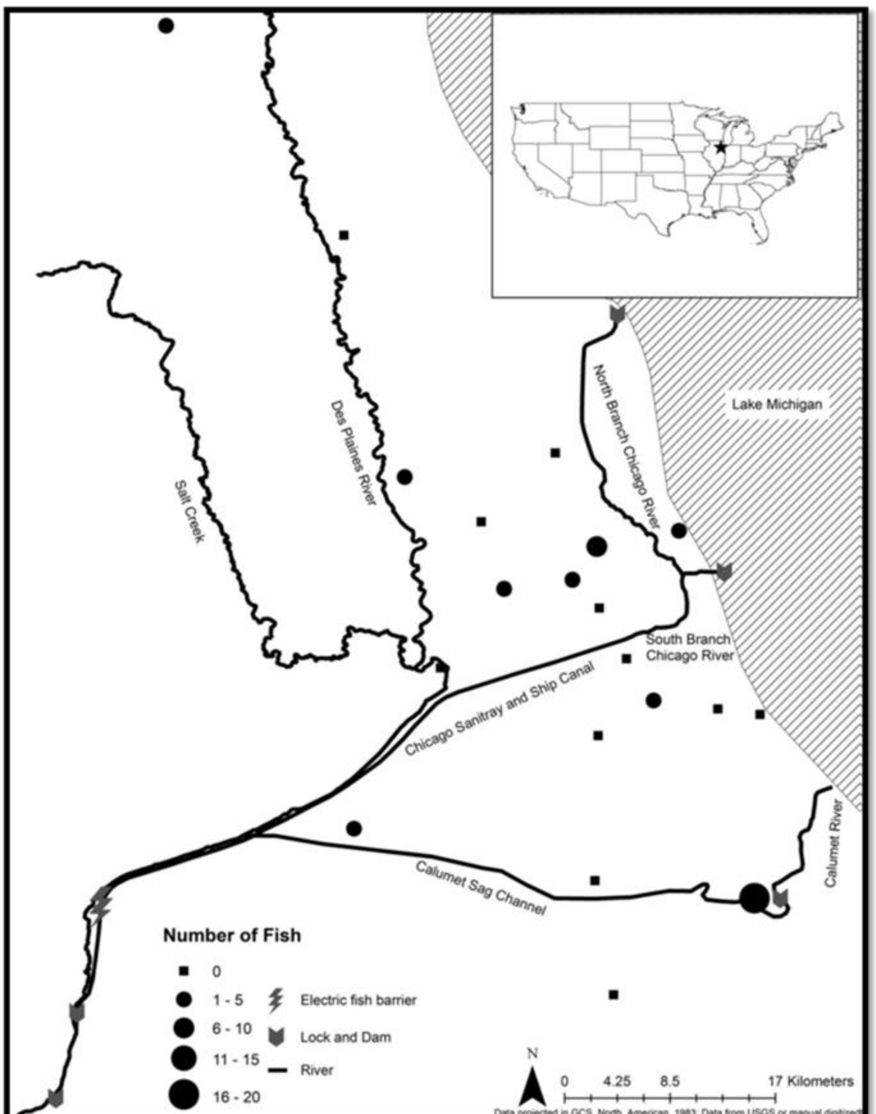

Figure 1. *Chicago area fishing ponds from which invasive carp have been removed and those from which no invasive carp have been collected or reported (yellow).*

Multiple Agency Monitoring of the Illinois River for Decision Making 2022 Plan

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

Location: Data from Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock and Peoria pools of the Illinois River below the EDBS (Figure 1)

Introduction and Need:

Detection and monitoring of invasive carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) below the EDBS is 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 2021 was within the Dresden Island Reach, for Grass Carp the CAWS, and for Black Carp the Peoria Reach (ACMRWG 2021). 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 – Peoria 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 Peoria Reach and incorporate information from projects outside Monitoring and Response Working Group(data from La Grange and Alton pools). 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.

Objectives:

(1) Monitor the geographic distribution and relative abundance of adult and juvenile invasive carp populations in reaches below the EDBS downstream to Peoria Reach.
(2) Provide data capable of detecting spatial and temporal changes in the invasive carp population and native fish community throughout the Illinois River Waterway between the EDBS and Peoria Reach.
(3) Inform other projects (i.e., Contracted invasive carp Removal, Hydroacoustic surveys, invasive carp demographics, Telemetry Monitoring, SEICarP model) with necessary invasive carp and fish community data to make management decisions.

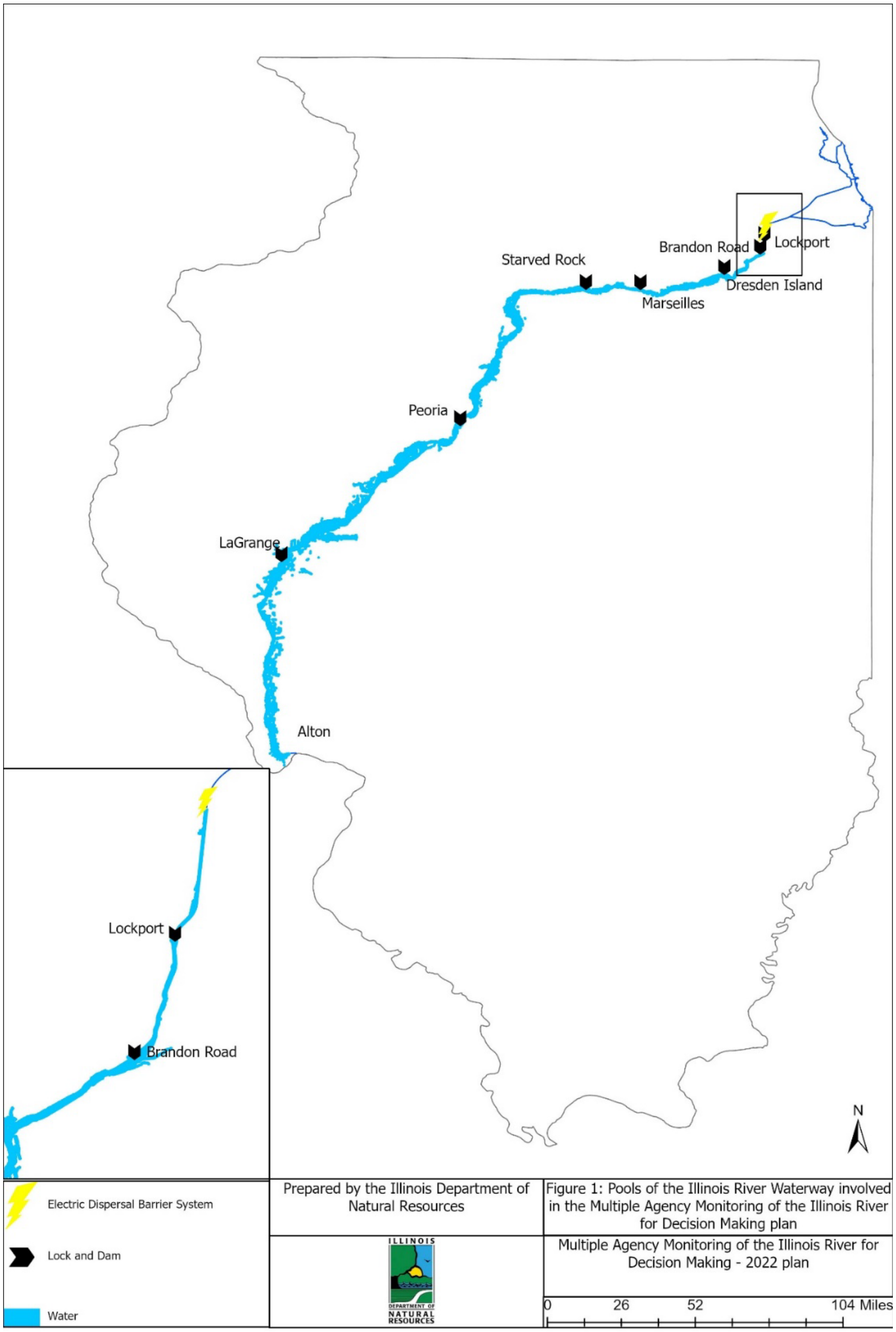

Figure 1. *Map of the sampling reaches of the Illinois River below the EDBS to the confluence of the Upper Mississippi River involved in the Multiple Agency Monitoring of the Illinois River for Decision Making plan.*

Status:

The Multiple Agency Monitoring of the Illinois River for Decision Making will follow a standardized sampling protocol that has been used to monitor the Illinois River Waterway for decades. The USACE's Upper Mississippi River Restoration program (Gutreuter *et al.* 1995, 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, Long-term Electrofishing project (LTEF), has sampled the main channel of the Dresden Island, Marseilles, Starved Rock, Peoria, and Alton reaches since 1959. The LTEF transitioned to modeling the LTRM electrofishing protocol in 2009 (Fritts *et al.* 2017). This standardized protocol will create a comprehensive picture of the spatial and temporal distribution of invasive carp populations within Lockport to Peoria reaches of the Illinois River Waterway and leverage those data collected by other projects in La Grange and Alton to creating a system wide understanding.

Methods:

Sampling will utilize several gear types including boat pulsed DC electrofishing (Table 1), fyke netting (Table 2), minnow fyke netting (Table 3) and paired large and small hoop netting (Table 4) in a stratified random approach targeting all life stages of invasive carp. Sampling will occur at random sites (Figure 2) stratified among the various aquatic strata (main-channel-border, side-channel-border, backwater, impounded, and tailwater zone) within each river reach during spring (June 15 - July 31), summer (August 1 - September 15), and fall (September 16 - October 31). Detailed descriptions of gear specifications and sampling protocol can be found in Ratcliff *et al.* (2014), and Appendix O.

Collected fish will be identified to species, measured, and categorized into 10 mm length bins signified by their lower length boundary. Sampled invasive carp will be measured to total length (nearest mm), their sex assigned, and maturity status determined. In addition to length measurements, weight data from all invasive carp individuals greater than or equal to 100 mm and at least three individuals per 10-mm length group greater than or equal to 100 mm from of all other species will be collected during fall sampling (September 16 – October 31). Aging structures (Lapilli otoliths) will be collected from invasive carp as needed for the Invasive Carp Demographics project. Otoliths will be transferred and processed by the Invasive Carp Demographics project lead, the United States Fish and Wildlife Service Columbia field station.

Specimens not identified to species in the field will be placed in vials, preserved with 10% formalin or 95% 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 (ILDNR 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 (Appendix D). Fixed sites will be sampled every other week during 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, as well as maintain 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, ILDNR Yorkville (LIDNR-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
ILDNR-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
ILDNR-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
ILDNR-Y	3		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-LTRM	0	0	0	0	0	9
IRBS-BSH	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 ILDNR Yorkville (IDNR-Y), INHS Illinois River Biological Station Invasive carp (IRBS-BSH).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria
MCB						
IDNR-Y	8	8	8	8	0	0
IRBS-BSH	0	0	0	0	8	8
Total	**8**	**8**	**8**	**8**	**8**	**8**
SCB						
ILDNR-Y	0	0	6	6	0	0
IRBS-BSH	0	0			6	6
Total	**0**	**0**	**6**	**6**	**6**	**6**
BWC						
ILDNR-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 ILDNR Yorkville (ILDNR-Y), and the INHS Illinois River Biological Station Black Carp (IRBS-BC).*

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

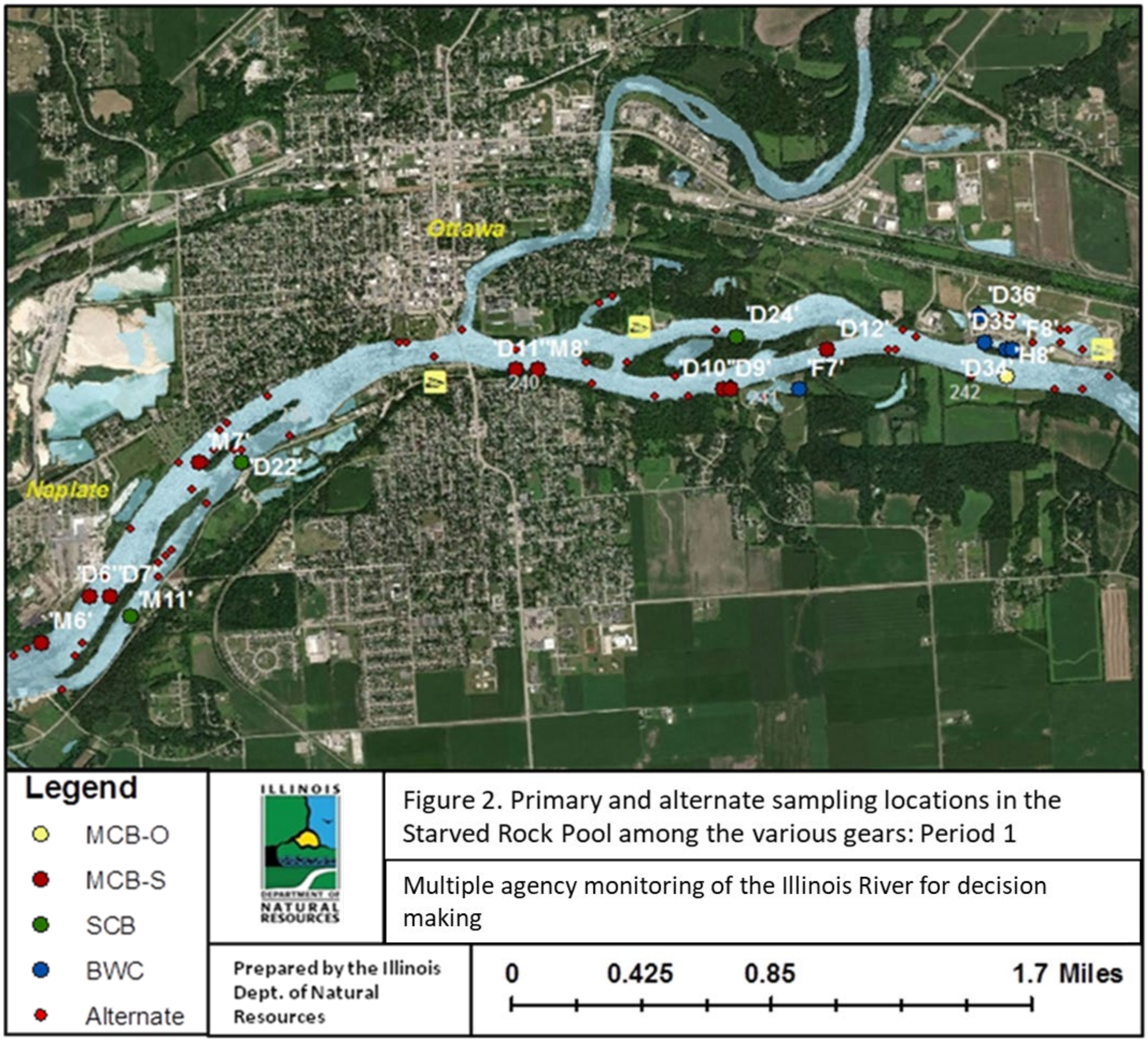

Figure 2. *Minnow fyke net ('M'), Daytime electrofishing ('D'), Paired Hoop Net ('H'), and Fyke net ('F') stratified random sampling locations: main channel border (MCB), side channel border (SCB), and backwater (BWC) habitats with alternate locations in the Starved Rock Reach of the Illinois River for Period 1 from river mile 242 to 237.*

Data management and 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://asiancarp.us/PartnerResources.html. Finalized sampling and fish data collected by each agency will be submitted to the USGS Upper Midwest Environmental Sciences Center by December 31st 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.

2022 Schedule:

- Sampling coordination: January 1 to June 14
- Sampling techniques workshop: Sometime in May
- 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
- Data upload: December 31

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MANAGEMENT AND CONTROL PROJECTS

USGS Invasive Carp Database Management & Integration Support 2022 Plan

Participating Agencies: USGS, Illinois DNR, INHS, USFWS, USACE, SIU-Carbondale, WIU

Location: Illinois River Waterway system

Pools Involved: Chicago Area Waterway System, 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 Illinois Waterway system as part of an adaptive management effort to mitigate, control, and contain invasive carp. In order to 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 Waterway system. These data are often in disparate formats; integrating these data into a common format allows both researchers and managers to assess invasive carp monitoring, control, and removal efforts at several scales. 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 Monitoring and Response Work Group (MRWG) partnership's collective understanding of bigheaded carp life history, distribution, and movement and can be used to facilitate adapative management actions (such as directing monitoring, sampling, and removal efforts, assessing invasive carp abundance to support modeling efforts, informing deployment of control actions, and so on). An effective data management strategy will streamline the database update process, providing partners with timely data and anlyses 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 Waterway system. Integrating and transforming invasive carp-related data sets into actionable information includes the following objectives:

(1) Continued maintenance of the FishTracks Telemetry Database and Illinois River Catch Database (ILRCdb) applications to facilitate objectives 2 and 3 via data standards, compilation, management, and summarization;

(2) Furthering 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 assessment; and

(3) 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 Telemetry Database and Illinois River Catch Database (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 the FishTracks Telemetry Database application and shared with partners to help inform management utilizing real-time receivers.

An application programming interface (API) has been developed for end users (such as modelers) to directly access invasive carp telemetry data stored in the FishTracks Telemetry Database application. 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 Work 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 Waterway 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, GIS software). Integrating these data sets into an online, easy-to-use data hub will allow for more efficient use by the multi-agency partnership.

Methods:

The FishTracks Telemetry Database, a Microsoft SQL Server application, and the ILRCdb application, developed in open-source relational database PostgreSQL, areactively 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). Updates and additions are made to the applications based on partner requests (such as customized monthly, quarterly, or annual reports based on specific monitoring or management needs).

An API has been developed to allow direct programmatic access to the FishTracks Telemetry database application, 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 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 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). 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 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.

2022 Schedule:

- Add new data to FishTracks Telemetry Database – annual basis (post-field season)
- Add new data to Illinois River Catch Database (ILRCdb) – approximately monthly basis (excluding non-field season)
- Finalize demographics-related data template to support population modeling objectives – March 2022
- Develop initial database application for demographics-related invasive carp data from the Upper Mississippi River basin (supported with USGS funding) – June 2022
- Deploy online hub of invasive carp data sets and tools – September 2022

Deliverables:

(1) 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 Illinois River Catch Database applications) with customized data reports, upload functionality for data sharing among partner agencies, and query-able data access for end users through an API.

(2) 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 Work Group).

(3) Online data hub with 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 web mapping tool that integrates existing bathymetric and benthic classification 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 2022 Plan

Participating Agencies: ILDNR (lead), INHS (field support)

Location: Will target the area between the EDBS at Romeoville, IL (~37 miles [60 km] 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:

This 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 towards the barrier, lessening the chances of invasive carp gaining access to upstream waters in the CAWS and Lake Michigan. Monitoring for upstream expansion of invasive carp should help identify changes in the leading edge, distribution, and relative abundance of invasive carp in the IWW. The "leading edge" is 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:

(1) 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.
(2) 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).
(3) Inform other projects (i.e., hydroacoustic verification and calibration, SEICarP model, small fish monitoring, telemetry master plan) with invasive carp population distribution, dynamics, and movement in the IWW downstream of the EDBS.

Contracted Commercial Fishing Below the Electric Dispersal Barrier System 2022 Plan

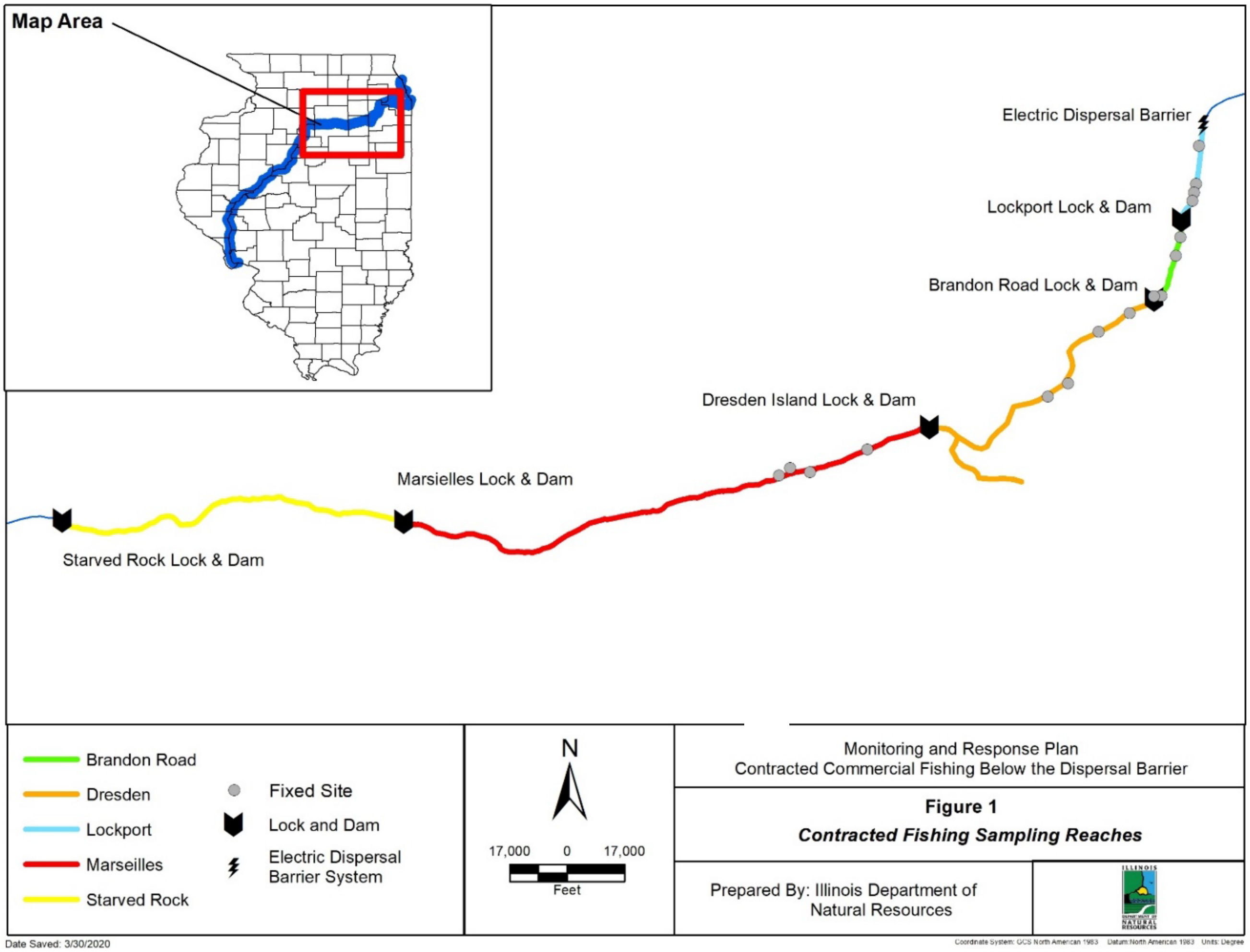

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites below the EDBS.*

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 (2010-2018). The two projects were combined into a single project in 2019 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 km) of gill/trammel net, 19 miles (31 km) 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 lbs.). Contracted commercial fishing effort indicates 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 ISR.

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 of the 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 ILDNR biologists will occur at targeted sites throughout each pool monthly. 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 heterogeneous spatially, areas of special interest to the MRWG (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 - 5.0 inch; 63.5mm-127mm) 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 20-30 minutes with overnight net sets occasionally occurring in off-channel habitat 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 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)
	Illini 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)

Sampling Schedule:

Sampling will occur from March 14th to December in 16th.

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 updated for annual revisions of the MRP.

Barrier Maintenance Fish Suppression
2022 Plan

Participating Agencies: ILDNR (lead), USFWS, USACE, MWRDGC, and USCG

Location: Romeoville, Illinois in vicinity of the EDBS

Pools Involved: Lockport Pool

Introduction and Need:

The USACE operates four Electric Dispersal Barriers (Demonstration Barrier, Barrier 1N, Barrier 2A and Barrier 2B) for aquatic invasive species in the 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. 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 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 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 aforementioned surveillance technologies to clear fish from between the barriers. The work area will be extended about 0.25 miles (0.4 km) in both upstream and downstream directions if a backup rotenone action is necessary to allow for chemical application and detoxification stations.

Objectives:

(1) Remove fish >300 mm (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 into nets from the area with mechanical technologies (surface noise, surface pulsed-DC electrofishing or, if needed, a small-scale rotenone action).

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

(3) Assess the results of fish clearing operations by reviewing the physical captures and surveying the EDBS with remote sensing gear (split-beam hydroacoustics 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 bases 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 is needed, the MRWG leads will meet to determine the necessary actions based on the current risk of invasive carp and safety of personnel.

2022 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 2022 and may require a fish clearing action are:

- January – April 2022: 2A controls replacement and annual maintenance
- January or February 2022: 2A and 2B one-week dive inspection
- February 2022: 1D annual maintenance (one week)

Deliverables:

Updates on planned and unexpected outages will occur via email notification and will be briefed in monthly summaries. 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 2022 Plan

Participating Agencies: USFWS Carterville FWCO, USGS Upper Midwest Environmental Sciences Center (leads); INHS, ILDNR, SIU, USGS Columbia Environmental Research Center, USFWS LaCrosse Fish and Wildlife Conservation Office, USFWS Columbia Fish and Wildlife Conservation Office, Michigan State University (collaborators)

Location: Alton, La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island 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 continue ongoing efforts to develop and implement the SEICarP model and develop novel quantitative tools such as stock assessment models to address emerging management questions.

The SEICarP model is a simulation-based mathematical representation of Silver Carp and Bighead Carp population dynamics. The model is used to inform management actions in the Illinois River in two primary ways. First, the model output is used to provide management recommendations concerning required levels and spatial allocations of mortality and upstream movement deterrence to minimize propagule pressure in the vicinity of the electrical dispersal barriers. Second, critical model assumptions and results from sensitivity analyses are used to provide recommendations concerning data collections and research in the Illinois River and guide ongoing model development aimed at extending model capabilities and reducing uncertainty.

Development of the SEICarP model is ongoing. Two limitations of the SEICarP model are tied to the underlying movement model, which describes the probabilities of fish movement between pools. First, the coverage of the current movement model is limited to the Illinois River. Consequently, 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, due to other limitations associated with movement estimates, model-based mortality recommendations are provided on a relatively coarse spatial resolution (i.e., pools above versus below Starved Rock L&D) rather than on an individual pool level. To address these limitations, this project will coordinate with the MRWG Telemetry Work Group to deliver an updated movement model with greater spatial coverage and finer spatial resolution. In addition, the SEICarP model will be recoded as needed to accept the updated movement model.

Development of an invasive carp stock-recruitment relationship represents a third area of ongoing model development. The stock-recruitment relationship is fundamental to the management of invasive carp in the Illinois River, because it determines how recruitment rates will respond to control-induced reductions in adult biomass. Although the SEICarP model was originally intended to include an invasive carp-specific stock-recruit relationship, there is currently no available stock-recruitment model that is compatible with the SEICarP model. In response to this knowledge gap, impacts of the stock-recruit relationship on SEICarP model predictions are currently assessed using sensitivity analysis. FY 2022 activities would address this limitation by leveraging data from the MRWG Hydroacoustics Work Group as well as age-structure data from field collections to develop an invasive carp stock-recruitment relationship. During FY 2022, a final report and manuscript based on results from the current version of the SEICarP model will be prepared.

In addition to ongoing development of the SEICarP model, a fourth area of ongoing model development involves estimating the rate at which individuals in a given pool contribute to Dresden Island Pool. The goal of this per-capita contribution modeling effort is to assist managers by providing a tool that would prioritize harvest locations (i.e., pools) and the placement of deterrents to movement among pools based on the contribution of individuals to the population at the invasion front.

Lastly, this project will include a feasibility study to determine if statistical catch-at-age or -length (SCAA/L) models could be successfully developed using currently available data from Illinois River invasive carp populations. SCAA/L modeling will provide insights into the impact of contracted and/or commercial harvest programs by estimating fishing mortality rates.

Objectives:

(1) Prepare and submit a manuscript for publication in a peer-reviewed journal describing the SEICarP model and the results from sensitivity analyses and population control (i.e., additive mortality, upstream movement deterrence) simulations.
(2) Collaborate with the MRWG Telemetry Work Group in its efforts to update pool-to-pool movement probabilities.
(3) Develop a stock-recruitment relationship using existing age structure and hydroacoustics data.
(4) Coordinate with MRWG co-chairs and work group leads to apply per-capita contribution modeling to invasive carp management.
(5) Complete SCAA/L model feasibility study to determine if currently available Illinois River data will support SCAA/L models or what additional data are required to support these models.

Status:

This is a continuing project from 2021. Accomplishments and ongoing tasks include the following:

- Updated results were presented at the annual MRWG meeting during January 2022 and 2020 ISR submission.
- SEICarP model manuscript being reviewed by coauthors.
- Updated demographics based on most recent data (over 40,000 individual fish); manuscript published (Erickson et al. 2021).
- Coordinated with MRWG sub-work groups (i.e., Telemetry, Monitoring) to address identified data needs and knowledge gaps.
- Per-capita contribution model results submitted as a peer-reviewed article and presented at the 2021 MRWG annual meeting.

Methods:

SEICarP model: Details of the SEICarP model have been described in previous MRP's and ISR's (ACRCC 2019). In summary, the SEICarP model is a forecasting simulation model that tracks the sizes and relative numbers of Silver Carp and Bighead Carp (hereafter "invasive carp") in each of the lower six pools of the Illinois River (Figure 1) throughout a 25-year time period using different control scenarios. Control scenarios are user-specified and include the location (i.e., pool) and magnitude of increased mortality (e.g., harvest, piscicide) and the effectiveness (i.e., percent reduction relative to baseline) of potential upstream movement deterrent(s) at Starved Rock, Marseilles, and Dresden Island pools locks and dams. Invasive carp population dynamics are modeled in annual time steps using embedded sub-models that describe survival, growth, pool-to-pool movement, and reproduction. Sub-models were parameterized using empirical results from published literature (i.e., Coulter et al. 2018; Erickson et al. 2021).

Each simulated control scenario is repeated 1,000 times to account for uncertainty in parameter estimates. For each iteration, new sets of growth, condition (i.e., length-weight), size-at-maturity, and pool-to-pool movement coefficients are randomly selected from a set of possible values (i.e., posterior distributions from Coulter et al. 2018; Erickson et al. 2021). The performance of different control scenarios is evaluated based on projected changes in total abundance and biomass through time relative to the no action scenario (i.e., no additional harvest, baseline movement).

Objective 1 of this project is to prepare the manuscript describing the SEICarP model for publication in a peer-reviewed journal using results from sensitivity analyses and population control (i.e., additive mortality, upstream movement deterrence) simulations.

Objectives 2 and 3 of this project will address critical limitations in our understanding of invasive carp population dynamics, including support for updated movement modeling (Objective 2) and development of an invasive carp-specific stock recruitment model (Objective 3). To address limitations associated with the movement model, the MRWG Modeling Work Group will coordinate with the MRWG Telemetry Work Group to incorporate updated movement model with greater spatial coverage and finer spatial resolution into SEICarP. In addition, these groups will collaborate to incorporate density and size or maturity status effects on invasive carp movement probabilities. To parameterize the stock-recruitment model (Ricker 1954) age-length keys (ALK's, Ailloud et al. 2019) will be developed from age-structure data. ALK's will be paired with existing hydroacoustics data to quantify and determine the relationship between, recruitment (fall age-1 abundance) and spawning stock biomass.

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

Lastly, Objective 5 of this project is to complete the feasibility study to determine how successfully

Statistical Catch-at-Age (Syslo et al. 2020) or Statistical Catch-at-Length (Sullivan et al. 1999), collectively referred to as SCAA/L modeling, could be completed given current data availability. During 2021, members of the modeling work group compiled metadata for available data resources and met with stock assessment experts from Michigan State University's Quantitative Fisheries Center to discuss how the available data align with data needs for SCAA/L models. During FY 2022, MSU, with the help of the modeling work group, will develop a report detailing the results of this feasibility study. This report will include:

- Comprehensive data summary describing available data inputs for SCAA/L model analysis.
- Determination of feasibility based on expert opinion and existing data.
- Limitations associated with current data availability.
- Data collection recommendations designed to address limitations of current data availability.

2022 Schedule:

July 2022

- Updated pool-specific growth, length-weight, and size at maturity estimates
    - February – August 2022
- Coordinate with MSU's QFC to develop a report describing the results of the SCAA/L feasibility study
    - January – September 2022
- Application of per-capita contribution modeling scoping to address management questions
    - February – September 2022
- Develop a stock-recruit relationship for the lower three pools of the Illinois River using previously collected age structure and hydroacoustics data (2012 – present).
    - February – September 2022
- SEICarP model manuscript/report preparation and submission

Deliverables:

- Comprehensive report and corresponding manuscript describing the SEICarP model and model findings
    - Stock-recruit relationship for the lower three pools of the Illinois River derived from age-structure and hydroacoustics data (2012 – present)
    - Per-capita contribution modeling manuscript
    - Report describing results of SCAA/L feasibility study
    - Updated pool-specific growth, length-weight, and size-at-maturity estimates

References:

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Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP) 2022 Plan

Participating Agencies: USFWS- Carterville FWCO, Wilmington Substation

Location: Illinois Waterway.

Pools Involved: Starved Rock and Peoria pools

Introduction and Need:

The SEICarP model was developed as a means of assessing 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 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 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 carps and is used to parameterize the transition probability component of the SEICarP model. This research provides an improved understanding of invasive carp movement in the IWW and its effects on population dynamics. 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:

(1) Quantify movement frequency and distance by invasive carp in the IWW.

(2) Refine movement across locks and dams.

(3) Address limitations with regards to the movement aspect of the SEICarP model by tagging additional adult carp to increase accuracy and precision of pool-to-pool estimates of movement in the IWW.

Status:

This project was started in 2018 and will continue in 2022. During 2018, 130 invasive carp were tagged throughout Peoria Pool. The total length of tagged fishes ranged from 391-635 mm. During 2019, 161 Silver Carp were tagged throughout Peoria Pool. The total lengths of tagged fish ranged from 374-776 mm. No invasive carp were tagged in 2020 due to COVID-19 working restrictions. In 2021, 100 invasive carp were tagged throughout the Peoria Pool, with an additional 49 invasive carp being tagged in the Alton Pool by SIU staff. The total lengths of tagged fish ranged from 419-748 mm in Peoria Pool and 509-856 mm in Alton 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 Work Group.

Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP)
2022 Plan

Methods:

In 2022, USFWS staff will tag an additional 150 adult invasive carp with Vemco V-9 or V-13 tags which are on the 69 kHz 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 one hour in an aerated 60 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% isopropyl alcohol between surgeries. All acoustic tags will be tested for functionality with an active receiver (VR100, InnovaSea, Halifax, 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 (mm) and weight (g), 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 (~3.5 cm) and wide enough (~1.5 cm) 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 cm 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 towards 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 betadine 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. Total holding time for fish will generally be less than two 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.

Acoustic receivers (VR2W, 69khz, InnovaSea, Halifax, Canada) will be tethered to trees and set perpendicular to 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 eight receivers will be maintained in 2022.

For more information on the SEICarP model please refer to the Invasive Carp Population Modeling to Support an Adaptive Management Framework.

Telemetry Support for the Spatially Explicit Invasive Carp Population Model (SEICarP) 2022 Plan

2022 Schedule:

January – March 2022:	Gear preparation, planning field work, crew scheduling
March – April 2022:	Fish tagging, gear deployment
April – November 2022:	Data download, gear maintenance and relocations, range testing, active tracking
November – December 2022:	Receiver removal, final data downloads
December 2022 – January 2023:	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 summarized into a MWRG summary report/presentation for the winter of 2022-2023.

Invasive Carp Demographics
2022 Plan

Participating Agencies: USFWS-Columbia FWCO (lead); INHS, ILDNR (collaborators)

Pools Involved: Alton, La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island pools of the Illinois River.

Introduction and Need:

Demographic data are commonly used to test for exploitation effects such as skewed sex ratios and increased growth and condition in fish populations. In addition, demographic data can be used to parameterize population models (e.g., SEICarP) used to inform management and decision-making. This project will collect invasive carp demographic data, including abundance, size, age, sex structure, growth, and size at maturity data. The proposed 2022 work described herein is a continuation of previous efforts and includes field collections, laboratory processing, and data analysis, including analysis of aging structures collected by the MAMP. Project results will supplement relative abundance, length-weight, sex structure, maturity, and size-at-age data (i.e., growth) collected through the MAMP and other projects supported through the Invasive Carp Action Plan.

Objectives:

(1) Quantify size and sex structure, size at maturity, and relative abundance of invasive carp during spring and fall in the lowest six pools of the Illinois River (Alton, LaGrange, Peoria, Starved Rock, Marseilles, Dresden Island).

(2) Use Lapilli otoliths to generate age and growth information for Illinois River invasive carp captures

(3) Collaborate with the MAMP to reduce overlap and increase efficient data collection to update parameter estimates associated with the SEICarP model

Status:

This is a continuing project from 2018-2021. Following are some highlights of this project and relationships to other projects supported through the MRP.

- In spring 2021, a standardized Silver Carp assessment was implemented in the lower three pools of the Illinois River (Alton, LaGrange, and Peoria) to collect demographic data, primarily maturity data. Collections included 1,548 Silver Carp; total effort was 150 5-minute trawls or ~12.5 h of active sampling. These samples included the capture of over 600 immature Silver Carp.
- In fall 2021, a standardized Silver Carp assessment was implemented in the lower six pools of the Illinois River (Alton, LaGrange, Peoria, Starved Rock, Marseilles and Dresden Island) to collect demographic data. Collections included 2,645 Silver Carp; total effort was 304 5-minute trawls or ~25.3 h of active sampling. These efforts included collection of over 1,100 age structures.

- Completed age structure analysis with INHS to determine the viability of using postcleithra (bone in the pectoral girdle of teleost fish) for age and growth analyses of Silver Carp.
- Collected age and growth information from the Illinois River in fall of 2018, 2019, and 2020.
- Completed gear evaluation study to determine sample size needed to assess invasive carp populations.
- Trained with USGS CERC staff to correctly assign maturity status of small-bodied invasive carp.
- Coordinated with the MAMP leads and supported efforts to expand MAMP biolgical data collections using lessons learned from two years of implementing the Invasive Carp Demographics project.
- Coordinated with ILDNR and MRWG co-chairs to develop a general approach for evaluating aging structures.

Methods:

The USFWS Columbia FWCO will collect fisheries-independent data including age, size, sex structure, size at maturity, and relative abundance during spring (May – June) and fall (September – November) in each of the lower six pools of the Illinois River using a random design stratified by habitat type (i.e., backwaters, island side channels, main-channel borders; Figure 1). Habitat classifications are based on aquatic area designations developed by the Habitat Needs Assessment II project (USACE 2017). Prior to each sampling event, collection sites will be randomly selected from a Geographic Information System that includes habitat data and an indexed 50 m^2 grid. Collection sites will be sampled by conducting 5-minute trawls at 4.8 kilometers per hour (calculated by GPS tracking) using electrified dozer trawl (Hammen et al. 2019). Catch rates from 2018 and 2019 will be used to determine pool-specific sample sizes based on criteria from Koch et al. (2014). Maturity status and sex data will be collected during spring sampling in Alton, La Grange, and Peoria pools using macroscopic observations of the gonads. Fish length and weight will be measured for all spring- and fall-caught Bighead Carp and Silver Carp. Subsamples consisting of 10 male and 10 female (Coggins et al. 2013) fall-caught Silver Carp per 50-mm total length (TL) class will be retained for laboratory analysis (i.e., age, sex). All non-Bigheaded Carp captures will be identified to species, counted, and measured to the nearest millimeter.

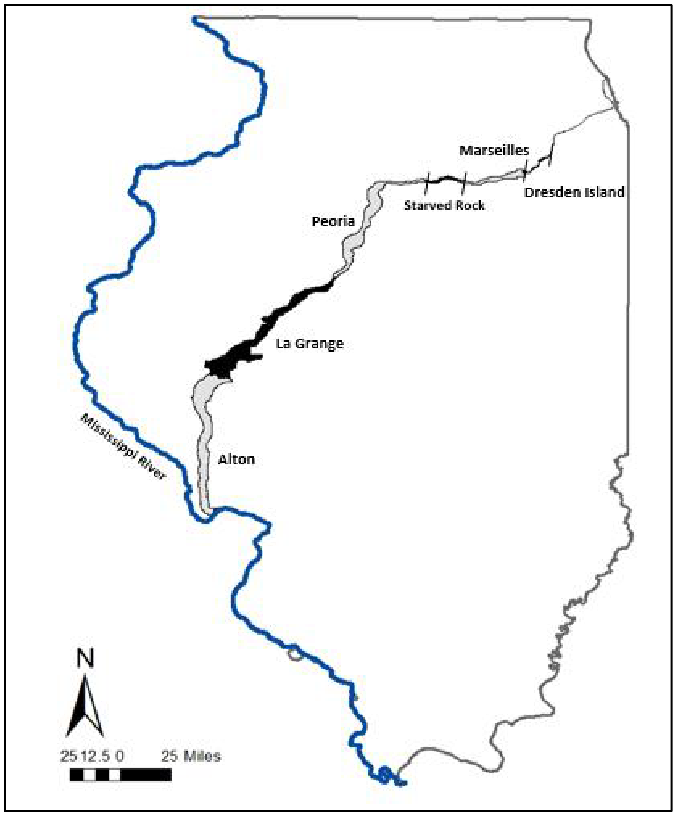

Figure 1. The six lowest pools of the Illinois River, Illinois.

2022 Schedule:

February – April 2022:	Gear preparation, logistics, planning, and scheduling
May – June 2022:	Spring field sampling and data entry
July – August 2022:	Data entry, preliminary data analysis and protocol evaluation
September – November 2022:	Fall field sampling and data entry
	Coordination with existing invasive carp sampling programs
December 2022–January 2023:	Data analysis, laboratory aging, and annual report development

Deliverables:

The invasive carp demographics project will provide underlying demographic data (i.e., age, length, sex structure, and size at maturity) needed to parameterize decision support tools such as the SEICarP model and test for control effects (e.g., spatial or temporal demographic effects associated with control actions). This project will also help develop a standardized invasive carp sampling protocol that is directly transferable to other large river systems such as the Missouri and Mississippi River systems. An annual report and presentation summarizing sampling results will be provided to the MRWG, agency partners, and any other interested parties. Finally, a report or manuscript will be produced, characterizing the age, size, and sex structure of the Illinois River Bigheaded carp.

References:

Coggins Jr, L.G., Gwinn, D.C. and Allen, M.S. 2013. Evaluation of age–length key sample sizes required to estimate fish total mortality and growth. Transactions of the American Fisheries Society, 142:832-840.

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Experimental Field Testing of Longitudinal Bubbler Arrays for Barge Entrainment Mitigation 2022 Plan

Participating Agencies: USFWS-Carterville FWCO Wilmington Substation

Location: Juvenile invasive carp will be captured from Alton, LaGrange, and/or Peoria Pools and transported to the National Great Rivers Research and Education Center (NGRREC; Alton, IL) and Southern Illinois University (SIU; Carbondale, IL) where they will be held in fish raceways until they are used to test a prototype Automatic Barge Clearing (ABC) bubbler arrays at Peoria Lock and Dam in September 2022.

Pools Involved: Alton, LaGrange, and Peoria

Introduction and Need:

This project is a continuation of previous studies that investigated small fish entrainment, retainment, and upstream transport by commercial barge tows. The USFWS and partner agencies USACE and USGS have conducted several years of barge entrainment studies that demonstrate small fish can become entrained and retained in the box-to-rake junction of commercial tows (e.g., Davis et al. 2016). These previous studies illustrate the need for mitigation technologies capable of removing entrained small fish and, therefore, reducing the risk of upstream transport in the IWW.

In 2020-2021, the USACE ERDC facility in Vicksburg, Mississippi utilized a 1:16 scale physical model of Peoria Lock with remote control tow and barges to evaluate the interaction between barges, fluid motions, and nearly neutral buoyant objects under a variety of vessel speeds and barge configurations typical of a navigation lock. The goal of this effort was to evaluate the effectiveness of several potential bubble array configurations at removing small fish entrained in the rake-to-box junction gap of the model barge tow. Preliminary results from these experiments indicated that that longitudinal bubbler arrays were the most effective of the configurations tested, with greater than 80% effectiveness at flushing particles from rake-to-box junction. However, it is unknown how these scaled-laboratory trial results will translate to full-sized barges with live fish.

In 2022, USFWS, USACE, and USGS plan to carry out a full-scale barge study to test the efficacy of a longitudinal bubble array at mitigating retainment and transport of invasive carp by commercial barge tows. Conducting this test requires at least 18,000 juvenile invasive carp between 40- and 60-mm total length (TL). It is not feasible to obtain this quantity of appropriately sized carp via direct field capture at the time of the study because juvenile carp are elusive. Therefore, invasive carp for the experimental trials will be collected in Peoria, LaGrange, and/or Alton Pools as post-larva (<10 mm TL) and “grown out” in the National Great Rivers Research and Education Center’s (NGRREC) and SIU’s fish raceway facilitates to a size of 40-60 mm TL. Once grown-out, the captive-raised carp will be for use ABC bubbler array field testing in August or September 2022. This study will evaluate the efficacy of the longitudinal bubble array at clearing carp from barge junction gaps, which will inform the design of the ABC deterrent at Brandon Road Lock and Dam and, potentially, other locations in the IWW.

Experimental Field Testing of Longitudinal Bubbler Arrays for Barge Entrainment Mitigation 2022 Plan

In a 2021 experimental carp aquaculture pilot study (action item T-9), USFWS raised 1190 invasive carp at NGRREC from <10 mm to 43 mm TL (mean) with a mortality rate of ~90%. Findings from that study have been incorporated into protocols that will be used to capture and rear invasive carp in captivity in 2022. USFWS has contracted additional raceway space at NGRREC and partnered with SIU to scale-up fish production to meet the fish production needs of the barge entrainment mitigation study in 2022.

Objectives:

(1) Capture approximately 100,000 post-larva (<10 mm TL) invasive carp in Alton, LaGrange, and/or Peoria Pools and transport them to NGRREC and SIU with minimal mortality.

(2) Grow greater than 18,000 captive invasive carp until August/September when the fishes are approximately 40-60 mm TL.

(3) Conduct a full-scale barge entrainment mitigation study, at Peoria Lock and Dam, that tests the hypothesis: *The number of small carp recaptured from the barge box-rake junction gap following fish stocking, and transport into a lock, is less for barge tows that pass over a longitudinal bubble array compared to barge tows that do not pass over a bubble array before entering the lock.*

Status:
This project is a continuation of the 2021 action item T-6 during which USACE conducted a 1:16-scale laboratory experiment to evaluate the effectiveness of air bubble arrays at removing entrained fish surrogates from barge junction gaps. USFWS, USACE, and USGS will collaborate on a full-scale barge entrainment mitigation study in 2022, with analysis and reporting expected in 2023.

Methods:

Captive Rearing of Invasive Carp

Small post-larval (<10 mm TL) invasive carp will be captured from Alton, LaGrange, and/or Peoria pools in May and June 2022 using dip nets, beach seines, and mini-fyke nets. Captured invasive carp will be transported in an oxygen-aerated 200-gallon water tank to NGRREC in Alton, IL and SIU in Carbondale, IL. At NGRREC, invasive carp will be acclimated then transferred to mesh live cars that are suspended within the outdoor fish raceways. Live cars minimize fish escapees while allowing water flow. Raceways will be configured as flow-through systems with fresh Mississippi River water. Raceway cleaning and fish husbandry duties will be performed routinely to minimize fish mortality until the fish are used to test the ABC array in September 2022. At SIU, invasive carp will be acclimated then transferred to an indoor recirculated system equipped with 12 round fiberglass (~2000 L) tanks, three trickling biofilters (~1500 L each), propeller-washed bead filter (PW4-1), and a bubble bead filter. The recirculation system will be charged with thiosulfate-treated city water and/or well water and the temperature in that system will be controlled by a heat pump. SIU will follow their standard larval fish rearing procedures with Artemia nauplii feeding for the first few days before transitioning to Otohime feed and then to a more cost-effective feed to avoid any skeletal deformities.

Barge Field Trials

This study is designed to test the efficacy of a prototype longitudinal bubble array at clearing small invasive carp from the rake-to-box junction gap of commercial tows in the Illinois Waterway. Specifically, the study will utilize a control versus treatment, mark-recapture, experimental design to test the following hypothesis:

The number of small invasive carp recaptured from the barge box-rake junction gap following fish stocking, and transport into a lock, is less for barge tows that pass over a longitudinal bubble array compared to barge tows that do not pass over a bubble array before entering the lock

To avoid transporting invasive carp upstream in the IWW, the study will be completed at Peoria Lock and Dam where juvenile invasive carp are already present and abundant. In order to test the hypothesis, USFWS will conduct 30 treatment and 30 control trials then compare total fish recaptures (retainment) between the two trial types. Treatment trials will consist of stocking 300-500 small invasive carp (marked with fin clips) directly into the barge tow junction gap then having the tow traverse 300 m upstream passing over a 61 m long longitudinal bubble array immediately prior to entering Peoria Lock. Control trials will be identical with the exception that the longitudinal bubble array will not be functional (i.e., not bubbling). In both the treatment and control trials, once the tow enters the lock and the chamber doors close, nets will be used to attempt to recapture any retained fishes. In addition to netting, ARIS multibeam sonar videos of the junction gap will be recorded for the duration of each trial in order to provide a second measure of estimated fish retainment. A two-sample t-test will be used to compare data from the control and treatment trials and test the experimental hypothesis.

2022 Schedule:

- January – May 2022: Planning, crew scheduling, and equipment preparation
- May – June 2022: Fish collection sampling in Alton, LaGrange, and Peoria pools followed by transport to NGRREC and SIU
- June – September 2022: Grow invasive carp in captivity September 2022:

  Complete field trials
- October 2022 – December 2023: Analyze data, report, and manuscript preparation

Deliverables:

- Final project report and presentation to the MRWG/ICRCC and barge industry.
- Manuscript for publication in peer-reviewed journal.

References:

Davis, Jeremiah J., P. Ryan Jackson, Frank L. Engel, Jessica Z. LeRoy, Rebecca N. Neeley, Samuel T. Finney, and Elizabeth A. Murphy. 2016. "Entrainment, Retention, and Transport of Freely Swimming Fish in Junction Gaps between Commercial Barges Operating on the Illinois Waterway." *Journal of Great Lakes Research* 42 (4): 837–48. https://doi.org/10.1016/j.jglr.2016.05.005.

Participating Agencies: ILDNR (lead)

Location: Surveillance and enforcement activities will be conducted throughout Illinois; however, some investigations require a multi-agency response which will result in actions occurring in other jurisdictions.

Introduction and Need:

The ILDNR ISU developed in 2012 is a specialized law enforcement component to the ICRCC. Illegal activities within the commercial fishing, aquaculture, transportation, bait, pet, aquarium, live fish market, and sport fishing industries increase the risk of invasive carp or other species getting introduced and established into new areas. ISU dedicates all its time and resources searching for and apprehending individuals or businesses that violate environmental rules and regulations. These concentrated efforts produce substantial results on an annual basis, verifying human activities are a credible risk for invasive species expansion.

It is essential to designate personnel to specialized assignments such as the ISU. This ensures adequate training, experience, and time will be allocated to specific areas of concern. It creates a liaison for non-law enforcement divisions within an agency and outside agencies to contact with invasive species law enforcement related issues. Questions or complaints from the public requiring law enforcement assistance regarding invasive species can be immediately addressed. Additionally, ISU enables a multi-jurisdictional approach to the long-term protection of the Great Lakes Basin by increasing communication and enforcement efforts amongst law enforcement personnel and other stake holders.

Objectives:

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

(1) Update the Invasive Species Enforcement training curriculum and instruct the course to Conservation Police Officers to maximize outcomes across a larger geographical area.

(2) Conduct a minimum of ten inspections on industries linked to the invasive carp trade where the highest likelihood for regulatory violations has been identified.

(3) Organize and implement a minimum of five fish truck transportation inspection details to determine compliance and gather information on current market trends.

(4) Investigate all suspicious activities and complaints.

(5) Coordinate enforcement objectives developed by the Great Lakes Law Enforcement Committee to advance and remedy multi-jurisdictional, invasive species issues.

Status:

This project is on-going and has been extended into 2022. 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.

2022 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 MWRG as they become available. Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRP.

References: Not applicable

Invasive Carp Enhanced Contract Removal Program
2022 Plan

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

Pools Involved: Throughout the Illinois River and IWW. Enhanced removal efforts are currently focused in Peoria Pool.

Introduction and Need:

The ICRCC and this MRP recognize the value of 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 protection of the Great Lakes by preventing fish population growth in upstream reaches.

Objectives:

(1) 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.

(2) Removal under the Enhanced Contract Fishing Program for 2022/2023 has a goal of 3.77 million pounds (cumulative from 2019 of 10+ million pounds.

(3) 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.

(4) 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 in the Peoria Pool. As of January 2022, over 6.7 million pounds have been removed under this program. Removal from the lower Illinois River has been recommended and to that end Peoria Pool has been targeted to begin these efforts. The use of targeted contract fishing in the Illinois River is a key component of the multipronged strategy. Since inception in late 2019, 31 contracts were entered into with Illinois-licensed commercial fishing. While it has been acknowledged that reducing abundance of invasive carp in the three lower IWW pools would be beneficial, initial contracts target Peoria Pool, with expectation that LaGrange and Alton pools will follow as fish landings and data evaluation suggest.

RESPONSE PROJECTS

Upper Illinois Waterway Contingency Response Plan

Participating agencies: ILDNR, USFWS, USACE, USGS, INHS, USEPA, GLFC, MWRDGC

Introduction and Need:

This CRP describes specific actions within the five navigation pools of the Upper IWW - Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools (Figure 1) (River Miles [RM] 231 to 327). In the event a change is detected in the status of invasive carp in those pools, indicating an increase in risk level, this plan will be implemented to carry out response actions. 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 ISRs describing these efforts (including extent of monitoring and invasive carp detection probabilities) 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 particular jurisdictions. For instance, no other state has 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]).

Purpose:

The purpose of this CRP is to outline the process and procedures the MRWG and ICRCC member agencies will follow in response to the change in invasive carp conditions in any given pool of the upper IWW.

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 analysis in both the field and laboratory setting, it is critical that potential changes are immediately forwarded to the MRWG Co-Chairs. 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, as well as rare occurrences of specific life stages within the Upper Illinois River should be reported. It is equally important to recognize and establish a baseline of understanding as to where all life stages of invasive carp and their life stages have been captured, but it is important to prevent that from convoluting what information needs to be communicated to the Co-Chairs. For example, while invasive carp less than 6 inches have been captured in Starved Rock Pool, no invasive carp less than 6 inches have been captured in the pool since2015. Even though those fish were captured previously, it is a rare occurrence and any additional capture of fish less than 6 inches should be reported. In general, it is best to be conservative 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 ILDNR. The MRWG has a robust monitoring plan and it is possible that MRWG partner agencies may come across other invasive species that may pose a threat to aquatic resources in the region. If a novel or uncommon introduced species is captured during the MRWG monitoring activities, please report those findings to IDNR immediately, so they can make a risk-based decision about the need for additional actions outside of the CRP and MRWG MRP.

Background:

Existing plans for responding to the collection of invasive carps or changing barrier operations have been in place since 2011 and provided guidance focused on potential actions that could be undertaken in and around the USACE EDBS and in the CAWS, upstream of the Lockport Lock and Dam (RM 291). The ICRCC relies on the EDBS within the CSSC at Romeoville, Illinois, operated by USACE, as a key tool to prevent the establishment of invasive carp in the Great Lakes Basin. In support of the current EDBS and the goal of preventing establishment, this CRP ensures invasive carp populations in the upper IWW remain low and that arrival at the EDBS is as low as practicable.

Previous response operations have been successfully conducted by the ICRCC in response to detections of potential invasive carp above the EDBS. This includes an interagency monitoring response in 2017 which used physical detection and capture gears in Lake Calumet and the Little Calumet River and a 2010 response in the Little Calumet River where piscicide was applied to over two miles of waterway. In addition, a response was conducted downstream of the EDBS in 2009 to prevent fish passage during a scheduled maintenance outage in which five miles of the CSSC was treated with a piscicide.

This enhanced CRP expands the geographic scope of contingency planning efforts prior to 2017, as well as the scope of potential tools to be utilized in such an event. This plan also considers operations and status of the EDBS, and related fish suppression considerations, which are detailed in Appendix A.

Finally, this CRP provides a communication framework and response procedure that may be utilized for any planned event or those actions in response to knowledge of actions that may elevate the risk of invasive carp passage into Lake Michigan. These events may include scheduled maintenance of the EDBS 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. An operationalized application of the contingency response process for planned EDBS outages is detailed in Appendix A.

Invasive carp distribution has not changed significantly based on location in the upper IWW since individuals were discovered directly in the Dresden Island Pool in 2006. Conversely, abundances of adult invasive carp in the Upper IWW from 2012 to 2019 have declined through time based on hydroacoustic scans. The 2019 MRP ISR highlights a significant amount of monitoring effort 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, 2019). Lack of range expansion and decreased abundances 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, it is generally recognized that fish populations may expand their range and abundance. Examples of introduced fishes 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 as effectively repelled by electric barriers or small invasive carp may become inadvertently entrained in areas between barge tows and propelled through locks. In 2017, biologist 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 mm) 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 has 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 include 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 population dynamics of Black Carp in the Illinois River, increases in captures within the Peoria Pool or occurrences above Starved Rock Lock and Dam may result in a response action by the MRWG.

Location:

The IWW is a series of rivers and canals running from Lake Michigan circa 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: Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock (Figure 1), RM 231 to 327. Each pool is defined as the body of water between two structures; such as a series of lock and dams, as well as 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. The distances (miles) from the upstream structure of a given pool to the EDBS are as follows: Lockport- N/A, Brandon Road- 5.5, Dresden Island-10.5, Marseilles- 26, and Starved Rock-49.5. While LaGrange and Peoria Pools, and Alton Reach of the Lower IWW are not covered by this CRP, the population status and trends are monitored by the MRWG to elevate awareness of potential changes in the upper pools.

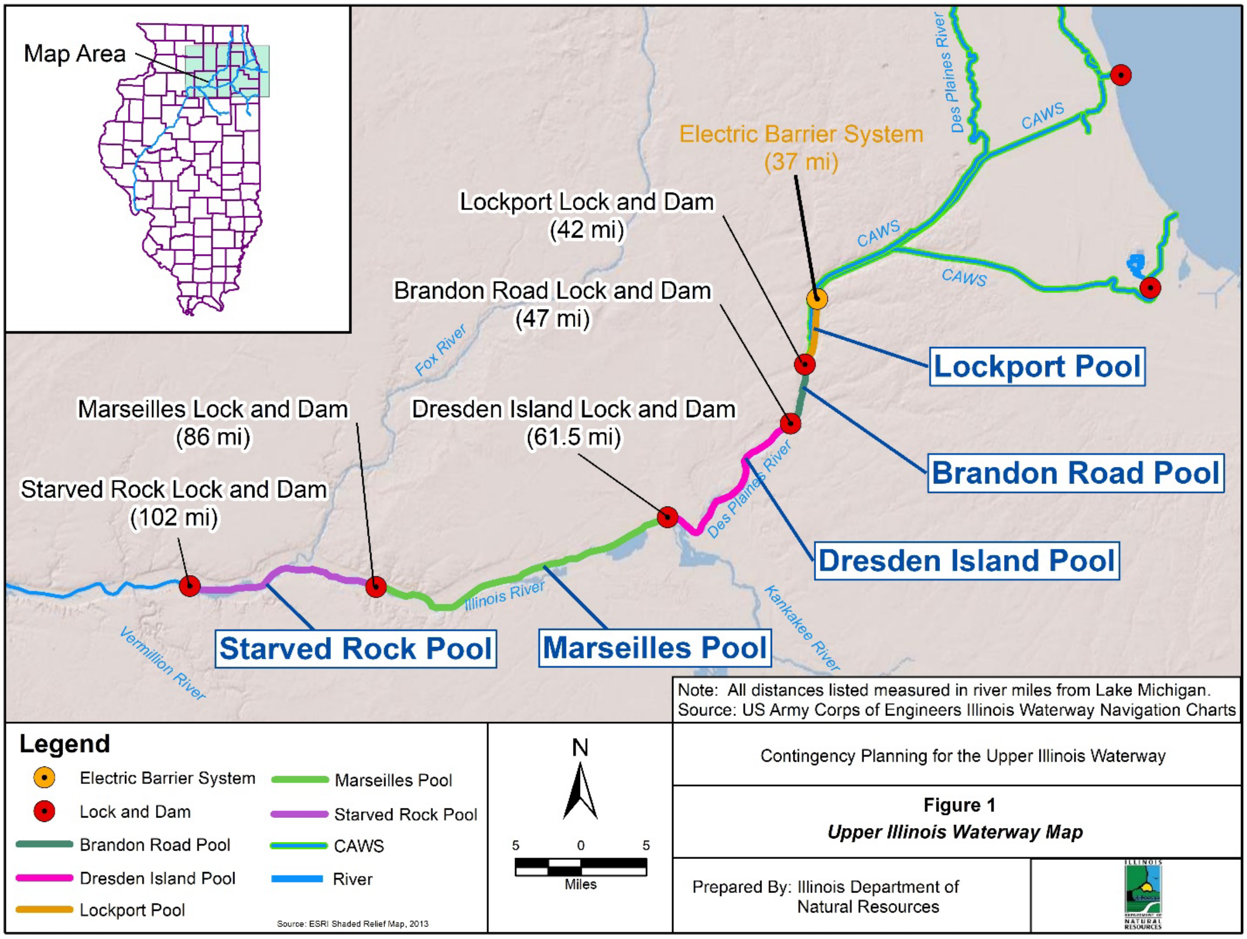


Figure 2. Illinois Waterway Map and Profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.

Mission and Goal:

The MRWG convened a panel of experts on local invasive carp populations, waterways, and navigational structures, and charged the panel to evaluate the invasive carp population status, waterway conditions, forecast invasive carp scenarios, and develop a plan to direct appropriate, prudent, and 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 define 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 fully consider 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 flexibility needed to ensure response actions fully address situation-specific issues. The plan uses consistent terminology as defined by the MRWG panel of experts and is designed to be effective and transparent. This plan ensures open and transparent communication with the public and special stakeholder groups while providing consistent terminology in relation to the invasive carp populations, 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 CO_2 barriers; attractants such as pheromones, audio cues, or feeding stimulants, or other unspecified tools that may be developed at a future time.

Additional Resources Considerations:

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

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 for operational needs or life/safety concerns of water users. Such restrictions fall under the authority of the USCG. As with temporary modification of 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 spring 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 located the IWW. Figure 2 (below) summarizes our current knowledge of the status of Bighead Carp and Silver Carp developed through ongoing monitoring and historical accounts. This graphic was originally established in 2015 as the benchmark year from which to evaluate progress in future years. The MRWG concurred that the establishment of 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, which led to a thorough understanding of the invasive carp population status. Due to increased efforts the MRWG reach a consensus on invasive carp status in 2015. The results of ongoing surveillance and management efforts, including those through December 2020, 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
- **Chicago Area Waterway System (CAWS):** No established invasive carp population
- **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 for the first time in 2015 and have not been observed since. No Black Carp have been captured
- **Marseilles Pool:** Adult Silver and Bighead Carp consistently present, and their 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 present, 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. In 2020, early stage invasive carp larvae were captured in Starved Rock Pool at RM 238.5 and 240.5 for the first time. These larvae were pre-gas bladder inflation (See definitions in Appendix A). No Black Carp have been captured.
- **Peoria Pool (downstream to confluence with 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.

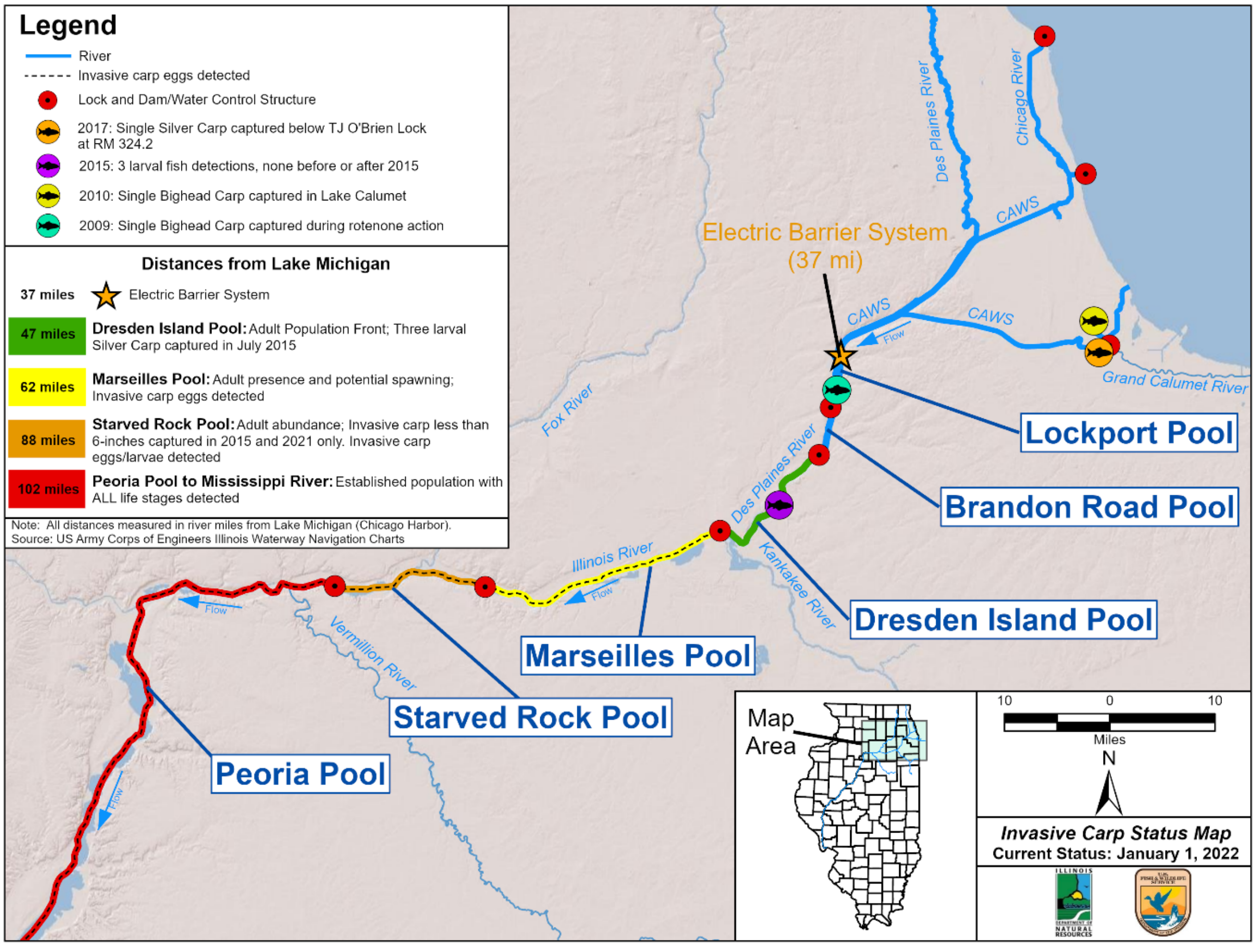


Figure 2. Invasive carp Status Map. Current Status: January 1, 2022.

- [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 3 captured in Dresden Island in 2015) have been captured was at river mile 197 near Henry, IL.*
- [2] *Black Carp over 6 inches have been captured in Peoria Pool.*

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 the waterway conditions, and 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, may also serve to inform potential response actions in the event a Black Carp is captured above Starved Rock Lock and Dam.

Command, Control, and Coordination Assumptions

- All response operations will be conducted under the 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. http://www.cglslgp.org/media/1564/ais-mutual-aid-agreement-3-26-15.pdf
- The need for mobilization of 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, potentially causing the invasive carp populations to change and result in an increased invasion potential of the Great Lakes. The subject matter experts independently evaluated the extent of change each scenario warranted and then the group met jointly to discuss and develop a consistent opinion about the degree of change. Individuals then made independent assessments as to what 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 described in Attachment 1 of Appendix A: Barrier Maintenance Fish Suppression.

Direct Considerations for Response:

The contingency table identifies whether change (moderate or significant) in management or monitoring actions is needed. It then takes into direct consideration: location of invasive carp populations (at the pool scale), life history stages (eggs/larvae, small fish (less than 6”), and large fish), and abundance (rare, common, and abundant) of invasive carp collected.

Pool:

Navigation pool was determined to be the best and most appropriate scale for the location of invasive carp in a population (relation to distance from the EDBS). Since pools are impoundments defined by locks and dams that could at least partially restrict movements of fish, they were chosen as the most appropriate locational references and geographic scales for contingency planning purposes.

Life History:

Fish life history relates to the size of fish (i.e., smaller fish are less susceptible to electricity; 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 invasion risk. Generally, larval invasive carp have not been found in the upper IWW. Finding invasive carp larvae would represent a potential change in the dynamics of the population in the upper IWW. Responses related to the detection of larval invasive carp would likely be directed at other adult or juvenile life stages of invasive carp.

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. That is, 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, Barrier Maintenance Fish Suppression. This process, outlined in Appendix A, uses the same decision-making structure as the Contingency Response Plan in a more routine and operationalized manner.

Additional Considerations for Actions and Decision-Making Process:

This process will include a recommended set of response actions for decision makers to consider when a change to the baseline condition is identified. Changes may include, but are not limited to, changes in fish population abundance, life stage presence, or 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 by 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. The status of populations is continuously monitored by the MRWG and communication of important findings occurs immediately. 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 upon 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 in implementing individual tactics necessary to accomplish each objective. Local command and control involves directing resources to establish 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 as well as provides a visual representation of the basic command, control and coordination relationships for invasive carp response personnel serving during an event.

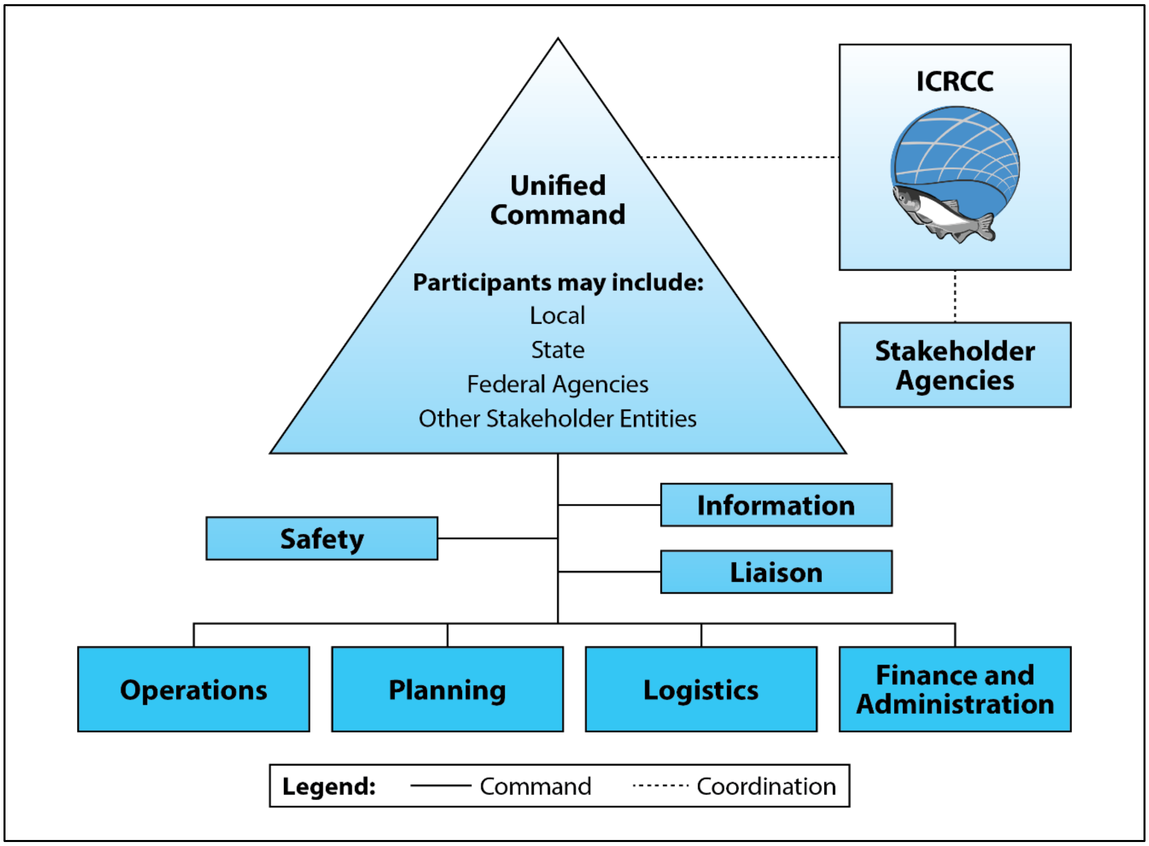


Figure 3. *Unified Command Organization Structure*

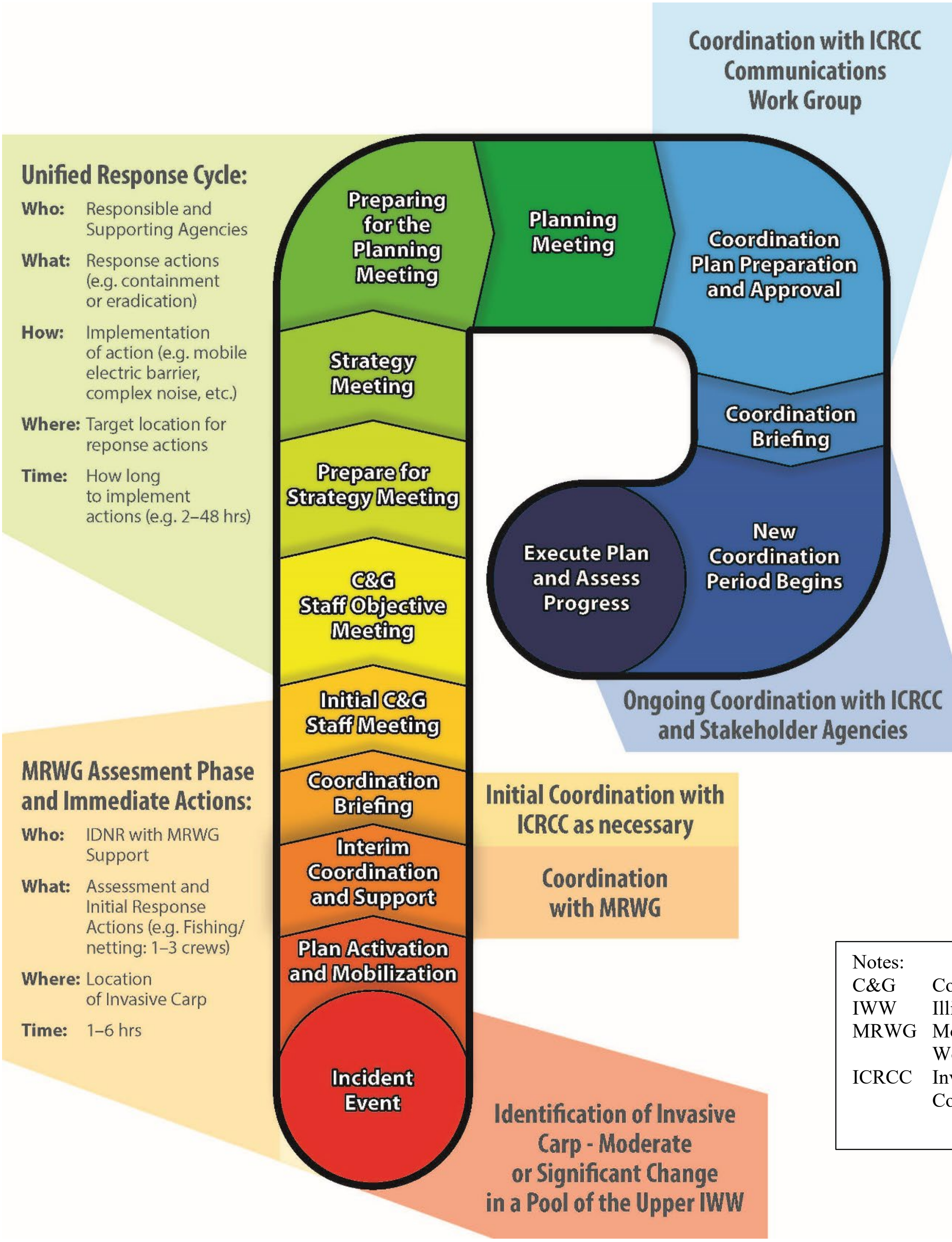
Incident Action Planning:

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) Task-oriented. 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.

> **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 farther than just preparation and distribution of the IAP. This planning includes the routine activities during each operational period of an incident response that provide 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 manage invasive carp under catastrophic 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.



Notes:

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

Figure 4. *ICS Planning "P"*

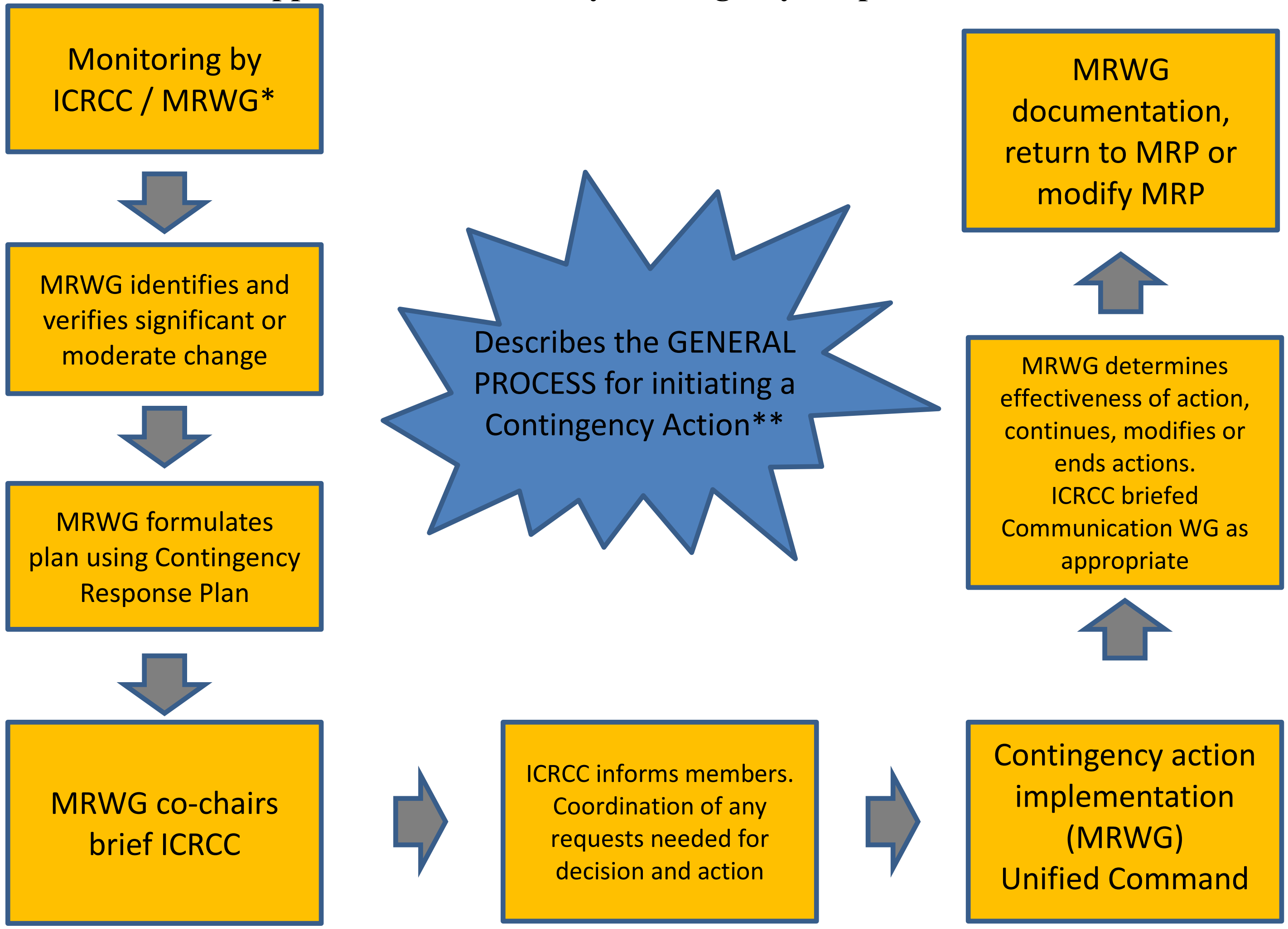
Response Decision Matrix

For the purposes of informing contingency response planning in the upper IWW, MRWG developed a situation-based "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 (see 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.

Figure 5 describes the entire contingency response process for all ICRCC stakeholder agencies. The decision support trees are utilized in steps 3 through 7 to assess the need for further response actions.

Once all determinations have been made, the decision response matrix (Figure 6) 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 upon the options available. A chart of the potential response actions to be considered is provided in Table 1. An example is also provided at the end of the decision support trees for illustrative purposes.

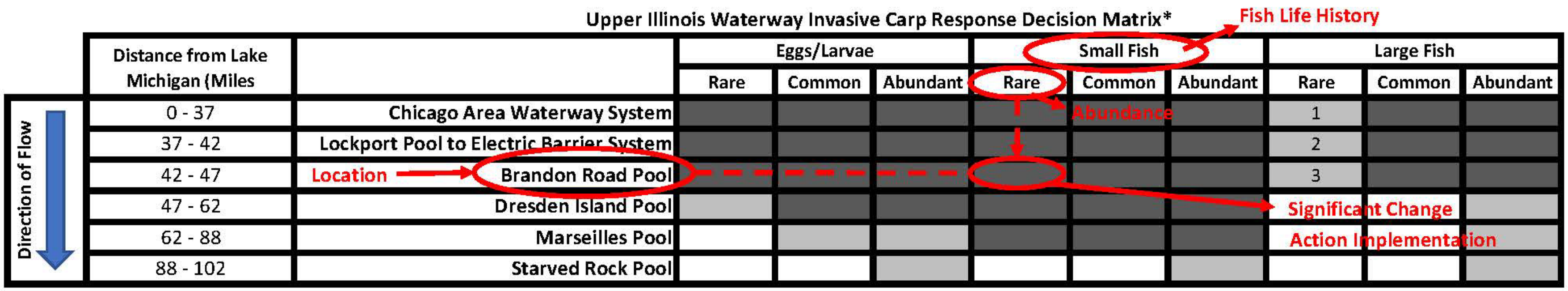
Upper Illinois Waterway Contingency Response Plan



* Monitoring and Response Workgroup (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 is implemented.

Figure 5. *Simplified Process Flow Chart for a Contingency Response*



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.

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

3 This status is based upon sightings of 1 Bighead Carp and 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.

Figure 6. *Upper IWW Invasive Carp Response Decision Matrix for Silver Carp and Bighead Carp*

Table 2. *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 ($-$$$$)
Significant Change	Increased Sampling Efforts[3]	All	IDNR/USFWS	1-7 days	Sampling permits	($$)
	Modify Barrier Operations	LP, BR	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents	All	USGS/USACE	1-7 days	Coordinate with local stakeholders	($$)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS/SIU/USGS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
	Temporary Flow Control	LP, BR	MWRD	1 day	Notice to navigation	($)
	Mobile Electric Array	All	INHS/IDNR	1-7 days	Coordinate with local stakeholders and Coast Guard	($$$)
Moderate Change	Increased Sampling Efforts	All	IDNR	1-7 days	Sampling permits	($$)
	Modify Barrier Operations	All	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents	All	USGSUSACE	1-7 days	Coordinate with stakeholders	($$)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
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 US Coast Guard 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

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

Information and Data Management

The ICRCC Communications Work 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 Work Groups. There are many factors that may drive potential response actions including the nature of the change, severity of the change, time of year and environmental conditions.

Essential Elements of Information

At all points of the incident management process, Essential Elements of Information (EEI) 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 fish, numbers of each 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, space, capability gaps, and projections 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: Barrier Maintenance Fish Suppression

The USACE operates three Electric Dispersal Barriers (Demonstration Barrier, Barrier 2A and Barrier 2B) for aquatic invasive species in the Chicago Shipping and Sanitary Canal (CSSC) at approximate river mile 296.1 near Romeoville, Illinois. These three separate barriers are operated together in what is referred to as the Electric Dispersal Barrier System or EDBS. The Demonstration Barrier (Demo Barrier) is located farthest upstream (800 feet [243.8 m] above Barrier 2B) and is operated at a setting that has been shown to repel adult fish. Barrier 2A is located 220 feet (67.1 miles) downstream of Barrier 2B and both 2A and 2B now operate at parameters that have been shown to repel fish as small as 3.0 inches (76.2 mm) long in the laboratory (Holliman 2011). Barrier 2A and 2B must be shut down for maintenance approximately every 6 months and the Illinois Department of Natural Resource (IDNR) 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, which was before Barrier 2B was constructed. With Barrier 2A and 2B now operational, fish suppression actions will be smaller in scope because one barrier can remain on while the other is taken down for maintenance.

The Demo Barrier, Barrier 2B and Barrier 2A have previously been operated with the Demo Barrier in continuous operation and only Barrier 2B or Barrier 2A in concurrent operation. Beginning in January 2014, the EDBS received approval to operate all three barriers concurrently to increase redundancy in the event of an unplanned shutdown. 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 unacceptable level of risk that invasive carp could gain access to the upper Chicago Area Waterway Systems (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.

A more specific plan of action has been fleshed out in previous Monitoring and Response Plans (MRP) to address outages at the EDBS and was previously included as a specific project titled "Barrier Maintenance Fish Suppression." The Monitoring and Response Work Group (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 Contingency Response Plan (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, a MRWG resource agency review of the current level of risk for invasive carp presence is documented, and a decision on actionable responses occurs and, if warranted, 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 >300 mm in total length are present, then additional surveillance to further inform the risk invasive carp pose at this location or possible mechanical collection or driving techniques will be used to move fish downstream out of the target area. Additional actions may be directed to utilize physical capture techniques (electrofishing, netting, trapping, etc.) and/or remote sensing techniques (hydroacoustics, telemetry downloads or mobile tracking) may also be directed by the MRWG to gain up-to-date data for which 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 those 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 considered by MRWG participating agencies in 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 U.S. Geological Survey (USGS) with assistance from U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center and Chicago District personnel. Up to 5 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-hp boat motor sound, a 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 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 feasible for field applications.

Fish suppression decisions should be made each time there is a planned or unplanned outage at the EDBS which 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 1) and anticipated operational changes between March 2019 to March 2020 (Table 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 1 outlines those scenarios in which an immediate assessment and clearing decision should be made by action agencies. Additional clearing decisions may be requested from the invasive carp Regional Coordinating Committee (ICRCC) stakeholders or MRWG resource agencies as necessary.

Appendix A: Barrier Maintenance Fish Suppression

Table 1. *Potential operational scenarios at the Electric Dispersal Barrier System and recommended responses*

Barrier Operational Status			Clearing Decision Required
Barrier IIA	Barrier IIB	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

*Eventually the Demonstration Barrier will be integrated completely with Barrier I. Barrier 1 will consist of three parts: Demo Barrier, Barrier I North and Barrier I South (Construction set for 2022). However, the demonstration barrier will continue to be activated as an individual barrier until Barrier I is through endurance testing and fully operational. Despite both barriers operating separately in the short term, the table above would be applicable for both barriers whether they are operating separately or as one barrier.

Table 2. *Operational changes anticipated from March 2020 – March 2021*

Barrier Operational Status				Clearing Decision	Activity	Season
Barrier IIA	Barrier IIB	Demonstration	Barrier I North*			
On	Off	On	On*	No	Cooling System Upgrade at IIB	Late Winter/Early Spring 2021
Off	On	On	On	Yes	IIA Controls Replacement	Summer 2021
Off	Off	On	On	No	IIB Controls Replacement, IIA Enclosure, and Electrode Inspection	Winter 2021 to Spring 2022

*Barrier I North will go through endurance testing in late winter of 2021. It is anticipated that Barrier I North will continue to be operational, however the results of endurance testing may result in intermittent outages to troubleshoot issues as they arise.

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, next 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

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**					Abundance		1		
	37 - 42	**Lockport Pool to Electric Barrier System**							2		
	42 - 47	Location **Brandon Road Pool**							3		
	47 - 62	**Dresden Island Pool**							Significant Change		
	62 - 88	**Marseilles Pool**							Action Implementation		
	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.

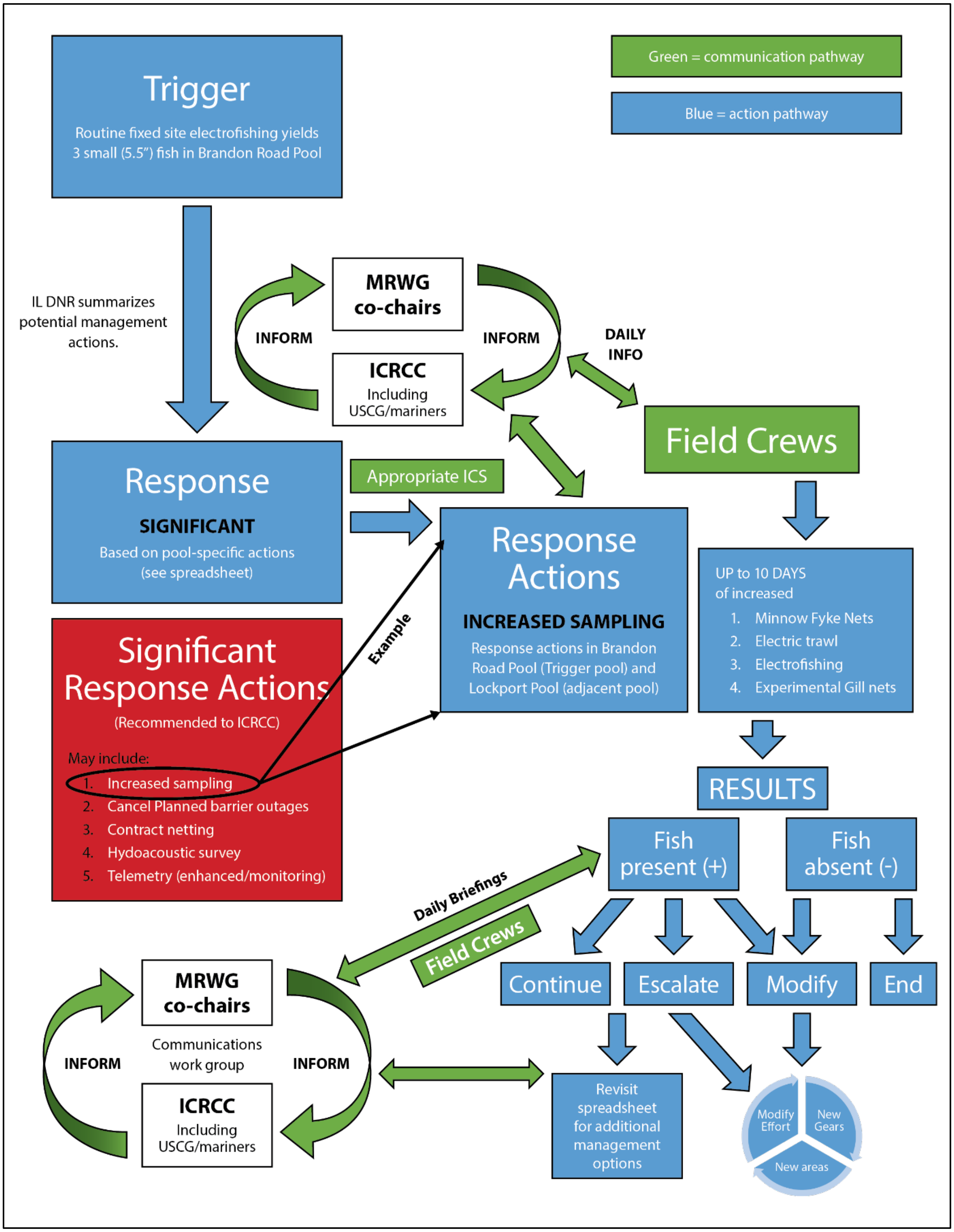
2 This status is based upon the collection of a single Bighead Carp during piscicide treatment in 2009.

3 This status is based upon sightings of 1 Bighead Carp and 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.

Attachment 2: Sample Action Process

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



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 3 larvae captured in Dresden Island, post-gas bladder inflation larvae have been captured as far upstream as RM 197 near Henry, IL.
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.
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.
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, 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; invasive carp collections are not predictable and may take multiple sampling trips to collect just one individual.
Common	Consistent catches across the pool; invasive carp collection is predictable with one or multiple individuals being collected in a given day/week of sampling.
Abundant	Consistent catches across the 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.

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.
Paupier Net Boat	Experimental fish sampling method to sample small and adult invasive carp currently used by MRWG.
Electrified Dozier Trawl	Experimental fish sampling method to sample small and adult invasive carp currently used by MRWG.
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 sample small and adult invasive carp currently used by MRWG.

Potential Response Actions	
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.
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: Authorities

Key authorities linked to response actions are listed below. 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), ILDOA but key ILDNR authorities below

ILDNR (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

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

Appendix A
Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal
2022 Plan

Participating Agencies: INHS (lead), SIU - Carbondale (field and lab support)

Location: Zooplankton and water chemistry sampling will take place throughout the Illinois Waterway from the downstream terminus of the CAWS in the vicinity of the Lockport Lock and Dam (Brandon Road Pool) to the lower Illinois River (LaGrange Pool; Figure 1).

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

Introduction and Need:

Due to their ability to efficiently filter large volumes of water and capture small particle sizes, 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). The trophic impact of bigheaded carp is of great concern because of the importance of zooplankton as grazers as well as prey for native planktivores and early life stages of all fishes (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). An aggressive invasive carp removal program has been implemented in the upper navigation pools of the IWW to limit further advances of bigheaded carp towards Lake Michigan (Tsehaye et al. 2013; MacNamara et al. 2016; Love et al. 2018). One challenge with the removal program has been assessing whether or not 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 fish assemblages in the IWW by mitigating some of the ecological impacts that bigheaded carp have had on this system. However, the extent and pace of ecosystem responses to such removals 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 ideal 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.

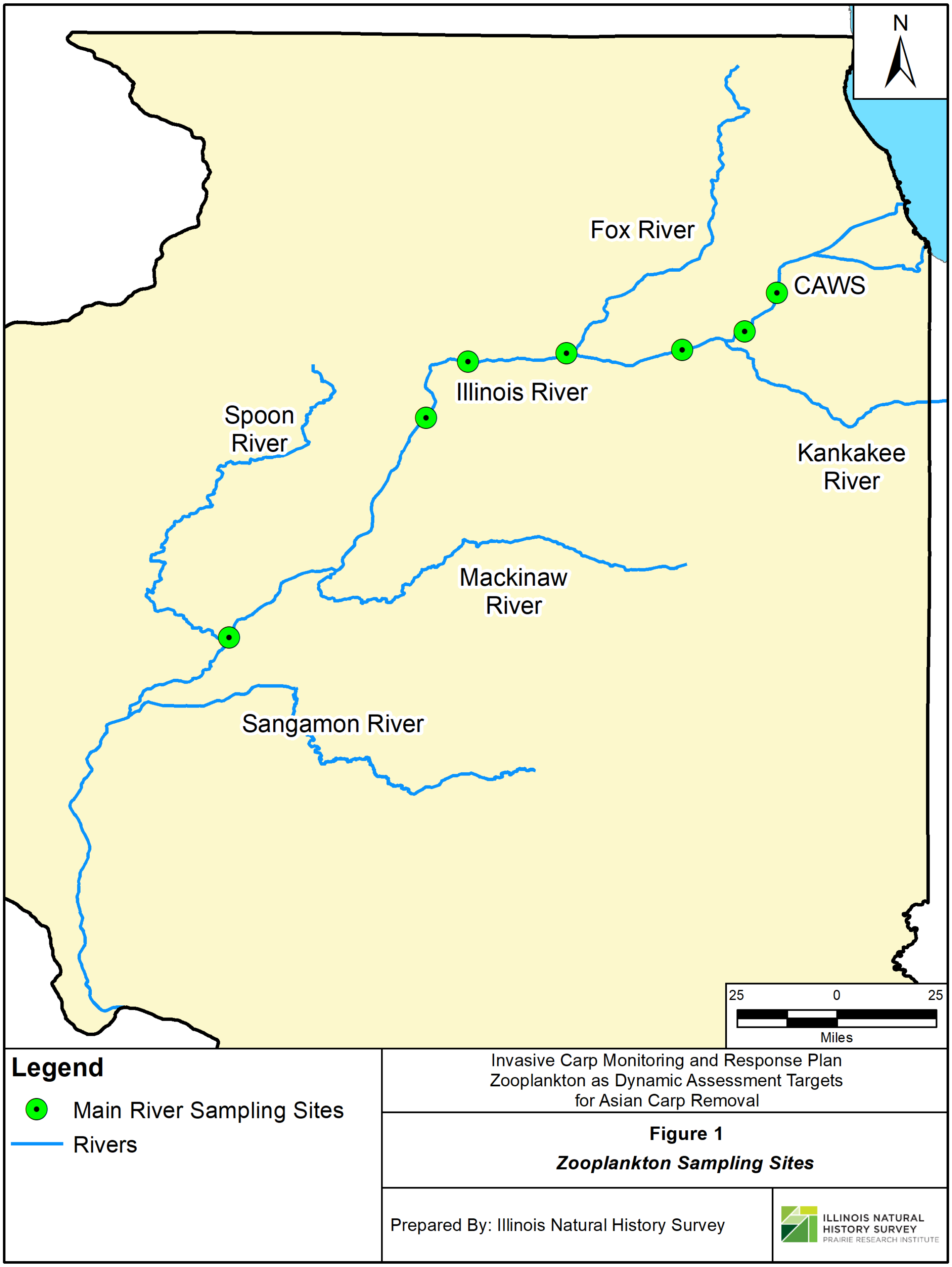


Figure 1. *Map of zooplankton sampling sites in the Illinois Waterway.*

Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal 2022 Plan

Objectives:

(1) Quantify zooplankton density, body size distribution, biomass, and community composition in the Illinois Waterway.

(2) Assess the sensitivity of a range of zooplankton taxa to bigheaded carp density.

(3) 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 during 2011-2021. Comparison of zooplankton data collected during recent years with pre-invasion zooplankton collections indicate 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 a number of zooplankton taxa and identified June *Bosmina* densities as a more sensitive performance metric than other assessed taxa. More recent analyses examined the influence of bigheaded carp density and hydrologic and water chemistry variables on annual peak densities of select Caldoceran, copepod, and rotifer taxa. As with analyses of June densities, peak density of *Bosmina* sp. was found to be the only metric that demonstrated sufficient sensitivity to variation in bigheaded carp density. The most supported model included peak chlorophyll *a* concentration and bigheaded carp density, with peak *Bosmina* densities negatively related to bigheaded carp density. An initial test of the application of peak *Bosmina* density as an assessment metric was conducted by setting the lowest non-zero bigheaded carp density estimate in the time series (0.003 individuals/1000 m^3) as a management target and using observed chlorophyll *a* concentrations as well as observed and target densities of bigheaded carp to compare observed and model-based predictions of *Bosmina* density in four navigation pools in the 2012 – 2019 assessment period. Based on the *Bosmina* peak density performance metric, 2019 was the only year when the target of reduced invasive carp impact was met in the LaGrange and Peoria navigation pools, the Starved Rock Pool showed evidence of diminished bigheaded carp impact during the latter four years of the assessment period, and the Marseilles Pool met management targets of diminished impact to zooplankton during every year of the assessment period (Figure 1). During 2022, continued zooplankton collections will be conducted to assess if expanded invasive carp harvest in the Peoria Pool is able to reduce the ecosystem impacts of bigheaded carp. Further analyses of a broad range of potential performance metrics, including both monthly and peak density and biomass estimates for a number of 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 and metric development, are expected by 2024.

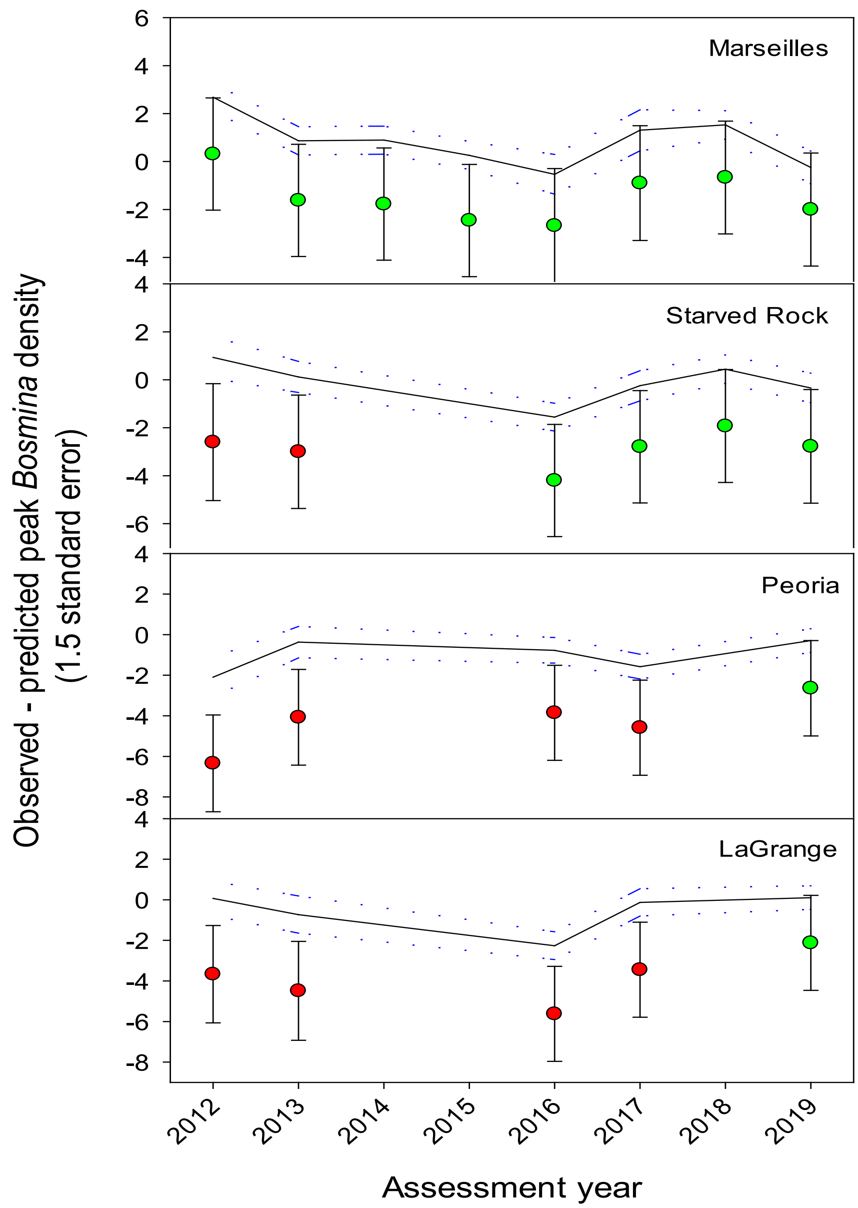


Figure 2. *Assessment plots for navigation pools during the 2012 – 2019 assessment period. Residuals from model predictions based on observed environmental conditions are the control intervals and are plotted as solid black lines with ± 1.5 standard error (dashed blue lines). Performance metric residuals from model predictions using target invasive carp densities are plotted as red and green circles with ± 1.5 standard error. When target variance is outside of control intervals, the assessment point is red and considered to be a year when the management target was not achieved. When target variance overlaps the control interval, the point is green and the management target of diminished ecosystem impact was considered to be achieved.*

ILLINOIS NATURAL HISTORY SURVEY
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Appendix A
Zooplankton as Dynamic Assessment Targets for Invasive Carp Removal
2022 Plan

Methods:

Field sampling for assessment of zooplankton trends will occur biweekly between April and October of 2022 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 L of water will be filtered through a 55 μm mesh to obtain crustacean zooplankton (macrozooplankton), whereas 10 L of water will be filtered through a 20 μm mesh to obtain rotifers. Organisms will be transferred to sample jars and preserved in either Lugol's solution (4%; for macrozooplankton) or buffered formalin (10%; 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. Zooplankton densities 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 SIU – Carbondale.

Targets for ecosystem response to bigheaded carp removals will be developed by 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 time 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 modelled using observed environmental conditions and bigheaded carp densities in each pool to calculate the difference between 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.

2022 Schedule:

- Bi-weekly sampling at all sites from April to October.
- Updated assessment of potential performance metrics and evaluation of ecosystem impacts of harvest efforts in each navigation pool by end of 2022.
- Project completion, including final model parameterizations and metric development, expected in 2024.

Deliverables:

Results of 2022 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 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.

Co-Chairs		**Agency Representatives**	
Kevin Irons	IDNR	Mindy Barnett	IDNR
John Dettmers	GLFC	Nick Barkowski	USACE
		Mike Thomas	USFWS
		Jason Goeckler	USFWS
		Brent Knights	USGS
		Marybeth Brey	USGS
		Jim Lamer	INHS
		Joe Parkos	INHS

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Amy McGovern	USFWS	Nathan Lederman	IDNR	Allison Lenaerts	INHS
Brian Elkington	USFWS	Rebecca Redman	IDNR	Andrea Whitten	INHS
Ben Marcek	USFWS	Andrew Strassman	USGS	Andrew Mathis	INHS
Brett Yonker	USFWS	Aaron Cupp	USGS	Brandon Harris	INHS
Charlie Wainright	USFWS	Brent Knights	USGS	Dan Roth	INHS
Edward Sterling	USFWS	Duane Chapman	USGS	Jason DeBoer	INHS
Emily Pherigo	USFWS	Enrika Hlavacek	USGS	Jehnsen Lebsock	INHS
Eric Brossman	USFWS	Jake Faulkner	USGS	Jesse Williams	INHS
Greg Conover	USFWS	James Wamboldt	USGS	Kris Maxson	INHS
Jahn Kallis	USFWS	Jim Duncker	USGS	Sam Schaick	INHS
Jen Abeln	USFWS	John Vallazza	USGS	Steven Butler	INHS
Jenna Bloomfield	USFWS	Jon Hortness	USGS	John Vondruska	EA
Jason Goeckler	USFWS	Josey Ridgway	USGS	Julia Wozniak	EA
Kristen Towne	USFWS	Kevin Hop	USGS	Mike Kacinski	EA
Kyle Von Ruden	USFWS	Mark Gaikowski	USGS	Phil Hilbert	EA
Michael Glubzinski	USFWS	Patrick Jackson	USGS	Alex Catalano	SIU
Mike Weimer	USFWS	Patrick Kroboth	USGS	Alison Coulter	SIU
Nathan Evans	USFWS	Richie Erickson	USGS	Dave Coulter	SIU
Neal Jackson	USFWS	Rip Shively	USGS	Jim Garvey	SIU
Nick Frohnauer	USFWS	Robin Calfee	USGS	Collen Condon	MWRD
Patrick DeHaan	USFWS	David Michla	USACE	Dustin Gallagher	MWRD
Rebecca Neeley	USFWS	John Belcik	USACE	Tom Minarik	MWRD
Teresa Lewis	USFWS	Mark Cornish	USACE	Cory Suski	UI
Brandon Fehrenbacher	IDNR	Chris Tantillo	USCG		
Charmayne Anderson	IDNR	Lincoln Puffer	USCG		
Christine Waters	IDNR	Sasha Queary	USCG		
Claire Snyder	IDNR	Adam Peterca	Tetra Tech		
Eli Lampo	IDNR	Cheryl Vaccarello	Tetra Tech		
Justin Widloe	IDNR				

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

[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.

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

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>](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.

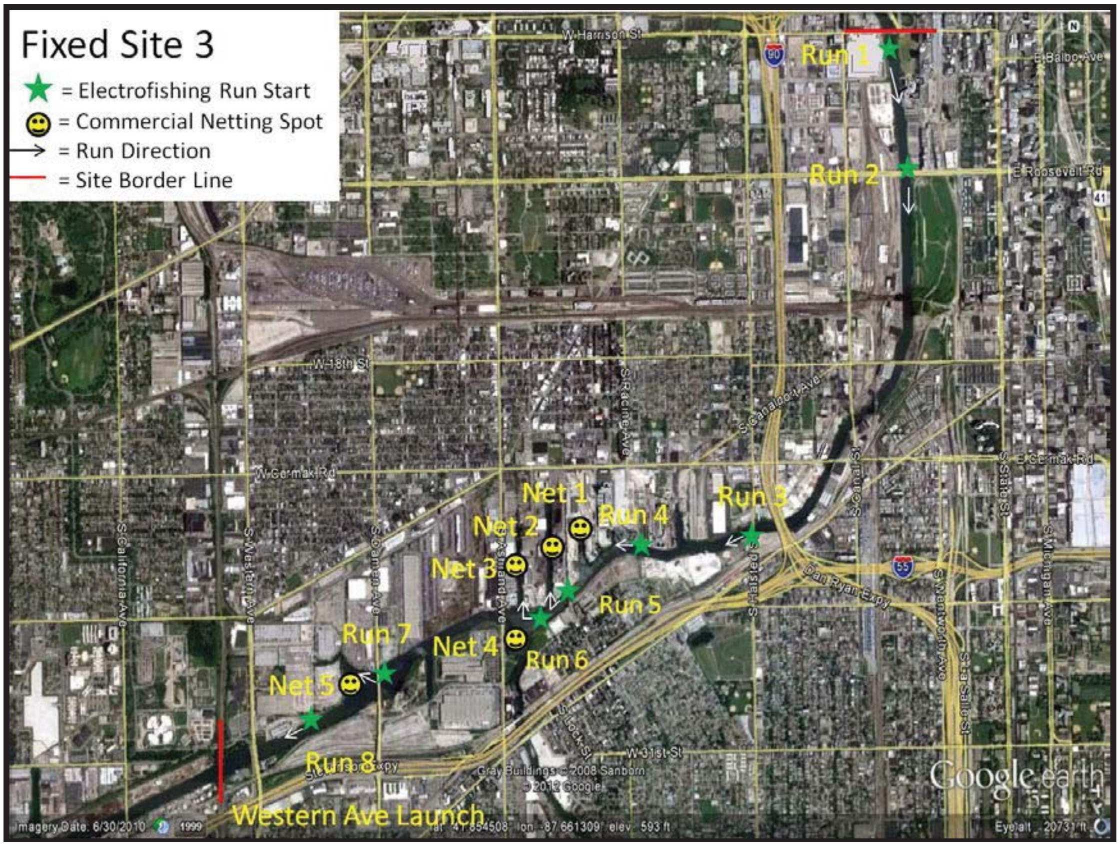
76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

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.


Fixed Site 3
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Run 5
Run 6
Run 7
Run 8
Net 1
Net 2
Net 3
Net 4
Net 5
Western Ave Launch
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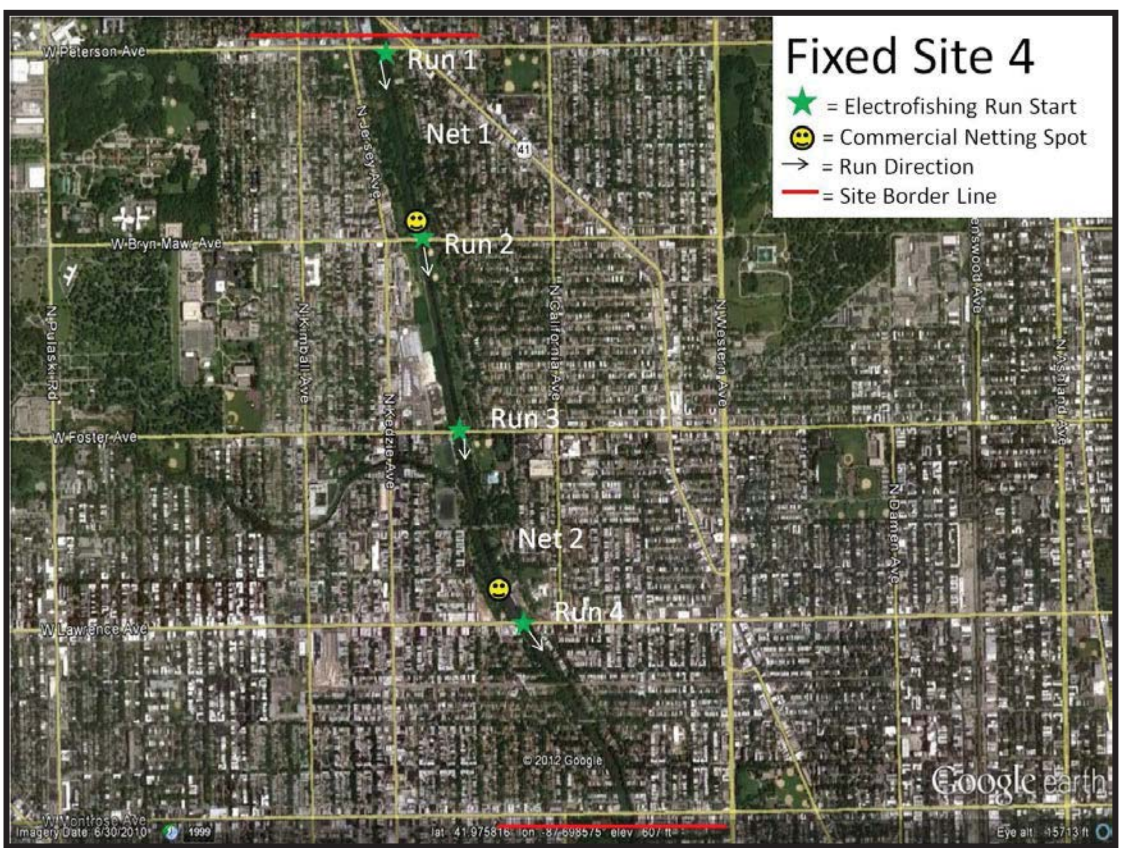
W Roosevelt Rd
W 18th St
W Cermak Rd
S Western Ave
S California Ave
Dan Ryan Expy
Google earth


Fixed Site 4
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
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W Bryn Mawr Ave
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N Damen Ave
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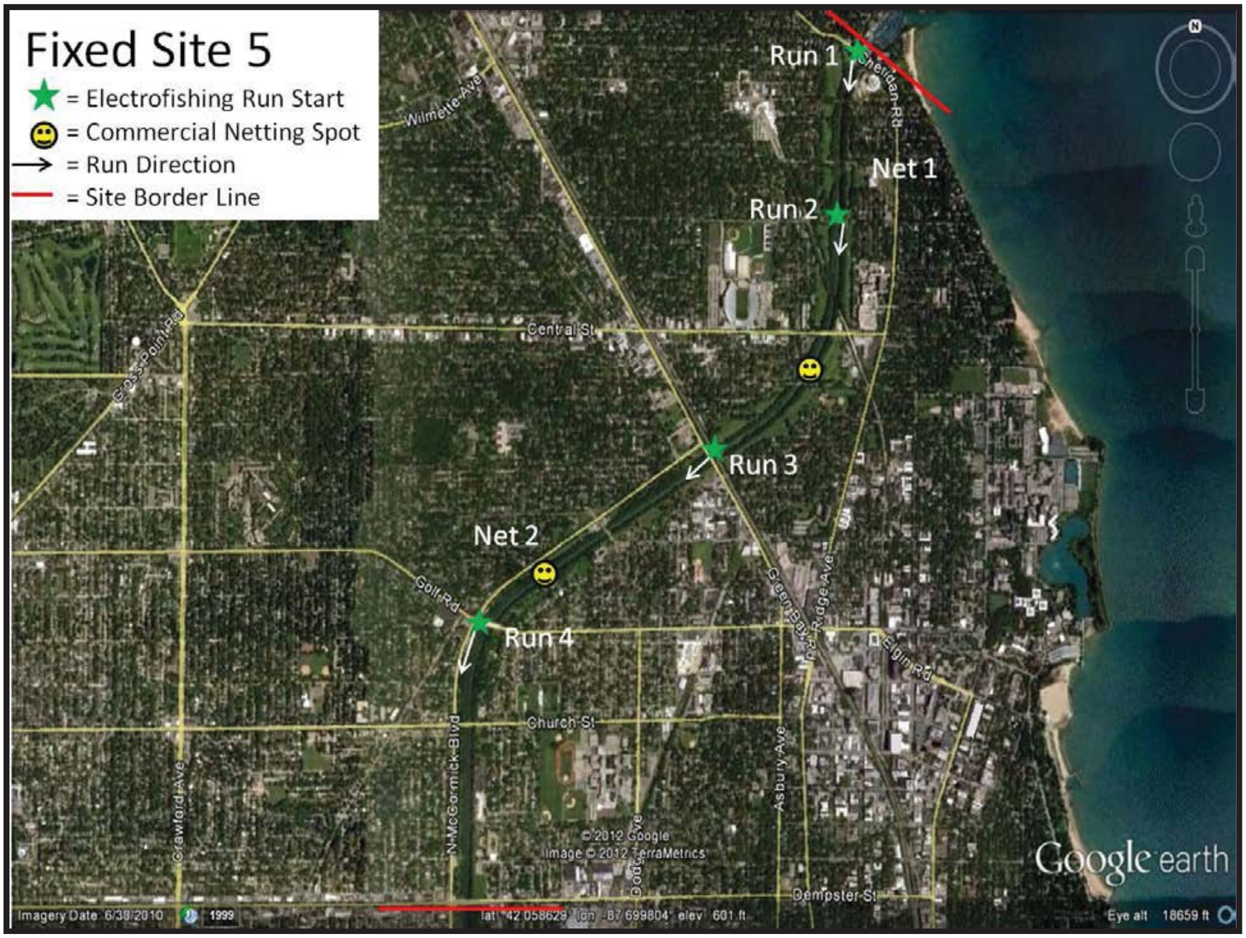
Fixed Site 5
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Net 1
Run 2
Run 3
Net 2
Run 4
Wilmette Ave
Sheridan Rd
Central St
Gross Point Rd
Golf Rd
Church St
N McCormick Blvd
Crawford Ave
Asbury Ave
Dempster St
Elgin Rd
Ridge Ave
© 2012 Google
Image © 2012 TerraMetrics
Imagery Date: 6/30/2010
1999
lat 42.058629 lon -87.699804 elev 601 ft
Eye alt 18659 ft
Google earth


Calumet River - Area 1
= Area Boundary
Random Site Area
Lake Calumet
Wolf Lake
Highway 12
Chicago Skyway
Bishop Ford Fwy
S Halsted St
Calumet Ave
© 2012 Google
Image © 2012 TerraMetrics
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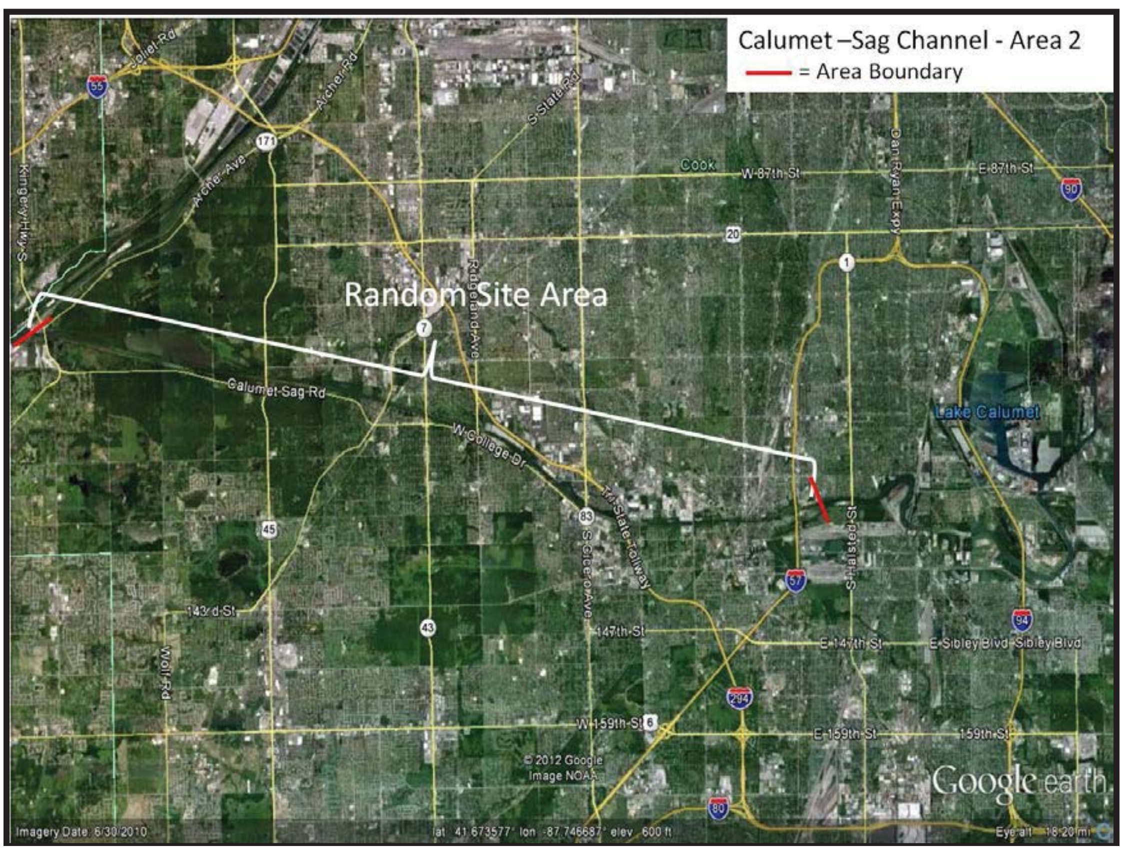
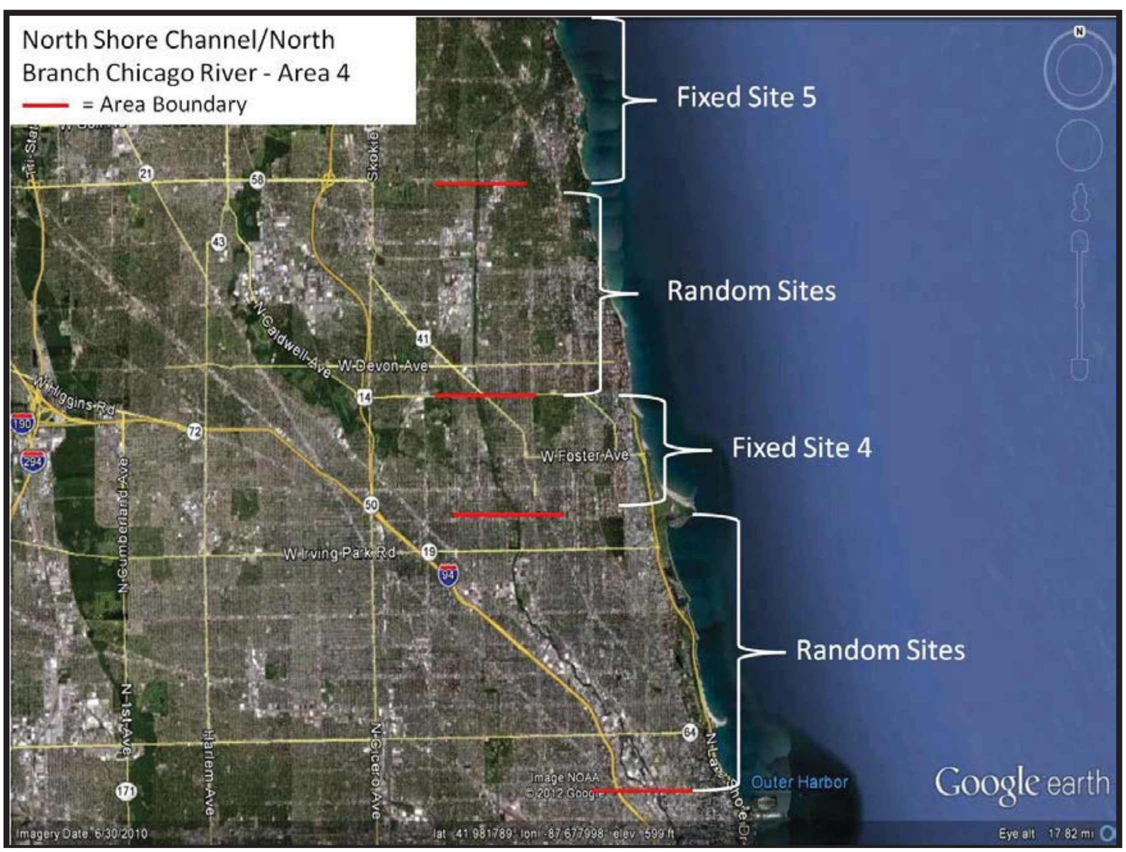
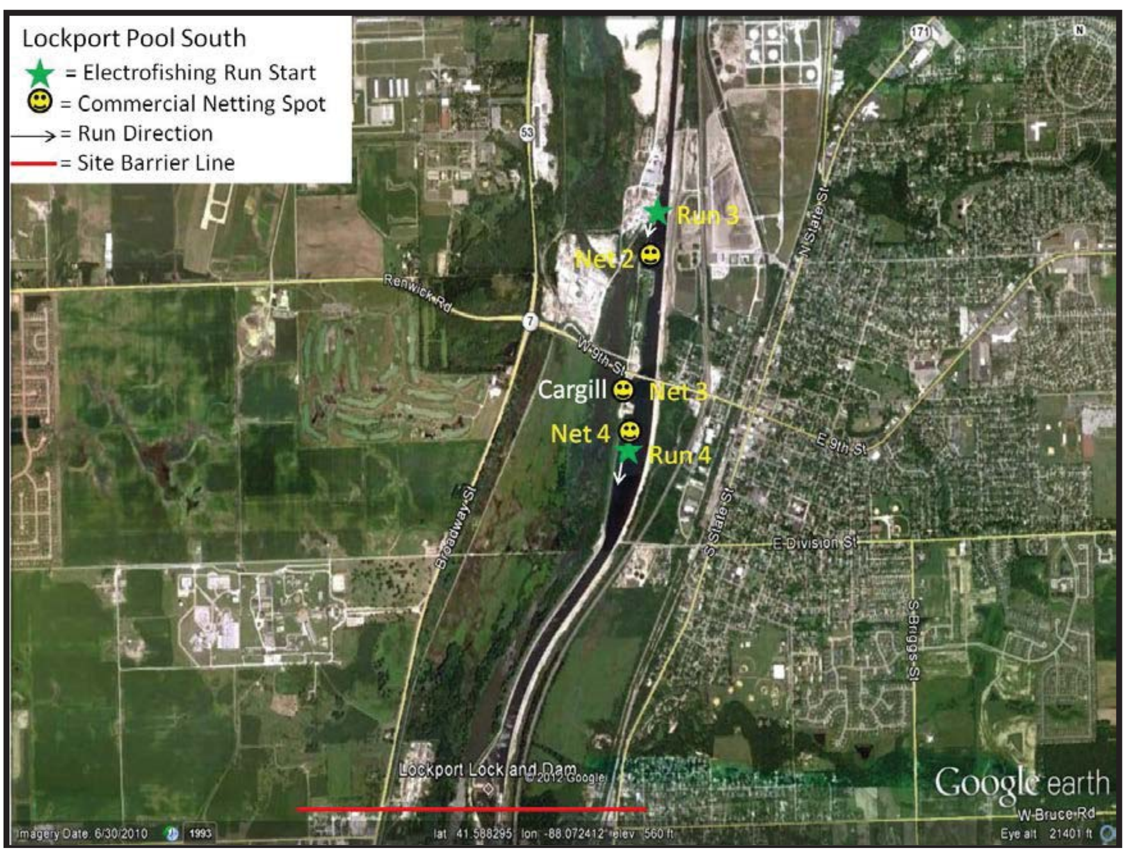
Eye alt 39389 ft
Google earth

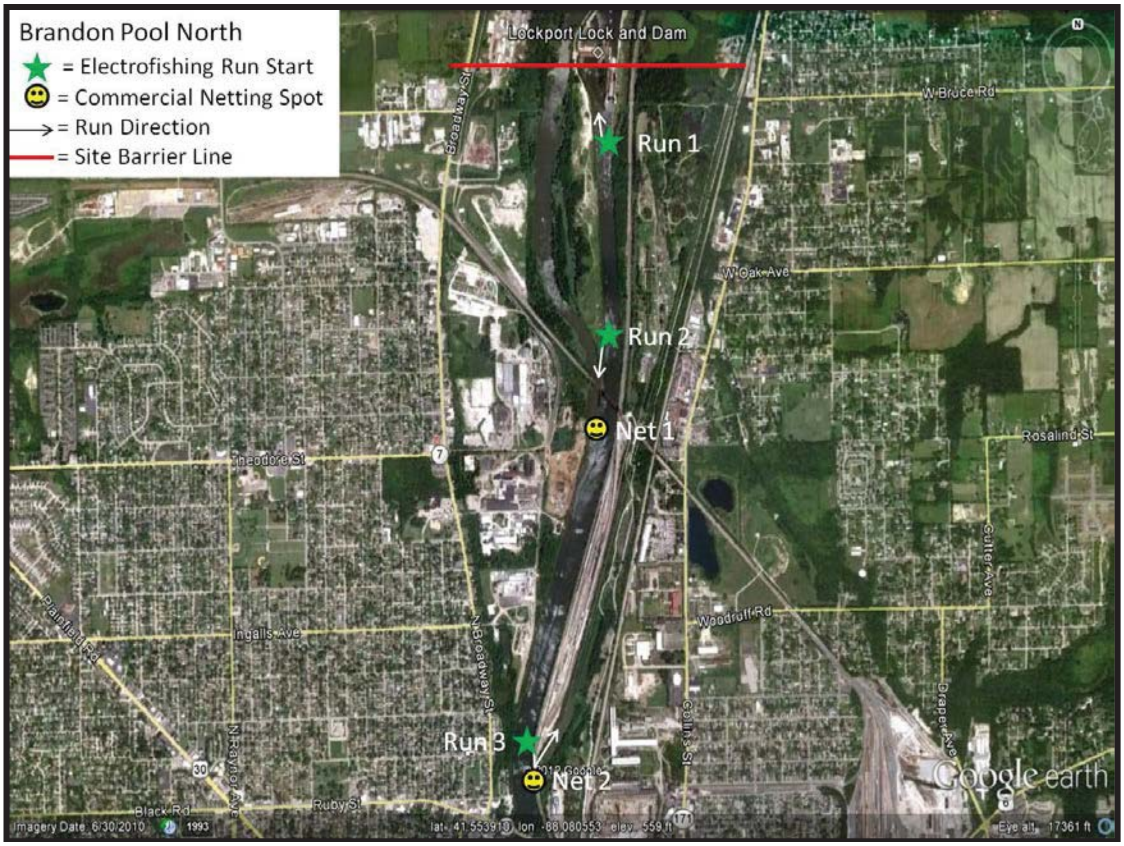

Calumet –Sag Channel - Area 2
= Area Boundary
Random Site Area
Lake Calumet
Archer Ave
Calumet-Sag Rd
W College Dr
Ridgeland Ave
Dan Ryan Expy
S Halsted St
Tri-State Tollway
W 87th St
E 87th St
143rd St
147th St
E 147th St
E Sibley Blvd
Sibley Blvd
W 159th St
E 159th St
159th St
Wolf Rd
© 2012 Google
Image NOAA
Imagery Date: 6/30/2010
lat 41.673577° lon -87.746687° elev 600 ft
Google earth

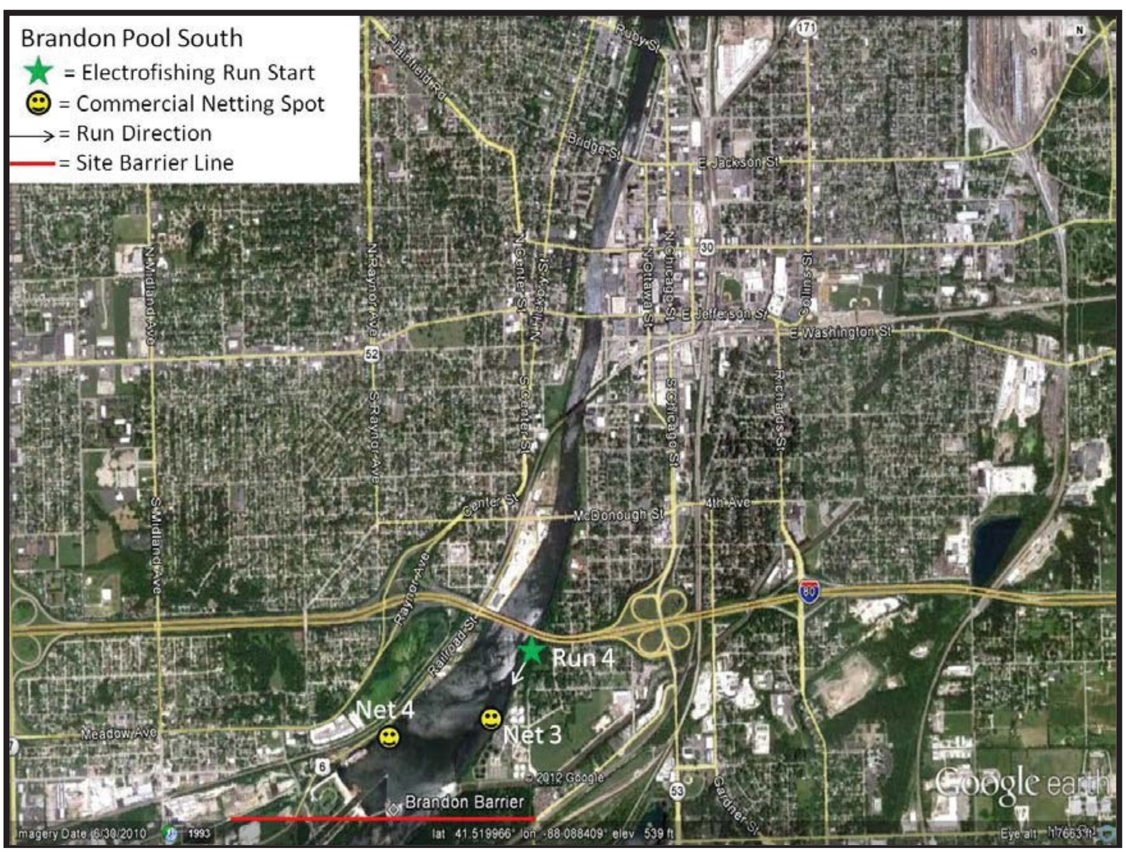

CSSC - Area 3
= Area Boundary
Random Sample Area
Roosevelt Rd
Butterfield Rd
DuPage
E Ogden Ave
W Ogden Ave
Stevenson Expy
Archer Rd
Archer Ave
Cook
W 87th St
Highway 12
Google earth
Imagery Date: 6/30/2010

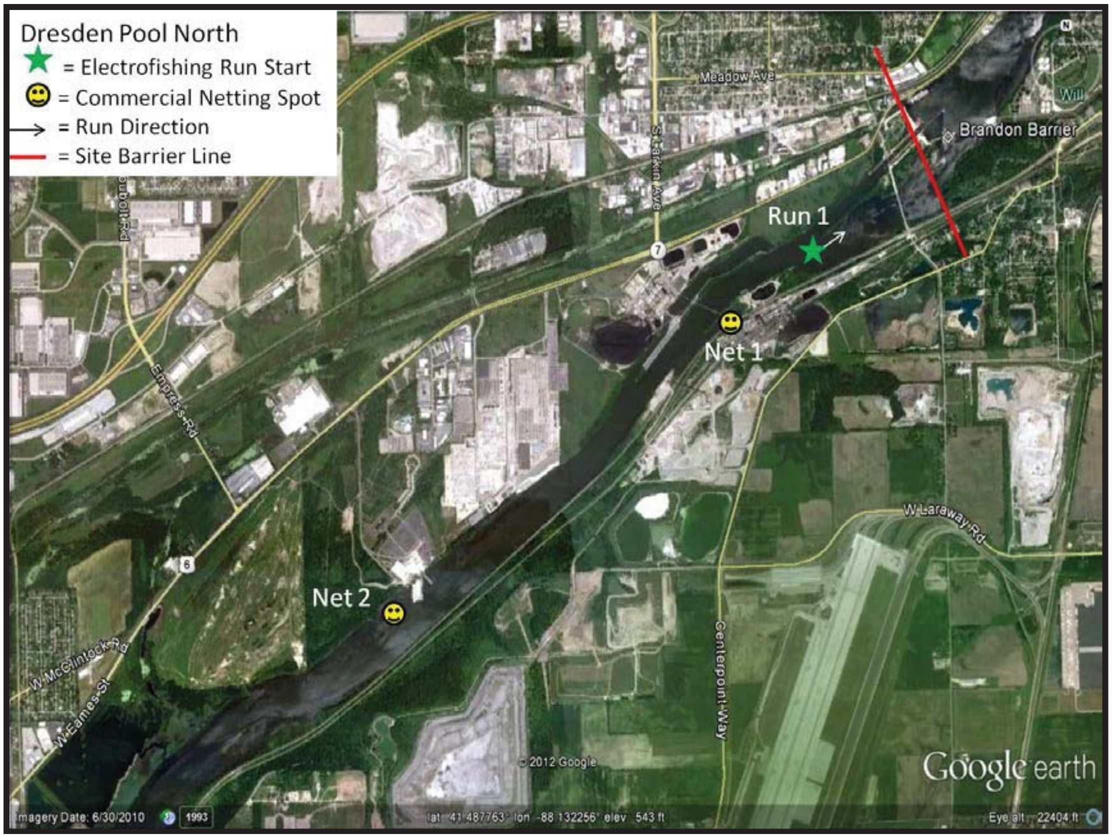

North Shore Channel/North Branch Chicago River - Area 4
= Area Boundary
Fixed Site 5
Random Sites
Fixed Site 4
Random Sites
W Devon Ave
W Foster Ave
W Irving Park Rd
N Caldwell Ave
Outer Harbor
Google earth
Imagery Date: 6/30/2010


Lockport Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Dispersal Barrier
Run 1
Run 2
Net 1
E Romeoville Rd
W 135th St
S Independence Blvd
W 151st St
Archer Ave
© 2012 Google
Google earth


Lockport Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 3
Net 2
Renwick Rd
W 9th St
Cargill
Net 3
Net 4
Run 4
E 9th St
N State St
S State St
E Division St
Broadway St
S Briggs St
Lockport Lock and Dam
© 2012 Google
Google earth
W Bruce Rd

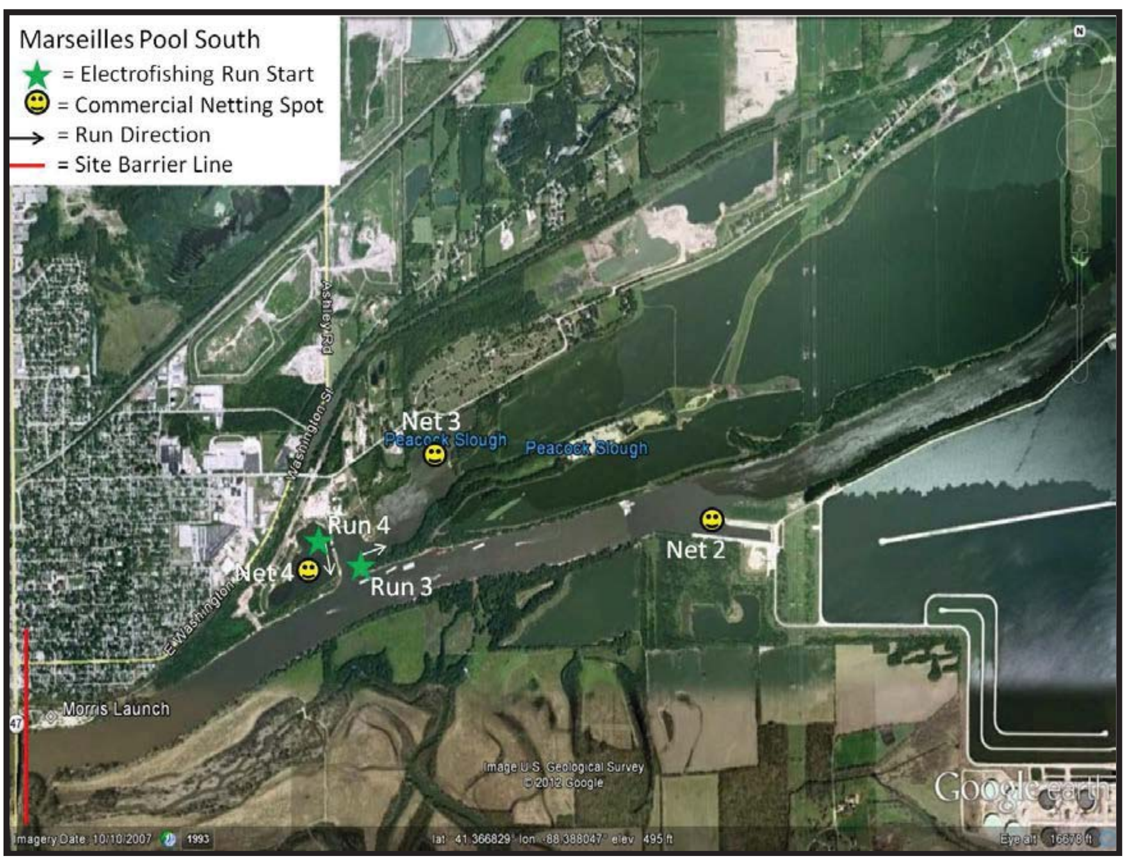

Brandon Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Lockport Lock and Dam
Run 1
Run 2
Net 1
Run 3
Net 2
W Bruce Rd
W Oak Ave
Rosalind St
Theodore St
Ingalls Ave
Woodruff Rd
Broadway St
Ruby St
Black Rd
Collins St
Draper Ave
Google earth


Brandon Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Ruby St
Bridge St
E Jackson St
E Jefferson St
E Washington St
McDonough St
4th Ave
Meadow Ave
Run 4
Net 4
Net 3
Brandon Barrier
Google earth


Dresden Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Brandon Barrier
Run 1
Net 1
Net 2
Meadow Ave
Empress Rd
W Laraway Rd
Centerpoint Way
W McClintock Rd
W Eames St
© 2012 Google
Google earth
Imagery Date: 6/30/2010
1993
lat 41.487763° lon -88.132256° elev 543 ft
Eye alt 22404 ft


Dresden Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Net 3
Run 2
Run 3
Net 4
Big Basin Launch
Run 4
Craig Rd
Centerpoint Way
S Frontage Rd
E Frontage Rd
W Bluff Rd
S Brandon Rd
W Manhattan Rd
Co Hwy 17
Image U.S. Geological Survey
© 2012 Google
Google earth
Imagery Date: 6/30/2010
1993
lat 41.439826° lon -88.159206° elev 532 ft
Eye alt 25931 ft


Marseilles Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 2
Run 1
Net 1
Negro Slough
Dellos Rd
Image U.S. Geological Survey
© 2012 Google
Google earth
Imagery Date: 4/30/2008
lat 41.386214° lon -88.314243° elev 498 ft
Eye alt 19308 ft


Marseilles Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Net 3
Peacock Slough
Peacock Slough
Run 4
Net 4
Run 3
Net 2
Ashley Rd
Morris Launch
Image U.S. Geological Survey
© 2012 Google
Imagery Date 10/10/2007
lat 41.366829° lon -88.388047° elev 495 ft

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:

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.

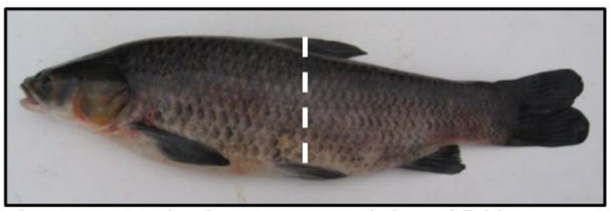


Figure 1. Example of step 4.a: Lateral view of fish's entire left side. Dashed white line indicates location for girth measurement.

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.

<u>Eyeball Sample Preparation for Overnight Shipment – **Do Not Freeze**:</u> 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.**

<u>Blood Sample Preparation for Overnight Shipment – **Do Not Freeze**:</u> 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.**

<u>Shipping Eye or Blood Samples: Contact Laboratory Staff to make Overnight Shipping arrangements</u>

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.

<u>Step 4: Carcass and Digestive Tract Preparation and Shipping Procedures</u>

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.

<u>Carcass Sample Preparation for Overnight Shipment:</u>

If possible, *<u>ship samples on ice or ice packs within 36 hours of catch</u>*. 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 ***<u>NOT</u>*** 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.

<u>Carcass Shipping Procedures:</u>

1. Contact Columbia Environmental Research Center personnel to make Overnight Priority (for morning delivery) shipping arrangements (contact information below). Do ***<u>NOT</u>*** 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

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
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

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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

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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

Appendix H: Sample data sheets.

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.

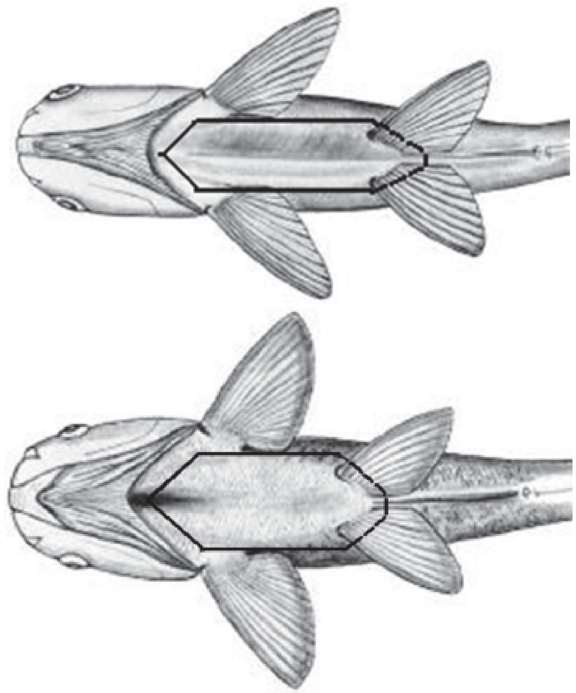

Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection 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

Photo: Greg Whitledge, SIU

Grass Carp

Photo: James Candrl, USGS

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.

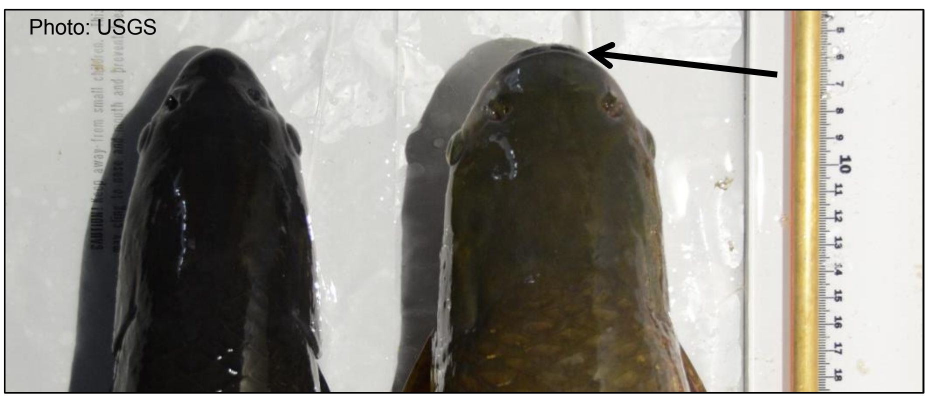

Photo: USGS

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**.

Photo: USGS

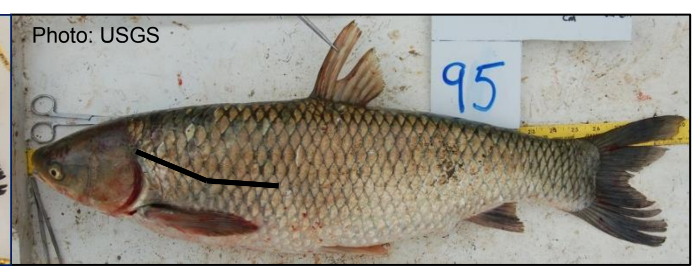

Photo: USGS

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

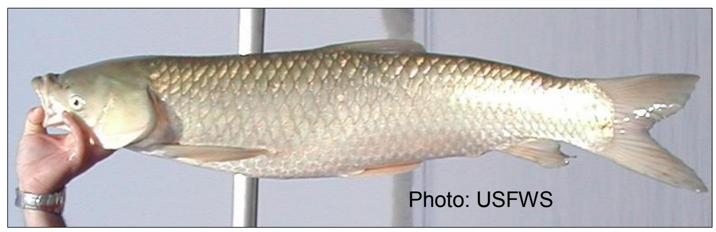
Photo: USFWS

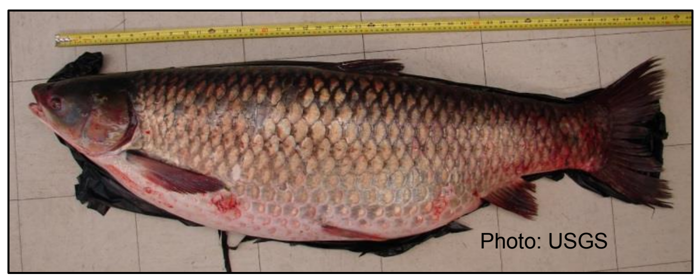
Photo: USGS


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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Keywords Asian carps Bi·head carp Density gradient· Illinois River·Mississippi–Great Lakes basins·Removal· Silver carp

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.

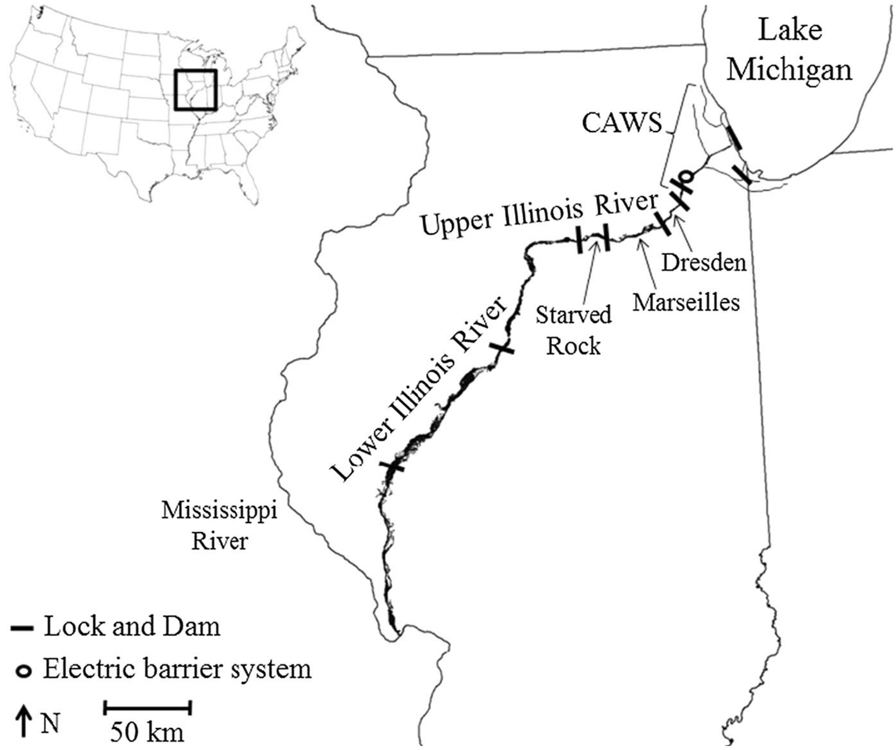

Fig. 1 The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM 372 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

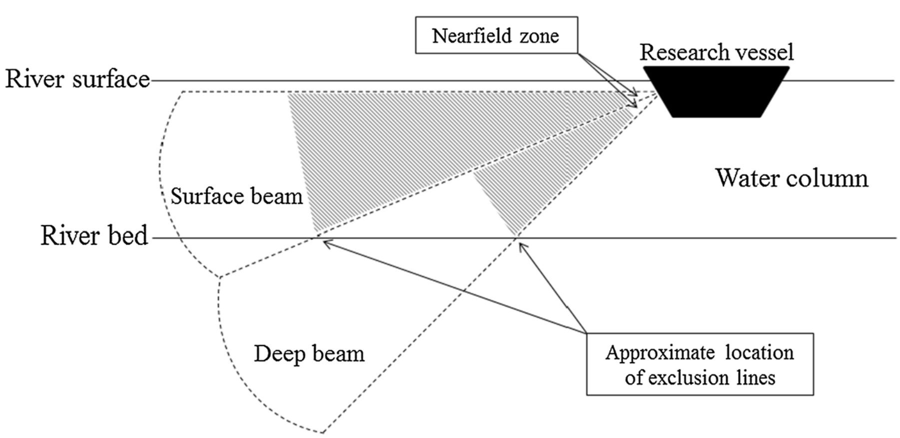

Fig. 2 Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in which 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

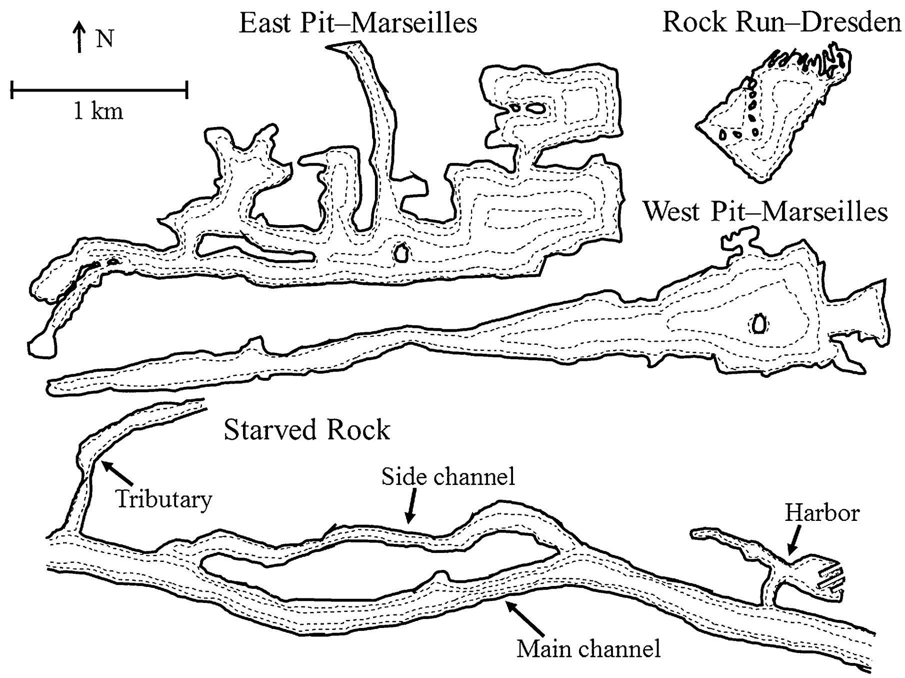

Fig. 3 Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after harvest 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:

$$\bar{\rho}_h = \frac{1}{n_h}\sum_{i=1}^{n_h} \rho_{h,i} \qquad (1)$$

$$Var(\bar{\rho}_h) = \frac{1}{n_h - 1}\sum_{i=1}^{n_h} \left(\rho_{h,i} - \bar{\rho}_h\right)^2 \qquad (2)$$

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:

$$\bar{\rho} = \frac{1}{A}\sum_{h=1}^{L} A_h \cdot \bar{\rho}_h \tag{3}$$

$$SE(\bar{\rho}) = \sqrt{\sum_{h=1}^{L}\left(\frac{A_h}{A}\right)^2\left(\frac{Var(\bar{\rho}_h)}{n_h}\right)} \tag{4}$$

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

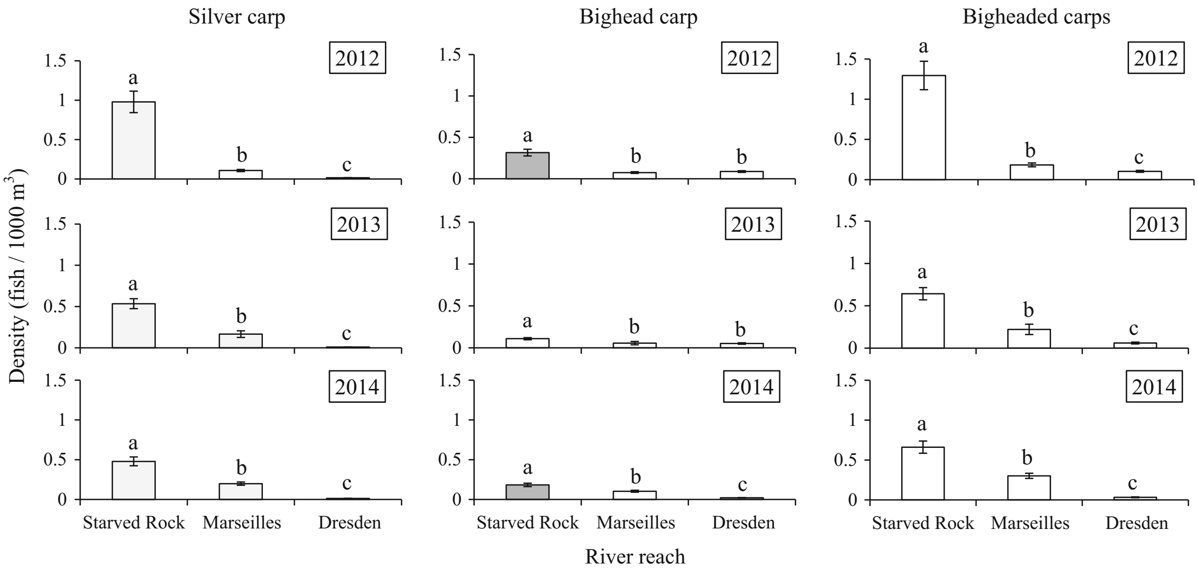

Fig. 4 Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated by *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

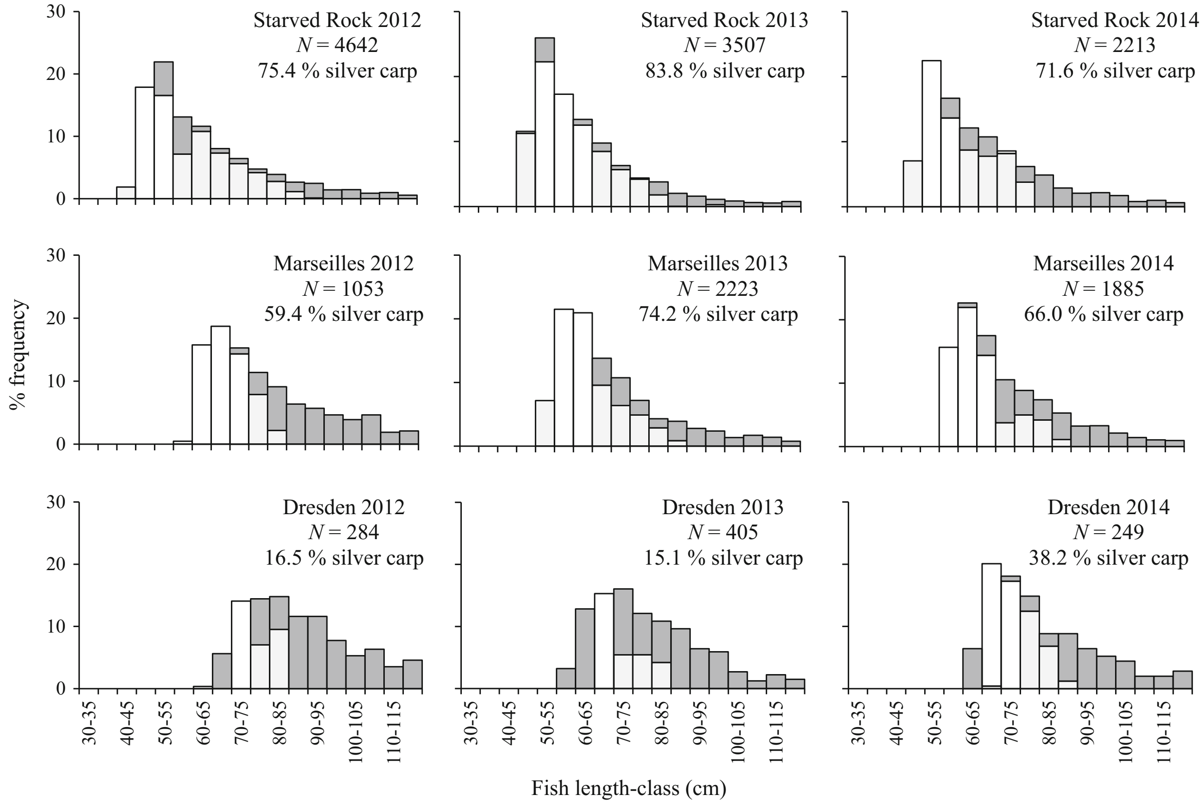

Fig. 5 Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding to each size distribution are shown

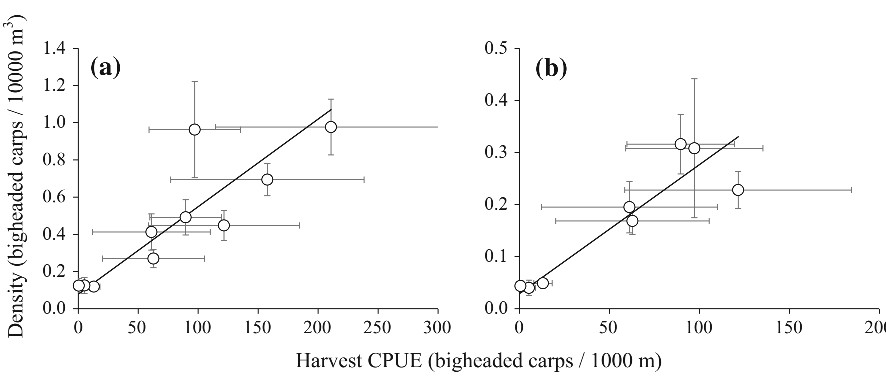

Fig. 6 Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence intervals

reaches combined) declined significantly, from 0.492 ± 0.053/1000 m^3 in 2012 to 0.278 ± 0.034/1000 m^3 in 2013, but remained stable between 2013 and 2014 (0.254 ± 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 0.270 ± 0.049[a] 0.101 ± 0.023[b] (62.5 and 812)	19 May → 20 May 0.491 ± 0.095[a] 0.175 ± 0.037[b] (83.1 and 855)	7 July → 8 July 0.963 ± 0.259[a] 0.655 ± 0.126[b] (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 0.125 ± 0.042[a] 0.078 ± 0.037[a] (5.1 and 26)	24 July → 25 July 0.124 ± 0.039[a] 0.069 ± 0.029[b] (0.5 and 1)	
2015			
East Pit (Marseilles)	6 Aug → 7 Aug 0.420 ± 0.099[a] 0.217 ± 0.048[b] (56.6 and 150)	7 Sep → 8 Sep 0.448 ± 0.081[a] 0.220 ± 0.045[b] (116.2 and 701)	

Different superscript letters indicate a significant difference ($P \setminus 0.01$) 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

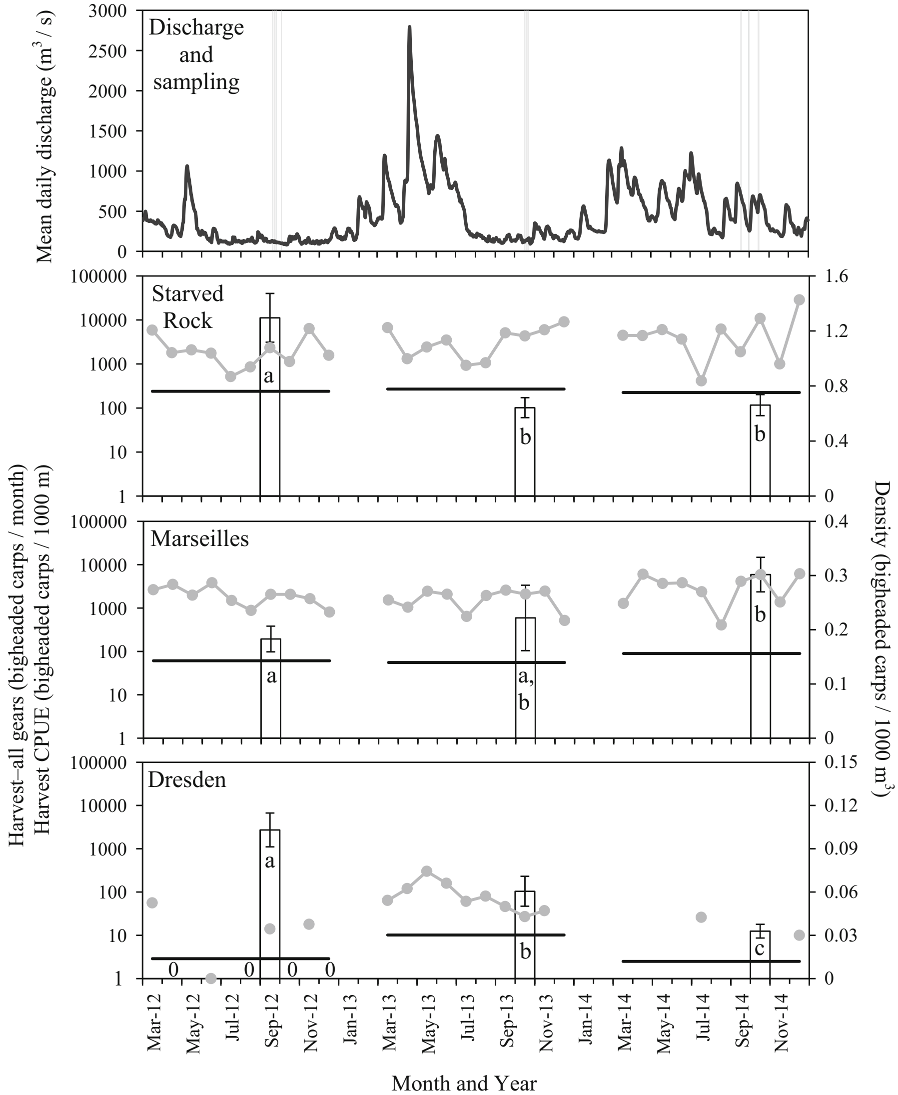

Fig. 7 *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks* 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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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 leading edge of well-established invasions and for rapid response to early detection of a new invasion (e.g., Taylor and Hastings 2004; Kadoya and Washitani 2010; Vander Zanden et al. 2010). Gear development for optimal harvest of bigheaded carps (Collins et al. 2015), coupled with fish-pinpointing technologies like mobile hydroacoustic surveys (this study) or 'Judas fish' telemetry (Bajer et al. 2011) are additional resources that can be applied at these low density (yet high priority) locations, to further improve detection probabilities and hence harvest rates.

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.

Acknowledgments Funding for this study was provided by the Great Lakes Restoration Initiative, via Illinois Department of Natural Resources. We are grateful to colleagues from Southern Illinois University (G. Whitledge, M. Brey, A. Lubejko, M. Lubejko, B. Szynkowski, A. Kern, J. Rosenquist and J. Seibert) and Illinois Department of Natural Resources (M. O'Hara, D. Wyffels and T. Widloe) for assistance with various aspects of this project. We acknowledge the co-operation of the contracted fishing crews and Illinois Department of Natural Resources biologists during the Asian carps harvest program, Hansen Material Services Corporation and the Forest Preserve District of Will County for site access, Illinois Natural History Survey (Illinois River Biological Station, Havana) for providing electrofishing data, and D. Coulter, A. Coulter and two anonymous referees for providing constructive comments on earlier drafts.

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APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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Participating Agencies: Illinois Department of Natural Resources, Illinois Natural History Survey, U.S. Fish and Wildlife

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.).

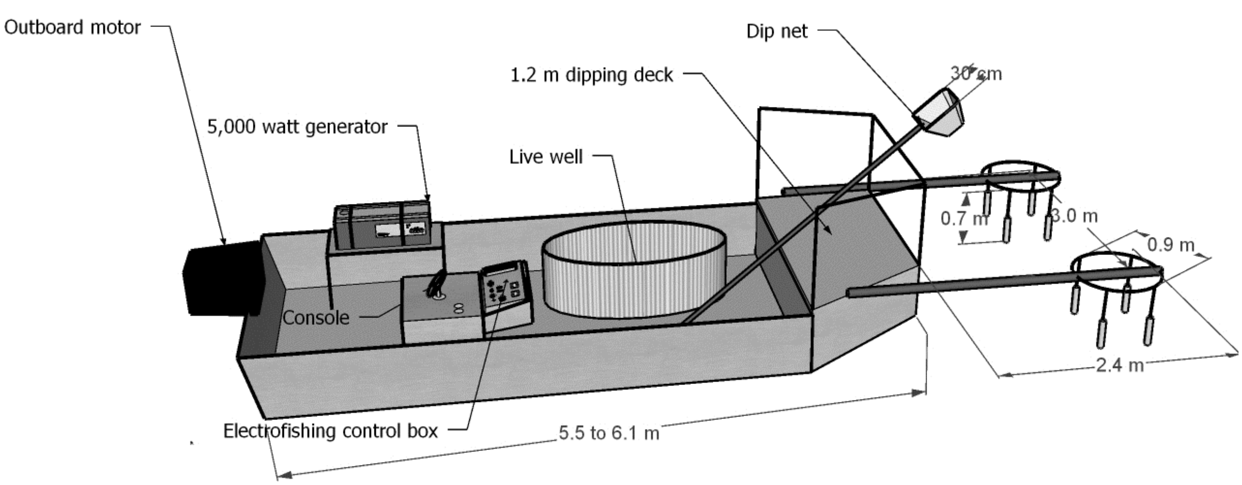

Figure 1. *Schematic of electrofishing boat.*

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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.).

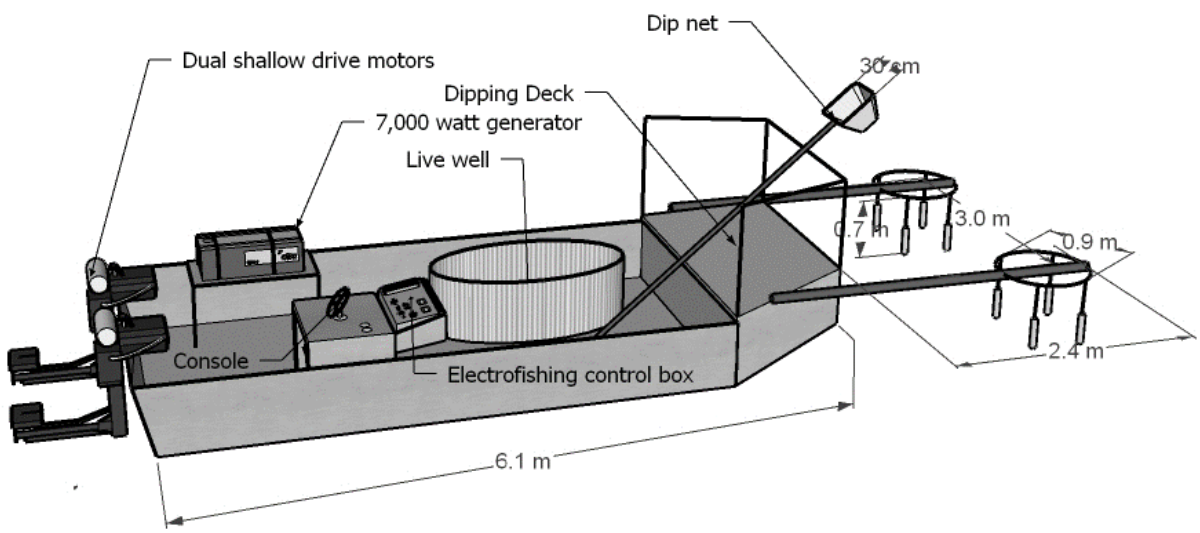

Figure 2. *Schematic of the shallow drive electrofishing boat.*

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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).

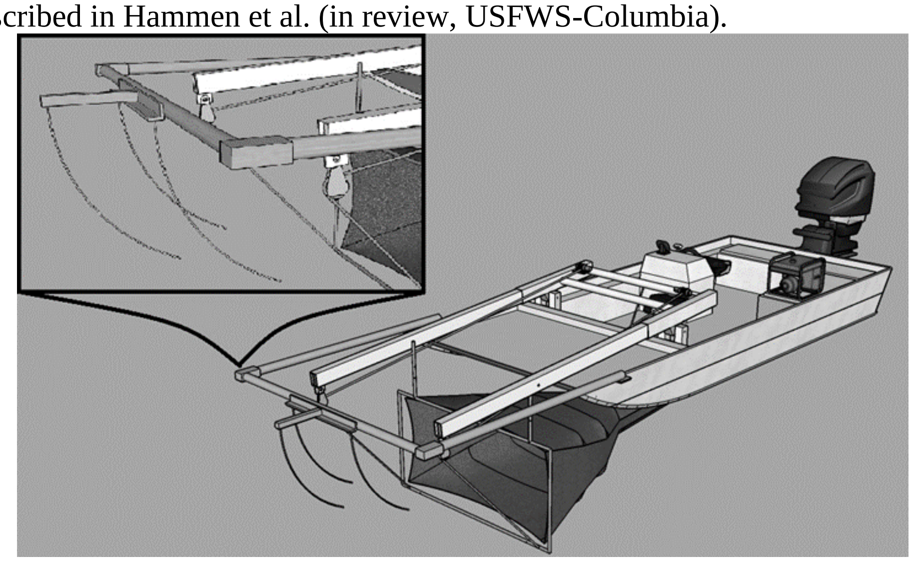

Figure 3. *Generalized schematic of the electrified dozer trawl.*

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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).

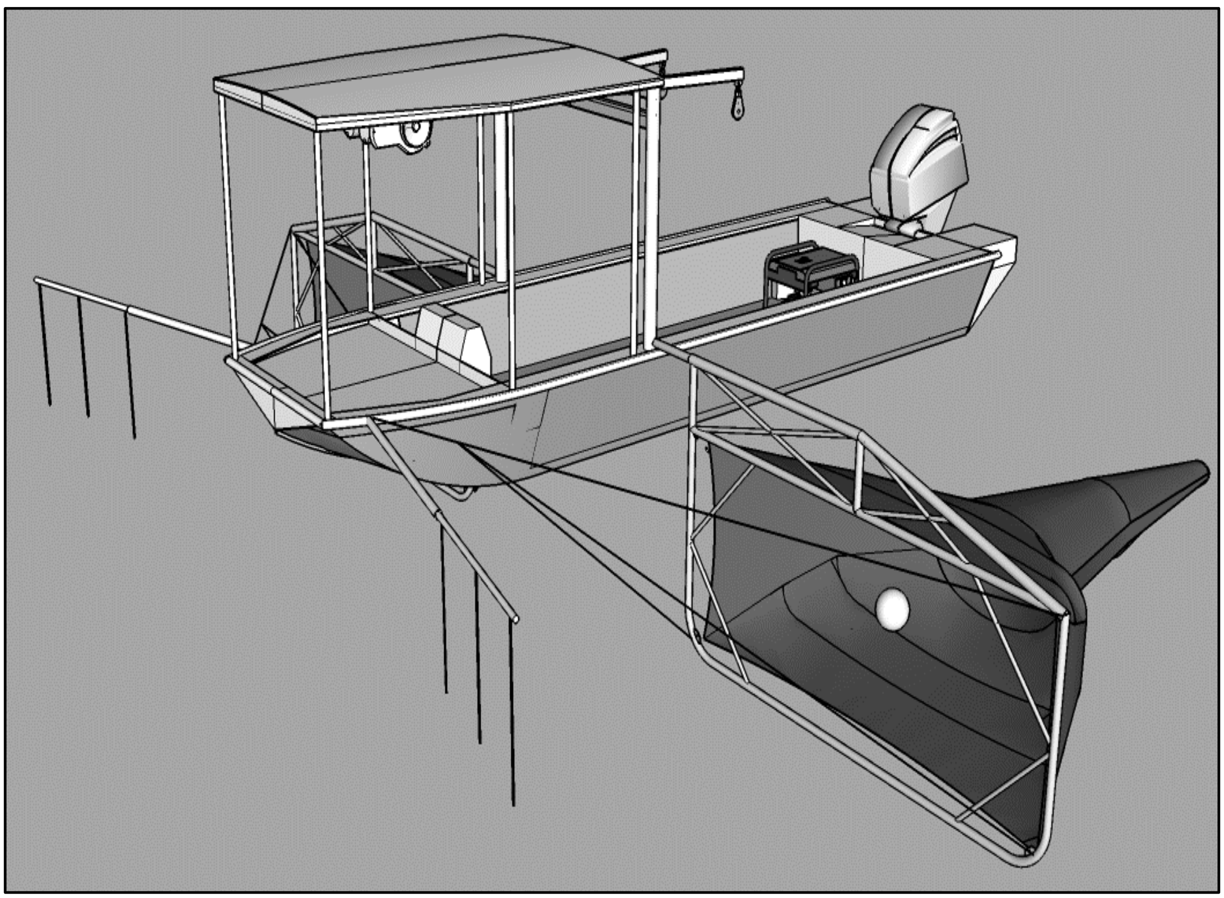
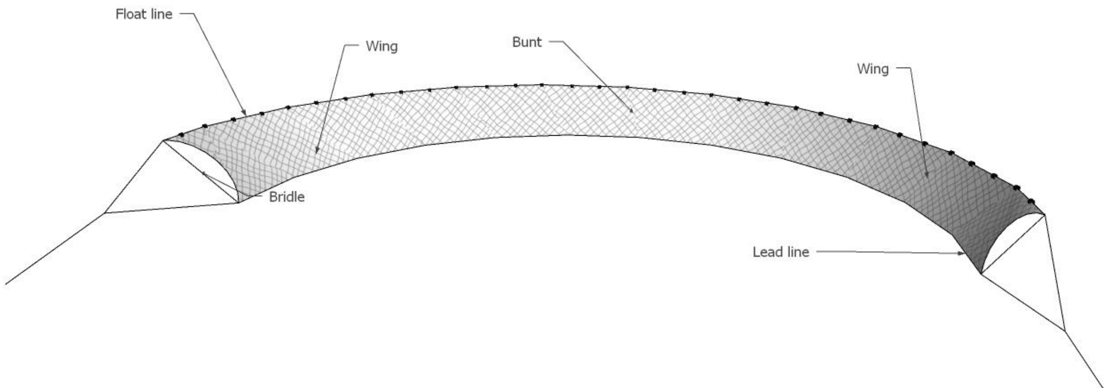


Figure 4. *Schematic of electrified Paupier trawl*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.).



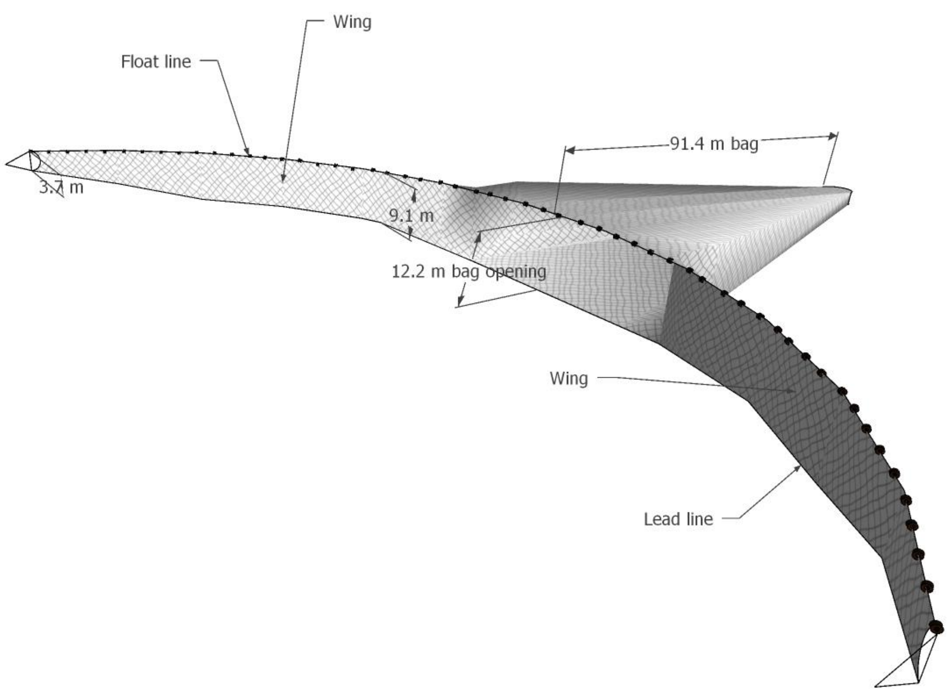


Figure 5. *Generalized schematic of a commercial seine without a bag (top) and with a bag (bottom).*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.

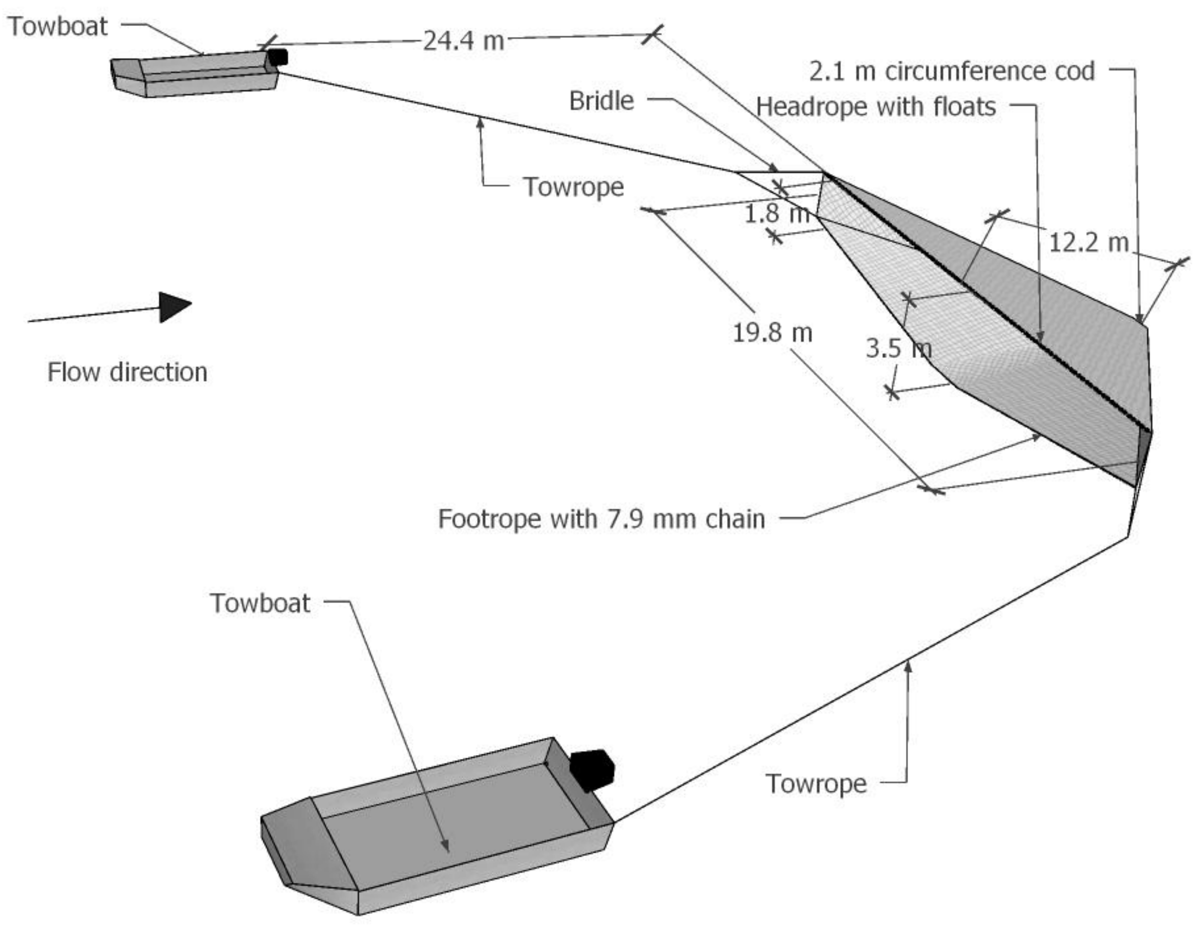


Figure 6. *Generalized schematic of a trawl.*

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.).

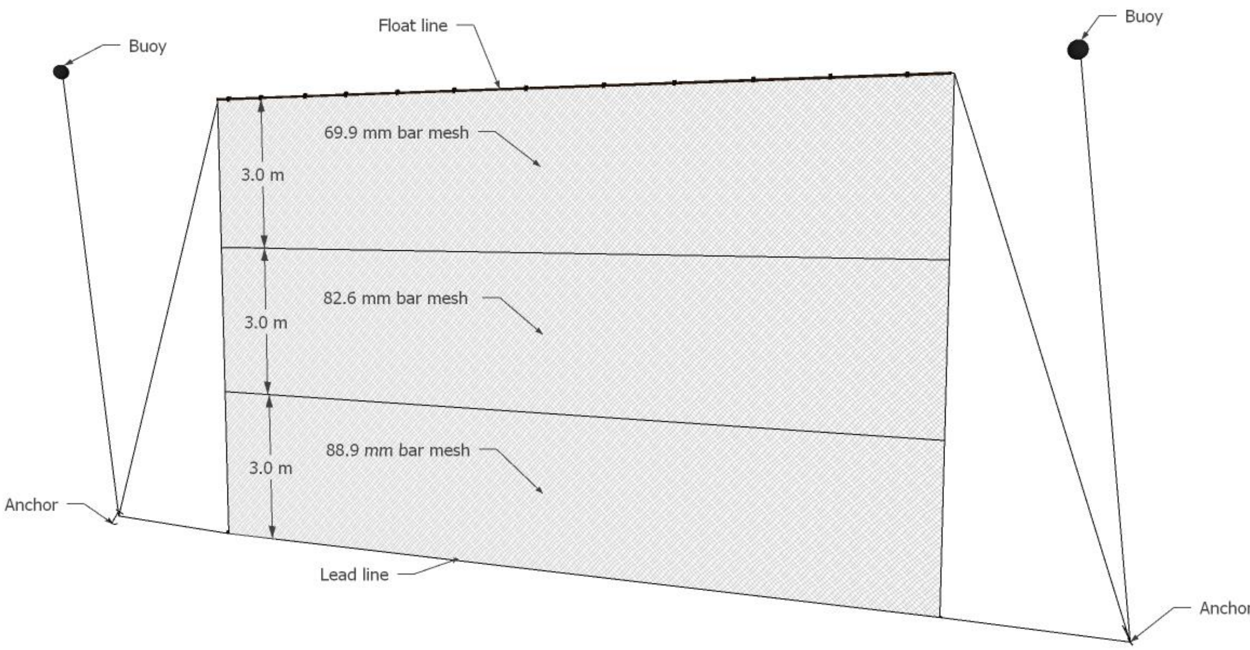


Figure 7. *Generalized schematic of a deep-water gill net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.).

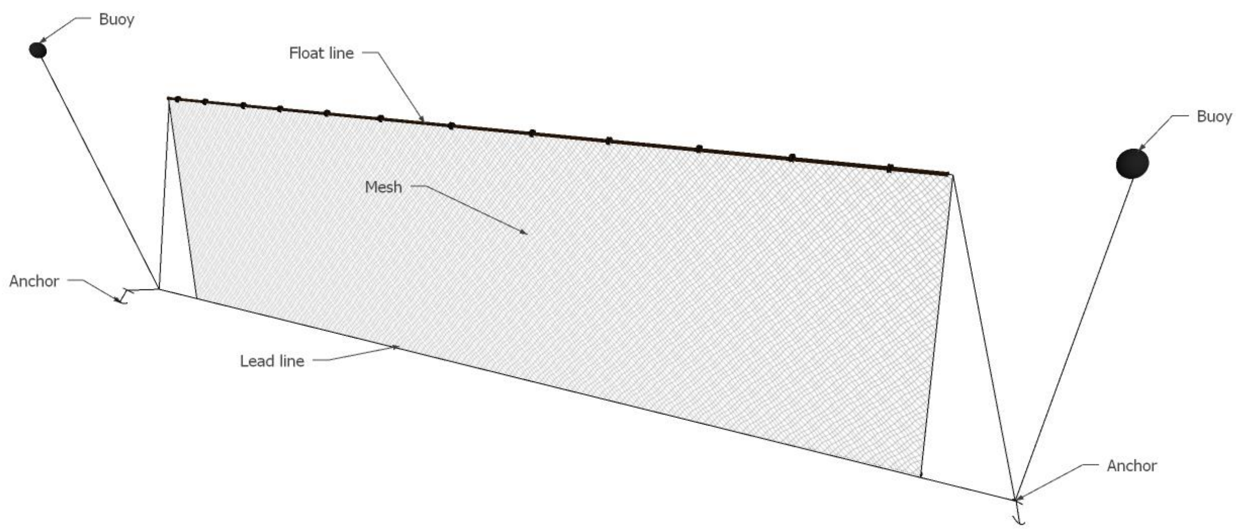

Figure 8. *Generalized schematic of a commercial shallow gill net.*

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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.).

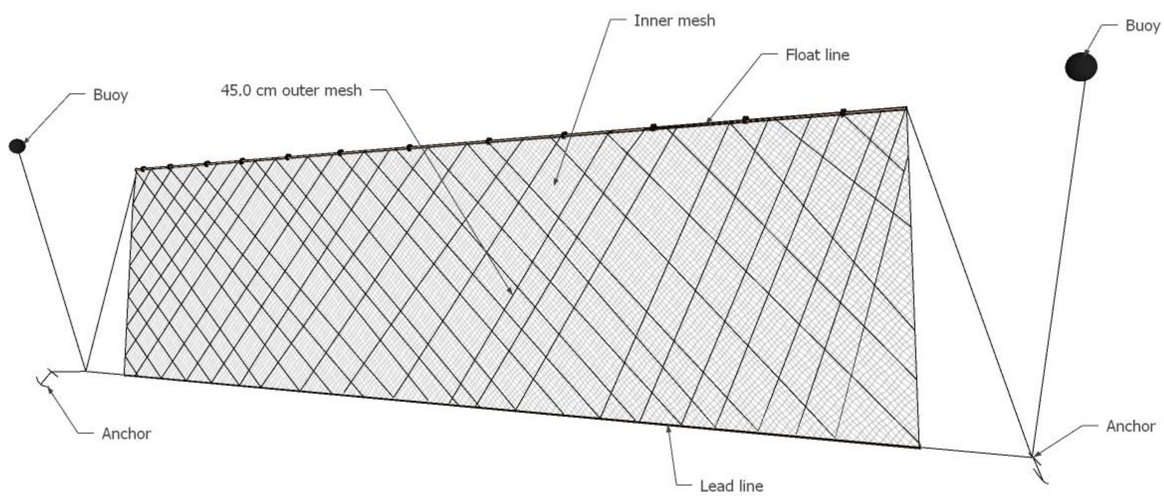

Figure 9. *Generalized schematic of a commercial trammel net.*

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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.

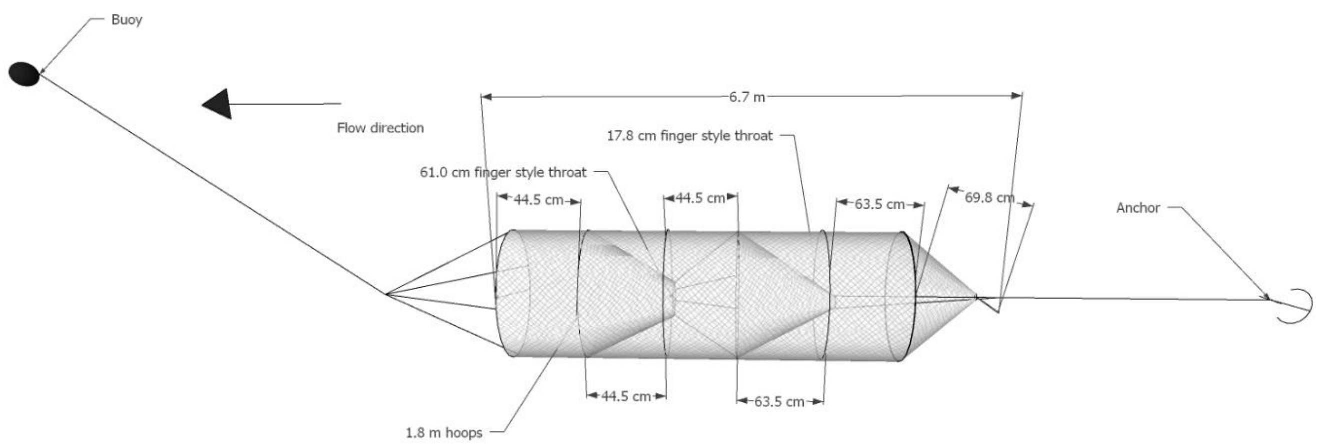

Figure 10. *Schematic of commercial hoop net*

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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.

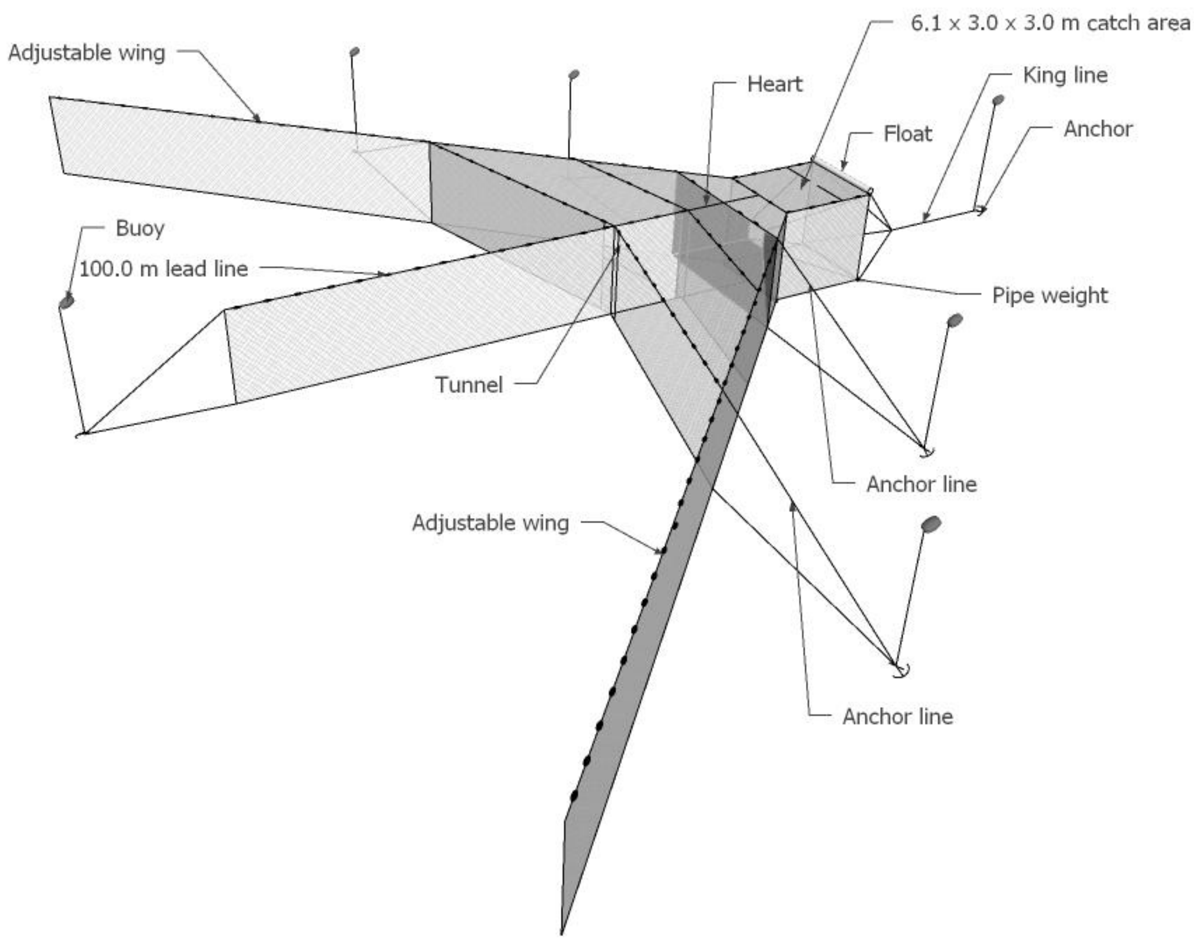

Figure 11. *Schematic of the great lakes style pound net*

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.

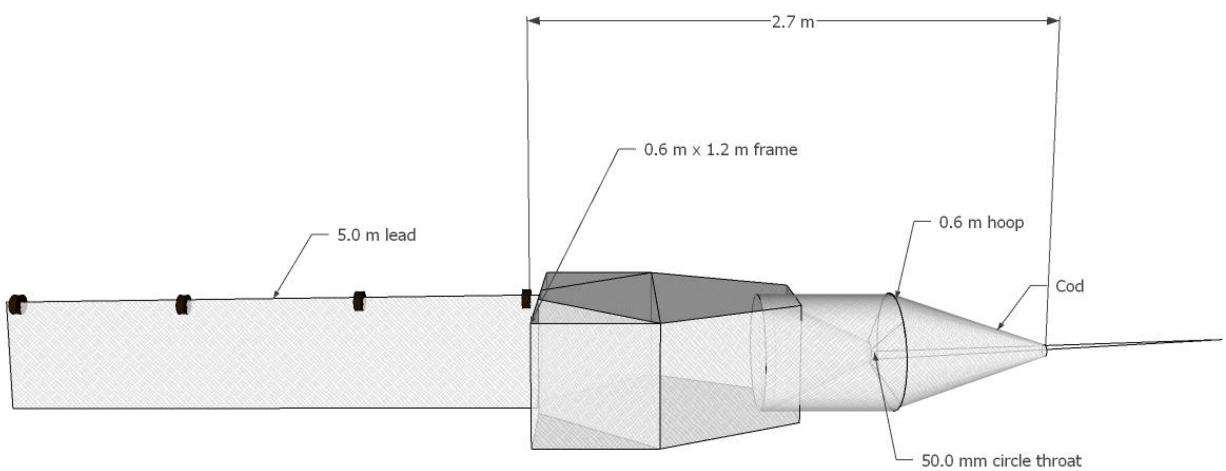

Figure 12. *Schematic of mini modified fyke net*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.

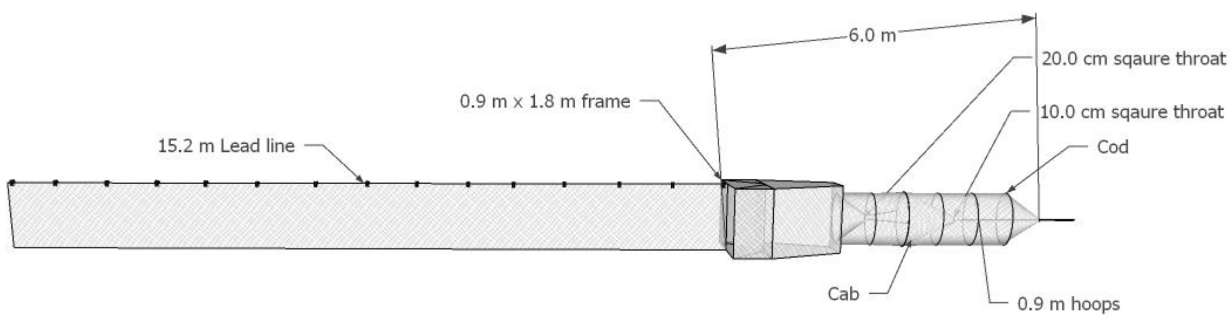

Figure 13. *Schematic of modified fyke net*

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.

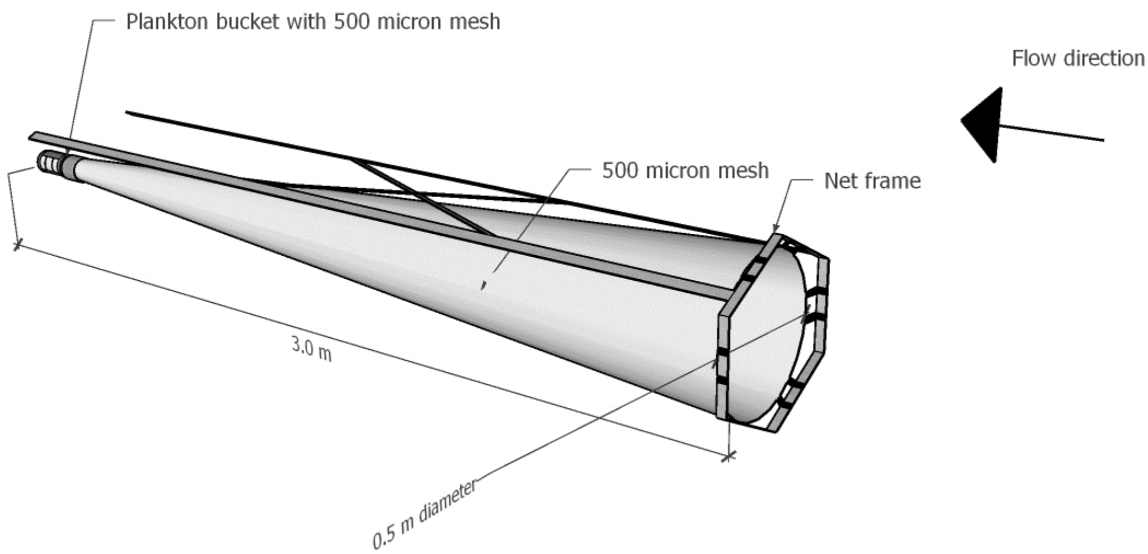

Figure 14. *Generalized schematic of a pushnet.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.

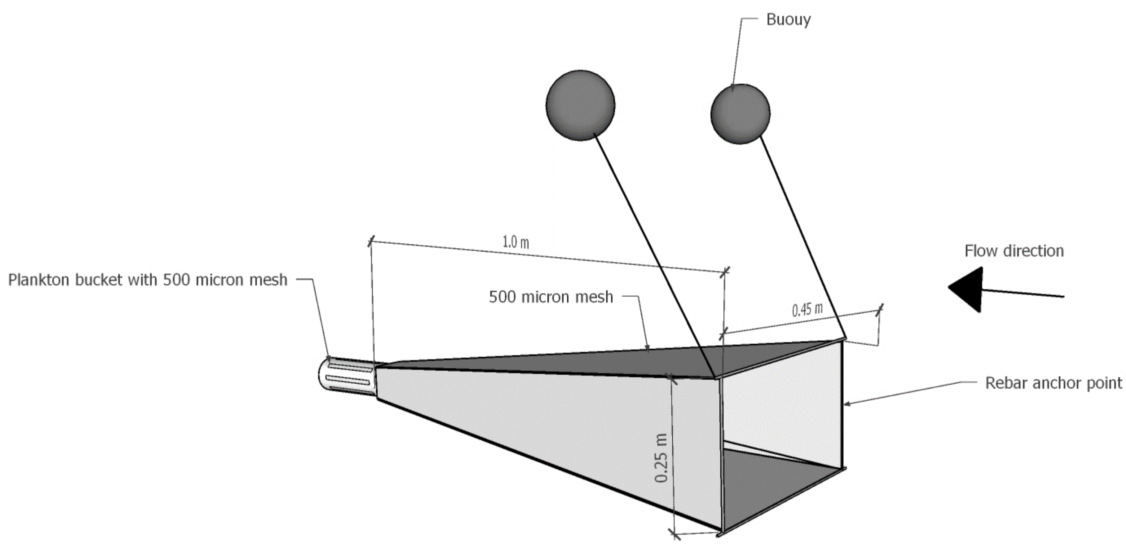

Figure 15. *Generalized schematic of a drift net.*

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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.

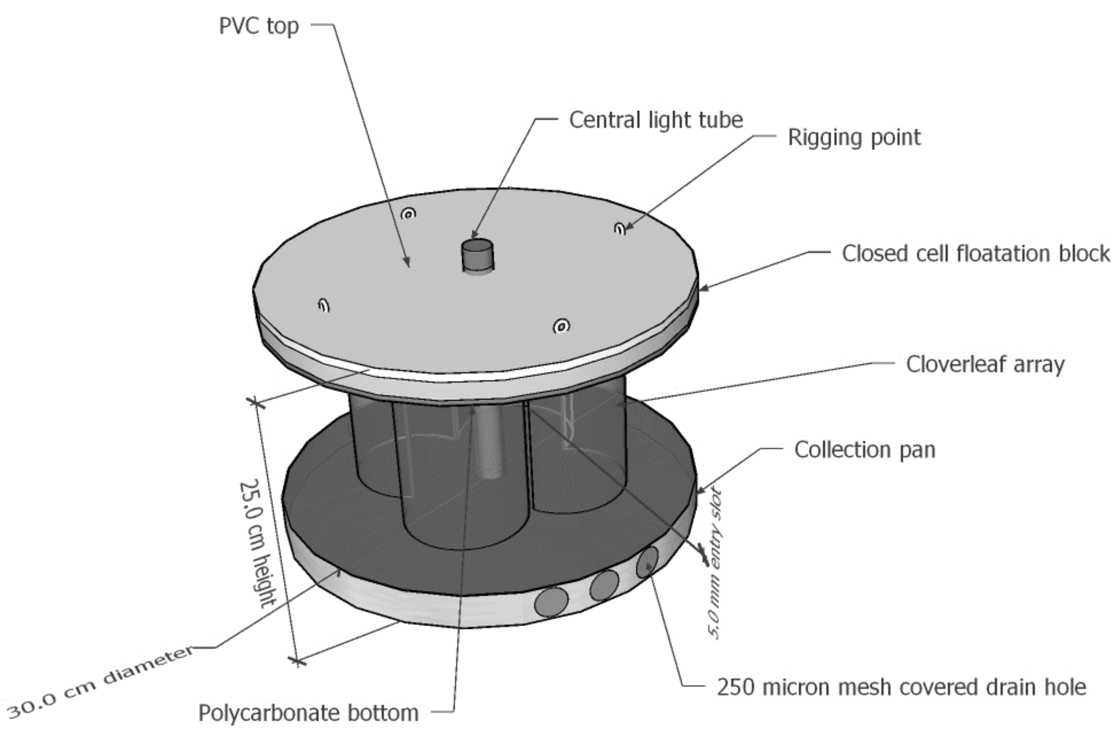

Figure 16. *Schematic of Quadrafoil light trap*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.

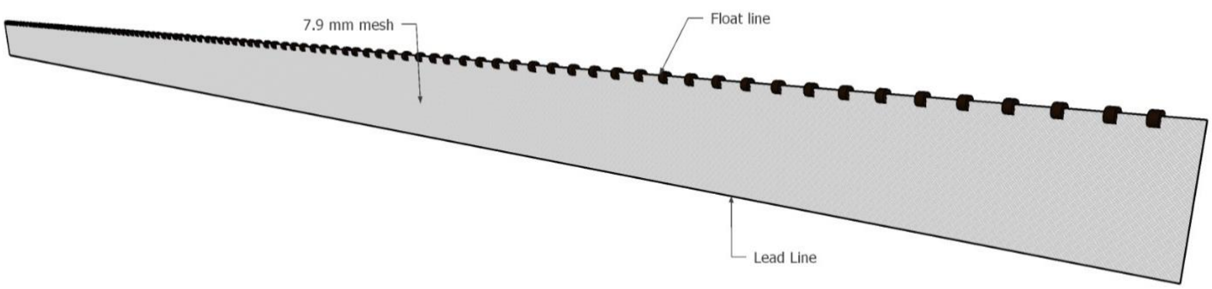

Figure 17. *Generalized schematic of a block net.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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.

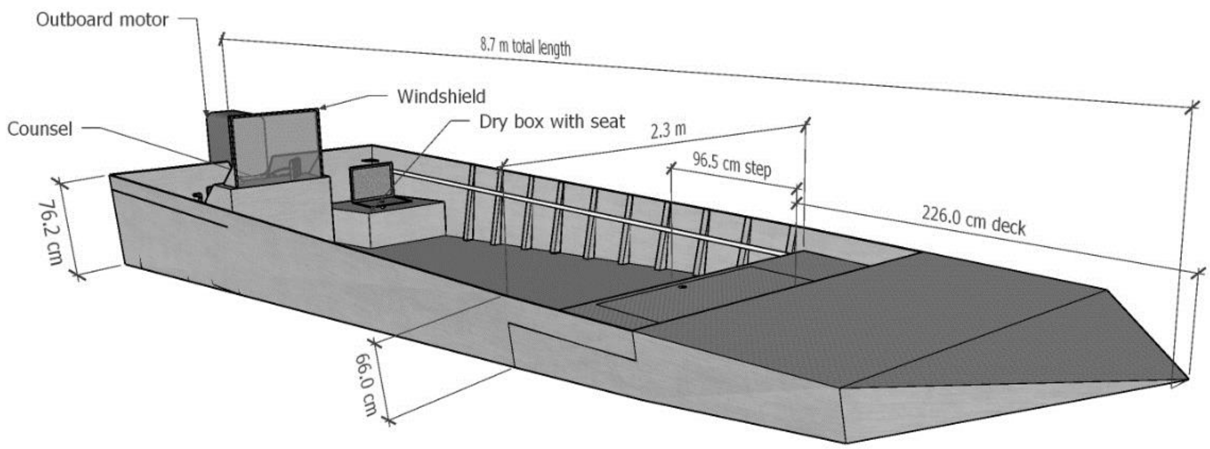

Figure 18. *Generalized schematic of netting boat.*

APPENDIX L
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.

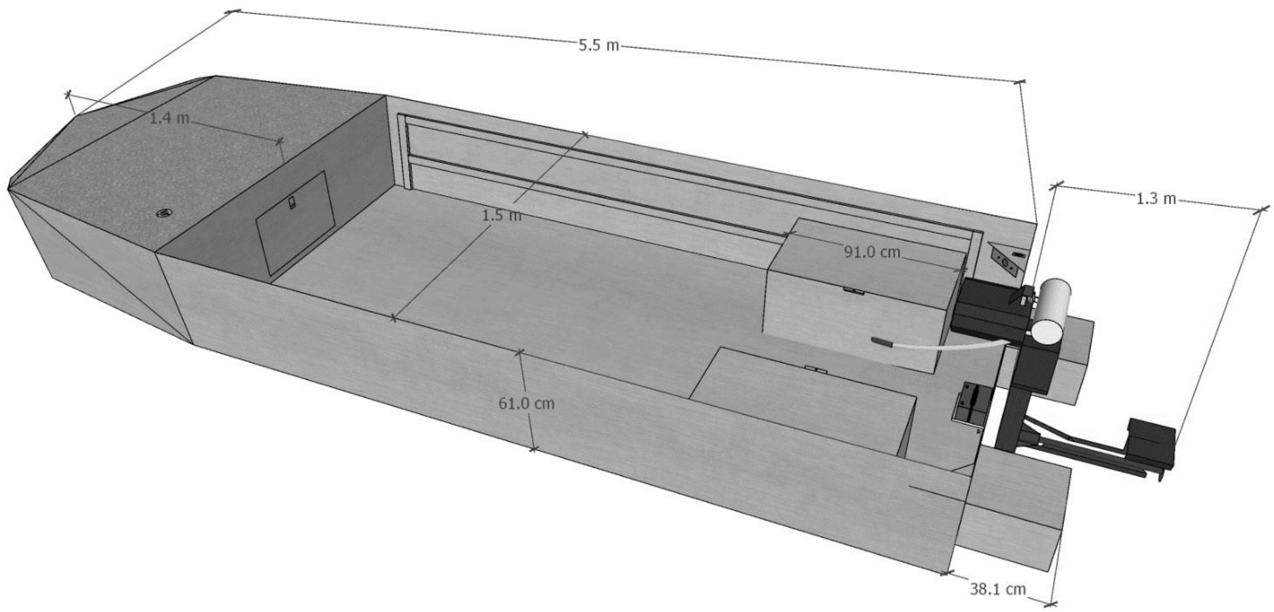

Figure 19. *Schematic of the shallow drive boat.*

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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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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 area				
	SRS strata				**Engineered Structures**
Sampling gear	**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

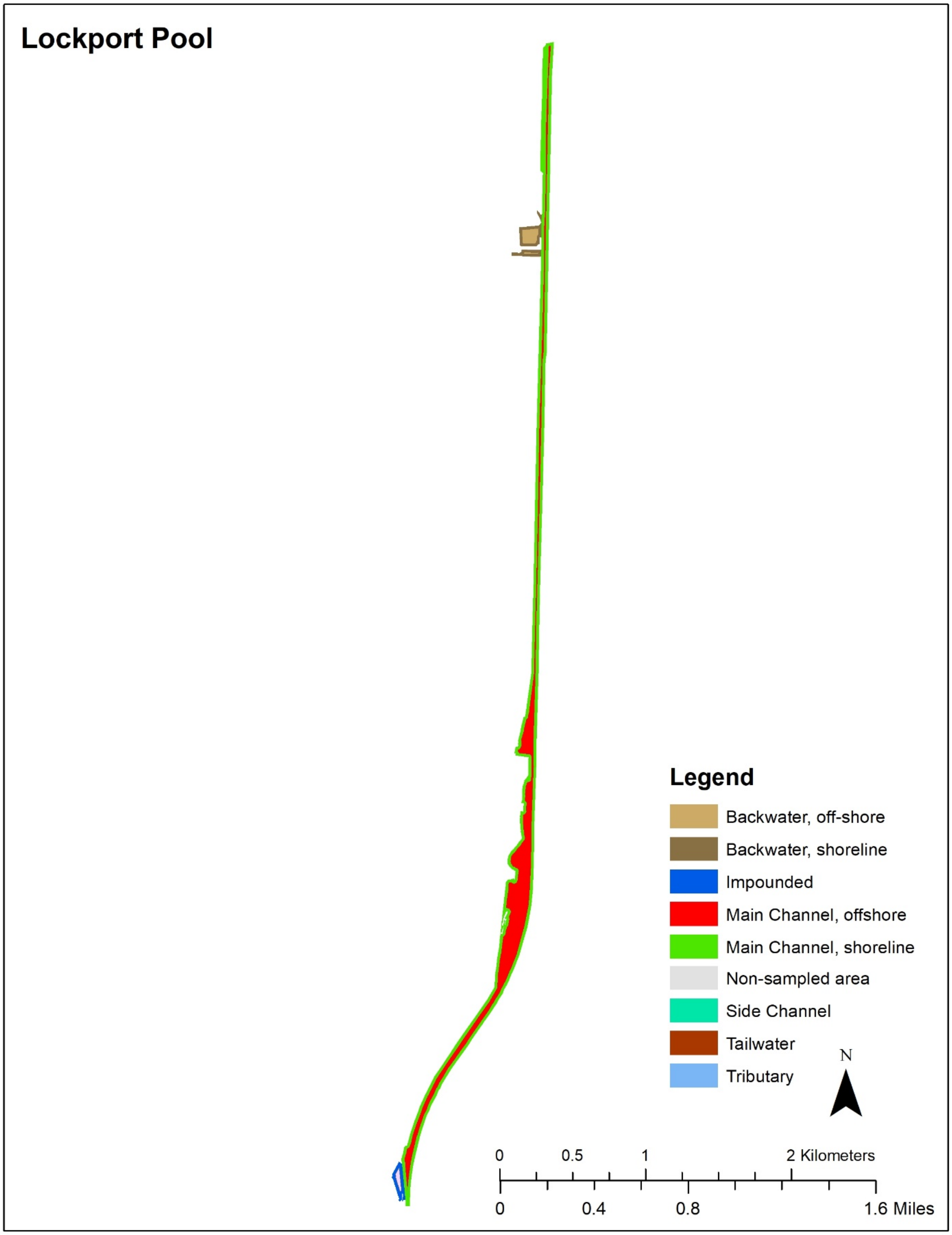

Figure 1. *Lockport Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

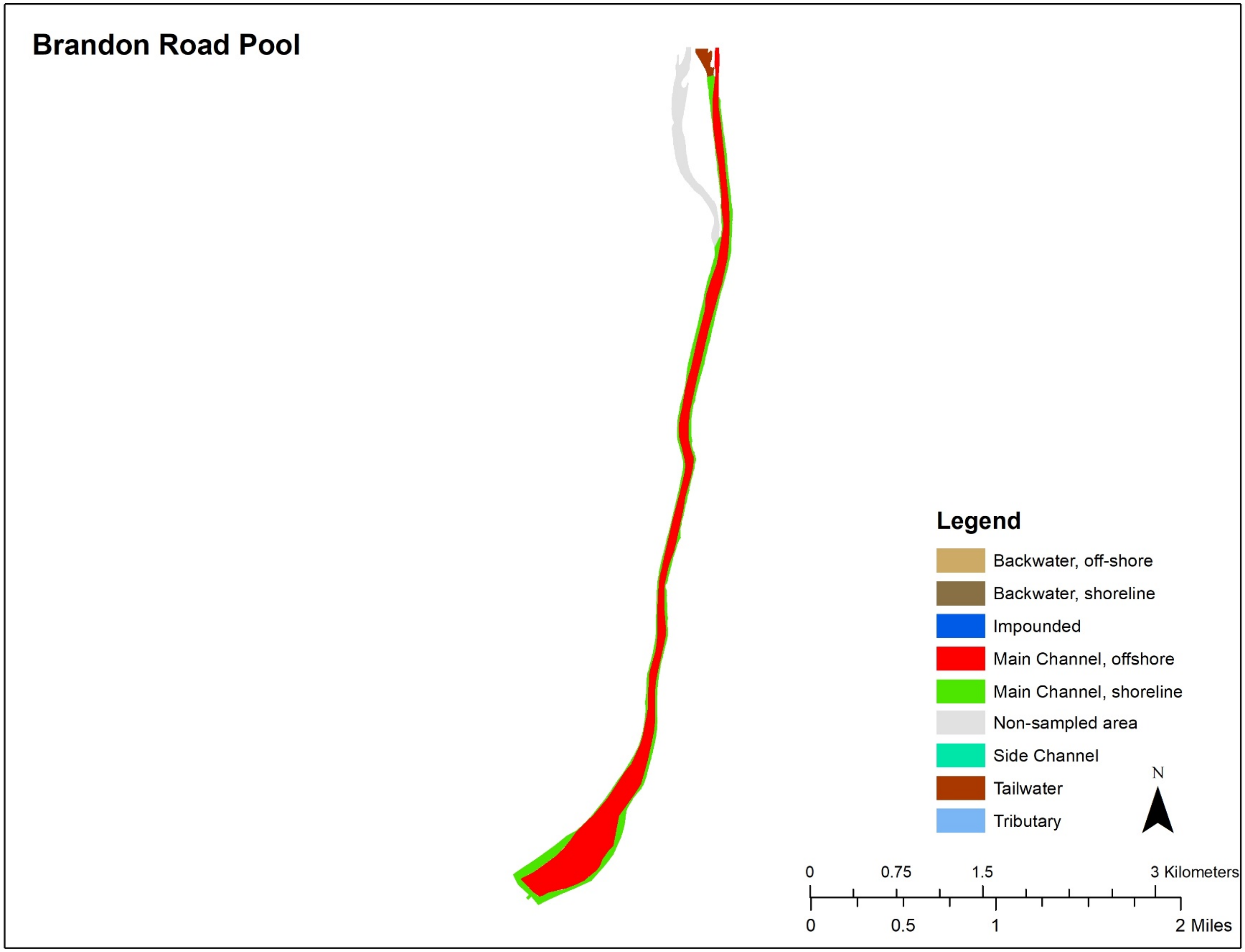

Figure 2. *Brandon Road Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

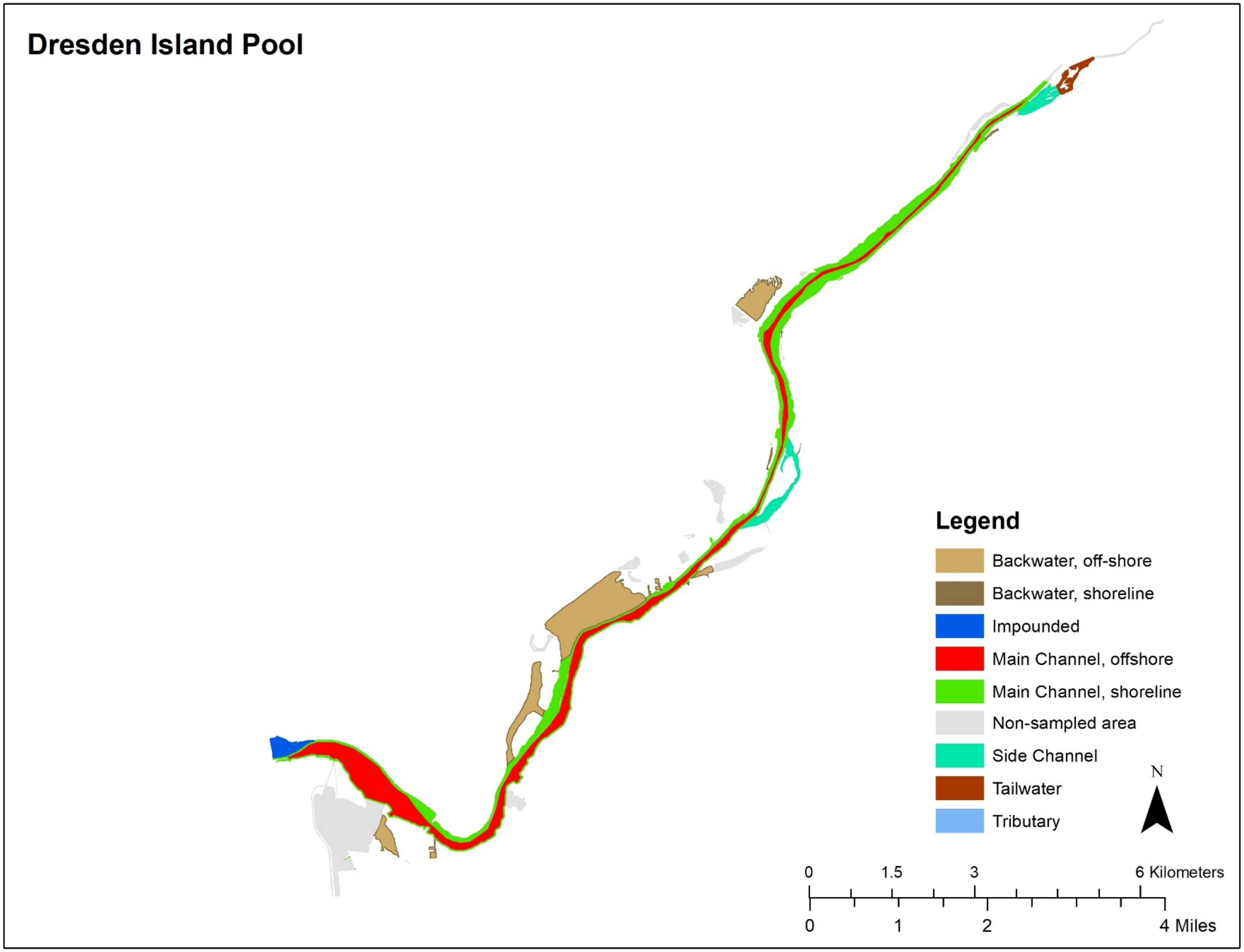

Figure 3. *Dresden Island Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

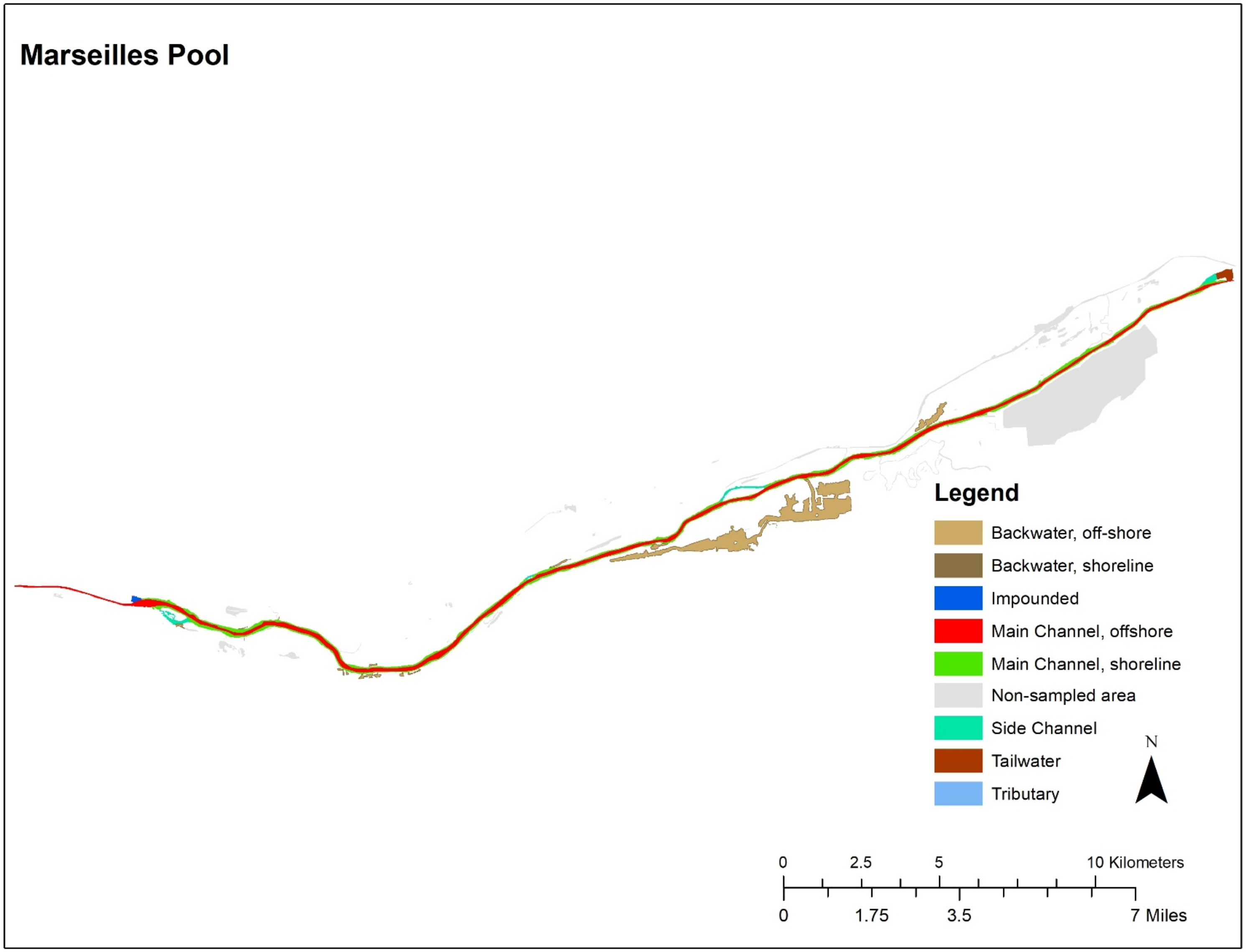

Figure 4. *Marseilles Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

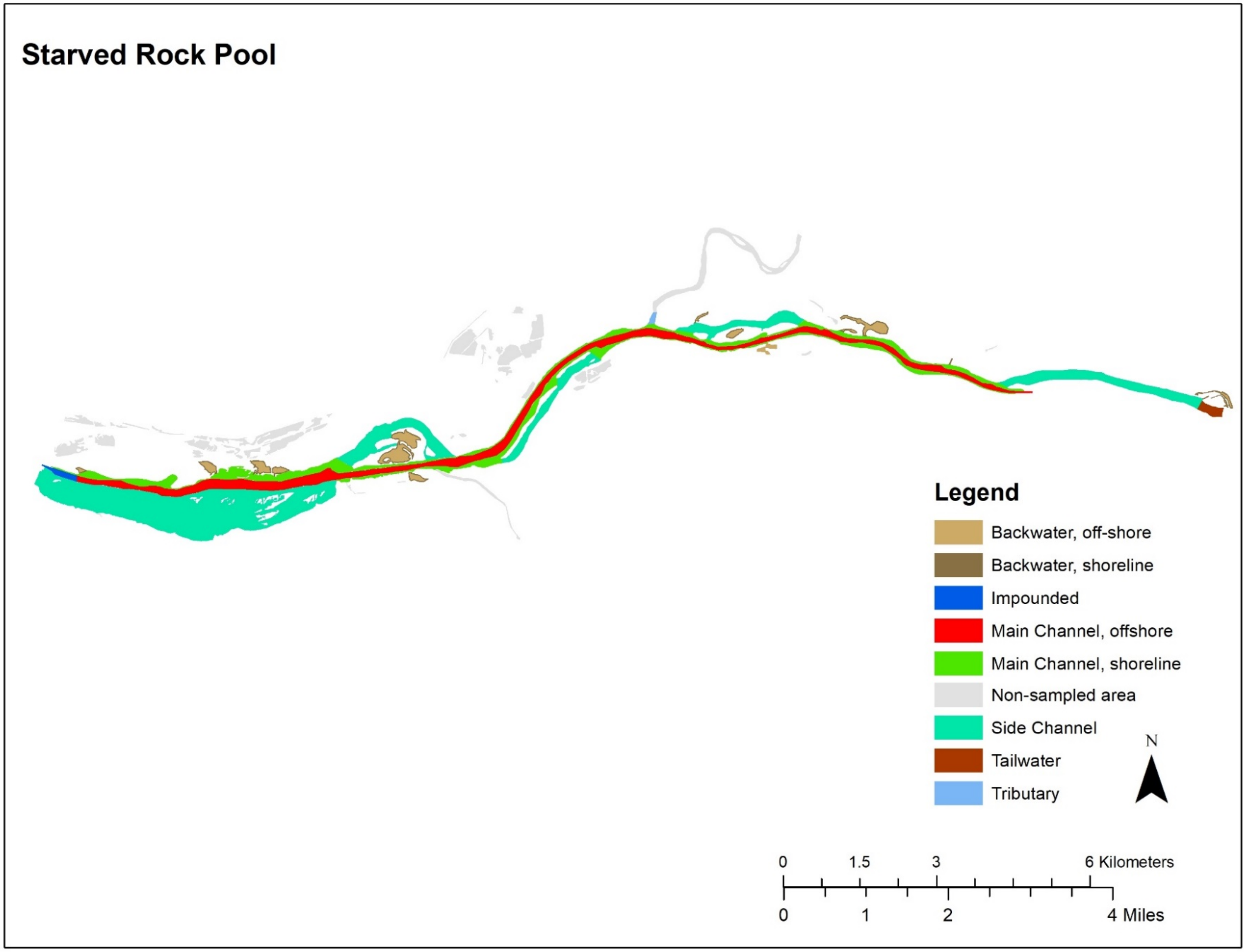

Figure 5. *Starved Rock Pool sampling strata from the 1989 coverages modified with 2019 field observations.*

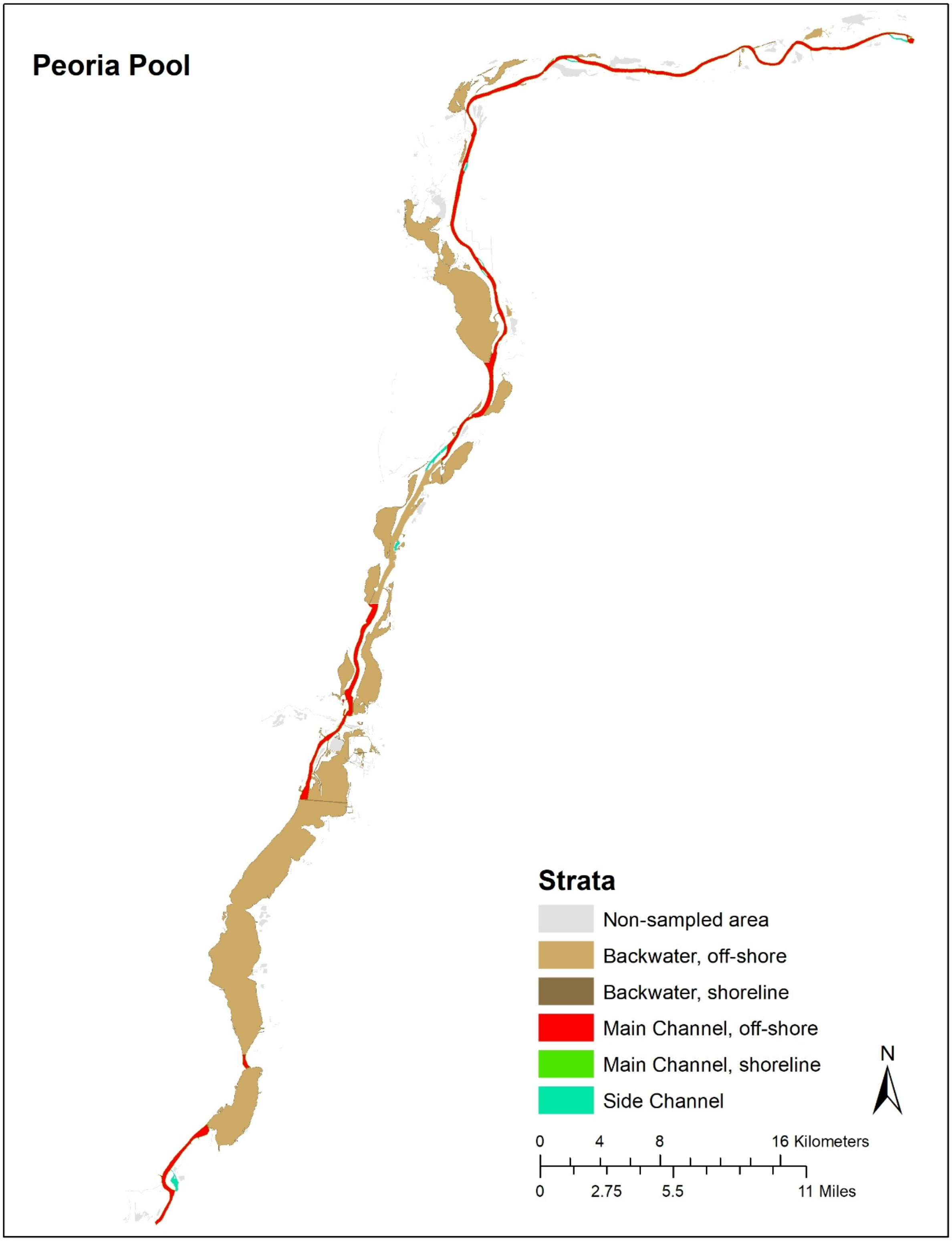

Figure 6. *Peoria Pool sampling strata from the 1989 coverages modified with 2019 field observations.*