
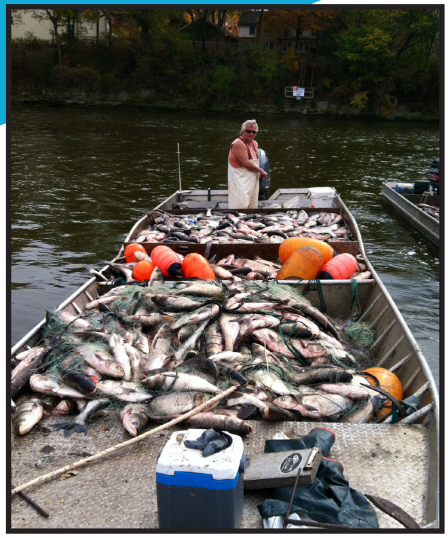


2019

Asian Carp Regional Coordinating Committee

United States Coast Guard
U.S. Department of Homeland Security

USGS science for a changing world

Illinois Natural History Survey
Prairie Research Institute

Illinois Department of Natural Resources

SIU Carbondale

Asian Carp Monitoring and Response Plan



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EXECUTIVE SUMMARY

This Asian Carp Monitoring and Response Plan (MRP) was prepared by the Monitoring and Response Workgroup (MRWG) and released by the Asian Carp Regional Coordinating Committee (ACRCC). It is intended to act as an update to previous MRPs, and present up-to-date information and plans for a host of projects dedicated to preventing Asian carp from establishing populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. Specifically, this document is a compilation of 26 individual project plans, each of which plays an important role in preventing the expansion of the range of Asian carp, and in furthering the understanding of Asian carp location, population dynamics, behavior, and the efficacy of control and capture methods. Each individual plan outlines anticipated actions that will take place in 2019, including project objectives, methodology, and highlights of previous work.

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

1) **Detection:** Determine the distribution and abundance of Asian carp to guide response and control actions.
2) **Manage and Control:** Prevent upstream passage of Asian 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 Asian carp population status, test these procedures through exercises, and implement if necessary.

The plans included in this 2019 MRP build upon considerable work completed since 2010. Selected highlights of past efforts are presented below, grouped by primary objective. For a more detailed accounting of the results and findings of previously completed work, please refer to the 2018 Asian Carp Interim Summary Report, presented as a companion document to the 2019 MRP.

HIGHLIGHTS OF PAST EFFORTS

Detection Projects

- A total of 423,516 fish representing 73 species and six hybrid groups were sampled above the Electric Dispersal Barrier, including 2,388 Banded Killifish (state threatened species) from 2010-2018.
- From 2009-2019 multi-agency efforts have found and removed one Bighead Carp and one Silver Carp upstream of the Electric Dispersal Barrier. Details of these captures can be found on www.asiancarp.us.
- No small (< 6 inches) Asian carp were captured upstream of Starved Rock Lock and Dam in 2017. One juvenile Silver Carp was found in Starved Rock Pool in 2018.
- Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2018 indicate that some reproduction occurs above Starved Rock Lock and Dam in some years,

but the contribution of these fish to the population and the frequency of such occurrences remain uncertain.

- Fixed and random sampling below the Electric Dispersal Barrier has resulted in the collection of over 346,000 fish to date. No Asian carp have been captured in Brandon Road or Lockport Pools. The detectable Asian carp population front is near River Mile 281, approximately 46 miles from Lake Michigan.
- 81 juvenile Silver Carp in LaGrange and Peoria pools were collected and tagged for acoustic telemetry studies in 2018. Studies of previously tagged juvenile Silver Carp measured mean distance traveled per week and residency time in different habitat types.
- There were three positive detections for Asian carp eDNA above the Electric Dispersal Barrier during sampling in 2018.
- 34 Bighead Carp have been removed from urban ponds since 2011.

Manage and Control Projects

- Through Illinois Department of Natural Resources (IDNR) and U.S. Fish and Wildlife Service (USFWS) harvest efforts, over 3,880 tons of Asian carp have been removed from the Illinois Waterway (IWW) below the Electric Dispersal Barrier since 2010. This tonnage consists of 93,469 Bighead Carp; 868,967 Silver Carp; and 6,216 Grass Carp.
- Telemetry study of tagged fish has observed no upstream passage past the Electric Dispersal Barrier. Five lock passages were observed in the Upper IWW.
- The estimated mean density of Asian carp in Dresden Island Pool has declined by 96% between 2012 and 2018. Ongoing MRWG removal efforts through contracted commercial fishing in the upper IWW likely play an important role in this observed decline.
- No Asian carp have been captured during sampling in the Des Plaines River. This spans the collection of 11,830 fish since 2011.
- Modifications to the configuration and deployment of nets and electrofishing arrays were explored, resulting in new deployment techniques that increase the coverage of net deployments and electrofishing arrays.
- Law enforcement conservation officers have completed inspections of multiple aquaculture facilities and numerous fish trucks. These and other efforts have resulted in citations 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 Asian carp range and population status, and prescribes appropriate response actions based on particular changes to population status on a pool-by-pool basis.

In addition to these highlights, a brief summary of work anticipated to be completed in 2019 is provided below for each project, grouped by primary objective. For a detailed description of project plans, methods, and objectives, refer to each project's individual plan for 2019.

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

Seasonal intensive monitoring is a modified continuation of Fixed and Random Site Monitoring Upstream of the Dispersal Barrier and Planned Intensive Surveillance in the CAWS. These events will be planned for the spring season (Weeks of June 3rd and 11th) and the fall season (Weeks of September 9th and 16th). This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers at sites in the CAWS upstream of the Electric Dispersal Barrier System. 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 Electric Dispersal Barrier, 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 known as Operation Silver Bullet. The two-week event in the fall will focus on the North Shore Channel/Chicago River. The Seasonal Intensive Monitoring provides a spatially and temporally adequate assessment of relative abundance and distribution of Asian carp in the CAWS upstream of the Electric Dispersal Barrier System.

Strategy for eDNA Sampling in the CAWS

In 2019, the project will focus on targeted areas in the CAWS upstream of the Electric Dispersal Barrier. Based on the results of other recent eDNA studies, samples will be focused on side channel and backwater areas that have longer retention times for eDNA.

Telemetry Monitoring Plan

This project uses ultrasonically tagged Asian carp and surrogate species to assess whether tagged fish challenge and/or penetrate the Electric Dispersal Barrier 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 Asian carp and surrogate species movements.

USGS Real-time Telemetry in Support of Management

This project uses real-time acoustic telemetry receivers for detecting bigheaded carp and surrogate fishes. 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.

USGS Illinois River Catch Database and Visualization

This project focuses on incorporating all data from removal and monitoring efforts into a centralized database to facilitate data standardization, accessibility, sharing, and analysis to aid in Asian carp removal efforts, evaluations of management actions, and population modeling (e.g.

SEAcarP model). An initial version of the Illinois River Catch Database (ILRCdb) was deployed for partner testing in FY 2018, but further development and maintenance are needed to expand database and visualization functionality, and ensure continued data availability, standardization, quality, security, and accessibility. In 2019 efforts will focus on meeting partner agency data needs, continuing to expand database function, and developing new data visualization tools.

Young-of-year and Juvenile Asian Carp Monitoring
This project gathers and analyzes data on young-of-year and juvenile Asian carp within the CAWS, lower Des Plaines River, and Illinois River with the intent to determine the uppermost waterway reaches where young Asian carp are successfully recruiting. Small fish will be collected by other detection projects, and the data provided by these projects will be synthesized to meet project objectives.

Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier
This project continues to evaluate non-Asian carp fish behavior between the narrow arrays where the highest-voltage electrical field is located to determine the species of fish present in and directly adjacent to the barrier system. The overarching goal of this multifaceted monitoring program is to quickly identify any change in fish community species composition, fish abundance, or fish behavior near the Electric Dispersal Barrier; especially with regard to small size classes of fish. This project will provide insights on fish behavioral responses to biological, abiotic, and anthropogenic changes within the system. Additionally, fish surveys supporting barrier clearing operations will be performed "as necessary" to support barrier maintenance needs or requests from the ACRCC.

Distribution and Movement of Small Asian Carp in the Illinois Waterway
This project specifically targets sampling of young Asian carp in areas not sampled by standard monitoring and gear evaluation projects in an effort to better understand distribution and habitat use by young Bighead and Silver Carp in the IWW. Specific areas include backwaters, isolated pools, main channel border, side channels, side channel borders, marinas, or tributary mouths, habitats known to function as nursery areas for young Asian carp. Movement patterns of young Asian carp will be determined with acoustic telemetry. Sampling will occur during the months of March through November. Sampling effort will be distributed between Dresden Island, Marseilles, and Starved Rock pools.

Larval Fish Monitoring in the Illinois Waterway
Larval fish sampling will occur at weekly to biweekly intervals at 7 sites located in the Illinois and Des Plaines rivers downstream of the Electric Dispersal Barrier from April to October. Additional sampling will occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee rivers to assess potential Asian carp spawning in tributaries of the Illinois River. Sampling may occur more frequently during periods when Asian carp eggs and larvae are likely to be present (e.g., May - June, during periods of rising water levels, or shortly after peak flows). Observation of Asian carp eggs or larvae will help to inform other agencies of the upcoming likelihood of

capturing young-of-year Asian carp. Analyses of the spatial and temporal distribution of Asian carp eggs and larvae will aid in identifying spawning locations, environmental factors associated with successful reproduction, and factors contributing to Asian carp recruitment.

Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam

This project continues previous work by Southern Illinois University (SIU) that has intensively monitored movement and density of Asian 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 Asian carp in the Illinois River. Because these surveys have been ongoing since 2012, they provide valuable long-term trends. Work comparing surrogate fish movements to bigheaded carps' movement will begin early in 2019 and is estimated to continue through 2020.

The native fish passage study continues work begun by SIU in 2017. Water chemistry data and fin ray chemistry data for native fish species have been collected in 2017 and 2018 and will continue through spring 2019. Previously collected data are being analyzed to assess differences among rivers and species, and a classification model has been developed to enable determination of whether fish captured upstream of Brandon Road Lock and Dam had previously been in the Illinois or Kankakee rivers based on fin ray chemistry data and therefore must have passed upstream through Brandon Road Lock and Dam.

Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry

During 2019 this project will focus on maintaining an adequate number of tagged juvenile carp, and will also implement a new smaller tag, which will allow for the monitoring of smaller (younger) fish. Telemetry will be used to observe juvenile Asian carp behavior, with a focus on (1) determining movement distance and direction; (2) determining macrohabitat selection; (3) determining whether movement is related to water temperature or flow conditions; (4) creating the home range estimate for juvenile Asian carp; (5) determining the age of tagged fish; and (6) performing genetic analysis to identify behavior differences between Bighead Carp, Silver Carp, and hybrids. Sampling and telemetry monitoring will take place from March through November.

Des Plaines River and Overflow Monitoring

This project performs monitoring for Asian carp within the Des Plaines River using electrofishing and gill netting. The Des Plaines River runs parallel to the CAWS and represents a possible route for Asian carp to bypass the Electric Dispersal Barrier 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 Asian carp in the Des Plaines River to determine the threat posed to the CAWS by Asian carp populations within the Des Plaines River. A minimum of three sampling events will be conducted in 2019, focusing on capturing the spawn and post-spawn time frames.

Alternative Pathway Surveillance – Urban Pond Monitoring
This project provides monitoring and removal efforts for Asian carp that may have been unintentionally stocked in urban fishing ponds in the Chicago Metropolitan Area. Monitoring with eDNA technology and conventional gears (electrofishing and netting) has previously occurred in local fishing ponds and has detected and removed Asian carp (possibly introduced as contaminants in shipments of stocked sport fish). During 2019, urban pond sampling will be based upon photographic evidence of Asian carp or reports from credible sources.

Multiple Agency Monitoring of the Illinois River for Decision Making
This project will utilize a standardized sampling approach to 1) effectively monitor Asian carp population demographics (i.e., presence/absence, distribution, and abundance) and 2) assess native fish communities throughout pools of the Illinois River below the Dispersal Barrier that may be adversely impacted by Asian 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.

MANAGE AND CONTROL PROJECTS

USGS Telemetry Database and Analyses in Support of SEAcarP
A centralized database for telemetry receiver and fish transmitter data has been developed, deployed, and released internally to partners for functionality testing and feedback. The FishTracks database, hosted and maintained by the U.S. Geological Survey (USGS) at the Upper Midwest Environmental Sciences Center, includes both real-time and stationary acoustic telemetry receiver location data, and bigheaded carp tagging and detection data from partner agencies. Efforts during 2019 will focus on enhancing database reporting capabilities, and developing a model of inter-pool movement of Asian carp to support the SEAcarP model.

Underwater Acoustic Deterrent System Deployment in the CAWS
This project aims to deploy and further evaluate underwater acoustic deterrence as a system that is relatively low cost, quick to deploy, stimulates a behavioral response in bigheaded carps, and once deployed, has minimal effects on humans or vessel navigation (although, additional data will be collected to confirm this). An underwater acoustic deterrence system has been requested to be deployed as a supplement to the Electric Dispersal Barrier when the barrier must be taken offline for maintenance. In 2019, an underwater acoustic deterrence system will be deployed downstream from the Electric Dispersal Barrier, and the impacts of its use on native fish, humans, and vessel navigation will be evaluated.

USGS Geospatial Support for Unified Fishing Method
This project intends to build a greater understanding of Asian carp response to the Unified Fishing Method. The project will equip all crews involved in Unified Fishing Method events with reliable GPS tracking equipment, and some crews will use real-time tracking technology. Following events, all geospatial data will be collected and analyzed in conjunction with fish

tracking data. These combined datasets will allow for the evaluation of how fish react to boat movements over time throughout Unified Fishing Method events. This analysis will be used to identify methods for optimizing the use of the Unified Fishing Method, including successful techniques, and locations where Asian carp tend to concentrate during fishing efforts. The project will work to develop a standardized process for post-processing geospatial data, allowing for the rapid and accurate creation of key data outputs.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Contracted Commercial Fishing Below the Dispersal Barrier uses contracted commercial fishers to reduce Asian carp (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) numbers and monitor for their expansion in the upper Illinois River and lower Des Plaines River downstream of the Electric Dispersal Barrier. By decreasing Asian carp numbers, we anticipate reduced migration pressure towards the barrier lessening the chances of Asian Carp gaining access to upstream waters in the CAWS and Lake Michigan. Monitoring for upstream expansion of Asian carp should help identify changes in the leading edge, distribution, and relative abundance of Asian carp in the IWW.

Mass Harvest and Removal Techniques

This project aims to (1) identify areas with high densities of bigheaded carps using low-cost sonar; (2) characterize the habitat that hosts those aggregations; and (3) develop efficient methods for removing such aggregations. The project has previously developed effective methods for identifying high-density groups of Asian carp using low-cost sonar and determining which habitat types are most conducive to these aggregations. In 2019, efforts will focus on evaluating the best methods for removing large groups of Asian carp, with a focus on testing different styles of pound nets and trap nets. The project will also aim to gain an understanding of the optimal times to remove large groups of Asian carp based on location and time of year.

Asian Carp Population Modeling to Support an Adaptive Management Framework

This project continues to build upon past efforts to develop a Spatially Explicit Asian carp Population (SEAcarP) model that includes spatial components (i.e., river pools) of the Illinois River system. During 2019, the model will be updated with the most recent available data, including data from other basins, such as the Mississippi River and Ohio River basins. Pool-to-pool movement modeling will be updated based on new techniques. Sensitivity analyses will be performed on the model to determine which model inputs require additional data and research. Statistical catch models will be used to estimate vulnerability to fishing based on fish size, exploitation rates, and immigration to the upper Illinois River. The model will be used to inform adaptive management efforts to control Asian carp populations in the Illinois River.

Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEAcarP)

This project aims to provide a more robust telemetry dataset to inform Asian carp movement within the SEAcarP model. During 2019, this project will focus on maintaining a sufficient number of tagged small and juvenile Asian carp to better understand their movement tendencies, including interactions with dams and macro-habitat selection. Tagging efforts will focus on Starved Rock Pool. The results of this study will be incorporated in the SEAcarP model to better evaluate the risk posed by movement of small and juvenile Asian carp, and to better understand the habitat selection of juvenile Asian carp as they mature.

Asian Carp Demographics

Management of invasive Asian 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 Asian carp demographic data over time and space will support managing and monitoring efforts of these species within the Illinois River.

Evaluation of a Modular Electric Deterrent Barrier

This project is exploring the use of a modular, portable electric barrier to prevent fish passage. This modular barrier is the first of its kind, as all previous electric barriers intended to control fish movement have been permanently deployed in a fixed location. The ability to deploy a modular system would allow managers to schedule deployments in numerous settings. Potential uses for the modular barrier include blocking Asian carp access to specific habitats, acting as an electroshock barrier to support capture efforts, and acting as a temporary replacement for the Electric Dispersal Barrier System when the system must be shut down for maintenance. During 2019 the modular barrier will be deployed in both test ponds and the field to evaluate its effectiveness.

Alternative Pathway Surveillance in Illinois – Law Enforcement

This project created a more robust and effective enforcement component of IDNR's invasive species program by increasing education and enforcement activities at bait shops, bait and sport fish 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 and the collar counties, with eventual expansion statewide and potentially across state boundaries.

Asian Carp Enhanced Contract Removal Program

This new program will reduce the abundance of Asian carp in the Illinois River Peoria Pool through controlled and contracted fishing efforts. This program will be implemented by issuing fishing contracts to those commercial fishers willing to target Asian carp in Peoria Pool and fulfill contractual obligations of selling, reporting, transporting, and fishing in the identified area. This project will also provide critical information about population densities of Asian carp through time in the Peoria Pool as well as the Illinois River system to guide management efforts. This project will also 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 the delivery 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 for coordinating between agencies and communicating with the general public. In 2019, 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

This Asian Carp Monitoring and Response Plan (MRP) was prepared by the Monitoring and Response Workgroup (MRWG) and released by the Asian Carp Regional Coordinating Committee (ACRCC). It builds upon previous MRPs and presents plans for an integrated suite of projects dedicated to preventing Asian carp from establishing populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. The MRP also seeks to reduce the impact of Asian carp in the Upper Illinois Waterway (IWW) and further reduce the risk of spread toward Lake Michigan. Specifically, this document is a compilation of 26 individual project plans, each of which plays an important role in preventing expansion of the range of Asian carp, and in furthering the understanding of Asian carp location, population dynamics, behavior, and the efficacy of control and capture methods. Each project outlines anticipated actions that will take place in 2019, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2019 Asian Carp Action Plan (Action Plan) which outlines funding and actions taken through the USEPA's Great Lakes Restoration Initiative. The Fiscal Year 2019 Action Plan contains a portfolio of more than 60 high-priority strategic activities for implementation in the coming year. The Action Plan serves as a foundation for the work of the ACRCC 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 Asian 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 ACRCC is to prevent the introduction and establishment of Asian carp into the Great Lakes, the work of the MRWG is clearly focused on Bighead Carp and Silver Carp in the Illinois Waterway. For the purpose of this MRP, the term 'Asian 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 'Asian carp' moniker. The MRWG believes that techniques showing promise with Bighead and Silver carp are also techniques that are appropriate for successful surveillance, management/control and response for Grass and Black Carps.

This MRP builds on prior plans developed for 2011 – 2018. More specifically, it is intended to identify actions to be taken in 2019, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2019 MRP takes advantage of information gathered since 2011 to provide the most robust suite of activities to accomplish MRWG objectives. The MRP is a living document and will be revisited at least annually. All MRPs to date, including the 2019 MRP, have benefitted from the review of technical experts and MRWG members, including, but not limited to, Great Lakes states' natural resource agencies and non-governmental organizations. Contributions to this document have been made by several state and federal agencies.

This 2019 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 2018 Asian Carp Monitoring and Response Plan Interim Summary Report (ISR), has also been completed by the MRWG. The 2018 ISR presents a summary of each individual project's activities, results, findings, and recommendations for future actions. Similar to the MRP, the ISR functions as a living document, and will be updated at least annually. Collectively, the 2019 MRP and 2018 ISR present a comprehensive accounting of the projects being conducted to prevent establishment of Asian 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 2019 MRP have been grouped in accordance with the core strategic objectives of the MRWG. These core objectives consist of:

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

The projects that will address each of these core objectives are presented in the table on the next page.

Detection
Seasonal Intensive Monitoring in the CAWS
Strategy for eDNA Sampling in the CAWS
Telemetry Monitoring Plan
USGS Real-time Telemetry in Support of Management
USGS Illinois River Catch Database and Visualization
Young-of-year and Juvenile Asian Carp Monitoring
Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System
Distribution and Movement of Small Asian Carp in the Illinois Waterway
Larval Fish Monitoring in the Illinois Waterway
Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam
Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
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Manage and Control
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Asian Carp Demographics
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Alternative Pathway Surveillance in Illinois – Law Enforcement
Asian Carp Enhanced Contract Removal Program
Response
Upper Illinois Waterway Contingency Response Plan

In addition to these project plans that directly address the primary objectives of the MRWG, additional key information is provided in this MRP as appendices. Additional project plans for 2019 are provided in the following locations:

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

Key background information on Asian carp that may be useful to field crews or the general public is provided in Appendices B through L. Appendix L provides descriptions and pictorial displays of common fishing gears that are used during Asian carp field projects.

CURRENT STATUS

Detection projects have informed agency actions and development of the 2019 MRP.

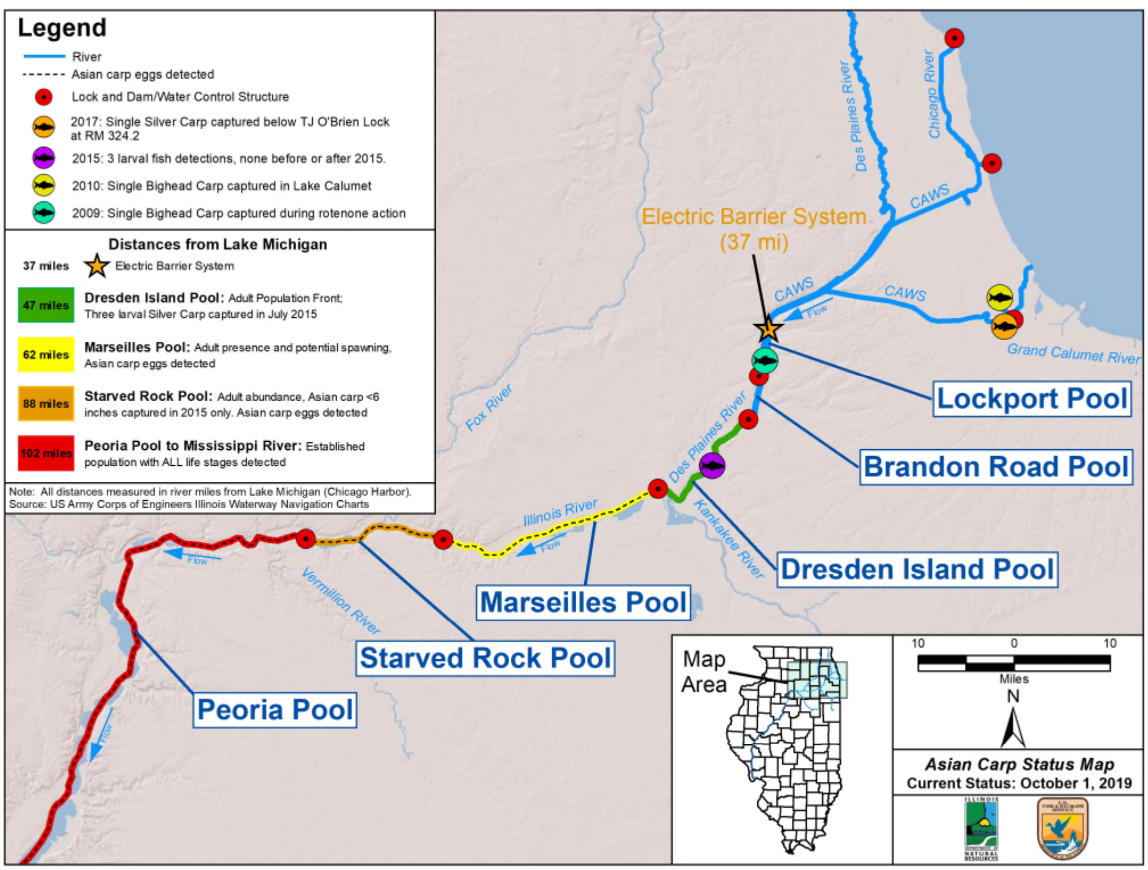
No Asian carp have been detected in Lake Michigan, and no Asian carp have been collected between Brandon Road Lock and Dam and the Electric Dispersal Barrier since detection efforts were intensified in 2010. Acoustic-based surveys performed in 2018 suggest relative abundance (measured as mean Asian carp density based on hydroacoustic surveys) has been reduced by an estimated 96% from 2012 levels. This is an improvement on prior estimates demonstrating relative abundances of adult Asian 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 Asian 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 Asian carp population on a pool-by-pool basis and evaluation of potential change of risk of Asian carp approaching the electric barrier system, in addition to traditional techniques.

The management and control aspects of this MRP have also contributed to observations of 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, the resulting eggs travel downstream with prevailing flow direction, away from Lake Michigan. Data suggest that any eggs produced in these pools experience mortality or drift downstream to hatch in the Peoria and LaGrange pools, below the Starved Rock Lock and Dam. Larval and juvenile Asian carp are present in the Lower IWW, which acts as the source of Asian carp throughout the IWW. The MRWG believes that small Asian carp (< 6 inches) and those larger Asian carp found above the Starved Rock Lock and Dam have immigrated to the Upper IWW from the Lower IWW. Because Asian carp are produced only 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 Asian carp further downstream in the lower Illinois River can be effectively accomplished. The 2019 Asian 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 in the IWW. The graphic below summarizes our current knowledge of the status of Bighead Carp and Silver Carp developed through ongoing monitoring and historical accounts. This graphic also denotes 2015 as the baseline year to evaluate progress in future years. 2015 was selected as a baseline year for two primary reasons: (1) the MRWG and ACRCC concurred that the establishment of a baseline year would aid in evaluating the status of Asian carp in the Upper

IWW; and (2) 2015 was characterized by significant monitoring and detection efforts, which led to a thorough understanding of the Asian carp population status, and allowed MRWG to reach a consensus on Asian carp status in 2015. The results of ongoing surveillance and management efforts, including those through December 2018, have been used to establish the current status of Asian carp populations in each pool of the IWW, as described below:

- **Lake Michigan:** No established Asian carp population.
- **Chicago Area Waterway System (CAWS):** No established Asian carp population.
- **Lockport Pool:** No established Asian carp population.
- **Brandon Road Pool:** No established Asian carp population.
- **Dresden Island Pool:** Adult Asian carp population front. Larval Asian carp observed in 2015, and have not been observed since (source of larval carp unknown).
- **Marseilles Pool:** Adult Asian carp consistently present, and Asian carp eggs have been detected. Spawning has been observed.
- **Starved Rock Pool:** Abundant Asian carp present, and Asian carp eggs have been detected. Early life-stage Asian carp (<6 inches total length) were observed in 2015, and have not been observed since.
- **Peoria Pool (downstream to confluence with Mississippi River):** Established population with all life stages of Asian carp present.



Specific highlights from the 2018 field season include:

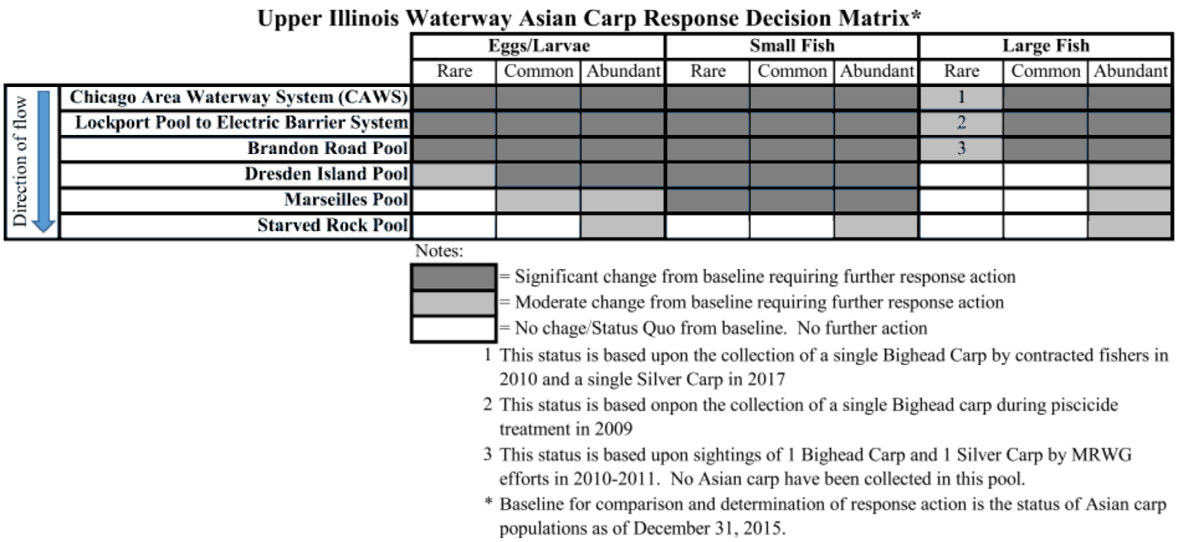
- No Asian carp collected or observed in Lake Michigan or Brandon Road Pool.
- No small Asian carp detected in Upper IWW.
- 1.37 million pounds of Asian carp removed from Upper IWW.
- Successfully implemented Chinese Unified Fishing Method, at multiple locations in Marseilles and Dresden Island pools.

In 2019, detection efforts below the electric dispersal barrier will be standardized to provide even more Asian carp and ecologically relevant fisheries data. In combination, and as part of a scientifically based approach, a multi-agency monitoring framework will be used. The methods and protocols will be based upon a large river monitoring effort. Additional additive measures may be applied for specific purpose, subject to agency and MRWG review. Those standard methods are found within the fisheries portion of the Long Term Resource Monitoring element of Upper Mississippi River Restoration Program. Those methods can be found here: https://www.umesc.usgs.gov/reports_publications/ltrmp/fish/fish_methods.html

In addition to these direct findings, data collected via surveillance and management projects have been used to develop a model that combines the propensity of Asian carp to move, the effects of harvest, and basic biological parameters such as age, growth, and condition of Asian carp. The model will serve 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 Asian carp removal efforts in the upper river. However, a long term strategy bolstered by market-driven forces to remove Asian carp in the lower IWW that could lead to much greater removal than can be accomplished in the Upper IWW would lead to increased risk reduction. Achieving these greater removal levels requires working in concert with economic forces in the lower Illinois Waterway. Based on the results of modeling work, the amount of fish required to be removed exceeds current funding available to agencies implementing removal projects. Additional commercial fishing pressure is needed to achieve a significant increase in harvest of Asian carp from the Lower Illinois River and other large rivers of the US. This increased harvest is necessary to minimize the risk of Asian carp arrival at the Electric Dispersal Barrier. To that end, ACRCC efforts are evaluating appropriate business models and planning efforts to enable such business development. Although the upstream removal strategy may have less impact on the Asian 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 Asian carp cannot be established and sustained in the relatively near future.

Despite current activities, Asian carp populations may respond in unpredictable ways. Based on this realization, this MRP is designed to respond to unforeseen developments in carp detections.

The MRWG will continue to characterize the populations in a pool by pool fashion in the Upper IWW and identify collections that suggest changes to Asian 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 Asian carp in the Upper IWW. The MRWG has selected 2015 as an appropriate baseline for comparisons in future years as noted above. The Response Decision Matrix presented below outlines the conditions which trigger response actions on a pool-by-pool basis.



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 emergency action is not observed. The contingency plan was successfully implemented on June 24, 2017 with the capture of a Silver Carp 9 miles from Lake Michigan. The event "Operation Silver Bullet" applied the framework of the contingency plan, which continued for 2 weeks until actions were ceased following the guidelines set forth in the contingency response plan.

The Contingency Response Plan provides a communication framework and response procedure that may be utilized for any planned event or in response to findings that may elevate the risk of Asian carp passage into Lake Michigan. These events may include scheduled or unscheduled maintenance of the Electric Dispersal Barrier System or the opening of hydraulic connections which may allow the passage of Asian 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 has been documented in the Lower Illinois River as early as 1991. Grass Carp are not as numerous as Bighead and Silver Carp in the Upper IWW pools of Starved Rock, Marseilles, and Dresden Island, but Grass Carp are found in Brandon Road Pool and the CAWS. Since Grass Carp is a large-bodied cyprinid species similar to Silver Carp and Bighead Carp, MRWG believes methodologies included in this MRP and developed based on past work will also provide sufficient gears, methods for detection, and removal techniques for Grass Carp. Most of the Grass Carp detected by MRWG efforts in the CAWS are triploid individuals, which means that they are infertile. However, diploid (fertile) Grass Carp have been detected. There is no record of reproducing Grass Carp in Lake Michigan, but reproducing populations have been noted in Lake Erie. Grass Carp are removed by monitoring and removal crews when encountered unless tagged and identified for further research. The 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 March 2018, 17 individual fish have been documented in the Illinois River. Commercial fishermen reported catching 10 Black Carp in the Illinois River during 2018. An additional nine Black Carp were reported caught in Horseshoe Lake, Illinois. In response to these reports, USFWS performed a sampling event in Horseshoe Lake, and removed two additional Black Carp. Reproduction has been documented in the middle-Mississippi river, but little is known about its success or the general distribution of the species. Illinois Department of Natural Resources (IDNR) has imposed a bounty/reward of $100 for Black Carp captured from large rivers of the Midwest in hopes of increasing data on this species, 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 fact sheet 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 2019 MRP outlines three broad categories of implementing objectives as a guide for both **short-term** and **long-term** objectives for preventing the spread of Asian carp to Lake Michigan:

1) Detection
2) Manage and Control
3) Response

Specific Objectives for the 2019 MRP

1. Aggressive Asian carp **detection** in each of the pools upstream of Starved Rock to enable effective response to any detection before invaders challenge the Electric Dispersal Barrier, CAWS, or further threaten the Great Lakes.
2. Provide aggressive Asian carp surveillance in the Des Plaines and Kankakee rivers outside of the Upper IWW to enable effective response to any detection before invaders challenge the Electric Dispersal Barrier, CAWS, or further threaten the Great Lakes.
3. Continue to evaluate and review the Contingency Response Plan to assure efficacy and appropriate response. In 2019, convene at least one table-top exercise with agency and identified natural resource professionals to provide insights into effective response techniques, review technologies available, and incorporate lessons learned into an updated Contingency Response Plan and the 2020 MRP.
4. Manage and control Asian carp populations between Starved Rock Lock and Dam and Brandon Road Lock and Dam, with the goal of removing at least 1.1 million pounds of Asian carp during 2019.
5. Continue implementing discipline-specific work groups to improve coordination within and among agencies, and to advise the MRWG about detection technique development, possible efficiencies, acoustic techniques/evaluations, strategy development, or to identify 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 management and control efforts in the future (2019 and beyond).
7. Assess/review technology development (tools) for field deployment in 2019 as a pilot (e.g. modular electric deterrent barrier). In order to identify key new technologies, strategies for implementing ones under development are necessary. Agency and sub work groups will be formed to implement and evaluate this pilot with the goal to realize additional effectiveness or additional efficacy of existing projects. Such pilots will be reviewed for possible implementation in the 2020 MRP. Discipline-specific workgroups, agencies, and researchers will recommend findings to MRWG co-chairs. Co-chairs will work with ACRCC representatives for concurrence and further review of potential tools.
8. Encourage business development to increase harvest of Asian carp in the lower IWW from approximately 4 million pounds in 2016 to 8 million pounds by 2019.

9. Establish additional management of the Lower IWW through contract fishing. During 2019, an enhanced contracted fishing program will be established. The initial program will have a goal of removing 4.5 million pounds of Asian carps through contracting with any legally licensed Illinois commercial fisher. The program will seek a contract worth 10 cents per pound after the fisher sells the fish, no caveats for purpose of those sales will exist save a minimum sale value of 7 cents per pound. This model may be expanded other Illinois River pools in the future based upon success.
10. To remain diligent with outreach and law enforcement activities to discourage other pathways of movement and introduction of Asian Carp.

MRWG Work Groups

Discipline-specific work groups will be formed to assist in developing the most informed Monitoring and Response Plans in the future. Work groups may also be useful to focus expertise for further evaluation, assist in decision making, or otherwise provide MRWG Co-chairs, agencies, and ACRCC with insights as technical experts on a range of subjects. Expected work groups for 2018 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 ACRCC needs.

2019 Work Group	Lead/Agency
Contingency Planning	Matt Shanks/USACE
Removal	Justin Widloe/ILDNR
Hydroacoustic Assessments	Dave Coulter/SIU
Telemetry	Brent Knights /USGS
Modeling	Jahn Kallis/USFWS
Behavioral Deterrent Technologies	Aaron Cupp/USGS
Monitoring	Jim Lamer/INHS, Nathan Lederman/ILDNR

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

It is important to note that the short-term strategic vision laid out below is dependent on continued funding at levels similar to 2018 funding received. It is crucial that the necessary funds are available to continue 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 Asian carp range, population dynamics, and behavior.

Detection

- Ensure sufficient surveillance effort through standardized multi-agency monitoring is deployed throughout the IWW, Des Plaines and Kankakee rivers to inform management and control, or response needs. This includes:
  - Adult fish assessment
  - Small fish assessment
  - Larval/egg assessment
  - Population changes and movements

Manage and Control

- Remove Asian carp from between Starved Rock Lock and Dam and Brandon Road Lock and Dam to reduce upstream migratory pressure at the leading edge of the population.
  - Reduce the estimated biomass of Asian carps in the Dresden Island Pool by an additional 50% from the biomass observed in 2015.
  - Reduce the estimated biomass of Asian carps in the Marseilles Pool by an additional 25% from the biomass observed in 2015.
  - Reduce the estimated biomass of Asian carps in the Starved Rock Pool by an additional 25% from the biomass observed in 2015.
- Prevent the movement into or sustained presence of Asian carp between the Brandon Road Lock and Dam and the Lockport Lock and Dam.
  - Link between detection and response actions
- Use existing and newly developed techniques to maximize annual removal efforts of more than 1 million pounds annually.
  - Contracted harvest
  - Agency efforts
  - Telemetry to enhance removal
  - Strategically deploy the Unified Method
  - Establish hydroacoustic steering committee to advise MRWG and ACRCC for enhanced understanding of technique.
- Utilize technical expertise and recommendations provided by discipline-specific workgroups to determine whether algal attractants, complex noise generation, and use of CO2 to herd fish can be effectively incorporated into MRWG actions.
  - If the answer is no or is ambiguous, consider removing techniques that show limited demonstrable effectiveness from future MRPs and MRWG actions.
  - Develop standardized methods for evaluating ongoing research efforts, including set decision points for continuing or stopping research efforts, and recommended timelines for including regulatory input and evaluations.
- Evaluate ongoing management efforts to measure the effectiveness of management actions, adjust activities to improve effectiveness and adapt to future changes.

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

- Assist in developing an enhanced market for Asian carps in the lower three pools of the Illinois River by 2019.
  - Use established business development techniques to provide guidance and information to agency, industry, and entrepreneurs to improve ability of business establishment and success.
    - This market would build upon the existing commercial fishery in Illinois that can harvest as much as 6 million pounds of Asian carp annually from the Illinois River.
  - Increase harvest by expanding the commercial fishery to 8 million pounds by 2019 and 15 million pounds of Asian carp annually by 2022.

Response

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

Long-Term (5+-year) MRWG Strategic Vision: 2022 and beyond

Detection

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

Manage and Control

- Sustain management and control effort of Asian carp with continued population reduction as baseline 2015 levels in Dresden Island Pool suggest.
- Provide guidance to minimize Asian carp populations in the Upper IWW with no impacts on native fish or mussel populations, human health and safety, recreational use, or industrial uses of the waterway.
- Dynamic economic business strategy in place in the lower IWW to remove 20-50 million pounds of Asian carp annually.
- Support development of management and control strategies in other river basins, as requested.

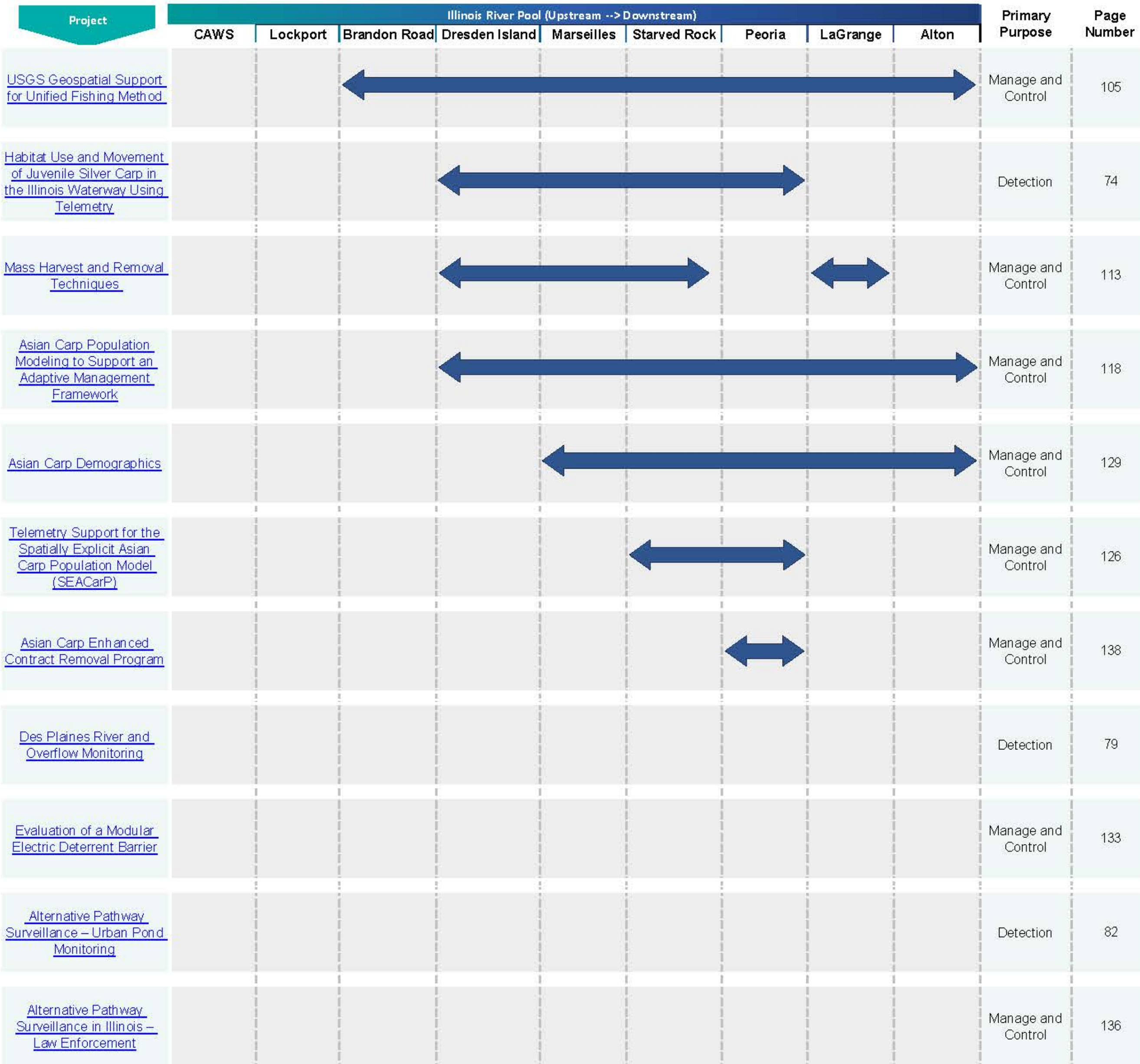
Response

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

PROJECT LOCATIONS

In an effort to more clearly depict the geospatial scale and focus of the projects included in the MRP, the MRWG has prepared a project location cross-walk. This cross-walk is intended to be used 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	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	LaGrange	Alton	Primary Purpose	Page Number
	Illinois River Pool (Upstream --> Downstream)										
Seasonal Intensive Monitoring in the CAWS	↔									Detection	18
Strategy for eDNA Sampling in the CAWS	↔	↔								Detection	27
Telemetry Monitoring Plan	↔	↔	↔	↔						Detection	31
USGS Real-time Telemetry in Support of Management	↔	↔	↔	↔	↔	↔				Detection	42
USGS Illinois River Catch Database and Visualization	↔	↔	↔	↔	↔	↔				Detection	45
Young-of-year and Juvenile Asian Carp Monitoring	↔	↔	↔	↔	↔	↔	↔	↔	↔	Detection	51
Multiple Agency Monitoring of the Illinois River for Decision Making	↔	↔	↔	↔	↔	↔	↔	↔	↔	Detection	86
USGS Telemetry Database and Analyses in Support of SEACarP	↔	↔	↔	↔	↔	↔	↔	↔	↔	Manage and Control	94
Underwater Acoustic Deterrent System Deployment in the CAWS		↔								Manage and Control	99
Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary		↔	↔	↔						Detection	54
Upper Illinois Waterway Contingency Response Plan		↔	↔	↔	↔	↔				Response	141
Contracted Commercial Fishing Below the Electric Dispersal Barrier		↔	↔	↔	↔	↔				Manage and Control	109
Distribution and Movement of Small Asian Carp in the Illinois Waterway		↔	↔	↔	↔	↔	↔			Detection	58
Larval Fish Monitoring in the Illinois Waterway			↔	↔	↔	↔	↔	↔		Detection	62
Zooplankton as Dynamic Assessment Targets for Asian Carp Removal (Appendix A)			↔	↔	↔	↔	↔	↔	↔	Not Applicable	A-1
Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon			↔	↔	↔	↔	↔	↔	↔	Detection	18


Project
Illinois River Pool (Upstream --> Downstream)
CAWS
Lockport
Brandon Road
Dresden Island
Marseilles
Starved Rock
Peoria
LaGrange
Alton
Primary Purpose
Page Number
USGS Geospatial Support for Unified Fishing Method
Manage and Control
105
Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
Detection
74
Mass Harvest and Removal Techniques
Manage and Control
113
Asian Carp Population Modeling to Support an Adaptive Management Framework
Manage and Control
118
Asian Carp Demographics
Manage and Control
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Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEACarP)
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Asian Carp Enhanced Contract Removal Program
Manage and Control
138
Des Plaines River and Overflow Monitoring
Detection
79
Evaluation of a Modular Electric Deterrent Barrier
Manage and Control
133
Alternative Pathway Surveillance – Urban Pond Monitoring
Detection
82
Alternative Pathway Surveillance in Illinois – Law Enforcement
Manage and Control
136

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

Kevin Irons, Matt O'Hara, Justin Widloe, Rebekah Anderson, Nathan Lederman, Seth Love (Illinois Department of Natural Resources), Andrew Mathis, Eric Hine (Illinois Natural History Survey)

Participating Agencies: Illinois Department of Natural Resources (lead); Illinois Natural History Survey, US Fish and Wildlife Service, US Army Corps of Engineers, and Southern Illinois University (field support); US Coast Guard (waterway closures when needed), US Geological Survey (flow monitoring when needed); Metropolitan Water Reclamation District of Greater Chicago (waterway flow management and access); and US Environmental Protection Agency and Great Lakes Fishery Commission (project support).

Pools Involved: CAWS

Introduction and Need:

Detections of Asian carp eDNA upstream of the Electric Dispersal Barrier in 2009 initiated the development of a monitoring plan using boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the barrier. In addition, random area sampling began in 2012 in order to increase the chance of encountering Asian carp in the CAWS beyond the designated fixed sites. Based on the extensive sampling performed upstream of the Electric Dispersal Barrier from 2010 through 2013 (682 hours of electrofishing, 445.8 km (277 mi) of gill/trammel net, 2.2 km (1.4 mi) of commercial seine hauls) and only one Bighead Carp being collected in Lake Calumet in 2010, fixed site and random area sampling effort was reduced upstream of the barrier to two Seasonal Intensive Monitoring (SIM) events from 2014-2017. During SIM on June 22nd, 2017, one (1) Silver Carp was captured in a trammel net in Little Calumet River. This capture prompted two weeks of intensive sampling (Operation Silver Bullet) in Lake Calumet, Calumet River, Calumet Harbor, and Little Calumet River. During Operation Silver Bullet, crews from IDNR and contracted commercial fishers, USACE, and USFWS conducted 95.25 hours of electrofishing (378 transects), set 74 km (46 miles) of trammel/gill netting (388sets), and fished 1-pound net and 7 trap nets for 61 net nights. The electrified paupier expended 24-person hours with 6 hours of sampling effort (32 transects, 15 miles). An estimated 2,054-person hours were allocated for the field operations of this event. Across all locations and gears, 22,156 fish representing 52 species and 6 hybrid groups were collected. No Bighead or Silver Carp were captured or observed during the operation.
Based on the extensive effort and results of Operation Silver Bullet and that no Bighead or Silver Carp were captured during that event or two SIM events in 2018, fixed site and random area sampling upstream of the Electric Dispersal Barrier will continue as two SIM events from 2014-2019. This reduced effort upstream of the Electric Dispersal Barrier will allow for increased monitoring efforts downstream of the barrier. The increase in sampling downstream of the Electric Dispersal Barrier will focus sampling efforts on the leading edge of the Asian carp population, which will serve to reduce their numbers in this area thus mitigating the risk of individuals moving upstream towards the Electric Dispersal Barrier and Lake Michigan by way

of the CAWS. Results from SIM upstream of the Electric Dispersal Barrier will contribute to our understanding of Asian carp abundances in the CAWS and guide conventional gear or rotenone rapid response actions designed to remove Asian carp from areas where they have been captured or observed.

Objectives:

(1) Remove Asian carp from the CAWS upstream of the Electric Dispersal Barrier when warranted.

(2) Determine Asian carp population abundance through intense targeted sampling efforts at locations deemed likely to hold fish.

Status:

SIM is a modified continuation of Fixed and Random Site Monitoring Upstream of the Electric Dispersal Barrier and Planned Intensive Surveillance in the CAWS.

Methods:

A variety of gears will be used during SIM, including pulsed DC-electrofishing, trammel and gillnets, deep water gill nets, Fyke nets, a commercial seine and Great Lake pound nets to capture and remove any Asian carp present in areas where eDNA has been found to accumulate. The goal is to complete 150 electrofishing runs and 150 net sets (trammel/gill nets, deep water gill nets) during each two-week event.

Electrofishing Protocol:

All electrofishing will use pulsed DC current and include 1-2 netters (two netters preferred). Locations for each electrofishing transect will be identified with GPS coordinates. Electrofishing transects should begin at each coordinate and continue for 15 minutes in a downstream direction in waterway main channels (including following shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Electrofishing boat operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat. Common Carp will be counted without capture and all other fish will be netted and placed in a tank where they will be identified and counted, after which they will be returned live to the water. Schools of young-of-year (YOY) Gizzard Shad < 152.4 mm (6 inches) long will be subsampled by netting a portion of each school encountered and placing them in a holding tank along with other captured fish. Due to similarities in appearance and habitat use YOY Gizzard Shad will be examined closely for the presence of Asian carp and enumerated. Crew leaders should fill in as much information on the data sheets as possible for each station/transect and record the location for the start of each run with GPS coordinates (decimal degrees).

Seasonal Intensive Monitoring in the CAWS

Netting Protocol:

Contracted commercial fishers will be used for net sampling at fixed and random sites and nets used will be large mesh gill nets that are 3 meters (10 feet) deep x 91.4 meters (300 feet) long in bar mesh sizes ranging from 88.9-108 mm (3.5-4.25 inches). Locations for each net set will be identified with GPS coordinates. Most sets will be of short duration and include driving fish into the nets with noise (e.g., plungers on the water surface, pounding on boat hulls, or revving tipped up motors). Though longer duration sets, particularly in Lake Calumet, may also be incorporated. In an effort to standardize netting effort, short duration sets will be 15- to 20-minutes long and "pounding" will extend no further than 137.2 meters (450 feet) from the net. Captured fish will be identified to species and enumerated. Locations of net sets should be recorded with GPS coordinates (decimal degrees). An IDNR biologist will be assigned to each commercial net boat to monitor operations and record data.

Fixed and Random Area Sites Upstream of the Electric Dispersal Barrier* - *(weeks of June 3rd and September 9th)

The sampling design includes intensive electrofishing and netting at five fixed sites and four random site sampling areas (Figure 1). Random area sampling will exclude areas of the waterway designated as fixed sites. Random sites will be generated with GIS software from shape files of designated random site areas and will be labeled with latitude-longitude coordinates in decimal degrees.

Upstream Fixed Site Descriptions and Effort - A description of fixed site locations and sampling effort targets is summarized below. The duration of each electrofishing run will be 15 minutes and length of each net set will be 182.9 meters (600 feet).

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 miles).

Site 3 – Chicago Sanitary Ship Canal (CSSC) and South Branch Chicago River from Western Avenue upstream to Harrison Street ~6.4 km (4 miles).

Site 4 – North Branch Chicago River and North Shore Channel from Montrose Avenue north to Peterson Avenue ~3.2 km (2 miles).

Site 5 – North Shore Channel from Golf Road north to Wilmette Pumping Station ~3.2 km (2 miles).

Seasonal Intensive Monitoring in the CAWS

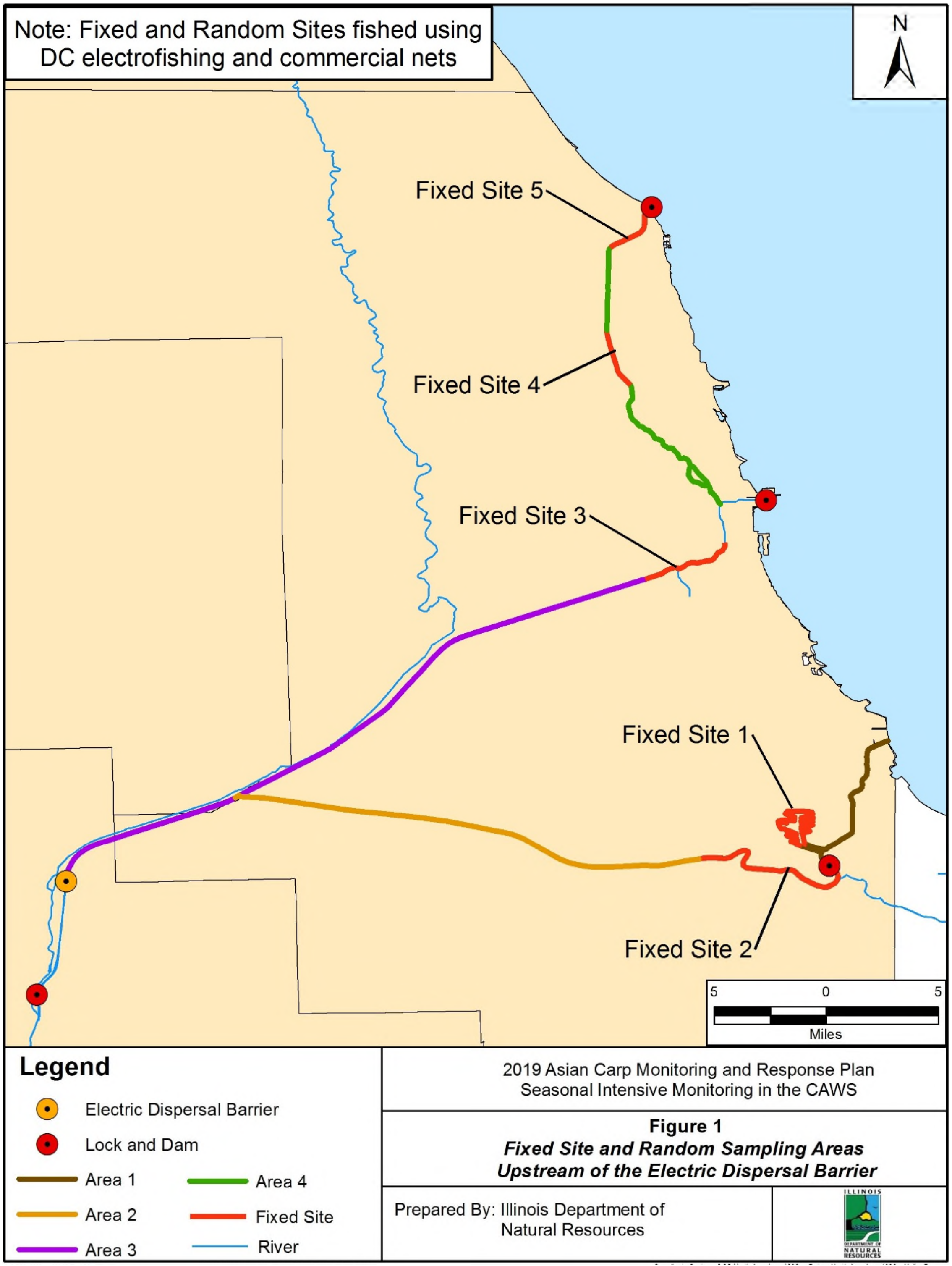

Figure 1. *Fixed site and random site sampling areas for electrofishing and commercial netting upstream of the Electric Dispersal Barrier.*

Seasonal Intensive Monitoring in the CAWS

Upstream Random Site Sampling Area Descriptions and Effort

A description of random sampling areas and sampling effort targets is summarized below. As with fixed sites, the duration of each electrofishing run will be 15 minutes and length of each net set will be 182.9 meters (600 feet). Four random areas have been identified to facilitate coordination with fixed site sampling (Figure 1).

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 Electric Dispersal Barrier

Area 4 – North Shore Channel (between Fixed Site 4 and 5), North Branch Chicago River, and Chicago River

Lake Calumet, Calumet River and Random Area Sites Upstream of the Electric Dispersal Barrier - *(week of June 1th)*

Lake Calumet

Prior to sampling, crews will set Great Lake pound nets at the entrance to Lake Calumet to prevent fish immigration/emigration (Figure 2). This will, however, be contingent on water conditions as flows in and out of Lake Calumet prevented pound nets from being set in 2014. Commercial seining will occur in the north section for two days, then in the south section for one day (Figure 2).

Commercial gill/trammel nets and deep water gill nets will be fished in Lake Calumet, Calumet Connecting Channel and Calumet River. Gill and trammel nets will be set for short duration and will have fish driven into the nets with noise as described above. Deep water gill nets may be set for longer duration. They will be well marked with buoys when left unattended, with IDNR law enforcement officers securing the area. Agency electrofishing crews will operate throughout the monitoring event. Samples will be collected 15 minutes at a time, enumerating catches of fish netted. Electrofishing may also be used in conjunction with commercial fishers to move fish into nets. In conjunction with sampling efforts in Lake Calumet and the Calumet River, electrofishing and gill/trammel netting will also take place at four random site sampling areas throughout the CAWS upstream of the Electric Dispersal Barrier as mentioned above (Figure 1).

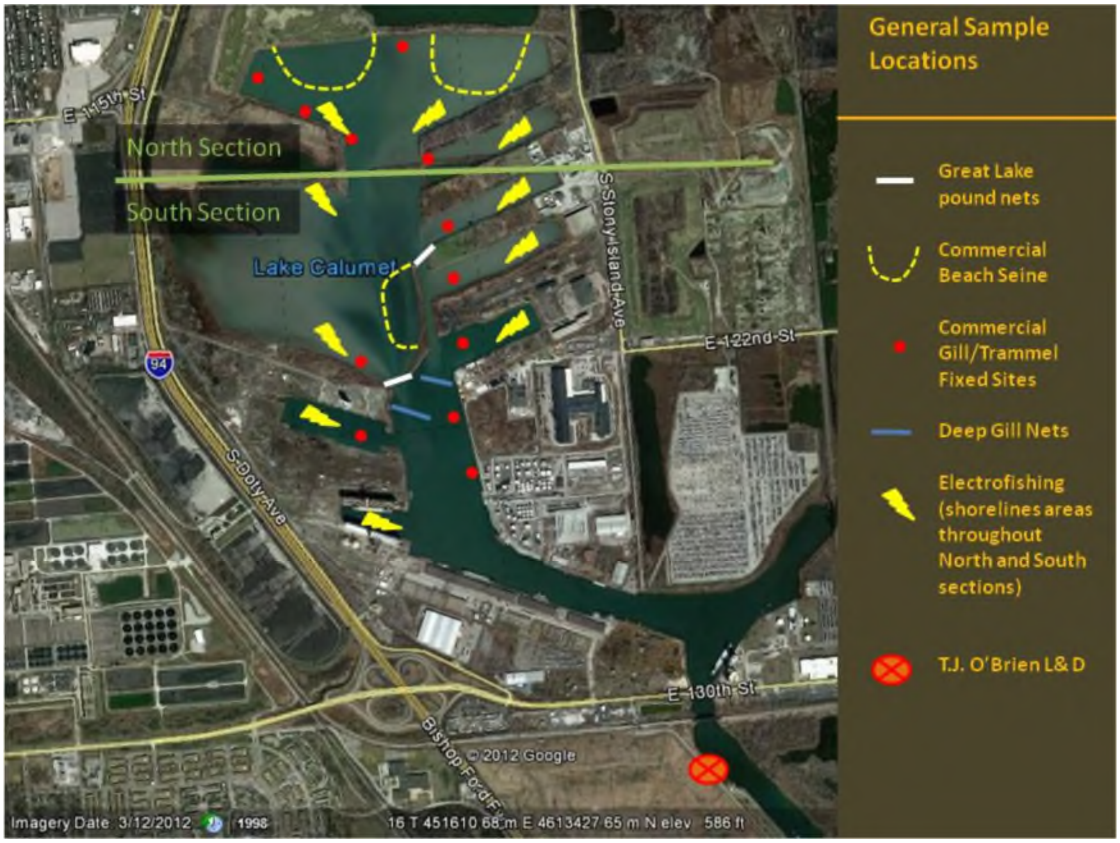

Figure 2. *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

North Shore Channel, Chicago River and Random Area Sites Upstream of the Electric Dispersal Barrier **-** *(week of September 16th)*

North Shore Channel

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). Teams will begin at the upper and lowermost site boundaries and work toward the middle. Each team of two electrofishing boats and one net boat will work together to set nets across the channel and drive fish to nets with electrofishing and noise from "pounding" on the hull of boats and revving trimmed up motors. Each team will set three nets across the channel at intervals of 457.2 to 731.5 meters (500 to 800 yards) apart, after which electrofishing and noise to drive fish will occur between the nets. The net closest to the outer site boundary will then be pulled and reset 457.2 to 731.5 meters (500 to 800 yards) closer to the site center and the process repeated. 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.

Seasonal Intensive Monitoring in the CAWS

Chicago River and South Branch Chicago River/Bubbly Creek

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). During this time net boats will set deep water gill nets (IDNR will provide one 9.1 meters (30 feet) deep gill net for each net boat) in areas off of the main navigation channel. Nets will be set for short duration and attended at all times. Noise from "pounding" on the hull of boats and revving trimmed up motors will be used to drive fish into the nets. Electrofishing boats will also be used to drive fish into the nets. When sampling in these areas is complete crews will travel down river and sample eight barge slips and backwater areas in the South Branch Chicago River near Bubbly Creek (Figure 3). Barge slip sampling will have a block net set at the entrance of each 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 net may be set midway within longer slips to sample them more effectively. In conjunction with sampling efforts in the North Shore Channel and Chicago River, electrofishing and gill/trammel netting will take place at four random site sampling areas throughout the CAWS upstream of the Electric Dispersal Barrier as mentioned above (Figure 1). For all SIM activities accurate sampling time will be recorded with all fish identified to species. GPS coordinates (decimal degrees) will be taken at the location of all net sets and at the beginning of electrofishing runs. Grass Carp will be kept and put on ice for transfer to Dr. Greg Whitledge (SIU) for ploidy analysis. Any Bighead Carp or Silver Carp collected will immediately be reported to the Operations Coordinator and/or Law Enforcement who will bring a cooler to secure fish. GPS location, time, and specific gear will be recorded as accurately as possible (mesh size, type, depth). Any Asian carp will be transferred to Dr. John Epifanio, with tissues shared among research agencies as per the 2018 MRP. 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.

2019 Sampling Schedule:

<u>Spring Event</u>

Week of June 3: Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of June 10: Lake Calumet, Calumet River and random area sites upstream of the Electric Dispersal Barrier

<u>Fall Event</u>

Week of September 9: Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of September 16: North Shore Channel, Chicago River and random area sites upstream of the Electric Dispersal Barrier

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

Seasonal Intensive Monitoring in the CAWS

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

Participating Agency: U.S. Fish and Wildlife Service (Midwest Fisheries Center (Lead) and Carterville Fish and Wildlife Conservation Office, Wilmington Sub-Station)

Location: Chicago Area Waterway System (CAWS)

Pools Involved: CAWS, Lockport

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 Asian carp from establishing in the Great Lakes. Environmental DNA (eDNA) has been used as a surveillance tool to sample for the genetic presence of Bighead Carp and Silver Carp in the CAWS since 2009. The goal of using eDNA in the CAWS was and still is to apply a monitoring tool that has a much lower false negative (fail to detect eDNA that is present) rate than other monitoring methods, such as electroshocking and gill netting, which have a very high false negative rate when animals are present in very low abundance (Darling and Mahon 2011). 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. To maintain vigilence above the Electric Dispersal Barrier, eDNA has been collected at four regular monitoring sites. Sampling was deployed twice per year 2014-2015, and was reduced to once per year in 2016 and 2017. Sampling returned to twice per year in 2018 and will be conducted similarly in 2019. Since 2014, eDNA results are no longer consdidered a trigger for any kind of response, which will continue in 2019.

Objective:

(1) Sample Asian carp DNA in targeted areas of the CAWS to maintain vigilence above the Electric Dispersal Barrier.

Status:

Sampling for eDNA in the CAWS above the Electric Dispersal Barrier has been conducted since 2009. In 2013 equipment decontamination and separation protocols were implemented. Then in 2014, improved DNA markers were deployed, and in 2015 the processing methodology switched from filtering to centrifugation. Together, these improvements have made for more sensitive and specific eDNA results. For example, in 2015 and 2017, there were zero positive eDNA samples in the CAWS, and in 2016 there was a single sample positive for both species' DNA. Since 2014, 1,958 eDNA samples have been collected above the Electric Dispersal Barrier. Of these, 34 have been positive for Silver Carp DNA, and 3 have been positive for Bighead Carp DNA. 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 reflect that only one Silver Carp was captured alive in 2017, and one Bighead Carp was captured alive in the CAWS in 2010. As of 2013, all response actions to eDNA results were terminated, and there will not be any response actions based on eDNA results this year. Beginning in September 2017, changes were made to the distribution of eDNA samples collected in the CAWS based on lessons learned deploying eDNA in other carp-infested rivers such as the Wabash and Upper Mississippi Rivers. Extra emphasis was put on slack-water and off-channel areas, which have been demonstrated to be more effective in recent eDNA studies. Most notably, changes were made to add samples in the areas of Bubbly Creek and Goose Island, and near the Chicago Lock. Additionally, more barge slips were sampled and all thalweg samples were relocated to shorelines or other off-channel areas, based on results of eDNA studies in other rivers where DNA has been shown to be moved quickly downstream in the thalweg. In October 2018, sample numbers were increased slightly and concentrated even more heavily in off-channel areas.

eDNA sampling below the Electric Dispersal Barrier has been adapted to information obtained through the MRP. In 2014, eDNA samples were collected below the barrier as part of a calibration study, which ultimately lead to the program switching from filtering to centrifugation. In 2015, eDNA monitoring below the Electric Disperal Barrier began as part of a project to refine the use of eDNA in the Illinois Waterway. eDNA samples were collected along a gradient of Asian carp densities across several pools to see if the eDNA results reflected the population gradient. Indeed, a greater proportion of positive samples occurred in areas of high carp density and reflected the decreasing Asian carp population up river towards the Electric Dispersal Barrier. Efforts for eDNA sampling in 2016 were modified in response to the detection of juvenile Asian carp in Starved Rock Pool and evidence that small fish may be entrained in barge junction gaps. The USFWS increased eDNA surveillance to monitor for potential movement of these juveniles upstream into pools with low or zero carp density: Lockport Pool, Brandon Road Pool, the upper portion of Dresden Island Pool, and part of the Kankakee River above the Wilmington Dam. Only a single eDNA sample was positive in Brandon Road Pool, which was in agreement with other fish detection efforts that indicated there were no changes in Asian carp populations in Lockport and Brandon Road Pools, and lack of dispersal upriver by the large cohort of juvenile fish observed the year prior. The lack of detections in Dresden Island Pool were likely due to the fact that samples were collected in the upper portion of the pool, where there are very few fish collected outside of Rock Run Rookery and the flow is dominated by water coming from the pool above, which is devoid of carp and their eDNA.

In 2017, efforts below the Electric Dispersal Barrier were expanded to the entire Dresden Island Pool, but limited to that single pool. In 2017, eDNA results closely reflected the carp density gradient present in the pool. Hotspots of positive eDNA detections consistently reflected the areas where the most Asian carp were captured by traditional gears in the months surrounding eDNA sampling events. The habitat location of eDNA detections also shifted noticeably between sampling events and was consistent with the predicted movment of Asian carp responding to changing water level conditions observed in systems where their movements were tracked through telemetry. Since 2015, nearly 1600 samples have been collected below the Electric Dispersal Barrier in various pools. With several years of eDNA data reflecting the Asian carp desity gradient, eDNA sampling below the barrier ceased and no samples were collected in 2018 nor will be in 2019.

Methods:

In 2019, to maintain vigilance within the CAWS and enhance other ongoing monitoring efforts, the CAWS will be sampled for Bighead Carp and Silver Carp eDNA in a method similar to the October 2018 event. Specifically, nearly all samples will target off-channel areas, where fish and their DNA may collect. Since DNA shed in this high flow area will be rapidly transported downstream, areas with significant flow will not be sampled. The goal of using eDNA in the CAWS is to apply a monitoring tool that has been shown in literature to have a much lower false negative (fail to detect eDNA that is present) rate than other fishing methods when animal abundance is low. Use of more than one observation method increases monitoring strength in any system, including the CAWS. The distribution of samples is more concentrated than in years past, encompassing targeted areas of the Chicago Sanitary and Ship Canal (CSSC), North and South Branches of the Chicago River, the Chicago River, the Little Calumet River, the Calumet River, and Lake Calumet that have negligible flow, or depositional bank areas where eDNA may accumulate. Based on research conducted in the Upper Mississippi River (Mize et al., in reivew) sampling will occur in the spring, when Asian carp have been shown to congregate in off-channel habitats in other systems, and in the late fall when discharge and water temperatures are low. There will be no eDNA sampling conducted below the Electric Dispersal Barrier in 2019.

Similar to previous years, sample collection and processing methods will follow the most up to date Quality Assurance Project Plan (QAPP) (http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf). The state of Illinois will be notified of the results from the CAWS following our Communication Protocol (see QAPP) after sample processing is complete. Results (CAWS) will then be posted online and made available to the MRWG in the 2019 Interim Summary Report.

2019 Schedule:

Week 1: April/May – 300 samples

Week 2: October – 300 samples

Strategy for eDNA Sampling in the CAWS

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 an annual interim report and project plans will be updated for annual revisions to the MRP.

References:

Darling, J.A. and A.R. Mahon. 2011. From molecules to management: adopting DNA-based methods for monitoring biological invasions in aquatic environments. Environmental Research 111:978-988. https://doi.org/10.1016/j.envres.2011.02.001.

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Telemetry Monitoring Plan

Participating Agencies: USACE (lead); IDNR, SIUC, USGS, MWRDGC & USFWS (support)

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

Overview:

The Asian Carp Regional Coordinating Committee (ACRCC) developed the Asian Carp Control Strategy Action Plan to protect the Great Lakes from Silver Carp (*Hypophthalmichthys molitrix*), and Bighead Carp (*H. nobilis*), present in the Illinois Waterway (IWW). As part of this Action Plan, the ACRCC formed a sub-committee, the Asian Carp Monitoring and Response Work Group (MRWG), to develop and implement a Monitoring and Response Plan (MRP) for these invasive species. The plan consists of a series of scientific studies to detect, monitor, and respond to the invasion before reproducing populations of Silver and Bighead Carp become established in Lake Michigan. Telemetry has been identified as one of the primary tools to assess the efficacy of the Electric Dispersal Barrier system as well as investigating inter-pool movements and invasion front habitat use.

In summer 2010, an acoustic telemetry sampling strategy was initiated using a network of acoustic receivers supplemented by mobile surveillance to track the movement of tagged Bighead Carp, Silver Carp and associated surrogate fish species in the area around the Aquatic Nuisance Species Electric Dispersal Barriers in the Chicago Sanitary and Ship Canal (CSSC) and Upper IWW. This network has been maintained to date through a partnership between the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (USFWS), the Metropolitan Water Reclamation District of Greater Chicago (MWRD), Southern Illinois University of Carbondale (SIUC), the U.S. Geologic Survey (USGS), and the Illinois Department of Natural Resources (ILDNR) as part of the MRWG's monitoring plan.

Introduction:

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 by a mobile hydrophone unit to collect information from acoustic transmitters (tags) implanted into free-swimming Bighead Carp, Silver Carp and surrogate species. Acoustic receiver coverage within the Upper IWW is primarily focused at the Electric Dispersal Barriers with secondary coverage surrounding lock and dams and emigration routes such as tributaries and backwater areas. In 2015 a total of 31 stationary receivers were placed from the confluence of the Cal-Sag to Dresden Island Lock and Dam and up the Kankakee River near the Wilmington Dam. In 2016, receiver coverage was added to the Dresden Island Pool (n=2) and Kankakee River (n=3) while a positioning receiver array within the Electric Dispersal

Barriers was removed (n=8). In 2017, the network was similar to 2016 except the receivers upstream of the Wilmington Dam on the Kankakee River were removed. Additionally, SIUC, USGS, and USFWS deployed a total of nine receivers to the Dresden Island Pool and one receiver to the Brandon Road Pool in support of alternative projects. The data from these receivers were collated with the USACE database to supplement our understanding of fish movements within the study area. Figure 1 at the end of this report displays the full receiver network inclusive of partner agency receivers within the USACE study area. The 2018 network was similar to the 2017 receiver network. The only differences were that one receiver upstream of the Electric Dispersal Barrier was removed due to a barge strike and no suitable replacement location was determined. The other change occurred in the Dresden Island Pool where a receiver was not placed in the backwater behind Moose Island due to excessive vegetation preventing accessibility and limiting detection capability.

This telemetry monitoring project has provided valuable insights to resource managers about fish behavior at the Electric Dispersal Barriers, movement between navigation pools, and Bighead and Silver Carp movement within the Dresden Island Pool. The telemetry program has demonstrated a high efficacy for the Electric Dispersal Barriers 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 Electric Dispersal Barrier system. 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 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 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 of this data has been utilized by resource managers and response agencies to improve harvest efforts and make informed decisions on the Electric Dispersal Barrier operations and maintenance.

However, as more research is conducted on Bighead and Silver Carp and the Upper IWW ecosystem; information gaps are being identified and monitoring plans continue to be refined. Acoustic telemetry monitoring was the only continuous monitoring project for the Electric Dispersal Barrier system in 2018. 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. Acoustic telemetry can also be used to address several information gaps that have been identified at the leading edge of the invasion front. Specific habitat use by Bighead and Silver Carp has not been detailed by existing monitoring projects for locations difficult to access by boat such as wetland shelves. Additionally, movement patterns and habitat use have not been characterized in relation to water quality parameters that may vary both spatially and temporally within the system. Acoustic telemetry can be used to help address these issues by modifying the goals and objectives of the plan in coordination with other MRWG activities. Finally, the USACE telemetry plan can also be adjusted to incorporate advancements in technology with the goal of streamlining data collection and reporting results. 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 Electric Dispersal Barrier on tagged fish in the Chicago Area Waterways (CAWS) and Upper IWW using ultrasonic telemetry. The goals and objectives for the 2019 season have been identified as:

Goal 1: Monitor the Electric Dispersal Barrier system for upstream passage of large fishes and assess risk of Bighead and Silver Carp presence (Barrier Efficacy);

- **Objective:** Monitor the movements of tagged fish in the vicinity of the Electric Dispersal Barrier system using receivers placed immediately upstream and immediately downstream of the barriers.
- **Objective:** Utilize deployed real-time receiver locations upstream of strategic control points and develop a reporting protocol to provide quality-controlled information to resource managers in an efficient and timely manner.
- **Objective:** Support barrier efficacy and mitigation studies through supplemental data collection of tagged fish in the vicinity during controlled experimental trials.

Goal 2: Identify lock operations and vessel characteristics that may contribute to the passage of Bighead 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 (N=8) placed above and below and within each lock.
- **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 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 and Silver Carp have been captured and relay information to the population reduction program undertaken by IDNR 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.
- **Objective:** Work with SIUC on an expanded surrogate comparison study in the middle IWW.
- **Objective:** Act as active participant in the telemetry working group.

Work Plan:

Sample size and distribution – Sample size was selected through review of similar studies, past catch data and expert opinion from the MRWG. In 2010, the workgroup decided that a baseline minimum of 200 transmitters be implanted for telemetry monitoring in the vicinity of the Electric Dispersal Barriers and that this level of tags be maintained as battery life expires or specimens exit the study area. At the conclusion of the 2018 sampling season there were 142 live, tagged fish within the study area with varying expiration dates. Tag implantations will be required in the spring to achieve recommended minimum levels of the sampling size. As in previous years, surrogate species will be used throughout the study area while Bighead and Silver Carp will only be released downstream of the known population front in order to reduce the risk of assisting any upstream advance of the invasive species.

The proposed distribution of tags across the study area is influenced by several factors including the carrying capacity for the receiver network per pool, the increasing focus and attention on the Brandon Road Lock, and available source populations of the target species. Fifty-six of the 62 tags implanted into surrogate fish species within the Lower Lockport Pool will remain active throughout the 2019 calendar year. Of the 62 tags that were implanted in previous years, eight of them have migrated to Brandon Road Pool (three have returned to Lockport Pool in 2018) and 6 of them are likely expelled or the fish carrying them have expired. Previous data suggests that the highest emigration rates occur from the Lower Lockport Pool into Brandon Road Pool due to lock passage and water draw down events that entrain fishes through water control structures at the dam and Lockport Controlling Works spillway. The Lower Lockport Pool is also a critical area for telemetry monitoring efforts. The primary monitoring goal of assessing efficacy of the Electric Dispersal Barrier system is dependent on tag density immediately below the barriers. Increasing the number of deployed tags at this location is warranted to help maintain a minimum level of tag density. An additional 20 tags (Vemco V16-4x-069k-1) are planned for implantation and release within the Lower Lockport Pool. Deployment of these tags will be split between spring and fall to assist in even distribution of the transmitters across the year.

Twelve tags released in the Brandon Road Pool will remain active through the 2019 sampling season. However, 8 tagged surrogates emigrated from Lockport Pool in 2017 and 1 fish has emigrated from Brandon Road Pool to Dresden Island Pool. Three tags that were released in Lower Lockport Pool and immigrated to Brandon Road Pool before the 2018 season have moved back into Lower Lockport Pool during 2018. An additional 34 tags are anticipated for 2019 to achieve a target of 50 active tagged fish within the pool (Table 1). Immigration from the Lockport and Dresden Island pools is expected and will also assist in maintaining elevated transmitter density in the spring and summer months.

There are currently 39 USACE transmitters within Dresden Island Pool that will remain active through 2019 and an additional 27 tags in Dresden Island Pool are set to expire during the later portion of the 2019 calendar year. In an effort to maintain the target goal of 75 tags, and replace transmitters that are set to expire in 2019, 36 transmitters (V13TP-1x-069k-0017m) will be implanted into Asian carp in 2019.

Table 1: *Recommended transmitter implementation for the 2019 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..*

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	10	10	75
Brandon Road/RM286.5	Common Carp	17	17	50
Dresden Island/RM276	Bighead and Silver Carp	36	0	75
Total	-	63	27	200

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 species vary and are considered rare to absent near the Electric Dispersal Barriers. Therefore, in order 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 in the CSSC because "Common Carp are naturalized and widespread throughout the CSSC and Illinois water bodies in general. 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 Asian carp would respond to the dispersal barrier if they were in close proximity to this deterrent." These characteristics could also justify the use of other species such as Smallmouth and Black Buffalo (*Ictiobus bubalus* and *I. niger*), Grass Carp (*Ctenopharyngodon idella*), and Freshwater Drum (*Aplodinotus grunniens*). USACE is partnering with SIUC in 2019 to further understand the differences and similarities between Common Carp and the invasive Bighead and Silver Carps. A total of 50 transmitters have been set aside for SIUC to implant into Common Carp within the middle reaches of the IWW for direct comparison to tagged Bighead and Silver Carp behavior, habitat use, and movement patterns. This research will be reported through SIUC under a separate MRP project title.

Tagging efforts will continue to utilize fish site fidelity to increase the probability of attempted fish passage through the Electric Dispersal Barrier as well as lock and dams. Previous results along with published literature (ACRCC, 2013; Jones and Stuart, 2009) indicate that captured fish display high site fidelity upon release and tend to return to the area of capture. For example, fishes to be released in Lower Lockport Pool will be captured upstream of the Electric Dispersal Barriers and tagged and released downstream. These fishes will have a greater propensity to return to their capture site, hence, challenging the Electric Dispersal Barriers more often. While this technique is encouraged with surrogate species to increase the sample size of barrier challenges, Bighead Carp and Silver Carp will be tagged and released near their capture location. It is important to remove any bias in experimental design when attempting to describe patterns of habitat use and movement.

Tag specifications and Implantation procedure – Tagging efforts will be focused during spring (March – 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 (2012). Adult Bighead and Silver Carp will be collected from the IWW in Dresden Island Pool (RM 271.5 to 286). Surrogate species will be collected from Lockport Pool and Brandon Road Pool (RM 286 to 304). The primary method of capture will be electrofishing; although supplemental gear such as fyke and trammel/gill nets may also be used to harvest fish for tagging. Fish collected will be weighed, measured, and sex will be identified if possible. Water quality parameters such as dissolved oxygen, pH, and conductivity will be taken at each release site using a water quality probe (Pro Plus Instrument, Yellow Springs Inc.) In an effort 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).

In an attempt to reduce the amount of tagged fish losses due to harvesting, all fishes undergoing surgery will also be fitted with an external tag for other agencies. Commercial fishermen and action agencies working with the MRWG will be made aware of the project and will be requested to release any externally marked fishes including Bighead and Silver Carp if they are suitable for release, otherwise they will be requested to save the fish and return it to USACE so we can save the transmitter and tag a replacement fish. No Bighead 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 and Silver Carp captured in Lockport or Brandon Road will be turned over to IDNR for species voucher.

Acoustic Network Array:

Stationary Receivers – A system of passive, stationary receivers (Vemco VR2W and VR2C) are placed throughout the IWW in order to monitor movement of tagged fishes. The receivers log data from tagged fish when they swim within the detection range of the receiver (typically at least one quarter mile from the receiver). Test transmitters will be used to test the detection range of each receiver. VR2W's will be placed from the Dresden Island Lock and Dam (RM 245 of Dresden Island Pool, Illinois Waterway) to the confluence of the Cal-Sag Channel with the CSSC upstream of the Electric Dispersal Barrier system within Lockport Pool (RM 303.5 of Lockport Pool). In some areas, two VR2W's will be placed to increase the detection capability, or to duplicate monitoring efforts in high risk environments (where receivers may be subject to damage or loss). VR2W's will be deployed by attaching receivers to stationary objects (canal walls, mooring cells, lock guide walls) or bottom deployed using a lead line or marked buoy. Vinyl coated steel cable is used to moor all deployments to minimize loss due to vandalism. In the immediate vicinity of the barrier, receivers are placed inside areas of degradation along the canal walls for protection against barge traffic. These receivers are placed immediately downstream of the Romeoville Road Bridge and approximately 1.5 miles upstream of the Demonstration Barrier. At the conclusion of each field season (late November to early December) a minimized network of receivers are 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 Electric Dispersal Barrier; above and below Lockport Lock; above, below and within Brandon Road Lock; and above Dresden Island Lock. Additionally, a receiver will continue to be placed just upstream of the Des Plaines/Kankakee River confluence to monitor residency time of an area where up to 50% of the detections in Dresden Island Pool occur during the normal sampling season. Three other receivers will remain upstream, downstream, and at the location of a temporary Acoustic Deterrent System that will be operating during winter 2018-2019 just below the Electric Dispersal Barrier. 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 2019 (N=27 USACE receivers) with USACE receivers displayed in red, USFWS receivers displayed in orange, and USGS receivers displayed in Green. The priority is to achieve the most coverage (detection capacity) in the immediate vicinity of the Electric Dispersal Barriers with VR2W receivers. To accomplish this, receivers immediately downstream and upstream of the Electric Dispersal Barriers will provide a system that will help USACE biologists monitor and track any fish movement through the Electric Dispersal Barriers. The network will expand throughout the system to track overall movement, and to determine what type of movement occurs from fish negotiating 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.

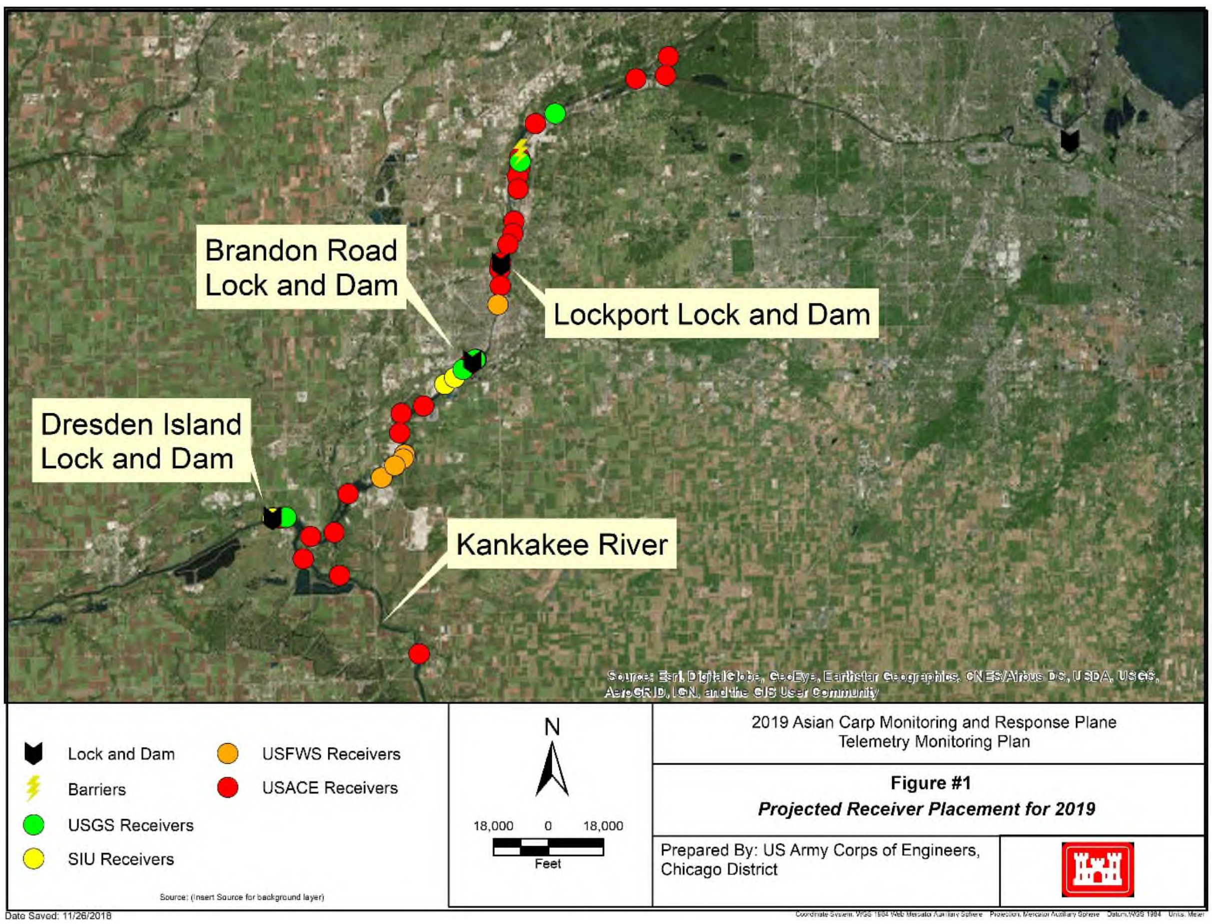

Figure 1: *VR2W receiver network within the Upper IWW and CAWS.*

Receivers will be downloaded bi-monthly to retrieve data for analysis, and for maintenance of the acoustic network (i.e. decrease risk of vandalism, ensure operation of device, check battery life, replacement if necessary). Bi-monthly field visits will also allow for flexibility in receiver position adjustments near the leading edge of the invasion front. Receivers may be downloaded more frequently if needed. An additional sampling trip has been scheduled to download only those receivers within Dresden Island Pool between normally scheduled downloads to increase sampling frequency during spring spawning. All receivers will be downloaded via Bluetooth-USB capability. The software is available free online from the Vemco website (http://www.vemco.com/support/vue_dload_form.php). Water quality parameters (DO, pH, conductivity, and temperature) will be recorded at each station during downloads.

In addition to the receiver network maintained by USACE there will also be continued coordination with other telemetry studies external to USACE. USFWS, SIUC and USGS all maintain a number of receivers throughout the study area outlined here. Data sharing will occur across all agencies to leverage the resources of each agency for a greater benefit to each individual study. The USGS receivers are specifically set up to provide real-time data to a centralized online database. The deployment of these receivers is being coordinated to track fish movements above known invasion fronts and upstream of barriers to fish passage. These locations include the CSSC upstream and downstream of the Electric Dispersal Barriers in Lemont, the Des Plaines River upstream and downstream of Brandon Road Lock and Dam, and within the Kankakee River. This data will supplement the bi-monthly downloads. These receivers allow for reporting and response actions to be completed more rapidly in the event of a fish passage occurrence across a barrier or beyond the known invasion front.

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 and Silver Carp in coordination with IDNR contracted commercial fishermen. In doing so, increased harvest of Bighead and Silver Carp may occur. In addition, the VR-100 will be used to further investigate tags that may cross the Electric Dispersal Barrier or Locks and Dams.

Contingency Measures:

Tagged fish crossing Electric Dispersal Barrier system – As described above, any suspicion (indicated by stationary receiver data) of any tagged fish crossing the Electric Dispersal Barrier system can be confirmed by the mobile tracking unit. This will enable crews to locate the exact location of a fish, instead of the approximation detected by a stationary receiver. USACE leadership, all 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 stationary receiver in the vicinity.

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

Other Relevant Studies:

An ancillary benefit of this project will be the enhancement of the regional capability of fish tracking at a basin scale. This project will complete the IWW basin acoustic receiver network which extends from the Mississippi River to Lake Michigan and will enable cooperating researchers to document large scale movements of Bighead and Silver Carp and other fish species within the system. The information gathered from this system will enhance the understanding of systemic movement in the basin. Additionally, any fish tagged from this effort that disperse outside of the USACE telemetry network detection area have the probability of being detected on another researcher or agency's network. A list of tagged fish and receiver locations will be available to other researchers, and will be registered with the Great Lakes Acoustic Telemetry Observation System (https://glatos.glos.us/) and within the USGS-lead database Fishtracks (https://umesc-gisdb03.er.usgs.gov/Fishtracks/Account/Login?ReturnUrl=%2FFishtracks). Points of contact for other studies in the region using the Vemco acoustic telemetry system include:

- Alison Coulter, Southern Illinois University. Species tagged in Illinois and Mississippi Rivers include: Bighead Carp, Silver Carp, Paddlefish, Shovelnose Sturgeon, Blue Catfish, White Bass, Walleye, Sauger, and Hybrid Striped Bass.
- Rebecca Neeley, USFWS Region 5, Carterville Field Office. Species to be tagged in middle IWW include: Grass Carp. This study began summer of 2016 and will focus on the movement patterns and habitat use of adult Grass Carp.
- Jim Lamer, Western Illinois University. Species tagged include Bighead Carp in the Illinois River. The study is evaluating emerging technology in the field of telemetry.

Telemetry Monitoring Plan

Sampling Schedule: A tentative work schedule is presented below.

March – May 2019	VR2W network inspected and new receivers installed and range tested. Tagging efforts of Bighead and Silver Carp in the Dresden Island Pool and Common Carp in Lockport Pool
ONGOING	VR2W network maintenance, downloads and mobile tracking
Oct – Nov 2019	Tagging of surrogate fish in Lockport Pool
December 2019	Prepare receiver array within the IWW and CAWS for winter months

Reporting of Results

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 and Silver Carp above the Brandon Road Lock. Periodic updates will be given to the MRWG in the form of briefings at regular meetings, and the year-end summary report will be compiled after the 2019 sampling season.

USGS Real-time Telemetry in Support of Management

Brent Knights, Marybeth Brey and Michael Montenero (U.S. Geological Survey, Upper Midwest Environmental Sciences Center); Jim Duncker (U.S. Geological Survey, Central Midwest Water Science Center);

Participating Agencies: USGS, IDNR, USACE, USFWS, Southern Illinois University

Location: Upper Illinois Waterway

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

Introduction and Need:

This project uses real-time acoustic telemetry receivers for detecting bigheaded carp and surrogate fishes. 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 Chicago Area Waterway System with the intent to support decisions on directing (1) removal efforts by contracted fishing and (2) contingency actions. This project supports primary goals and objectives of the MRWG telemetry workgroup in consideration of MRWG objectives. The real-time receivers deployed for this project detect bigheaded carp tagged with acoustic transmitters by agencies as part of other MRP efforts (e.g., USFWS Telemetry to Support the SEAcarP Model; USACE Telemetry Plan, and Southern Illinois University Monitoring Bigheaded Carp Movement and Density in the Illinois River). 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. This work is in direct support of the Contracted Asian Carp Removal Project and Upper Illinois Waterway Contingency Response Plan Project in the MRP.

Objectives:

(1) Provide bigheaded carp detections from existing network of real-time receivers in reaches of the Upper Illinois Waterways above Starved Rock Lock and Dam to biologists directing (1) fish removal to increase effectiveness and efficiency of those efforts and (2) contingency actions in response to aberrant detections of tagged bigheaded carp.

(2) Assess the potential usefulness of additional real-time receiver locations in the Upper Illinois Waterways in consult with IDNR biologists and analysis of existing or new data, to support decisions on removal.

(3) Maintain, deploy or remove real-time receivers in the Illinois River System in consultation with IDNR biologists and data analyses.

Status:

This project was initiated in 2015 and currently includes deployment and maintenance of seven real-time receivers in the Upper Illinois Waterways. An automated alert system for key personnel was established in 2017 for detections of tagged bigheaded carp in strategic locations to alert management agencies and inform contingency actions. USGS makes data from all real-time receivers in the network available online continuously. USGS also monitors, maintains and downloads data from these receivers and provides timely summaries to partners via MRWG monthly updates and the FishTracks telemetry database (FishTracks DB). Data from these receivers is available in FishTracks DB for modeling to estimate movement probabilities needed for population modeling (SEAcarP). USGS deploys and maintains receivers annually as necessary and conducts range testing to establish detection capabilities and limitations. Consultations in 2018 with partner agencies resulted in plans for deployment of 3 additional receivers in the east and west pits of the Hanson Material Services site (for harvest decision support) in Marseilles Pool and one new receiver below the electric dispersal barrier (to inform contingency actions and barrier evaluation). In the Hanson Material Services pits, consultations resulted in a call for one receiver on each side of the culverts separating east and west pits, and another near the entrance from the main channel into east pit. Two new real-time telemetry receivers were deployed in the Upper Illinois Waterway in 2018, one in the west pit of Hanson Material Services and another below the Electric Dispersal Barrier near Romeoville, Illinois.

Methods:

The seven real-time receivers in the Upper Illinois Waterway System will be redeployed (if necessary), maintained, and tested by USGS crews in spring 2019 to ensure that they are working properly. Data access for these receivers will be maintained online at https://il.water.usgs.gov/data/Fish_Tracks_Real_Time/Two (last 24 hours) and https://umesc-gisdb03.er.usgs.gov/Fishtracks/Account/Register (FishTracks database; all data). Real time alerts will be provided via email or text to key personnel as requested by partner agencies. Two new real-time telemetry receivers will be deployed in early spring of 2019 in the Upper Illinois Waterway at the Hanson Material Services site as identified in 2018 consultations with IDNR biologists directing removal efforts. Analyses of catch and detection data will be conducted in 2020 for the receivers in the Hanson Material Services pits to determine effectiveness. If "effective," as determined by IDNR, these receivers will be maintained in the future. We will also conduct analyses of existing data from stationary non-real-time receivers and bigheaded carp catch at several locations typically fished by removal crews (specific sites suggested in 2018 consultations) to determine the potential usefulness of real-time receivers at these sites for informing removal. Location adjustments and new deployments will be made in 2019 as determined by these site-specific analyses and further consultations with the IDNR biologists directing removal efforts and the telemetry workgroup.

2019 Schedule:

- Continue to archive, serve and incorporate data from the real-time network into an email/text messaging alert system, monthly MRWG summaries, and the FishTracks DB database for informing contingency planning and removal efforts (throughout FY2019)

USGS Real-time Telemetry in Support of Management

- Complete annual maintenance, field downloads, and range testing on deployed receivers (by end of FY2019_Q2)
- In coordination with the IDNR and telemetry workgroup, place two additional receivers in Hanson Material Services pits (complete by end of FY2019 Q2)
- Conduct analyses with new and existing telemetry and catch data at sites specified in 2018 consultation with IDNR biologists to optimize the location of real-time receivers to inform removal (complete by end of FY2019 Q3)
- Modify and add receivers to the real-time receiver network to facilitate removal and contingency planning for bigheaded carp as suggested by evaluation analyses and further consultations (complete by FY2019 Q4).

Deliverables:

- Database: Data from real-time receivers incorporated into FishTracks DB
- Analyses: Analyses to evaluate whether catch is related to telemetry detections in areas frequently fished for removal of bigheaded carp.
- Real-time receivers: Maintenance of existing receivers and placement/deployment of new real-time telemetry receivers in the Upper Illinois River at sites recommended previously and as agreed upon by IDNR biologists after evaluations are complete.
- Presentation and report: Presentation to MRWG and annual summary for MRWG Interim Summary Report

USGS Illinois River Catch Database and Visualization

Enrika Hlavacek, Travis Harrison, Brent Knights, and Marybeth Brey, (U.S. Geological Survey, Upper Midwest Environmental Sciences Center)

Participating Agencies: USGS, IDNR, USFWS, USACE

Location: Upper Illinois and Des Plaines River Basins and Chicago Area Waterway System (CAWS), collectively the Upper Illinois Waterway system

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

Introduction and Need:

Contract Asian carp removal and monitoring will continue throughout the Upper Illinois Waterway system as needed for adaptive management to mitigate, control, and contain Asian carp. Incorporating all data from removal and monitoring efforts into a centralized database will facilitate data standardization, accessibility, sharing, and analysis to aid in Asian carp removal efforts, evaluations of management actions, and population modeling (e.g. SEAcarP model). An initial version of the Illinois River Catch Database (ILRCdb) was deployed for partner testing in FY 2018, but further development and maintenance are needed to expand database and visualization functionality, and ensure continued data availability, standardization, quality, security, and accessibility.

In 2019, we will incorporate additional catch and monitoring data into ILRCdb as it becomes available from partners, develop additional database functionality, and finalize data sharing agreements between partners. Further development of the ILRCdb will focus on improved capabilities for spatial and temporal analyses, and interactive visualization of catch data to support Asian carp removal efforts. These improved visualization capabilities include integrating existing Asian carp-related data layers (including catch data) in a visualization tool to help provide a greater understanding of bigheaded carp habitat, particularly to gain a better understanding of the underlying conditions in areas where large removal efforts have been effective. Incorporating environmental variables (such as water discharge, water temperature, and benthic habitat classification layers), and adding tools to identify areas with similar conditions to user-identified areas or areas of large previous harvests will help to further inform removal efforts.

A suite of benthic data have previously been collected for priority areas of the main navigation channel and off-channels backwater areas in the Starved Rock, Marseilles, Brandon Road, and Dresden Island pools of the Illinois River system. These data will continue to be post-processed and distributed as usable GIS layers that can be incorporated into the analyses and interactive data visualization tools described above. Continued development of benthic layers for the Illinois River has further applicability for other Asian carp management efforts, including support for planning applications of the Unified Method, improving HEC-RAS modeling for FluEgg egg drift simulations, and for use in other modeling efforts undertaken with telemetry and hydroacoustic data collected as part of ongoing MRP projects.

Objectives:

(1) Maintain and serve the ILRCdb for partner access to monitoring and removal data from the Illinois River, to include new catch data and demographic data from sampling efforts.

(2) Develop and update functionality of the ILRCdb to ensure that data are secure, easily accessible to partners, and quality assured, and that tools within the ILRCdb are intuitive and easy for partners to use.

(3) Finalize data sharing agreements as memoranda of understanding between participating agencies so that it is clear what data will be shared (i.e. included in the database), how data will be formatted and stored, and how data can be used by participating agencies.

(4) Develop a spatial and temporal analysis tool to provide managers the capability to interactively explore ILRDdb catch data relative to location (i.e. pool/reach of the Illinois River), change through time, and in relation to other environmental factors (e.g. water temperature, discharge).

(5) Create an online, interactive habitat mapping visualization tool for predicting bigheaded carp locations, based on catch data from the ILRCdb, habitat suitability model(s), and water condition indicators, in order to identify areas of similar habitat and environmental conditions and to support decisions on site selection for focused removal efforts.

(6) Collect, process, and distribute high-resolution benthic data (sonar image mosaics, bathymetry, and benthic habitat classifications) for priority management areas of the Illinois River, to be integrated into the visualization tool described in Objective 5. Validation data for previously collected and processed data (from the Brandon Road, Dresden Island, Marseilles, and Starved Rock pools of the Illinois River) will be collected and used as quality control for the development of benthic habitat classification data layers.

Status:

An initial version of the ILRCdb has been developed, deployed, and released to partners for functionality testing and feedback. The database includes Asian carp commercial catch and monitoring data from the IDNR and the USACE. The ILRCdb includes standard data reporting capabilities (e.g. to summarize catch and catch per unit of effort by date and pool), data upload and download applications, and interactive data visualizations (e.g. pie charts, stacked bar graphs, line graphs, and maps). Additional customized data reports requested by partners are being added as they are requested.

Exploration of spatial and temporal data analysis methods using catch data from the ILRCdb have been completed and presented internally for feedback, which included the creation of kernel density maps for each year of catch data by monthly divisions for both the Brandon Road and Dresden Island pools of the Illinois River. These initial kernel density maps and analysis methods will be used to develop an interactive spatial and temporal analysis tool, to be incorporated into the ILRCdb.

The framework for an online, interactive habitat mapping visualization tool has also been developed, using the La Grange Pool of the Illinois River as the initial test area. This web mapping habitat visualization tool will be expanded to include data layers covering the full extent of the Illinois River (for which data layers are currently available), and further developed to incorporate additional data layers and functionality to identify areas that have similar environmental conditions to areas where large numbers of bigheaded carps are being caught, to aid in site selection for future removal efforts.

Sonar images and GIS-ready bathymetric layers for the Brandon Road, Dresden Island, Marseilles, and Starved Rock pools of the Illinois River have been or are in the process of being completed and distributed, with additional benthic data from the Peoria Pool scheduled to be collected during the summer of 2019. Initial exploration of developing a suitable benthic habitat classification system for the Illinois River has begun and these efforts will be continued to develop benthic habitat classification layers for priority management areas of the Illinois River, in support of the analysis and visualization tools described above.

Methods:

The ILRCdb (developed as a PostgreSQL application) will be actively maintained, which involves performing routine database maintainence (e.g. ensuring data backups, performing internal consistency checks, rebuilding indexes as needed, etc.) to keep the application online and available to users. Previously collected catch and monitoring data (that has not already been loaded into the ILRCdb) will be loaded into the database, after passing quality assurance checks for data consistency (i.e. standardized formatting of data, etc.). In addition, new catch and monitoring data collected by partner agencies will be loaded into the ILRCdb as it becomes available, following the same quality assurance procedures. As well, demographic data from partner sampling will be incorporated into the database, to support the SEAcarP population modeling project.

Updates and additions will be made to the ILRCdb, including functionality to automatically perform quality assurance for new data submissions to ensure consistency with data standards (e.g. consistency of data formatting, etc.). Improvements will be made to the existing data upload and download tools, based on recommendations from partner testing. Additionally, functionality requested by partners will be added to the application (e.g. customized monthly, quarterly, or annual reports based on specific monitoring or management needs as identified by users), as feasible.

Data sharing agreements will be finalized as formal memoranda of understanding between partners. This will be an iterative review process, to ensure partner concerns regarding data use and security standards are properly addressed and partners have a clear understanding of how their data will be formatted, stored, and used by others.

A visualization tool for the spatial and temporal analysis of catch data from the ILRCdb will be developed. The analysis will be based on estimated probability of the density of input catch data points, using the kernel density spatial analysis tool from Esri's ArcGIS platform. The objective is to incorporate water temperature and discharge datasets into the tool, which will allow users to explore changes in catch data over time in relation to these environmental variables. To develop this tool, parameters for the creation of kernel density maps will be determined, including 1) the kernel density search window radius, that determines how specific or generalized the data analysis results will be, and 2) the temporal division that will be used to show changes in the dataset(s) over time (e.g. weekly, monthly, or seasonal divisions). The spatial and temporal analysis functionality will be integrated with the ILRCdb application as an interactive visualization tool. Users will be able to select their desired input parameters, and analysis results will be displayed as kernel density maps (i.e. the distribution of catch data over a chosen time interval). Examples of user-selected input scenarios for visualization could include 1) displaying kernel density results of catch data from Brandon Road Pool in monthly divisions from 2016 to 2018 using a 200 square meter kernel density search radius window, or 2) displaying kernel density results of catch data from Dresden Island Pool from May of each year from 2012 to 2017. Creating an interactive tool for this analysis functionality will allow users to pull catch data directly from the ILRCdb, change input parameters to suit their intended purposes, and visualize the results in a spatial format.

Development of an online, interactive habitat mapping visualization tool will also continue, by expanding the existing tool framework to cover the full extent of the upper Illinois River. The visualization tool will ingest catch data from the ILRCdb, and will update these catch data layers in near-real time (feasibility of incorporating this data in near-real time to be dictated by finalized ILRCdb data sharing agreements). Additional water condition variables will also be incorporated into the visualization tool (e.g. USGS National Water Information Systems [NWIS] water discharge, velocity, and temperature values) through available web services. Functionality will be created within the visualization tool for users to locate 'similar areas' by searching ILRCdb catch records, identifying the underlying environmental conditions related to the returned records (e.g. water conditions, substrate type, benthic habitat classification type, etc.), and finding areas with similar conditions. This tool will also allow users to identify areas on a map (i.e. based on areas where large harvests have occurred) to identify the underlying environmental conditions and find areas with similar conditions.

In support of the analysis and visualization tool development described above, additional benthic data from the Illinois River will be collected and processed. Priority management areas of the Peoria Pool will be identified for further benthic data collection, to occur during the summer of

2019. Validation data (collected with a statistically valid random sampling design) will be collected from points within the Brandon Road, Dresden Island, Marseilles, and Starved Rock pools of the Illinois River. These validation points will be used in the development of the benthic habitat classification system for the Illinois River system. Post-processing and distribution (online, through the USGS ScienceBase platform) of benthic data from the Dresden Island and Brandon Road reaches collected in FY 2018 into GIS-ready sonar mosaics and bathymetry data layers will continue. Development of a benthic habitat classification system for the upper Illinois River will be finalized, based on a cross-walk of NOAA's benthic habitat classification and Ocean Wise Remote Sensor Object Based Image Analysis (RSOBIA) software, from which benthic habitat classification data layers will be developed for each reach of the Illinois River in which benthic data has been collected. These final, post-processed benthic data layers will be incorporated into the online visualization tools described above, to support adaptive management and informed removal strategies.

2019 Schedule:

1) Incorporate new catch data and perform routine database maintenance – *throughout FY 2019*
2) Add and improve ILRCdb functionality
   a. Complete programming of quality control checks for new data submissions – *complete by the end of FY 2019*
   b. Improve data submission and data download tools – *complete by the end of FY 2019*
   c. Add database functionality as requested by partners – *throughout FY 2019*
3) Finalize data sharing agreements or memoranda of understanding between agency partners – *complete by March FY 2019*
4) Develop spatial and temporal analysis tool for catch data
   a. Finalize parameters for kernel density analysis – *complete by June FY 2019*
   b. Complete development of code for spatial and temporal analysis tool – *complete by the end of FY 2019*
   c. Integrate visualization of spatial and temporal analysis with the ILRCdb – *complete in FY 2020 (as funding allows)*
5) Complete development of an online habitat mapping visualization tool
   a. Expand existing visualization tool to cover the extent of the upper Illinois River (for all currently available data layers) – *complete by June FY 2019*
   b. Add catch data from the ILRCdb (in near-real time, if feasible based on ILRCdb data sharing agreements) to the online visualization tool – *complete by the end of FY 2019*

c. Incorporate additional NWIS web services for water parameters such as discharge and temperature – *complete by June FY 2019*

d. Develop a tool to identify areas with similar environmental conditions to user-specified areas of management interest, to support decisions on removal efforts – *complete by the end of FY 2019*

6) Collect, process, and serve benthic data layers for the upper Illinois River system:

   a. Conduct field work to collect benthic data in priority areas of the Peoria Pool of the Illinois River – *complete by the end of FY 2019*

   b. Collect samples for validation data of benthic data layers from the Brandon Road, Dresden Island, Marseilles, and Starved Rock pools – *complete by the end of FY 2019*

   c. Complete processing and online distribution of benthic data collected in FY 2018 (from the Dresden Island and Brandon Road pools) – *complete by March FY 2019*

   d. Finalize development of a benthic habitat classification, generate benthic habitat data layers for reaches of the Illinois River with collected benthic data – *complete in FY 2020 (as funding allows)*

   e. Incorporate processed benthic data layers into online interactive habitat mapping visualization tool – *complete by the end of FY 2019*

Deliverables:

(1) Database: Continually maintained, updated, and accessible ILRCdb, including incorporating new catch data and demographic data from partner sampling.

(2) Data Analysis/Visualization Tool: Improved quality control functionality for new data submissions and data upload and download applications. Added customized data reports as requested by partners.

(3) Data Sharing Agreement: Formal data sharing agreements between partners contributing data to the ILRCdb.

(4) Data Analysis/Visualization Tool: An application that generates kernel density maps based on specified user input, to facilitate interactive spatial and temporal analysis of catch data from the ILRCdb. Spatial and temporal analysis functionality will be integrated with the database in out years.

(5) Data Analysis/Visualization Tool: Online, interactive habitat mapping visualization tool, incorporating Asian carp catch data from the ILRCdb, habitat suitability model data layers, benthic data layers, and pertinent water parameters (e.g. discharge, velocity, and temperature values), with functionality to identify areas with similar environmental conditions to support decisions on removal efforts of bigheaded carp in the Illinois River.

(6) Data: Benthic data layers, in a GIS-ready format, and applicable metadata, including sonar mosaics from side-scan and multibeam sonar, bathymetry data layers, and benthic habitat classification data layers for priority management areas of the Illinois River.

Young-of-Year and Juvenile Asian Carp Monitoring

Brennan Caputo, Justin Widloe, Rebekah Anderson, Eli Lampo, Nathan Lederman, Matt O'Hara and Kevin Irons (Illinois Department of Natural Resources), Scott F. Collins, Steven E. Butler, Joseph J. Parkos III, and David H. Wahl (Illinois Natural History Survey)

Participating Agencies: Illinois Department of Natural Resources and Illinois Natural History Survey (co-leads); US Fish and Wildlife Service – Wilmington, Carterville, Columbia, and La Crosse Fish and Wildlife Conservation Offices and US Army Corps of Engineers – Chicago District (field support).

Location: The monitoring for young-of-year and juvenile Asian carp will take place through targeted sampling by multiple participating agencies at multiple sites along the Illinois and Des Plaines rivers, and the Chicago Area Waterway System (CAWS). These efforts will occur as part of the following projects: *Monitoring Efforts Downstream the Electric Dispersal Barrier; Seasonal Intensive Monitoring in the CAWS; Asian Carp Demographics; Distribution and Movement of Small Asian Carp in the Illinois Waterway*. See individual project plans in the 2019 MRP for specific details.

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

Introduction and Need:

Successful reproduction and recruitment are crucial to the establishment and long-term viability of Asian carp populations in the Mississippi River basin. The upstream expansion of Asian carp through the Illinois Waterway increases the likelihood of them challenging or circumventing measures taken to block their access to Lake Michigan, potentially allowing for the invasion and establishment of viable populations in the Great Lakes. Although there is currently no evidence of successful Asian carp reproduction or recruitment in the CAWS or the Des Plaines River, it is necessary to continually monitor and track the numbers of young-of-year and juvenile Asian carp among navigation pools to assess potential advancement and to describe inter-annual fluctuations in the numbers of small Asian carp. Such information will inform agencies about the potential advancement of Asian carp populations through the Illinois Waterway towards the Great Lakes.

Objectives:

Multiple gears suitable for sampling small fish are being used to:

(1) Determine whether Asian carp young-of-year or juveniles are present in the CAWS, lower Des Plaines River, and Illinois River; and

(2) Determine the uppermost navigation pools where young Asian carp are present.

Young-of-year and Juvenile Asian Carp Monitoring

Status:

Since 2010, multiple gears have been deployed by participating agencies to track and quantify the numbers of young-of-year and juvenile Asian carp along the Illinois River and other connected waterways. DC-electrofishing has been conducted in all segments of the Illinois River, upper Des Plaines River and CAWS. Mini-fyke nets, trawling (multiple gears), and seining have been used in locations downstream of the Electric Dispersal Barrier from Lockport Pool to La Grange Pool. Annually, active sampling effort has been high across all pools, although effort varies yearly with projects and specific objectives. To date, a total of 2,713 hours of electrofishing has been conducted across all years and pools (2010 – 2018). Since 2010, numbers of small Asian carp, primarily Silver Carp, have varied by orders of magnitude between years. During 2014, sampling across agencies detected the first year of substantial abundances of young-of-year Asian carp since monitoring started in 2010. From 2015 to 2017, total catch of Asian carp was generally low (2015: n = 1,934; 2016: n = 912; 2017: n = 2,967) when compared to 2014 (n = 71,632). During 2018, there was an additional year of strong recruitment for Silver Carp, like that of 2014. The farthest upstream catch of juvenile Asian carp in 2015 and 2016 consisted of several Silver Carp in Marseilles Pool near Morris, Illinois, (river mile 263). However, in 2017 and 2018, no small Asian carp were detected in Marseilles Pool. Overall, an overwhelming majority (~99%) of all small Silver Carp have been collected in La Grange Pool. Such a pattern is consistent across years. With rare exceptions, almost all juvenile Asian carp have been Silver Carp.

Methods:

As in the past, 2019 sampling for young-of-year and juvenile Asian carp will occur through other projects outlined in the MRP. Data from participating agencies will be summarized as part of an ongoing effort to characterize the numbers of young-of-year and juvenile Asian carp in the Illinois River.

Sampling Schedule:

Sampling by participating agencies will occur along the Illinois River and connected waterways starting in the spring and ending in winter. Start and end dates vary by individual project. Additional sampling may occur at other sites on an as-needed basis in cooperation with other sampling and monitoring efforts. Sampling will be conducted as required to meet future research and monitoring objectives.

Young-of-year and Juvenile Asian Carp Monitoring

Deliverables:

At the conclusion of the 2019 sampling season, data will be collected from participating agencies and summarized as part of an ongoing synthesis of young-of-year and juvenile Asian carp monitoring. Findings will update agencies about the current status of young-of-year and juvenile Asian carp in the Illinois River and be used to refine individual project plans and annual revisions of the MRP.

Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System

Participating Agencies: USFWS-Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL (lead); USFWS- Carterville Fish and Wildlife Conservation Office, Marion, Illinois (field support)

Location: Work will take place in the Brandon Road, Dresden Island, and Lockport reaches of the Illinois Waterway including at the Electric Dispersal Barrier system.

Pools Involved: Lockport, Brandon Road, and Dresden Island

Introduction and Need:

The Electric Dispersal Barrier system located within the Chicago Sanitary and Ship Canal (CSSC) operates with the purpose of preventing dispersal of invasive fishes between the Mississippi River and the Great Lakes basins while maintaining continuity of this important shipping route. Numerous field and laboratory studies have examined the complexities associated with operations of the Electric Dispersal Barrier and sought to identify potential vulnerabilities using a wide range of methods. These studies included telemetered surrogate fish studies, electric field mapping, fish response studies, and studies that examined vulnerabilities associated with commercial barge tow passage (Asian Carp Regional Coordinating Committee Monitoring and Rapid Response Workgroup 2015, Bryant et al. 2016, Davis et al. 2016, Dettmers et al. 2005, Holliman et al. 2015, U.S. Army Corps of Engineers 2013). The results of these studies suggest that the barrier system reliably deters the passage of large fish. However, results also indicated that vulnerabilities for upstream passage of small wild fish through the Electric Dispersal Barrier systemcurrently exist (Bryant et al. 2016 and Davis et al. 2016).

The goal of this multifaceted monitoring program is to quickly identify any change in fish community species composition, fish abundance, or fish behavior near the Electric Dispersal Barrier; especially with regard to small size classes of fish. This project will provide insights on fish behavioral responses to biological, abiotic, and anthropogenic changes within the system. Additionally, fish surveys supporting barrier clearing operations will be performed "as necessary" to support barrier maintenance needs or requests from the ACRCC.

Objectives:

(1) Monitor fish abundance, fish behavior, and fish community species composition at the Electric Dispersal Barrier on a fine spatial and temporal scale.

Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System

(2) Evaluate potential changes in fish community species composition, fish abundance, and fish behavior in response to biological, abiotic, and anthropogenic influences within the study reaches.

Status:

Since 2012, USFWS has utilized a wide range of technologies to collect data under this comprehensive monitoring, assessment, and barrier efficacy program. Split beam sonar, side scan sonar, and multi beam sonar imaging systems have been used extensively to monitor fish behavior and abundance near the Electric Dispersal Barrier over varying temporal and spatial scales. Initial work conducted during the 2012 and 2013 field seasons showed that fish abundance near the barrier varies throughout the year (Parker et al. 2015). During summer large schools of small fish congregated directly below the operational barrier where fish were observed to demonstrate a “challenging” behavior. In some cases, schools of small fish penetrated the entirety of the portion of Barrier IIB with the greatest electric field strength (Parker and Finney 2013). Since 2015, hydroacoustic surveys have been completed on a biweekly to monthly basis to gain greater temporal resolution on fish community dynamics. An additional component to this work has been furthering the understanding of complexities introduced at the Electric Dispersal Barrier concurrent with passage of commercial barge traffic. Trials conducted during 2015 demonstrated that freely swimming small fish could be entrained and transported over the entire Electric Dispersal Barrier in junction gaps between barges (Davis et al. 2016). Additional trials conducted during 2016 demonstrated that small wild fish could also be transported upstream across the Electric Dispersal Barrier in return current flows associated with downstream barge transits at the Electric Dispersal Barrier (USFWS 2016).

In 2018, 23 barrier scans were conducted between February 16 and December 12. Mean fish density within the Electric Dispersal Barrier ranged from 0 to 15 large-fish targets per survey (overall mean ± SD = 2.7 ± 2.3). Mean fish density immediately below the Electric Dispersal Barrier ranged from 0 to 9 large-fish targets per survey (overall mean ± SD = 2.0 ± 2.4). Water volume sampled within the Electric Dispersal Barrier ranged 44,660 to 150,220 m^3 (overall mean ± SD = 115,875 ± 26,519 m^3). A smaller volume of water was sampled while Electric Dispersal Barrier maintenance was be performed in November and December. Water volume sampled immediately below the barrier ranged from 287,290 to 428,815 m^3 (overall mean ± SD = 336,502 ± 31,818 m^3). Pool scans were conducted in Brandon Road, Dresden Island, and Lockport pools during the spring and summer seasons. Additionally, Lockport Pool was sampled during the winter season. Data from the 2018 pool scans are being currently being analyzed and can be expected in the 2018 ISR. Barrier and pool scans will continue in 2019.

Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System

Methods:

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

Side-looking split beam hydroacoustic and side scan sonar surveys will be conducted immediately above and below the Electric Dispersal Barrier to assess fish abundance and distribution patterns on a fine temporal scale. Barrier surveys at the Electric Dispersal Barrier will take place every two weeks. Pool surveys will take place every month beginning in January 2019. The hydroacoustic survey equipment utilized for these surveys consists 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 are mounted in parallel on the starboard side of the research vessel 0.15 m below the water surface on Biosonics® dual axis automatic rotators. The side scan unit is attached to a port-side davit at the bow of the research vessel and is lowered less than a meter into the water. This approach, using both systems, will enable each survey to ensonify a large portion of the water column. These surveys will provide information on the size frequency distributions and spatial orientation of fish targets. Results of biweekly surveys will be communicated to the ACRCC as rapid communications if changes in fish abundance or behavioral status are detected. In addition, several scans will be conducted in conjunction with SIU throughout the summer to ensure that both entities are collecting data in the proper manner and comparable.

2019 Schedule:

- Mobile hydroacoustic fish surveys at the Electric Dispersal Barrier: Biweekly - January 2019 - December 2019, or as needed.
- Mobile hydroacoustic fish surveys in Brandon Road, Lockport, Dresden Island pools: Monthly – Winter 2019 – Fall 2019

Deliverables:

- Biweekly report on fish density and spatial distribution near the Electric Dispersal Barrier to the ACRCC/MRWG
- Annual reports, presentations, and peer-reviewed articles outlining significant findings of all program study areas
- Rapid communications to the ACRCC on moderate or significant changes in fish community species composition or fish behavioral observations at the Electric Dispersal Barrier

Monitoring Fish Abundance, Behavior, and Species Composition within the Illinois Waterway and Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System

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Distribution and Movement of Small Asian Carp in the Illinois Waterway

Lead Agency: USFWS-Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, Illinois

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

Location: Known populations of adult Asian carp exist in all pools of the Illinois River Waterway (IWW) downstream of Brandon Road Lock and Dam. In 2018, USFWS personnel surveyed for small Silver and Bighead Carp within the Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools. One juvenile Silver Carp (TL 222mm) was captured in Starved Rock Marina (Starved Rock Pool) on May 14, 2018. This fish was larger than the "small" size threshold of 153mm, however, due to variability in growth rates of fish this capture could suggest smaller fish were present. Additional sampling was conducted but no additional juveniles were captured. As of December 2018, the farthest upstream juvenile Silver Carp (≤400 mm TL) have been recorded was in Moody Bayou (Gundy County) at Illinois River Mile 256.4. These two Silver Carp (168 and 171 mm) were collected on October 22, 2015.

Introduction:

Silver Carp (*Hypophthalmichtys molitrix*) and Bighead Carp (*Hypophthalmichtys nobilis*) have been expanding in population and dispersing upstream in the Mississippi River basin since the 1970s and have become established in the Illinois River. Invasive Silver and Bighead Carp pose a significant threat to fisheries in the Great Lakes by competing with economically and recreationally important fish species for limited plankton forage resources. Populations of these fish now threaten to enter Lake Michigan through the upper Illinois Waterway (IWW) with the most probable pathways being the Chicago Sanitary and Shipping Canal or the Calumet River (Kolar et al. 2007). An Electric Dispersal Barrier system operated by USACE in the Lockport Pool is intended to block the upstream passage of Asian carp through these IWW pathways.

Laboratory tests have shown the Electric Dispersal Barrier system is sufficient at stopping large-bodied fish from passage, however, testing using small Bighead Carp (51 to 76 mm TL) indicated that the operational parameters of the barrier may be inadequate for blocking small fish passage (Holliman et al. 2011). USFWS research indicated that Golden Shiners (*Notemigonus crysoleucas*) can be entrained in barge junction gaps and transported through the Electric Dispersal Barrier. Other research by USFWS using Dual Frequency Identification Sonar (DIDSON) indicated that small fish (non-Asian carp species; suspected to be Gizzard Shad) are transported upstream through the barrier by return water current during downstream barge movement. These studies show that if small Silver or Bighead Carp are present near the Electric

Dispersal Barrier these fish may able to breach the barrier through multiple methods. For this reason, there is a critical need to monitor the distribution of juvenile Silver and Bighead Carp below the Electric Dispersal Barrier. Additionally, a need is present to understand the reproduction, demographics, and habitat usage of these fish in the IWW so small fish may be targeted for eradication or other management actions.

The purpose of this project is to determine the spatial distribution of small Asian carp in the IWW through intensive, targeted sampling. Silver and Bighead Carp specimens ≤153 mm TL (6 inches) are considered "small" based on discussions within the Monitoring and Response Working Group and will be the primary focus of this monitoring due to the operational weaknesses of the Electric Dispersal Barrier. Any Silver or Bighead Carp found smaller than 400mm will be considered juvenile based on previously published research on growth and maturity (Williamson and Garvey 2005). Due to variability in intrapopulation growth rates, it is important to monitor the behavior of juvenile Asian carp as some individuals may represent young fish with accelerated growth. Sampling techniques in 2019 will include but are not limited to: traditional boat electrofishing, tandem and single mini-fyke nets, electrified dozer trawl, backpack electrofishing, and seine hauls.

Objectives:

(1) Detect the furthest upstream location of juvenile Silver and Bighead Carp yearly.

(2) Determine the distribution and abundance of small Silver and Bighead Carp in the Illinois Waterway.

(3) Use distribution and abundance data to characterize the risk of small Asian carp entry into the Great Lakes via the CAWS.

Status:

This is a continued MRP project for 2019. Sampling conducted in 2018 using boat electrofishing, dozer trawl, and mini-fyke nets caught one juvenile Silver Carp (222 mm TL) in Starved Rock Pool and multiple "small" Silver Carp in Peoria Pool.

Methods:

Sampling site selection will be conducted in two ways: stratified-random generated sites and "targeted" sites. Targeted sites will be based off of sites where large numbers of Silver Carp are frequently captured, sites where juvenile Silver Carp have been captured in previous years, and predictive habitat areas based on results from juvenile Silver Carp telemetry project (Habitat use and Movement of Juvenile Silver Carp in the Illinois Waterway). Randomly generated sites will be created throughout the year in various habitat areas (backwater, main channel border, side channel border, and tributary) in Dresden Island, Marseilles, and Starved Rock pools. Sites will be stratified for habitat area and exclude certain zones that are not useable for each gear type deployed. Both site types are used to decrease the likelihood of missing fish simply due to not sampling thoroughly. In addition to the mainstem sampling, crews will sample small tributaries and floodplain lakes in these pools that have not been previously sampled. Sampling will occur in these places following high water events which could have resulted in spawning activity or movement of juvenile carp into the area.

Physical characteristics and water quality measurements are to be made at each collection site and will include: Secchi depth, 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. 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 sampling, all Bighead, Silver, and Grass Carp will be measured for TL (mm) and weighed (g); any other species will be tallied and released to increase processing speed. If a small Silver or Bighead Carp is captured, all fish at that site will be measured for TL (mm) and weighed (g) to provide bycatch information. At randomly selected sites throughout yearly sampling, all fish over 100mm will be measured for TL (mm) and weighed (g). This data will be used to inform hydroacoustics monitoring and to maintain fish community data for future years. Any fish not easily identified in the field will be preserved in Excel Plus or 70% ethanol for laboratory identification to the lowest possible taxonomic level. Effort will be quantified as net nights (mini-fykes) or minutes of electrofishing (boat electrofishing and dozer trawl).

Individual gear descriptions for 2019:

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

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 <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 in front of the trawl 1.5 meters and the trawl acting as the cathode. Length and duration of trawl sampling will be dependent on site characteristics and fish catch rate.

Distribution and Movement of Small Asian Carp in the Illinois Waterway

Backpack electrofishing – A MLES Backpack electrofisher unit will be used to sample small tributaries and shallow areas along and feeding into the mainstem Illinois River. Typical samples will be from riffle to riffle and include any shoreline or woody debris accessible. In the case of sampling a non-linear habitat (backwater or small floodplain lake) 200 meters of shoreline will be the study extent. Crews will consist of at least 3, with one member running the electrofisher and two netters.

Seine – The seine used for this project is 3m in length and 1m deep with 1/8" mesh and a 2m extended bag to hold captured fish. Seining will be used in sampling small tributaries of the mainstem Illinois after high water events in which spawning may have occured. A crew will consist of three people, with two people holding the brailles (net ends) and one person helping corral fish and picking up the seine when the haul is complete.

2019 Schedule:

February 2019: Gear preparation, planning field logistics, and crew scheduling

March – November 2019: Fish sampling, identification, and data entry

November – December 2019: Complete fish identification (preserved specimens), data entry, and verification

December 2019 – January 2020: Data analyses, prepare report and presentation

Deliverables:

Any small Asian carp captured upstream of Starved Rock Pool will be reported immediately to Todd Turner (USFWS Assistant Regional Director – Fisheries), Charlie Wooley (USFWS Acting Regional Director – Region 3) and MRWG. An annual MRWG report and presentation will be provided during the winter of 2019 – 2020. Juvenile Silver and Bighead Carp capture data from sampling will be used to define future sampling sites. Length weight data will be provided for the SEAcarP model development project and to hydroacoustics monitoring projects.

ILLINOIS NATURAL HISTORY SURVEY
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Larval Fish Monitoring in the Illinois Waterway

Steven E. Butler, Scott F. Collins, Joseph J. Parkos III, David H. Wahl (Illinois Natural History Survey), Robert E. Colombo (Eastern Illinois University)

Participating Agencies: Illinois Natural History Survey (lead), Eastern Illinois University (field and lab support), U.S. Geological Survey, U.S. Fish and Wildlife Service (lab support)

Location: Larval fish sampling will take place at 7 sites in the Illinois and Des Plaines River downstream of the Electric Dispersal Barrier (Figure 1). Larval fish sampling will also occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee Rivers to assess potential Asian 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:

Factors affecting the early life stages of fish strongly influence recruitment to adult populations. An evaluation of Asian carp reproduction and the distribution of early life stages in different sections of the Illinois Waterway and its tributaries is needed to better understand Asian carp population dynamics and the impacts of removal efforts on the reproductive potential of Asian carp populations. Reproduction and recruitment of Asian carp in the Illinois Waterway have been highly variable across years and multiyear efforts are necessary to evaluate conditions affecting reproduction and monitor for changes in the Asian carp reproductive front. Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2018 indicate that some reproduction and potential recruitment occurs above Starved Rock Lock and Dam in some years. Asian carp spawning also appears to occur in some years in smaller tributary rivers, but the frequency of spawning in these systems, or the contribution of these rivers to basin-wide Asian carp populations is not known. The frequency of spawning in different pools of the Illinois Waterway and the eventual fate of eggs, larvae, and juveniles in these areas has important implications for Asian carp control activities. If Asian carp larvae and juveniles regularly occur in the upper Illinois Waterway, then control strategies may have to account for local production of recruits in these upper navigation pools. Alternatively, even if spawning occurs in upper navigation pools, if recruitment is limited to the lower river, then this would suggest that populations in upstream pools are supported by immigrants from downstream. In this case, restricting movement of Asian carp past locks and dams could substantially limit the ability of these species to sustain populations in the upper Illinois River. Monitoring for Asian carp eggs and larvae can also provide data to assess stock-reproductive productivity relationships and evaluate the impact of Asian carp removal efforts on the reproductive potential of these populations. Simple relationships between stock abundance and reproductive potential are often lacking, in part because of density-dependent processes and spatial and temporal variability in spawning conditions, stock composition, and first-year survival. Quantifying the relationship between adult stock abundance and reproductive productivity, and the influence of environmental conditions on this relationship, will help to refine our understanding of the conditions and level of removal that reduce population growth rate.

Objectives:

We are sampling fish eggs and larvae in the Illinois Waterway and its tributaries to:

(1) Monitor for potential changes in the reproductive front of Asian carp populations,

(2) Monitor for Black Carp reproduction in the Illinois Waterway,

(3) Refine FluEgg model predictions of Asian carp reproductive hotspots, and

(4) Quantify the relationship between Asian carp stock abundance and reproductive output.

Status:

INHS has monitored for Asian carp eggs and larvae throughout the Illinois Waterway from 2010 to 2018. In the initial years of this study, Asian carp eggs and larvae were collected from the La Grange and Peoria pools of the Illinois River, but not from any upstream navigation pools. However, Asian carp eggs were collected from the Starved Rock and Marseilles pools during 2015 – 2018, and three Silver Carp larvae were collected in Dresden Island Pool during 2015. It therefore appears certain that Asian carp are spawning in the upper Illinois River, but the frequency of such occurrences, and the fate of eggs and larvae produced by these spawning events remains inadequately understood. Additionally, the numbers of eggs and larvae that have been collected during previous years of this study have been highly variable, with seemingly low reproductive output during 2010 – 2013, but large numbers of eggs and larvae collected during 2014 – 2018. Hydrodynamic modeling 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 Illinois Waterway are likely important spawning areas for Asian carp (Zhu et al. 2018). Additional modeling efforts using a more comprehensive set of egg data are needed to examine the extent of variability in spawning locations among years and the most likely areas of settlement for Asian carp larvae leaving the drift under various flow conditions. Collaborative efforts using samples collected from the Illinois River and elsewhere have produced a new qPCR screening method for identifying ichthyoplankton samples that are most likely to contain Asian carp (Fritts et al. *In Press*). This tool may help to substantially increase the efficiency of icthyoplankton sample processing, and may hold promise as an early detection tool for monitoring for Black Carp reproduction.

Methods:

Larval fish sampling will occur at weekly to biweekly intervals from spring through fall. At all Illinois Waterway sampling sites, larval fish 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 larval fish samples will be collected at each mainstem site on each sampling date. Sampling transects will be located on each side of the river channel, parallel to the bank, at both upstream and downstream locations within each study site.

At tributary sites (Sangamon, Spoon, Mackinaw, 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. Boat-mounted push nets will be used at boatable locations, whereas passive drift nets (0.45 x 0.25 m, 500 µm mesh) will be used at sites where boat access is restricted. Push net sampling will be conducted as for main channel sites, whereas passive drift nets will be deployed for 30 – 180 minute durations, depending on stream flow. Quatrefoil light traps will also be used at tributary sites to supplement larval fish collections.

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 4 mm being identified as potential Asian carp eggs and retained for later genetic analysis. Larval fish densities will be calculated as the number of individuals per cubic meter of water sampled. Spatial and temporal patterns in the densities of Asian carp eggs and larvae will be described, and relationships between Asian carp stock density and reproductive output will be quantified to assess the level of removal needed to diminish the regenerative ability of Asian carp populations. Developmental stages of Asian carp eggs and larvae will be determined, and collaborative modeling of Asian carp egg drift (FluEgg model) with USGS partners will be used to estimate spawning locations and zones of larval settlement.

Sampling Schedule:

In 2019 and subsequent years, larval fish sampling will occur at weekly intervals at all sites from April to early July, and biweekly intervals from late July to October. Additional sampling will occur during periods when Asian carp eggs and larvae are likely to be present (e.g., during periods of rising water levels, or shortly after peak flows).

Deliverables:

Results of each sampling event will be reported in monthly sampling summaries. Observations of large-diameter eggs or any identification of Asian carp larvae upstream of the Starved Rock Lock and Dam will be immediately reported to MRWG members. Results of modeling efforts will be provided to MRWG partners as relevant findings are produced. Data will be summarized and project plans updated for annual revisions of the MRP.

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Larval Fish Monitoring in the Illinois Waterway

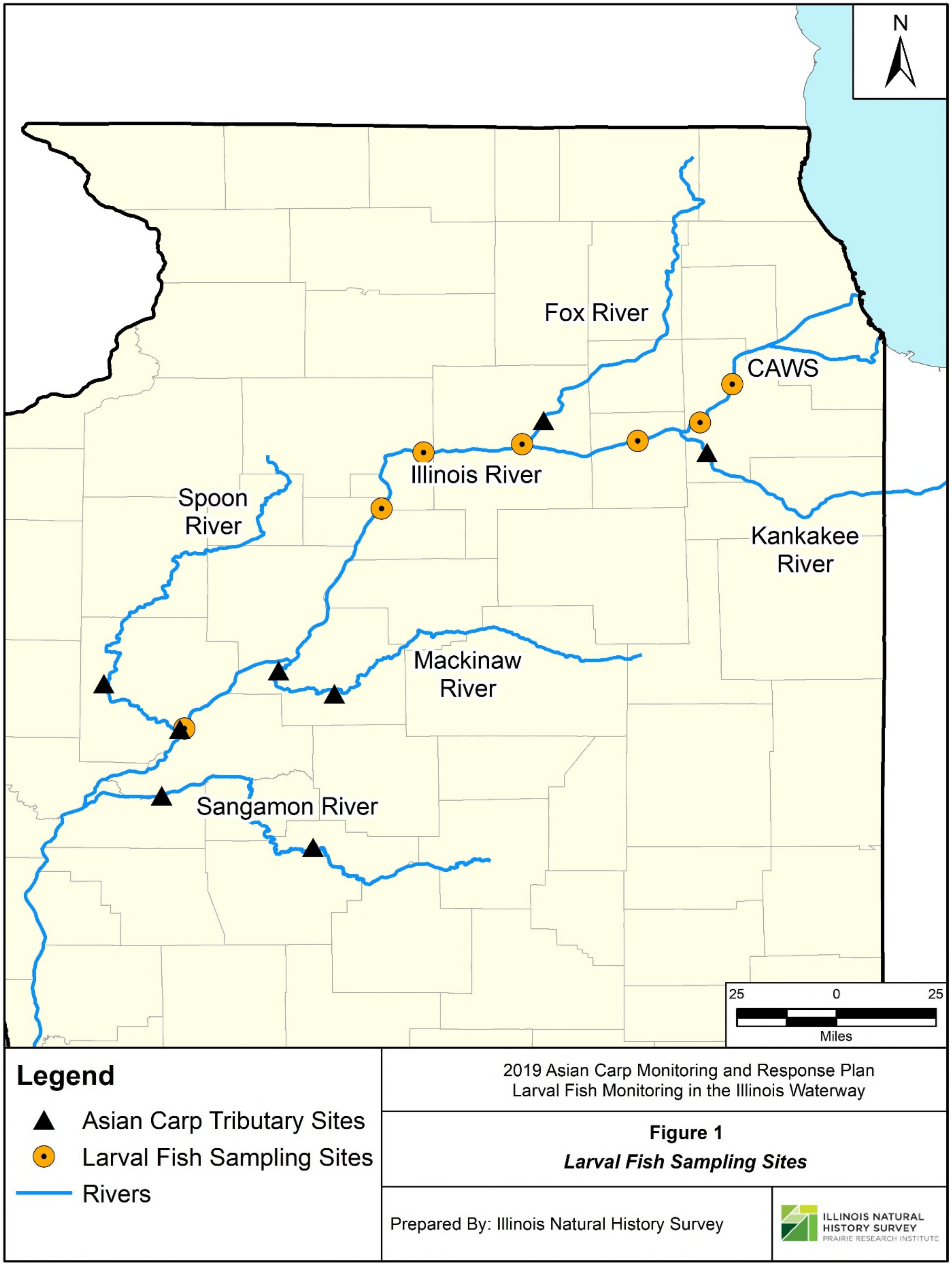

Figure 1. *Map of larval fish sampling sites in the Illinois Waterway (circles) and in tributary rivers (triangles).*

Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam

Participating Agencies: Southern Illinois Universtiy – Carbondale (lead), additional assistance/collaboration with USACE, USGS, Western Illinois University, Illinois DNR, INHS, USFWS

Location: Illinois River from Dresden Island Pool to Alton Pool, along with associated backwaters, side channels, and tributaries. Des Plaines River, with emphasis on locations upstream of Brandon Road Lock and Dam; Kankakee River.

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

Introduction and Need:

Management goals for bigheaded carp in the Illinois River have focused 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. These models simulate the effects of various management actions (e.g., harvest scenarios, locations of enhanced deterrent technologies) to determine which options are most likely to achieve management goals.

Monitoring of bigheaded carp densities via hydroacoustic sampling throughout the Illinois River (Alton to Dresden Island pools) by Southern Illinois University (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 the previous year 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 sites. 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. Frequent hydroacoustic surveys of bigheaded carp densities in these pools will identify locations where bigheaded carp aggregate, and determine whether or not these seasonal high-density hotspots remain in the same location each year.

A spatially-explicit population model of bigheaded carp in the Illinois River was recently developed to assess 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 collected by different agencies including bigheaded carp densities and movement data previously collected by SIU. Collaborations between MRWG modeling, telemetry, and hydroacoustic working 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), continued hydroacoustic monitoring of bigheaded carp densities throughout the Illinois River. Additionally, telemetry working group partners have also identified the need to better understand the meaning of telemetry data collected from surrogate fishes by comparing movements of surrogate species in relation to those of bigheaded carp. SIU will partner with USACE to exploit SIU's existing acoustic telemetry tags in bigheaded carp near Starved Rock Pool and their stationary receiver array.

Brandon Road Lock and Dam is located on the Des Plaines River approximately five miles upstream from the confluence of the Des Plaines and Kankakee rivers, which forms the Illinois River. Enhancement of Brandon Road Lock and Dam as a barrier to upstream movement of Asian carp has been proposed as an approach to reduce propagule pressure on the Electric Dispersal Barriers farther upstream. One potential concern regarding barrier enhancement (not just at Brandon Road Lock and Dam, but at other dams on other rivers) to limit Asian carp movement is potential fragmentation and loss of connectivity for native fish populations. The extent to which native fishes move through Brandon Road Lock and Dam (particularly upstream) is a major knowledge gap. Previous research at SIU has demonstrated that otolith or fin ray chemistry can distinguish fish from the Illinois, Kankakee, and Des Plaines rivers (Whitledge 2009; Smith and Whitledge 2010). Thus, this approach can be used to determine the frequency of occurrence of fishes in the Des Plaines River upstream of Brandon Road Lock and Dam that had previously been in the Illinois or Kankakee Rivers (downstream of Brandon Road Lock and

Dam). The advantage of this approach is that (unlike conventional mark-recapture methods or telemetry), fish do not need to be recaptured or relocated, making this a cost-effective approach for sampling a large number of fish to obtain an initial assessment of native fish movement upstream past Brandon Road Lock and Dam. Knowledge of the extent to which native fishes pass upstream through Brandon Road Lock and Dam could inform assessment of potential impacts of barrier enhancement at Brandon Road Lock and Dam and perhaps other lock and dam structures on native riverine fishes and also inform potential strategies to mitigate impacts of barrier enhancement on native fishes. SIU initiated a study to assess native fish passage through Brandon Road Lock and Dam using fin ray microchemistry in 2017; the second year of this study is in progress to boost sample sizes and potentially enable assessment of whether fish passage rates through Brandon Road Lock and Dam are consistent among years.

Objectives:

(1) Quantify Asian carp densities every other month in Dresden Island and Marseilles pools in 2019 using mobile hydroacoustic surveys to pinpoint high density areas that can be targeted during contracted removal. Surveys will also document how distributions of bigheaded carp change through time which can better inform targeted removal and could provide an indication of the effectiveness of harvest efforts. Data collection will occur bi-monthly as long as conditions allow and results will be available one month after the survey.

(2) Conduct hydroacoustic surveys at standardized sites in fall 2019 from Alton – Dresden Island pools to assess long-term trends in density, biomass, and size structure.

(3) Maintain SIU's extensive acoustic telemetry array currently in place in the Illinois River used to collect movement and dam passage. Share collected data with telemetry working group and those working on the SEAcarP population model.

(4) Collaborate with USACE to compare the movements of surrogate fish species (i.e., Common Carp) to the movements of bigheaded carps. This will help interpret movement information of surrogate fish species from Dresden Island Pool to the CAWS, as it pertains to hypothetical bigheaded carps in those areas.

(5) Estimate relative abundance of native fishes in the Des Plaines River upstream of Brandon Road Lock and Dam that had previously been in the Illinois or Kankakee Rivers using fin ray microchemistry to assess frequency of native fish movement upstream through Brandon Road Lock and Dam.

Status:

Continues previous work by SIU that has intensively monitored movement and density of Asian 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 Asian carp in the Illinois River.

Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam

Because these surveys have been ongoing since 2012, they provide valuable long-term trends. Work comparing surrogate fish movements to bigheaded carps' movement will begin early in 2019 and is estimated to continue through 2020.

The native fish passage study continues work begun by SIU in 2017. Water chemistry data and fin ray chemistry data for native fish species (primarily catostomids, centrarchids, and ictalurids) have been collected in 2017 and 2018 and will continue through spring 2019. Statistical analyses of water and fin ray chemistry data for 2017 samples have been conducted to assess differences among rivers and species and a classification model has been developed to enable determination of whether fish captured upstream of Brandon Road Lock and Dam had previously been in the Illinois or Kankakee rivers based on fin ray chemistry data and therefore must have passed upstream through Brandon Road Lock and Dam. Additional samples will be used to more precisely characterize river-specific chemical signatures by species, refine the classification model for assessing fish environmental history, and increase sample size for assessing relative abundance of native fishes in the Des Plaines River that passed upstream through Brandon Road Lock and Dam.

Methods:

Spatial and temporal variation in Asian 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 November in 2018, 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 Asian carp in the Illinois River

Hydroacoustic surveys will be conducted in the fall of 2019 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 (7 years as of 2018) 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. As with the bi-monthly sampling in Marseilles and Dresden Island pools, environmental conditions will be sampled during the hydroacoustic surveys to provide additional data across a variety of sites and environmental conditions for determining relationships between Asian carp density and water quality measurements.

Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam

Telemetry data to update pool-to-pool transition probabilities

The existing acoustic telemetry array of 65+ stationary receivers will be maintained and downloaded on two occasions in 2019. Additional acoustic telemetry tags (~100 tags) will be deployed by SIU in LaGrange and Alton pools, while 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 the receivers and hardware will be replaced as necessary. Data from the telemetry array will provide information on numbers of tagged Asian carp moving upstream or downstream through each dam, which provides an indication of the relative numbers of individuals in the population that may be moving among pools. Additional acoustic telemetry tags will be deployed in Marseilles, LaGrange and Alton pools to replace expiring tags and collect data on pool-to-pool transitions for the SEAcarP model. Pool-to-pool transition probabilities and mortality estimates can be incorporated into the spatially-explicit bigheaded carp population model.

Surrogate fish movements

In collaboration with USACE, this project will utilize an extensive array of stationary receivers (20+) around Starved Rock Lock and Dam and within Starved Rock Pool, as well as over 50 acoustic tags in bigheaded carp in Starved Rock Pool to monitor the movements of bigheaded carp and surrogate species. In this case, Common Carp will serve as a surrogate species as this is the most common species tagged as a surrogate for bigheaded carp by USACE above Brandon Road Lock and Dam. Fifty Common Carp will be tagged.

Using fin ray microchemistry to evaluate native fish passage through Brandon Road Lock and Dam

Water samples will be collected during late winter and spring 2019 from the Des Plaines, Illinois, and Kankakee rivers to verify persistence of previously observed differences in water strontium:calcium ratio (Sr:Ca) among these rivers. Water samples for determination of Sr and Ca concentrations will be conducted using a syringe filtration technique and analyzed using high resolution, inductively coupled plasma mass spectrometry (ICPMS). Results will build on data collected during prior years.

Native fishes will be collected from the Des Plaines River upstream of Brandon Road Lock and Dam during spring 2019, focusing on species for which additional samples would be useful for refining estimates of passage rates (e.g., catostomids, freshwater drum, gars). A leading pelvic fin ray will be removed from each fish at the base of the fin. A cross-section of the base of the fin ray from each fish will be analyzed for Sr:Ca along a transect from the core to the edge of the fin ray using laser ablation-ICPMS. A previously developed classification model will be used to interpret fin ray Sr:Ca data for each fish and identify individuals that passed upstream through Brandon Road Lock and Dam.

Monitoring Bigheaded Carp Movement and Density in the Illinois River and Assessment of Native Fish Passage Through Brandon Road Lock and Dam

2019 Schedule:

Bi-monthly hydroacoustic surveys will be conducted in the Marseilles and Dresden Island pools from March through November 2019, weather permitting. In addition, annual hydroacoustic surveys will occur in the Alton, LaGrange, Peoria, and Starved Rock pools in fall 2019, between September and October. Telemetry stationary receivers will be downloaded two times during 2019, once between April – June and once in November. Tagging of bigheaded carps in La Grange, Alton, and Marseilles pools and of surrogate fish near Starved Rock Lock and Dam will occur in April and May 2019. Water and native fish fin ray sample collections will be conducted during spring 2019.

Deliverables:

Hydroacoustic Asian carp density and biomass will reveal how density and biomass vary spatially and temporally at the edge of their invasion front. Results will consist of mean (and associated error) density estimates at each site and heat maps visually displaying Asian carp densities and environmental conditions in the Marseilles and Dresden Island pools throughout the year. Fall hydroacoustic sampling will provide a long-term assessment of Asian carp densities throughout the Illinois River (Alton through Dresden Island pools) by comparing 2019 densities to densities from the previous seven years.

Telemetry data will be used to determine the passage route (number of passages through lock vs. 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.

Surrogate fish data will help in interpreting how the observed movements of surrogate fish near Brandon Road Lock and Dam and upstream to the CAWS may relate to movements of bigheaded carps should they reach these areas.

Fin ray microchemistry data will be used to assess the relative abundance of native fishes collected upstream of Brandon Road Lock and Dam that had passed upstream through the lock and dam structure. These data will provide information for assessment of potential impacts of enhancing Brandon Road Lock and Dam as a barrier to Asian carp on native fish species.

References:

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Whitledge, G.W. 2009. Otolith microchemistry and isotopic composition as potential indicators of fish movement between the Illinois River drainage and Lake Michigan. Journal of Great Lakes Research 35:100-105.

Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry

Lead Agency: USFWS-Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, Illinois

Location: Known populations of adult Asian carp exist in all pools of the Illinois River Waterway (IWW) downstream of Brandon Road Lock and Dam. This study is being conducted in the Peoria Pool of the Illinois River with the current study area between Hennepin, Illinois and Peoria, Illinois.

Pools Involved: Dresden Island, Marseilles, Starved Rock (data used to determine sampling locations for YoY Silver Carp); and Peoria (study location)

Introduction:

Small Silver and Bighead Carp represent a greater risk of breaching the Electric Dispersal Barrier system than larger bodied adults due to the negative relationship between body size and electrical immobilization. Results of research by USFWS have also highlighted passive entrainment of small bodied fishes by barges as a weakness of the Electric Dispersal Barrier system. Multiple state and federal agencies have devoted resources to sampling the upper Illinois River to gain insight into the risks that juvenile Asian carp pose to the Great Lakes. Traditional sampling gears have limitations, including habitat-specific gear efficiency and detection probability, changing environmental conditions, and sparse species distributions. Identifying habitat areas used by juvenile Asian carp will help to inform monitoring efforts by the USFWS and IDNR focused on detecting juvenile Asian carp. Knowledge of the habitat usage and movement patterns of juvenile Asian carp when related to environmental factors are valuable for future management actions.

Objectives:

(1) Quantify movement frequency and distance of juvenile Asian carp.

(2) Determine macro-habitat selection based on periods of residency of juvenile Asian carp.

(3) Test for correlations in movement and habitat selection to a variety of river conditions: temperature, river discharge, habitat area average depth.

Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry

Status:

This project has been conducted since 2017. Field efforts in 2018 resulted in the tagging of 73 juvenile Silver Carp tracked using nine radio monitoring stations and 19 hydro-acoustic receivers. A sum of 146 fish from 2017 and 2018 have been tagged, though only 87 remain active. At the close of 2018, this number is expected to drop to 65 active tags (not including mortalities). Of the tagged juvenile Silver Carp, 45 had radio and acoustic transmitters implanted and 42 had only acoustic transmitters implanted due to the radio tags being too large. To date, telemetered fish have demonstrated movement and habitat-specific residencies correlated to current velocity and temperature. Juvenile Silver Carp have also shown differences in behavior from what is expected of adults. Data from 2018 are still being analyzed and can be expected in the 2018 ISR. This project is planned to continue for 2019 with a smaller size radio tag and an emphasis on fish less than 200mm in TL.

Methods:

For the purposes of this study, the Peoria Pool can be broken into four macrohabitat categories: main channel, side channel, backwater, and marinas. Areas of the river where the river is dredged to maintain 9-feet depth and commercial barge traffic is allowed to operate will be termed "main channel." Parts of the river which have flowing current but are separated from the main channel by land or very shallow (< 1 foot depth at base flow) areas will be termed "side channel." Any non-flowing water, still connected to the river, will be termed "backwater." Finally, any non-flowing area connected to the river that have depth maintained for boat traffic through dredging will be termed "marina."

Juvenile Asian carp will be captured using boat electrofishing and electrified dozer trawl from the Illinois River near Henry, Illinois and Lacon, Illinois. Marinas, backwaters, and side channels will be fished primarily due to the morphology of the river in the study area and gear effectiveness in this part of the river. Depending on the success of field capture events and in order to reduce personnel time commitments, post-larval Silver and Bighead Carp may be captured during spring spawning and raised until they reach a suitable tag size in a holding facility. Following tagging, fish will be released in proximity to their capture location. Fish tags used will be Vemco V5 ultrasonic transmitters (180 kHz, 0.46 g in water, Vemco Ltd.) and Lotek NTF nano radio transmitters (168 mHz, 0.35 g in water, Lotek Wireless).

Immediately after capture, fish will be held for no more than 1 hour in an aerated 60 gallon holding tank covered with ¼-inch mesh. In order to maintain semi sterile conditions, 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 95% isopropyl alcohol between surgeries. 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 foam board with a fish-shaped cut out 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 gently washed with several drops of betadine prior to making an incision. Using a #11 blade scalpel, a 1-cm (acoustic tags) or 2-cm (radio tags) incision will be made in the left 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. In the case of radio tags, the antenna will be positioned to exit at the posterior corner of the incision. Two non-absorbable nylon Oasis Brand (Mettawa, Illinois) sutures will be used to close the incision site for acoustic tags and a third suture will be placed to secure the antenna for radio tags. Immediately following suture closure, the incision site will be washed with betadine a second time and rinsed using sterile saline. The fish will then be placed into an aerated, salted holding tank for recovery. Once fish equilibrium has been reestablished and tags are tested, fish will be returned to the river. Total holding time for fish will generally be less than 2 hours.

Acoustic telemetry equipment has been deployed and will remain throughout the winter of 2018. Additional receivers may be deployed prior to tagging in 2019. Vemco VR2-W 180kHz (Vemco Ltd) hydrophone receivers will be placed from Hennepin, Illinois to Chillicothe, Illinois. In main channel areas and side channel sets, hydrophones will be attached using pipe clamps to 3/16-inch coated stainless steel cable with one end attached to a float and the other end tethered to a 60-pound concrete anchor. The concrete anchor will then have a second cable either tethered to a tree on shore and padlocked, or attached to an 800-pound holding force Danforth style river anchor. Similar deployment methods are to be used for backwater sets, though float lines will shorter.

Radio telemetry gear consists of 10 passive monitoring stations placed from the Peoria Lock and Dam to Hennepin, Illinois at key constriction points and entrances to backwater lakes or side channels. Three more stations will be constructed in the spring of 2019 at locations frequented by tagged fish not currently monitored by radio equipment. Fish tagging will occur simultaneously with the remainder of tracking equipment deployment throughout 2019. Each monitoring station consists of: a Lotek Wireless SRX800D (Lotek Wireless) datalogging radio receiver, deep cycle 150 AH battery, and a solar charge controller placed inside a weatherproof storage box. The equipment will be placed a minimum of 15 feet above any flood plain habitat, usually within tree branches to keep it safe from flooding. A solar panel will be mounted at similar height, facing south, at 41 degrees to the ground and connected to the solar charge controller with 12 gauge wire. Two to three 7-element (1.5-meter) Yagi antennas will be mounted a minimum of 25 feet above the ground using aluminum antenna mast poles, or strapped to trees, then attached to the SRX800D using coaxial cable. Generally, each site will have one antenna pointed upstream or downstream in the river channel and one antenna pointed into a backwater or side channel habitat so fish position can be differentiated depending on which habitat they enter.

Range testing was conducted for multiple locations during 2018 and will be conducted again in 2019 at each radio location and hydrophone. A test tag will be suspended 1 meter under the water and towed away from the antenna or hydrophone until signal is lost. One crew member will be stationed at the monitoring equipment to watch for signal strength decrease while the other crew members operate the test tag. These transects will be conducted three times for each antenna or hydrophone as they are deployed to generate data for the average detection distance of each type of gear used during statistical analysis.

Active tracking via boat will be conducted in 2019 shortly after tagging fish as time allows. Acoustic active tracking will be conducted using a Vemco VR100 (Vemco Ltd.) mobile telemetry receiver unit and 180 kHz underwater hydrophone which is mounted to an aluminum pole and attached to the front of the boat. Radio tracking will be conducted using a Lotek SRX800M (Lotek Wireless) mobile radio telemetry receiver unit and a 4-element or 6-element fixed mast Yagi antenna mounted 12 feet above the boat on an aluminum pole, or a 3-element handheld Yagi antenna when fish are in close proximity. Tracking will be conducted by driving at 5 mph or less down the river channel and into each backwater lake, side channel, and marina area, while monitoring for fish detections. Active tracking data will primarily be used to inform field efforts of fish outside of the receiver deployment zones.

2019 Schedule:

January - February 2019: Planning field work, crew scheduling, deployed gear maintenance and download, active tracking

March - November 2019: Fish tagging, deployed gear maintenance and download, active tracking, range testing

November - December 2019: Deployed gear maintenance, download, and winterization; 2019 data analysis and report preparation

January 2020 – December 2020: Similar to 2019 work as long as tags remain active (receiver maintenance, data download, active tracking

Deliverables:

Results from this study will be used to inform small Silver/Bighead Carp monitoring efforts throughout 2019 and for future years. Additionally, results from this study can be used for Silver Carp movement model development. Habitat usage and movement data is critical to improving knowledge of juvenile stages of Silver Carp and will make monitoring efforts more efficient. Data will be analyzed and results summarized into a MWRG summary report/presentation for the winter of 2019 – 2020, as well a scientific paper publication and presentation at the conclusion of this study.

Des Plaines River and Overflow Monitoring

Participating Agencies: USFWS-Carterville Fish and Wildlife Conservation Office Wilmington Substation (lead); USFWS-LaCrosse FWCO; Metropolitan Water Reclamation District of Greater Chicago, USACE, Southern Illinois University, and IDNR (field support)

Location: Des Plaines River above the confluence with the Chicago Sanitary and Ship Canal (CSSC).

Pools Involved: Not applicable

Introduction and Need:

The upper Des Plaines River rises in southeast Wisconsin and joins the CSSC in the Brandon Road Pool immediately below the Lockport Lock and Dam. Asian carp have been observed in this 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, Asian carp eDNA was detected in the upper Des Plaines River. No Asian carp eDNA sampling has been conducted in the Des Plaines River since 2011. It is possible that Asian carp present in the upper Des Plaines River could gain access to the CSSC upstream of the Electric Dispersal Barrier system during high water events when water flows laterally from the upper Des Plaines River into the CSSC. The construction of a physical barrier to reduce the likelihood of this movement was completed in the fall of 2010. The physical barrier was constructed by USACE and 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 Asian carp from infiltrating the CSSC, but it will likely allow Asian carp eggs and fry in the drift to pass. Opportunites 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. Understanding the population status of Asian carp in the Des Plaines River, monitoring for potential spawning events, and determining the effectiveness of the physical barrier are all necessary to inform management decisions and assess risk of Asian carp bypassing the dispersal barrier.

Objectives:

(1) Monitor Bighead and Silver Carp populations and 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 Bighead and Silver 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 – 2018, 11,082 fish have been collected via electrofishing (64.02 hours) and gill netting (21,316 yards). No Bighead Carp or Silver Carp have been collected or observed. Ten Grass Carp 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 dippers will attempt to dip all visible fish, with the exception of Common Carp. 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-Asian carp will be identified and released. Any Bighead or Silver Carp collected will be kept for further study, and MRWG will be notified. Grass Carp will be tested for ploidy.

A minimum of three sampling events are currently planned for 2019 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.

Des Plaines River and Overflow Monitoring

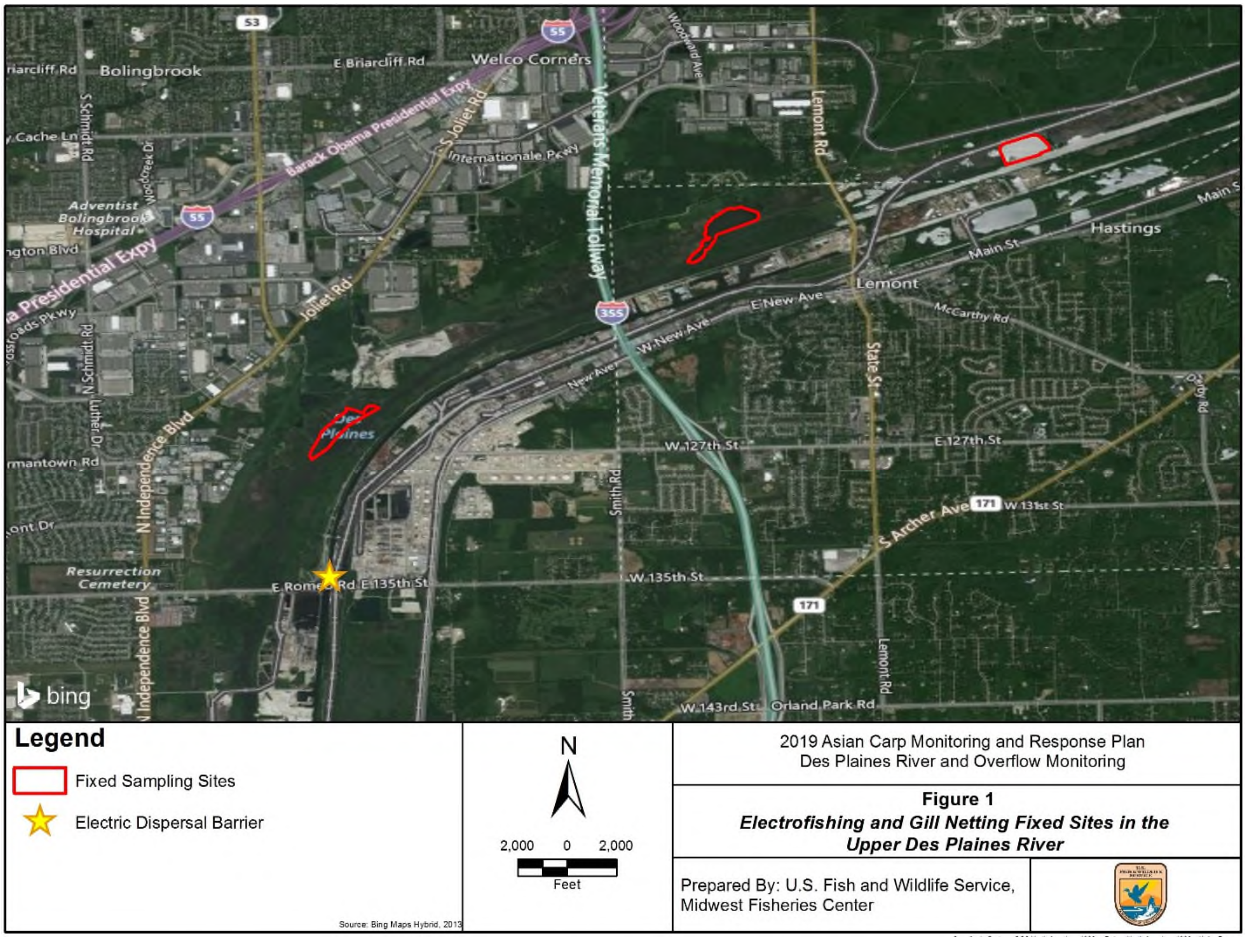

Figure 1. *Fixed site areas for electrofishing and gill netting in the upper Des Plaines River.*

Participating Agencies: IDNR (lead), SIUC (otolith chemistry analysis)

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

Pools Involved: Not applicable

Introduction and Need:

The Illinois Department of Natural Resources (IDNR) fields many public reports of observed or captured Asian 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 Asian 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 pounds]) were captured by electrofishing and netting in Flatfoot Lake and Schiller Pond, both fishing ponds located in Cook County once supported by the IDNR Urban Fishing Program.

As a further response to the Bighead Carp in Flatfoot Lake and Schiller Pond, IDNR reviewed Asian carp captures in all fishing ponds included in the IDNR Urban Fishing Program located in the Chicago Metropolitan area. To date, 9 of the 21 urban fishing ponds in the program have verified captures of Asian carp either from sampling, pond rehabilitation with piscicide, natural die offs or incidental take. One pond had reported sightings of Asian 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 miles). 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 miles). Although some ponds are located near Lake Michigan or the CAWS, most are isolated and have no surface water connection to Lake Michigan or the 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 Asian 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 Asian carp between waters within close proximity to one another, the CAWs, and Lake Michigan.

In addition to Chicago area ponds once supported by the IDNR Urban Fishing Program, ponds with positive detections for Asian carp eDNA were also reviewed. Eight of the 40 ponds sampled for eDNA by the University of Notre Dame resulted in positive detections for Asian carp, two of which are also IDNR urban fishing ponds (Jackson Park and Flatfoot Lake). Asian 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 miles). 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 Asian 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 Asian carp given the proximity to the CAWS.

Objectives:

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

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

Status:

This project began in 2011 and is on-going. A total of 43 Bighead Carp and one Silver Carp have been removed from nine ponds. 57 hours of electrofishing and 12 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 34 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 IDNR 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 Asian 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. Elliot Lake had banks too steep to back a boat in on a trailer. Lastly, Jackson Park and Garfield Park were drained in 2015 and, similar to Lincoln Park South, are no longer a source of Asian 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 2018 interim summary report document (MRWG 2018).

Methods:

Sampling Protocol

Trammel and gill nets used are approximately 3 meters (10 feet) deep x 91.4 meters (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, Asian 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- Asian carp captured in urban fishing ponds will have head, vertebrae, and post-cleithra removed and sent to SIUC for otolith microchemistry analysis and age estimation.

2019 Schedule:

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

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.

Alternative Pathway Surveillance – Urban Pond Monitoring

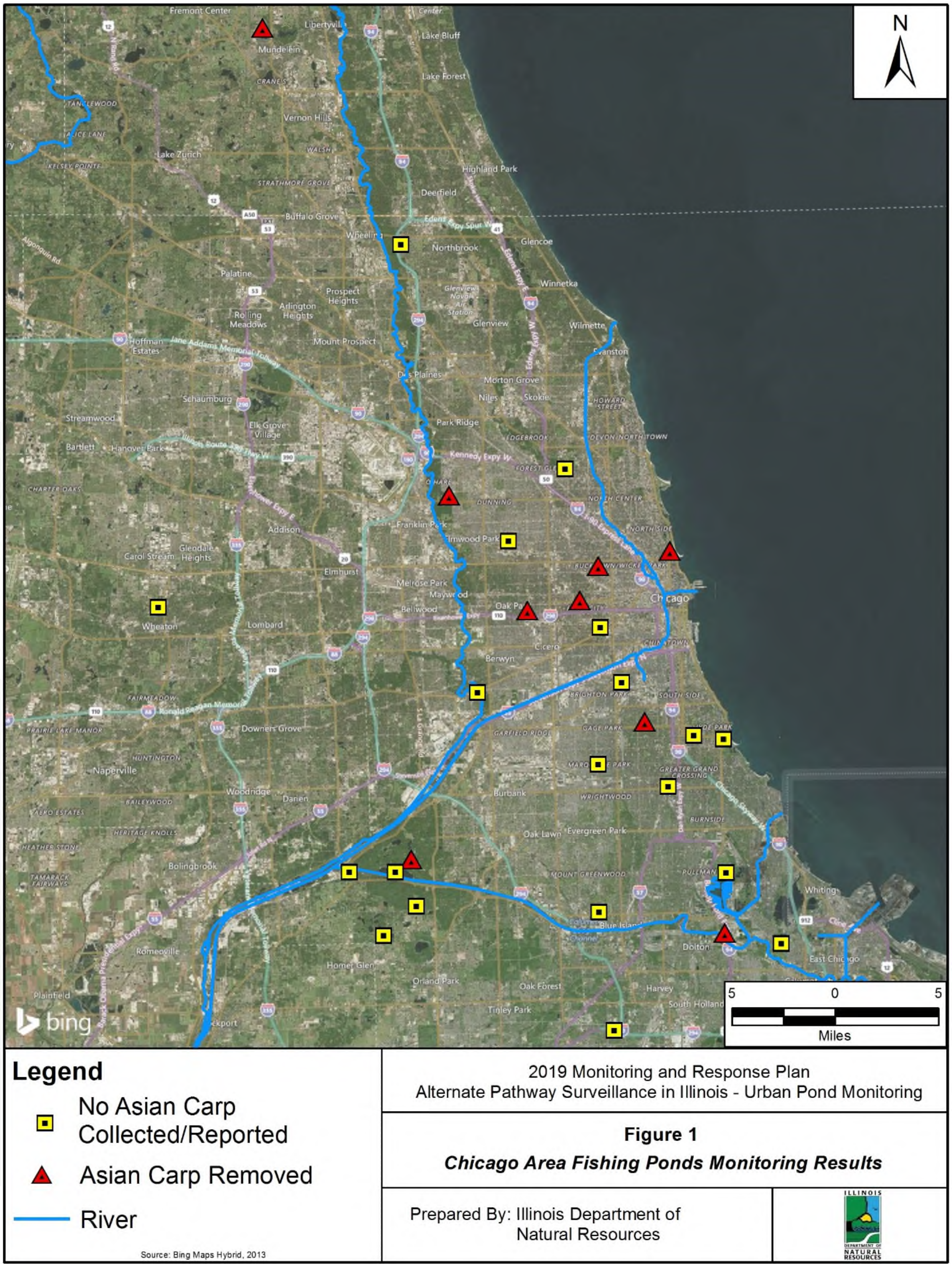

Figure 1. *Chicago area fishing ponds from which Asian carp have been removed (red) and those from which no Asian carp have been collected or reported (yellow).*

Multiple Agency Monitoring of the Illinois River for Decision Making - 2019 Plan

Participating Agencies: Illinois Department of Natural Resources and Illinois Natural History Survey (co-leads), U.S. Fish and Wildlife Service – Wilmington and Columbia Fish and Wildlife Conservation Offices and US Army Corps of Engineers – Chicago District (field support).

Location: The Multiple Agency Monitoring of the Illinois River for Decision Making project will occur in all pools of the Illinois River below the Electric Dispersal Barrier to the confluence of the Upper Mississippi River (UMR) near Alton, Illinois. Specifically, agencies will collaborate to sample: Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton pools (Figure 1).

Introduction and Need:

The Multiple Agency Monitoring of the Illinois River for Decision Making project will utilize a standardized sampling approach to 1) effectively monitor Asian carp population demographics (i.e., presence/absence, distribution, and abundance) and 2) assess native fish communities throughout pools of the Illinois River below the Dispersal Barrier that may be adversely impacted by Asian carp. This project will utilize Long Term Resource Monitoring (LTRM) design (described below) to provide a more robust and statistically powerful dataset than previous projects (e.g., Fixed Site Monitoring Downstream of the Dispersal Barrier 2010-2018) that will be comparable over time and among multiple agencies' data. Since 1994, the U.S. Army Corps of Engineer's Upper Mississippi River Restoration program's LTRM element has monitored fish communities in the Upper Mississippi River (UMR) basin (i.e., the LaGrange Reach of the Illinois River and five reaches of the UMR) and is ongoing. Methods and procedures used over the past two decades have been documented in Gutreuter *et al.* 1995, and subsequent revisions in Ratcliff *et al.* 2014 and have proven to be a key tool in gaining information that is scientifically valid, and comparable spatially and temporally throughout the UMR basin. Utilizing this standardized approach to data collection in reaches of the Illinois River is imperative to increasing our Asian carp monitoring effectiveness to better understand the threat of possible Asian carp invasion upstream the Dispersal Barrier.

Objectives:

(1) Provide a standardized, robust, and statistically powerful monitoring plan that will be comparable spatially and temporally throughout the entire Illinois River below the Dispersal Barrier.
(2) Monitor adult and juvenile Asian carp population demographics (i.e., presence/absence, distribution, and abundance) in pools below the Dispersal Barrier with a standardized design.

(3) Provide relevant data to detect changes to the native fish community adversely affected by Asian carp overtime throughout the entire Illinois River below the Dispersal Barrier
(4) Inform other projects (i.e., Contracted Asian Carp Removal, Telemetry Monitoring, SEAcarP model, etc.) with Asian carp demographic and fish community assemblage data necessary for making management decisions.

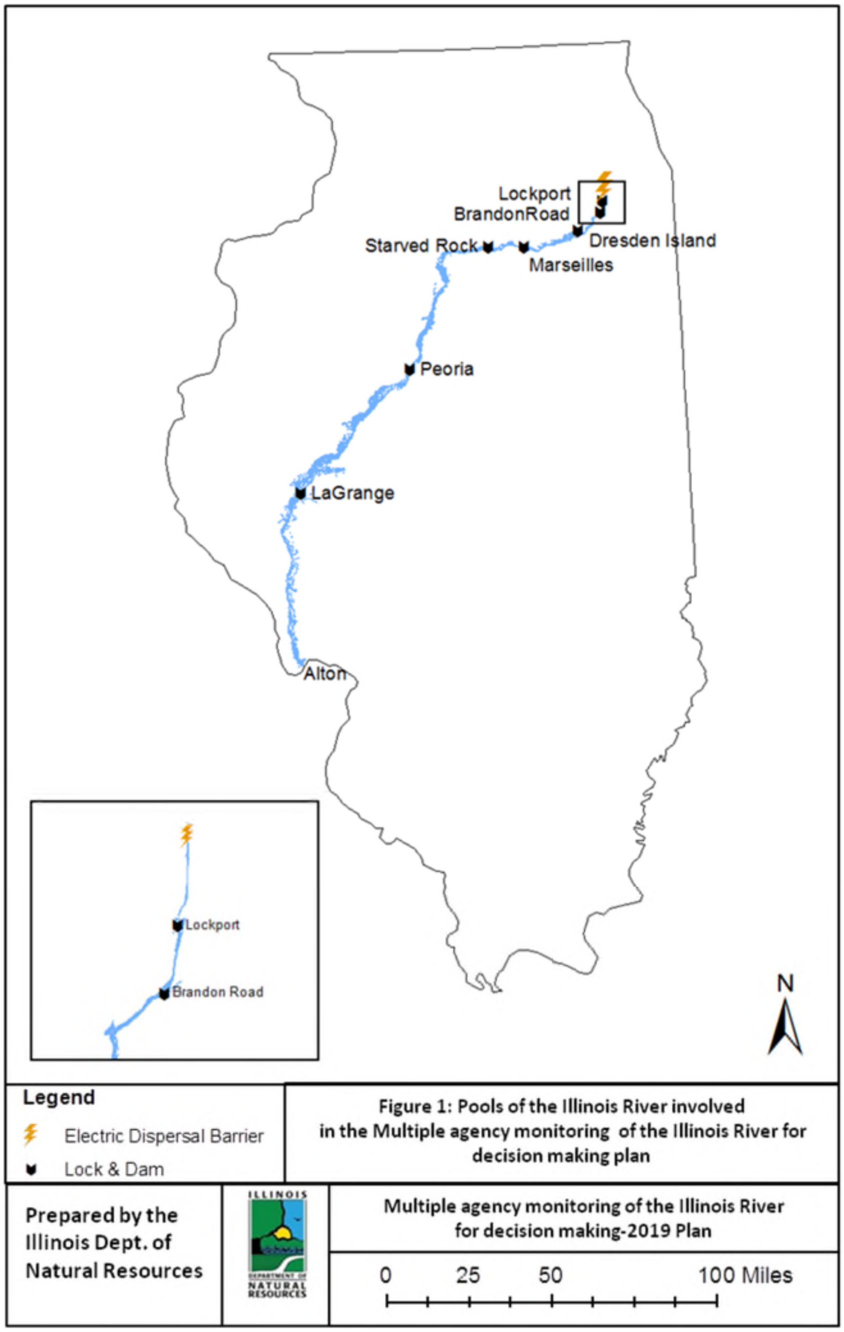

Figure 1. *Map of the sampling reaches of the Illinois River below the Dispersal Barrier to the confluence of the Upper Mississippi River (UMR) involved in the Multiple Agency Monitoring of the Illinois River for Decision Making plan: Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, and Alton pools.*

Multiple Agency Monitoring of the Illinois River for Decision Making - 2019 Plan

Status:

The Fixed Site Monitoring Downstream of the Dispersal Barrier and juvenile Asian carp monitoring projects (2010-2018) have been collecting Asian carp demographic data to meet Monitoring and Response Plan (MRP) objectives. These projects focused on the Starved Rock, Marseilles, Dresden Island, Brandon Road and Lockport pools utilizing electrofishing, hoop netting, and mini fyke netting sampling. Transitioning to the Multiple Agency Monitoring of the Illinois River for Decision Making project will provide a robust, proven, multi-gear, standardized methodology across agencies to increase MRP effectiveness in monitoring Asian carp and native fish communities in reaches of the Illinois River below the Electric Dispersal Barrier. Additionally, these methods will allow comparisons to monitoring in other river reaches outside of the program, giving additional context to observations.

Methods:

The 2019 Multiple Agency Monitoring of the Illinois River for Decision Making project will include daytime pulsed DC boat electrofishing, paired hoop netting, fyke netting, and minnow fyke netting gear types to assess Asian carp population demographics and native fish assemblages spatially and temporally. Efforts are focused in all pools of the Illinois River below the Dispersal Barrier to the confluence of the UMR (Figure 1). Sampling sites are randomly selected from specific habitat types (i.e., main channel borders-shorline (MCB-S), main channel border-open water (MCB-O), side channel borders (SCB), and backwater (BWC) habitats), designated by Wilcox 1993 (Figure 2). Random sampling locations are selected using a stratified random design, and the number of sites per pool are chosen based on calculations of habitat availability within each pool (Ratcliff *et al.* 2014). Fish are collected three times each year: 15 June to 31 July, 1 August to 15 September, 16 September to 31 October, using new random sites each time interval. Inaccessible areas, including those with private or no physical access will be omitted from consideration. If insufficient water depth or obstructions are present, the randomly selected site will be replaced with the nearest randomly selected alternative site.

Day Electrofishing:

Pulsed DC daytime boat electrofishing will be used to achieve comparable fish catch rates and standardization across all pools (Ratcliff *et al.* 2014). Each electrofishing run will last 15 minutes and span a ~200m stretch of shoreline. The electrofishing boat will be operated by a pilot and two dip netters. Dip netters will collect fish as they appear, regardless of size or species. Fish will be placed in a holding tank until the run is completed, and then enumerated, measured, weighed (period 3 only), recorded, and released to the river.

Paired Hoop Netting:

Paired deployment of a large 4 ft (1.2 m) baited hoop net and a small 2 ft (0.6 m) baited hoop net placed in the same sampling area will be used according to LTRM specifications (Ratcliff *et al.* 2014). Hoop nets will be baited with 3 kilograms (kg) of soybean cake. Hoop nets will be deployed in parallel sets, with the small hoop nearer to shore. Hoop nets are fished with the mouth of the net facing downstream, and must be deployed in sites where depth is sufficient to submerge the throats of the nets. Each hoop net will be anchored using a 15–61 m (50–200 ft)-long rope tied to either a stake or a net anchor, depending on which will work best given the substrate composition, depth, and velocity conditions at the sample location. Landmarks, GPS, or a visible float and rope attached at the mouth or anchor line of the net are aids in net retrieval. Hoop nets will be retrieved by towing a grappling hook to snare the anchor line, or by lifting the optional float. Each hoop net of the pair will be treated as an individual sample during data collection (i.e., separate data entry records are completed for each net). After approximately 48 hours, paired hoop nets will be removed, and captured fish will be enumerated, measured, weighed (period 3 only), recorded, and released back to the river.

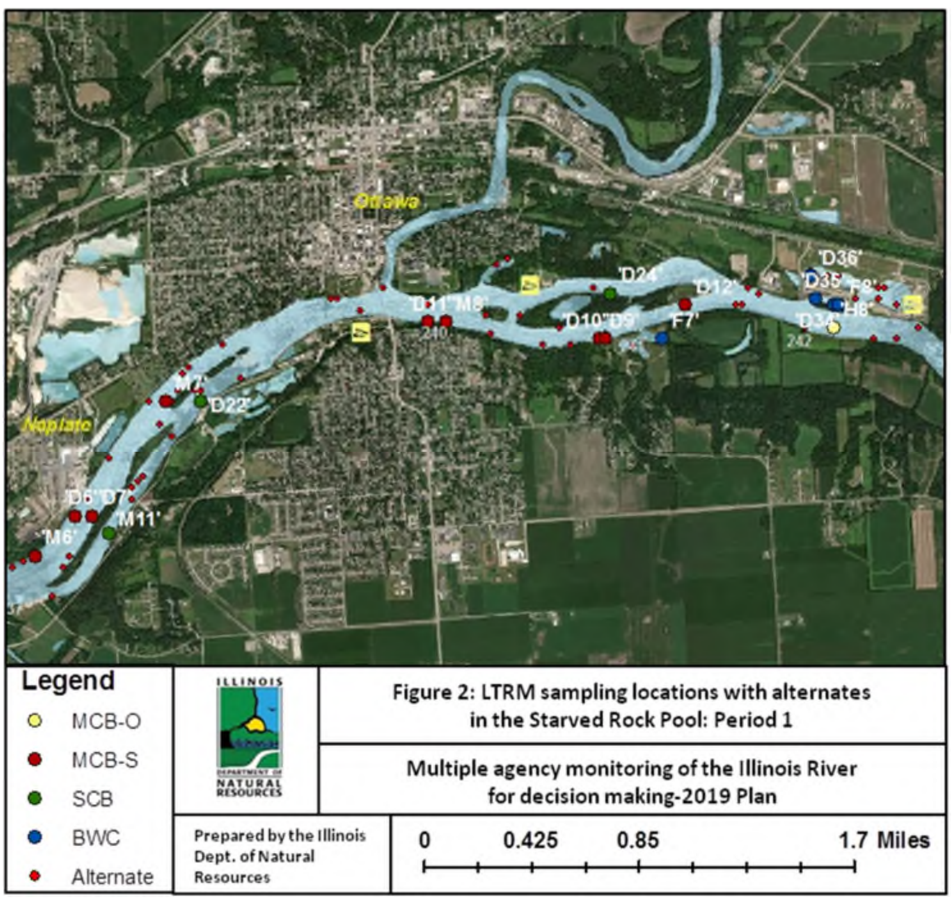

Figure 2. *Minnow fyke net ('M'), Daytime elctrofishing ('D'), Paired Hoop Net ('H'), and Fyke net ('F') stratified random sampling locations: main channel border (MCB), side channel border (SCB), and backwater (BWC) habitats with alternate locations in the Starved Rock Pool of the Illinois River for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

Fyke Netting:

Fyke nets (3.0 ft [0.9 m] x 6.0 ft [1.8 m] frame; 3/4 inch [19.1 mm] mesh; 50.0 ft [15.2 m] lead) will be deployed in areas where water depth is sufficient to submerge the throats of the nets. Leads will usually be fully extended. Exceptions include 1) where the bed slope is steeper than approximately 30 degrees, and 2) where full extension of the lead would put the cab in strong current that could roll the net. In either case, leads may be shortened to no less than 6.1 m (20.0 ft) to place the top of the cab at or above the water surface. In unvegetated or sparsely vegetated areas with accessible shorelines, fyke nets will be deployed perpendicular to shore with the lead anchored to shore or other structure (i.e., logjam or sunken barge). Where vegetation (aquatic or flooded terrestrial) is too dense for staking a net to shore, sampling efforts may be repositioned perpendicularly offshore to the vegetation bed edge. The net will be set perpendicular to the vegetation bed with the lead staked 1.0 m (3.2 ft) inside the outer edge of the vegetation bed. For other possible habitat scenarios affecting fyke net deployment, see page 21 of Ratcliff *et al.* 2014. The cod end may be anchored using a variety of techniques (i.e., rebar, concrete anchors, stakes) dependent on the habitat features of the site. After approximately 24 hours, fyke nets will be removed, and captured fish will be enumerated, recorded, measured, weighed (period 3 only), and released back to the river.

Minnow Fyke Netting:

Minnow fyke nets (2.0 ft [0.6m] x 4.0 ft [1.2m] frame; 1/8 inch [3.2mm] mesh, 15.0 ft [4.6m] lead) will be deployed following the same criteria and exceptions used for fyke nets. Where shortening of leads on minnow fyke nets is permitted, leads may be shortened to no less than 1.8 m (6.0 ft). A unique design feature of the LTRM minnow fyke nets is a 2.0 inch (51mm) inner diameter, 1/4 inch (6.4mm) -thick, stainless steel or nickel plated ring sewn into the throat of the net. This ring prevents turtles and larger predatory fish from getting through the throat of the net and has the added benefit of keeping the throat from collapsing. The cod end may be anchored using a variety of techniques (e.g., rebar, concrete anchors, stakes) dependent on the habitat features of the site. After approximately 24 hours, minnow fyke nets will be removed, and captured fish will be enumerated, measured, weighed (period 3 only), recorded, and released back to the river.

For further detail on LTRM standardized design for gear types please see Ratcliff *et al.* 2014 (https://pubs.usgs.gov/mis/ltrmp2014-p001/pdf/ltrmp2014-p001.pdf).

Data management:

Sampling and fish data collected by each agency as part of the Multiple Agency Monitoring of the Illinois River for Decision Making will be submitted to the United States Geological Service Upper Midwest Environmental Sciences Center for compilation. Data will be appended into a single database and be accessible to MRWG members upon request from the database curator.

Multiple Agency Monitoring of the Illinois River for Decision Making - 2019 Plan

Sampling Schedule:

Multiple Agency Monitoring of the Illinois River will occur among three six week time periods between 15 June to 31 October, 2019. Each agency is responsible for their sampling allocations each time period. Agency site allocation per pool, habitat type, and gear type is shown in Table 1.

Deliverables:

Results of each sampling event will be reported following each sampling period and included in monthly sampling summaries.

Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRP.

Multiple Agency Monitoring of the
Illinois River for Decision Making - 2019 Plan

Table 1. *Monitoring efforts by agencies per each 6 week time period: 15 June-31 July, 1 Aug-15 Sept, and 16 Sept - 31 Oct among main channel border (MCB), side channel border (SCB), and backwater (BWC) habitats using day electrofishing, paired hoop net, minnow fyke net, and fyke net gear types in pools of the Illinois River below the Dispersal Barrier.*

Day electrofishing		Alton	La Grange	Peoria Pool	Starved Rock	Marseilles	Dresden Island	Brandon Road	Lockport	Agency Total
MCB	Total	15	12	15	11	11	11	12	12	
	INHS Great Rivers-LTEF	15								15
	INHS IRBS-LTEF			15	3	6	3			27
	INHS IRBS-LTRM		12							12
	INHS IRBS-Exp. BC EF				4					4
	USFWS-Wilmington				4	5				9
	IDNR-Yorkville						8	4	4	16
	USACE							8	8	16
SCB	Total	12	12	15	12	12	4	0	0	
	INHS IRBS-LTRM		12							12
	INHS IRBS-Exp. BC EF	12		15						27
	USFWS-Wilmington				12	6				18
	IDNR-Yorkville					6	4			10
BWC	Total	12	12	15	12	8	8	0	3	
	INHS IRBS-LTRM		12							12
	INHS IRBS-Exp. BC EF	12		15						27
	USFWS-Wilmington				12					12
	IDNR-Yorkville					8	8		3	19
	USACE									0

Paired hoop netting		Alton	La Grange	Peoria Pool	Starved Rock	Marseilles	Dresden Island	Brandon Road	Lockport	Agency Total
MCB	Total	8	8	8	8	8	8	8	8	
	INHS IRBS-LTRM		8							8
	INHS IRBS-Exp. BC EF			8	8					16
	USFWS-Wilmington					8	8			16
	IDNR-Yorkville							8	8	16
	To be determined	8								8
SCB	Total	6	6	6	6	6	0	0	0	
	INHS IRBS-LTRM		6							6
	INHS IRBS-Exp. BC EF			6	6					12
	USFWS-Wilmington					6				6
	IDNR-Yorkville									0
	To be determined	6								6

Fyke netting		Alton	La Grange	Peoria Pool	Starved Rock	Marseilles	Dresden Island	Brandon Road	Lockport	Agency Total
BWC	Total	10	10	10	8	10	10	0		
	INHS IRBS-LTRM		10							10
	To be determined	10		10	8	10	10			48

Minnow fyke netting		Alton	La Grange	Peoria Pool	Starved Rock	Marseilles	Dresden Island	Brandon Road	Lockport	Agency Total
MCB	Total	8	8	8	8	8	8	8	0	
	INHS IRBS-LTRM		8							8
	INHS IRBS-Exp. BC EF									0
	USFWS-Columbia			8						8
	USFWS-Wilmington				8	8				16
	IDNR-Yorkville						8	8		16
	IDNR									0
	To be determined	8								8
SCB	Total	6	6	6	6	6	6	6	8	
	INHS IRBS-LTRM		6							6
	INHS IRBS-Exp. BC EF									0
	USFWS-Columbia			6						6
	USFWS-Wilmington				6	6				12
	IDNR-Yorkville						6	6	8	20
	IDNR									0
	To be determined	6								6
BWC	Total	10	10	10	10	10	10	10	0	
	INHS IRBS-LTRM		10							10
	INHS IRBS-Exp. BC EF									0
	USFWS-Columbia			10						10
	USFWS-Wilmington				10	10				20
	IDNR-Yorkville						10	10		20
	IDNR									0
	To be determined	10								10

MANAGE AND CONTROL PROJECTS

USGS Telemetry Database and Analyses in Support of SEAcarP

Brent Knights, Marybeth Brey, Travis Harrison, Tim Fox, and Jessica Stanton (U.S. Geological Survey, Upper Midwest Environmental Sciences Center); Jim Duncker (U.S. Geological Survey, Central Midwest Water Science Center)

Participating Agencies: USGS, IDNR, USFWS, USACE, SIU, WIU

Location: Illinois River, Mississippi, and Ohio River basins

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

Introduction and Need:

Telemetry of acoustically tagged bigheaded carp and surrogate fish species has become an invaluable tool in management for these species in the Upper Illinois Waterways and elsewhere. For example, movement probabilities between pools need to be estimated to parameterize the Spatially Explicit Asian Carp Population Model (SEAcarP) used for adaptive management. These 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. Removal by contracted fishers has become the primary method of controlling bigheaded carp in the Upper Illinois Waterways. 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 gain a better understanding of these demographics to meet management objectives, an existing network of real-time and non-real-time acoustic receivers in the Upper Illinois Waterways and elsewhere is collaboratively managed by multiple agencies and universities. This team also plans and executes tagging bigheaded carp with acoustic tags as needed to meet objectives. A telemetry workgroup has been established by the Monitoring and Response Workgroup (MRWG) to ensure that the multi-agency telemetry efforts are coordinated to efficiently and effectively meet MRWG goals. Two of the primary objectives identified by the telemetry workgroup included (1) development of a common standardized telemetry database with visualization and analysis tools; and (2) transitioning from Program MARK to a custom Bayesian multi-state model for estimating movement probabilities needed for SEAcarP. The telemetry database and visualization tools (the FishTracks DB) facilitate standardization, archiving, sharing, quality assurance, visualization and analysis of the telemetry data needed for management. Modifications and additions to FishTracks DB facilitate more problem free use of the database and associated applications, as well as useful extraction of information to meet management goals. The transition to a custom Bayesian multi-state model to estimate movement probabilities will support more efficient, effective and robust population modeling with SEAcarP by overcoming many short comings of Program MARK for this purpose. These shortcomings include customizability, extensibility, problems of singularities and poor-convergence, computer crashes, parameter exclusion from models, not providing estimates of movement probability, and not providing estimates of uncertainty.

Objectives:

(1) Maintenance and development of the telemetry database and associated tools

   a. Maintain and develop FishTracks DB for existing (2010-2018) and new Asian carp telemetry data from the Upper Illinois Waterways, and Mississippi and Ohio River basins, including data from real-time and non-real-time stationary acoustic receivers.

   b. Add and further develop FishTracks DB functionality to ensure data are secure, easily accessible to partners, standardized, and quality assured.

   c. Further develop visualization tools in FishTracks DB so that they are intuitive and easy for partners to use, including the addition of receiver optimization functionality.

   d. Finalize a custom program to analyze telemetry data to inform optimimal placement of acoustic receivers to meet management objectives

   e. Finalize data sharing agreements as memorandums of understanding between participating agencies so that it is clear what data will be shared (i.e. included in the database), how data will be formatted and stored, and how data can be used by participating agencies.

   f. Hold a workshop for the multi-basin telemetry partnership, to demonstrate the functionality of, answer questions about, get feedback on, and promote the use of FishTracks DB to achieve MRWG objectives.

(2) Development of a custom Bayesian multi-state model to estimate bigheaded carp movement probabilities with data in FishTracks DB

   a. Develop a custom program in WinBugs or other Bayesian-capable software to conduct multi-state modeling for estimating movement probabilities and parameter uncertainty needed for SEAcarP.

   b. Using the new program, estimate movement probabilities and uncertainty needed for SEAcarP.

Status:

Database

A centralized database for telemetry receiver and fish transmitter data has been developed, deployed, and released internally to partners for functionality testing and feedback. The FishTracks database, hosted and maintained by the USGS at the Upper Midwest Environmental Sciences Center, includes both real-time and stationary acoustic telemetry receiver location data, and bigheaded carp tagging and detection data from partner agencies. The FishTracks DB includes functionality to generate standard data reports, upload and download data, and interactively visualize bigheaded carp movement data throughout the river system. An initial program for analyses to inform optimization of receiver placement in support of SEAcarP have been completed and presented internally.

Bayesian multi-state model

Subgroups of the telemetry workgroup and population modeling workgroup have met with the USGS modeler hired to code the Bayesian multi-state model and a USFWS modeler with previous experience with this type of model, to finalize an approach and timeline for model development.

Methods:

Database

The FishTracks DB (developed as a Microsoft SQL Server application) will be actively maintained, which involves performing routine database maintainence (e.g. ensuring data backups, performing internal consistency checks, rebuilding indexes as needed, etc.) to keep the application online and available to users. New telemetry data will be incorporated into the FishTracks DB as it is collected, quality assured and submitted by partner agencies. We will also add or modify functions of the FishTracks DB in 2019 based on feedback from the initial round of partner testing. These updates include adding functions to automatically perform quality assurance and standardization for new data submissions, analyze data to optimize receiver locations, and output movement histories by fish for multi-state modeling of movement probabilities for SEAcarP. Modifications to existing functions include improvements in the online data submission and download features and customized monthly, quarterly, or annual reporting features. This optimization functionality will be improved upon and integrated into the FishTracks DB to facilitate relocation of existing receivers and placement of new receiver locations to optimize coverage of the receiver network for supporting SEAcarP modeling and other management objectives. We will also finalize data sharing agreements in 2019 as formal memoranda of understanding between partners. This will entail an iterative review process, to ensure partner concerns regarding data use and security standards are properly addressed and partners have a clear understanding of how their data will be formatted, stored, and used by others. Finally, in 2019 we will hold a multi-basin partner workshop to demonstrate the FishTracks DB and request further feedback.

Bayesian multi-state model

The USGS in collaboration with subgroups of the telemetry workgroup and population model workgroup of MRWG and the USFWS will develop a program to estimate interpool movement probabilities needed for SEAcarP. Specifically, Bayesian methods will be used to create a model syntax that maximizes user customizability and extensibility, while avoiding the problems of singularities and poor-convergence inherent to the rival frequentist 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 that feed into the SEAcarP model. Hierarchical models performed in a Bayesian framework will provide a direct expression of uncertainty estimates of parameters feeding into the SEAcarP model.

Schedule:

Database:

(1) Incorporate new telemetry data; perform routine database maintenance; provide telemetry data to support SEAcarP modeling project as needed – *throughout FY 2019*

(2) Add and improve FishTracks DB functionality

a) Complete programming of quality control checks for new data submissions – *complete by June 2019*

b) Improve data submission and data download tools – *complete by June 2019*

c) Add database functionality as requested by partners – *throughout FY 2019*

d) Integrate receiver optimization functionality with FishTracks DB – *complete by June 2019*

(3) Finalize data sharing agreements as memoranda of understanding between partner agencies – *complete by April FY 2019*

(4) Hold workshop to demonstrate FishTracks DB functionality with a complete dataset to the multi-basin telemetry partnership and solicit feedback for further improvements/additions –*by June FY 2019*

Bayesian multi-state model:

(1) Initial model that runs on a test dataset- *by April 2019*

(2) Complete model and a model run on the initial telemetry dataset that was used by Southern Illinois University in Program MARK. A comparison of movement probabilities between new (Bayesian) and old (MARK) methods- *by July 2019*

(3) Model run on new telemetry data to estimate movement probabilities and associated uncertainty for input to new run of SEAcarP – *by November 2020*

(4) Manuscript for publication on Bayesian multi-state model for estimating movement probabilities – *by February 2020*

USGS Telemetry Database and Analyses in Support of SEAcarP

Deliverables:

Database:

1) Database: Continually maintained, updated, and accessible FishTracks DB that incorporates new real-time and standard acoustic telemetry data on Asian carp.
2) Database tools: Improved quality control, upload, download, and receiver optimization functionalities for the FishTracks DB; additional database functionality as feasible and requested by partner agencies.
3) Data sharing agreement: Formal data sharing agreements between participating agencies using the FishTracks DB.
4) Workshop: Workshop and materials to facilitate understanding and use of the FishTracks DB.

Bayesian multi-state model:

1) Model: Bayesian multi-state model that provided movement probabilities and associated uncertainty
2) Presentation: Presentation to MRWG working groups on a comparison of movement probabilities between new (Bayesian) and old (MARK) methods.
3) Input for SEAcarP: Estimates of movement probabilities and associated uncertainty for input to new run of SEAcarP
4) Report: Manuscript on Bayesian multi-state model for estimating movement probabilities of acoustically tagged bigheaded carp.

Underwater Acoustic Deterrent System Deployment in the CAWS

Marybeth Brey (US Geological Survey, Upper Midwest Environmental Sciences Center), Nick Barkowski (US Army Corps of Engineers Chicago District), and Christa Woodley (US Army Engineering Research and Development Center)

Participating Agencies: USGS, USACE (Chicago District and ERDC) (leads); USFWS, IDNR, USCG, MWRD, NRG Energy, Hanson Material Services Corporation, Illinois River Carriers Association, NRG Energy, and the American Waterways Operators (cooperating)

Location: Hanson Material Services boat slips in the Lockport Pool

Pools Involved: Lockport

Overview:

Acoustic deterrent technologies are being considered to prevent the spread of Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*); hereafter, bigheaded carps, from the Mississippi River watershed to the Great Lakes. The Illinois Department of Natural Resources (IDNR), through the Asian Carp Regional Coordinating Committee (ACRCC) requested the deployment of an Underwater Acoustic Deterrent System (UADS) as a supplement to the Aquatic Nuisance Species Electric Dispersal Barriers (maintained by USACE) during winter Electric Dispersal Barrier operations and maintenance. The overall goal of this project is to determine if an UADS can be implemented in this area, evaluate any impacts to vessels in the area, and monitor the acoustics in the study area. No bigheaded carp are known to exist in this location, so fish monitoring is not a primary objective.

Introduction:

The Monitoring and Response Workgroup (MRWG) of the ACRCC, spearheaded by the IDNR, requested the activation of the ACRCC MRWG Upper Illinois Waterway Contingency and Response Plan as a preemptive action to reduce the risk of bigheaded carp crossing the Electric Dispersal Barrier during maintenance operations occurring from January through April 2018 and November 2018 through April 2019 (pending contracting delays). The MRWG requested a back-up deterrent system to be deployed just downstream of the Electric Dispersal Barrier, specifically, a temporary UADS. In addition to requested deterrent deployment, the MRWG requested passive (e.g., hydroacoustics and acoustic telemetry) and active (e.g., netting and electrofishing) monitoring to occur near the Electric Dispersal Barrier and UADS to monitor fish targets in the Lockport Pool.

Underwater Acoustic Deterrent System Deployment in the CAWS

The Electric Dispersal Barrier system (comprised of three electric arrays) is designed to prevent inter-basin transfer of fish between the Mississippi River and Great Lakes basins via the Chicago Sanitary and Ship Canal (CSSC). The barrier, located approximately 25 miles from Lake Michigan and within a 1,500-foot section of the CSSC, is composed of steel electrodes secured to the bottom of the CSSC. The demonstration barrier operates at 1 volt/inch, 5 Hz (hertz, cycles per second), 4 ms (pulse duration in milliseconds). Barrier IIA was placed into full-time operation in 2009, and Barrier IIB was activated in April 2011. Barrier IIA and IIB operate at 2.3 volts/inch, 34 Hz, 2.3 ms. The Electric Dispersal Barrier system is comprised of complex electrical and mechanical parts and must periodically be powered down for maintenance.

During winter 2017/2018, all three components of the Electric Dispersal Barrier system underwent extensive repair requiring periodic shut-downs. Maintenance of the Demonstration Barrier portion of the Electric Dispersal Barrier occurred in early January through February. An additional barrier shutdown (for maintenance) is occurring from November 15, 2018 through April 2019.

Currently, research is underway to identify potential biological and physical deterrent systems that may discourage the movement of bigheaded carps, while allowing passage of native fish to occur, and without impeding vessel navigation. Underwater acoustic deterrence has shown some promise (e.g., Vetter et al. 2015; 2017; Murchy et al. 2017) as a deterrent system that is relatively low cost, quick to deploy, stimulates a behavioral response in bigheaded carps, and once deployed, has minimal effects on humans or vessel navigation (although, additional data will be collected to confirm this). Thus, an UADS was deployed during the first barrier maintenance event in early 2018 and a second deployment occurred in November 2018.

Goals and Objectives:

(1) Deploy an UADS downstream of the Electric Dispersal Barrier at the edge of the Hanson Material Service (HMS) boat slips (facing the main channel).

(2) Operate and monitor continuous operation of the underwater UADS downstream of the Electric Dispersal Barrier for the duration of the Electric Dispersal Barrier outage events.

(3) Examine acoustic data collected during the deployment of speakers for system failures (system turned off or speaker malfunctioned) or anomalies (changes in frequencies or decibels over time) that would be important to the USACE by developing underwater acoustic propagation models relevant to future acoustic deployments.

Note: This is a technical project being completed at the request of partners. Because this system is designed to deter bigheaded carp, and no known invasive carp are known to occur in this area, measuring system efficacy to deter fish is not a primary objective of the study. However, the US Fish and Wildlife Service (USFWS) will be completing weekly barrier hydroacoustic scans for the duration of the deployment, and the USACE will be monitoring acoustic telemetry receivers in the area.

Methods:

Field study site

The UADS will be deployed along the right descending (north) bank at the Hanson Material Services site near Romeoville, Illinois (River mile 295.4; 41°37'45.56"N, 88° 3'42.98" W; Figure 1, left picture). The site is approximately one mile downstream of the Electric Dispersal Barrier (Figure 1). Equipment will be deployed from a work barge moored to the right descending (north) bank (Figure 1, right picture). A USGS site access agreement is in place with Hanson Material Services to use this site for the duration of the study.

Equipment

The UADS will consist of an array of 5 Lubell LL-1424HP underwater acoustic transducers (Figure 2; dimensions: 16.5-inches x 16.5-inches x 16.5-inches) suspended from iron posts that are attached to brackets and welded to a work barge. Each transducer will be connected via Seacon® XSEE3CCP connectors molded to one end of a 75-foot 14/3 SO cable. The other end will be connected to a bridging transformer box (AC1424HP; one per transducer; Lubell Labs®) connected to a Crown® CDi 2000 two channel power amplifier. One amplifier will supply power for up to two speakers. All amplifiers will be connected to one iPod mini with the recording of a 100 hp boat motor tested in prior studies. The system will be monitored using a minimum of two stationary SoundTrap® ST300 hydrophones located along the left descending (south) bank, across the main channel from the UADS and directly downstream of the UADS.

Fish Monitoring

Fish monitoring will be completed by other agencies and data will not be collected by the USGS. Three USACE-monitored Vemco® acoustic telemetry receivers are upstream and downstream of the UADS to monitor any tagged fish that are in the area. USACE personnel will be responsible for monitoring these receivers only to determine if any Bighead or Silver Carp are detected in the area. These data will not be used to gauge efficacy of the UADS and no new fish will be tagged for this project.

USFWS personnel will be conducting weekly hydroacoustic surveys in the area to monitor large fish targets. Data will be processed to determine if major changes in fish distribution occur over the study period. The USFWS are responsible for and will maintain the hydroacoustic data. USGS may be requested to assist with the hydroacoustic surveys or data summarizing. Information regarding fish monitoring is not the primary objective of the USGS. These data will be served by the USACE and USFWS, respectively. The data may be requested if deemed useful. At a minimum, surveys will be conducted prior to any deployment (October 2018) and every two weeks until the end of the study.

Acoustic deterrent signals

The acoustic boat motor recordings will play continuously for the duration of the deployment unless another acoustic stimulus is deemed more effective in lab or field trials.

Monitoring and data collection

During deployment and the initial set-up phase, drift tests in a fiberglass boat will be conducted to measure the area that is insonified by the UADS. The SoundTrap® hydrophone will be suspended from the port side of the vessel approximately one-meter below the water surface. The boat will be positioned above the water intake structure for the power plant, just north of the study site, in the main river channel. The motor will be turned off and the boat will drift downstream while the hydrophone records. The boat will drift until it has passed the opening of the Hanson Material Services boat slips. If the boat gets too close to shore, the motor will be turned on (the hydrophone removed from the water) and the boat will be positioned closer to the middle of the main channel. The hydrophone will then be put back into the water and the drift will continue. This process will be completed until the entire channel has been recorded (up to four drift transects and two independent drift tests will be completed).

During the operating period, a minimum of two SoundTrap® (Ocean Instruments, New Zealand) hydrophones will be deployed in the deployment area to monitor the acoustic propagation (across the channel from the UADS on the left descending (south) bank, south of the UADS on the right descending (north) bank, and on the UADS deployment vessel). Hydrophones will be set to record a digital audio file and temperature at the top 10 minutes of every hour for the duration of the deployment (to extend the battery/memory life of the hydrophone, the hydrophones will not run continuously). These data (.wav files labeled with the date, time, and location of the study within a metadata file) will be analyzed using MATLAB software to extract the decibel/amplitude of the underwater sound projections as well as the ambient sound. “Sound maps” will be created to illustrate the sound propagation in the area both with and without vessel traffic in the area. SoundTrap® hydrophones will be deployed from vessels during the testing period (first week of deployment). Acoustic propagation will be calculated and presented in “sound maps” overlaid on GIS imagery.

Additional acoustic monitoring from barges traversing the area may be possible, pending the availability of a vessel. In 2018, we were able to ride on the Hanson Material Services work barge with and without a tow. One SoundTrap® hydrophone was deployed off the port side (mid-point) at approximately 2 meters depth. GPS positioning was recording during the duration of the recording and notes regarding barge operation and ambient sound were recorded. In addition, an ExTech® Instruments Sound Level Meter (Model SDL600) was held at various positions along the barge to measure in-air Sound Pressure Levels. One Sony® PCM-D100 recorder recorded in-air sound for the duration of deployment (for drift tests and barge monitoring) to record .wav files (in-air). This process would be followed in 2019 if a vessel is available.

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Figure 1. The underwater acoustic deterrent system (left; yellow polygon) will be deployed at river mile 295.4, approximately 1 mile downstream of the Electric Dispersal Barrier (yellow star). The UADS will be deployed off the Limey II towboat (right; yellow rectangle).

Figure 2. The underwater acoustic deterrent system will consist of an array of 5 Lubell® LL-1424HP Underwater Acoustic Transducers (dimensions: 16.5" x 16.5" x 16.5").

Schedule (for deployment completed in 2019):

- The main study period will occur from 22 October 2018 – 1 April 2019
- Detailed schedule of events follows:
  - October 22– 25, 2018: Redeploy system (speaker installation), sound mapping, and system testing
  - November 5 – 14, 2018: Reserved for system recheck prior to operation
  - November 15, 2018: Electric Dispersal Barrier maintenance begins

- November 14 – April 1, 2019: Active 24-hour sound deployment
- Late March: conduct any additional sound mapping or acoustic data collection necessary helpful to evaluating system operation
- April 1, 2019: Tentative tear down (if barrier maintenance schedule does not change)
- Summary Report: December 2019

Deliverables:

Any deviations to normal operations of the UADS will be communicated through regularly scheduled calls led by the USACE as part of Barrier maintenance operations. All data and results will be made publicly available through a USGS-USACE report by December 2019.

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USGS Geospatial Support for Unified Fishing Method

Kevin Hop, Andrew Strassman, Jon Vallazza and Brent Knights, (U.S. Geological Survey, Upper Midwest Environmental Sciences Center)

Participating Agencies: USGS, IDNR, USFWS

Location: Illinois, Des Plaines, and Kankakee rivers

Pools Involved: Dresden Island, Marseilles, and other pools as needed

Introduction and Need:

Mass harvest of bigheaded carp (i.e. Silver Carp and Bighead Carp) is challenging, primarily due to their strong gear avoidance behavior. Alternative methods of mass harvest are being explored, including a Unified Fishing Method adapted from a traditional Chinese method. The adapted Unified Fishing Method being deployed in the Illinois River incorporates multiple driving, herding, and capture techniques (collectively fishing techniques) in an integrated fashion over multiple days to more efficiently and effectively capture bigheaded carp in a pre-determined area. Implementation of this method requires spatial and temporal coordination among multiple agencies' personnel and contracted fisherman to execute the various fishing techniques in a unified manner at scales ranging from individual backwaters to entire navigation pools. Better understanding the spatial and temporal aspects of these fishing techniques in relation to capture or movements of telemetered fish during the Unified Fishing Method could help improve the efficiency and effectiveness of this method of mass harvest.

To achieve this better understanding, we will examine data collected on boats and nets used for the various fishing techniques to identify spatial and temporal gaps in these data. Previous data collections during these events have either required extensive post-processing before use in a GIS, or data were not usable in a GIS (e.g. GPS data from recreational fish finders). Improving and standardizing data collection, particularly GPS tracking data, will improve the ability to visualize the fishing techniques that are part of the Unified Fishing Method in relation to capture and movement data. This will facilitate evaluations for improving the efficiency and effectiveness of future deployments of this method. We will also complete the evaluation of near-real time GPS-tracking devices on boats and nets during events as a means of increasing the resolution of collected data. In addition to providing reliable, accurate, and standardized data for post-event evaluations, this near-real time data should improve coordination during the event. As part of this project, we will also develop a method for processing the geospatial data to facilitate rapid delivery and visualizations of the data to managers and researchers conducting evaluations.

USGS Geospatial Support for Unified Fishing Method

Objectives:

(1) Develop a method for data collection on boats, nets, and catch during Unified Fishing Method events to minimize spatial and temporal gaps in the data and increase accuracy and standardization.

(2) Develop a method for post-processing the standardized geospatial data (i.e. on boats, nets, catch, and telemetered fish movement during events) into GIS visualizations to facilitate evaluations of the method.

Status:

In 2018, data collected from previously completed Unified Fishing Method events (i.e. West Morris Pits in the spring of 2017, Creve Coeur Lake in late winter of 2018, and Dresden Island Pool in the fall of 2017 and spring of 2018) were compiled and prepared for use in a GIS. Some collected data were unusable because consistent locational data was not available. As well, we concluded that data gaps likely occurred because a person was not dedicated solely to the task of ensuring GPS devices were deployed and functional on all boats and nets at all times during the Unified Fishing Method event. Three-dimensional (latitude, longitude, and time) visualizations were generated from the usable GPS boat tracks. These preliminary visualizations were used to identify gaps in data collection during events.

Gaps in data collections, identified from data and visualizations in previous events, were used to improve data collection efforts during the Dresden Island Pool event in fall of 2018. During this event, we dedicated a person to ensuring that GPS units were functioning and properly deployed on all participating boats. We also exclusively used GPS units with downloadable, time-stamped data. Preliminary results from the fall 2018 event indicate that we collected a near complete inventory of time-sequenced GPS boat tracks that are fully usable in a GIS environment. The data will be used to develop standardized post-processing methods and generate visualizations for the Dresden Island Pool fall of 2018 event that can be combined with catch and telemetered fish movement data to further evaluate and improve the Unified Fishing Method.

Methods:

We will develop a method for collecting geospatial data during Unified Fishing Method events on boats, nets, and catch to minimize spatial and temporal gaps for increased data accuracy and standardization. Identifying and testing GPS-, satellite-, and/or cellular-tracking equipment will occur to determine the most effective tracking devices to deploy on boats and nets during events. A person dedicated solely to geospatial data collection will be deployed during future Unified Fishing Method events. This person will deploy and monitor GPS-tracking devices on boats and nets, assess geospatial data collected after each day's removal efforts to ensure that tracking devices are properly collecting data, and troubleshoot any technical issues that arise during data collection. This method will be documented in detail with instructions for recommended use and deployment of tracking equipment during Unified Fishing Method events.

A method for post-processing the standardized geospatial data (e.g. from boats, nets, catch, and telemetered fish) collected during events into GIS visualizations to facilitate evaluations of the Unified Fishing Method will also be developed. Geospatial data collected during Unified Fishing Method events (specifically, the Dresden Island Pool fall of 2018 event) will be compiled and prepared for use in a GIS, which involves downloading data from GPS-tracking devices, formatting the data into a usable GIS format, and loading the data into a GIS (i.e. Esri ArcScene). Animated visualizations showing the movement of boats and nets in relation to telemetered fish movement, in the context of high-resolution bathymetry data (if available for the area) will be created. Visualizations can then be evaluated to identify areas and times where coordination of boats and nets were the most or least effective, for lessons learned to increase effectiveness of future Unified Fishing Method events.

2019 Schedule:

1) Develop a method for geospatial data collection during Unified Fishing Method events:
   a. Identify and test GPS-tracking devices during Unified Fishing Method events - *during the Dresden Island Pool fall of 2018 event and the Morris Pits spring of 2019 event*
   b. Deploy dedicated individual to deploy and monitor tracking equipment during Unified Method events - *during the Dresden Island Pool fall of 2018 event and the Morris Pits spring of 2019 event*
   c. Write document detailing method for recommended use and deployment of tracking devices during Unified Fishing Method events - *complete by the end of FY 2019*
2) Develop a method for post-processing geospatial data collected during Unified Fishing Method events:
   a. Compile and prepare data collected during the Dresden Island Pool fall of 2018 event – *complete by end December 2019*
   b. Create animated visualizations of the Dresden Island Pool fall of 2018 event – *complete by end of FY 2019*
   c. Write document detailing method for post-processing geospatial data collected during Unified Fishing Method events into GIS visualizations – *complete by end of FY 2019*

Deliverables:

1) Develop a method for data collection during Unified Fishing Method events:
   a. Report: Written document detailing method for data collection during Unified Fishing Method events, including recommendations for types of tracking equipment to use, where

and how to deploy tracking devices on boats and fishing gear, and resolutions for troubleshooting common technical issues.

2) Develop a method for post-processing collected data after the completion of Unified Fishing Method events:

   a. Data Analysis: Series of GIS visualizations showing coordination of boat movement during the Dresden Island Pool fall of 2018 event.

   b. Report: Written document detailing method for post-processing geospatial data collected during Unified Fishing Method events into GIS visualizations, including how to compile and prepare tracking data, how to import tracking data into GIS environment, and how to create animated visualizations combining tracking data of boats and nets, telemetered fish data, and high-resolution bathymetry data.

Contracted Commercial Fishing Below the Electric Dispersal Barrier - 2019 Plan

Participating Agencies: Illinois Department of Natural Resources (IDNR; lead), Illinois Natural History Survey field support

Location: Contracted Commercial Fishing Below the Dispersal Barrier will target the area between the Starved Rock Lock and Dam up to the Electric Dispersal Barrier at Romeoville, IL (~37 miles [60 km] from Lake Michigan). Removal effort will occur in the Starved Rock pool, removal and monitoring effort will occur in the Marseilles Pool and the Dresden Island Pool, and detection effort will focus in the Brandon Road Pool and the Lockport Pool (Figure 1).

Introduction and Need:

Contracted commercial Fishing Below the Dispersal Barrier uses contracted commercial fishers to reduce Asian carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) numbers and monitor for their expansion in the upper Illinois River and lower Des Plaines River downstream of the Electric Dispersal Barrier. By decreasing Asian carp numbers, we anticipate reduced migration pressure towards the barrier lessening the chances of Asian Carp gaining access to upstream waters in the Chicago Area Waterway System and Lake Michigan. Monitoring for upstream expansion of Asian carp should help identify changes in the leading edge, distribution, and relative abundance of Asian carp in the Illinois Waterway. The "leading edge" is defined as the furthest upstream location where multiple Bighead Carp or Silver Carp have been captured in 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 Asian carp population abundance and movement between and among pools of the Illinois Waterway.

Objectives:

Nine contracted commercial fishers will:

(1) Monitor for the presence of Asian Carp in the five pools (Starved Rock, Marseilles, Dresden Island, Brandon Road, Lockport) below the Electric Dispersal Barrier in the Illinois Waterway.

(2) Reduce Asian Carp densities, lessening migration pressure to the Electric Dispersal Barrier, thus decreasing chances of Asian carp accessing upstream reaches (e.g., Chicago Area Waterway and Lake Michigan).

(3) Inform other projects (i.e., hydroacoustic verification and calibration, SEAcarP model, small fish monitoring, telemetry master plan) with Asian carp population distribution, dynamics, and movement in the Illinois Waterway downstream of the Electric Dispersal Barrier.

Contract Fishing Below the Dispersal Barrier - 2019 Plan

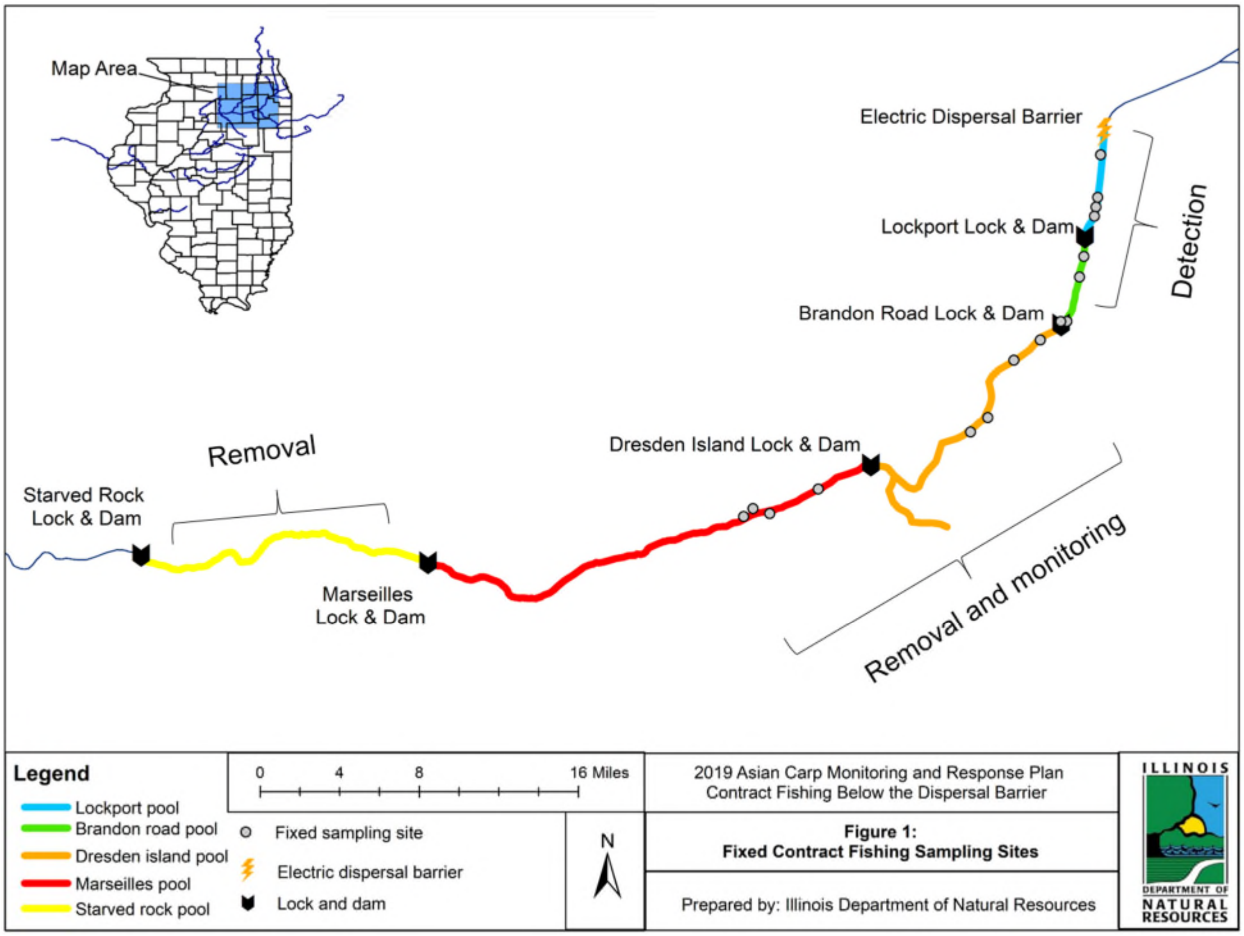

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites sampling of the contract fishing below the electric dispersal barrier project.*

Status:

Contracted commercial fishers have been used in the *Fixed Site Monitoring Downstream of the Dispersal Barrier* project and the *Barrier Defense Asian Carp Removal* project (2010-2018). Combing contracted commercial fishing efforts of those these two projects into a single project will provide a more comprehensive picture of the ongoing contracted commercial fishing effort and results. Since 2010, contracted commercial fishers' effort in the upper Illinois Waterway below the dispersal barrier includes 3,404 miles (5,478 km) of gill/trammel net, 22 miles (35km) of commercial seine, 184 pound net nights, and 3,970 hoop net nights. A total of 66,940 Bighead Carp, 775,867 Silver Carp, and 6,297 Grass Carp have been removed. The total weight of Asian carp removed is 3,618 tons. Contracted commercial fishing effort indicates a decreasing abundance trend of Asian carp as you progress upriver from Starved Rock Pool to Dresden Island with no Asian carp captured in Lockport or Brandon Road pool 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 2018 Interim Summary Report.

Contract Fishing Below the Dispersal Barrier - 2019 Plan

Methods:
Contracted commercial netting will occur from February through December in Starved Rock, Marseilles, Dresden Island, Brandon Road, and Lockport Pools of the Illinois Waterway. 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; therefore, an IDNR biologist will be required to accompany contracted commercial fishing crews working in this portion of the river. Contracted commercial fishers with assisting IDNR biologists will fish four days of the week during each week of the field season (February through December) except in June and September when contracted commercial fishers will be sampling upstream of the Electric Dispersal Barrier for the Seasonal Intensive Monitoring project (Table 1).

Fishing will occur in backwater, main channel, and side channel habitats known to hold Asian carp at fixed and targeted sites. Four fixed sites have been established within Marseilles, Dresden Island, Brandon Road, and Lockport pools in habitats Asian carp are suspected to congregate. Each fixed site will be sampled once a month by a contracted commercial fisher (Figure 1). Targeted sampling will occur when fixed sites are not sampled and will be selected at the discretion of the contracted commercial fishing crew with input from the IDNR biologist assigned to each boat.

Large mesh (2.5 - 5.0 inch; 63.5mm-127mm) gill and trammel nets set in 200 to 1,200 yard segments will be used and utilize fish herding (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors tipped 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 Asian carp and Common Carp will be checked for telemetry tags and all non-tagged Asian carp will be harvested and utilized by private industry for purposes other than human consumption (e.g., chum bait, converted to liquid fertilizer, lobster bait, pet treats, etc.). All tagged Asian carp and all non-Asian carp by-catch will be released into the water alive. A representative sample of up to 30 individuals of each Asian carp species (Bighead Carp, Grass Carp, and Silver Sarp) from each pool will be measured for total length and weighed in grams each day to provide estimates of total weight harvested.

Suggested boat launches for contracted commercial fisher sampling:

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

Brandon Road Pool: Ruby Street Launch in Joliet (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: Stratton State Park Launch in Morris (Griggs Dr, Morris, IL 60450)

Contract Fishing Below the Dispersal Barrier - 2019 Plan

<u>Starved Rock Pool:</u> Allen Park Launch in Ottawa off Route 71 (400 Courtney Street, Ottawa, Il 61350)

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

Sampling Schedule:

Sampling will occur from February untill December in 2019. The tentative distribution of 2019 contracted commercial fishers' effort is shown in table 1.

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 report and project plans updated for annual revisions of the Monitoring and Response Plan.

Table 1. *Tentative schedule for 2019 contract fishing below the Electric Dispersal Barrier.* **

Week of	Agency	Purpose	Week of	Agency	Purpose	Week of	Agency	Purpose
Feb 18*	IDNR	Monitoring	17-Jun	IDNR	Removal	30-Sep	IDNR	Removal
Mar 4*	IDNR	Removal	24-Jun	IDNR	Removal	30-Sep	IDNR	Monitoring
11-Mar	IDNR	Removal	24-Jun	IDNR	Monitoring	7-Oct	IDNR	Removal
18-Mar	IDNR	Removal	8-Jul	IDNR	Removal	14-Oct	IDNR	Monitoring
25-Mar	IDNR	Monitoring	15-Jul	IDNR	Monitoring	21-Oct	IDNR	Removal
1-Apr	IDNR	Removal	22-Jul	IDNR	Removal	28-Oct	IDNR	Monitoring
8-Apr	IDNR	Removal	29-Jul	IDNR	Removal	4-Nov	IDNR	Removal
15-Apr	IDNR	Monitoring	29-Jul	IDNR	Monitoring	12-Nov	IDNR	Removal
22-Apr	IDNR	Removal	5-Aug	IDNR	Removal	18-Nov	IDNR	Monitoring
29-Apr	IDNR	Removal	12-Aug	IDNR	Monitoring	Dec 2*	IDNR	Removal
6-May	IDNR	Monitoring	19-Aug	IDNR	Monitoring	Dec 9*	IDNR	Removal
13-May	IDNR	Removal	26-Aug	IDNR	Removal	Dec 16*	IDNR	Removal
20-May	IDNR	Removal	3-Sep	IDNR	Removal			
28-May	IDNR	Removal	23-Sep	IDNR	Removal			

* Weather permitting

** Additional netting may occur during weeks not listed in this table.

Mass Harvest and Removal Techniques

Robin D.Calfee and Duane Chapman (U.S. Geological Survey, Columbia Environmental Research Center)

Participating Agencies: USGS, IDNR, INHS

Location: Illinois River

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

Introduction and Need:

A multi-faceted approach has been taken to (1) identify areas with high densities of bigheaded carps using low-cost sonar; (2) characterize the habitat that hosts those aggregations; and (3) develop efficient methods for removing such aggregations. To date, we have improved our ability to estimate bigheaded carp abundance using low-cost sonar. Through newly-developed, automated processing techniques we can quickly calculate the number of fish in both sidescan and 360-degree sonar imagery to obtain an unbiased estimate of abundance. Collection of frequent carp abundance and habitat data in multiple harvest basins has also occurred in 2018 and analyses will aim to predict trends in carp abundance within those harvest basins. A variety of harvest methods have also been tested in 2018 including herding and trap net types and orientations. Continued research in these areas may assist management agencies with making decisions regarding (1) which regions and populations to remove and when; and (2) what techniques will be most effective for removal given habitat type and population size.

Trap nets, particularly Great Lakes-style pound nets, have been evaluated as passive gears for removing large numbers of invasive carps in the Illinois River system. We will expand on that research by developing and testing different trap net styles for passive capture effectiveness. Bighead and Silver Carp have demonstrated extreme net avoidance behavior, and unique trap net modifications may be required to facilitate consistent capture of bigheaded carps. In 2018, baseline data for a new trap net, the Merwin Trap in a comparison with the pound net, was collected to determine the capture efficiencies of each net. Additionally, testing of the Iruka net, another large trap net style began in 2018 and additional testing will occur in 2019. All selected sites were backwaters to the Illinois River. Future research will involve the use of herding to motivate fish to enter the trap nets. Factors to be considered for increasing the efficiency of fish harvest are gear types, site location, river dynamics (flowing, backwater), seasonality and productivity of the system.

Increasing harvest of Silver Carp (*Hypophthalmichthys molitrix)* and Bighead Carp (*Hypophthalmichthys nobilis)*, hereafter referred to as bigheaded carps, is a primary management action to contain the population growth and reduce upstream dispersal. Given their evasive behavior and gear avoidance, efficient capture of bigheaded carps is challenging. However, the robust behavioral response of bigheaded carps when exposed to acoustic stimuli may facilitate resource management agencies' ability to drive, corral, trap, and remove large numbers of individuals. Commercial fishers often attempt to increase catches by trimming the outboard motor and revving at high RPMs to throw water and chase fish into set gill nets. Broad-frequency sounds and deep-water electricity have recently been developed to build on available herding methods and have aided in several Unified Fishing Method events, resulting in the removal of several hundred tons of bigheaded carps in one major effort. Given promising results of this application, further investigation is warranted to refine herding techniques and test utility for use in more frequent, smaller-scale removal efforts.

Objectives:

(1) Identify, develop, and evaluate herding, containment, and capture methods to optimize mass harvest in tributary and backwater habitats.

(2) Validate low-cost sonar methods to identify and quantify Silver Carp aggregations and populations.

(3) Evaluate the passive capture efficiencies of the Great Lakes style pound net, Merwin trap, and Iruka style net in backwaters to the Illinois River.

(4) Develop methods and evaluate if herding techniques are effective in driving bigheaded carps into the various trap net styles.

(5) Compare effectiveness of different sound and electrofishing stimuli and settings to select optimal configurations for use in herding work and experimentation.

(6) Evaluate effectiveness of invasive carp herding techniques and stimuli including but not limited to sound and electrofishing in a variety of water body types and sizes.

Status:

Automated process for abundance estimation of bigheaded carps from low-cost recreational sonar imagery

In 2018, a procedure for the automated processing of recreational sonar imagery was developed. This process greatly reduces the amount of time for generating fish abundance estimates, and these estimates could be used for population monitoring and to measure the success of removal efforts. In 2019, research will continue to improve the method by testing it against research-grade equipment estimates and conducting a field validation. Additional work to standardize sonar data acquisition methods to better facilitate post-processing will also be conducted. These methods will also be useful to estimate carp abundance in areas where experimental gears are being tested.

Use of trap nets to enhance invasive carp removal

In 2018, four weeks of passive net sets were completed; two weeks in Lily Lake and two weeks in the Hanson Material Services pits. Each week, the Merwin trap and pound net were set in the same water body on Monday and removed on Friday, and fish were removed and enumerated every 24 hours. Two weeks of net sets were completed using an algal food attractant applied over the trap nets to determine if capture would be enhanced. Work in 2019 will focus on whether herding methods can enhance capture by the Merwin Trap, pound net, and Iruka net. New trap nets may also be tested.

Evaluation of Herding Techniques to Enhance Capture of Invasive Carp

Preliminary technique development studies were conducted in 2016 and 2017 in Marseilles Pool backwaters (Morris, Illinois), Starved Rock Pool, and the Spoon River near Havana, Illinois. These studies suggested that some techniques such as the use of sound and electrofishing did improve catch rates, and therefore merited further testing. In 2018, several different sounds and boat electrofisher settings and configurations were tested to identify the best stimuli and settings for motivating carps to move downstream. Those stimuli and others were further tested in a replicated field study in a tributary in 2018. Future work in 2019 will focus primarily on applying and further testing the results of the 2018 studies to other water bodies and water body types in Illinois, and developing methods for herding carps into trap nets using the stimuli found to be most effective.

Methods:

Automated process for abundance estimation of bigheaded carps from low-cost recreational sonar imagery

(1) Conduct study comparing population estimates from recreation sonar imagery transects with population estimates from research-grade sonar

(2) Conduct field validation study to determine how carp abundance estimates from sonar compare to what is actually there

Use of trap nets to enhance invasive carp removal

(1) Set nets in select study areas and evaluate capture success with and without herding as a supplemental capture method.

- Use ARIS sonar to identify carp behavior when they interact with the nets.
- Gather environmental data such as depth, flow, turbidity, etc.

Evaluation of Herding Techniques to Enhance Capture of Invasive Carp

(1) Development of methods for herding into trap nets

- The best-performing herding stimulus will be used to herd carps into different trap nets.

Mass Harvest and Removal Techniques

- Trap net trials will be conducted in several different locations.
- Net avoidance will be evaluated using sonar technology.

2019 Schedule:

Automated process for abundance estimation of bigheaded carps from low-cost recreational sonar imagery

- These studies will be conducted opportunistically in 2019.

Use of trap nets to enhance invasive carp removal

- Trials testing the Merwin Trap, pound net, Iruka, and new designs will be conducted in the spring and summer of 2019.

Evaluation of Herding Techniques to Enhance Capture of Invasive Carp

- In the spring 2019, several types of trap net will be set and herding will be used to motivate carps into the nets.

Deliverables:

Automated process for abundance estimation of bigheaded carps from low-cost recreational sonar imagery

- Manuscript detailing the low-cost recreational sonar processing methods.
- Manuscript comparing population estimates using this method with estimates from research-grade sonar.
- Field validation information to better understand how abundance estimates derived from low-cost sonar compare with what is actually present in the water body being sampled.

Use of trap nets to enhance invasive carp removal

- Data on fish catch for all tested trap nets with corresponding environmental conditions.
- Written summary detailing results of all netting trials.

Evaluation of Herding Techniques to Enhance Capture of Invasive Carp

- Data regarding the best-performing trap net(s) and information regarding net avoidance behavior by carps encountering those nets.

Mass Harvest and Removal Techniques

- Manuscript detailing 2018 herding study results.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Participating Agencies: USFWS-Carterville Fish and Wildlife Conservation Office, USFWS Columbia Fish and Wildlife Conservation Office, USGS Upper Midwest Environmental Sciences Center (leads); INHS, IDNR, Southern Illinois University, USGS Columbia Environmental Research Center (collaborators)

Location: Illinois River from Dresden Island Pool downstream to the confluence with the Mississippi River

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

Introduction and Need:

The Spatially Explicit Asian carp Population (SEAcarP) model was developed to inform decisions that minimize abundance of Asian carp in the upper Illinois River waterway, thereby reducing risk of population expansion toward the Great Lakes. This model provides an objective, data-driven approach to maximize return on investment for management actions (i.e., optimal harvest locations and intensity as well as optimal deterrent locations and efficacy) and facilitates the determination of research and monitoring priorities. The spatial structure of the SEAcarP model is superior to previous Asian carp population models (e.g., Tsehaye et al. 2013, Seibert et al. 2015) because it allows demographics (abundance, size structure, growth, condition, mortality, and recruitment) to be defined separately for each of the six pools of the Illinois River and allows for movement of Asian carp among these pools, all of which will affect how strongly Asian carp respond to management actions. The increased precision of population forecasts derived from incorporating spatial structure comes at the cost of increased data requirements. Sensitivity analyses using the SEAcarP model will facilitate prioritizing these data needs relative to their effect on decreasing uncertainty in expectations on how Asian carp might respond under different management strategies. The work herein represents a continuation of FY2018 efforts including model implementation and development such as sensitivity analyses and annually updated management recommendations based on contemporary data, and addressing model limitations and assumptions, such as incorporating vulnerability to fishing as a function of fish size and field-based estimates of fishing mortality, growth, and pool-to-pool movement.

Objectives:

(1) Estimate demographic rates using the most current data available and incorporate results into the SEAcarP model.

(2) Conduct sensitivity analyses and develop a prioritized list of data and research needs based on results thereof.

(3) Recommend mortality benchmarks and fish passage deterrent locations with efficacy requirements.

(4) Use statistical catch-at-length models to estimate vulnerability to fishing as a function of fish size, exploitation rates, and immigration into the upper Illinois River Waterway.

(5) Participate in annual coordination meeting.

Status:

This is a continuing project from 2018. Past project highlights and collaboration with other MRWG projects include:

- Preliminary results were presented at the annual MRWG meeting in Springfield Illinois during January 2017 and various other ACRCC meetings.
- Identified growth as large contributer to uncertainty, which lead to age/growth workshop recommendation and implementation; final analysis and manuscript in preperation by USGS-CERC.
- Identified important assumptions related to fish movement that require formal evaluation. Recommended tagging of smaller individuals (juveniles), tagging of more individuals downstream of Starved Rock Lock and Dam, and combining Upper Mississippi River and Illinois River telemetry to estimate inter-basin movement.
- Addressed demographic data gap via increased data collections in lower portions of the Illinois River.
- Primary SEAcarP model management recommendation (i.e., increase mortality below Starved Rock Lock and Dam) supported by independent research using Grass Carp as the study species and Integral Projection Model framework (Erickson et al. 2018).
- Modified the length-based structure of the model; uses integral projection models that define populations by a continuous variable instead of discrete length classes.
- Updated demographics based on most recent data (over 30,000 individual fish); manuscript in preparation.
- Implemented a standard procedure for data transfer from the following GLRI supported projects: (1) Asian carp population suppression in the Illinois River; (2) Asian carp demographics; (3) Illinois River monitoring and evaluation; and (4) Telemetry and telemetry database.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Methods:

Model parameterization updates

The SEAcarP model will be reparameterized using updated demographic rates estimated from all possible data sources. For example, using fish collected across multiple basins including the Illinois, Upper Mississippi, and Ohio river basins under programs such as the Ohio River Basin Partnership and Upper Mississippi River Partnership, and other partnerships with universities and state and federal agencies. Demographic rates (i.e., growth, mortality, condition, maturation schedule) for Bighead and Silver Carp will be estimated using Bayesian hierarchical models as described in the 2018 MRP. We will continue to work with MRWG Technical Workgroups and other partnerships to ensure minimum data standards are being met.

The SEAcarP model will be parameterized by estimating demographic rates for each pool of the Illinois, Upper Mississippi, and Ohio rivers as data availability allows. Combining data across multiple basins increases confidence in the overall population estimates and estimates for individual basins, including ones for the Illinois River, which is the current focus of the modeling effort. Results of demographic analyses will be presented in a peer-reviewed publication (Erickson et al. *in prep.*; code available at https://github.com/rerickson-usgs/CarpLifeHistoryModels). In summary, growth, maturity, and body condition will be analyzed using hierarchical Bayesian methods similar to those described previously (MRP 2018). Annual natural mortality will be estimated using indirect methods that relate mortality to demographic parameters (Then et al. 2016). Pool-to-pool movement will be estimated using an existing multistate model parameterized in program MARK (Coulter et al. 2018) or a new multistate temporary emigration movement model (e.g., Kendall et al. 1997) parameterized using Upper Mississippi River and Illinois River data. The updated model is in early stages of development.

Spatially explicit Asian carp Population model

The underlying simulation model captures the population dynamics of Asian carp in terms of pool- and length-specific abundance over time. The model calculates changes in length-distribution (i.e., a statistical distribution of the length of individuals) and total population (i.e., the sum or integral of the length-distribution) across time steps for the population P of size z at time t: $P(z, t)$. The model includes a constant mortality in the absence of harvest: M; growth as a function of the current size (z), and size at the next time step (z'): $G(z, z')$; inter-reach movement consisting of immigration ($I(z)$) and emigration ($E(z)$); as well reproduction as a function of size: $R(z)$. These terms are combined to form the kernel for the integral projection model and integrating over all possible lengths Ω projects the population forward one time step:

$$P(z', t+1) = \int_{\Omega} \left(\left((MG(z, z')) + I(z) + G(z, z')\right) R(z)\right) P(z, t) dz$$

Equation 1 will be placed in a spatial context and indexed (using sub-subscripts, omitted here for simplification) with each pool having its own sub-script (e.g., $P_{Alton}(z,t)$ would correspond to the length-distribution z at time t in the Alton Pool). Consistent with field observations, recruitment will be limited to the lower-reaches of the Illinois River (i.e., Alton, La Grange, Peoria pools). The number of recruits added to a given pool will be estimated using a stock-recruitment relationship scaled by pool length. Spawning stock biomass will be calculated using the product of abundance, probability of maturity, and mass summed over all size classes. The distribution of recruits will be assigned the length distribution using the von Bertalanffy growth function for sizes at age one.

Beverton-Holt and Ricker stock-recruit functions will provide parameter estimation for the population portion of the model. Additionally, taking the derivative of the von Bertalanffy growth function with respect to size produces the growth function, $G(z, z')$. Mortality can also be estimated from the von Bertalanffy growth function.

Initial population abundance will be determined by setting the pool with highest density of Asian carp (Silver Carp: La Grange Pool; Bighead Carp: Peoria Pool) to the stable distribution and scaling the remaining pools using hydroacoustics data thus preserving the relative differences in Asian carp abundance among pools.

Uncertainty in Asian carp demographic rates will be incorporated by repeating 25-year simulations for each fishing scenario using 1,000 iterations of growth, maturity, natural mortality, and condition parameters, randomly selected from Bayesian posterior distributions. Hence, the parameters drawn from the posterior distributions will be time invariant over a given 25-year simulation period. Interannual variability in recruitment, however, will be included using a Bernoulli distribution to simulate periodic reproductive success (i.e., frequent year class failure and occasional reproductive success). Specifically, for each time step the number of individuals estimated from the stock-recruitment function will be added to the population with probability 0.5 which was estimated from the relative frequency of successful reproduction in the La Grange Pool of the Illinois River and quantified using 2000 – 2015 USGS Long-Term Resource Monitoring Program (LTRMP) data. Annual data was classified as successful when the catch of age-0 fish (i.e., < 250 mm TL) was greater than zero.

Evaluating management scenarios

The SEAcarP model was designed to evaluate changes to the Asian carp population in response to different management actions involving increased adult harvest mortality and decreased upstream movement rates. Exploitation effects on Asian carp populations will be evaluated under different combinations of exploitation (0 to 1 in 0.1 intervals) in the lower- (Alton, LaGrange, Peoria pools) and upper-pools (Starved Rock, Marseilles, Dresden Island pools). Fishing mortality will be limited to fish ≥500 mm total length; vulnerability to harvest will be modeled as a function of size as determined from the statistical catch-at-length model described below. Similarly, deterrence barrier effects on Asian carp populations will be evaluated under different combinations of deterrence efficacies – proportional reduction (0 to 1 in 0.1 intervals) relative to baseline values – at Starved Rock Lock and Dam, Marseilles Lock and Dam, Dresden Island Lock and Dam. Additionally, effects associated with using multiple control strategies will be evaluated using all possible combinations of exploitation and deterrence.

Effectiveness, defined as the percent reduction in Asian carp abundance relative to the no action scenario (i.e., zero fishing mortality, baseline movement rates) will be used to measure performance of the different management scenarios. Effectiveness will be calculated by dividing the total number of Dresden Island Pool fish alive after 5 years into the simulation (short term) and at the end of the 25-year simulation (long term) by the number alive under the no action scenario using iterations as replicates (N=1,000). Thus, effectiveness represents a distribution of possible response values with uncertainty derived from variation in demographic rates. Effectiveness values will be presented using summary statistics and frequency histograms. In addition, effectiveness measures will be used to recommend mortality benchmarks and fish passage deterrent locations with efficacy requirements. This will be accomplished by identifying management scenarios that achieve 90% effectiveness at eliminating Asian carp in Dresden Island Pool over short-term and long-term periods in all 1,000 simulations.

Sensitivity analysis

Sensitivity analysis examines how model inputs change model outputs (i.e., how “sensitive” the model is to parameter values). Sensitivity analysis will be done to examine the impact of different inputs on the population in Dresden Island Pool. In the context of the SEAcarP model, Dresden Island Pool is the most upstream pool and is therefore the focus of sensitivity analyses – managers are most interested in the population nearest the Electric Dispersal Barrier. Sensitivity analysis will be used to prioritize data and research needs, which will ultimately reduce model uncertainty. Sensitivity analysis can be one-factor-at-a-time (Saltelli 2008) or by changing multiple parameters and looking at the importance of different parameters (Campolongo and Saltelli 2007). Both approaches will be explored and applied to SEAcarP.

Addressing limitations and assumptions

Statistical catch-at-length models will be used to address limitations and assumptions associated with the SEAcarP model and provide a second source of demographic information for comparison and validation. Statistical catch-at-length models are based on the length structure of an exploited population. The model will use proportional catch-at-length data from contracted commercial fisheries to estimate relative abundance, exploitation rates, vulnerability to fishing as a function of fish size, growth, and immigration into upper pools of the Illinois River Waterway.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Demographic rates estimated using the statstical-catch-at-length approach will be used to validate estimates from Bayesian heirarchial models and telemetery-based transition probabilites (Project: Identifying Movement Bottlenecks and Changes in Population Characteristics of Asian Carp in the Illinois River, ACRCC-MWRG). Other results will be directly incorported into the simulation model. For example, the relationship between vulnerability to fishing and fish length will replace the assumption that only fish ≥500 mm total length are suseptible to harvest.

The assumption that the Illinois River is a closed populaion will be addressed through incorporation of a multistate temporary emmigation movement model (e.g., Kendall et al. 1997). The updated movement model is being developed by teams from the Upper Mississippi and Illinois rivers and will capture movement dynamics within and between systems. The work is not part of this MRP. Although it is widely known that fish move among basins (Norman and Whitledge 2015), data and resources needed to model inter-basin movement patterns have only recently become available. The new model will improve our overall understanding of within and between basin movement leading to increased accuracy and precision with respect to current (i.e., SEAcarP) and future population modeling efforts.

2019 Schedule:

February – March 2019:

- Multi-state movement modeling with MRWG Telemetry Technical Workgroup

June 2019:

- Finalize sensitivity analyses and report out on prioritized data needs

July – August 2019:

- Statistical catch-at-length model development

September – November 2019:

- Data compilation from partners, QA/QC, and data standardization
- Statistical catch-at-length parameterization and modeling
- Demographic data analyses and SEAcarP model reparameterization as necessary

November – December 2019

- Management scenario simulations

December 2019 – January 2020

- Prepare presentation and reports

Deliverables:

- Prioritized list of data and research needs

Asian Carp Population Modeling to Support an Adaptive Management Framework

- Updated demographic rates using the most current data available
- Estimates of vulnerability to fishing as a function of fish size, current exploitation rates, and immigration into the upper Illinois River
- Recommendations for mortality benchmarks and fish passage deterrent locations with efficacy requirements

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Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEAcarP)

Lead Agency: USFWS- Carterville Fish and Wildlife Conservation Office

Location: Peoria and Starved Rock pools within the Illinois Waterway

Pools Involved: Starved Rock and Peoria

Introduction:

Movement is the backbone of the spatially explicit Asian carp population model (SEAcarP) and is the primary driver for how researchers expect the population to respond to management strategies. The simulation model makes several assumptions associated with inter-pool and inter-basin movement. The current movement model provides pool-to-pool transition probabilities, but does not incorporate influential factors such as season, hydrology, fish density, and fish size. Harvest effects such as changes in fish density and size distributions likely impact movement and will thus influence our ability to predict population responses. Further, estimates from the movement model may be biased high and not directly transferable to small fish as initial tagging efforts focused on larger and more mobile individuals (i.e., fish >500 mm TL that passed one or more lock and dam complexes).

Small Silver and Bighead Carp represent a greater risk of breaching the Electric Dispersal Barrier system than larger bodied adults due to the negative relationship between body size and electrical immobilization. Results of research conducted by USFWS have also highlighted passive entrainment of small bodied fishes by barges as a weakness of the Electric Dispersal Barrier system. Traditional sampling gears have limitations, including habitat-specific gear efficiency and detection probability, changing environmental conditions, and sparse species distributions. Identifying habitat areas used by juvenile Asian carp will help to inform monitoring efforts by the USFWS and IDNR focused on detecting juvenile Asian carp. Increased knowledge of the habitat usage and movement patterns of juvenile Asian carp, when related to environmental factors, are invaluable for future management actions.

Asian carp demographic information will once again be collected throughout 2019 to further bolster the SEAcarP. For further information on this work please refer to the USFWS Asian carp demographics monitoring and response plan. For more information on small Asian carp telemetry please refer to the USFWS distribution and movement of small Asian carp in the Illinois Waterway using telemetry monitoring and response plan.

Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEAcarP)

Objectives:

(1) Quantify movement frequency and distance of Asian carp.

(2) Refine movement across locks and dams.

(3) Address limitations with regards to the movement aspect of the SEAcarP model by tagging sexually immature fish as well as adults to increase accuracy and precision of pool-to-pool estimates of movement.

(4) Determine macro-habitat selection based on periods of residency of juvenile Asian carp.

Status:

This project was started in 2018 and will continue in 2019. During 2018, 130 Asian carp were tagged throughout Peoria Pool. Locations of released fish were distributed throughout the pool as was discussed with the MRWG telemetry worlgroup. The average total length was 485.9 mm and ranged from 391-635 mm TL. All fish were collected using standard boat electrofishing and an electrified dozer trawl. In addition, fin clips were taken from each tagged fish and are being analyzed for hybridization.

Methods:

In addition to the juvenile Asian carp habitat project which is focused on tagging fish 300 mm and smaller, staff will also tag all Asian carp collected that are 300 – 500 mm. The Vemco V-5 tags currently used for the small fish telemetry project use 180 kHz receivers which are different than the 69 kHz array which is currently dispersed throughout the Illinois River. Work conducted in support of the SEAcarP model will use Vemco V-9 or V-13 tags which are on the 69 kHz frequency. This will give biologists a better understanding of large-scale movement of these smaller individuals that are assumed to move at the same rates as larger, sexually mature individuals within the population model.

In 2019, USFWS crews will tag an additional 150 Asian carp (<300mm) in and around Starved Rock Pool. This large-scale tagging of adult and juvenile Asian carp will continue to provide additional information for the model to better estimate current levels of exploitation and to bolster estimates of large-scale pool-to-pool movement.

Asian carp will be captured using boat electrofishing and electrified dozer trawl from the Illinois River. Immediately after capture, fish will be held for no more than 1 hour in an aerated 60 gallon holding tank covered with ¼-inch mesh. In order 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. 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 foam board with a fish-shaped cut out 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 gently washed with several drops of betadine prior to making an incision. Using a #12 hook blade scalpel, a 1 cm (Vemco -5 acoustic tags) or 2.5 cm (Vemco- 9 or 13 acoustic tags) incision will be made in the left 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 Oasis Brand (Mettawa, Illinois) 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 and tags are tested, fish will be returned to the river in proximity to their capture location. Total holding time for fish will generally be less than 2 hours.

Fish will be tracked using the current acoustic array within the Illinois Waterway. Additional receivers will be placed in areas with reduced coverage and the MRWG Telemetry Working Group will be consulted prior to deployment.

For more information on the SEAcarP model please refer to the SEAcarP Modeling monitoring and response plan.

2019 Schedule:

May – June 2019: Gear preparation, planning field work, crew scheduling

July – November 2019: Fish tagging, range testing, active tracking, data download, gear maintenance and relocations

November – December 2019: Receiver removal, final data downloads

December 2019 – January 2020: Data analyses, prepare report and presentation

Deliverables:

Results from this project will be used to support the SEAcarP model. Data will be analyzed and results summarized into a MWRG summary report/presentation for the winter of 2019-2020.

Asian Carp Demographics
2019 Plan

Participating Agencies:
Lead: U.S. Fish and Wildlife Service (USFWS)-Columbia Fish and Wildlife Conservation Office (Columbia FWCO)

Collaborators: USFWS-Carterville Fish and Wildlife Conservation Office (Carterville FWCO), Southern Illinois University (SIU), USGS-Columbia Environmental Research Center (USGS-CERC)

Pools Involved: Marseilles, Starved Rock, Peoria, La Grange, and Alton

Introduction and Need:
Management of invasive Asian carp in the Illinois Waterway (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 Asian carp demographic data over time and space will support managing and monitoring efforts of these species within the Illinois River. Additionally, these data will be used to address data gaps associated with the SEAcarP model. The USFWS Columbia FWCO will collect fisheries-independent data including spawner biomass, recruitment, age, sex, and growth data from the upper IWW (i.e., Starved Rock and Marseilles pools) and lower IWW (Alton, La Grange, and Peoria pools; Figure 1) for which there is a paucity of data. The demographic data collected from the project will be crucial in helping to better understand what appropriate management actions are needed to protect the Great Lakes and how those management actions effect the Asian carp populations within the Illinois River.

Objectives:

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

(2) Using standard methods agreed upon from the Asian Carp Demographics 2018 age and growth workshop (Age Demographic Template 2018), generate age and growth information for the Illinois River Asian carp at all five pools

(3) Develop spawner and cohort abundance indices for Asian carp using summarized field data (i.e., catch rate, sex ratio, and length structure); use indices to evaluate when year class strength is set and the relationship between fall and spring spawner abundance

(4) Provide data to update parameter estimates associated with the SEAcarP model

(5) Identify advantages and limitations of using dozer trawl to inform hydroacoustic data by comparing species composition and size structure from dozer trawl collections

with capture gears currently being used to inform hydroacoustics (i.e., gill and trammel nets, electrofishing)

Status:
This is a continuing project from 2018. Following are some highlights of this project and relationships to other GLRI-funded projects.

- In 2018, a standardized Silver Carp assessment was implemented in five pools of the Illinois River to collect representable demographic data.
- Gear evaluation studies conducted from 2014-2017 under the "Gear Evaluation for Removal and Monitoring of Juvenile Asian Carp" template provided fundamental understanding of how electrified frame trawls can be used to survey the Silver Carp population in the Illinois River.
- The information gained from the age and growth workshop in 2018 (USGS-CERC) and synthesized as part of the "Asian Carp Demographics – USGS" project will be used to guide efforts for appropriately aging Asian carp species.
- Collaborations with SIU hydroacoustics sampling associated with the Illinois River Stock Assessment/Management Alternatives" project will inform the possible integration of these techniques.
- Data will be provided to update parameter estimates with the SEAcarP model "Asian Carp Population Model to Support an Adaptive Management Framework" project.

Methods:
The USFWS Columbia FWCO 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 lowest five 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 will be 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 (GIS) that includes habitat data and an indexed 50- by 50-m grid. Collection sites will be sampled by conducting 5-minute trawls at 4.8 kilometers per hour (calculated by GPS tracking) using either the electrified dozer or paupier trawls. Previous findings indicate that relative size distributions of the Silver Carp catch do not differ between the two gear types and that catch rates can be readily converted from one gear to the other using linear relationships fit to existing data. Trawl runs will not be allowed to overlap. The electrified dozer trawl will be used primarily; however the paupier may be deployed in low density conditions owing to its ability to sample larger volumes of water. An initial sample size of 50 (5-minute trawls) per pool were sampled in 2018 based on previous projects (2014-2017 Template: Gear Evaluation for Removal and Monitoring of Juvenile Asian Carp). Results from 2018 will be used to determine sample sizes specific to each pool to ensure precision associated with this effort is within acceptable levels (i.e., 25% relative standard error;

Koch et al. 2014). Fish length and weight will be measured for all captured Bighead and Silver carp. Subsamples consisting of 10 juvenile (≤300 mm total length) or five large (>300 mm total length) Silver Carp per 50 mm length class will be retained for laboratory analysis (i.e., age, sex, maturity status). All by-catch will be identified to species and enumerated.

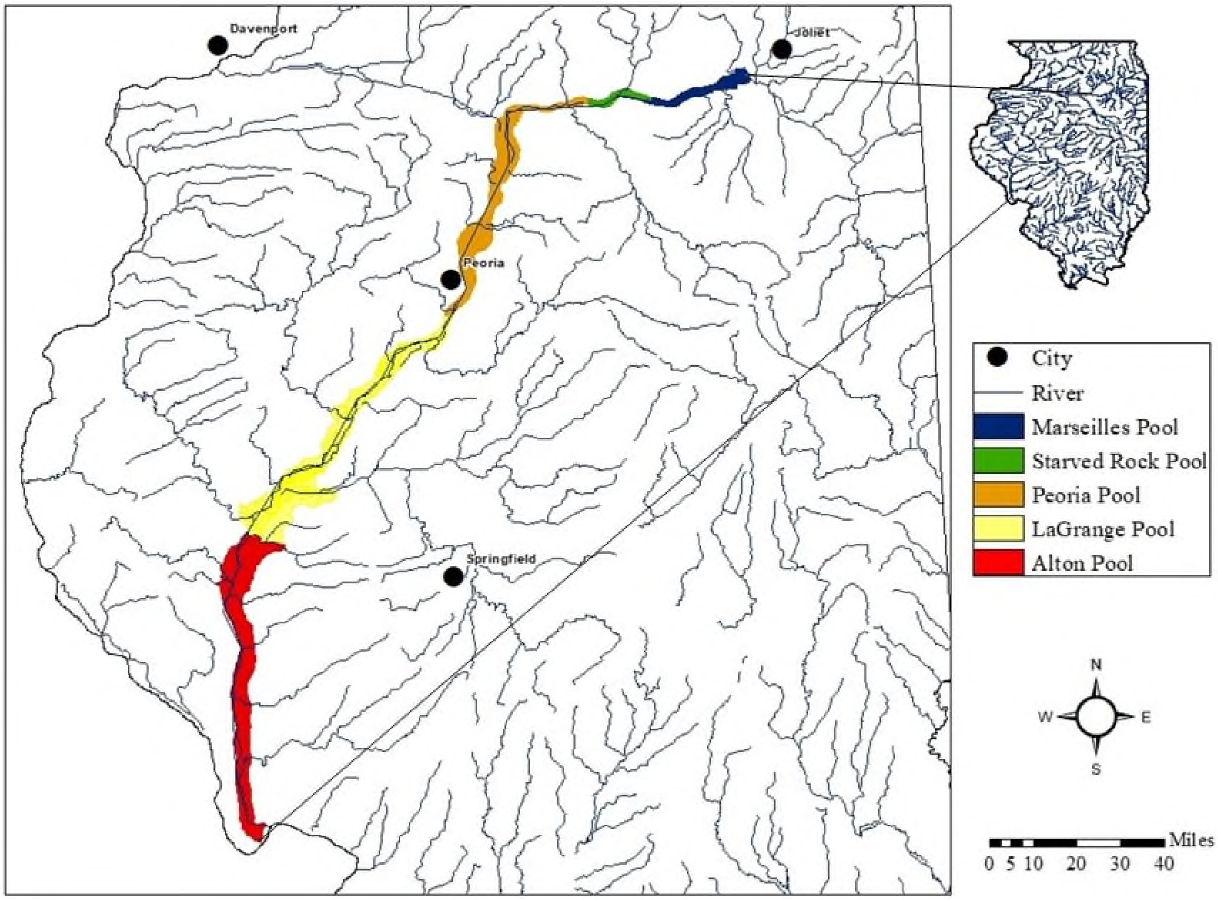

Figure 1. *The five lowest pools in the Illinois River, Illinois, will be sampled in spring and fall as part of the 2019 Silver Carp demographics study.*

Effort will be made to coordinate dozer trawl collections with SIU hydroacoustics sampling to ensure that comparisons among gear types are meaningful. Protocol and study design will be based on results from 2018 coordinated efforts among dozer trawl demographic data collection with capture gears currently being used to inform hydroacoustics (i.e., gill and trammel nets, electrofishing). Ongoing conversations with SIU will further refine the study design and determine the season and location (i.e., pool) for this data comparison.

Detecting changes in population status and trends through time is crucial for understanding what appropriate management actions are needed to control Asian carp in the Illinois River, Illinois. Silver Carp size and sex structure, length at maturity, and relative abundance will be quantified in the five lowest pools of the Illinois River. Silver carp catch rates, sex ratios, and length structure will be used to develop spawner and cohort abundance indices. These indices will be used to evaluate when year class strength is set and the relationship between fall and spring spawner abundance. Results from these analyses will be used to determine if a single season sampling design sufficiently meets data needs regarding indices of spawner abundance and recruitment. All data will be transferred to the modeling workgroup for analyses associated with the SEAcarP model.

2019 Schedule:

February – April 2019: Gear preparation, logistics, planning, and scheduling

May – June 2019: Spring field sampling and data entry

July – August 2019: Data entry, preliminary data analysis and protocol evaluation

September – November 2019: Fall field sampling and data entry

December 2019–January 2020: Data analysis, Annual report

Deliverables:

The Asian carp demographics project will provide updated demographic data for parameterizaing the SEAcarP model and addresses data gaps identified by the modeling workgroup (i.e., stock-recruit data, growth of small fish from the lower pools, vulnerability, exploitation, and immigration levels). Lastly, this project will develop a standardized Asian 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.

Literature cited:

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Evaluation of a Modular Electric Deterrent Barrier

Scott F. Collins, Anthony P. Porreca, Steven E. Butler,
Joseph J. Parkos III, David H. Wahl (Illinois Natural History Survey)

Participating Agencies: INHS (lead)

Location: Continuing experimental tests of the modular electric barrier system will be conducted at the Illinois Natural History Survey's Sam Parr Biological Station. Locations for future field trials will be evaluated among select locations in Illinois Waterway tributaries, side channels, or backwaters.

Pools Involved: To be determined

Introduction:

Fisheries professionals have used electric fields as deterrent barriers to impede the movement of fishes for many years. However, almost all electric barriers used by fisheries agencies are constructed at fixed locations and are therefore stationary. Stationary electrical barriers currently serve as a line of defense in blocking the expansion of Asian carp into the Laurentian Great Lakes. Although useful for specific management objectives, such designs lack spatial flexibility. Modular electric barriers may provide managers with more flexibility and the option to deploy control measures in pre-determined locations to achieve specific management objectives. Recently, a modular deterrent barrier was procured by INHS with the intent of aiding fisheries managers in inhibiting the movement of Asian carp in appropriate locations. Because habitat and environmental conditions (e.g., conductivity, waterbody dimensions) vary spatially, the modular system can potentially be adapted to generate a suitable electric field for deterring fish under a variety of situations. The modular electric barrier may be suitable for management scenarios including potential deployment near stationary barriers when they are powered down for repairs or maintenance, blocking entry into specific habitats (backwaters, side channels, known spawning areas), herding fish into the barrier to be immobilized (akin to electroshocking), and directing fish into entrapment and entanglement gears that have previously been shown to be effective for capturing Asian carp. Before routine deployments of this modular barrier can be performed, measures must be taken to thoroughly develop field and safety protocols, evaluate the effectiveness of the barrier system at deterring Asian carp and other fishes, and develop cost estimates to inform management agencies of anticipated deployment and maintenance expenses. This study will evaluate a new control measure and its effectiveness at deterring Asian carp. Findings will aid decision making by management agencies regarding deployment of this control system, which will contribute to broader efforts to prevent the spread of Asian carp.

Evaluation of a Modular Electric Deterrent Barrier

Objectives:

(1) Evaluate the effectiveness of a modular electric deterrent barrier for inhibiting passage of Asian carp and other fishes, develop operational protocols, and identify operational costs and constraints.

(2) Conduct field trials to test the effectiveness of the barrier at locations on the Illinois Waterway.

Status:

Mobile electric barriers were uncommon prior to the development and procurement of the current modular electric barrier system. Consequently, little empirical data existed regarding the response of Asian carp or other fishes to a mobile deterrent barrier. Pond trials were conducted during 2017 and 2018 by INHS staff to address this knowledge gap. Experiments examined the effectiveness of the modular electric barrier and found that Silver Carp and Bighead Carp passage rates could be reduced by > 95% when the barrier was in operation. However, the modular electric barrier was not shown to be 100% effective at blocking fish. This finding is consistent with other studies demonstrating that non-physical barriers are not 100% effective. Nonetheless, the modular electric barrier did effectively reduce the activity rates of native and invasive fishes while in operation. Based on experimental findings, logistical issues, and experiences operating this barrier system, further pond trials and field-based assessments are needed to improve system efficacy across a range of conductivity conditions and further evaluate the effectiveness of this technology at locations on the Illinois Waterway. Efforts are underway to identify effective operational settings, detail safety and transport protocols, and estimate cost scenarios.

Methods:

During 2019, experiments to assess the effectiveness of the mobile electric deterrent barrier for inhibiting passage of Asian carp and other fishes will be conducted in controlled settings at the Sam Parr Biological Station and at locations on the Illinois Waterway. At the pond facility, trials will quantify the strength of the electrical field (voltage at the surface) along the length of the barrier, and further evaluate the ability of Asian carp and other fishes to cross the barrier under different conductivities and operational settings. Mapping surface voltages will allow for the examination of the degree of spatial heterogeneity of the electric field. Field trials will be initiated to test the effectiveness of the barrier at locations on the Illinois Waterway. Sites will be selected following consultation with IDNR, USACE, and USCG. Evaluation of barrier effectiveness in the field will include comparison of catch rates in fisheries gears (pound nets) deployed near the barrier, passage of fish implanted with passive integrated transponder (PIT) tags across an antenna array, and/or quantification of fish passage using imaging systems (sidescan or DIDSON sonar systems) during periods when the barrier is operational and when it is inactive. Field deployments will also aid in identifying potential limitations of the modular barrier, logistical issues, operational costs, and help to further develop protocols for the application of the modular barrier in the field.

Schedule:

In 2019, tests of the modular electric deterrent barrier will occur in either pond or field settings during May through October.

Deliverables:

Preliminary results of modular barrier pond trials will be reported for monthly sampling summaries. Summaries of findings from field trials will be provided to MRWG partners as relevant findings are produced. An operations manual developed by Smith-Root is being evaluated by INHS staff in order to provide clear and safe guidance for barrier operation under different deployment scenarios. Data will be summarized and project plans updated for annual revisions of the MRP.

Alternative Pathway Surveillance in Illinois – Law Enforcement

Brandon Fehrenbacher & Heath Tepovich
Illinois Department of Natural Resources

Participating Agencies: Illinois Department of Natural Resources (lead)

Location: Surveillance and enforcement operations will be conducted throughout Illinois and within other jurisdictions when necessary.

Introduction and Need:
The IDNR Invasive Species Unit (ISU) focuses on detecting and preventing intentional and unintentional activities by mankind that could spread aquatic invasive species. Illegal actions substantially increase the risks of spreading invasive species, and it is imperative that we minimize those risks through proactive enforcement of laws. Past enforcement efforts exposed numerous people and companies that prioritized financial profits and/or personal gratification over obeying the law. It is essential to remove habitual offenders from the aquatic life industry, but typically new lawbreakers emerge to fill those gaps. ISU investigates any suspicious activities that arise and responds to all requests for assistance from project members. The work being done to protect the Great Lakes from Asian carp is a huge undertaking with many moving parts. All the fish removal, monitoring, research and deterrent efforts within the Asian carp project could be sabotaged without a law enforcement component to mitigate the human introduction risk factor. ISU is the first and only fully dedicated aquatic invasive species law enforcement unit in North America, and it serves as a model to other agencies wishing to start similar specialized units.

Objectives:
In order to detect, dissuade, prevent and/or apprehend those involved with activities that could spread aquatic invasive species we propose to:

(1) Develop an invasive species and aquatic life industry enforcement training curriculum for the Conservation Police Academy to enhance capabilities of law enforcement in protecting the State from invasive species threats.

(2) Implement a multi-jurisdictional surveillance operation of potential or suspected illegal commercial fishing activities on applicable river systems.

(3) Obtain the proper security clearance and inspect shipments of live aquatic species being imported into Chicagoland airports.

(4) Conduct commercial inspections within the aquatic life industry to ensure compliance of relevant laws.

(5) Investigate all complaints, events, and suspicious activities that pose a threat to the Asian Carp Project.

(6) Allocate adequate time to complete training and stay updated with current trends and regulations related to the aquatic life industry.

Alternative Pathway Surveillance in Illinois – Law Enforcement

Status:

This project is on-going and has been extended into 2019. The Unit has active investigations pending and an overall strategy to proactively search for emerging threats.

Methods:

Intelligence gathering and Surveillance - The ISU utilized law enforcement databases, Internet search tools, surveillance, inspections, and intelligence sources to successfully meet objectives.

Schedule:

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

Deliverables:

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

2019 – 2020 ISU Work Activities:

Investigations into illegal activities associated with any aquatic invasive species will be conducted as they are encountered. The Unit will build upon any newly developed information to guide future project planning.

Enhanced Contract Removal Program Development

Participating Agencies: Illinois Department of Natural Resources

Location: The Enhanced Contract Removal Program evaluates actions throughout the Illinois River and IWW. Enhanced removal efforts are currently focused in Peoria Pool.

Introduction and Need:

The ACRCC and this MRP recognize the value of increased harvest of Asian carp in the Illinois River informed by current fishery stock assessment data. Modeling from SIU and USFWS have provided insights 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 Asian carp per year from the IWW below Starver Rock Lock and Dam.
(2) Removal under the Enhanced Contract Fishing Program for 2019/2020 has a goal of 4.5 million pounds, while working toward a goal of removing 15 million pounds annually by 2022.
(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 Asian carp.
(4) Leverage other programs such as the Market Value Program to continue building increased demand for harvested Asian carp.

Status:

A goal has been set with current funding to augment removal of 4.5 million pounds beginning in 2019 while working toward a goal of removing 15 million pounds annually by 2022 below the Starved Rock Dam, with enhanced removal recently starting and focused in Peoria. Removal from 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. Concurrent recommendations for increased harvest are identified in a comprehensive Asian Carp Business Process Analysis Report and Action Plan (Business Analysis Plan, or Report) and corroborated by SEAcarP model output. The Report recommends actions to accommodate increased commercial harvest as a control option and expand alternative uses of Asian carp to increase fishing by identifying end-users for fish. The end goal is to approach removal of 20 to 50 million pounds of Asian carp annually from the IWW below Starved Rock Lock and Dam to further reduce the population and risk of their spread to the Great Lakes. These efforts will be in addition to contracted effort upstream of Starved Rock Lock and Dam.

Enhanced Contract Removal Program

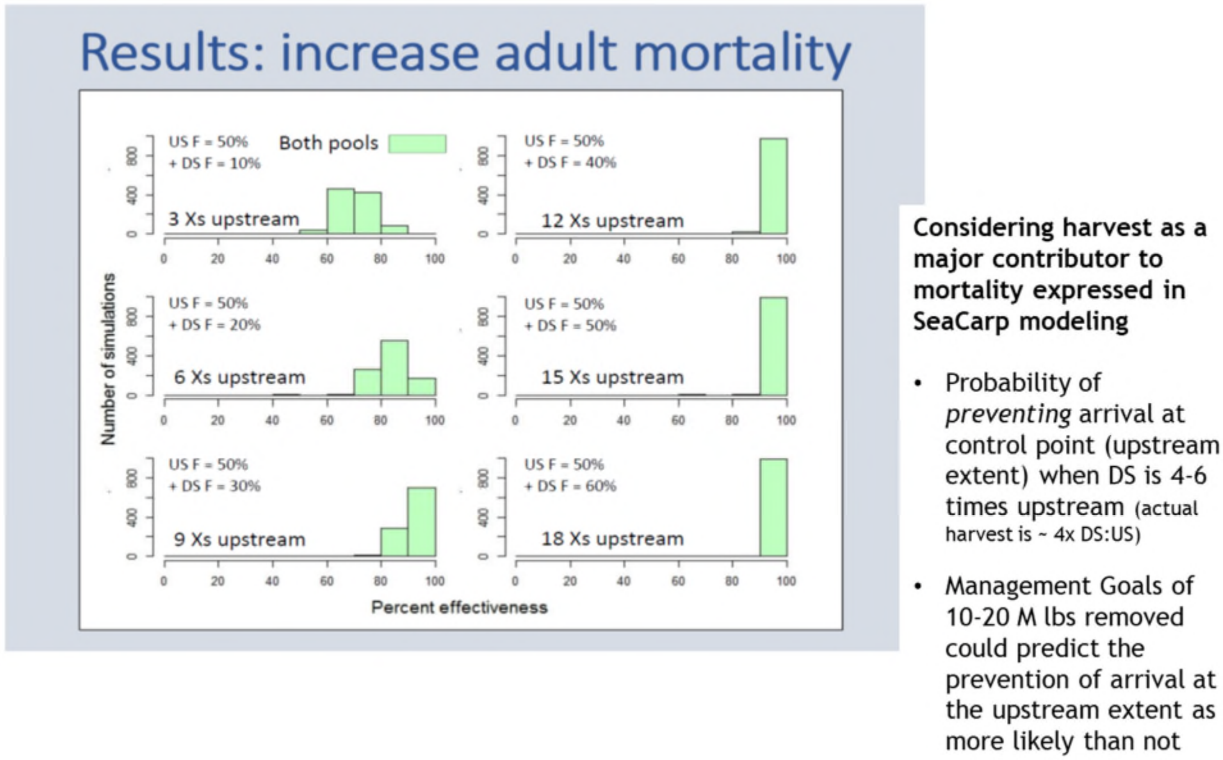


Figure 1: *Effects of increased harvest on likelihood of Asian carp migration; output from SEAcarP model*

RESPONSE PROJECTS

Upper Illinois Waterway Contingency Response Plan

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

Introduction and Need:
This Contingency Response Plan (CRP) describes specific actions within the five navigation pools of the Upper Illinois Waterway (IWW) - Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools (Figure 1) (river miles 231 to 327). In the event a change is detected in the status of Asian carp in those pools indicating an increase in risk level, this plan will be implemented to carry out response actions. The interagency Monitoring and Response Work Group (MRWG) has maintained a robust and comprehensive Asian carp monitoring program in the CRP area and will continue these efforts as the foundation for early detection capability in the IWW. Annual interim summary reports describing these efforts (including extent of monitoring and Asian carp detection probabilities) can be found at www.asiancarp.us. Based on this experience, MRWG is confident in its ability to detect changes to Asian carp status in the navigation pools in the upper IWW.

The MRWG and ACRCC member agencies acknowledge that any actions recommended by the MRWG or ACRCC 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 with regard to their particular jurisdictions. For instance, no other state has authority to direct or approve actions affecting the Illinois Waterway 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 ACRCC member agencies will follow in response to the change in Asian carp conditions in any given pool of the upper IWW.

Background:
Existing plans for responding to the collection of Asian 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 Electric Dispersal Barrier System (EDBS) and in the CAWS, upstream of the Lockport Lock and Dam (River Mile, RM 291). The ACRCC relies on the EDBS within the Chicago Sanitary and Ship Canal (CSSC) at Romeoville, IL, operated by USACE, as a key tool to prevent the establishment of Asian carp in the Great Lakes Basin. In support of the current EDBS and the goal of preventing establishment, this CRP ensures Asian 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 ACRCC in response to detections of potential Asian carp above the EDBS. This includes an interagency monitoring response in 2017 which used physical detection and capture gears in Lake Calumet and 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 Asian 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 Asian 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.

Asian carp distribution has not changed significantly in either abundance or location in the upper IWW since individuals were discovered directly in the Dresden Island Pool in 2006 or they were first detected in the Kankakee River in 1990. The 2018 Monitoring and Response Plan Interim Summary Report 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, 2018). Lack of range expansion and increased abundances may be due to intensive contracted fishing efforts, lack of suitable habitat upstream, water quality conditions, food availability, or a combination of other factors not yet fully understood. Despite no evidence of range expansion or increasing abundance of the Asian 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 Asian 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 Asian 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 Asian carp entrainment. Biologists found that small Silver Carp (< 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 or Silver Carp outside of these studies.

Observations of small fish in advance of adult population fronts has not been reported in either the Illinois Waterway or other large navigable rivers of the U.S.

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), river miles 231 to 327. Each pool is named for the downstream Lock and Dam which impounds the water body. 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. The body of water upstream of a lock and dam is given the name of that lock and dam. 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.

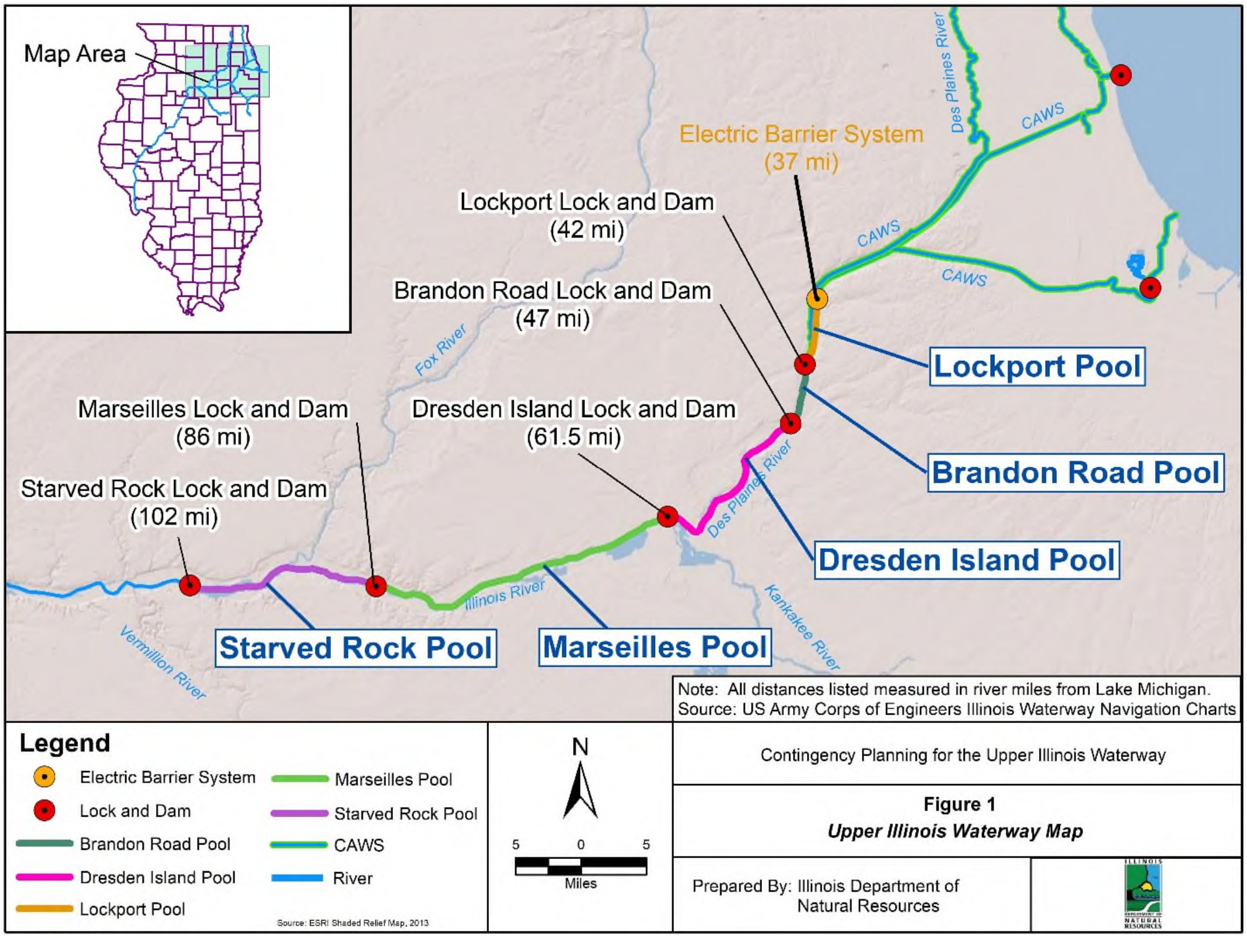


Figure 1. *Illinois Waterway Map and Profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.*

Mission and Goal:

The MRWG convened a panel of experts on local Asian carp populations, waterways, and navigational structures, and charged the panel to evaluate the Asian carp population status, waterway conditions, forecast Asian 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 ACRCC mission as stated:

> *The purpose of the ACRCC 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 Asian 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 CO2 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 ACRCC, and the governmental agency holding locational or operational jurisdictional authority. For example, one of the most aggressive responses in Asian carp prevention occurred in 2009, when approximately 6 miles of the Chicago Sanitary and Ship Canal was treated with a fish piscicide (Rotenone) in support of a EDBS maintenance operation. This control action occurred at a time when Asian carp abundance and risk of a barrier breech was less understood. The Illinois DNR 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 tools in this CRP for the MRWG to consider, the Illinois DNR 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 Contingency Response Plan. 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. 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.

Upper Illinois Waterway Contingency Response Plan

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 Asian carp control.

Data collected since 2011 have further clarified where Asian 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 also denotes 2015 as the benchmark year from which to evaluate progress in future years. 2015 was selected as a benchmark year for two primary reasons: (1) MRWG concurred that the establishment of a point of reference would aid in evaluating the status of Asian carp in the Upper IWW; and (2) 2015 was characterized by significant monitoring and detection efforts, which led to a thorough understanding of the Asian carp population status. These benchmarks allowed MRWG to reach a consensus on Asian carp status in 2015. The results of ongoing surveillance and management efforts, including those through December 2018, have been used to establish the current status of Asian carp populations in each pool of the IWW, as described below:

- **Lake Michigan:** No established Asian carp population
- **Chicago Area Waterway System (CAWS):** No established Asian carp population
- **Lockport Pool:** No established Asian carp population
- **Brandon Road Pool:** No established Asian carp population
- **Dresden Island Pool:** Adult Asian carp population front. Larval Asian carp observed for the first time in 2015, and have not been observed since
- **Marseilles Pool:** Adult Asian carp consistently present, and Asian carp eggs have been detected. Spawning has been observed.
- **Starved Rock Pool:** Abundance of adult Asian carp present, and Asian carp eggs have been detected. Early life-stage Asian carp (<6 inches total length) were observed in 2015 and have not been observed since.
- **Peoria Pool (downstream to confluence with Mississippi River):** Established population with all life stages of Asian carp has been observed.

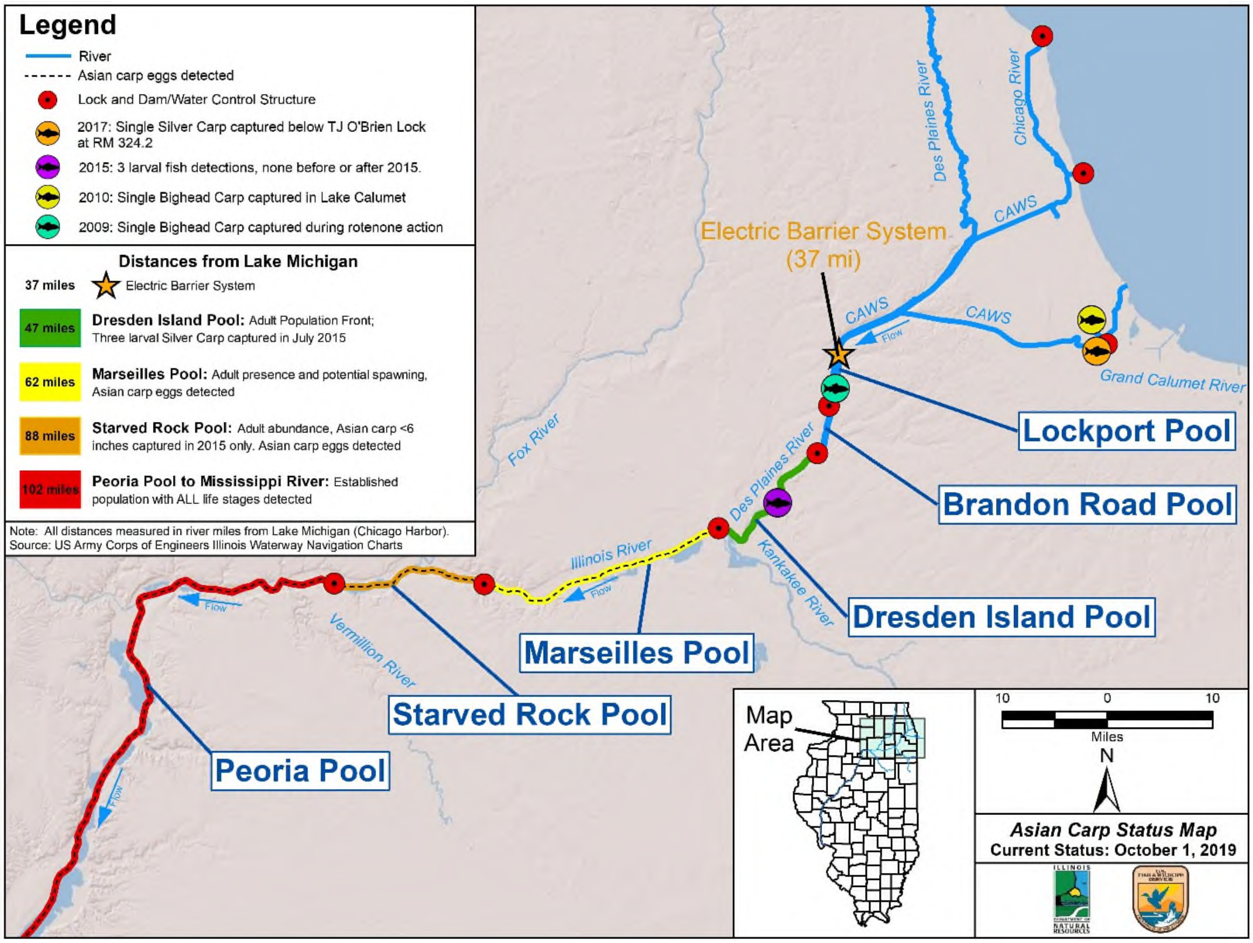


Figure 2. *Asian carp Status Map. Current Status: October 1, 2019.*

Planning Assumptions:

These planning assumptions anticipate potential realistic situations and constraints on the ACRCC, 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 Asian carp detection, and other factors.
- Response actions will be located within the designated area of the upper IWW described in the Contingency Response Plan (from Starved Rock to the Lockport Pool, as depicted in Figure 1).
- For planning purposes, under this CRP Asian carp refers to Bighead and Silver Carp.

Command, Control, and Coordination Assumptions

- All response operations will be conducted under the Incident Command System (ICS) or Unified Command as mandated under Presidential Policy Directive 8.
- Actions recommended by the ACRCC are dependent on agency authority to act at their discretion.

Logistics and Resources Assumptions

- The MRWG may request ACRCC 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 ACRCC 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 Incident Command System (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 and the Asian carp populations that could potentially 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 Section 3.5.

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 Asian carp populations (at the pool scale), life history stages (eggs/larvae, small fish (< 6"), and large fish), and abundance (rare, common, and abundant) of Asian carp collected.

Upper Illinois Waterway Contingency Response Plan

Pool:
Navigation pool was determined to be the best and most appropriate scale for the location of Asian carp in a population (relation to distance from the EDBS). Since pools are impoundments defined by locks and dams that have the ability to 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 also 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 Asian carp have not been found in the upper IWW. Finding Asian carp larvae would represent a potential change in the dynamics of the population in the upper IWW. Responses related to the detection of larval Asian carp would likely be directed at other adult or juvenile life stages of Asian carp.

Electric Barrier Functionality:
The operational status of the EDBS (barrier functionality), directly impacts the ability of Asian carp to potentially breach the barriers and move upstream of the Lockport Pool. That is, decreased barrier function increases the probability of Asian carp passage. Barrier operational status will inform actions considered when planning responses. Meetings of the MRWG and ACRCC 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 Asian 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 Asian carp presence to 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 group. 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 as just one example of when a contingency plan is called into action, and 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 Asian carp response in the IWW will be implemented under the MRWG. The Incident Command System (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 Asian carp during a response operation.

Figure 3 shows the basic Unified Command organization structure that will be utilized 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 Asian carp response personnel serving during an event.

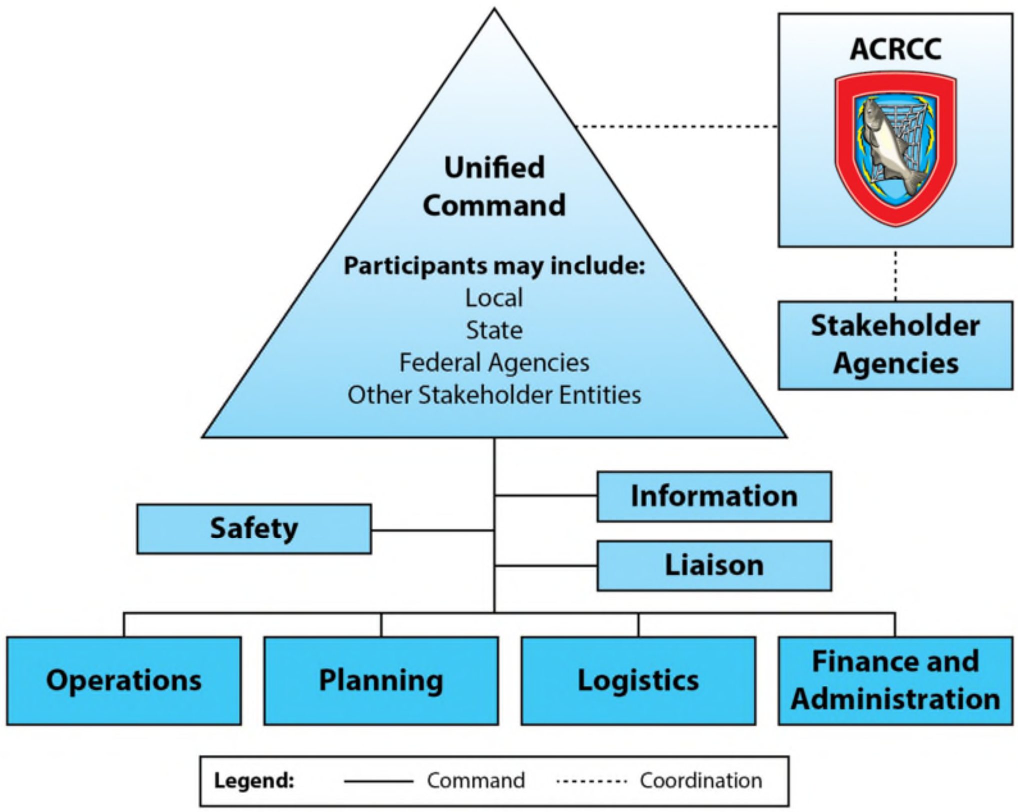


Figure 3. *Unified Command Organization Structure*

Incident Action Planning:
An Incident Action Plan (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.

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 Asian 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.

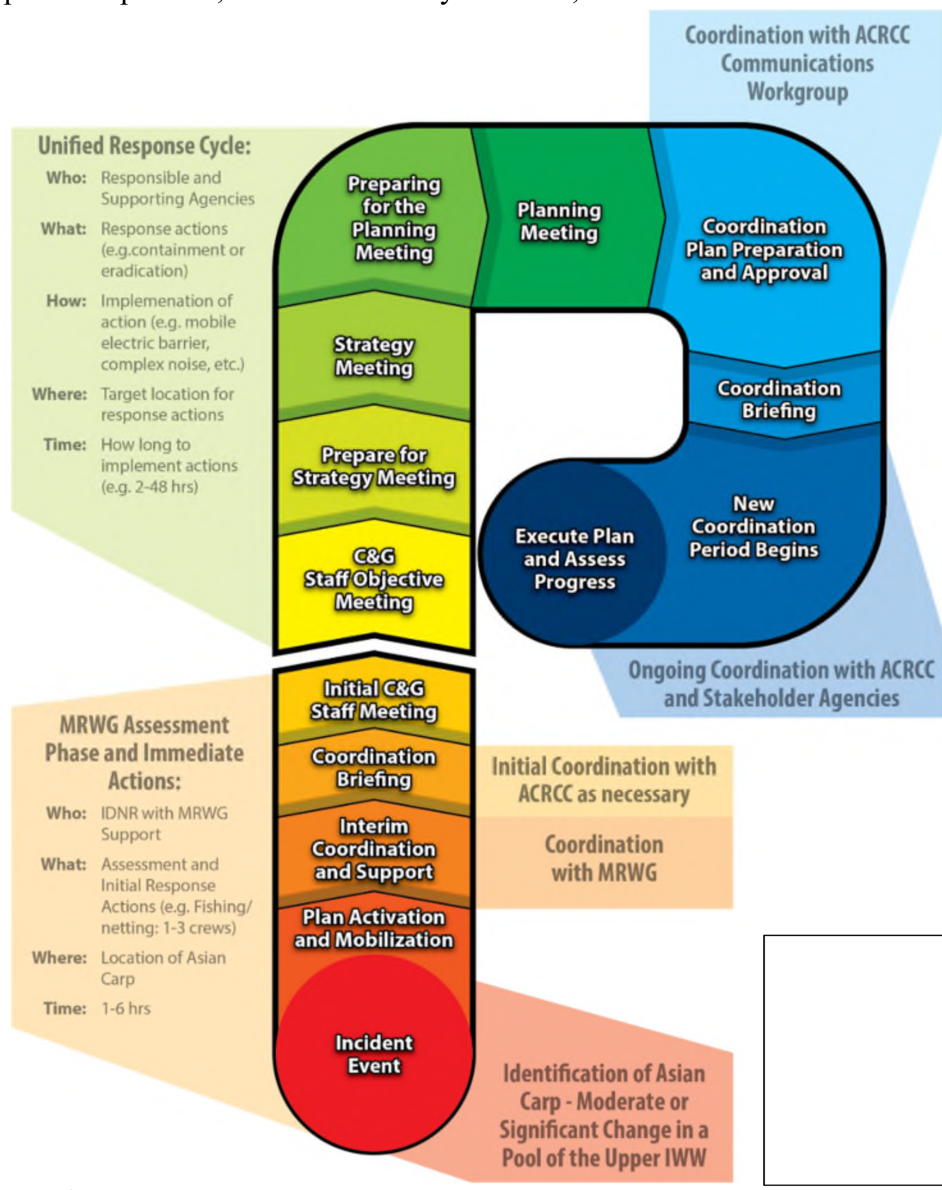


Figure 4. *ICS Planning "P"*

Response Decision Matrix

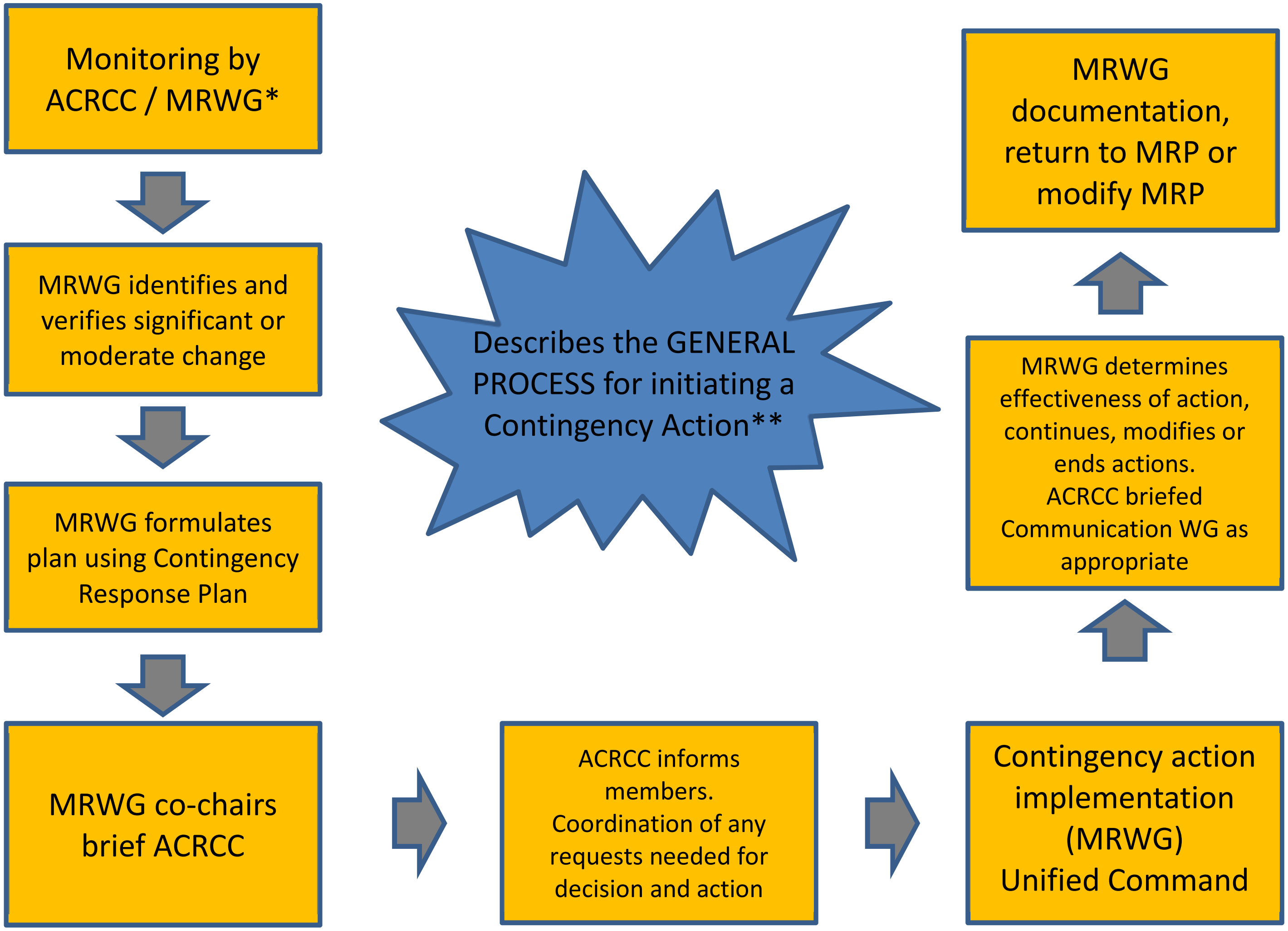
For the purposes of informing contingency response planning in the upper IWW, MRWG developed a situational-based "response decision matrix" that will aid the MRWG in determining the need for a contingency response action. This decision-support guide uses common, agreed-upon definitions (see Attachment 3). The process consists of: 1) identifying the pool of interest,

2) identifying the proper life stage of Asian 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 ACRCC 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 ACRCC. 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*

Upper Illinois Waterway Asian Carp Response Decision Matrix*

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

Notes:

= Significant change from baseline requiring further response action

= Moderate change from baseline requiring further response action

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

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

2 This status is based upon the collection of a single Bighead Carp during piscicides 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 Asian carp have been collected in this pool.

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

Figure 6. *Upper IWW Asian carp Response Decision Matrix*

Upper Illinois Waterway Contingency Response Plan

Table 1. *Contingency Response Action Matrix*[*1]

Level of Urgency (Action Response	Potential Actions[2]	Applicable Locations	Responsible Agencies	Estimated Time to Implement	Regulatory or Other Requirements	Relative Cost ($-$$$$)
Significant Change	Increased Sampling		IDNR/USFWS	1-7 days	Sampling permits	($$)
	Modify Barrier	LP, BR	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents		USFWS/IDNR	1-7 days		($$)
	Commercial Contract	All	IDNR	1-7 days	permits/contracts	($)
	Hydroacoustics		USFWS/SIU/USGS	1-7 days		($)
			IDNR	1-7 days	Notice to navigation	($$)
	Temporary Flow Control	LP, BR	MWRD	1 day	Notice to navigation	($)
	Mobile Electric Array		INHS/IDNR	Months	Finalize contracting, construction	($$$)
Moderate Change	Increased Sampling	All	IDNR	1-7 days	Sampling permits	($$)
	Modify Barrier	All	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents		USFWS/IDNR	1-7 days		($$)
	Commercial Contract	All	IDNR	1-7 days	permits/contracts	($)
	Hydroacoustics		USFWS	1-7 days		($)
			IDNR	1-7 days	Notice to navigation	($$)
No Change	Maintain Current Level	N/A	All	Ongoing		($)

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 brought to bare 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, ILDNR, INHS, USACE
Netting (Gill, Trammel, Pound, ichthyoplankton)	USFWS, ILDNR, INHS
Paupier Trawling	USFWS
Fyke Netting	ILDNR, USFWS, USACE
Dozer Trawl	USFWS
Telemetry	USGS, USACE, SIU,

Information and Data Management

The ACRCC Communications Workgroup will be the primary conduit for ensuring open and transparent communication with both the public and other stakeholder agencies during an Asian 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 ACRCC Communications Workgroups. 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 that 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.

Citations

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 Sanitary Shipping Canal 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 m) downstream of Barrier 2B and both of these barriers 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 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 Asian carp could gain access to the upper CAWS and Lake Michigan, and reduces the redundancy that is considered an essential feature of the entire barrier system. The intent is to drive fish below the barrier system after repairs and/or maintenance have been completed and normal operations have been resumed.

A more specific plan of action has been flushed out in previous Monitoring and Response Plans to address outages at the EDBS and was previously included as a specific project titled "Barrier Maintenance Fish Suppression". 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 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 Asian carp presence is documented, and a decision on actionable responses occurs and if warranted is implemented.

Appendix A: Barrier Maintenance Fish Suppression

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 Asian 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.

Fish suppression decisions should be made each time there is a planned or unplanned outage at the Electric Dispersal Barrier System 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 Electric Dispersal Barrier System 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 ACRCC stakeholders or MRWG resource agencies as necessary.

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	
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

Appendix A: Barrier Maintenance Fish Suppression

Table 2. *Operational changes anticipated from March 2019 – March 2020*

Barrier Operational Status			Clearing Decision	Activity	Season
Barrier IIA	Barrier IIB	Demonstration			
Off	On	On	Yes	2019 Annual Maintenance	2019 Spring
On	On	Off	No	2019 Annual Maintenance	2019 Spring
Off	On	On	Yes	Maintenance	2019 Summer
Off	Off	On	Yes	Dive Inspection	2019-20 Winter
On	On	Off	No	2020 Annual Maintenance	2019-20 Winter
On	Off	On	No	2020 Annual Maintenance	2019-20 Winter
Off	On	On	Yes	2020 Annual Maintenance	2019-20 Winter

Attachment 1: Hypothetical scenario

Small Asian 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 Asian Carp Response Decision Matrix*

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

Direction of flow

Fish Life History

Abundance

Location

Significant Change

Action Implemented

Notes:

= Significant change from baseline requiring further response action

= Moderate change from baseline requiring further response action

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

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

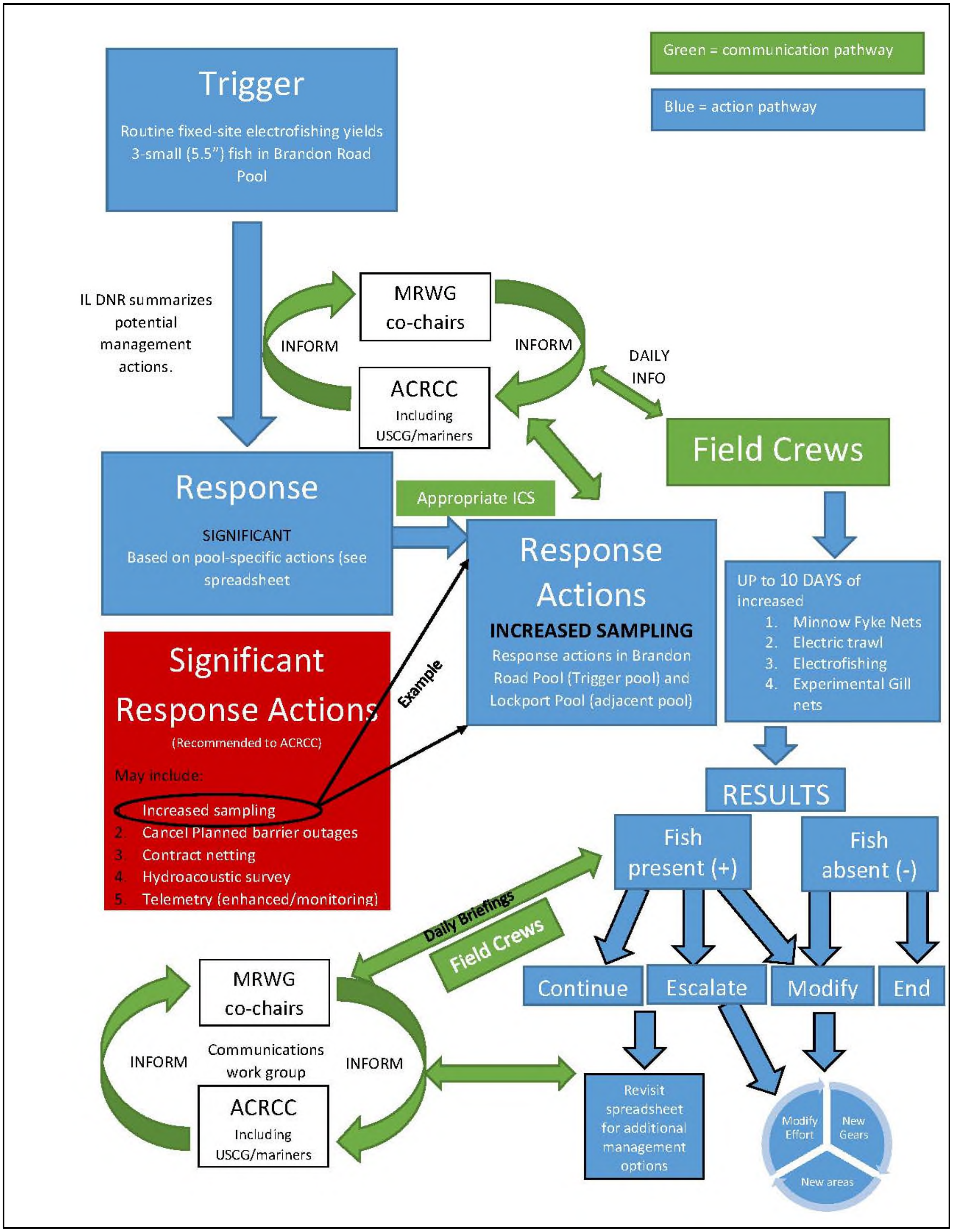
2 This status is based upon the collection of a single Bighead Carp during piscicides treatment in 2009.

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

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

Attachment 2: Sample Action Process

This example illustrates the process should three small Asian 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 growth into larger life stages.
Young of Year (YOY)	Fish hatched that calendar year. Also known as age 0 fish.
Juvenile	An 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 and 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/larvae 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; Asian carp collections are not predictable, and may take multiple sampling trips to collect just one individual.
Common	Consistent catches across the pool; Asian 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. Asian 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 ACRCC 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 ACRCC. The ACRCC, 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 Asian carp currently used by MRWG in Fixed and Targeted Sampling.
Hoop Netting	Standard fish sampling method to sample adult Asian carp currently used by MRWG in Fixed and Targeted Sampling.
Minnow Fyke Netting	Standard fish sampling method to sample small Asian carp currently used by MRWG in Fixed and Targeted Sampling.

Paupier Net Boat	Experimental fish sampling method to sample small and adult Asian carp currently used by MRWG.
Electrofied Dozier Trawl	Experimental fish sampling method to sample small and adult Asian carp currently used by MRWG.
Icthyoplankton Tows	Standard fish sampling method to sample larvae and eggs of Asian carp currently used by MRWG in Fixed and Targeted Sampling.
Pound Nets	Experimental fish sampling method to sample small and adult Asian carp currently used by MRWG.
Modify Barrier Operations	MRWG and USACE will coordinate upon potential postponements and operations of planned Barrier outages.
Acoustic Deterrent	Noise methods to drive/herd/deter fish including revving of outboard boat motors, banging on boats in the waterway, and deployment of speakers with developed sounds.
Commercial Contract Netting	Mobilizing contracted commercial fisherman and using commercial fishing methods used currently by MRWG in sampling/detection and removal including gill netting, trammel netting, large mesh seine, small mesh seine, and hoop netting.
Hydroacoustics	Electronic Fish survey and locating techniques used currently by MRWG including side-scan sonar, and DIDSON sonar to evaluate the number and density of large or small Asian 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 Asian 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 Asian 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 Asian 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., IEPA, ILDOA but key IDNR authorities below

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

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

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

Section 890.30 Treatment of the Water Area

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

515 ILCS 5/1-135

515 ILCS 5/1-150

ARTICLE 5. FISH PROTECTION

515 ILCS 5/5-5

USACE

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

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

USFWS

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

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 Asian Carp Removal

Anthony P. Porreca, Thomas M. Detmer, Joseph J. Parkos III, Kris Maxson, Steven E. Butler, David H. Wahl (Illinois Natural History Survey)

Participating Agencies: Illinois Natural History Survey (lead)

Location: Zooplankton sampling will take place in main channel and backwater habitats throughout the Illinois Waterway from the downstream terminus of the Chicago Area Waterways in the vicinity of the Lockport Lock and Dam to the lower Illinois River (LaGrange Pool).

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

Introduction and Need:

An aggressive Asian carp removal program has been implemented to reduce the spread and impact of Asian carp populations. However, the extent and pace of ecosystem responses to such removals is uncertain. Zooplankton abundance and community composition are known to have been affected by the establishment of Asian carp, with densities of large-bodied crustacean zooplankton reduced to a greater extent than rotifers. Zooplankton are known to be a rapid index of ecosystem response, are distributed throughout the Illinois Waterway, and are a critical food web component for larval and adult native fishes, making them ideal performance metrics for assessing the effectiveness of Asian carp control efforts. This project will help determine the extent to which the removal strategy is working to reverse ecosystem impacts from Asian carp and continue long-term monitoring of zooplankton in the Illinois Waterway. This work will help inform management agencies regarding ecosystem responses to Asian carp removals and define explicit targets for evaluating the outcome of Asian carp control efforts.

Objectives:

(1) Assess zooplankton abundance, body size distribution, biomass, and community composition in the Illinois Waterway during 2019.

(2) Assess the magnitude and time lag for ecosystem responses to past and ongoing Asian carp removal efforts.

(3) Compare current zooplankton abundances, body size distributions, and biomass with targets derived from pre-invasion conditions to develop a stoplight assessment tool for evaluating the outcome of Asian carp control and removal efforts.

Appendix A: Zooplankton as Dynamic Assessment Targets for Asian Carp Removal

Status:

Zooplankton have been sampled from sites throughout the Illinois Waterway during 2011 – 2018. Previous data collected during 2011 – 2015 along the Illinois River indicate that zooplankton abundance has been significantly reduced since the establishment of Asian carp and that backwaters may experience greater fluctuations in plankton densities than main channel sites where Asian carp are established. Community composition has also been affected by the establishment of Asian carp, with shifts in both macrozooplankton and rotifers. However, large-bodied crustacean zooplankton have been reduced to a greater extent than rotifers. Zooplankton data collected from the Hanson Material ServiceS backwater in the Marseilles Pool, where known numbers and biomass of Asian carp have been removed, are being analyzed to understand ecosystem responses to Asian carp removal. Further system-wide analyses of zooplankton data are ongoing and may also reveal larger-scale ecosystem responses to Asian carp removals, and indicate management targets that can help to guide Asian carp removal and control efforts.

Methods:

Field sampling for assessment of zooplankton trends will take place biweekly between April and October of 2019 at established sites to maintain consistency and data comparability (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, 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 Lugols 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 digitizing pad. Zooplankton densities will be calculated as the number of individuals per liter of water sampled. Density and body size estimates 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, temperature) will also be collected. Discharge data will be acquired from the USGS monitoring program on the Illinois Waterway.

Targets for ecosystem response to Asian carp removals will be developed by using monitoring data from the pre-assessment time period to model zooplankton indicators as a function of Asian carp abundance and the seasonal environmental variation driving their spatiotemporal dynamics (e.g., discharge, temperature, total phosphorus, chlorophyll *a*). Models of zooplankton indicators will be parameterized over conditions including pre- or early-invasion time periods, when bigheaded carp were absent or at very low abundance. Environmental values from the assessment time period will be entered into these models while holding carp abundance at zero to produce target values for zooplankton metrics (i.e., zooplankton values in the absence of carp but still under control of seasonal environmental conditions). A second set of predicted zooplankton values will be generated using observed carp abundances in combination with observed environmental values (i.e., full set of observed conditions during assessment period).

A stoplight assessment report card will be developed for locations throughout the Illinois Waterway based on deviation of zooplankton performance measures from predicted management targets. The stoplight report will code locations as impacted by Asian carp (red light) if the deviation (± 2 standard error) between observed and target predictions of zooplankton metrics falls outside of the deviation (± 2 standard error) between observed zooplankton values and predictions based on the full set of observed conditions (this deviation interval is known as the control limits of a given metric). Locations will be coded as warranting caution (yellow light) if zooplankton target intervals fall outside of the ± 1.5 standard error control limit. Locations where zooplankton targets fall within the ± 1.5 standard error control limit will be considered as not having an impact of carp and will be coded as a green light.

Sampling Schedule:

In 2019 and subsequent years, zooplankton sampling will occur at bi-weekly intervals at all sites from April to October. At most sites, zooplankton will be sampled concurrently with ichthyoplankton sampling (collected to monitor for Asian carp eggs and larvae).

Deliverables:

Results of 2019 sampling and on-going assessments of patterns of zooplankton response to annual variations in Asian carp densities and harvest operations will be provided to MRWG partners as relevant findings are produced. A stoplight assessment report card will be developed for locations throughout the Illinois Waterway based on deviation of zooplankton performance measures from predicted management targets. Data will be summarized and project plans updated for annual revisions of the MRP.

Appendix A: Zooplankton as Dynamic Assessment Targets for Asian Carp Removal

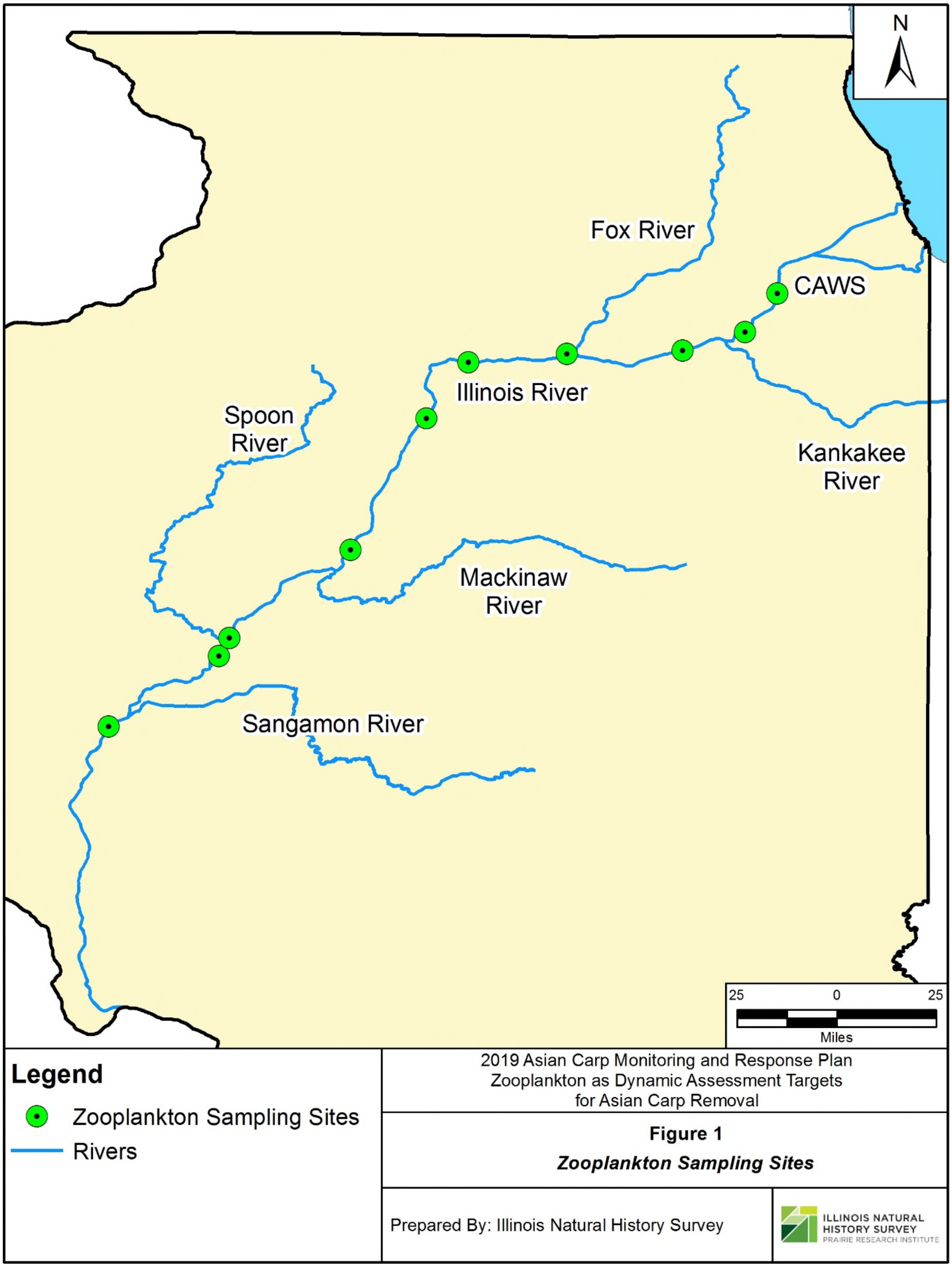


Figure 1. *Map of zooplankton sampling sites in the Illinois Waterway.*

Appendix B. Participants of the Monitoring and Response Workgroup, Including Their Roles and Affiliations.

Co Chairs
Kevin Irons, Aquatic Nuisance Species and Aquaculture Program Manager, Illinois Department of Natural Resources
John Dettmers, Senior Fishery Biologist, Great Lakes Fishery Commission

Agency Representatives
Matt O'Hara, IDNR
Kevin Irons, IDNR
Matt Shanks, USACE
Sam Finney, USFWS
Kelly Bearwaldt, USFWS

Independent Technical Experts
Scudder Mackey, Habitat Solutions NA/University of Windsor
Irwin Polls, Ecological Monitoring and Associates
Phil Moy, Wisconsin Sea Grant
Duane Chapman, US Geological Survey
John Epifanio, University of Illinois

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Cory Suski, U of I
Ed Little, USGS
Emily Pherigo,USFWS
Emy Monroe, USFWS
Brandon Fehrenbacher, IDNR
Kevin Irons, IDNR
Jeff Finley, USFWS
Jennifer Jeffrey
Jeremiah Davis, USFWS
Jim Bredin, IWF
Jim Duncker, USGS
Jim Garvey, SIU
John Dettmers, GLFC
John Goss, IWF
John Tix, U of I
Jon Amberg, USGS

Kelly Baerwaldt, USFWS
Kelly Hannah, U of I
Ken Barr, USACE
Mark Cornish, USACE
Marybeth Brey, USGS
Matt Diana, INHS
Matt Lubejko, SIU
Matt Shanks, USACE
Mike Weimer, USFWS
Nathan Jensen , USGS
Neal Jackson, KDNR
Luke Nelson, IDNR
Nick Barkowski, USACE
Nick Bloomfield, USFWS
Matt O'Hara, IDNR
Rob Simmonds, USFWS
Robin Calfee, USFWS
Ruairi MacNamara, SIU
Blake Ruebush, IDNR
Ryan Manning, USCG
Scott Collins, INHS
Skyler Schlick , UFWS
Steve Butler INHS
Heath Tepovich, IDNR
Widloe, Justin , 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

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

equipment being treated should be sprayed.[E]

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

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

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

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

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

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

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

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

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

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

[J] Stockton, K.A. and C.M. Moffitt. 2013. Disinfection of three wading boot surfaces infested with New Zealand mudsnails. North American Journal of Fisheries Management. 33:529-538.
[K] Clarkson, R.M., A.J. Moule, and H.M. Podlich. 2001. The shelf-life of sodium hypochlorite irrigating solutions. Australian Dental Journal. 46(4):269-276.
[L] Johnson, B.R. and N.A. Remeik. 1993. Effective shelf-life of prepared sodium hypochlorite solution. Journal of Endodontics. 19(1):40-43.
[M] Brylinski, M. 2003. How long does diluted bleach last? Email from clorox@casupport.com to the Director of WCMC EHS Dated February 6, 2003. http://weill.cornell.edu/ehs/forms_and_resources/faq/biological_safety.html

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

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

7. *Freezing*

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

Gear-Specific Tips for Decontamination

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

Nets

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

Personal Gear and Clothing

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

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

Dip nets, measuring boards, and other gear

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

Boats, trailers, and live wells

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

Motors

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

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	☑	☑[4,37,41,42,4,3]	⊗[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)	☑	☑[29,30,31,6,4]	⊗[4*]	☑[28,29,30,64]	☑[28]	⊗[29]
Largemouth Bass Virus (LMBv)	®	®	®	☑[24,28]	☑[24,28]	⊗[32]
Viral Hemorrhagic Septicemia Virus (VHSv)	☑	☑[4,72,73]	☑[4,72,74]	☑[28]	☑[28,72]	☑[26,29,63] ⊗[75]
Lymphosarcoma	®	®	®	☑	®	®
Whirling Disease	☑[33]	⊗[20,33,71]	☑[5,33]	☑[5,20,28,33]	®	☑[5,33]
Heterosporis	®	®	☑[34]	☑[34]	®	☑[34]

References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Recommends 10% bleach/water solution.

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

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

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

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

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

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

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

    Direct quotes:

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

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

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

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

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

    Direct Quote:

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

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

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

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

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

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

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

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

    Direct Quote:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

    Two weeks needed for mortality.

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

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

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

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

    >38°C (100°F) for 12 hours.

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

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

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

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

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

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

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

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

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

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

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

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

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

    EWM seeds are viable to excessive periods of desiccation.

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

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

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

EWM seeds likely experience increased viability after freezing.

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

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

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

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

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

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

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

N. peltata seeds show high tolerance to desiccation.

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

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

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

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

>50°C (122°F) for 15 seconds

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

Dry in full sunlight for >50 hours.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

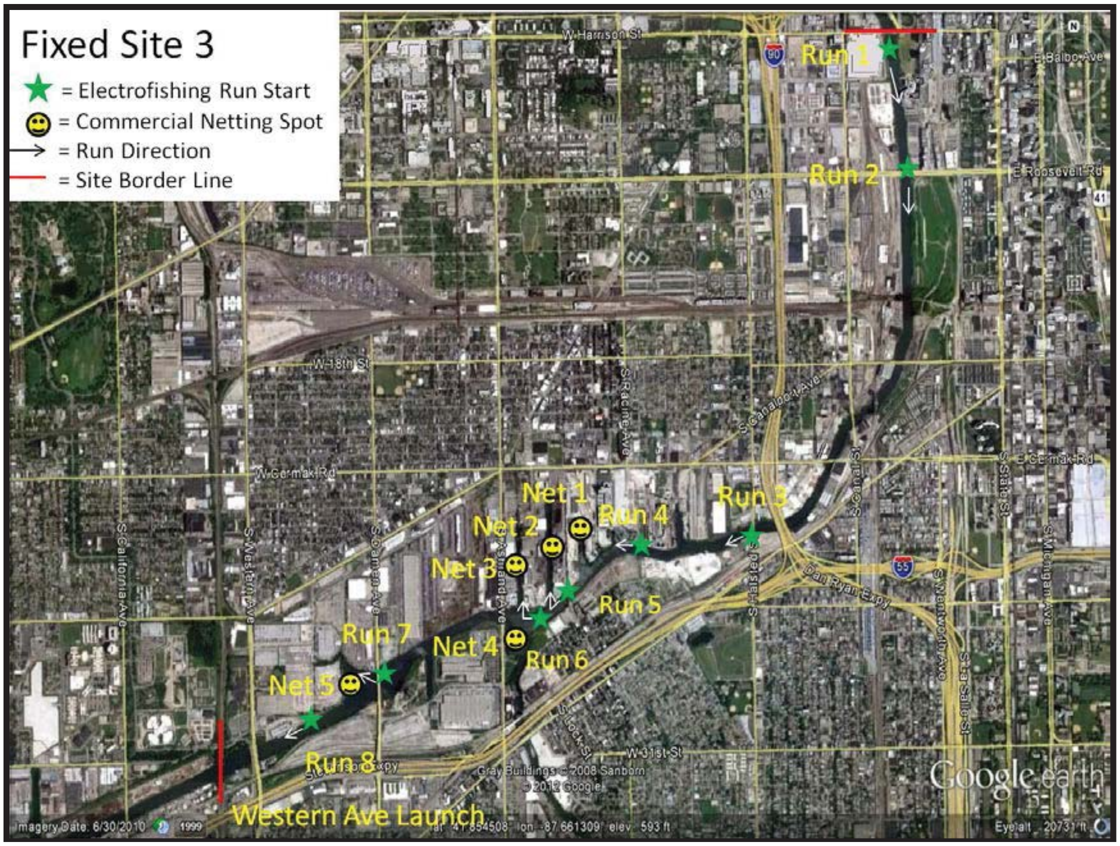
76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

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

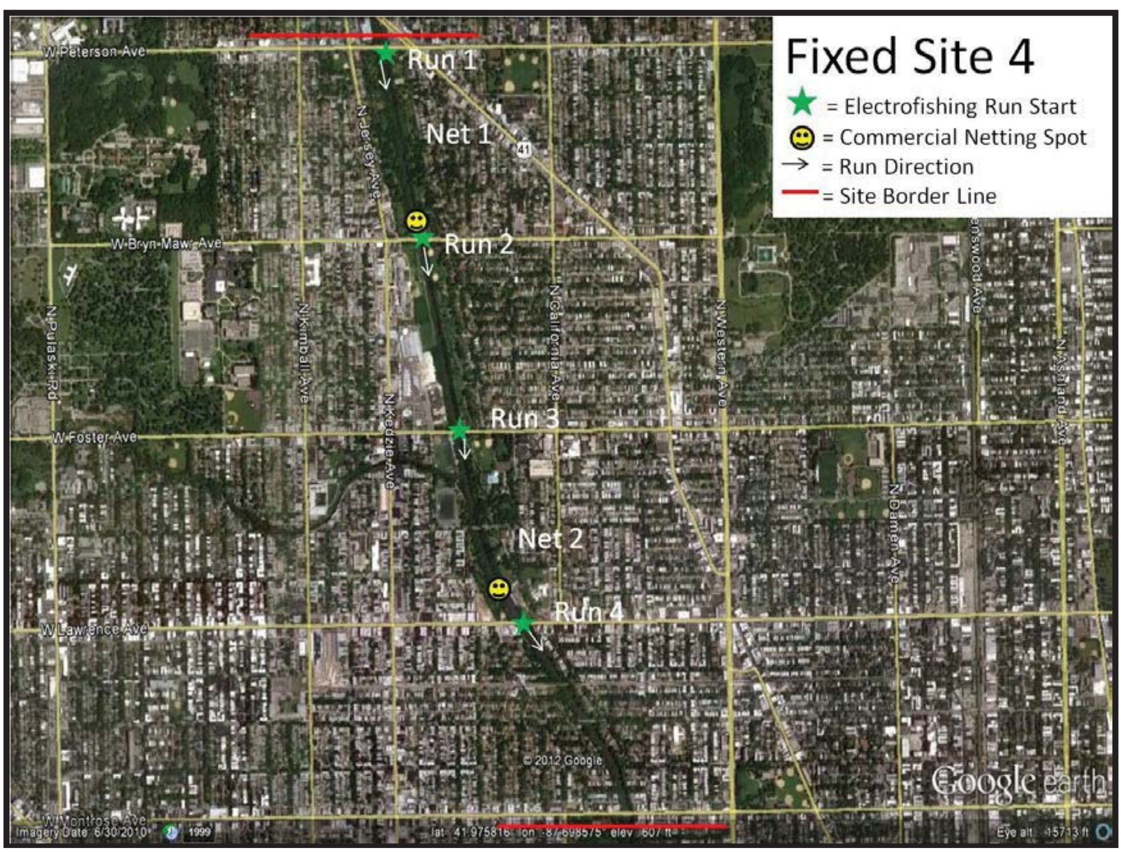
77. DiVittorio, J., M. Grodowitz, and J. Snow. 2010. Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species [2010 Edition]. U.S. Department of the Interior Bureau of Reclamation. Technical Memorandum No. 86-68220-07-05.

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

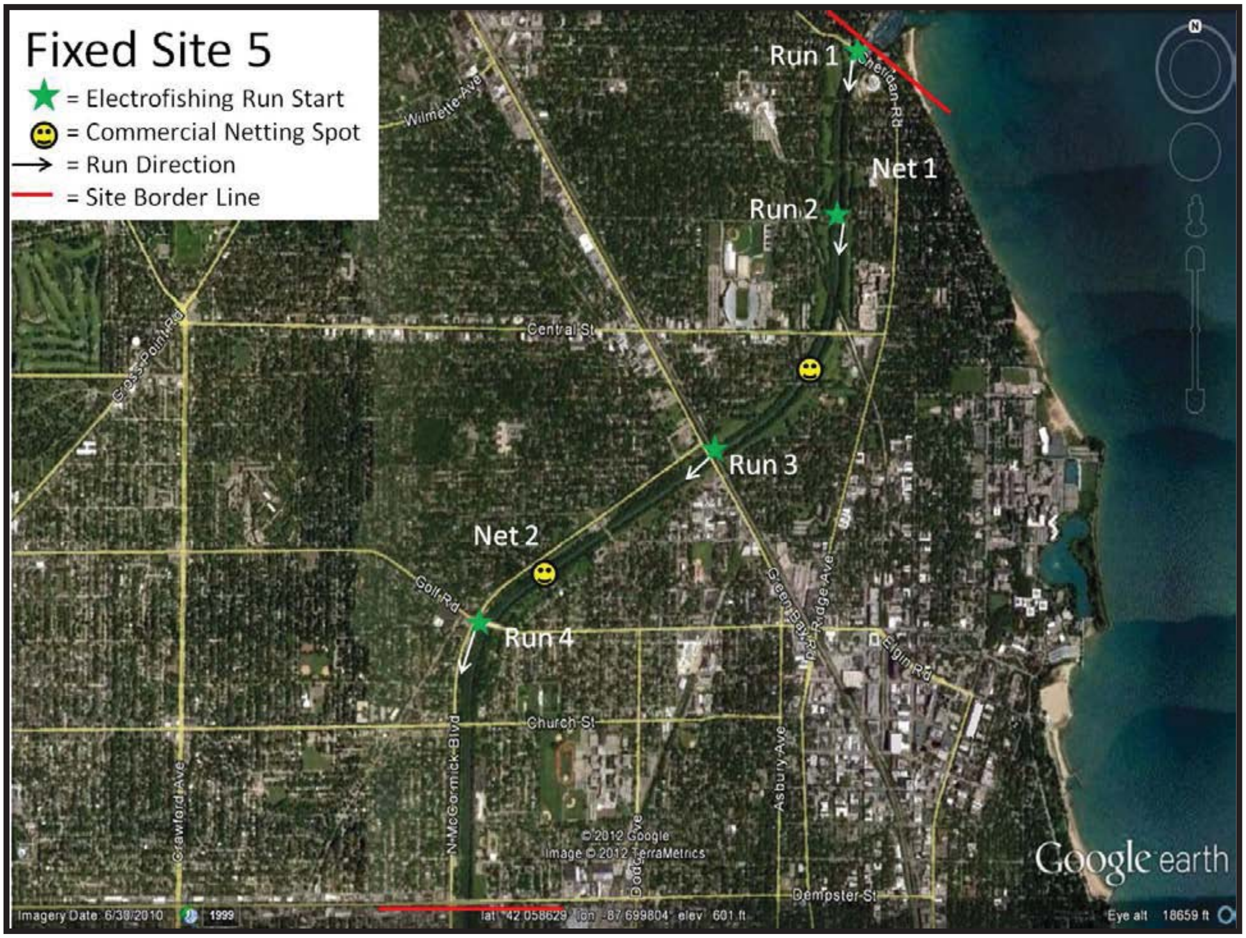
Appendix D. Detailed Maps of Fixed and Random Site Sampling Locations.



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
W Harrison St
W 18th St
W Cermak Rd
S California Ave
S Western Ave
S Ashland Ave
S Racine Ave
Dan Ryan Expy
Google earth

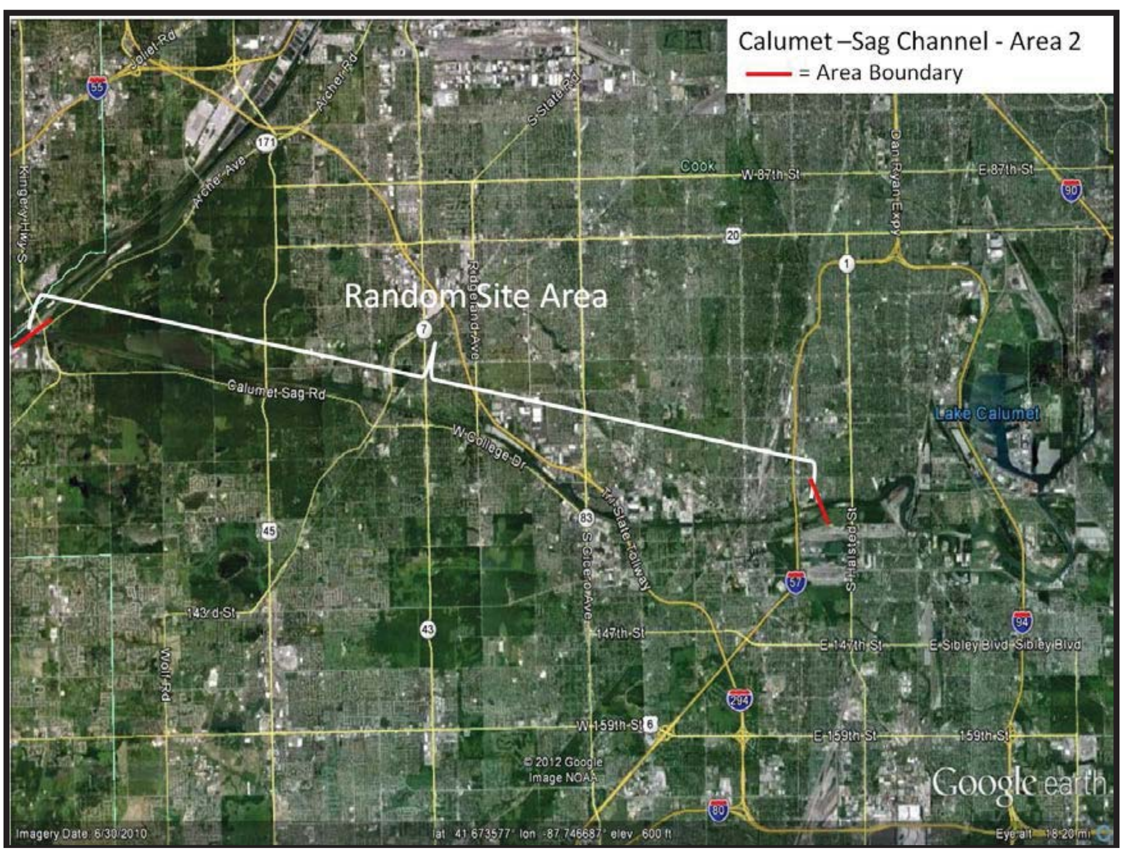


Fixed Site 4
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
W Peterson Ave
W Bryn Mawr Ave
W Foster Ave
W Lawrence Ave
W Montrose Ave
N Pulaski Rd
N Kimball Ave
N Kedzie Ave
N California Ave
N Western Ave
N Damen Ave
N Ashland Ave
N Jersey Ave
Google earth

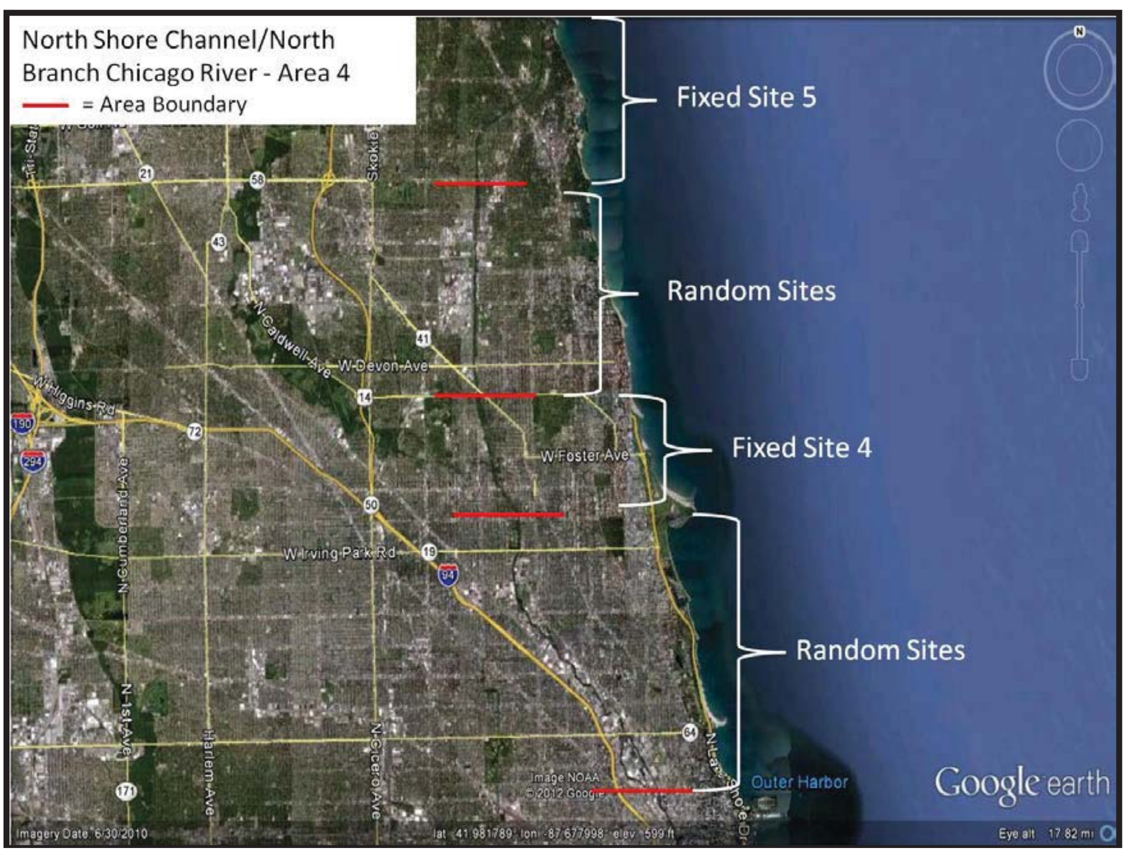


Fixed Site 5
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Net 1
Run 3
Net 2
Run 4
Wilmette Ave
Central St
Gross Point Rd
Golf Rd
Church St
Crawford Ave
N McCormick Blvd
Asbury Ave
Dempster St
Sheridan Rd
Elgin Rd
© 2012 Google
Image © 2012 TerraMetrics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

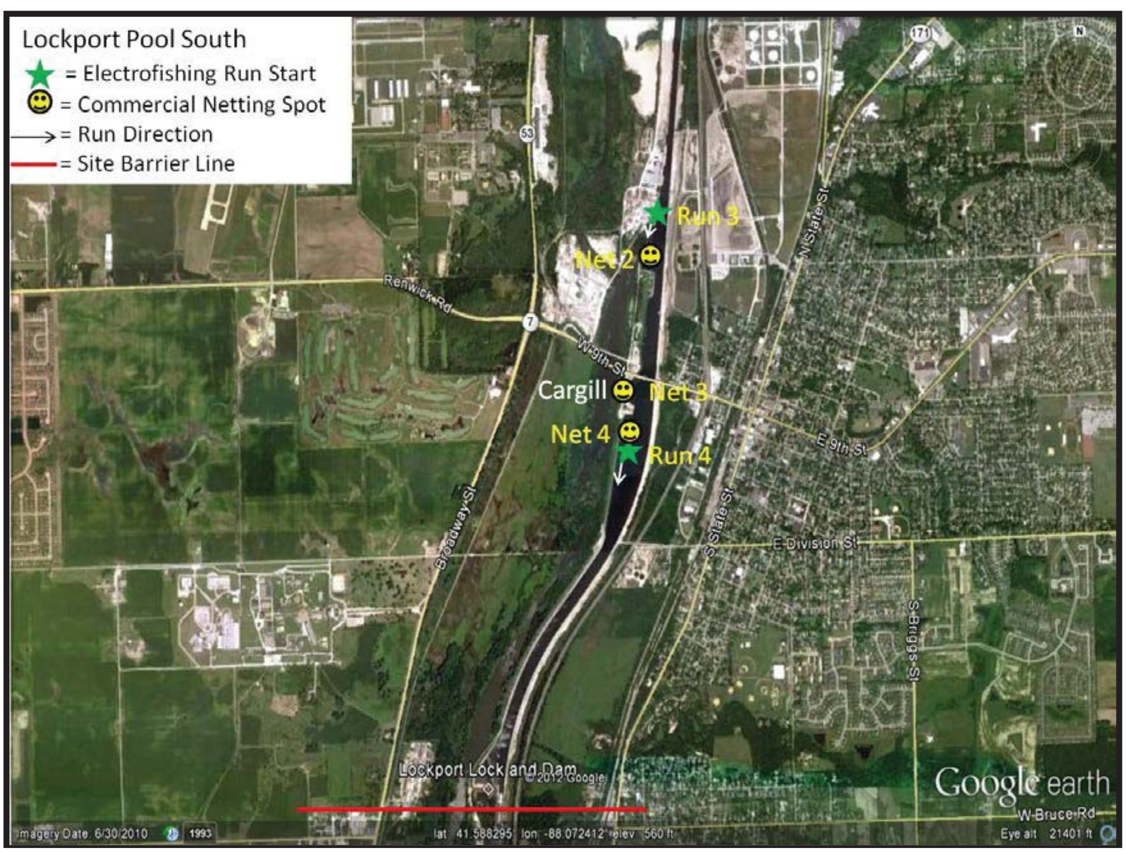

Calumet River - Area 1
= Area Boundary
Random Site Area
Lake Calumet
Wolf Lake
Highway 12
E 87th St
Chicago Skyway
Bishop Ford Fwy
S Halsted St
Calumet Ave
© 2012 Google
Image © 2012 TerraMetrics
Imagery Date: 6/30/2010
lat 41.697566° lon -87.564513° elev 586 ft
Eye alt 39389 ft
Google earth


Calumet –Sag Channel - Area 2
= Area Boundary
Random Site Area
Lake Calumet
Calumet-Sag Rd
W College Dr
Archer Ave
Archer Rd
Joliet Rd
S State St
W 87th St
E 87th St
Cook
Dan Ryan Expy
Ridgeland Ave
Kingery Hwy S
Tri-State Tollway
S Cicero Ave
S Halsted 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
Eye alt 18.20 mi
Google earth

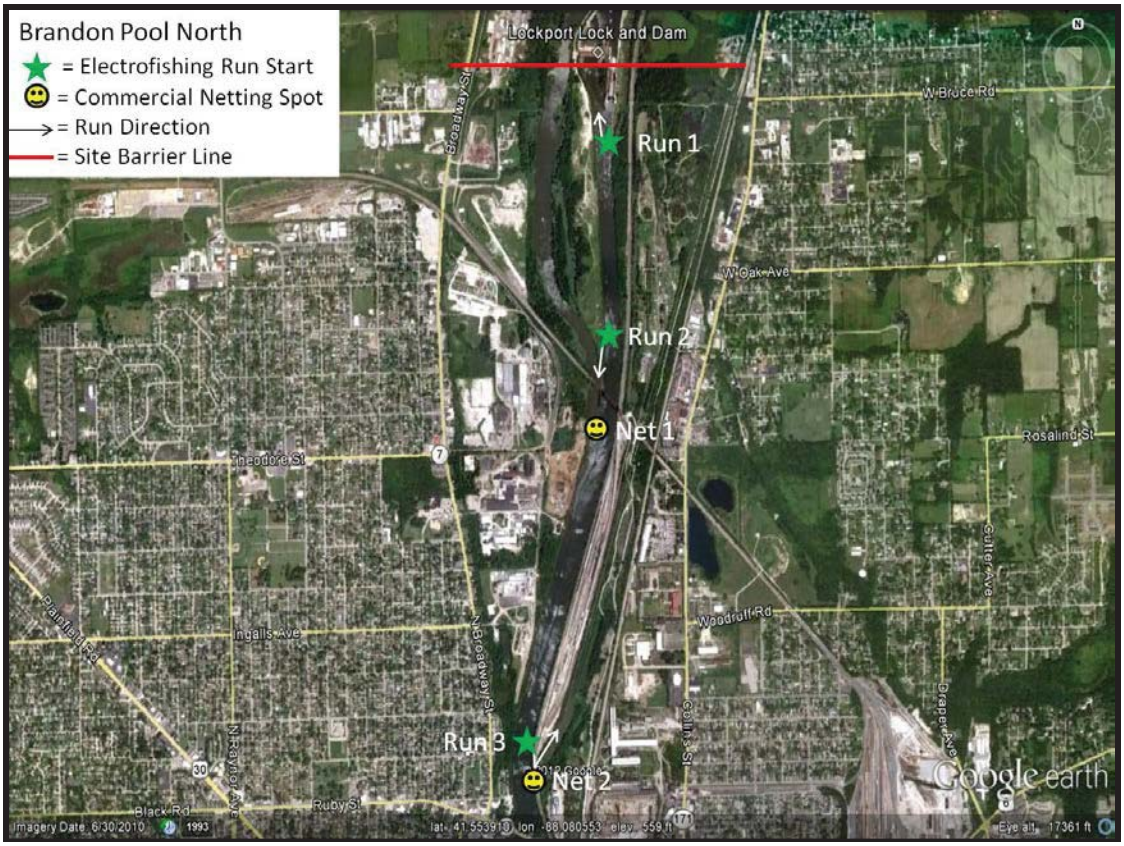

CSSC - Area 3
= Area Boundary
Random Sample Area
Roosevelt Rd
Butterfield Rd
DuPage
E Ogden Ave
W Ogden Ave
Stevenson Expy
Archer Ave
Archer Rd
State Rd
Cook
W 87th St
Highway 12
© 2012 Google
Google earth
Imagery Date: 6/30/2010

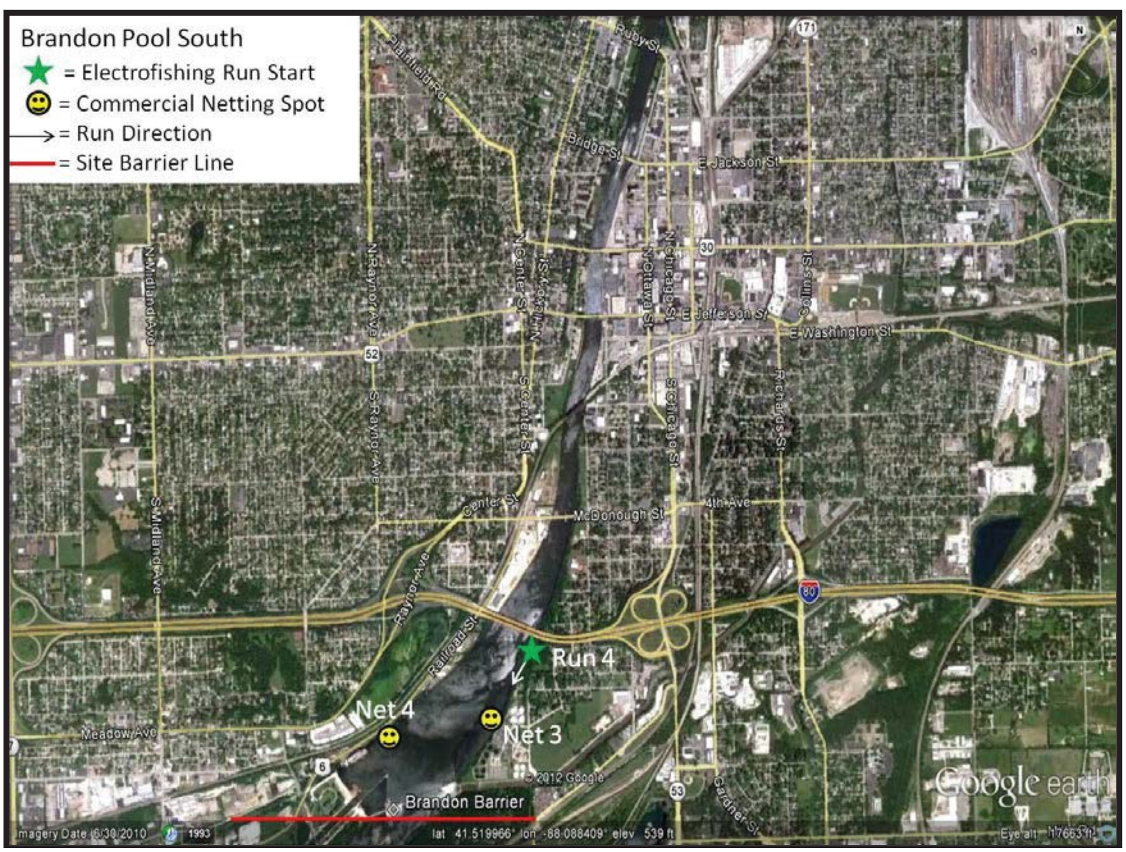

North Shore Channel/North Branch Chicago River - Area 4
= Area Boundary
Fixed Site 5
Random Sites
Fixed Site 4
Random Sites
W Devon Ave
N Caldwell Ave
W Foster Ave
W Irving Park Rd
Outer Harbor
Google earth
Imagery Date: 6/30/2010

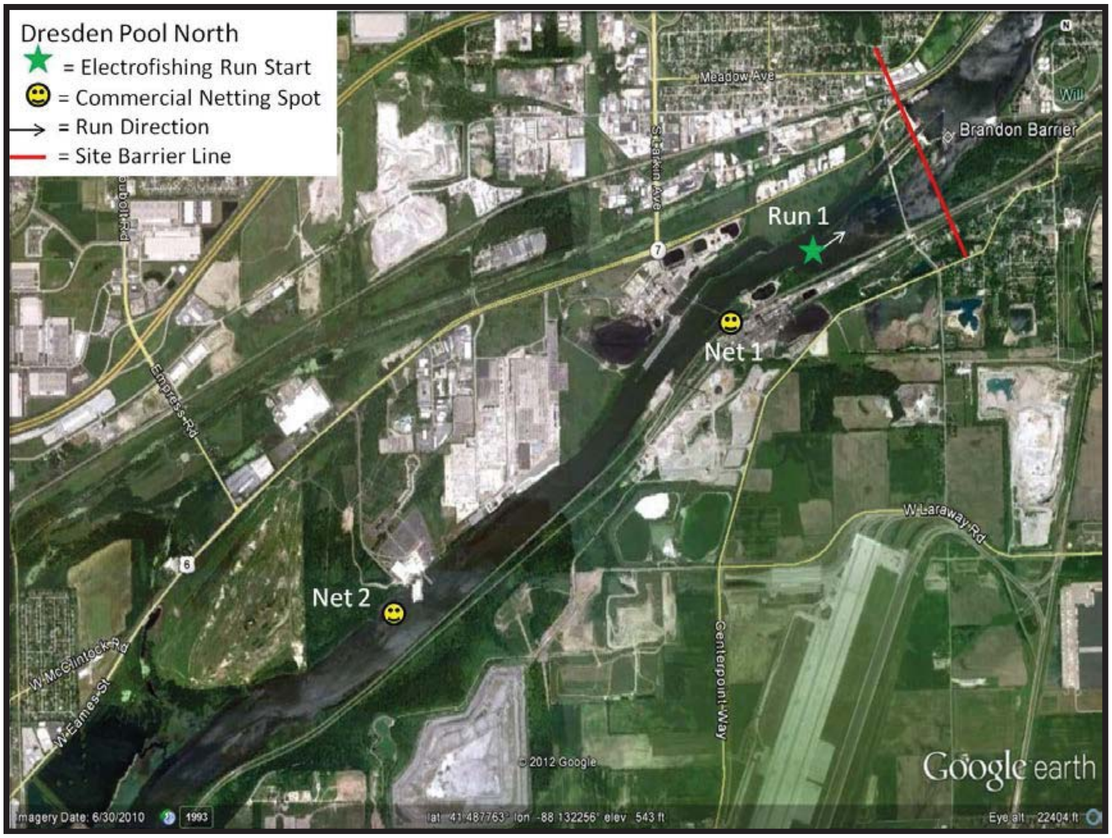
Lockport Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Dispersal Barrier
Run 1
Run 2
Net 1
E Romeoville Rd
W 135th St
S Independence Blvd
Archer Ave
W 151st St
Google earth



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
W Bruce Rd
Google earth


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
Woodruff Rd
Ingalls Ave
Broadway St
N Broadway St
Plainfield Rd
N Raynor Ave
Collins St
Draper Ave
Gutter Ave
Black Rd
Ruby St
Google earth


Brandon Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 4
Net 3
Net 4
Brandon Barrier
Ruby St
Plainfield Rd
Bridge St
E Jackson St
E Jefferson St
E Washington St
N Midland Ave
S Midland Ave
N Raynor Ave
S Raynor Ave
N Center St
S Center St
N Chicago St
S Chicago St
N Ottawa St
Collins St
Richards St
McDonough St
4th Ave
Center St
Railroad St
Meadow Ave
Gardner St
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
S Frontage Rd
E Frontage Rd
W Bluff Rd
Centerpoint Way
Craig 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
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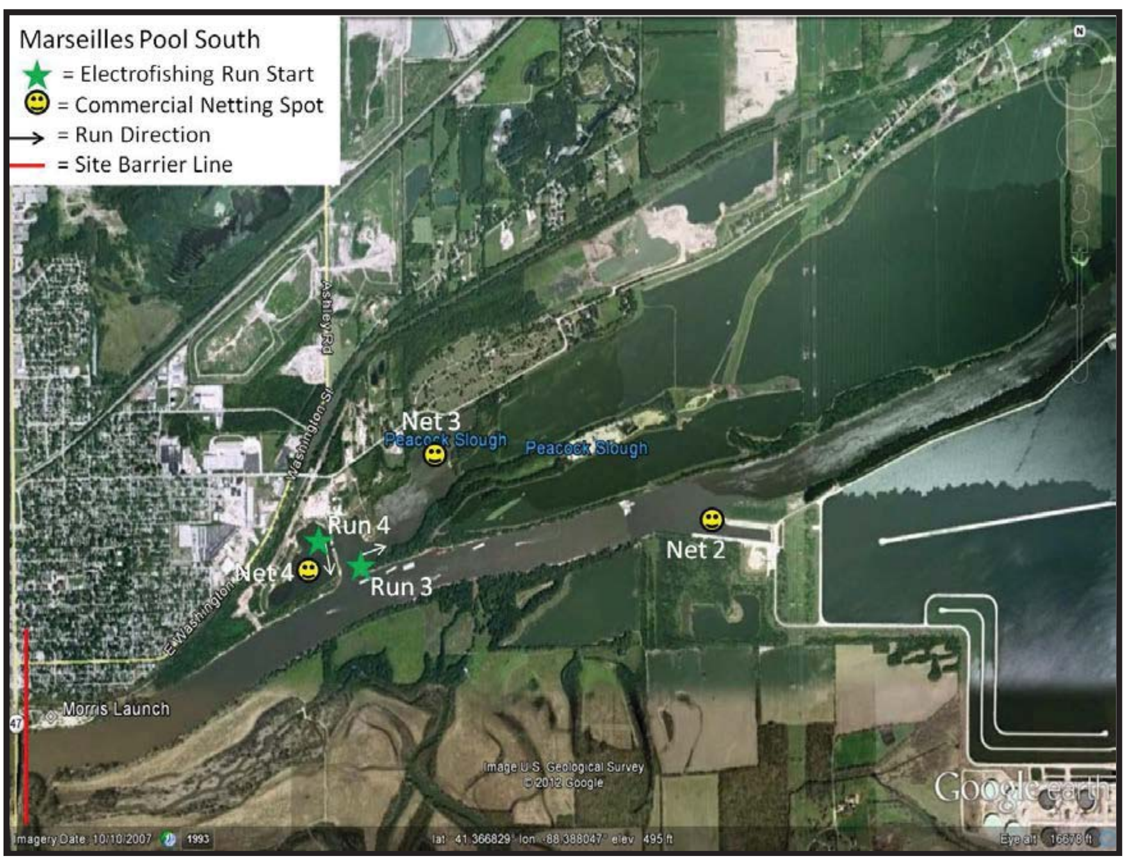
1998
lat 41.386214° lon -88.314243° elev 498 ft
Eye alt 19308 ft


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
1993
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:

Appendix F. Shipping, Handling, and Data Protocols for Wild Captured Black Carp and Grass Carp.

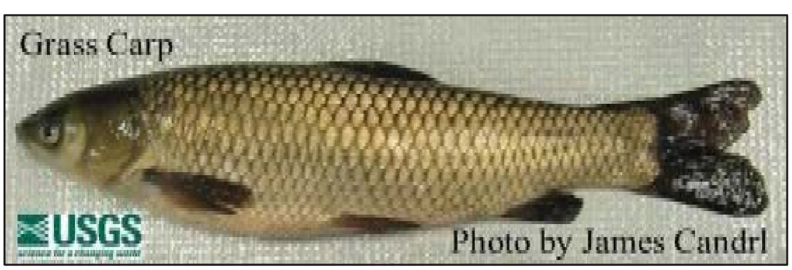
Any suspect black carp collected in the wild in the United States and grass carp collected in the Great Lakes Basin, or other novel locations in the U.S., should be immediately reported to the appropriate resource management agency in the state where the fish was collected. Do ***not*** release suspect black or grass carp unless required by state laws or 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 attached for your reference. 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 or grass carp as soon as possible after capture. In addition to collection and basic biological data, we are interested in collecting multiple structures and organs from each fish for management and research purposes. Protocols are provided for 1) collection information, basic biological data, and digital images; 2) removal, preparation, and shipment of eyes for ploidy analysis; and 3) preparation and shipment of black and grass carp carcasses. These protocols are intended to provide resource management agencies, or authorized personnel, with streamlined instructions for the proper collection, preparation, and shipping of data, samples, and carcasses. It is important that all collections of black and grass carp (from the identified locations above) are immediately reported to the appropriate resource management agency in the state where the fish was collected before collecting more than collection information, basic biological data, and digital images.

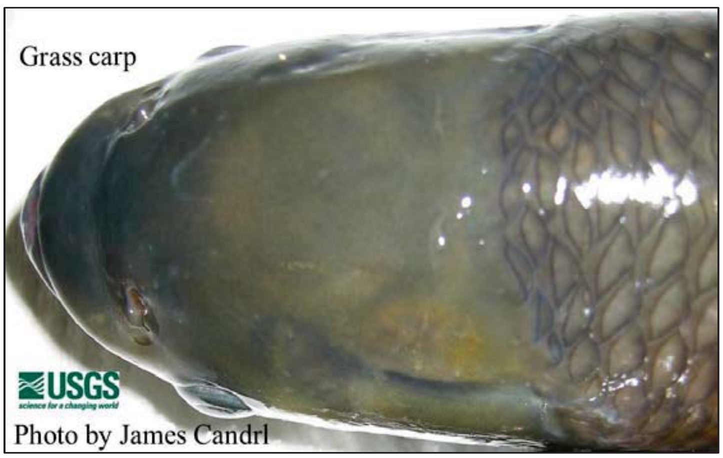
Step 1: Data Collection

1. Record GPS Location (if available, otherwise a description of collection location);
2. Record date and time of capture, method of capture, and collecting individual or agency;
3. Record fish weight, girth, length, and species (number samples if necessary);
4. Take high resolution digital pictures (see examples below):
   a. Lateral view of fish's entire left side,
   b. Close-up lateral view of head,
   c. Dorsal view of head with mouth ***fully*** closed (taken from directly above the fish's head).
5. Record name, telephone number, and/or email address for point of contact;
6. E-mail data and digital images to Sam Finney at sam_finney@fws.gov.
7. Proceed to Step 2.



Example of 4.a: Lateral view of fish's entire left

Example of 4.b: Close-up lateral view of



Example of 4.c: Dorsal view of head with mouth fully

Step 2: Eyeball Removal, Sample Preparation, and Shipping Procedures for Ploidy Analysis

Materials:

- Forceps; scalpel; blunt or curved scissors
- 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)
- Permanent marking pen
- Cooler or insulated container with ice packs, packing tape to seal cooler
- Optional: methanol if freezing and storing samples longer than 8 days.

Procedure for Removing Carp Eyeballs**:**

1. Euthanize fish with an overdose of tricaine methanesulfonate (MS-222) or sharp blow to head.
2. Label small plastic container with collection date, species and sample number if applicable (e.g. 25MAR13, black carp, #12)
3. Insert scalpel blade between the eyeball and socket wall. Taking care not to puncture the eyeball, cut around the circumference of the eyeball, keeping the blade pointed toward the socket wall. You may use forceps to hold the eyeball steady. The goal is to cut the tissue responsible for holding and moving the eye.
4. Once you feel confident all the tissue around the eye is cut, 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 to pop the eye out and trim off any excess tissue.
5. Place eye in labeled container, fill to top with buffer solution, and put on ice or refrigerate at 4 to 8°C.
6. Follow Eyeball Sample Preparation and Shipping Procedures below.

Sample Preparation for Overnight Shipment or Storage 1 to 8 Days:

This option will provide the highest quality of samples for analysis.

1. Label a small, plastic container with collection date, species, and sample number if applicable (e.g. 25MAR13, black carp, #12)
2. Remove both eyeballs without puncturing from fish and place in labeled container. (See removal procedures above.) Fill to top with contact lens solution or saline.
3. Place container(s) in a sealable plastic bag to contain leaks and place on ice or in a cooler with ice packs.
4. Ship immediately following shipping procedures for Whitney Genetics Lab (below) or keep refrigerated (4°C - 8°C) up to 8 days.
5. Proceed to Step 3.

Eyeball Sample Preparation for Storage Longer than 8 Days:

If samples cannot be shipped within 8 days, or if many samples will be collected over a known period of time, you can store and ship all together.

1. Label a small, plastic container with collection date, species, and sample number if applicable (e.g. 25MAR13, black carp, #12)

2. Remove both eyeballs without puncturing from fish and place in labeled container. (See removal procedures above.) Fill to top with 20% methanol in contact lens solution or saline.
3. Place container(s) in a sealable plastic bag to contain leaks and place on ice or in a cooler with ice packs. Refrigerate (4°C - 8°C) overnight to allow methanol to diffuse into fish eyes.
4. Move samples to a freezer (-20°C). Store frozen until overnight shipment can be arranged. Sample quality will not degrade as long as sample remain frozen (-20°C) until shipment.
5. Ship to Whitney Genetics Lab following procedures below.
6. Proceed to Step 3.

Shipping Procedures:

1. Contact Whitney Genetics Lab personnel to make Overnight Priority (for morning delivery) shipping arrangements. If possible, ship samples on same day of catch.
2. Do ***NOT*** ship samples until arrangements have been made for receipt of package.
3. Pack samples in a Ziploc bag to prevent leakage and then enclose in a sealed, insulated container with ice packs to maintain 4 to 8°C. Do ***NOT*** use dry ice for shipping. Include collection data (and sample number if necessary) with package. If using a cooler for shipping, make sure lid is taped securely.
4. Ship priority overnight to the attention of Whitney Genetics Lab Contact.
5. Email confirmation of shipment and tracking numbers to recipient.

Contact Information:

Jennifer Bailey – fish biologist
608-783-8451
608-397-4416 (mobile)
jennifer_bailey@fws.gov

Maren Tuttle-Lau – fish biologist
608-783-8403
maren_tuttle-lau@fws.gov

Shipping Address:

Whitney Genetics Lab – La Crosse Fish Health Center
U.S. Fish and Wildlife Service Resource Center
555 Lester Ave, Onalaska, WI, 54650
608-783-8444

Step 3: Carcass Preparation and Shipping Procedures

Carcass Sample Preparation for Overnight Shipment:

If possible, *ship samples immediately on ice on same day of catch*. Otherwise, freeze the carcass before shipping.

1. Pack entire specimen (with eyes extracted) in an insulated container with plenty of ice packs, frozen water bottles, or ice to keep cool. Do ***NOT*** use dry ice for shipping.
2. Include collection data (and sample number if necessary) in double ziplock bag in container.
3. Seal container to contain leaks. If using a styrofoam cooler within a box, make sure the lid is taped and sealed securely.
4. Ship immediately or keep frozen until Overnight Priority shipping arrangements are made.

Shipping Procedures:

1. Contact Columbia Environmental Research Center personnel to make Overnight Priority (for morning delivery) shipping arrangements.
2. Do ***NOT*** ship samples until arrangements have been made for receipt of package.
3. Ship specimen in sealed, insulated container (see sample preparation instructions above) priority overnight to the attention of Duane Chapman or Joe Deters.
4. Email confirmation of shipment and tracking numbers to (dchapman@usgs.gov).

Contact Information:	Duane Chapman 573-875-5399 573-289-0625 (mobile) dchapman@usgs.gov
	Joe Deters 573-875-5399 573-239-9646 (mobile) jdeters@usgs.gov
Shipping Address:	Duane Chapman or Joe Deters Columbia Environmental Research Center U.S. Geological Survey 4200 New Haven Road Columbia, MO 65201 573-875-5399

Appendix G. List of Asian Carp fish species codes arranged in alphabetical order by fish common name. Four-digit species codes are the same as codes used by the Long Term Resource Monitoring Program (Ratcliff et al. 2014). Nomenclature follows the American Fisheries Society standard naming conventions (Nelson et al. 2004).

Common name	**Scientific name**	**Code**
Age-0 fish (young-of-the-year)	Age-0 fish	YOYF
American brook lamprey	Lampetra appendix	ABLP
American eel	*Anguilla rostrata*	AMEL
Banded darter	*Etheostoma zonale*	BDDR
Bigeye chub	*Hybopsis amblops*	BECB
Bigeye shiner	*Notropis boops*	BESN
Bighead carp	*Hypophthalmichthys nobilis*	BHCP
Bigmouth buffalo	*Ictiobus cyprinellus*	BMBF
Bigmouth shiner	*Notropis dorsalis*	BMSN
Black buffalo	*Ictiobus niger*	BKBF
Black bullhead	*Ameiurus melas*	BKBH
Black crappie	*Pomoxis nigromaculatus*	BKCP
Black crappie x white crappie hybrid	*P. nigromaculatus x P. annularis*	BCWC
Blackside darter	*Percina maculata*	BSDR
Blackspotted topminnow	*Fundulus olivaceus*	BPTM
Blackstripe topminnow	*Fundulus notatus*	BTTM
Blacktail shiner	*Cyprinella venusta*	BTSN
Bleeding shiner	*Luxilus zonatus*	BDSN
Blue catfish	*Ictalurus furcatus*	BLCF
Blue sucker	*Cycleptus elongatus*	BUSK
Bluegill	*Lepomis macrochirus*	BLGL
Bluegill x longear sunfish hybrid	*L. macrochirus x L. megalotis*	BGLE
Bluegill x orangespotted sunfish hybrid	*L. macrochirus x L. humilis*	BGOS
Bluegill x redear sunfish hybrid	*L. macrochirus x L. microlophus*	BGRS
Bluegill x warmouth hybrid	*L. macrochirus x L. gulosus*	BGWM
Bluntnose darter	*Etheostoma chlorosoma*	BNDR
Bluntnose minnow	*Pimephales notatus*	BNMW
Bowfin	*Amia calva*	BWFN
Brassy minnow	*Hybognathus hankinsoni*	BSMW
Brook silverside	*Labidesthes sicculus*	BKSS
Brook stickleback	*Culaea inconstans*	BKSB
Brown bullhead	*Ameiurus nebulosus*	BNBH
Brown trout	*Salmo trutta*	BNTT
Bullhead minnow	*Pimephales vigilax*	BHMW
Burbot	*Lota lota*	BRBT
Central mudminnow	*Umbra limi*	CMMW
Central stoneroller	*Campostoma anomalum*	CLSR
Channel catfish	*Ictalurus punctatus*	CNCF
Channel shiner	*Notropis wickliffi*	CNSN
Chestnut lamprey	*Ichthyomyzon castaneus*	CNLP
Common carp	*Cyprinus carpio*	CARP

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Common name	**Scientific name**	**Code**
Common carp x goldfish hybrid	*C. carpio x Carassius auratus*	CCGF
Common shiner	*Luxilus cornutus*	CMSN
Creek chub	*Semotilus atromaculatus*	CKCB
Creek chubsucker	*Erimyzon oblongus*	CKCS
Crystal darter	*Crystallaria asprella*	CLDR
Dusky darter	*Percina sciera*	DYDR
Emerald shiner	*Notropis atherinoides*	ERSN
Fantail darter	*Etheostoma flabellare*	FTDR
Fathead minnow	*Pimephales promelas*	FHMW
Flathead catfish	*Pylodictis olivaris*	FHCF
Flier	*Centrarchus macropterus*	FLER
Freckled madtom	*Noturus nocturnus*	FKMT
Freshwater drum	*Aplodinotus grunniens*	FWDM
Ghost shiner	*Notropis buchanani*	GTSN
Gizzard shad	*Dorosoma cepedianum*	GZSD
Golden redhorse	*Moxostoma erythrurum*	GDRH
Golden shiner	*Notemigonus crysoleucas*	GDSN
Goldeye	*Hiodon alosoides*	GDEY
Goldfish	*Carassius auratus*	GDFH
Grass carp	*Ctenopharyngodon idella*	GSCP
Grass pickerel	*Esox americanus vermiculatus*	GSPK
Green sunfish	*Lepomis cyanellus*	GNSF
Green sunfish x bluegill hybrid	*L. cyanellus x L. macrochirus*	GSBG
Green sunfish x orangespotted sunfish hybrid	*L. cyanellus x L. humilis*	GSOS
Green sunfish x pumpkinseed hybrid	*L. cyanellus x L. gibbosus*	GSPS
Green sunfish x redear hybrid	*L. cyanellus x L. microlophus*	GSRS
Green sunfish x warmouth hybrid	*L. cyanellus x L. gulosus*	GSWM
Greenside darter	*Etheostoma blennioides*	GSDR
Highfin carpsucker	*Carpiodes velifer*	HFCS
Hornyhead chub	*Nocomis biguttatus*	HHCB
Inland silverside	*Menidia beryllina*	IDSS
Iowa darter	*Etheostoma exile*	IODR
Johnny darter	*Etheostoma nigrum*	JYDR
Lake sturgeon	*Acipenser fulvescens*	LKSG
Largemouth bass	*Micropterus salmoides*	LMBS
Largescale stoneroller	*Campostoma oligolepis*	LSSR
Larval fish	Larval fish	LRVL
Least brook lamprey	*Lampetra aepyptera*	LBLP
Logperch	*Percina caprodes*	LGPH
Longear sunfish	*Lepomis megalotis*	LESF
Longnose gar	*Lepisosteus osseus*	LNGR
Longnose gar x spotted gar hybrid	*L. osseus x L. oculatus*	LNST

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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

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.

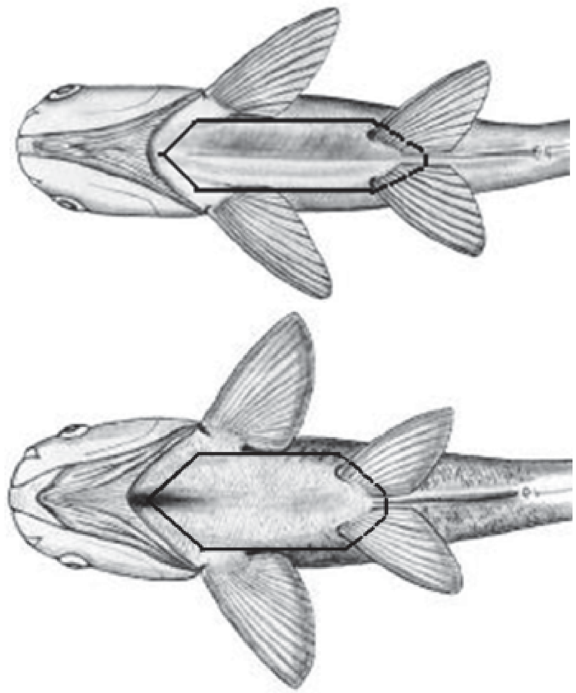

Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection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

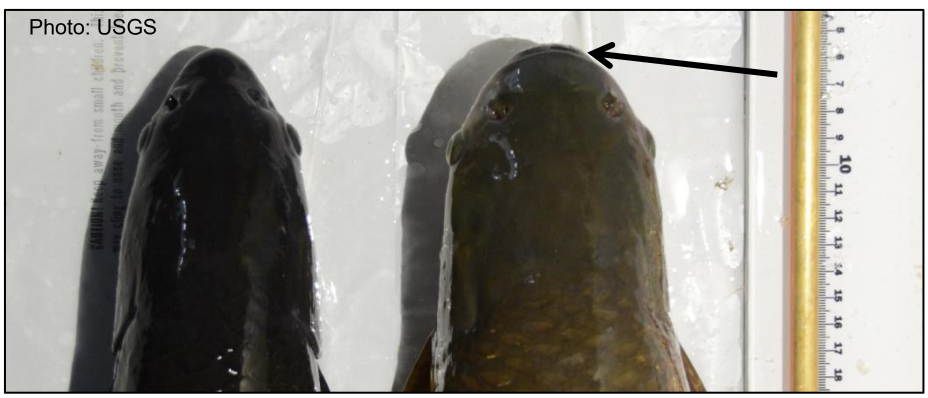
Photo: USGS

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

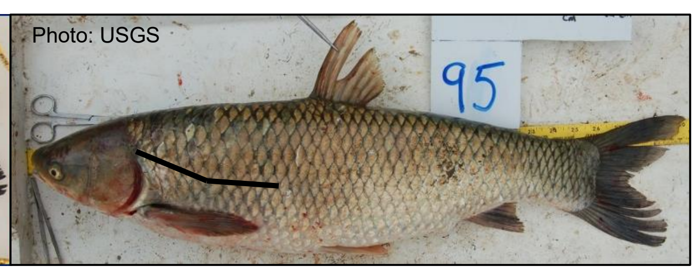
Photo: USGS

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

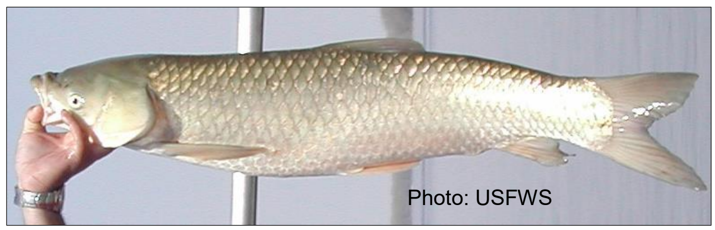
Photo: USFWS

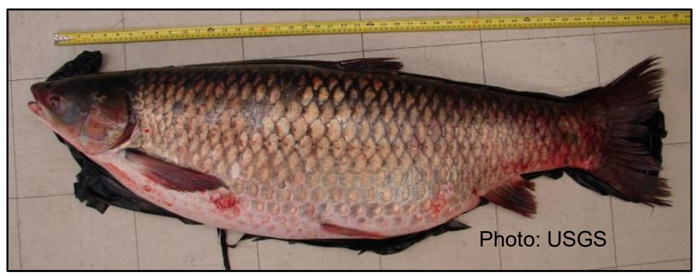
Photo: USGS

Photo: USGS

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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

Ruairí MacNamara · David Glover · James Garvey · Wesley Bouska · Kevin Irons

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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 · Bighead 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 (Vander Zanden et al. 2010). In the central United States, preventing interbasin movement of non-native species between the Mississippi and Great Lakes is a key management objective (USACE 2014). Bigheaded carps (silver carp *Hypopthalmichthys molitrix* and bighead carp *H. nobilis*), large planktivores native to east Asia (Kolar et al. 2007; Garvey 2012), are among the fish species of highest concern. Since the early 2000s, many studies have focused on the ecology of bigheaded carps at the core of their North American range, specifically in the Middle Mississippi, Lower Missouri and Lower Illinois Rivers (e.g., Schrank and Guy 2002; Williamson and Garvey 2005; Sass et al. 2010; Cudmore et al. 2012; Garvey et al. 2012; Norman and Whitledge 2015). Theoretical work has also examined the potential threat posed by the species to the uninvaded Great Lakes (Kocovsky et al. 2012; Cuddington et al. 2014; Zhang et al. 2016; see review by Cooke 2016). However, critical information on bigheaded carps adjacent to novel ecosystems is limited (see Hayer et al. 2014; Stuck et al. 2015; Coulter et al. 2016). These are the propagules most likely to be successful new invaders and, thus, their presence corresponds to locations at which immediate control measures need to be implemented.

The Illinois River is a major Mississippi River tributary that is hydrologically connected to the Great Lakes basin (Lake Michigan) via a network of canals and heavily modified rivers called the Chicago-Area Waterway System (CAWS). Bigheaded carps are established in the lower reaches of this river at high densities (Sass et al. 2010; Garvey et al. 2012). In the upper river, the 'last line of defense' preventing dispersal into Lake Michigan is an electric barrier system located in the CAWS (Moy et al. 2011), although concerns exist about its effectiveness under certain conditions (Parker et al. 2015). Management agencies aim to reduce the population of bigheaded carps (and hence the likelihood of bigheaded carps reaching and challenging the barrier system) through contracted commercial harvest in the Starved Rock (river km (RKM) 372–394), Marseilles (RKM 394–437) and Dresden (RKM 437–460) reaches of the upper river (Fig. 1). The population front has remained in the Dresden reach for several years (ACRCC 2015), *c.* 17 RKM downstream of the electric barrier system.

As bigheaded carps in the Upper Illinois River represent an immediate threat to Lake Michigan, collection of accurate empirical data on this advancing population is needed to understand range expansion dynamics and develop effective management strategies (Cooke 2016). However, many sampling challenges exist: silver carp and bighead carp occupy a variety of habitat types (e.g., main channel, backwater lakes, side channels) over a relatively large spatial scale (three river reaches extending 88 RKM); both species may respond differently to capture sampling gears like electrofishing or netting (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014; Collins et al. 2015); and it is likely that a density gradient exists over the 88 RKM occupied by the advancing population, so sampling would have to be equally effective at a variety of densities. Mobile hydroacoustic sampling has begun to feature more prominently in fisheries research in riverine environments (e.g., Lucas and Baras 2000; CEN 2014) and, considering the constraints outlined above, this technology may represent the optimal approach in terms of spatial coverage and unbiased representation of the target species. We therefore initiated a program of mobile hydroacoustic surveys in the Upper Illinois River in 2012 with the objectives of (1) quantifying key demographics (density, size structure and species composition) of the advancing population of bigheaded carps, (2) ground-truthing hydroacoustic density estimates by reference to localized harvest metrics, and (3) evaluating the efficacy of harvest at suppressing overall population levels. We outline a unique sampling framework that can be applied in a variety of contexts (e.g., population assessment, control strategy evaluation, early detection) for management of invasive fish species.

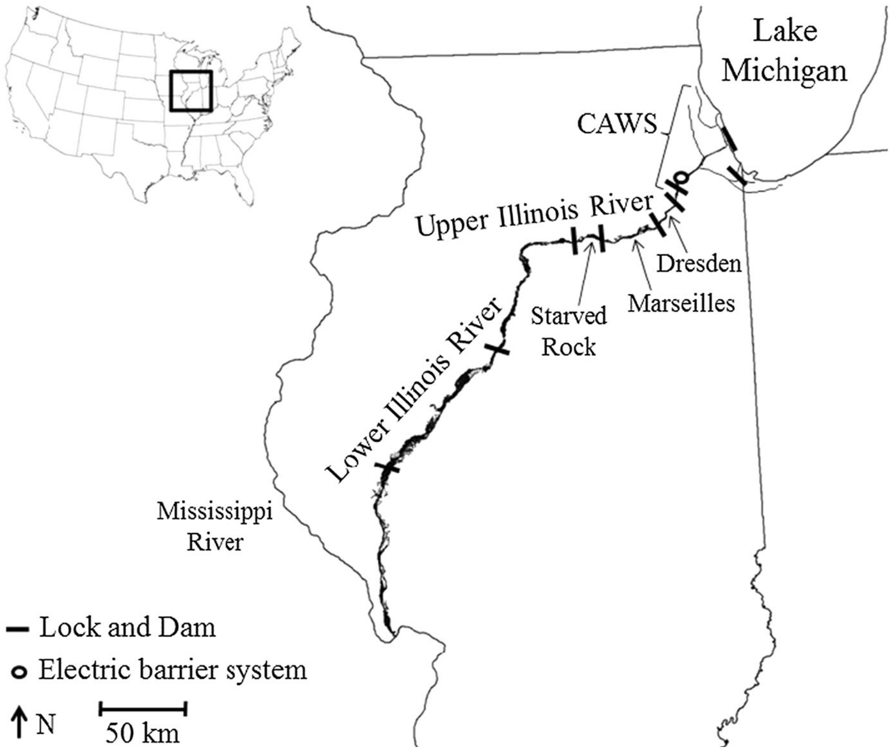

Fig. 1 The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM 372 and RKM 460. Also shown is the electric barrier system (RKM 477) located in the Chicago-Area Waterway System (CAWS)

Methods and materials

Harvest program

Commercial fishing is prohibited in the Upper Illinois River but fishing crews have been specially contracted by the Illinois Department of Natural Resources (IDNR) to harvest Asian carps (silver carp, bighead carp and grass carp *Ctenopharyngodon idella*) in the Marseilles and Dresden reaches since 2010 and in Starved Rock reach since 2011. Grass carp accounted for <1 % of the total harvest annually so were not considered further in this study. Each crew consisted of an experienced two-person team whose fishing location, effort, and catch was recorded by an onboard IDNR biologist. Suitable locations in the upper river were fished by up to five crews per day during the season, which extended from March to December (*c.* 340 crew-days per year). All bycatch was returned alive, while Asian carps were donated to a processor for conversion to liquid fertilizer (ACRCC 2015). The program goal was to maximize harvest, so a variety of gear types (e.g., gill and trammel nets, hoop nets, seine hauls) and fishing strategies (e.g. short-set, overnight set) were used, depending on river conditions and location. However, the mainstay of the harvest program has been the use of short-set (20–30 min), large-mesh (7.6–10.2 cm) gill and trammel nets. These accounted for 93.6–98.5 % of crew-days annually. As it was not possible to quantify effort for all gear types combined, we used gill and trammel net catch-per-unit-effort (CPUE; bigheaded carps/1000 m of net) as a relative indicator of harvest intensity and for comparison with hydroacoustic density estimates (see below).

Research vessel, hydroacoustic equipment and settings

The mobile hydroacoustic system (BioSonics DT-X) consisted of two horizontal-orientated split-beam transducers positioned on a stable, 9 m research vessel. The upper acoustic beam extended parallel to the water surface, and the lower beam was offset to ensonify the water column directly below the first beam (Fig. 2). Transducer pitch and horizontal plane was maintained by automatically adjusting dual-axis rotators. Data were collected out to a maximum distance of 50 m, at a ping rate of 5 pings/s and pulse duration of 0.40 ms. Transducers of frequencies

70 kHz (5° beam angle) and 200 kHz (6.6° beam angle) were deployed in various combinations (i.e. two 70 kHz, two 200 kHz, or 70 and 200 kHz) and each transducer was individually calibrated on-axis with the appropriate tungsten carbide sphere (Foote et al. 1987). This involved mooring the research vessel to a fixed object, in sufficiently deep water, with the transducers deployed as shown in Fig. 2 and aimed outward from the shore. The calibration sphere was attached to a 3 m pole using nylon fishing line and suspended in each acoustic beam.

Hydroacoustic sampling throughout the Upper Illinois River

As much boat-accessible habitat (>1–1.5 m depth) as possible within each reach was sampled annually (2012–2014) during September and October. The upper river consists of main channel (typically 150–250 m wide with a minimum depth of 2.7 m maintained over the thalweg for navigation) and connected backwaters. Backwater sites suitable for hydroacoustic sampling included backwater lakes ($N = 3$), side channels ($N = 5$), tributaries ($N = 2$), harbors ($N = 2$) and bays ($N = 1$) of varying size (0.1–1.8 km^2). In the main channel, transects consisted of a nearshore loop following the *c*. 1 m depth contour and a mid-channel loop. Only a single nearshore transect loop was generally required in side channels, bays, harbors and tributaries (Fig. 3). In the typically larger backwater lakes, transect loops were repeated progressively closer to the center, at intervals that would limit beam overlap while ensuring maximum possible coverage (Fig. 3). The acoustic beams were aimed outward from the nearest shoreline for all transects. Vessel speed was kept constant at approximately 6.5 km/h, and transects were as similar as possible to the previous year with some exceptions (e.g., allowing for boat traffic, debris, changes in water levels). River discharge data were obtained from a main channel gaging station at Seneca, IL in the Marseilles reach (http://waterdata.usgs.gov/nwis).

Hydroacoustic sampling of harvest events (ground-truthing of density estimates)

To test whether a relationship existed between localized hydroacoustic density estimates and harvest CPUE, three backwater lakes were sampled during summer 2014 and 2015, independent of the fall sampling outlined above. These lakes were created as gravel quarries that are now either active (East Pit, 1.8 km^2 surface area, 2.7 m mean depth, located at approx. RKM 422 in the Marseilles reach), inactive (West Pit, 1.3 km^2, 2.4 m, RKM 418 in the Marseilles reach), or converted to a nature preserve (Rock Run, 0.3 km^2, 4.4 m, RKM 453 in the Dresden reach) (Fig. 3). Hydroacoustic sampling was undertaken directly before and after harvest events (i.e. within a <24 h period), and subsample length and weight

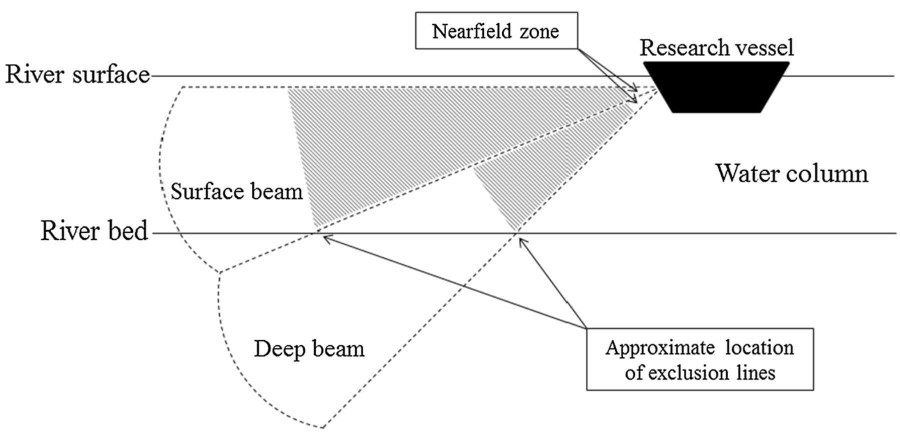

Fig. 2 Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in which acoustic targets were analyzed are indicated by the *gray shading* (no data analyzed in the nearfield zone or beyond the exclusion *line*). The surface beam typically accounted for *c*. 75 % of the volume of water sampled

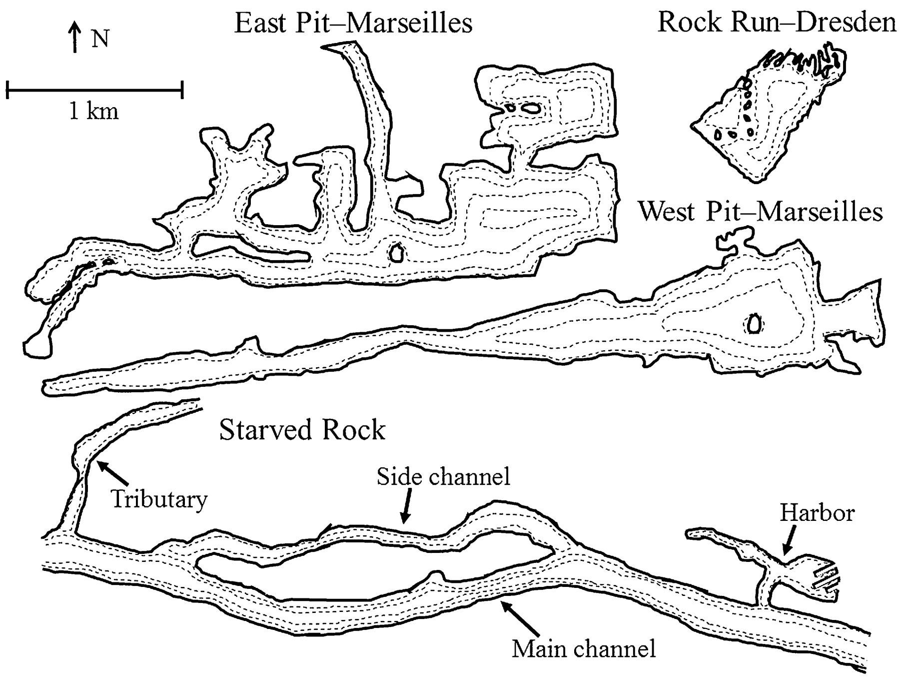

Fig. 3 Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after harvest events in the three backwater lakes consisted of a single nearshore loop only, rather the multiple loops undertaken as part of the river-wide surveys (as shown). For all surveys, the acoustic beams were aimed outward from the nearest shoreline

measurements of all species captured were taken. To minimize the time interval between hydroacoustic sampling and the harvest event (and thus the possibility of fish movement between the main channel), transects consisted of a single nearshore loop only (i.e. the area where harvest netting is focused) rather than multiple loops.

Hydroacoustic post-processing

Hydroacoustic data were processed using Echoview 5.4 software. An exclusion line was manually drawn at the point where the acoustic beams intersected the river bed (Fig. 2). Only data in the water column >1 m from the transducers (i.e. two times the near-field zone; Simmonds and MacLennan 2005; Rudstam et al. 2009) and before the exclusion line were analyzed. Areas of high interference (e.g., caused by passing boats or wind-generated waves) where acoustic targets could not be reliably distinguished were also excluded. Background noise was filtered by removing acoustic signals less than −60 decibels (dB). The volume of water sampled was calculated between the near-field and exclusion lines (Fig. 2) using the 'wedge volume sampled' method in Echoview.

Fish targets were identified using Echoview's 'split-beam single target detection (method 2)' algorithm following Parker-Stetter et al. (2009). Echoview's 'fish track detection' algorithm was then used to group targets originating from a single fish (Table 1). All fish tracks were manually inspected and edited to ensure accuracy. The mean compensated target strength (TS; in dB) of each fish track was then converted to fish total length (TL) using the side-aspect TL–TS equation given by Love (1971). Unlike most TL–TS equations, this multi-species equation is not frequency-specific and hence could be applied to the various transducer frequencies used. One shortcoming of using Love's (1971) equation is that it relates to maximum side-aspect target strength; this assumes that fish targets are ensonified near-perpendicular to the acoustic beam axis. Though likely in the main channel due to fish orientation relative to river flow and our parallel transect design, fish orientation may not be as uniform in lentic backwaters (i.e. acoustic ensonification may not always be exactly side-aspect). Adopting a TL–TS equation developed at multiple body aspects, for example 360°(Kubecka and Duncan 1998) could reduce this potential source of bias but, to our knowledge, such studies are all frequency-specific. Thus, for consistency across habitats and transducer frequencies, we opted to use the Love (1971) TL–TS equation and believe that using the mean TS of a fish track for conversion to TL

Table 1 Single target and fish track algorithm properties used for hydroacoustic post-processing

Split-beam single target detection (method 2)	
Min. and max. TS threshold (dB)	Dependent on transducer frequency used (Love 1971); corresponded to fish TL range of 30–120 cm
Pulse length determination level (dB)	6
Min. and max. normalized pulse length	0.6 and 1.5
Max. beam compensation	6
Max. standard deviations of minor and major axis angles	0.6
Fish track detection	
Min. number of single targets	1
Min. number of pings in track	1
Max. gap between single targets	3

adequately accounts for fish targets that may not have been ensonified exactly in the side aspect.

To further improve the accuracy of the fish track algorithms and manual editing, only acoustic targets corresponding to >30 cm TL were included in the analysis (the smallest silver carp or bighead carp captured in any year of the study was 48.8 cm).

Paired sampling

To interpret the acoustic data, we used information gathered annually in each reach during late summer/early autumn from a random site pulsed-DC electrofishing program (The Long-term Illinois, Mississippi, Ohio, and Wabash Rivers Fish Population Monitoring Program; http://wwx.inhs.illinois.edu/fieldstations/irbs/research/ltef-website/; see also McClelland et al. 2012) and the Asian carps harvest program (subsampling of target and bycatch species captured using short-set gill and trammel nets). Fish collected were identified, measured (TL; mm) and weighed (g). Both capture methods were combined to reduce selectivity biases (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014) and all fish >30 cm TL were separated into three categories (i.e. silver carp, bighead carp, and other fish species). For each reach, proportional abundance of silver carp, bighead carp and other fish species was determined for each 2 cm TL-class (i.e. 30–32, 32–34 cm…) and then linearly interpolated for each 0.1 cm TL increment, up to a maximum of 120 cm TL; if the largest fish captured was less than this cut-off point, a 1.0 bighead carp proportion was assumed for the remaining length increments, which was corroborated with field observations.

Estimating bigheaded carps demographic parameters

Surveys were analyzed following the protocols developed by Scheaffer et al. (1996) and Parker-Stetter et al. (2009). Main channel transects were separated into two strata, the first stratum consisting of the nearshore loop and the second stratum consisting of the mid-channel loop (Fig. 3). Each 0.926 km (0.5 nautical mile) sampled along these strata represented replicates. Backwaters had one to four strata (depending on whether single or multiple transect loops were undertaken) (Fig. 3) and 0.463 km replicates were used. Initial density calculations were made based on all fish detected (i.e. converted acoustic targets equating to fish of 30–120 cm TL). Stratum-specific fish density $\bar{\rho}_h$ and within-stratum variance $Var(\bar{\rho}_h)$ were calculated as:

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

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

where n_h = number of replicates in stratum h and $\rho_{h,i}$ = mean fish density of replicate i within stratum h. For single stratum backwaters, this was the final mean fish density. For multi-strata survey sites, final mean fish density $\bar{\rho}$ and standard error ($SE(\bar{\rho})$) were calculated as:

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

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

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

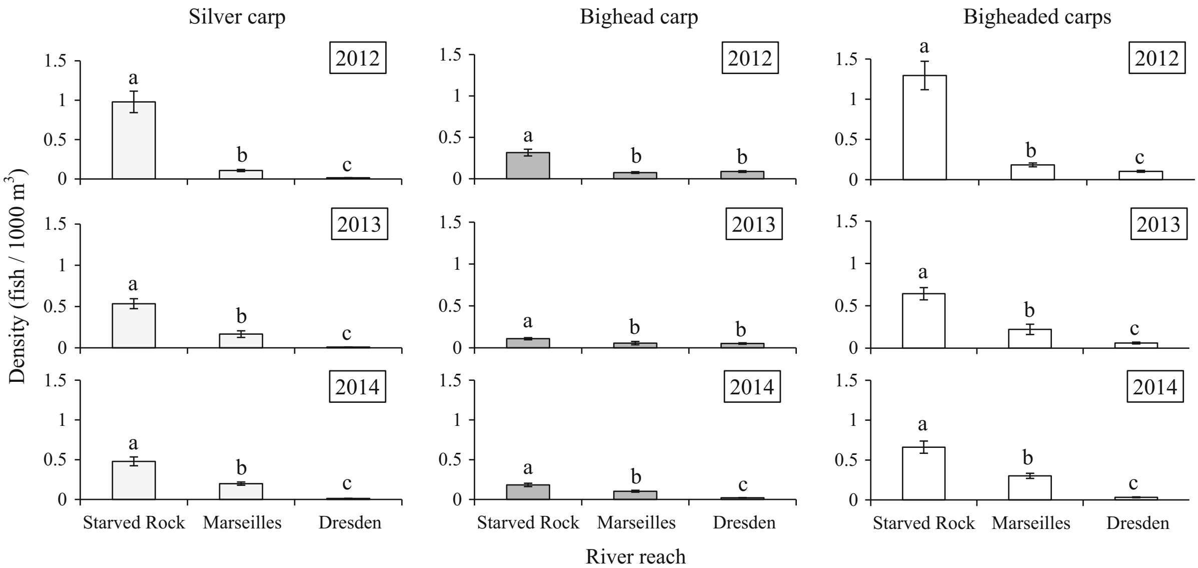

Fig. 4 Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated by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

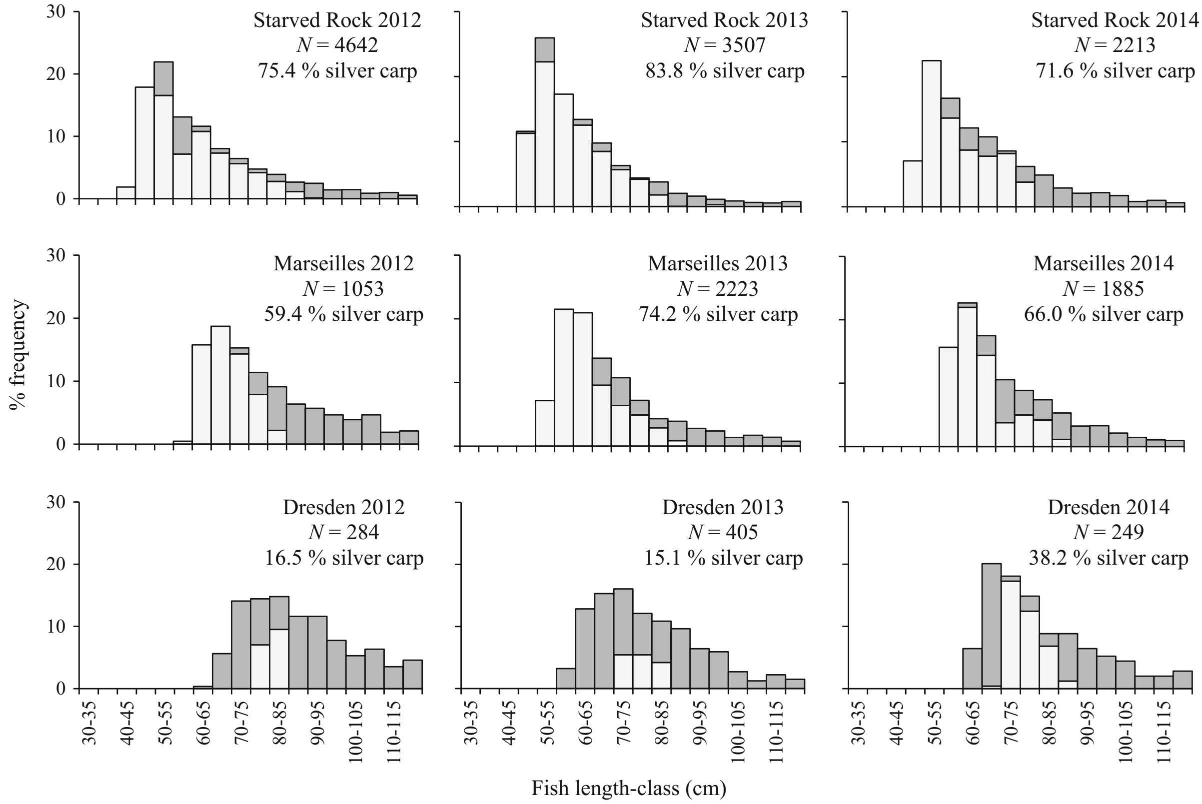

Fig. 5 Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding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

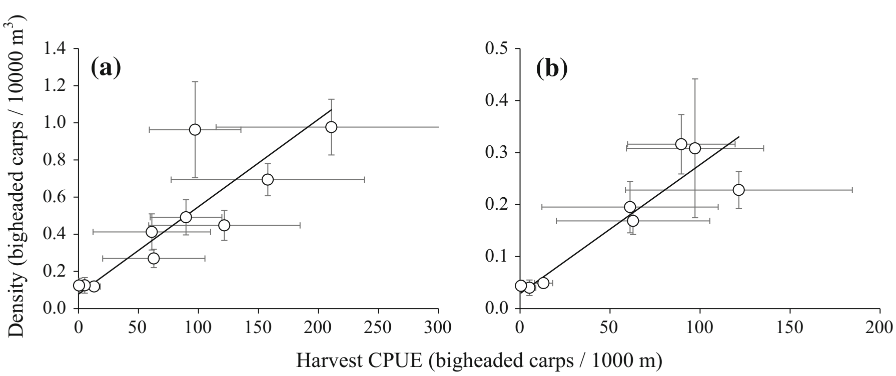

Fig. 6 Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence 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		19 May → 20 May		7 July → 8 July	
	0.270 ± 0.049^{a}	0.101 ± 0.023^{b}	0.491 ± 0.095^{a}	0.175 ± 0.037^{b}	0.963 ± 0.259^{a}	0.655 ± 0.126^{b}
	(62.5 and 812)		(83.1 and 855)		(87.3 and 1301)	
West Pit (Marseilles)	20 May → 21 May					
	0.119 ± 0.020^{a}	0.070 ± 0.023^{b}				
	(13.4 and 66)					
Rock Run (Dresden)	8 July → 9 July		24 July → 25 July			
	0.125 ± 0.042^{a}	0.078 ± 0.037^{a}	0.124 ± 0.039^{a}	0.069 ± 0.029^{b}		
	(5.1 and 26)		(0.5 and 1)			
2015						
East Pit (Marseilles)	6 Aug → 7 Aug		7 Sep → 8 Sep			
	0.420 ± 0.099^{a}	0.217 ± 0.048^{b}	0.448 ± 0.081^{a}	0.220 ± 0.045^{b}		
	(56.6 and 150)		(116.2 and 701)			

Different superscript letters indicate a significant difference ($P < 0.01$) for each before and after sequence

year to year, but did increase significantly between 2012 and 2014) and Dresden (where consecutive annual declines in density occurred) (Fig. 7). At the scale of the entire upper river, the population response appears closely linked with the prevailing seasonal/annual discharge regime, as increasing annual harvest elicited an apparent 43.5 % decline after a drought year, but only maintenance of the reduced density levels following a flood year.

Discussion

The Upper Illinois River, as the conduit that links two major hydrological basins (one invaded and one not), is a critical location at which to investigate bigheaded carps invasion dynamics and the population response to control efforts (Cooke 2016). We adapted marine and large lake hydroacoustic protocols (Simmonds and MacLennan 2005; Parker-Stetter et al. 2009; Rudstam et al. 2009) for use in this shallow riverine environment, to estimate key demographic parameters of the advancing population at the edge of their range and, thus, by extension evaluate the efficacy of harvest in the Upper Illinois River.

Advancing population characteristics

Density of bigheaded carps was assessed on a volumetric basis, on the assumption that it is the most representative measure of population status (i.e. direct measurement rather than extrapolation). Annual fall surveys of the advancing populations' continuous longitudinal distribution confirmed that bigheaded carps were more prevalent downstream than upstream. The advancing population in each reach was

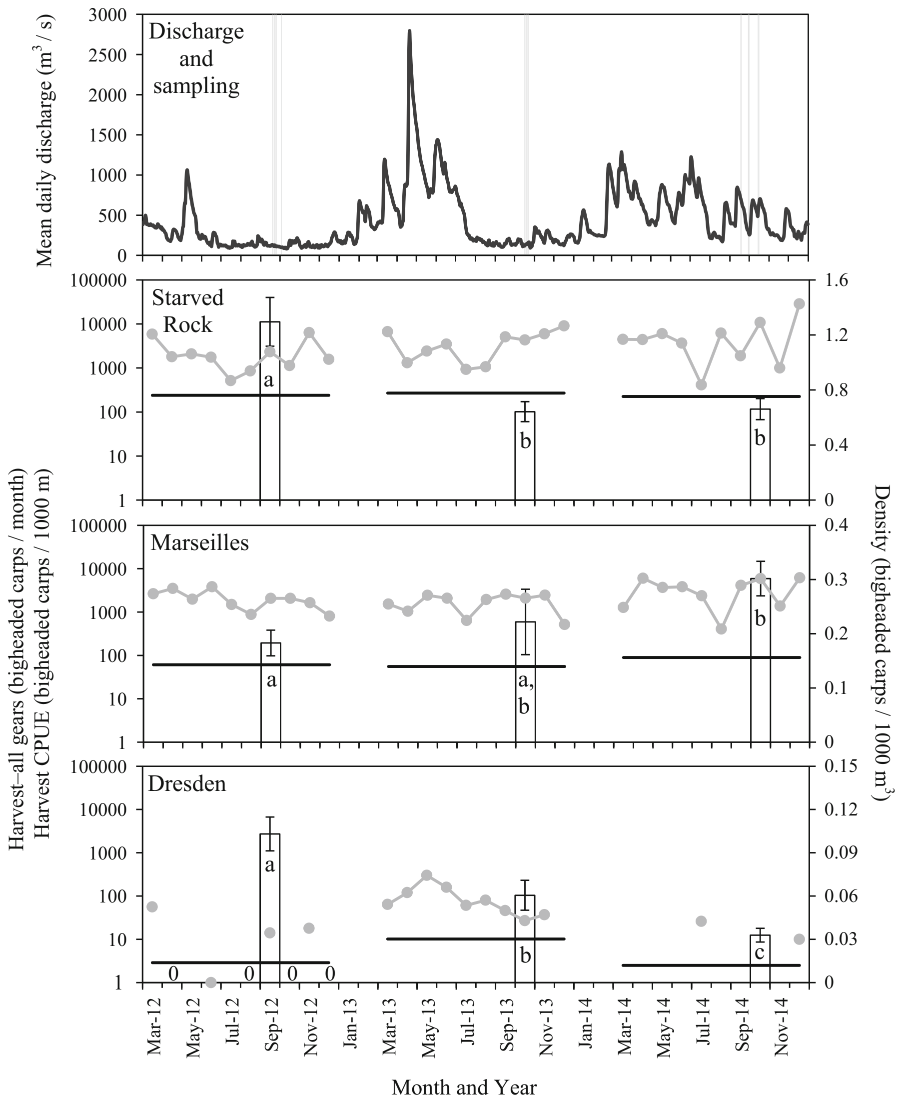

Fig. 7 *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks* indicate no fishing), annual bigheaded carps gill/trammel net CPUE (*horizontal black lines*) and bigheaded carps mean density ±95 % confidence intervals (*white bars*). Note y-axis logarithmic scale for harvest and CPUE, and the different scales for density in each reach. Significant differences ($P < 0.05$) in densities within a reach are indicated by *different letters*

categorized into distinct density components, ranging from the highest levels in Starved Rock to the lowest in Dresden. Site-specific densities within a reach may lie outside the observed ranges (reflecting habitat preferences of bigheaded carps e.g., DeGrandchamp et al. 2008), but these overall classifications provide an indication of the density gradient of this advancing population. Such information is useful where bigheaded carps are expanding their range, so as to quantify the invasion process and set appropriate removal targets (e.g., Tsehaye et al. 2013; Green et al. 2014).

Size structure and species composition also appear linked with each bigheaded carps density component, as body size (both species) and proportion of bighead carp increased from downstream to upstream. To what extent this is attributable to species-specific upstream dispersal or other density-dependent mechanisms is not clear. It also remains to be seen if the interannual variability in size structure and species composition observed within a particular reach reflects natural trends (e.g., a strong year-class) or is harvest-induced through gear selection for a particular species or size-class (Irons et al. 2011; Tsehaye et al. 2013).

Harvest evaluation (short-term, local scale)

The series of before–after harvest experiments in backwater lakes showed that in nearly all cases, density of bigheaded carps was reduced immediately post-harvest. It is probable that the large quantities of bigheaded carps removed by harvest caused most of the observed declines, but fish actively moving from the backwater to the main channel in response to the disturbance of the harvest event may also have contributed. This is especially likely in the smallest lake, Rock Run, which would help explain the somewhat less consistent results there.

Regardless of initial densities, recolonization of the backwater lakes occurred in as little as two weeks. Rebound rate is an important metric for evaluating targeted harvest (Frazer et al. 2012) and it appears that, in these locations at least, some features and/or conditions are continually re-attracting bigheaded carps (e.g. Cuddington et al. 2015). An integrated pest management approach (Koehn et al. 2000; ACRCC 2015), involving removal of individuals present (i.e. by harvest) and prevention of recolonization by new individuals (e.g., by behavioral barriers at strategic locations or manipulation of water levels), may be a rational approach to pursue, but the potential for altering upstream dispersal must also be carefully considered.

Hydroacoustic and capture gear comparisons can be highly variable, with the level of accuracy depending on the environment, gear type and characteristics of the species under consideration (e.g., Mehner and Schulz 2002; Dennerline et al. 2012; Guillard et al. 2012). Though the use of mobile hydroacoustic methods in shallow environments is increasing (e.g., Lucas and Baras 2000; CEN 2014), few studies have verified estimates against known relative abundance indices. The positive density–CPUE relationships obtained during the backwater lake experiments provided the basis upon which to use our river-wide hydroacoustic surveys as a tool to evaluate harvest on a broader spatiotemporal scale (i.e. throughout the upper river over three consecutive years).

Harvest evaluation (long-term, river-wide)

The river-wide fall surveys were not intended to directly correspond with harvest events, as sampling occurred during alternate weeks to harvest. Instead, we aimed to provide ‘snapshots’ of the population status in the entire upper river, at a comparable stage of each year (i.e. during suitable hydrological conditions, and when the harvest season had been underway for *c.* 6 months). Therefore, while harvested quantities and CPUE of bigheaded carps broadly reflected the density components estimated from the hydroacoustic surveys, they appear to lack the resolution of the hydroacoustic surveys to map fluctuations within these ranges (see Dennerline et al. 2012). The complexity of these reach-specific density trends likely reflects between-reach movement and differential harvest rates. Biases associated with the unstandardized, catch-maximizing approach of the harvest program further confound the interpretation of the capture statistics and highlight the need for the present fishery-independent evaluation.

Despite the large quantities of bigheaded carps removed from the Upper Illinois River annually, harvest alone is clearly not the only factor regulating population dynamics in the river (see also Tsehaye et al. 2013). Total harvest increased annually, yet density did not decline between 2013 and 2014. Instead, the prevailing discharge regime may play a key role. In situ reproduction is currently a negligible source of bigheaded carps in the upstream portion of the river (ACRCC 2015), thus Starved Rock Lock and Dam is the only immigration pathway to the Upper Illinois River from the high density reaches farther downstream (Sass et al. 2010; Garvey et al. 2012). Discharge is important for upstream fish passage at low-head dam structures (Zigler et al. 2004; Tripp et al. 2014) and it is likely that population densities were sustained by high immigration via Starved Rock Lock and Dam to the upper river in the latter two study years due to ‘open-river’ conditions (i.e. dam gates open to varying degrees to prevent flooding during high discharge). Both silver carp and bighead carp have shown increased movement rates during periods of high water levels (DeGrandchamp et al. 2008; Coulter et al. 2016).

The observed decline in bigheaded carps density in the Dresden reach (*c.* 68 % cumulative decline between 2012 and 2014) is interesting to note, suggesting that continued harvest at the low density population front may be effective (likely aided somewhat by the spatial isolation from higher densities downstream). From an invasion biology perspective, the ability to suppress at such low density has important management implications, both at the 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.

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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.).

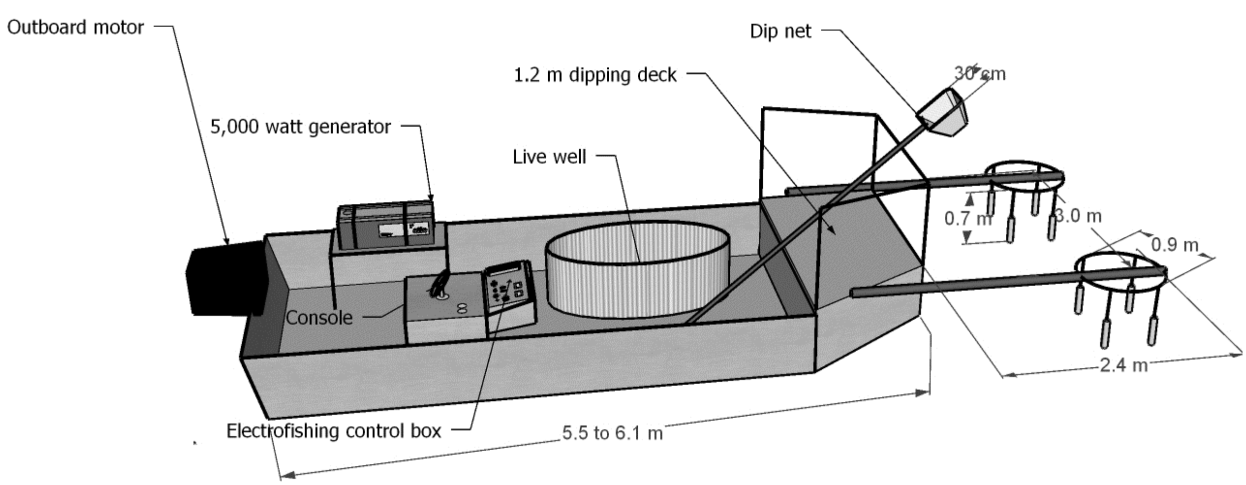

Figure 1. *Schematic of electrofishing boat.*

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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.).

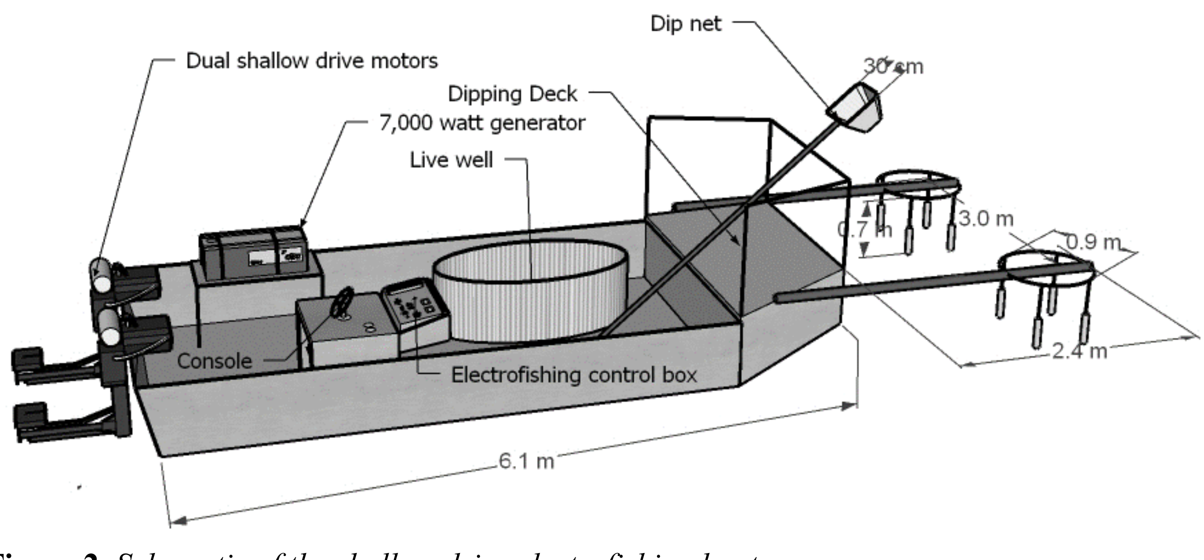

Figure 2. *Schematic of the shallow drive electrofishing boat.*

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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).

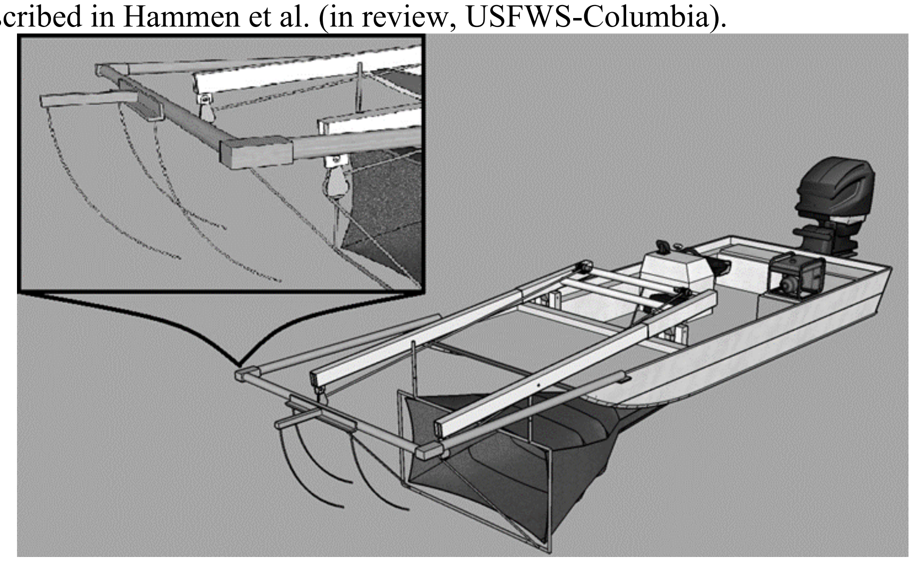

Figure 3. *Generalized schematic of the electrified dozer trawl.*

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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).

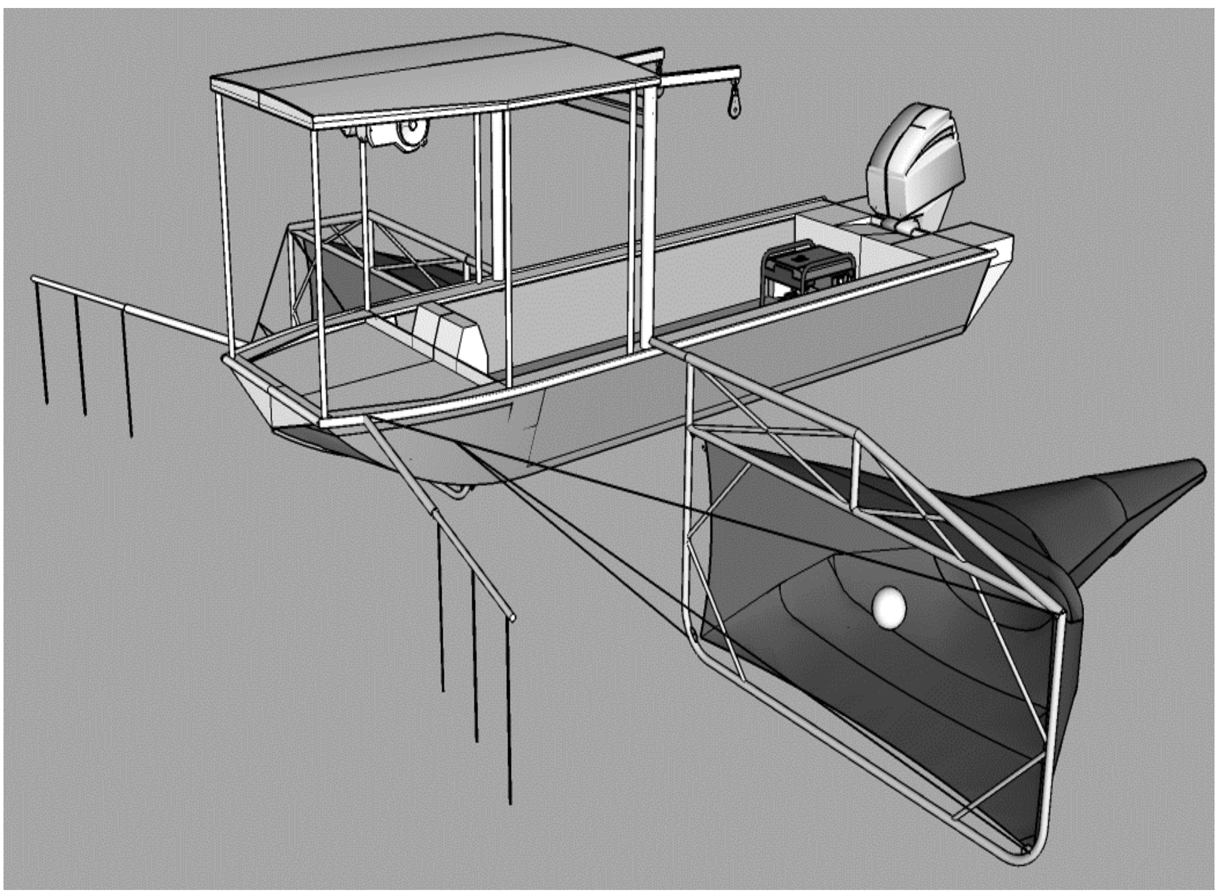

Figure 4. *Schematic of electrified Paupier trawl*

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Seine (Figure 5):

Seines consisted of two wings and a bunt section or a bag (extra material in the middle of the seine concentrating fish) secured to a float line and lead line. Floats were attached every 25.4 cm (10.0 in.) on the float line and a solid core lead line was used as the lead line. Floats were 41.3 mm x 111.0 mm (1.6 in. x 4.4 in.) hard orange foam that produced 85.0 g (3.0 oz.) of buoyancy. Bar measure of mesh was uniform within a seine, but two different mesh sizes of seines were used. The large mesh seine was 50.8 mm (2.0 in.) black asphalt coated bar-measured mesh and the small mesh seine was 1.6 cm (0.6 in.) black asphalt coated bar-measured mesh. Wings had a height of 3.2 m (10.0 ft.) tapering down to the bunt or bag section with a height of 9.1 m (30.0 ft.) for large mesh seines and 6.1 m (20.0 ft.) for small mesh seines. Total length of large mesh seines varied from 274.3 m (900.0 ft.) to 731.5 m (2400.0 ft.). Total length of the small mesh seine was 182.8 m (600.0 ft.).

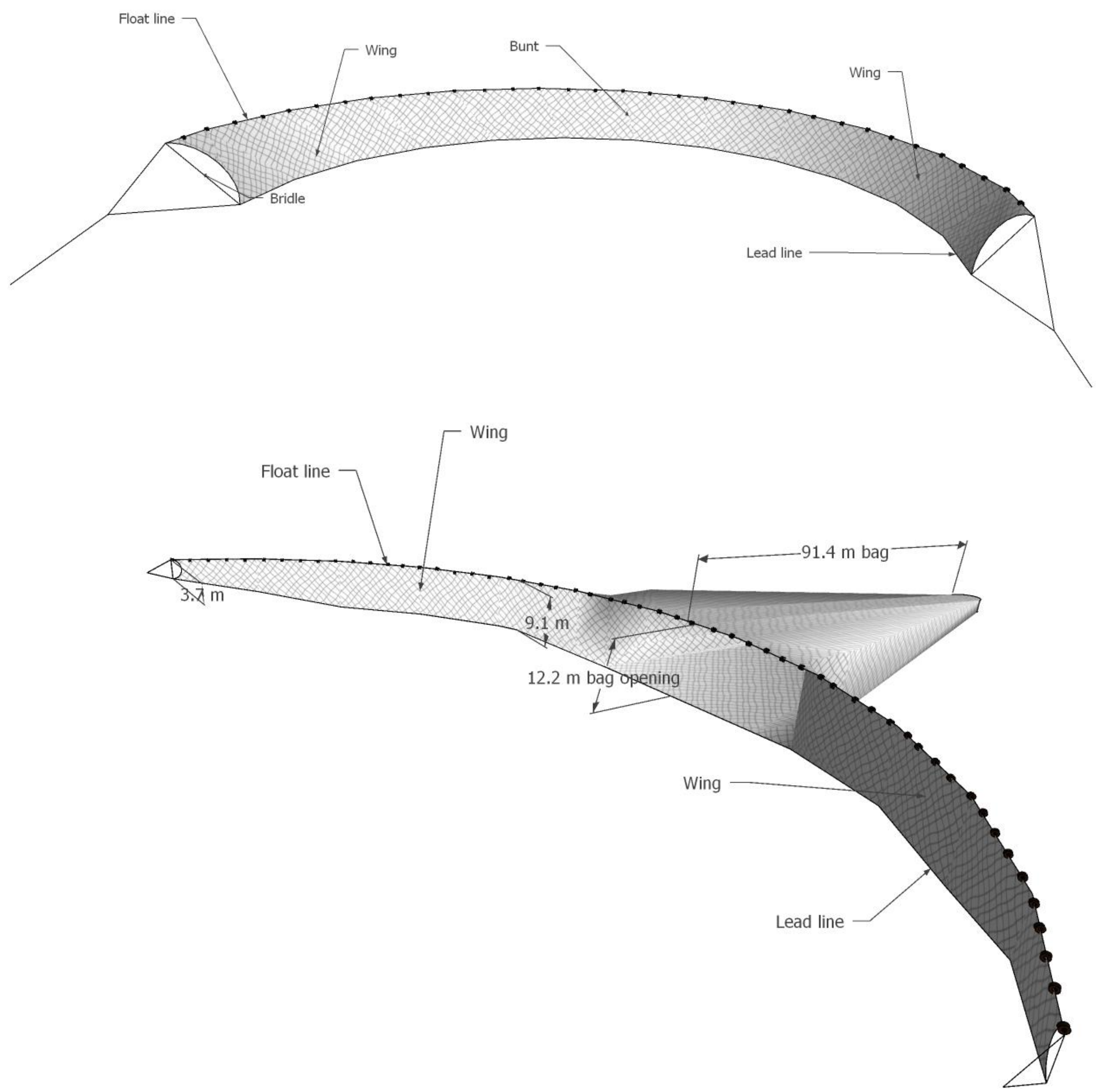

Figure 5. *Generalized schematic of a commercial seine without a bag (top) and with a bag (bottom).*

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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.

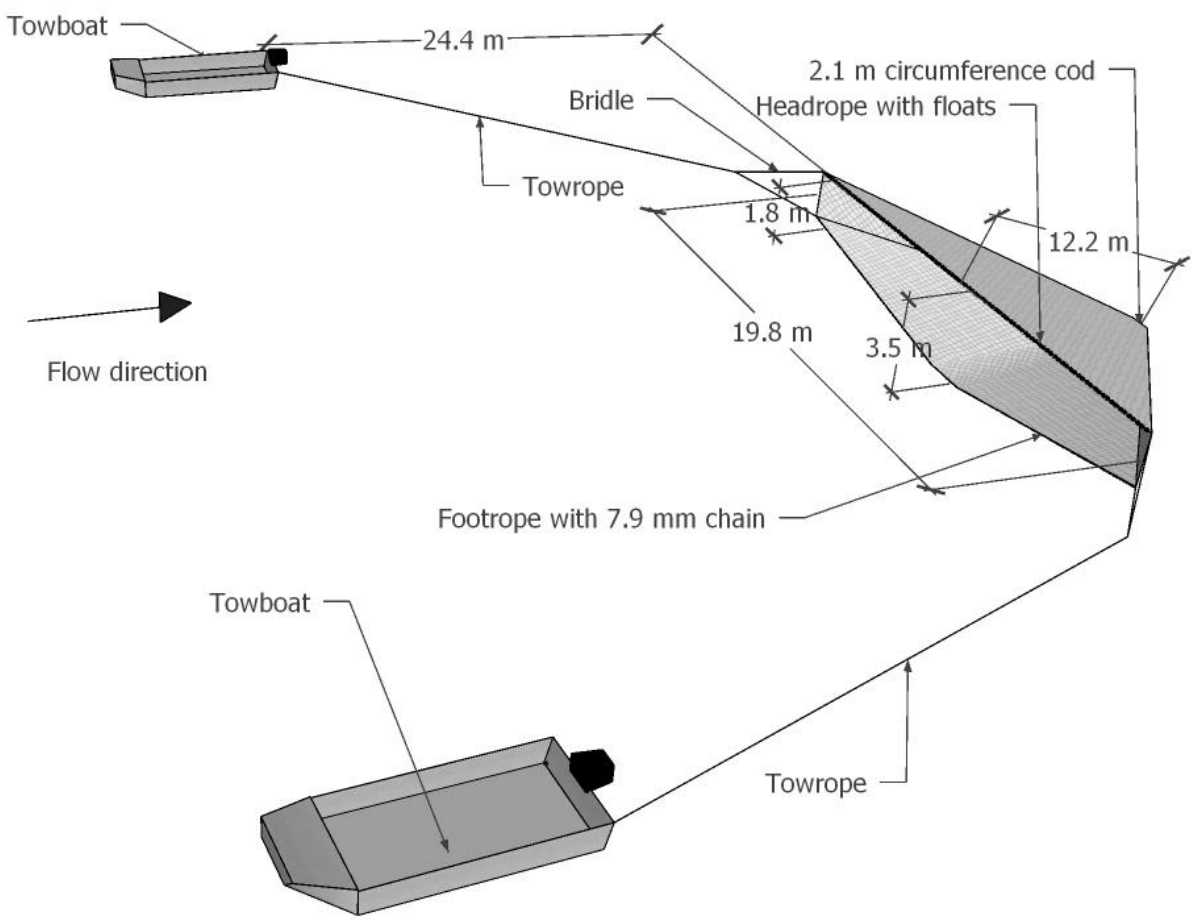

Figure 6. *Generalized schematic of a trawl.*

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Passive capture gears

Deep-water gill net (Figure 7):

Deep-water gill nets were constructed of three single walled panels made of clear monofilament webbing panels stitched vertically together. Each panel was 3.0 m (10.0 ft.) deep and 91.4 m (300 ft.) long. Stitched panels produced a 9.1 m (30.0 ft.) deep net. The multi-paneled net was tied to a single float line and single lead line. Float line was created from 127.0 mm (0.5 in.) foamcore float line producing 9071.0 g (320.0 oz.) of buoyancy. Lead line was created from #30 leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale; lower number meaning more webbing length per foot of float line) of each panel was 0.5. The bag created (depth of webbing versus the depth of the net) was 0.6 m (2.0 ft.). Bar-measured mesh size of webbing for each panel was 69.9 (2.8 in.), 82.6 mm (3.3) or 88.9 (3.5 in.) attached in a quasi-random experimental fashion (panels of different mesh size attached together to reduce effects of size selectivity). Two multi-panel deep-water gill nets were tied together increasing the total length of the net to 183.0 m (600.0 ft.).

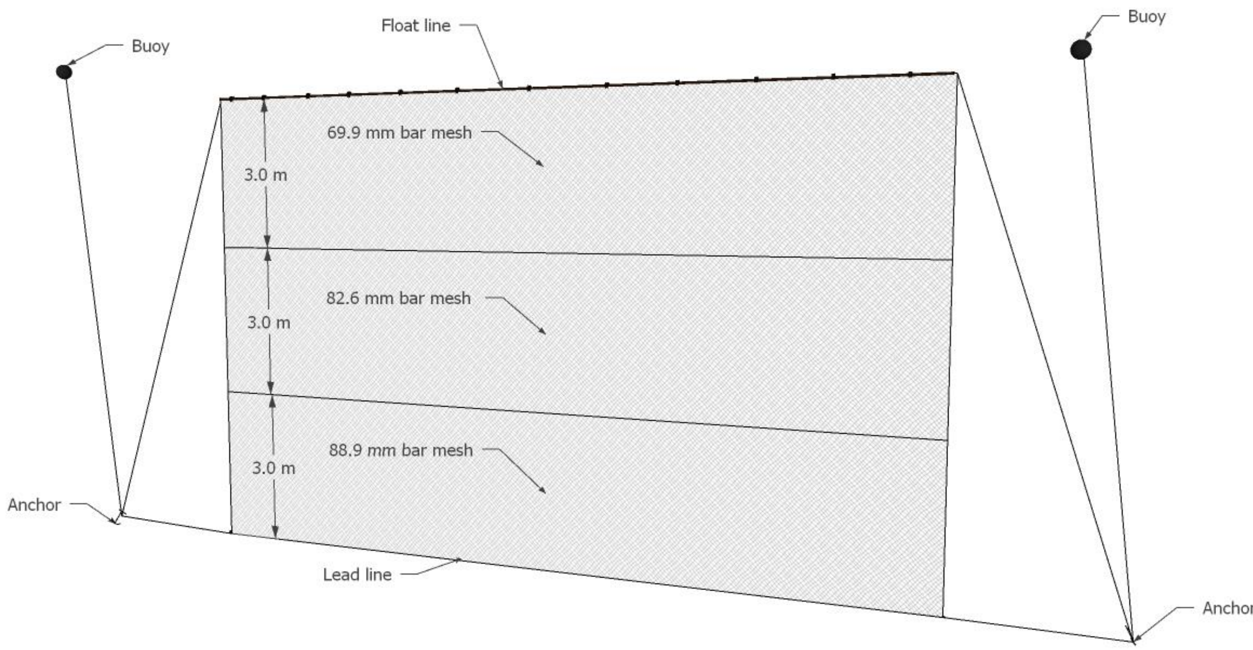

Figure 7. *Generalized schematic of a deep-water gill net.*

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Shallow gill net (Figure 8):

Shallow gill nets were constructed of a panel of single walled monofilament, multi-strand monofilament or multifilament webbing stitched to a float line and a lead line in 91.4 m (300.0 ft.) increments. The float line was created from 95.0 mm (0.4 in.) or 127.0 mm (0.5 in.) foamcore float line producing 4,536.0 g (160.0 oz.) or 9,071.0 g (320.0 oz.) of buoyancy, respectfully. Lead line was created from #30 solid leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale with lower number meaning more webbing length per foot of float line) of each panel varied between 0.5 to 0.2. The bag created (depth of webbing versus the depth of the net) varied between 3.7 m (12.0 ft.) to 1.2 m (4.0 ft.). Color of panel webbing was black, clear, green, purple, red, or white depending on the net. Bar-measured mesh size of webbing varied from 63.5 mm to 127 mm (2.5 - 5.0-in.) depending on the panel. Depth of panel walling varied from 2.4 m (8.0 ft.) to 4.3 m (14.0 ft.) depending on the net. Multiple 91.4 m (300.0 ft.) panels could be tied together increasing the total length of a net to over 914.0 m (3,000.0 ft.).

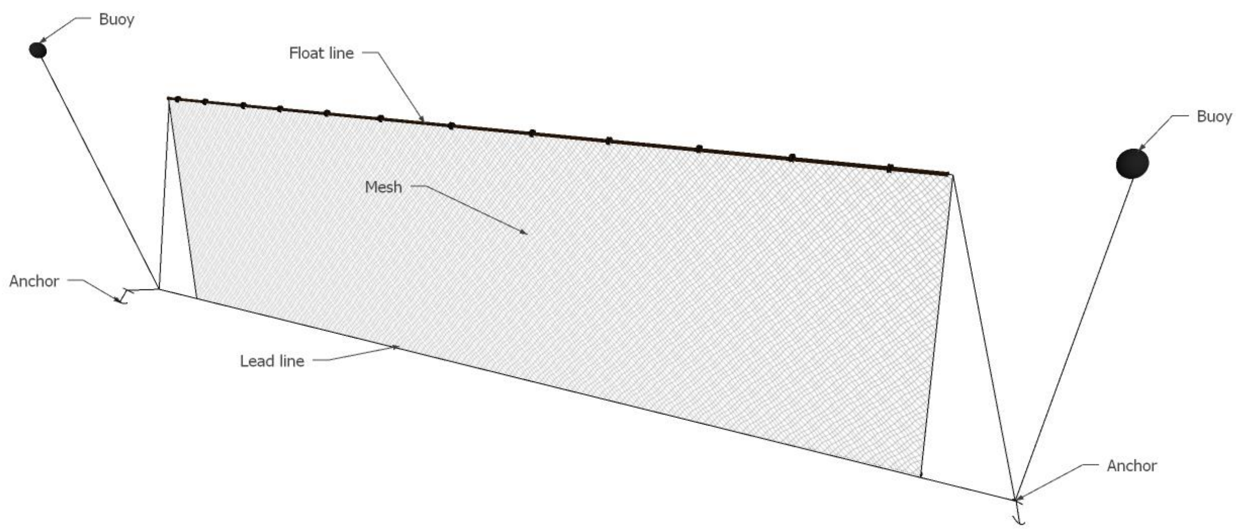

Figure 8. *Generalized schematic of a commercial shallow gill net.*

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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.).

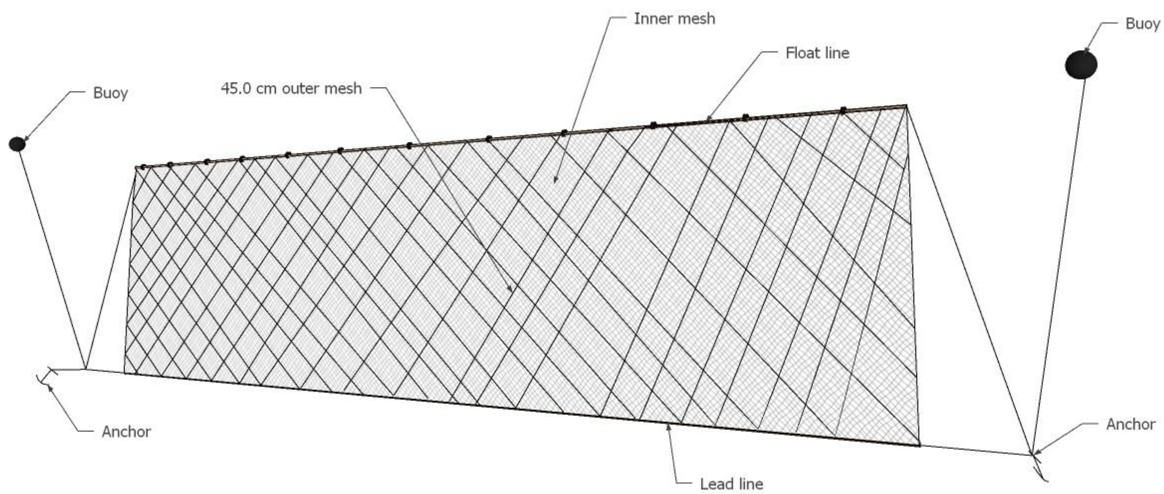

Figure 9. *Generalized schematic of a commercial trammel net.*

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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.

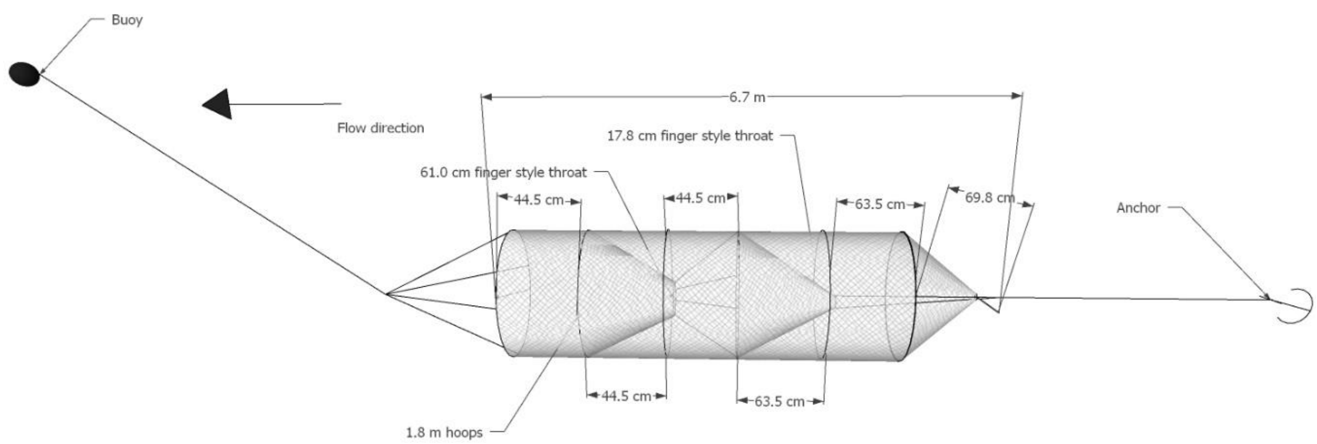

Figure 10. *Schematic of commercial hoop net*

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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.

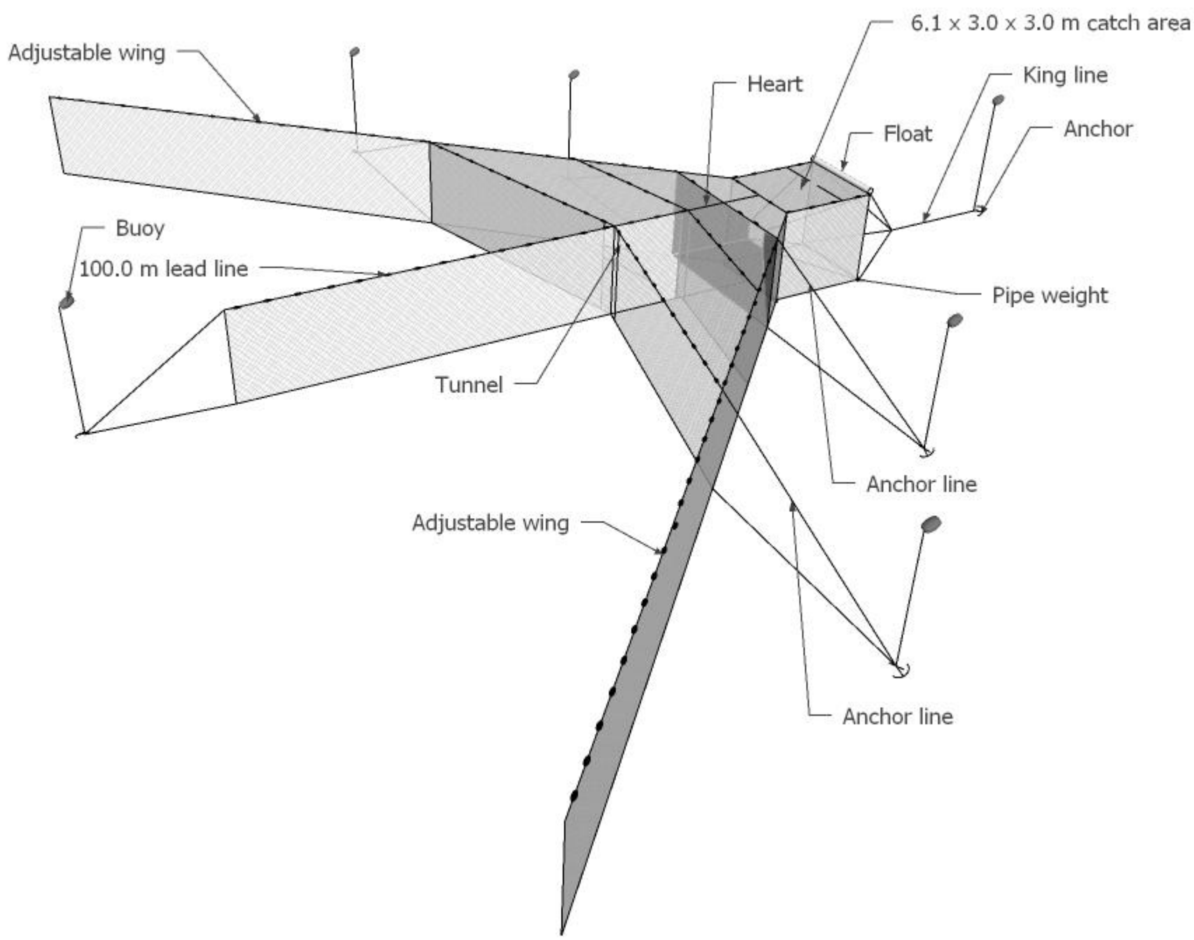

Figure 11. *Schematic of the great lakes style pound net*

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Mini modified fyke net (Figure 12):

Mini modified fyke nets had a single, 5.0 m (16.4 ft.) long by 0.6 meter (2.0 ft.) deep lead. Floats were attached to the float line of the lead every 91.4 cm (36.0 in.) and lead weights attached every 45.7 cm (18.0 in.) along the lead line. Floats were made of 41.3 mm x 111.0 mm (1.6 in. by 4.4 in.) black hard foam that produced 85.0 g (3.0 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long, made from lead weighing approximately 28.3 g (1.0 oz.). The lead continued to the rear of the rectangular frame and was sewn to the vertical crossbar stitching the frame and lead together. The frame of the net was constructed of two, 0.6 m by 1.2 m (2.0 ft. by 4.0 ft.) rectangular bars made of 8.0 mm (0.3 in) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extend from outer corners of the front rectangle to middle of the rear rectangle. A 5.1 cm (2.0 in.) vertical gap existed between wings and either side of the lead at middle of rear rectangle. A 0.76 m (2.5 ft.) webbing covered gap connected the cab and frame together. The cab was constructed of two, 8 mm (0.3 in.) spring steel hoops that were 0.6 m (2.0 ft.) in diameter, spaced 0.6 m (2.0 ft.) apart. Cab and frame combined created a net that was 2.7 m (9.0 ft.) in total length. A single throat in the cab was attached to the first hoop from the mouth and tapered down to a 50.0 mm (2.0 in.) diameter hole at the rear. The throat was created with a 50.0 mm (2.0 in.) inner diameter by 6.4 mm thick (2.0 x 0.3 in.) stainless steel or nickel-plated ring sewn in the mesh. Four tension strings tied to the ring were secured to the rear hoop. A 1.8 m (6.0 ft.) long by 5.0 mm (0.2 in.) diameter braided nylon drawstring was sewn in a casing on the cod end secured the cod end closed. All webbing for the net was 3.0 mm (0.1 in.) ace type nylon netting coated with green latex type dip.

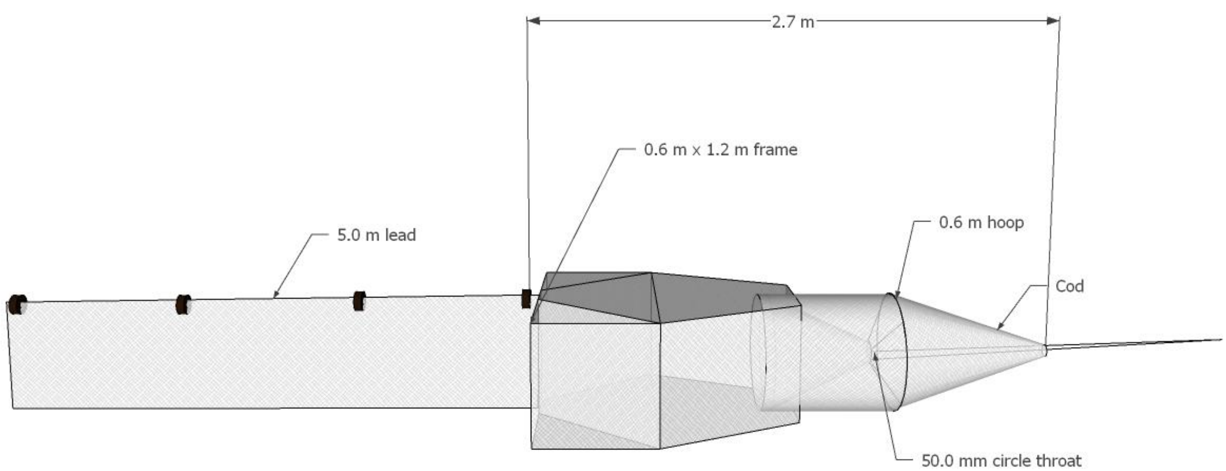

Figure 12. *Schematic of mini modified fyke net*

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Modified fyke net (Figure 13):

Modified fyke nets had a single 15.2 m (50.0 ft.) long by 1.4 m (4.5 ft.) deep lead. Floats were attached every 91.4 cm (36.0 in.) on the float line of the lead, and lead weights every 30.5 cm (12.0 in.) along lead line of the lead. Floats were made from 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge producing about 156.0 g (5.5 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long lead weighing approximately 28.3 g (1.0 oz.). Lead continued into the rear of the net frame and was sewn to the vertical crossbar joining the frame and lead. The frame of the net was constructed of two, 1.2 m (4.0 ft.) by 1.8 m (5.0 ft.) rectangular bars made of 8.0 mm (0.3 in.) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extended from outer corners of the front rectangle to the middle of the rear rectangle. A 76.0 mm (3.0 in.) vertical gap existed on either side of lead at middle of rear rectangle. A 1.2 m (4.0 ft.) mesh covered gap connected the cab and frame together. The cab was constructed of six, 0.9 m (3.0 ft.) diameter spring steel hoops spaced 61.0 cm (24.0 in.) apart from each other and covered in webbing. Cab and frame together were 6.0 m (20.0 ft.) in total length. The front throat of the cab began at the first hoop from the mouth and was a 203.0 mm (8.0 in.) square style throat, 20 meshes long, and knitted to 40 meshes around (10 per side) at rear. The rear end of the front throat was attached to the third hoop with 4 tension strings. The rear throat of the cab began at the third hoop from the mouth and was a 102.0 mm (4.0 in.) crowfoot style throat 28 meshes long, knitted to 32 meshes around at rear. The rear end of the second throat was attached to cod end drawstring with 2 tension strings. A 2.4 m (8.0 ft.) long, 6.0 mm (0.3 in.) diameter asphalt coated braided nylon drawstring secured the cod end closed. All finger lines were made of #15 black nylon twine and tension strings were made of #72 black nylon twine. Webbing for the modified fyke net was 18.0 mm (0.8 in.) bar measured mesh coated with a black asphalt coating.

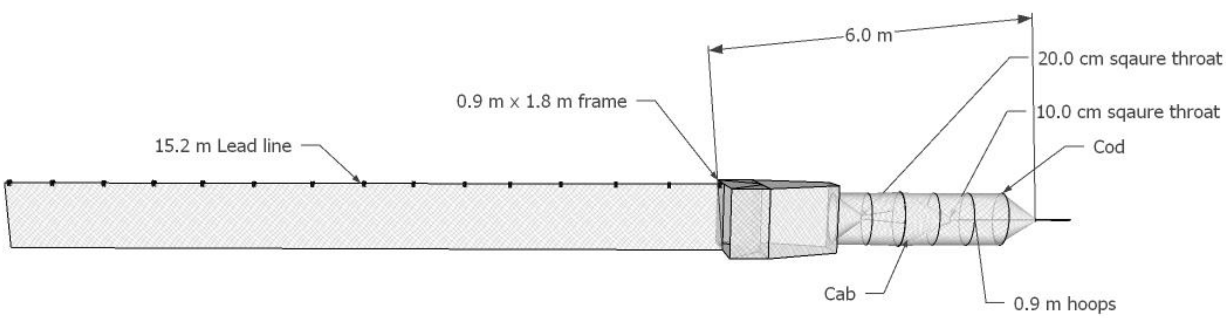

Figure 13. *Schematic of modified fyke net*

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Larval fish capture gears

Active capture gears

Larval pushnet (Figure 14):

Larval pushnets were created from a nylon-mesh cone stitched to a steel rod cylinder secured to an aluminum frame. The nylon mesh cone was 500 µm mesh and was 3.0 m (9.8 ft.) in total length that tapered down to an 8.9 cm (3.5 in.) diameter circle at the distal end. The steel rod cylinder was made of 3.2 mm (0.1 in.) stainless steel rod bent and welded into a 0.5 (1.6 ft.) diameter circle. The distal end of the nylon mesh cone had an 8.9 cm (3.5 in.) adapter secured to it allowing a 1,000 ml hard-plastic plankton bucket to be attached. The plankton bucket had multiple rectangular sections removed and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. A flow meter or flow rocket was secured one-fourth the distance of the diameter of the steel cylinder in the net mouth (approximately the middle of the mouth) to estimate volume of water filtered. The pushnet was attached to an aluminum hexagon frame with industrial strength zip ties. The hexagonal frame was secured to the bow of the boat with 2.8 m (9.2 ft.) long aluminum bars.

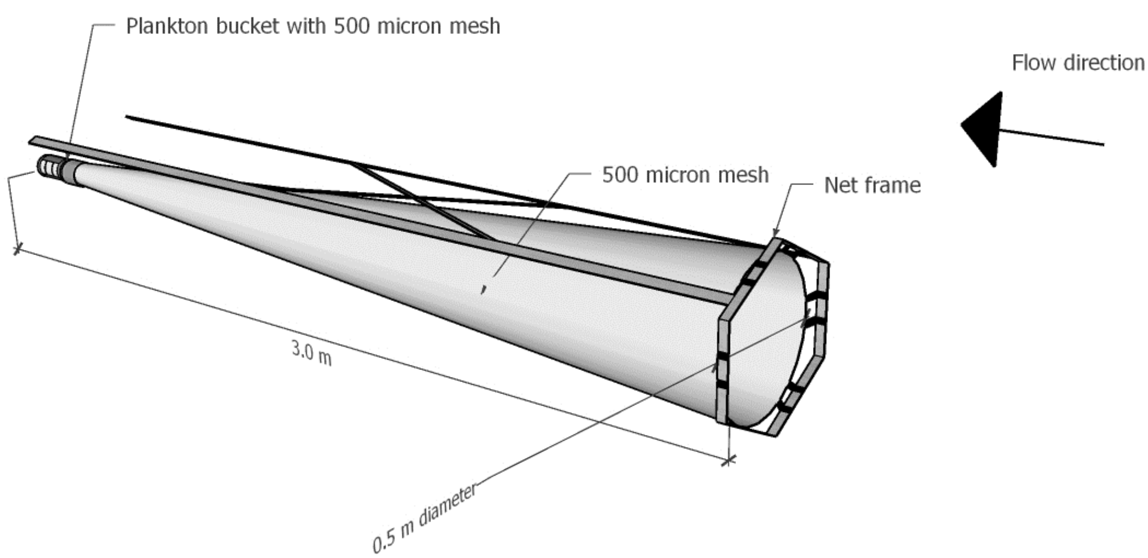

Figure 14. *Generalized schematic of a pushnet.*

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Passive capture gears

Larval driftnet (Figure 15):

Larval driftnets were created from 1.0 m (3.3 ft.) long plankton net stitched to a 0.3 m (0.8 ft.) by 0.5 m (1.5 ft.) rectangular made from 3.2 mm (0.1 in.) aluminum rod stock. Mesh pores of the plankton net were 500 µm. The plankton net tapered down to an 8.9 cm (3.5 in.) circumference circle on the distal end. An adapter was secured to the distal end of the plankton net allowing a 1,000 ml hard-plastic plankton bucket to be attached. The driftnet bucket had multiple sections cut out from the sides and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. Flow was recorded prior to setting a driftnet with a flow meter for an estimate of the volume of water sampled. Drift nets were anchored to the river bottom using rebar stakes.

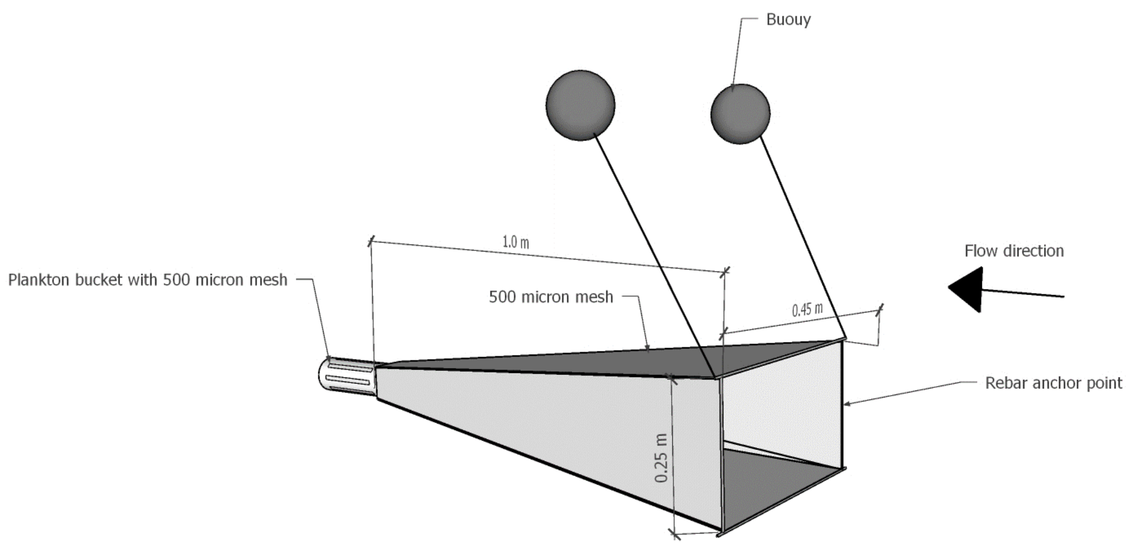

Figure 15. *Generalized schematic of a drift net.*

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Larval quadrafoil light trap (Figure 16):
Quadrafoil light traps consisted of a collection pan, a cloverleaf array and a closed cell floatation block. Collection pans were constructed of a 30.0 cm (11.8 in.) diameter aluminum pan with 5.1 cm (2.0 in.) tall sides. Six, 3.8 cm (1.5 in.) diameter drain holes were drilled into side of the collection pan and covered with 250 µm mesh allowing water to drained from the trap while retaining captured organisms upon retrieval. The cloverleaf array was created from four half circle polycarbonate tubes 10.2 cm (4.0 in.) in diameter with 6.4 mm (0.25 in.) thick polycarbonate cemented to a top and bottom 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick clear polycarbonate circles. The top polycarbonate circle of the cloverleaf array was secured to the closed cell floatation block with four, 4.8 mm (0.2 in.) by 25.4 mm (1.0 in.) stainless steel eye bolts. The closed cell floatation block consisted of the top polycarbonate circle of the cloverleaf array, a 30.0 cm (11.8 in.) diameter by 10.0 cm (3.9 in.) thick Styrofoam middle and a 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick polyvinyl chloride top. The bottom polycarbonate circle was secured to aluminum collection pan with two paracord straps using four 3.2 mm (0.1 in.) zinc plated spring snap link carabiners on each end which were clipped to one of the rigging point eyebolts. A 20.0 mm diameter by 25.0 cm long capped central light tube at the center of the cloverleaf array stored the light source for light traps. Light sources for light traps were green photochemical light sticks. Rigging point eyebolts served as a point to tether the trap to a tree, the bank, or anchor at each sampling location.

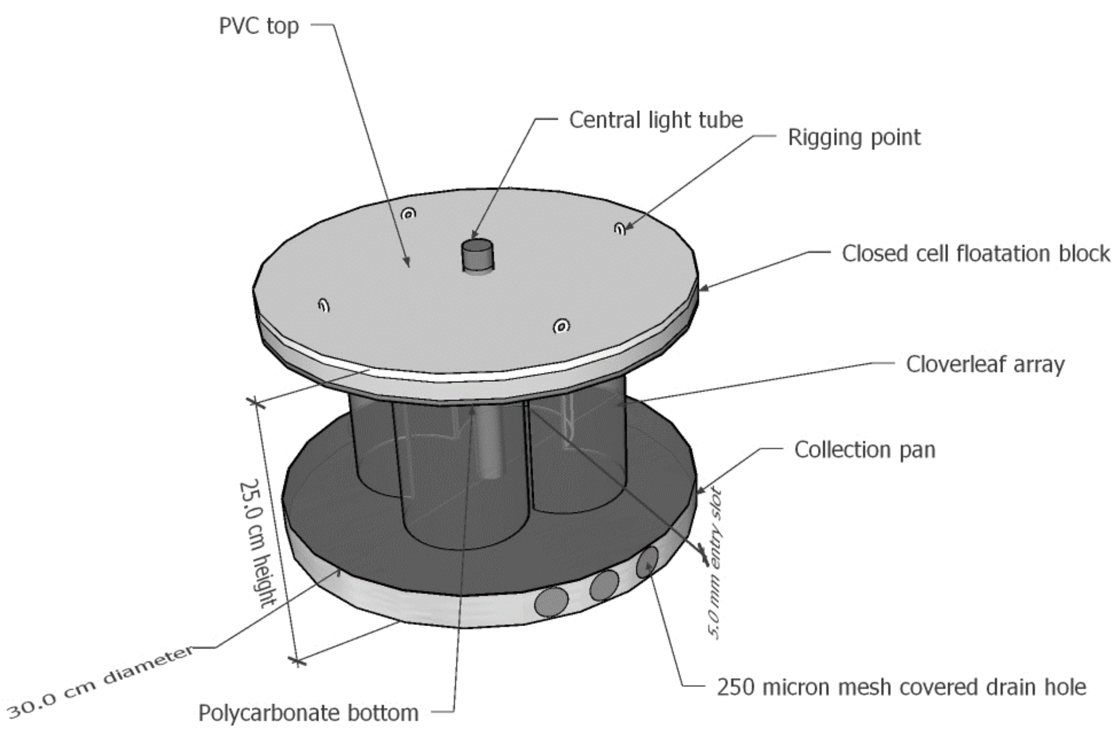

Figure 16. *Schematic of Quadrafoil light trap*

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Non-capture gears

Nets

Block net (Figure 17):

Block nets consisted of nylon mesh webbing sewn to a float line and a lead line. Float lines had 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge floats attached every 30.5 cm (12.0 in.). Each float produced about 156.0 g (5.5 oz.) of buoyancy. Lead lines were 95.3 mm (0.3 in.) braided solid leadcore rope. Webbing of block nets was 7.9 mm (0.3 in.) bar measured nylon mesh covered in a black asphalt coating. Depth of block nets where either 9.1 m (30.0 ft.) or 6.1 (20.0 ft.) with webbing depths of 9.8 m (32.0 ft.) or 6.7 m (22.0 ft.), respectfully. Total lengths of block nets were either 152.4 m (500.0 ft.), 304.8 m (1,000.0 ft.) or 762.0 m (2,500.0 ft) with the webbing fully stretched to the same length as the total length of the block net (hanging ratio: 1.0 [measure of how tightly webbing is stretched along float and lead lines]). Block nets were used in conjunction with other sampling gears (e.g., electrofishing, gill/trammel nets) as they did not directly sample fish but prevented fish movement out of or into a new area.

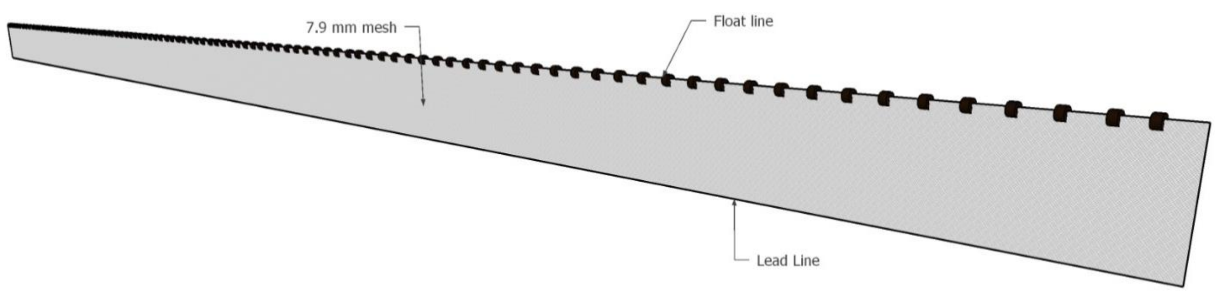

Figure 17. *Generalized schematic of a block net.*

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Sampling boats

Netting boat (Figure 18):

Flat bottomed aluminum boats, 4.9 m to 8.7 m (16.0 ft. to 28.0 ft.) in length powered with 90-horsepower or greater counsil or tiller controlled outboard motor set various active and passive capture gears. Outboard motors were controlled with a tiller handle or steering counsel. Netting boats had 2.3 m (7.5 ft.) wide hull with sides around 66.0 cm (25.0 in.) tall. Netting boats were made of 3.2 mm (0.1 in.) thick aluminum. A front 1.5 m to 2.3 m (5 ft. to 7.4 ft.) aluminum deck created a front platform with larger netting boats having a 1.0 m (3.2 ft) long step up to the deck. Under the step in larger netting boats was a 94.6-liter (25.0 gallon) fuel cell while smaller boats had a removable gas tank toward the stern. Two, 91.4 cm (36.0 in.) by 75.0 cm (29.5 in.) by 40.0 cm (16.0 in.) deep dry storage boxes were on the port and starboard freeboards in the stern of both the larger and smaller netting boats. Coupled with the outboard motor was a 3-blade stainless steel propeller.

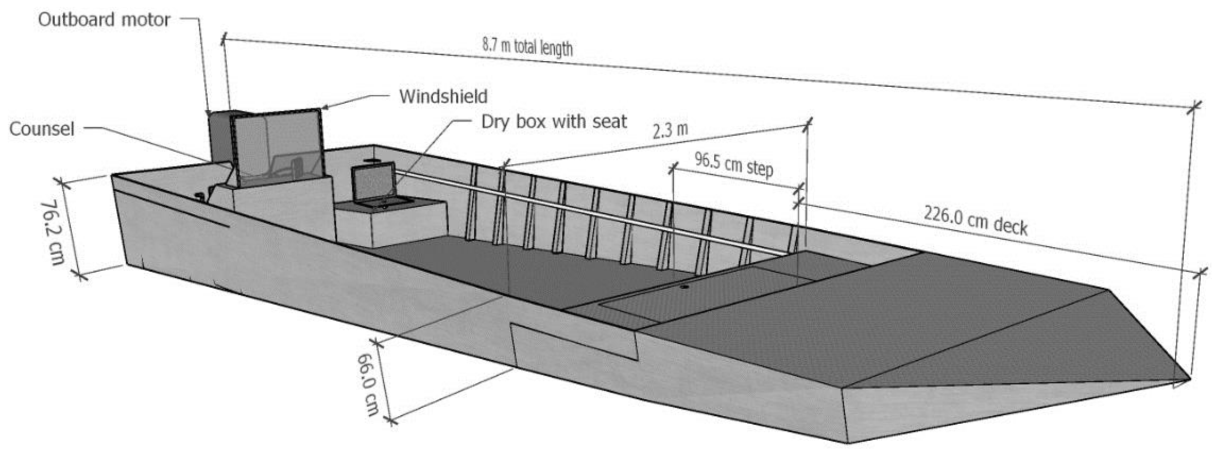

Figure 18. *Generalized schematic of netting boat.*

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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.

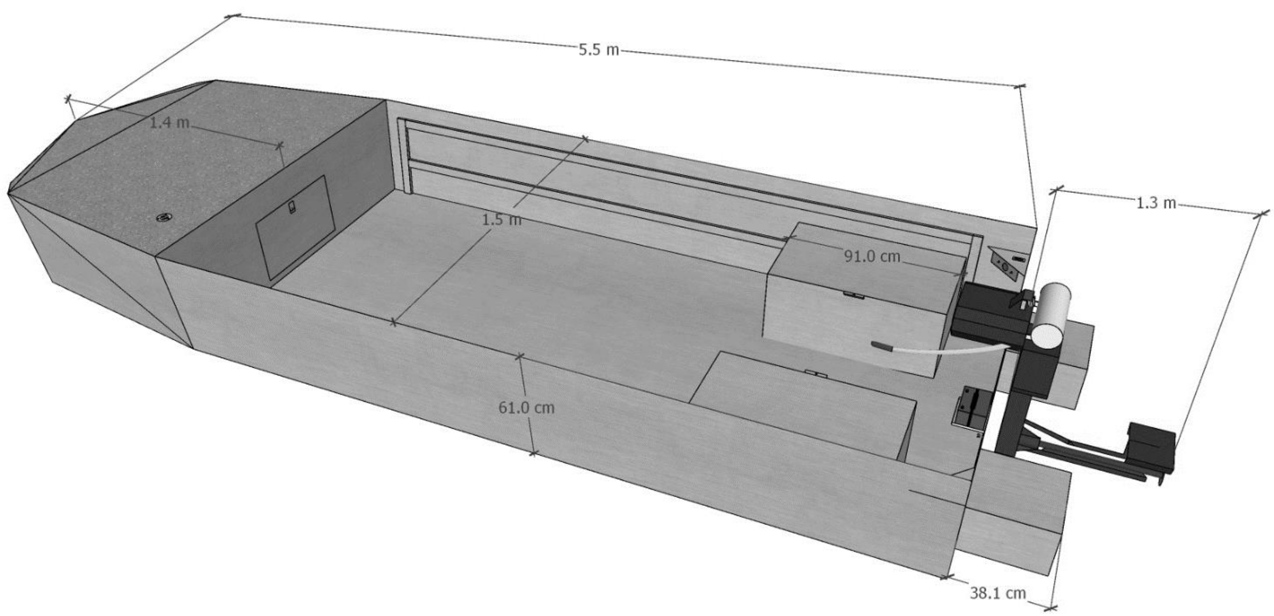

Figure 19. *Schematic of the shallow drive boat.*

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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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	Forestry Suppliers	
Description	**Vendor**	**Vendor contact**
Pound net	Stuth Fishing	stuthfishing@charter.net
Seine	Commercial fisherman	——
Trawl	Commercial fisherman	——
Miscellaneous: anchors, floats, grapple, net preservative, rebar/stakes, rope, twine, webbing,		