
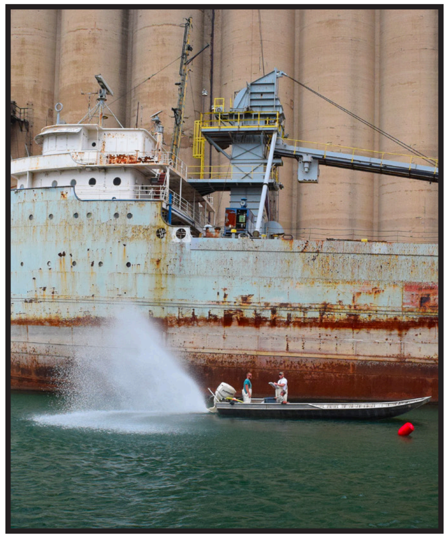


2020

SIU CARBONDALE

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

U.S. FISH & WILDLIFE SERVICE

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

USGS
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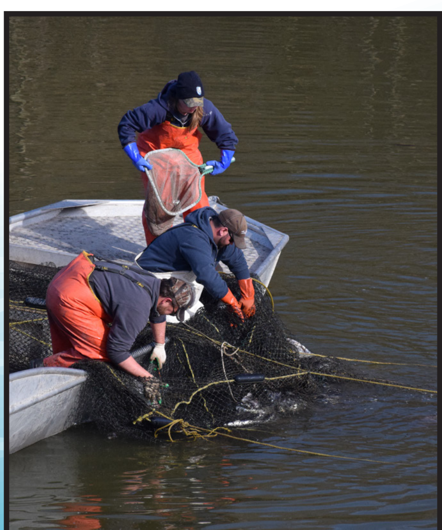
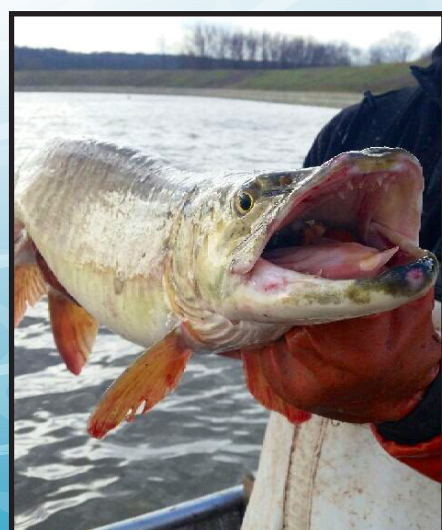
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Asian Carp Monitoring and Response Plan


A statement on extenuating circumstances:

The international COVID-19 pandemic during 2020 created a unique set of challenges for members of the Monitoring and Response Workgroup. Guidance from the Centers for Disease Control and public health authorities impacted the ability to accomplish planned workgroup activities that were to begin in March 2020. However, MRWG and ACRCC partners remained fully committed to the mission of preventing the movement of Asian carp into the Great Lakes with the health and safety of our members as the top priority. The U.S. Army Corps of Engineers continued to operate the electric dispersal barriers in Romeoville, Illinois within the constraints of maintaining a safe working environment. The Illinois Department of Natural Resources, in cooperation with ACRCC and MRWG, also remained prepared to respond accordingly within 24-48 hours if a situation arose. The 2020 Interim Summary Report will report any necessary adjustments to activities or timetables as a result of this global emergency; such modifications are not included in this 2020 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 21 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 2020, 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 2020 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 2019 Asian Carp Interim Summary Report, presented as a companion document to the 2020 MRP.

HIGHLIGHTS OF PAST EFFORTS

Detection Projects

- A total of 471,730 fish representing 86 species and seven hybrid groups have been sampled above the Electric Dispersal Barrier, including 2,842 Banded Killifish (state threatened species) during 2010-2019.
- During 2009-2019 multi-agency efforts 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 2019.
- Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2019 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 due to lack of Asian carp smaller than 6-inches in the upper IWW.

- Fixed and random sampling below the Electric Dispersal Barrier has resulted in the collection of over 496,000 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.
- 37 juvenile Silver Carp in LaGrange and Peoria pools were collected and tagged for acoustic telemetry studies in 2019. Studies of previously tagged juvenile Silver Carp measured mean distance traveled per week and residency time in different habitat types.
- Four samples were positive for Asian carp DNA in Lake Calumet: one positive for only Silver Carp DNA, one for only Bighead Carp DNA, and two for DNA of both species. In early October, 49 samples were positive for Asian carp DNA in the South Branch of the Chicago River: 22 for only Silver Carp DNA and 27 for both species. These findings in the South Branch of the Chicago River differed greatly from previous years. As a result, additional eDNA sampling was conducted, and Illinois DNR coordinated an intense, multi-agency two week sampling response using gill netting and electrofishing gears.
- No Asian carp have been captured during sampling in the Des Plaines River. This spans the collection of 12,776 fish since 2011.
- 35 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 4,528 tons of Asian carp have been removed from the Illinois Waterway (IWW) below the Electric Dispersal Barrier since 2010. This tonnage consists of 97,849 Bighead Carp; 997,732 Silver Carp; and 9,373 Grass Carp.
- Telemetry study of tagged fish has observed no upstream passage past the Electric Dispersal Barrier. 18 lock passages were observed in the Upper IWW in 2019.
- 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.
- During November 2019 a two-week long, multiagency response was conducted using the Incident Command System to investigate the source of multiple positive eDNA results in the Bubbly Creek portion of the Chicago Area Waterway System. Dissolved oxygen levels were extremely low during sampling within the area where positive eDNA detections were located. No Bighead Carp or Silver Carp were captured or observed during the response.

In addition to these highlights, a brief summary of work anticipated to be completed in 2020 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 2020.

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 2nd and 9th) and the fall season (Weeks of September 15th and 22nd). 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 2020, 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. Sampling will not be conducted in the South Branch Chicago River and areas of the Chicago Ship and Sanitary Canal that have previously been sampled, due to the potential influence of combined sewer overflows.

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 Telemetry Project

This project uses real-time acoustic telemetry receivers for detecting bigheaded carp and surrogate fishes, and also provides supplementary support to telemetry projects, including development and maintenance of the FishTracks DB database, and development of a model to estimate Asian carp movement probabilities. Real-time telemetry receivers are deployed at strategic locations in channel and off-channel areas in the Upper Illinois and Des Plaines river systems and in the CAWS with the intent to support decisions on directing (1) removal efforts by contracted fishing and (2) contingency actions. Location information of tagged bigheaded carp from real-time detections at these receivers are available online to biologists directing day-to-day removal efforts, and as email or text alerts to managers responsible for executing contingency actions. The FishTracks DB acts as a centralized database for telemetry receiver and fish transmitter data, and allows project stakeholders to upload, download, and query relevant datasets. The movement probability model estimates the probability of inter-pool movement throughout the Illinois River, and has been updated and run with up-to-date data.

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 June through October. 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 May 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.

Movement and Density of Bigheaded Carp in the Illinois River
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 continue through 2020.

Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
This project has been conducted since 2017. Field efforts in 2019 resulted in the tagging of 37 juvenile Silver Carp tracked using nine radio monitoring stations and 19 hydro-acoustic receivers. A sum of 190 fishes from 2017, 2018, and 2019 have been tagged. 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 2019 are still being analyzed and can be expected in the 2019 ISR. This project in its current form will conclude in 2020 and transition towards providing greater support of juvenile telemetry within the SEAcarP model framework; as has been requested by the MRWG Telemetry Workgroup.

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 2020, 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 2020, 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 began in 2019, and utilizes 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 Electric 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 Illinois River Monitoring and Evaluation

This project intends to use data compilation and analysis to inform ongoing management and control actions. Compiling data from monitoring and removal efforts into a centralized database (Illinois River Catch Database application) facilitates data standardization, quality, accessibility, sharing, and analysis to aid in Asian carp removal efforts, evaluations of management actions, and modeling efforts (e.g., SEAcarP model). Data summarization, visualization, and modeling supports a better understanding of bigheaded carp life history, behavior, and habitat use. Integrating Asian carp-related data and analyses into decision support tools and products aids in applying control and containment methods in an informed and transparent manner (e.g., improved efficiencies in implementations of the Unified Method, inform targeted removal efforts or deterrent deployments in key locations based on preferential benthic characteristics and environmental conditions).

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Contracted Commercial Fishing Below the 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.

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 2020, the model will be submitted to reviewers/advisors for feedback, and any feedback that is received will be addressed. Sensitivity analyses will be performed on the model to update 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 2020, 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 Peoria and Starved Rock pools. 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. During 2020 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 lower six pools of the Illinois River (Figure 1) using a random design stratified by habitat type

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 2020 the modular barrier will be deployed in 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 program aims to reduce the abundance of Asian carp in Peoria Pool through controlled and contracted fishing efforts. This program issues 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 also provides 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 also works to identify and

employ mechanisms for use of the harvested fish by private industry for purposes including human consumption. Through a cooperative relationship of agency and fishers along with end users/markets, advice and support will be provided as necessary to further inform fishers on 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 2020, 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 21 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 2020, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2020 Asian Carp Action Plan (Action Plan) which outlines funding and actions taken through the USEPA's Great Lakes Restoration Initiative. The Fiscal Year 2020 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 – 2019. More specifically, it is intended to identify actions to be taken in 2020, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2020 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 2020 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 2020 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 2019 Asian Carp Monitoring and Response Plan Interim Summary Report (ISR), has also been completed by the MRWG. The 2019 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 2020 MRP and 2019 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 2020 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 Telemetry Project
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
Movement and Density of Bigheaded Carp in the Illinois River
Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
Des Plaines River and Overflow Monitoring
Alternative Pathway Surveillance – Urban Pond Monitoring
Multiple Agency Monitoring of the Illinois River for Decision Making
Manage and Control
USGS Illinois River Monitoring and Evaluation
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Asian Carp Population Modeling to Support an Adaptive Management Framework
Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEAcarP)
Asian Carp Demographics
Evaluation of a Modular Electric Deterrent Barrier
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 2020 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.

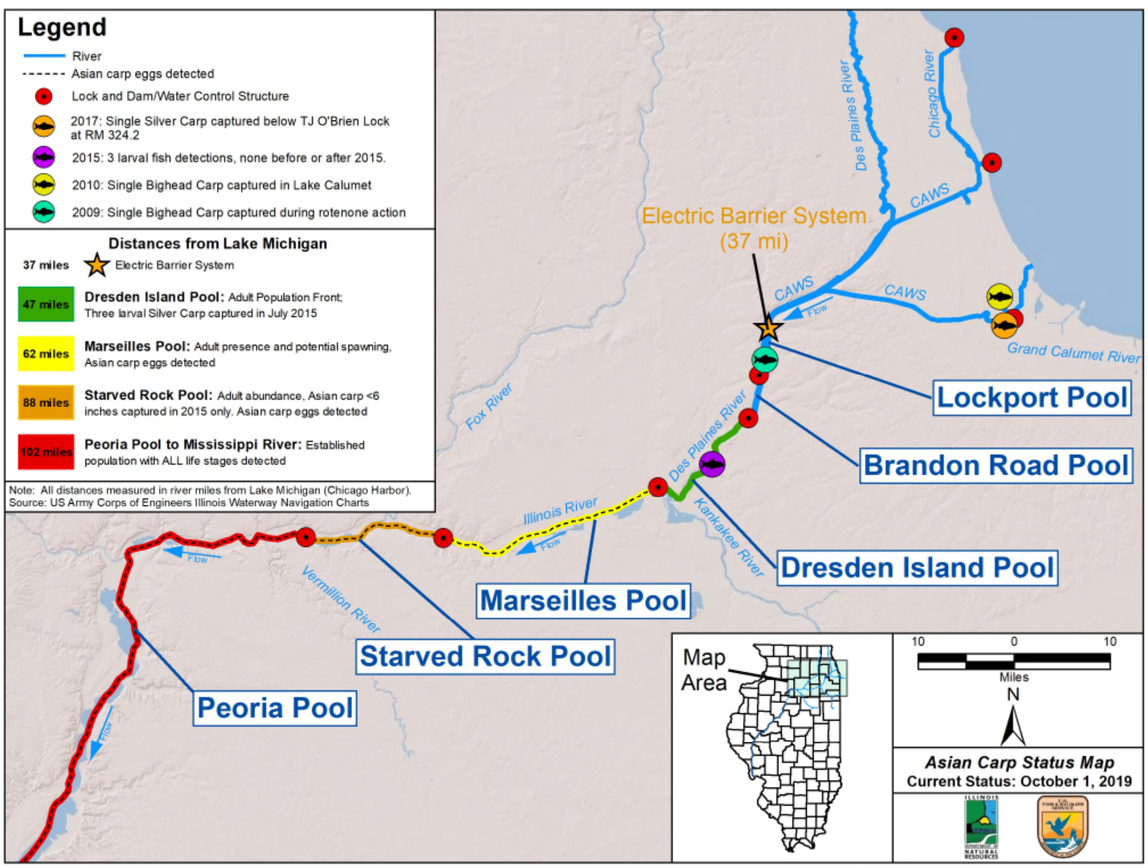
CURRENT STATUS

Detection projects have informed agency actions and development of the 2020 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 2019 suggest relative abundance (measured as mean Asian carp density based on hydroacoustic surveys) has been reduced by an estimated 96.7% 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 in the past, 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 La Grange pools, below the Starved Rock Lock and Dam. During 2019, eggs and larval Asian carp were only collected in Peoria and La Grange pools. 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 2020 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 2019, 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 2019 field season include:

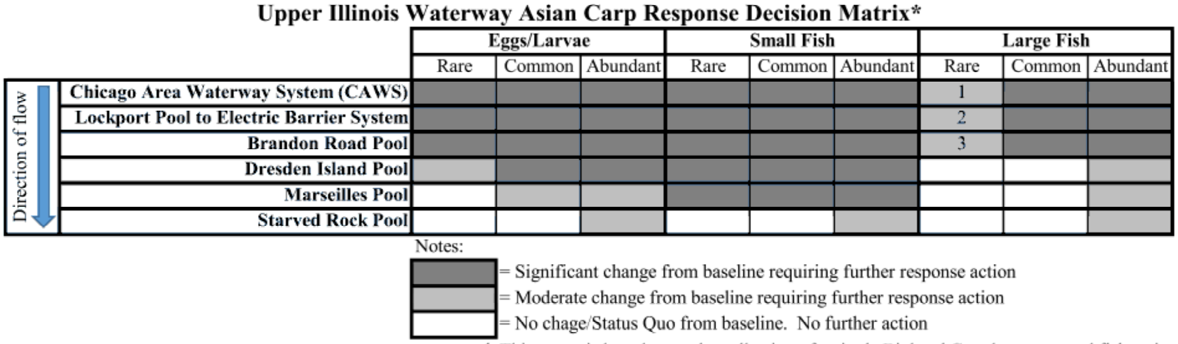
- No Asian carp collected or observed in Lake Michigan or Brandon Road Pool.
- No small Asian carp detected in Upper IWW.
- 1.52 million pounds of Asian carp removed from Upper IWW.
- During November 2019 a two-week long, multiagency response was conducted using the Incident Command System to investigate the source of multiple positive eDNA results in the Bubbly Creek portion of the Chicago Area Waterway System. Dissolved oxygen levels were extremely low during sampling within the area where positive eDNA detections were located. No Bighead Carp or Silver Carp were captured or observed during the response.

In 2020, detection efforts below the Electric Dispersal Barrier will continue to utilize a standardized, scientifically-based multi-agency monitoring framework to provide even more Asian carp and excologically relevant fisheries data. The methods and protocols that have been adopted are 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 m odel 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 MRWG'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.

Upper Illinois Waterway Asian Carp Response Decision Matrix*



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 onpon the collection of a single Bighead carp during piscicide treatment in 2009

3 This status is based upon sightings of 1 Bighead Carp and 1 Silver Carp by MRWG efforts in 2010-2011. No 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.

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 2019, 22 individual fish have been documented in the Illinois River. Five Black Carp were reported captured in the Illinois River during 2019. 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 2020 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 2020 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 2020, 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 2021 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 2020.
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 (2020 and beyond).
7. Assess/review technology development (tools) for field deployment in 2020 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 2021 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 and enhanced contract fishing to increase harvest of Asian carp in the lower IWW from approximately 4.5 million pounds in year one (project started in fall 2019) to 8 million pounds by conclusion of year four (2024).
9. Establish additional management of the Lower IWW through contract fishing. During 2020, an enhanced contracted fishing program will be continued and expanded. The initial program will have a goal of removing 4.5 million pounds of Asian carp 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 to other Illinois River pools in the future based upon success, with a four year goal to remove 8 millions pounds of Asian carp from Peoria Pool.
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 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 2020 are listed below with leads identified to assist in communication and structure. Co-leads may also be identified to assist with managing these work groups as appropriate and helpful. Workgroups may be added or deleted to serve MRWG and ACRCC needs.

2020 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 maintain aggressive removal efforts to reduce the risk of range expansion, as well as to continue focused surveillance to ensure that management agencies have an accurate understanding of changes to Asian carp range, population dynamics, and behavior.

Detection

- Ensure sufficient surveillance effort through standardized multi-agency monitoring deployed throughout the IWW, Des Plaines and Kankakee rivers to inform 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.
    - 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 (4.5 million pounds in Peoria Pool plus additional from downstream pools).
    - Increase total Illinois harvest by expanding the commercial fishery to greater than 4.5 million pounds by 2021 and exceeding 8 million pounds of Asian carp annually by 2024.

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.

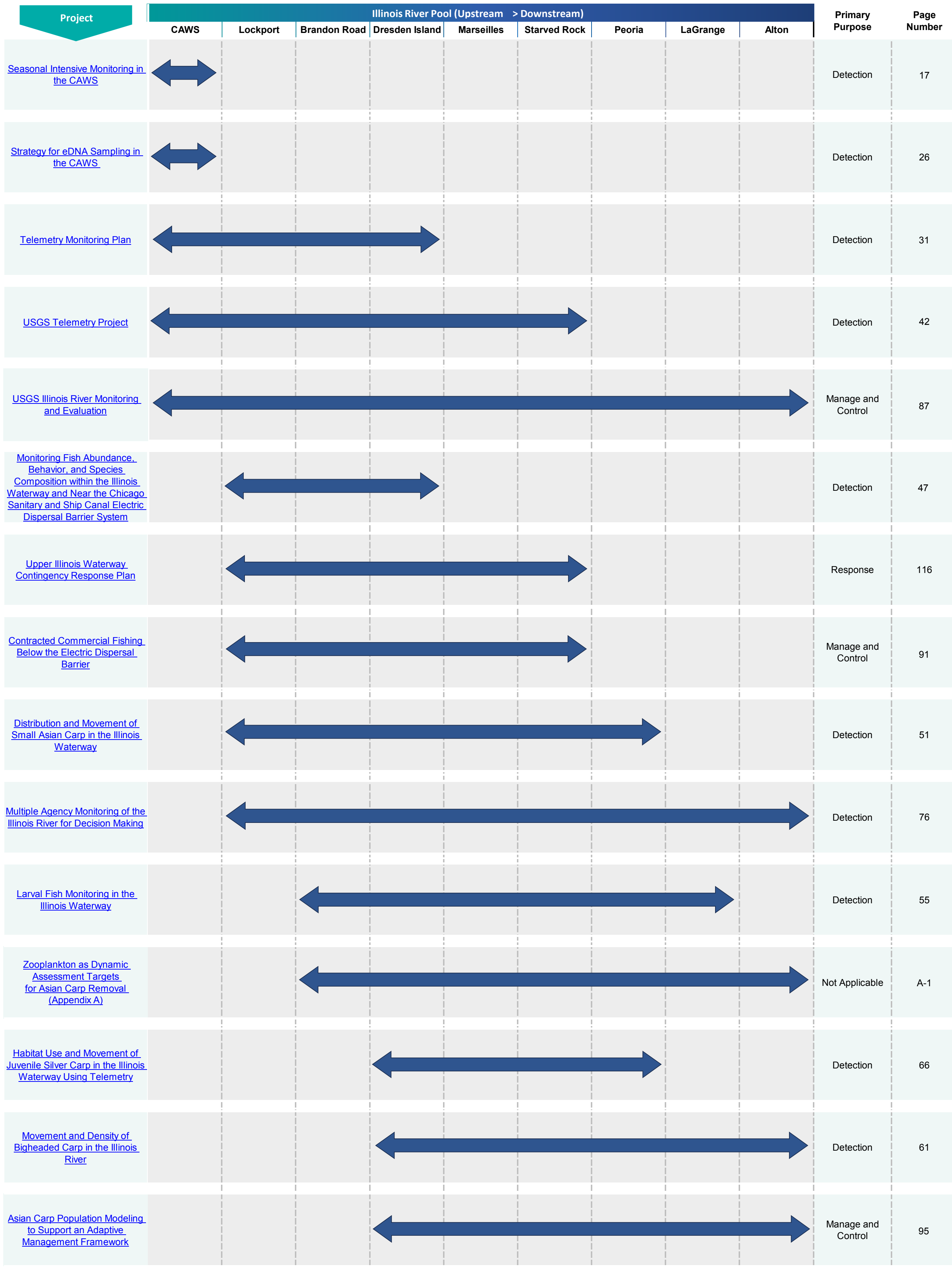
- Provide guidance to minimize Asian carp populations in the Upper IWW with no impacts on native fish or mussel populations, human health and safety, recreational use, or industrial uses of the waterway.
- Dynamic economic business strategy in place in the lower IWW to remove 20-50 million pounds of 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
Illinois River Pool (Upstream > Downstream)
CAWS
Lockport
Brandon Road
Dresden Island
Marseilles
Starved Rock
Peoria
LaGrange
Alton
Primary Purpose
Page Number
Seasonal Intensive Monitoring in the CAWS
Detection
17
Strategy for eDNA Sampling in the CAWS
Detection
26
Telemetry Monitoring Plan
Detection
31
USGS Telemetry Project
Detection
42
USGS Illinois River Monitoring and Evaluation
Manage and Control
87
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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Upper Illinois Waterway Contingency Response Plan
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116
Contracted Commercial Fishing Below the Electric Dispersal Barrier
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Distribution and Movement of Small Asian Carp in the Illinois Waterway
Detection
51
Multiple Agency Monitoring of the Illinois River for Decision Making
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76
Larval Fish Monitoring in the Illinois Waterway
Detection
55
Zooplankton as Dynamic Assessment Targets for Asian Carp Removal (Appendix A)
Not Applicable
A-1
Habitat Use and Movement of Juvenile Silver Carp in the Illinois Waterway Using Telemetry
Detection
66
Movement and Density of Bigheaded Carp in the Illinois River
Detection
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Asian Carp Population Modeling to Support an Adaptive Management Framework
Manage and Control
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Project	Illinois River Pool (Upstream > Downstream)									Primary Purpose	Page Number
	CAWS	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	LaGrange	Alton		
Asian Carp Demographics				↔	↔	↔	↔	↔	↔	Manage and Control	104
Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEAcarP)						↔	↔			Manage and Control	101
Asian Carp Enhanced Contract Removal Program							↔			Manage and Control	113
Des Plaines River and Overflow Monitoring										Detection	69
Evaluation of a Modular Electric Deterrent Barrier										Manage and Control	108
Alternative Pathway Surveillance – Urban Pond Monitoring										Detection	72
Alternative Pathway Surveillance in Illinois – Law Enforcement										Manage and Control	111

DETECTION PROJECTS

Seasonal Intensive Monitoring in the CAWS

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).

Location: Seasonal intensive monitoring takes place within the Chicago Area Waterway System, above the Electric Dispersal Barrier.

Pools Involved: Chicago Area Waterway System (CAWS)

Introduction and Need:

The CAWS represents a direct connection between the Mississippi River and Great Lakes basins and serves as a potential avenue for Asian carp (Silver Carp and Bighead Carp) to expand into the Great Lakes. The current Asian carp population front is in Dresden Island Pool. As a final barrier, an Electric Dispersal Barrier is operational upstream of the population front within the Chicago Sanitary and Ship Canal to prevent movement of Asian carp between the systems. Downstream of the Electric Dispersal Barrier, monitoring and removal efforts occur to reduce the risk of Asian carp challenging or bypassing the barrier. However, the threat exists that Asian carp may move through the Electric Dispersal Barrier or otherwise be introduced upstream of it. Therefore, it is critical to monitor the CAWS for the presence of any Asian carp and to react accordingly if an individual is detected. Results from the Seasonal Intensive Monitoring (SIM) upstream of the Electric Dispersal Barrier will contribute to our understanding of Asian carp distribution and abundance in the CAWS and guide conventional gear or rapid response actions designed to remove Asian carp from areas where they have been captured or observed. Sampling efforts will continue in 2020 with two seasonal intensive interagency multi-gear sampling efforts in June and September.

Objectives:

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

(2) Determine Asian carp abundance and distribution in the CAWS through intense targeted sampling efforts at locations deemed likely to hold fish.

Seasonal Intensive Monitoring in the CAWS

Status:

Detections of Asian carp (Silver Carp and Bighead Carp) environmental DNA (eDNA) upstream of the Electric Dispersal Barrier in 2009 initiated the development of a monitoring plan that utilized boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed reaches upstream of the barrier. Random area sampling was added in 2012 to increase the chance of detecting Asian carp in the CAWS beyond the designated fixed sites. 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) resulted in only one Bighead Carp being collected in Lake Calumet in 2010. Fixed site and random area sampling effort was then reduced upstream of the Electric Dispersal Barrier to two SIM events and has been conducted in the same manner in subsequent years (2014-2019). SIM in its current form is a modified continuation of Fixed and Random Site Monitoring Upstream of the Electric Dispersal Barrier and Planned Intensive Surveillance in the CAWS. SIM utilizes an intensive two-week multiagency sampling effort in the fall and spring of each year using coordinated netting and electrofishing effort at fixed and random sites in a comprehensive effort to detect the presence of Asian carp in the CAWS upstream of the Electric Dispersal Barrier. Following effort reduction, one Silver Carp was collected in the Little Calumet River in 2017, resulting in a rapid, interagency contingency response effort (see the 2017 Interim Summary Report for additional information). Reduced effort upstream of the Electric Dispersal Barrier allows for increased monitoring efforts downstream of the barrier. Increases in sampling downstream of the Electric Dispersal Barrier focuses effort on the leading edge (Dresden Island Pool) of the Asian carp population, serving to further reduce their numbers in that area, reducing the risk of individuals moving upstream towards the Electric Dispersal Barrier and Lake Michigan by way of the CAWS.

Methods:

Sampling reaches:

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

Upstream Fixed Site Area Descriptions

- Site 1 – Lake Calumet. Sampling will be limited to shallower areas north of the Connecting Channel (this avoids deep draft areas with steep walls but includes channel drop off areas that exist north of the Connecting Channel).
- Site 2 – Calumet/Little Calumet River from T.J. O’Brien Lock and Dam to its confluence with the Little Calumet River South Leg ~11.3 km (7 mi).

- Site 3 – Chicago Sanitary Ship Canal (CSSC) and South Branch Chicago River from Western Avenue upstream to Harrison Street ~6.4 km (4 mi).
- Site 4 – North Branch Chicago River and North Shore Channel from Montrose Avenue north to Peterson Avenue ~3.2 km (2 mi).
- Site 5 – North Shore Channel from Golf Road north to Wilmette Pumping Station ~3.2 km (2 mi).

Upstream Random Site Sampling Area Descriptions

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

Seasonal Intensive Monitoring in the CAWS

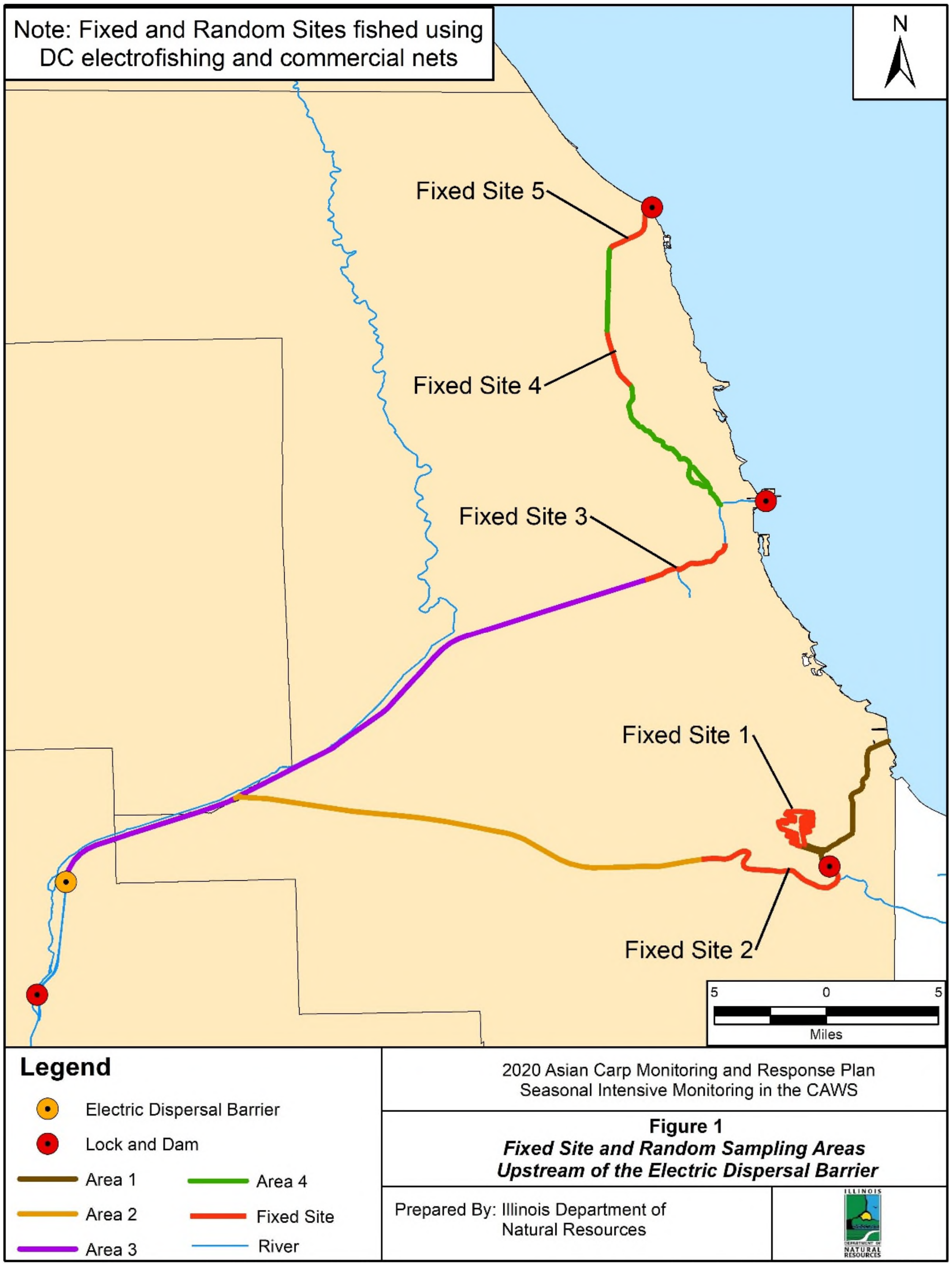

Figure 1. *Fixed site and random site sampling reaches for electrofishing and commercial netting upstream of the Electric Dispersal Barrier.*

Decontamination Protocol: To prevent contamination of eDNA samples from of residual Asian carp genetic material on sampling equipment (boats, netting gear, etc.), hot water pressure washing and chlorine washing (10% solution) of boats and potentially contaminated equipment used in the SIM is required (see Appendix C). Additionally, nets specifically for monitoring upstream of the Electric Dispersal Barrier will be used.

Seasonal Intensive Monitoring in the CAWS

Electrofishing Protocol:

Pulsed DC Electrofishing will be used at fixed and random sites and include 1-2 netters (two netters preferred). Locations for each electrofishing transect will be identified with GPS coordinates. Fixed or random electrofishing transects will be sampled for 15 minutes in a downstream direction in waterway main channels (including following shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Electrofishing boat operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat. Electrofishing may also be used in conjunction with commercial fishers to herd fish into nets. Common Carp will be counted without capture and all other fish will be netted and placed in a tank where they will be identified and counted, after which they will be returned live to the water. Schools of young-of-year (YOY) Gizzard Shad < 152.4 mm (6 in) long will be subsampled by netting as many fish as possible from each encountered school and placing them in a holding tank along with other captured fish. Young of year Gizzard Shad will be examined closely for the presence of Asian carp and enumerated due to similarities in appearance and habitat between the species. All fish that are not Asian carp will be returned live to the water after data collection. The goal is to complete 150 electrofishing runs during each two-week event.

Netting Protocol:

Contracted commercial fishers will set large mesh gill nets that are 3 m (10 ft) deep x 91.4 m (300 ft) long in bar mesh sizes ranging from 88.9-108 mm (3.5-4.25 in) at fixed and random sites (Appendix M). Deep water gill nets may also be used as appropriate. One 9.1 m (30 ft) deep gill net for each net boat will be provided by the IDNR as necessary (Appendix M). Locations for each net set will be identified with GPS coordinates. Net sets will be 15-20 minutes long and will incorporate fish herding techniques within 137.2 m (450 ft) of the net (e.g., plungers on the water surface, pounding on boat hulls, or revving trimmed up motors) to increase detection probability (Butler et al. 2018). An agency biologist will be assigned to each commercial net boat to monitor operations and record data. All fish that are not Asian carp will be returned live to the water after data collection. The goal is to complete 150 net sets (gill nets and deep water gill nets) during each two-week event.

Special protocols:

Lake Calumet/Calumet River (week of June 9):

Prior to sampling, crews will set Great Lake pound nets at the entrance to Lake Calumet if water conditions allow to prevent fish immigration/emigration (Figure 2). Pound nets will have a single lead, two adjustable length wings, and a 54.9 m^3 (1938.8 ft^3) mesh cab (catch area) (Appendix M). Pound nets will be checked and emptied each day. Contracted commercial beach seining will occur in the north section of Lake Calumet for two days, then in the south section for one day (Figure 2). The 731.5 m (2400 ft) seine will be staked to shore on one end, deployed in an arc through the water by boat, and winched up on shore. Gill nets, deep water gill nets and electrofishing will also be utilized in Lake Calumet, the Calumet Connecting Channel and the Calumet River as described above (Figure 2). See Appendix M for a more complete description of Asian carp sampling gears.

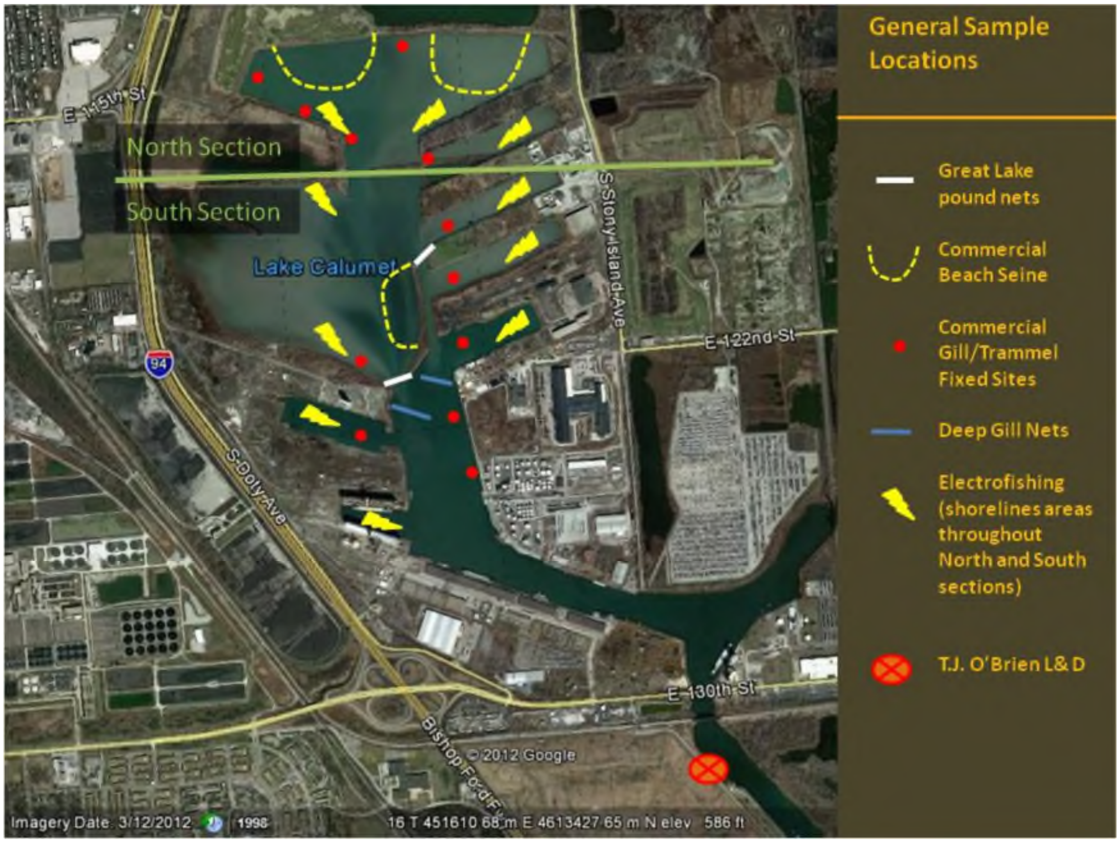

Figure 2. *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

North Shore Channel (week of September 22):

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

Seasonal Intensive Monitoring in the CAWS

Chicago River and South Branch Chicago River/Bubbly Creek (week of September 22):

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

Data collection:

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

Detection of Asian carp:

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

Seasonal Intensive Monitoring in the CAWS

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

2020 Schedule:

Spring Event

- Week of June 2: All fixed and random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols)
- Week of June 9: Lake Calumet/Calumet River (see special protocols) and all random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols)

Fall Event

- Week of September 15: All fixed and random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols)
- Week of September 22: North Shore Channel/Chicago River/South Branch Chicago River/Bubbly Creek (see special protocols) and all random area sites upstream of the Electric Dispersal Barrier (see netting and electrofishing protocols)

Deliverables:

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

Strategy for eDNA Sampling in the CAWS

Participating Agency: U.S. Fish and Wildlife Service (Midwest Fisheries Center)

Location: Chicago Area Waterway System (CAWS)

Pools Involved: CAWS

Introduction and Need:

Monitoring with multiple gears in the CAWS has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of 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 historically been collected at four regular monitoring sites, however collection has been adapting in both location and sample size in recent years due to emerging research. eDNA sampling events are typically conducted twice per year when conditions allow. Since 2013, eDNA results do not automatically trigger any kind of physical sampling response.

Objectives:

(1) Sample for Bighead and Silver carp DNA in targeted areas of the CAWS to maintain vigilence and compliment other ongoing monitoring efforts 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. Between 2014 and 2018, 1,958 eDNA samples were collected above the Electric Dispersal Barrier. Of these, 34 samples have been positive for Silver Carp DNA, and 3 samples 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 automatic response actions to eDNA results were terminated. 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. In October 2018, total sample numbers were increased slightly and concentrated even more heavily in off-channel areas. In 2019, on two occasions in October, an unsually high number of postive DNA detections were observed in the Bubbly Creek area (South Fork South Branch Chicago River). A physical sampling effort followed yielding no observations or captures of live Asian carp. Due to the location of the positives and the proximity to a large wastewater pumping station, followup eDNA samples were collected from the underground sewer lines leading to the pumping station. Results revealed that one of four sewer intercepers leading to the facility was highly contaminated with Asian carp DNA, likely from fish markets and households consuming Asian carp. Given this information, sampling of Bubbly Creek and the surrounding area will be discontinued during future sampling events.

CAWS eDNA sampling has also occasionally included sampling below the Electic Dispersal Barrier. Sampling below the barrier has been adapted based on information obtained through the MRP and has been used to refine eDNA as a monitoring tool for Asian carp. 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. In 2017, efforts below the Electric Dispersal Barrier were expanded to the entire Dresden Island Pool, but limited to that single pool. The 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 1,600 samples have been collected below the Electric Dispersal Barrier in various pools. With several years of eDNA data reflecting the Asian carp density gradient and the completion of sampling method comparisons, eDNA sampling below the barrier ceased after 2017.

Methods:

Due to the potential for eDNA contamination from sewer outflows, as indicated by the eDNA sampling results in the Bubbly Creek (South Fork South Branch Chicago River) in October 2019 and the results of the followup sample collection in the underground sewers feeding into the Racine Avenue Pumping Station, eDNA sampling in 2020 will not include the areas of the CSSC and South Branch Chicago River that were previously sampled since 2017. Instead, at minimum, the CAWS will be sampled for Bighead Carp and Silver Carp eDNA in a method similar to the October 2019 event but only in the Lake Calumet and Little Calumet River areas (Figure 1). Specifically, nearly all samples will target off-channel areas, where fish and their DNA may collect. The distribution of samples will encompass targeted areas of 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) one sampling event will be planned for spring, when Asian carp have been shown to congregate in off-channel habitats in other systems, and one additional event in the late fall when discharge and water temperatures are low. eDNA sample collections may occur in additional locations in the CAWS in 2020 as needed or requested. All eDNA sampling efforts in 2020 will be documented in the 2020 Interim Summary Report. There will be no eDNA sampling conducted below the Electric Dispersal Barrier in 2020.

Similar to previous years, sample collection and processing methods will follow the most up to date Quality Assurance Project Plan (QAPP 2020) (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 2020) after sample processing is complete. Results will then be posted online and made available to the MRWG in the 2020 Interim Summary Report.

2020 Schedule:

- Week 1: May – 260 samples
- Week 2: October – 260 samples

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.

Figure 1. *Distribution of Bighead and Silver Carp eDNA samples (yellow dots) to be collected in Lake Calumet and the Little Calumet River in 2020.*

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.

Mize, E., R. Erickson, C. Merkes, N. Berndt, K. Bockrath, J. Credico, N. Grueneis, J. Merry, K. Mosel, M. Tuttle-Lau, K. Von Ruden, Z. Woiak, J. Amberg, K. Baerwaldt, S. Finney, and E. Monroe. In Revision. Refinement of eDNA as an early monitoring tool at the landscape-level: Study design considerations. Ecological Applications. 50 pp., 1 table, 7 figures, appendix 4 pp.

U.S. Fish and Wildlife Service (USFWS). 2020. Quality Assurance Project Plan (QAPP) eDNA monitoring of bighead and silver carps. Midwest Region Bloomington, MN. Available: http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf

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

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

Introduction and Need:

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 Barrier system 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.

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 Barrier system 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 Barrier system 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. The 2018 USACE network was similar to the 2017 receiver network. The differences were that one receive upstream of the barrier was removed due to a barge strike and no suitable replacement location was determined and the other 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. Also in 2018 the U.S. Geological Survey (USGS) installed six stationary, real-time receivers around areas of interest. One receiver was installed in Upper Lockport Pool, one below the Electric Dispersal Barrier system, one above and below Brandon Road Lock and Dam, and one above and below Dresden Island Lock and Dam. In 2019, the USACE network was similar to that of 2018, but an additional receiver was removed from a location upstream of the Electric Dispersal Barrier system, bringing coverage in that portion of the pool to a total of four receivers and total network coverage to 25 receivers.

This telemetry monitoring project has provided valuable insights to resource managers about fish behavior at the Electric Dispersal Barrier system, 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 Barrier system 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 system 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 2019. 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.

Objectives:

The overall goal of this telemetry monitoring plan is to assess the effect and efficacy of the Electric Dispersal Barrier system on tagged fish in the Chicago Area Waterways (CAWS) and Upper IWW using ultrasonic telemetry. The goals and objectives for the 2020 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.

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.

Methods:

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 Barrier system and that this level of tags be maintained as battery life expires or specimens exit the study area. At the conclusion of the 2019 sampling season there were 140 USACE tagged fish within the study area with varying expiration dates, 129 will remain active through 2020, and 11 will expire early in 2020. 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. All 75 of the presently tagged surrogate fish released within the Lower Lockport Pool will remain active throughout the 2020 calendar year. Previous data suggests that the highest rates of interpool movement occur between the Lower Lockport Pool into Brandon Road Pool. This is due to lock passage and water draw down events that entrain fishes through water control structures at the dam and Lockport Controlling Works spillway. During 2019 there were 12 fish that made 19 movements between the two pools. Of those 12 fish, six started in Lower Lockport Pool and were last detected in Brandon Road Pool; four went from Lockport Pool, to Brandon Road Pool, then back to Lockport Pool; one started in Brandon Road Pool and ended in Lockport Pool; and one started in Brandon Road Pool, went to Lockport Pool, then ended back in Brandon Road Pool. The Lower Lockport Pool is 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.

The 12 tags released in the Brandon Road Pool that were active through the 2019 have expired. During the 2020 season 50 tags are anticipated to be implanted during 2020 to achieve a target number of active tagged fish within the pool (Table 1). Immigration from the Lockport Pool is expected and will assist in maintaining elevated transmitter density in the spring and summer months. Immigration from Dresden Island Pool is possible, though it is not as frequent as from Lockport Pool.

There are currently 54 USACE transmitters that were released within Dresden Island Pool that will remain active through 2020 and none are set to expire during the 2020 sampling season. There is an active removal effort underway in this pool so there is possibility for tagged individuals to be removed and immigration is likely to occur between the Marseilles pool. In an effort to maintain the target goal of 75 USACE tags, 21 transmitters (V13TP-1x-069k-0017m) will be implanted into Asian carp in 2020. Supplemental tagging events have occurred in previous years by other agencies, and there are several additional fish within this pool that were not tagged by USACE. These additional fish provide additional data that can be used to supplement data deficiencies created as fish are lost to tag attrition.

Table 1: *Recommended transmitter implementation for the 2020 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	0	0	75
Brandon Road/RM286.5	Common Carp	25	25	50
Dresden Island/RM276	Bighead and Silver Carp	21	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 Barrier system. 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 studies 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 partnered with SIUC in 2019 and will continue to do so in 2020 to further understand the differences and similarities between Common Carp and the invasive Bighead and Silver carp. A total of 50 transmitters were used in 2019 by SIUC to implant into Common Carp within the middle reaches of the IWW, a similar number will be set aside in 2020 for their use to continue comparisons to tagged Bighead and Silver carp behavior, habitat use, and movement patterns. This research is to 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 system 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 that were released in Lower Lockport Pool, but captured upstream of the Electric Dispersal Barrier system have shown a greater propensity to return to their capture site, hence, challenging the Electric Dispersal Barrier system 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 early summer (May-June) 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 pools 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 within 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 system; above and below Lockport Lock; above, below and within Brandon Road Lock; and above Dresden Island Lock. The receiver network is re-established to its full capacity at the commencement of the following season, typically late March.

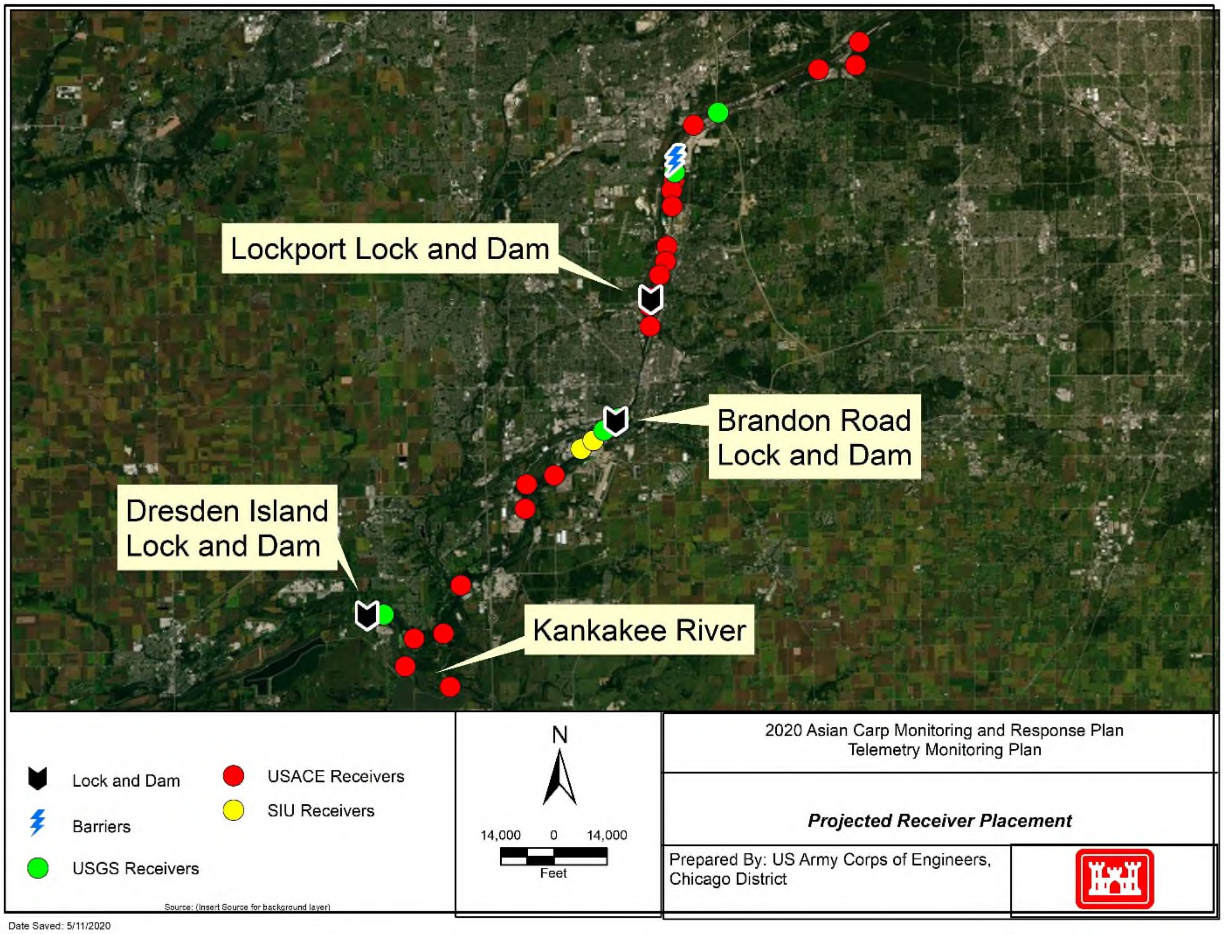

Figure 1: *Proposed USACE 2020 telemetry network to be deployed throughout the IWW.*

Figure 1 shows the general strategy of VR2W placement for 2020 (N=27 USACE receivers). The priority is to achieve the most coverage (detection capacity) in the immediate vicinity of the Electric Dispersal Barrier system with VR2W receivers. To accomplish this, receivers immediately downstream and upstream of the Electric Dispersal Barrier system will provide a system that will help USACE biologists monitor and track any fish movement through the Electric Dispersal Barrier system. The remaining network throughout the system is used to track overall movement, and to determine what type of movement occurs from fish navigating lock structures. Receivers will also be deployed at possible escape routes from the telemetry network such as tributary confluences. Movement through lock structures will be compared to USACE lockage data from Dresden Island, Brandon Road, and Lockport locks. Leading edge movements will be monitored by the receiver network within Dresden Island Pool, Brandon Road Pool, and the Kankakee River. Other significant movement patterns will also be compared to river stage and temperature data.

Receivers will be downloaded bi-monthly 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).

In addition to the receiver network maintained by USACE there will also be continued coordination with other telemetry studies external to USACE. Notably, USGS maintains a number of real-time receivers throughout the study area outlined here. Data sharing will occur across 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 Barrier system in Romeoville, 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 system 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, 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.

Nathan Evans, 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, Illinois Natural History Survey. Species tagged include Bighead Carp in the Illinois River. The study is evaluating emerging technology in the field of telemetry.

2020 Schedule:

- May – June 2020: VR2W network inspected and new receivers installed and range tested.
- Ongoing: VR2W network maintenance, downloads and mobile tracking
- May – June 2020: Tagging of surrogate fish in Brandon Road and Dresden Island pools
- December 2020: Prepare receiver array within the IWW and CAWS for winter months

Deliverables:

All agency leads involved with the telemetry plan, as well as the MRWG, will be notified immediately of any suspected barrier breach or detection of Bighead 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 2020 sampling season.

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

Location: Upper Illinois River and upper Illinois Waterway System

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

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. Fish removal by contracted fishers has become the primary method of controlling bigheaded carp in the upper Illinois Waterway System. Variable patterns in bigheaded carp distribution, habitat, and movement, influenced by seasonal and environmental conditions, make targeting bigheaded carp for removal and containment challenging and costly. Understanding these patterns for bigheaded carp through modeling and real-time telemetry applications informs removal efforts and facilitates planning of contingency actions.

To develop a better understanding of these population dynamics to meet management objectives, an existing network of real-time and non-real-time acoustic receivers in the Upper Illinois Waterway System and elsewhere is collaboratively managed by multiple agencies and universities. A Telemetry Workgroup has been established by the Monitoring and Response Workgroup (MRWG) to ensure that the multi-agency telemetry efforts are coordinated to efficiently and effectively meet MRWG goals. This workgroup plans and executes the placement of receivers, tagging of bigheaded carp with acoustic tags, and data management as needed to meet objectives. Three primary objectives to meet MRWG goals identified by the Telemetry Workgroup included (1) development of a common standardized telemetry database with visualization and analysis tools, (2) transitioning from Program MARK to a custom Bayesian multi-state model for estimating movement probabilities needed for SEAcarP and (3) deploying, maintaining, and serving data from real-time acoustic receivers to inform contingency planning and removal. The telemetry database and visualization tools (FishTracks DB) facilitate standardization, archiving, sharing, quality assurance, visualization and analysis of the telemetry data needed for management. 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 real-time receiver network will be maintained and tested to ensure reliability and accuracy of the real-time alerts. Analyses to compare nearby harvest and detections at the real-time receivers at Hanson Material Services gravel pits and near the mouth of the Kankakee River will be conducted to determine the potential usefulness of detections at these receivers for informing decisions about removal efforts. 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 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) *Database*: Maintenance and development of the FishTracks Telemetry Database (FishTracks DB) and associated tools

(2) *Movement Model*: Complete custom Bayesian multi-state model and estimate bigheaded carp movement probabilities with 2014-2019 data in FishTracks DB

(3) *Real-time receiver network*: Deploy, maintain, and serve data from real-time acoustic receivers to inform decisions on contingency actions and removal

Status:

Database: A centralized database for telemetry receiver and fish transmitter data has been developed, deployed, and released to partners for use. The FishTracks DB, 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. A programmatic approach to summarize telemetry records (i.e., dwell time analysis) are being used to determine transition probabilities in support of SEAcarP and inform receiver placement for optimal network coverage and effective tagging schemes.

Movement model: A Bayesian multi-state transition probability model for the Illinois River Waterway System has been developed and run on the original data used by Coulter et. al. 2018 as a test. In preparation for running the transition probability model on the 2014-2019 FishTracks DB data, analyses have been conducted on data completeness and quality and issues are being resolved by partners. Programming of analyses to summarize individual fish movement histories by navigation pool (i.e., dwell time analysis) needed for the transition probability model is complete and has been tested on a portion of the FishTracks DB data.

Real-time receivers: Nine real-time receiver locations have been established (Table 1) to support the barrier evaluation study (see USACE Telemetry Monitoring Project) and inform contingency actions and removal. An email alert system has been created to alert key MRWG and ACRCC members of detections of Asian carp in strategic areas.

Table 1. *Names and locations of the nine real-time receivers in the Illinois River and Upper Illinois Waterway System for monitoring acoustically tagged Asian carp.*

Station name	Location
Chicago Sanitary and Ship Canal above barrier	Lemont, IL
Chicago Sanitary and Ship Canal below barrier	Romeoville, IL
Des Plaines River above Brandon Road Lock and Dam	Rockdale, IL
Des Plaines River below Brandon Road Lock and Dam	Rockdale, IL
Illinois River above Dresden Island Lock and Dam	Minooka, IL
Hanson Gravel Pit Entrance Channel	Morris, IL
Hanson Gravel East Pit	Morris, IL
Hanson Gravel West Pit	Morris, IL
Illinois River below Starved Rock Lock and Dam	Utica, IL

Methods:

Database: The FishTracks DB (developed as a Microsoft SQL Server application) is being 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 is incorporated into the FishTracks DB as it is collected and submitted by partner agencies through the online upload tool and checked for quality assurance. Additions and modifications to FishTracks DB functionality continue to be made based on partner testing and feedback. Updates include improvements to customized reporting features, an application programming interface (API) to allow direct query access from R, and adding programmatic functionality that summarizes data to output fish movement histories for multi-state modeling of movement probabilities (in support of the SEAcarP model) and to optimize receiver locations. This optimization functionality will facilitate relocation of existing receivers and placement of new receiver locations to improve coverage of the telemetry receiver network.

Movement model: The USGS in collaboration with personnel on the Telemetry Workgroup and Population Model Workgroup of MRWG developed a Bayesian program to estimate interpool movement probabilities needed for SEAcarP. Bayesian methods were used to create a model syntax that maximizes user customizability and extensibility, while avoiding the problems of singularities and poor-convergence inherent to the Program MARK. For example, previous multi-state modeling with Program MARK has been fraught with difficulties (computer crashes, automatically excluding parameters from the model, and not providing estimates) thought to be related to number of states, recapture periods, and specification of random effects to account for individual, and spatial and temporal heterogeneity. As well, Program MARK does not provide uncertainty estimates for the estimated parameters 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.

Real-time receiver network: Seasonal real-time receivers (i.e., the three at Hanson Material Services gravel pits) will be redeployed in spring of 2020. All nine receivers (three seasonal, six year-round) will be maintained, downloaded and range tested in 2020 to determine maximum range and detection efficiency (percent detections of test tag within 100-m intervals) within the maximum range. Range test results will be presented to MRWG members via teleconference and in a USGS Open-file Report. The real-time email alert system will be maintained and updated as necessary to alert key MRWG and ACRCC members of Asian carp detections of interest to those members. Correlation analyses will be conducted to examine relations between nearby harvest and detections on real-time receivers near the mouth of the Kankakee River in the Des Plaines River and at Hanson Material Services gravel pits in the Marseilles Pool of the Illinois River.

2020 Schedule:

1) Database
    - Incorporate new telemetry data with online data upload tools following annual partner reporting/data submission schedule; perform routine database maintenance – *throughout FY 2020*
    - Add and update FishTracks DB functionality:
        a) Optimize database query efficiency; provide API query access to FishTracks DB through R – *complete by June 2020*
        b) Integrate code for summarization of data records and receiver network optimization – *complete by September 2020*
        c) Add database functionality as requested by partners – *throughout FY 2020*
2) Movement model
    - Analyze 2014-2019 telemetry data in FishTracks DB for quality assurance, completeness and movement histories (i.e., dwell time anlaysis) – *complete by July 2020*
    - Estimate movement probabilities and associated uncertainty with the new model and present these results to the Population Workgroup for discussion of data adequacy to inform tagging and monitoring network, and for use with SEAcarP – *complete by September 2020*
3) Real-time receiver network
    - Complete annual deployments and maintenance including range testing of nine real-time receivers in the upper Illinois Waterways system – *complete by September 2020*

- Provide email alerts and monthly summaries to managers regarding Asian carp detections on the real-time receivers to inform contingency actions – *complete by September 2020*
- Conduct correlation analyses of nearby harvest data and real-time detections at two receivers – *complete by September 2020*
- Incorporate real-time receiver data into the FishTracks DB for modeling and visualization – *complete by September 2020*

Deliverables:

1) Database
   - Continually maintained, updated, and accessible FishTracks DB that incorporates new real-time and stationary acoustic telemetry data related to Asian carp
   - Improved quality control, query access, and data summarization functionalities for FishTracks DB; additional database functionality as feasible and requested by partner agencies
2) Movement model:
   - Model: Bayesian multi-state model that estimates movement probabilities and associated uncertainty
   - Presentation: Presentation to Modeling Workgroup on estimated movement probabilities and associated uncertainty with discussion for moving forward with tagging, receiver placement, and SEAcarP modeling
   - Input for SEAcarP: Estimates of movement probabilities and associated uncertainty for parameterizing future SEAcarP modeling
   - Report: Manuscript for scientific journal article on Bayesian multi-state model for estimating movement probabilities of acoustically tagged bigheaded carp.
3) Real-time receiver network
   - Real-timer receiver network with nine real-time receivers in the upper Illinois Waterways system
   - Email alerts and monthly summaries to managers regarding Asian carp detections on the real-time receivers to inform contingency actions
   - Real-time receiver data uploaded to the FishTracks DB for use in modeling and visualization
   - Presentation to Telemetry Workgroup on real-time receiver range testing results and correlation analyses for harvest and real-time detections
   - USGS Open-file report on real-time receiver range testing and correlation analysis results for harvest and real-time detections

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, Illinois

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 Electric Dispersal 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 system currently 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.

(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.

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

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 2019, 25 barrier scans were conducted between February 4 and December 26. Mean fish density within the Electric Dispersal Barrier ranged from 0 to 8 large-fish targets per survey (overall mean ± SD = 1.7 ± 2.2). Mean fish density immediately downstream of the Electric Dispersal Barrier ranged from 0 to 13 large-fish targets per survey (overall mean ± SD = 3.2 ± 3.9). Water volume sampled within the Electric Dispersal Barrier ranged 99,700 to 164,732 m^3 (overall mean ± SD = 120,995 ± 14,798 m^3). Water volume sampled immediately downstream of the barrier ranged from 244,891 to 423,127 m^3 (overall mean ± SD = 327,814 ± 35,209 m^3).

Pool scans were conducted in Brandon Road, Dresden Island, and Lockport Pools during the summer and fall seasons. Fish density was greater in Dresen Island Pool during the summer surveys relative to the densities in Brandon Road and Lockport pools. The greatest fish density was observed during the August survey of Dresden Island Pool. The lowest fish density was observed in during the September survey of Dresden Island Pool. Overall fish density was similar among the three pool during the fall surveys. Barrier and pool scans will continue in 2020.

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 2020 except in Dresden Island Pool during months when Southern Illinois University (SIU) surveys. Data will be obtained from SIU for those Dresden Island surveys to avoid duplicating effort. 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.

2020 Schedule:

- Mobile hydroacoustic fish surveys at the Electric Dispersal Barrier: Biweekly - January 2020 - December 2020, or as needed.
- Mobile hydroacoustic fish surveys in Brandon Road, Lockport, Dresden Island pools: Monthly – January 2020 – November 2020.

Deliverables:

- Biweekly report on fish abundance 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 2019, targeted sampling in support of this project was limited due to obligations requested in support of the newly implemented a Multi-agency Monitoring Long-Term River Monitoring (LTRM) style of sampling under the Illinois River Monitoring and Response project. Approximately 2.5 weeks (compared to 22 weeks in 2018) of targeted effort in the form of fyke net sets and boat electrofishing were expended in the Starved Rock, Marseilles and Dresden Island pools of the Illinois River. No age-0 Asian carp were captured during this effort. As of December 2019, 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:

Since the 1970s, invasive Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*Hypophthalmichthys nobilis*) populations in the Mississippi River basin have been expanding upstream and are established in the Illinois River (Chick and Pegg 2001, Sass et al. 2010). Silver Carp and Bighead Carp pose a significant threat to economically and recreationally valuable fisheries in the Laurentian Great Lakes through competition for limited plankton forage resources (Cooke and Hill 2010). The most probable invasion pathway for Silver Carp and Bighead Carp to enter Lake Michigan is through the upper Illinois Waterway (IWW) including the Chicago Area Waterway System (Kolar et al. 2007). An Electric Dispersal Barrier system, operated by the U.S. Army Corps of Engineers, in Lockport Pool is intended to block the upstream passage of Silver Carp and Bighead Carp through the IWW pathway.

Laboratory tests have shown the Electric Dispersal Barrier system is sufficient at stopping large-bodied fishes from passage (Holliman 2011). However, tests with small Bighead Carp (51-76 mm total length [TL]) have indicated that the operational parameters of the Electric Dispersal Barrier system may be inadequate for blocking passage of small-bodied fishes (Holliman 2011). Moreover, research using Golden Shiners (*Notemigonus crysoleucas*) as a non-invasive surrogate species for juvenile Silver Carp, indicated that small fish can become entrained in barge junction gaps and transported through the Electric Dispersal Barrier system (Davis et al. 2016). Furthermore, research using Dual Frequency Identification Sonar (DIDSON) indicated that small fishes (unknown species) can be transported upstream through the Electric Dispersal Barrier system by return water current created during downstream barge movement. These studies illustrate a vulnerability in the Electric Dispersal Barrier system and some potential mechanisms by which small-bodied Silver Carp and Bighead Carp, if present in the vicinity, could pass upstream through the Electric Dispersal Barrier system. For this reason, there is a need for high spatial- and temporal-resolution monitoring data on the distribution of juvenile Silver Carp and Bighead Carp in the IWW. Additionally, a need is present to understand the reproduction, demographics, and habitat usage of these fishes, in the IWW, so juvenile fish may be targeted for eradication or other management actions.

The objective of this study was to determine the spatial distribution of small Silver Carp and Bighead Carp in the IWW through intensive targeted sampling. For the purposes of this study "small" Silver Carp and Bighead Carp are defined as individuals ≤153 mm TL (6 inches) based on the field limitations of the Electric Dispersal Barrier system (Holliman 2011) as well as discussions within the Monitoring and Response Working Group. Any individuals found smaller than 350 mm TL will be considered juvenile, age 1, based on previously published research on the growth and maturity of Silver Carp and Bighead Carp (Williamson and Garvey 2005). Due to variability in intrapopulation growth rates, it is important to monitor the distribution of juvenile Silver Carp and Bighead Carp as some individuals may represent young fish with accelerated growth. In 2019, sampling techniques included traditional boat electrofishing, mini-fyke nets, and electrified dozer trawl.

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 2020. Sampling conducted in 2019 using boat electrofishing, dozer trawl, and mini-fyke nets caught multiple "small" Silver Carp in Peoria Pool.

Methods:

Sampling site selection will be supplemental to the stratified-random approach of the Multi-agency Monitoring project and will be conducted via "targeted" site sampling. 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*). Sites will be stratified for habitat area and exclude certain zones that are not useable for each gear type deployed. 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 2020:

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.

Seine – The seine used for this project is 3 meters in length and 1 meter deep with 1/8” mesh and a 2 meter 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 occurred. 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.

2020 Schedule:

- February – May 2020: Gear preparation, planning field logistics, and crew scheduling
- June – October 2020: Fish sampling, identification, and data entry
- November – December 2020: Complete fish identification (preserved specimens), data entry, and verification
- December 2020 – January 2021: Data analyses, prepare report and presentation

Deliverables:

Any small Asian carp captured upstream of Starved Rock Pool will be reported immediately to Aaron Woldt (USFWS Assistant Regional Director – Fisheries), Charlie Wooley (USFWS Regional Director – Region 3), and the MRWG. An annual MRWG report and presentation will be provided during the winter of 2020 – 2021. 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.

Larval Fish Monitoring in the Illinois Waterway

Participating Agencies: Illinois Natural History Survey (lead), Eastern Illinois University, Southern Illinois University, U.S. Geological Survey (field and 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 LaGrange; Illinois River tributaries (Kankakee, Fox, Mackinaw, Spoon, and Sangamon Rivers)

Introduction and Need:

Successful reproduction is fundamental to the establishment and spread of invasive species. Understanding the spatial and temporal dynamics of reproduction by invasive fishes can offer insight into the risk of further population expansion, factors influencing recruitment to the population, and the success of control measures. An evaluation of Asian carp reproduction and the distribution of early life stages in different sections of the Illinois Waterway and its tributaries is therefore necessary for understanding Asian carp population dynamics and the impacts of removal efforts on the reproductive potential of Asian carp populations. While egg and larval densities may not be consistent indicators of recruitment strength, successful reproduction is a prerequisite for recruitment. Because of the challenges associated with accurately assessing the abundance of later juvenile stages, standardized monitoring for eggs and larvae may provide rapid, early detection for this essential first step in population renewal. 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 indicate that some reproduction and potential recruitment occurs above Starved Rock Lock and Dam in some years. Due to egg and larval drift, reproduction in upper river pools may also be an important source for recruits in downstream pools, particularly the Peoria Pool. Asian carp spawning also appears to occur in some years in smaller tributary rivers. These systems may provide sources of recruits to basin-wide Asian carp populations, and may offer insight for the suitability of Great Lakes basin tributaries were Asian carp to become established there. Continued monitoring for Asian carp reproduction, particularly in the upper Illinois Waterway, is therefore needed to identify any changes in the leading edge of the reproductive front of Asian carp populations, and to 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 of fish populations are typically 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) Quantify the relationship between Asian carp stock abundance and reproductive output.

Status:

Prior to 2015, Asian carp eggs and larvae were collected from the LaGrange 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 the 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. 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. Tributary sampling has revealed that Asian carp spawning occurs in smaller tributary rivers in some years, particularly in the Sangamon River. The Fox River is the most upstream tributary along the length of the Illinois Waterway where Asian carp eggs have been detected. However, the locations of spawning within these rivers, the conditions associated with reproduction in these systems, and the contribution of these rivers to basin-wide recruitment remain uncertain.

The numbers of eggs and larvae collected during previous study years have been highly variable, with seemingly low reproductive output during 2010-2013, but moderate to high levels of Asian carp reproduction evident during 2014-2019. Juvenile Asian carp abundances have also been extremely variable. Low numbers of Silver Carp juveniles were produced during years with low production of egg and larval stages, but high levels of reproductive output were no guarantee of high recruitment, likely due to prevailing environmental conditions. Understanding how spawning stock density and environmental factors contribute to variation in reproductive output among navigation pools through time will be necessary to predict the level of carp removal that is necessary to diminish the reproductive potential of these species. 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. 2019). 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 intervals during May and June, and biweekly intervals from July to October. At all Illinois Waterway sampling sites, larval fish samples will be collected using a 0.5 meter-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-meter x 0.25-meter, 500 µm mesh) will be used at sites where boat access is restricted. Push net sampling will be conducted similar to mainstem sites, whereas passive drift nets will be deployed for 30 – 180 minute durations, depending on stream flow. Relative abundance of adult Asian carp in tributaries will be estimated using modified Long-Term River Monitoring electrofishing protocols.

Illinois Waterway ichthyoplankton samples will be assessed for the presence of species-specific Asian carp DNA derived from eggs or larvae. Potential presence of adult carp DNA will be removed by exchanging sample ethanol with fresh molecular-grade ethanol. Samples will be gently inverted in the refreshed ethanol, and aliquots of sample preservative will be removed to screen for the presence of DNA derived from Asian carp eggs or larvae. Following DNA extraction, DNA assays for the four taxa of invasive carps will be run in multiplex reactions, following quantitative PCR (qPCR) methodology. Samples will be run in triplicate with a dilution series and no-template controls. The lowest concentration of DNA distinguishable from the control and at which coefficient of variation of estimated copy number is 20% or less will be quantified. Samples with species-specific DNA copy numbers above a given threshold (Fritts et al. 2019) will be considered to have a high probability of containing eggs or larvae of that species of Asian carp. The relationship between DNA copy number and the number of Asian carp eggs and larvae in a sample will also be further assessed following microscopic identification of all specimens.

In the laboratory, fish eggs and larvae will be separated from other materials, and all larval fish will be identified to the lowest possible taxonomic unit. Fish eggs will be separated by size, with all eggs having a membrane diameter larger than 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 (estimated from hydroacoustic surveys in each Illinois Waterway navigation pool and from electrofishing surveys in tributary rivers) 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 identify spawning locations and zones of larval settlement.

2020 Schedule:

During 2020, larval fish sampling will occur at weekly intervals at all sites during May and June, and at biweekly intervals from 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). Changes to this proposed sampling schedule may arise from restrictions on travel due to the COVID-19 pandemic. All efforts will be expended to conduct all sampling that is possible during 2020 while following all legal requirements and exercising an abundance of caution regarding staff and community health concerns.

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 partners. Results from qPCR assays will potentially be available within days of sample collection, and the likelihood of recent to current spawning by specific Asian carp species will be communicated to MRWG partners following qPCR runs. Locations of Asian carp spawning based on FluEgg 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

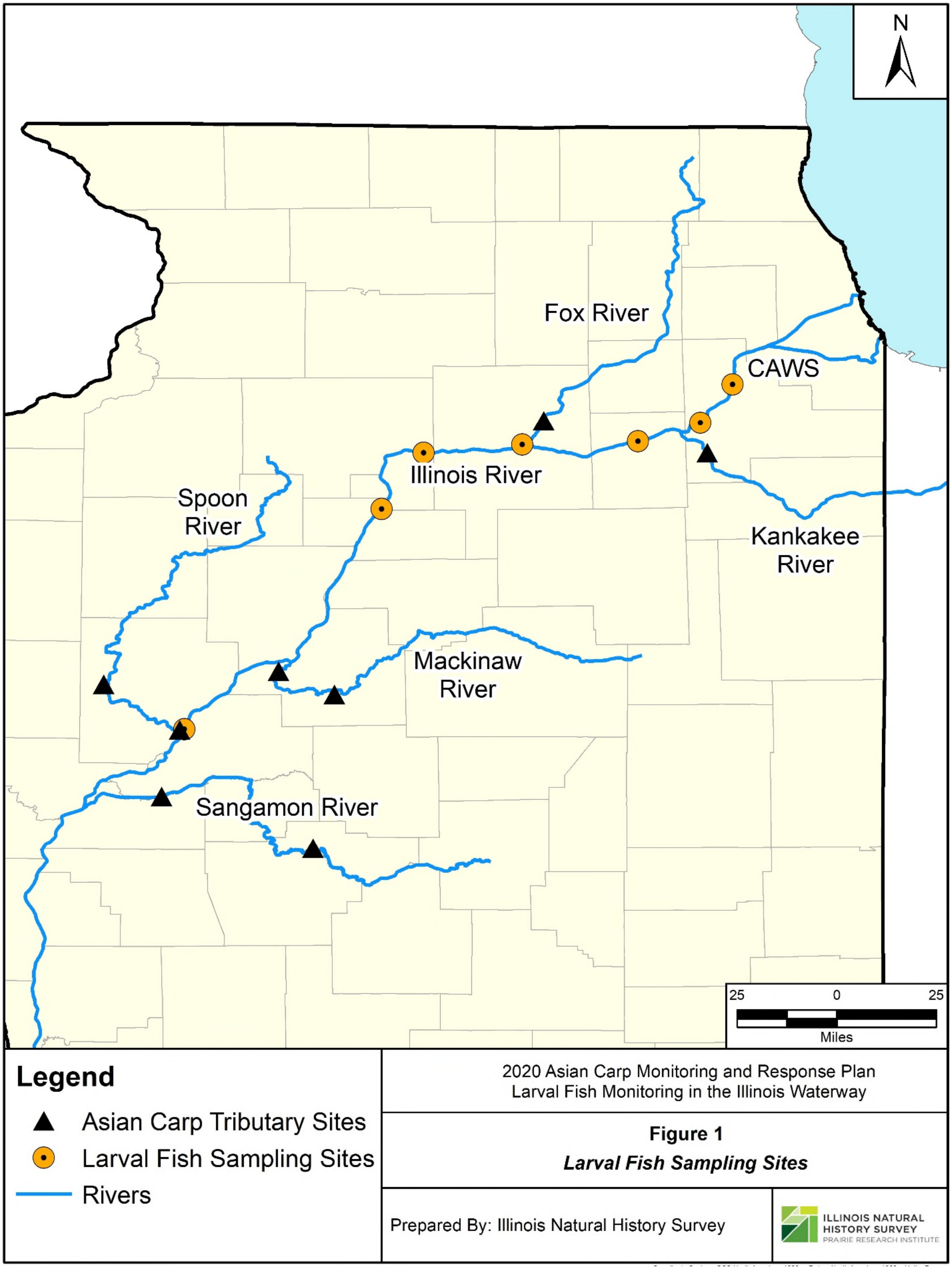

Figure 1. *Map of larval fish sampling sites in the Illinois Waterway (circles) and in tributary rivers (triangles).*

Movement and Density of Bigheaded Carp in the Illinois River

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

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

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

Introduction and Need:

Management goals for bigheaded carp in the Illinois River focus on limiting upstream dispersal through monitoring, assessing movement barriers, and reducing abundance through contracted harvest. Bigheaded carp spatial distributions vary 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.

Movement and Density of Bigheaded Carp in the Illinois River

While annual monitoring provides a snapshot to document long-term trends in bigheaded carp abundance, seasonal surveys can be used to help improve removal by identifying and directing harvest efforts to high-density locations. Dresden Island Pool represents the current population front for the adult bigheaded carp invasion in the Illinois River, while Marseilles Pool is the most upstream pool where young-of-year have been found. Frequent hydroacoustic surveys of bigheaded carp densities in these pools will identify locations where bigheaded carp aggregate to inform harvest, and determine whether or not these seasonal high-density hotspots remain in the same location each year.

The spatially-explicit population model of bigheaded carp in the Illinois River (SEAcarP) assesses how bigheaded carp populations respond to a variety of management actions (e.g., location and intensity of harvest; location and effectiveness of deterrent technologies). This model draws on a wide variety of data collected by different agencies including bigheaded carp densities and movement data 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), and 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 continue to partner with USACE to exploit SIU's existing acoustic telemetry tags in bigheaded carp near Starved Rock Pool and their stationary receiver array.

Objectives:

(1) Quantify Asian carp densities every other month in Dresden Island and Marseilles pools in 2020 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.

(2) Conduct hydroacoustic surveys at standardized sites in fall 2020 from Alton – Dresden Island pools to assess long-term trends in density and biomass.

(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.

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 size structure 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 continue work started in 2019.

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 2020 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 (8 years as of 2019) dataset. Such data are essential to fully understand population dynamics, especially when biotic (e.g., annual variability in recruitment success) and abiotic (e.g., drought, flood years) processes fluctuate through time.

Telemetry data to update pool-to-pool transition probabilities

The existing acoustic telemetry array of 65+ stationary receivers will be maintained and downloaded on two occasions in 2020. Additional acoustic telemetry tags (100 total tags) will be deployed by SIU in LaGrange and Alton pools (50 tags per pool), 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. Total numbers of tags in LaGrange and Alton pools will total 100 by the end of 2020. 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 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 (25+) around Starved Rock Lock and Dam and within Starved Rock Pool. This study will also utilize previously tagged bigheaded carp and Common Carp in this area to compare the movements and habitat use of bigheaded carp and Common Carp. Common Carp are the most common species tagged as a surrogate for bigheaded carp by USACE above Brandon Road Lock and Dam. This study began in 2019 and will continue through 2020. Up to 50 Common Carp will be tagged in 2020, in addition to 50 Common Carp already tagged in 2019 and tagged bigheaded carp already at large in Starved Rock Pool.

2020 Schedule:

Bi-monthly hydroacoustic surveys will be conducted in the Marseilles and Dresden Island pools from March through November 2020, weather permitting. In addition, annual hydroacoustic surveys will occur in the Alton, LaGrange, Peoria, and Starved Rock pools during October of 2020. Telemetry stationary receivers will be downloaded two times during 2020, once between April – June and once in November. Tagging of bigheaded carps in LaGrange, and Alton pools and of surrogate fish near Starved Rock Lock and Dam will occur in May 2020 with possible additional tagging in September – November 2020.

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 that visually display Asian carp densities 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 2020 densities to densities from the previous eight years.

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

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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 young-of-year 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.

Status:

This project has been conducted since 2017. Field efforts in 2019 resulted in the tagging of 37 juvenile Silver Carp tracked using nine radio monitoring stations and 19 hydro-acoustic receivers. A sum of 190 fishes from 2017, 2018, and 2019 have been tagged. 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 2019 are still being analyzed and can be expected in the 2019 ISR. This project in its current form will conclude in 2020 and transition towards providing greater support of juvenile telemetry within the SEAcarP model framework; as has been requested by the MRWG Telemetry Workgroup.

Methods:

In 2020, no additional juvenile Silver Carp will be tagged in support of this project's objectives. Instead, USFWS staff will focus on maintaining and retrieving telemetry equipment associated with tracking the active tags that remain in Peoria Pool from previous year's tagging efforts. Data from the entirety of the project's duration will be analyzed and summarized in a report to the MRWG in 2020. Moreover, USFWS staff will explore the potential for tagging Asian carp as small as 200 mm TL with 69 kHz acoustic tags for tracking via the interagency telemetry array and enable for parameterizing the SEAcarP model with juvenile Asian carp movement data.

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 absorbable, antibacterial 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.

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

2020 Schedule:

- January - February 2020: Planning field work, crew scheduling, deployed gear maintenance and download, active tracking
- March - November 2020: Fish tagging, deployed gear maintenance and download, active tracking, range testing
- November 2020- February 2021: Retrieve all deployed gear; data analysis and final report preparation

Deliverables:

Results from this study will be used to inform small Silver/Bighead carp monitoring efforts throughout 2020 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 MRWG final report during winter 2020-2021 as well a scientific paper publication and presentation.

Des Plaines River and Overflow Monitoring

Participating Agencies: USFWS-Carterville Fish and Wildlife Conservation Office Wilmington Substation (lead), and USACE Chicago District

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 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. Opportunities for fish to pass occurred during high discharge events in 2011 and 2013 when water breached the physical barrier. USACE reinforced these and other low-lying areas to prevent scouring during future lateral water transfers. These reinforcements withstood high flow events in 2017 and 2019. 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 for Bighead and Silver carp populations in the Des Plaines River above the confluence with the CSSC.

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

(3) Monitor for Bighead and Silver carp eggs and larvae around the physical barrier when water moves laterally from the Des Plaines River into the CSSC.

Des Plaines River and Overflow Monitoring

Status:

This project began in 2011 and is ongoing. Between 2011 and 2019, 12,776 fish have been collected via electrofishing (73 hours) and gill netting (23,684 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 2020 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.

2020 Schedule:

- Three sampling events will be conducted from pre-spawn to post-spawn periods.

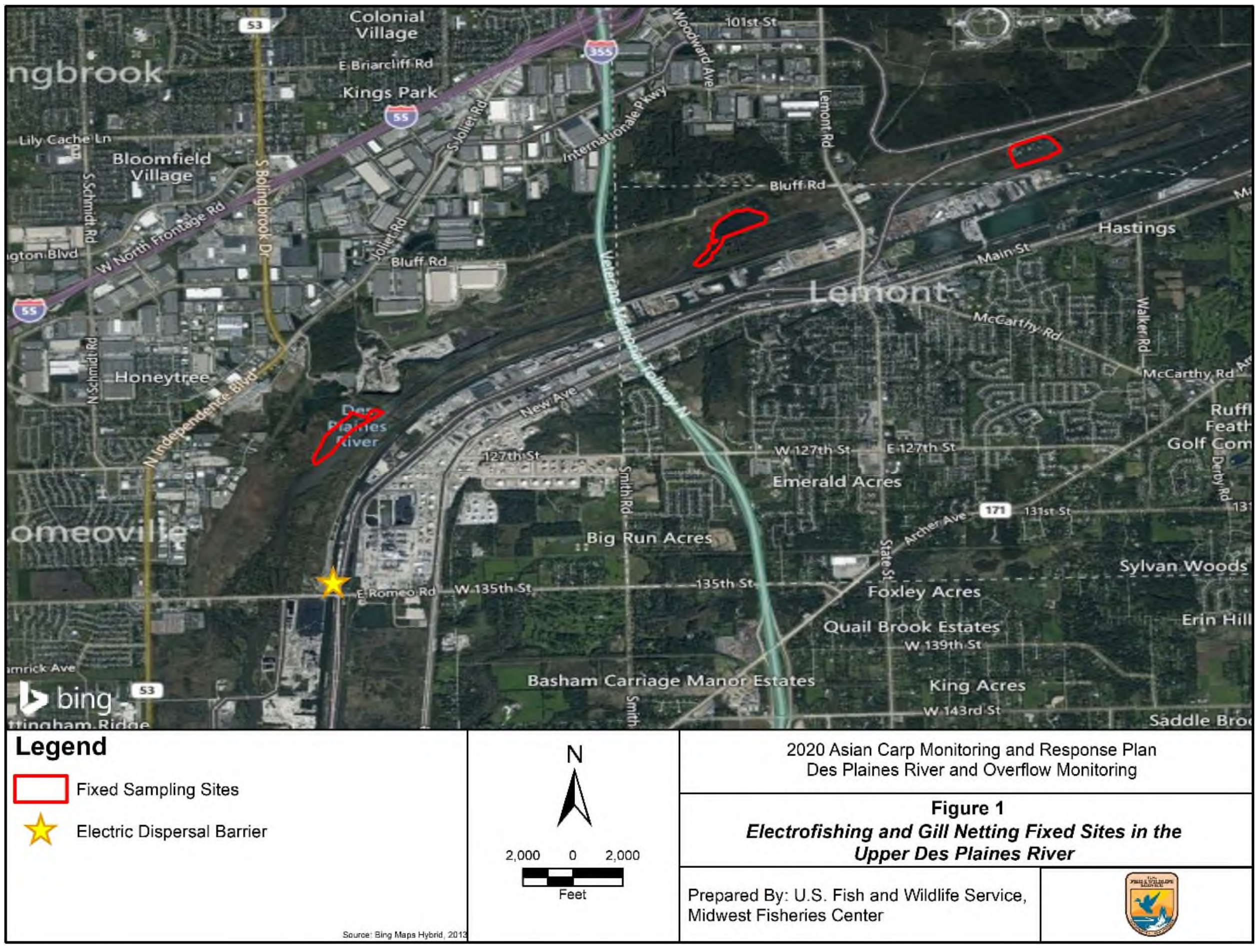

Figure 1. *Fixed site areas for electrofishing and gill netting in the upper Des Plaines River.*

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 lbs]) 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, 10 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 mi). The distance from these ponds to the Chicago Area Waterway System (CAWS) upstream of the Electric Dispersal Barrier ranges from 0.02 to 23.3 km (0.01 to 14.5 mi). Although some ponds are located near Lake Michigan or the CAWS, most are isolated and have no surface water connection to Lake Michigan or CAWS upstream of the Electric Dispersal Barrier. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively. Gompers Park never had a report of 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 mi). The distance from these ponds to the CAWS upstream of the Electric Dispersal Barrier ranges from 0.05 to 7.6 km (0.03 to 4.7 miles). The lake at Harborside International Golf Course has surface water connectivity to the CAWS. However, no 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 44 Bighead Carp and one Silver Carp have been removed from 10 ponds. 58 hours of electrofishing and 13 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 35 Bighead Carp removed from five ponds since 2011. Additionally, eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. Lastly, one Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield Park 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. 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 2019 interim summary report document (MRWG 2018).

Methods:

Sampling Protocol

Trammel and gill nets used are approximately 3 m (10 feet) deep x 91.4 m (300 feet) long in bar mesh sizes ranging from 88.9 – 108 mm (3.5 – 4.25 inches). Multiple nets will be set simultaneously to increase the likelihood of capturing fish. Electrofishing, along with pounding on boats and revving trimmed up motors, will be used to drive fish from both shoreline and open water habitats into the nets. Upon capture, 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.

2020 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.

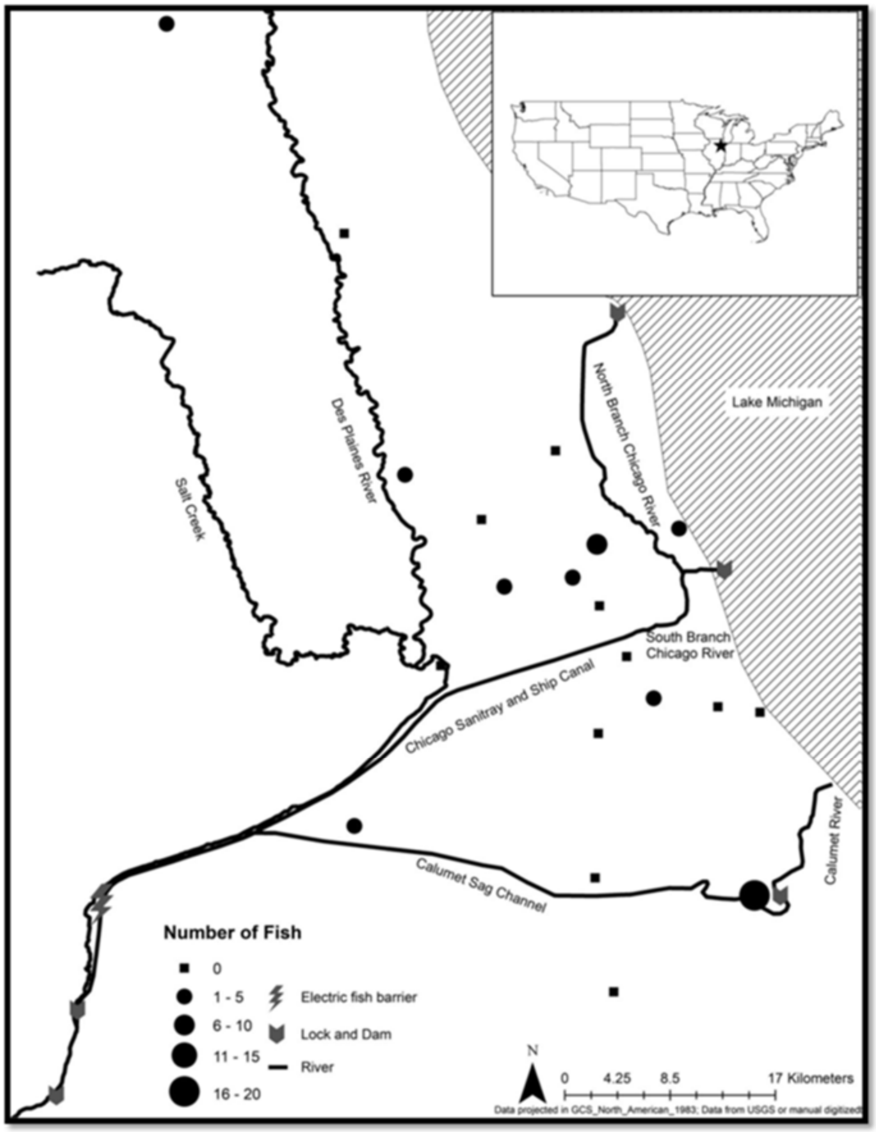

Figure 1. *Chicago area fishing ponds from which Asian carp have been removed and those from which no Asian carp have been collected or reported.*

Multiple Agency Monitoring of the Illinois River for Decision Making

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

Location: The Multiple Agency Monitoring of the Illinois River for Decision Making will include data from Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock and Peoria pools of the Illinois River below the Electric Dispersal Barrier (Figure 1).

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

Introduction and Need:

Detection and monitoring of Asian carp (Bighead Carp, Black Carp, Grass Carp and Silver Carp) below the Electric Dispersal Barrier system is pertinent for understanding the threat of expansion into Lake Michigan and effectively controlling their spread. Surveillance is particularly important in pools deemed the most upstream expanse for each Asian carp species with Bighead Carp and Silver Carp being within the Dresden Island Pool, Grass Carp being in the Chicago Area Waterway, and Black Carp being in the Peoria Pool. A standardized, multiple gear approach has proven useful for detecting populations of Asian carp (Ickes et al. 2005) and monitoring their relative abundance (Irons et al. 2011). Additionally, this multiple gear approach can provide information on non-target species such as abundance and condition (Love et al. 2017, Irons et al. 2007), recruitment (DeBoer et al. 2018), and fish community structure (Solomon et al. 2016), providing additional lines of evidence about the presence and impact of Asian carp. Therefore, there is value in monitoring pools downstream of the Electric Dispersal Barrier system (Lockport – Peoria pools) using a standardized, multiple gear sampling approach. Doing so will allow for an accurate, comparable, and representative understanding of Asian carp distribution and their relative abundance to be determined, along with being able to begin to evaluate the potential impacts of Asian carp on the native fish community.

Objectives:

(1) Monitor the geographic distribution and relative abundance of adult and juvenile Asian carp populations in pools below the Electric Dispersal Barrier system downstream to Peoria Pool.

(2) Provide comparable data capable of detecting spatial and temporal changes in the Asian carp population and native fish community throughout the entire Illinois River Waterway between the Electric Dispersal Barrier system and Peoria Pool.

(3) Provide other projects (i.e., Contracted Asian Carp Removal, Telemetry Monitoring, SEAcarP model, etc.) with necessary Asian carp demographic and fish community data to inform management decisions.

Multiple Agency Monitoring of the Illinois River for Decision Making

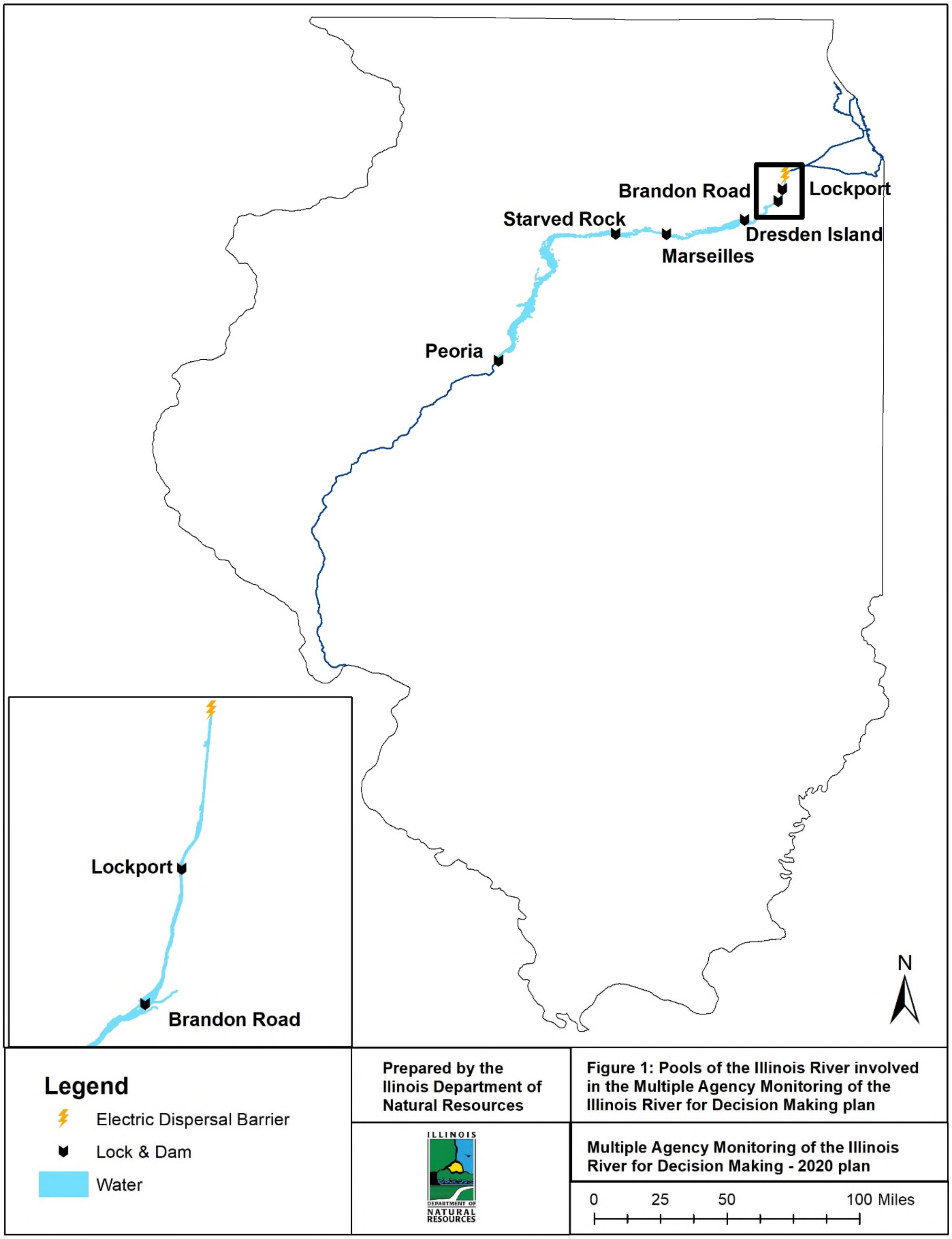

Figure 1. *Map of the sampling reaches of the Illinois River below the Electric Dispersal Barrier to the confluence of the Upper Mississippi River involved in the Multiple Agency Monitoring of the Illinois River for Decision Making plan: Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock,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

Multiple Agency Monitoring of the Illinois River for Decision Making

Status:

Much of the Illinois River has been monitored in some fashion by multiple agencies for decades. The U.S. Army Corps of Engineers' Upper Mississippi River Restoration program (Gutreuter *et al.* 1995, Ratcliff *et al.* 2014) has been sampling the LaGrange Reach of the Illinois River with a standardized, multiple gear monitoring approach since 1994. The Long-term Survey and Assessment of Large-River Fishes in Illinois (LTEF; formerly, Long-term Electrofishing project) has sampled the main channel border of the Dresden Island, Marseilles, Starved Rock, Peoria, and Alton pools since 1959 transitioning to the LTRM electrofishing protocol in 2009 (Fritts *et al.* 2017). Those time-tested protocols have been utilized in the Multiple Agency Monitoring of the Illinois River for Decision Making since 2019 to detect and monitor Asian carp populations within Lockport to Peoria pools of the Illinois River Waterway. Standardization among projects allows data from each project to be incorporated into a single comprehensive dataset providing a holistic understanding of Asian Carp presence and abundance within the Illinois Waterway.

Methods:

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

Collected fish will be identified to species, measured, and categorized into 10 mm total lengths groups signified by their lower length boundary. Sampled Asian carp will be measured to total length (nearest mm), their sex assigned, and maturity status determined. In addition to length measurements, weight data from all Asian carp individuals greater than or equal to 100 mm and at least three individuals per 10-mm length group greater than or equal to 100 mm from of all other species will be collected during Autumn sampling (September 16 – October 31). A subsample of weighed Asian carp (10 individuals of each sex per 50 mm length group; per pool) will have their pectoral fin ray, lapilli otolith, postcleithra, and dorsal spine removed for age estimation.

Specimens that cannot be identified to species in the field will be placed in plastic containers, preserved with 10% formalin or 95% alcohol, labeled with location code, pool/reach, start date and time, gear code, and stratum code. Preserved specimens will be identified, measured, enumerated and recorded in the laboratory as time permits. Any specimen identified to a species that has not been found previously within the Illinois River or is recognized as state threatened or endangered should be photographed or be vouchered.

Multiple Agency Monitoring of the Illinois River for Decision Making

Historically sampled fixed sites, upstream of the known Asian carp invasion front within Brandon Road Pool and Lockport Pool, will also be sampled with DC electrofishing (Appendix D). Fixed sites will be sampled every other week during March through November, providing a higher frequency and lengthier temporal range than the randomized sampling design. This approach provides additional opportunities to detect whether Asian carp are present near the Electric Dispersal Barrier system in periods outside of the standard sampling window, as well as maintain the collection of historic trend data.

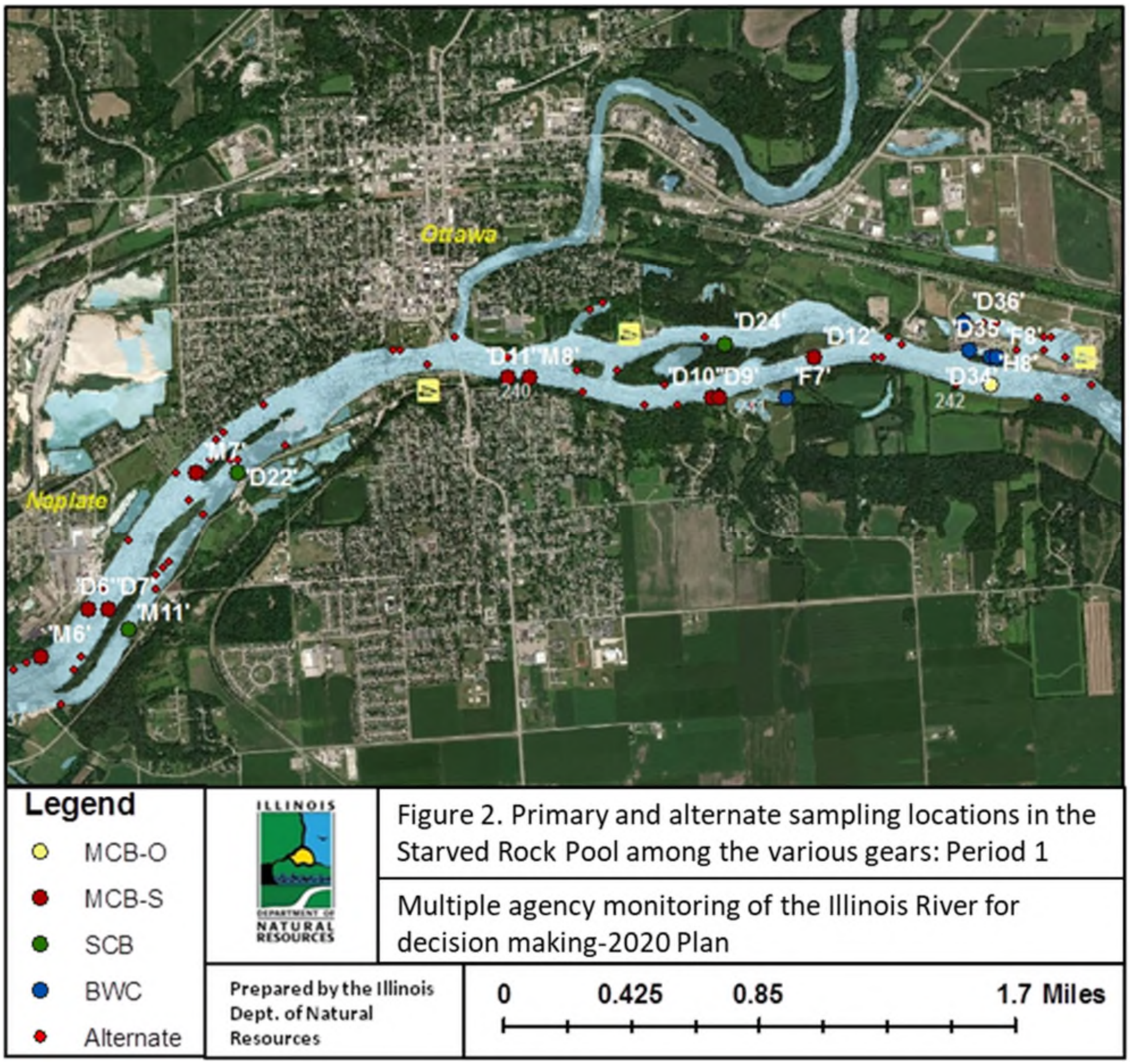

Figure 2. *Minnow fyke net ('M'), Daytime electrofishing ('D'), Paired Hoop Net ('H'), and Fyke net ('F') stratified random sampling locations: main channel border (MCB), side channel border (SCB), and backwater (BWC) habitats with alternate locations in the Starved Rock Pool of the Illinois River for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

Data Management and Deliverables:

Collected data will be recorded in a standardized Microsoft Access data entry application. Catch and effort data will be preliminarily summarized by each participating agency following the completion of each 6 week period and sent to the Monitoring and Response Working Group Monthly Summary assembler to be posted to https://asiancarp.us/PartnerResources.html. Finalized sampling and fish data collected by each agency will be submitted to the USGS Upper Midwest Environmental Sciences Center by November 28th using the online portal. Following submission, data will be appended into a single database, summarized for an annual interim report and accessible to Monitoring and Response Working Group members upon request from the database curator.

2020 Schedule:

- Sampling coordination: January 1 to June 14
- Sampling techniques workshop: May 28
- Period 1 sampling: June 15 to July 31
- Period 1 summary: August 14
- Period 2 sampling: August 1 to September 15
- Period 2 summary: September 30
- Period 3 sampling: September 16 to October 31
- Period 3 summary: November 15
- Data quality assurance and summarization: November 1 to November 24
- Data upload: November 28

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Table 1. *Electrofishing effort by agency and project type among each 6-week time period among habitat strata within the pools of the Illinois River below the Dispersal Barrier. Strata sampled include main channel border (MCB), side channel border (SCB), and backwater (BWC). Participating agencies and projects include Illinois Department of Natural Resources Havana (IDNR-H), Illinois Department of Natural Resources Yorkville (IDNR-Y), Illinois Natural History Survey Great Rivers Fields Station Long Term Survey and Assessment of Large River Fishes in Illinois (GR-LTEF), Illinois Natural History Survey Great Rivers Fields Station Long Term Resource Monitoring (GR-LTRM), Illinois Natural History Survey Illinois River Biological Station Asian Carp (IRBS-BSH), Illinois Natural History Survey Illinois River Biological Station Black Carp (IRBS-BC), Illinois Natural History Survey Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM), Illinois Natural History Survey Illinois River Biological Station Long Term Survey and Assessment of Large River Fishes In Illinois (IRBS-LTEF), United States Fish and Wildlife Service (USFWS), United States Army Corps of Engineers (USACE).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton	MRWG Project
MCB									
GR-LTEF								15	No
IRBS-LTEF			3	6	3	15			No
IRBS-LTRM							12		No
IRBS- BSH					4				Yes
USFWS				5	4				Yes
IDNR-H									No
IDNR-Y	4	4	8						Yes
USACE	8	8							Yes
Total	12	12	11	11	11	15	12	15	
SCB									
IRBS-LTRM							12		No
IRBS-BC						15			Yes
USFWS				6	12				Yes
IDNR-H								2	No
IDNR-Y			4	6					Yes
GR-LTRM								1	No
IRBS-BSH								9	Yes
Total	0	0	4	12	12	15	12	12	
BWC									
IRBS-LTRM							12		No
IRBS-BC						15			Yes
USFWS					12				Yes
IDNR-H									No
IDNR-Y	3		8	8					Yes
USACE									Yes
IRBS-BSH									Yes

Table 1. *Electrofishing effort by agency and project type among each 6-week time period among habitat strata within the pools of the Illinois River below the Dispersal Barrier. Strata sampled include main channel border (MCB), side channel border (SCB), and backwater (BWC). Participating agencies and projects include Illinois Department of Natural Resources Havana (IDNR-H), Illinois Department of Natural Resources Yorkville (IDNR-Y), Illinois Natural History Survey Great Rivers Fields Station Long Term Survey and Assessment of Large River Fishes in Illinois (GR-LTEF), Illinois Natural History Survey Great Rivers Fields Station Long Term Resource Monitoring (GR-LTRM), Illinois Natural History Survey Illinois River Biological Station Asian Carp (IRBS-BSH), Illinois Natural History Survey Illinois River Biological Station Black Carp (IRBS-BC), Illinois Natural History Survey Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM), Illinois Natural History Survey Illinois River Biological Station Long Term Survey and Assessment of Large River Fishes In Illinois (IRBS-LTEF), United States Fish and Wildlife Service (USFWS), United States Army Corps of Engineers (USACE).*

Total	3	0	8	8	12	15	12	12	

Table 2. *Fyke net effort by agency and project type among each 6-week time period among habitat strata within the pools of the Illinois River below the Dispersal Barrier. Strata sampled include backwater (BWC). Participating agencies and projects include Illinois Department of Natural Resources Havana (IDNR-H), Illinois Natural History Survey Illinois River Biological Station Asian Carp (IRBS-BSH), Illinois Natural History Survey Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton	MRWG Project
BWC									
IRBS-LTRM						10	10		No
IRBS-BSH			5	5	5				No
IDNR-H									No
Total	0	0	5	5	5	0	10	0	

Table 3. *Minnow fyke net effort by agency and project type among each 6-week time period among habitat strata within the pools of the Illinois River below the Dispersal Barrier. Strata sampled include main channel border (MCB), side channel border (SCB), and backwater (BWC). Participating agencies and projects include Illinois Department of Natural Resources Havana (IDNR-H), Illinois Department of Natural Resources Yorkville (IDNR-Y), Illinois Natural History Survey Great Rivers Fields Station Long Term Resource Monitoring (GR-LTRM), Illinois Natural History Survey Illinois River Biological Station Asian Carp (IRBS-BSH), Illinois Natural History Survey Illinois River Biological Station Black Carp (IRBS-BC), Illinois Natural History Survey Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM), United States Fish and Wildlife Service (USFWS).*

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock	Peoria	La Grange	Alton	MRWG Project
MCB									
IRBS-LTRM							8		No
IRBS-BC									Yes
USFWS				8	8	8			Yes
IDNR-H								6	No
IDNR-Y	8	8	8						Yes
GR-LTRM								1	No
IRBS-BSH								1	Yes
Total	8	8	8	8	8	8	8	8	
SCB									
IRBS-LTRM							6		No
IRBS-BC									Yes
USFWS				6	6	6			Yes
IDNR-H								1	No
IDNR-Y		6	6						Yes
IRBS-BSH								5	Yes
Total	0	6	6	6	6	6	6	6	
BWC									
IRBS-LTRM							10		No
IRBS-BC									Yes
USFWS				10	10	10			Yes
IDNR-H									No
IDNR-Y		10	10						Yes
IRBS-BSH									Yes
Total	0	10	10	10	10	10	10	10	

Table 4. *Paired hoop net effort by agency and project type among each 6-week time period among habitat strata within the pools of the Illinois River below the Dispersal Barrier. Strata sampled include main channel border (MCB) and side channel border (SCB). Participating agencies and projects include Illinois Department of Natural Resources Havana (IDNR-H), Illinois Department of Natural Resources Yorkville (IDNR-Y), Illinois Natural History Survey Great Rivers Fields Station Long Term Resource Monitoring (GR-LTRM), Illinois Natural History Survey Illinois River Biological Station Asian Carp (IRBS-BSH), Illinois Natural History Survey Illinois River Biological Station Black Carp (IRBS-BC), Illinois Natural History Survey Illinois River Biological Station Long Term Resource Monitoring (IRBS-LTRM), United States Fish and Wildlife Service (USFWS).*

	Lockport	**Brandon Road**	**Dresden Island**	**Marseilles**	**Starved Rock**	**Peoria**	**La Grange**	**Alton**	**MRWG Funded**
MCB									
IRBS-LTRM							8		No
IRBS-BC					8	8			Yes
USFWS			8	8					Yes
IDNR-H								4	No
IDNR-Y	8	8							Yes
GR_LTRM								2	No
IRBS-BSH								2	Yes
Total	8	8	8	8	8	8	8	8	
SCB									
IRBS-LTRM							6		No
IRBS-BC					6	6			Yes
USFWS			6	6					Yes
IDNR-H								1	No
IRBS-BSH								5	Yes
Total	0	0	6	6	6	6	6	6	

MANAGE AND CONTROL PROJECTS

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

Location: Illinois River Waterway system

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

Introduction and Need:

Asian carp monitoring and contracted removal will continue throughout the Upper Illinois Waterway system as needed for adaptive management to mitigate, control, and contain Asian carp. Compiling data from monitoring and removal efforts into a centralized database (Illinois River Catch Database application) facilitates data standardization, quality, accessibility, sharing, and analysis to aid in Asian carp removal efforts, evaluations of management actions, and modeling efforts (e.g., SEAcarP model). Data summarization, visualization, and modeling supports a better understanding of bigheaded carp life history, behavior, and habitat use. Integrating Asian carp-related data and analyses into decision support tools and products aids in applying control and containment methods in an informed and transparent manner (e.g., improved efficiencies in implementations of the Unified Method, inform targeted removal efforts or deterrent deployments in key locations based on preferential benthic characteristics and environmental conditions).

Objectives:

Provide data, informational products, and decision support tools to aid and inform the management, control, and removal of bigheaded carp in the Upper Illinois River waterway system.

(1) Maintain and develop the Illinois River Catch Database (ILRCdb) application and new catch data from the Upper Illinois Waterway to compile multi-agency Asian carp monitoring and removal data in a standardized repository to facilitate data summarization, visualization, and modeling among partner agencies.

(2) Provide geospatial support for Unified Method fishing events and generate overview and animated visualizations of the fishing event, incorporating catch records and bigheaded carp movement from telemetry data, to assess efficiencies for maximizing future removal operations.

(3) Validate benthic classification system developed using high-resolution hydroacoustic data from priority removal areas of the Illinios River to integrate environmental variables with decision support tools (objective 4) to further understanding of bigheaded carp life history and other factors that might influence the efficacy and efficiency of removal or control management approaches.

(4) Integrate data, informational products, and decision support tools in a centralized location (e.g., as web mapping services and applications) for management agencies to access and utilize Asian carp-related data and tools to inform removal efforts and other management actions.

Status:

The Illinois River Catch Database (ILRCdb) application, which contains queryable, downloadable catch data and customized data reports for the Illinois River, has been developed, deployed, and released to partners. The ILRCdb provides centralized access to standardized monitoring and removal data to facilitate data sharing, use, and analysis among partner agencies to aid in Asian carp removal efforts. Automated monthly reporting features have been updated, standardized data requirements are being utilized during the data collection process, and data quality assurance checks are implemented during the data upload process.

Equipment requirements, deployment techniques, and a methodology for collecting time-stamped GPS tracking and activity data from boats and gear deployments during Unified Method fishing events have been developed. Compiling these data into summarized time-elapsed visualizations provides an assessment of a Unified Method fishing event's successes and incorporating telemetry and catch data provides information on fish movement relative to fishing activities and quantifies both Asian carp and by-catch data.

Benthic classification layers have been developed and are being validated using previously collected high-resolution hydroacoustic data from priority removal areas of the Illinois River Waterway system (Brandon Road, Dresden Island, Marseilles, Starved Rock, and Peoria pools).

Benthic classification data layers, telemetry and catch data records from database applications, other environmental variables (e.g., water conditions, classified aquatic areas), and analysis tools are being integrated into an online, centralized location for researchers and managers to access and utilize Asian carp-related data and applications. Access to existing database applications and Asian carp-related data layers (available as web mapping services in map viewer applications) provides a platform for sharing, integration, and analysis of datasets collected by the multi-agency partnership. Decision support tools, including monthly catch reports by pool, web mapping services of Asian carp-related data layers, interactive spatial and temporal analysis of catch data, and tools to geographically query areas of similar environmental conditions and benthic habitat characteristics can be used to further the understanding of bigheaded carp life history and inform an adaptive management approach.

Methods:

The ILRCdb application (developed in PostgreSQL) is being actively maintained, which involves performing routine database maintenance (e.g. ensuring data backups, performing internal consistency checks, rebuilding indexes as needed, etc.) to keep the application online and available to users. New catch and monitoring data collected by partner agencies is loaded into the ILRCdb after passing quality assurance checks for data consistency (i.e., standardized formatting of data, etc.). Updates and additions will be made to ILRCdb functionality, based on partner requests (e.g., customized monthly, quarterly, or annual reports based on specific monitoring or management needs) as time allows.

A method for collecting GIS-ready data on boats, gear deployments, and catch locations during Unified Method fishing events has been developed and will be refined as necessary to minimize spatial and temporal gaps for increased data accuracy and standardization. An individual dedicated solely to geospatial data collection is used during Unified Method events to deploy and monitor GPS-tracking devices, assess geospatial data collected after each day's removal efforts to ensure proper data collection, and troubleshoot any technical issues encountered during data collection. Standardized, time-stamped geospatial data collected during events are post-processed into overview and animated visualizations in a GIS environment. Data are downloaded from GPS-tracking devices, reformatted, and loaded into a GIS (i.e., Esri ArcScene, ArcGIS Pro), along with both telemetry and catch data. Animated visualizations that show the movement of boats and gear deployments in relation to telemetered fish movement and catch events, in the context of high-resolution bathymetry data (if available for the area), are then created. Visualizations can be evaluated to identify areas and times where coordination of boat and nets were the most or least effective, for lessons learned to increase effectiveness of future Unified Method events.

Hydroacoustic and sonar data previously collected in the Illinois River using high-resolution sonar equipment (including multibeam and side scan sonar) are being processed into benthic classification layers that characterize Asian carp habitats using GIS and object-based image analysis software. These benthic classifications (e.g., landform and substrate classification) are being validated using additional ground-sampling data (using a statistically valid random sampling design). These benthic classification data layers will be incorporated (as web mapping services) into analyzes and decision support tools aimed to further the understanding of Asian carp life history, behavior, and distribution.

An online platform for Asian carp-related data, informational products, and decision support tools is being developed to provide a framework for researchers and managers to access these data and tools. Tools within the platform include programmatic/API access to directly query data from the FishTracks Telemetry Database and ILRCdb applications, serving benthic classification data layers as web mapping services incorporated into map viewer applications, interactive spatial and temporal analysis of Asian carp catch data records (based on kernel density estimations) to investigate the distribution of catch data over time in relation to other environmental conditions (e.g., water temperature, discharge), and tools to geographically query areas with similar conditions to user-defined locations or specific catch locations based on data from the ILRCdb. Incorporated data and tools aim to inform targeted removal efforts or deterrent deployments based on a better understanding of Asian carp preferential habitat types and environmental conditions through the integrated analysis of datasets collected by the multi-agency partnership.

USGS Illinois River Monitoring and Evaluation

2020 Schedule:

- Incorporate new catch data from partner agencies into ILRCdb; perform routine database maintenance; add and update functionality as requested by partners – *throughout FY 2020*
- Provide geospatial support for data collection during for Unified Method events (Dresden Island fall of 2019 and other events, as needed); utilize method to post-process data into overview and animated visualizations for post-event agency review – *complete by end of FY 2020*
- Apply and validate benthic classification system to previously collected and processed high-resolution hydroacoustic data from high priority removal areas of the Illinois River Waterway system; incorporate benthic data layers as web mapping services into decision support tools – *complete by end of FY 2020*
- Integrate Asian carp-related data (telemetry and catch data), informational products, and decision support tools into a centralized, online platform – *throughout FY 2020*

Deliverables:

(1) Database Application: Continually maintained, updated, and accessible ILRCdb, incorporating new catch data as it is collected and submitted by partner agencies.

(2) Data & Data Analysis/Visualization Tool: Methodology for GPS-tracking and fishing activity data collection during Unified Method events and series of overview and animated GIS visualizations showing coordination of fishing activity in relation to telemetered fish movement and catch locations.

(3) Data: Benthic classification data layers (i.e., landform classification, substrate) for high priority removal areas of the Illinois River Waterway system, in a GIS-ready format with applicable metadata and available as web mapping services.

(4) Data Analysis/Visualization Tool: Online platform for reseachers and managers to access Asian carp-related data, informational products, and decision support tools.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

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

Location:

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

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

Introduction and Need:

The Contracted Commercial Fishing Below the Electric Dispersal Barrier project uses contracted commercial fishers to reduce Asian carp (Bighead Carp, Silver Carp, Grass Carp, and Black Carp) relative abundance and monitor for their expansion in the upper Illinois River and lower Des Plaines River downstream of the Electric Dispersal Barrier. By decreasing Asian carp relative abundance, we anticipate reduced migration pressure towards the Electric Dispersal 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, distribution, and movement between and among pools of the Illinois Waterway.

Objectives:

(1) Monitor for the presence of Asian carp in the five pools (Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock) 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 System 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.

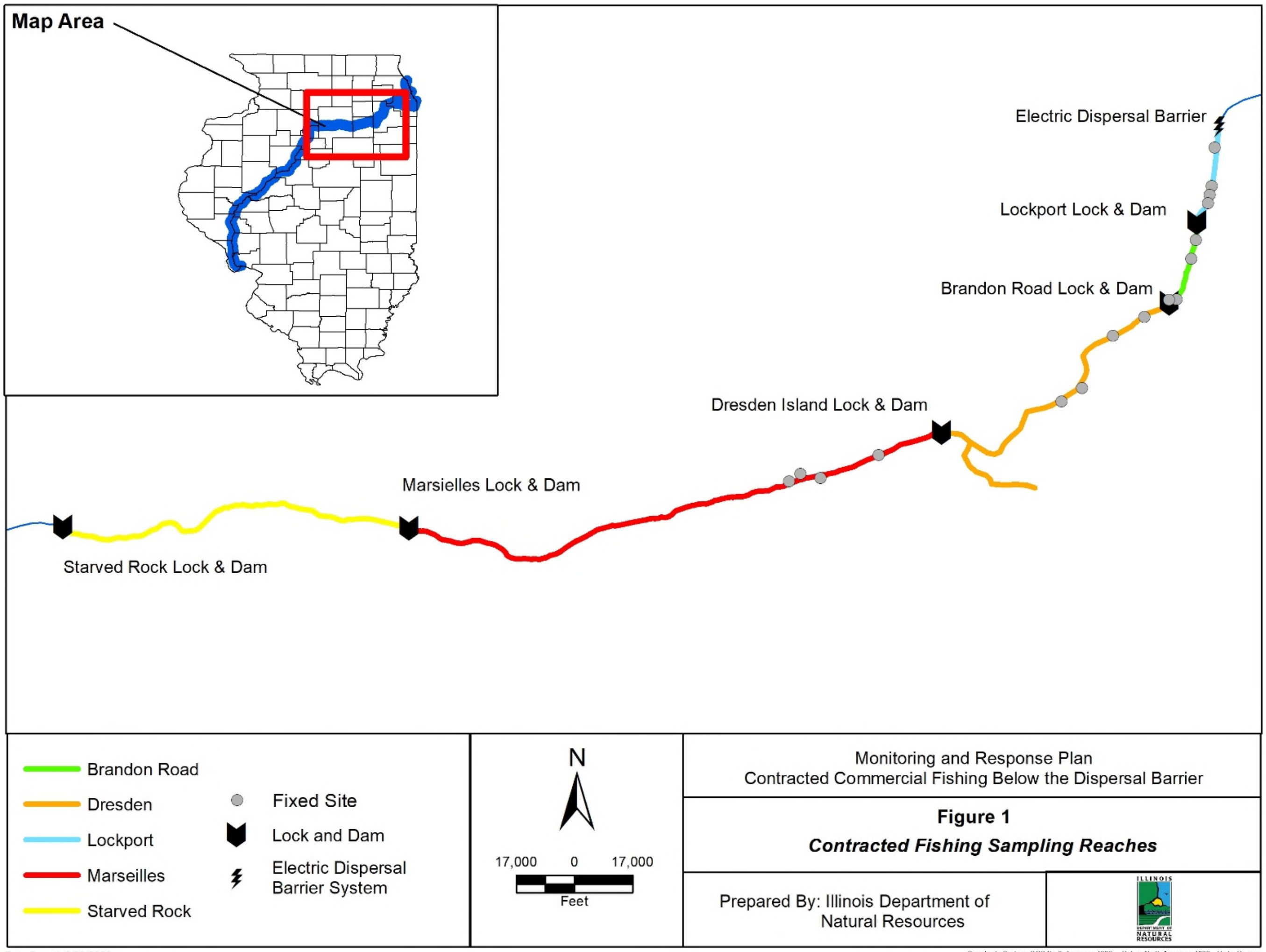

Figure 1. *Contracted commercial fishing sampling area and locations of fixed sites sampling of below the Electric Dispersal Barrier project.*

Status:

Contracted commercial fishers have been used in the *Monitoring Efforts Downstream of the Electric Dispersal Barrier* project and the *Barrier Defense Asian Carp Removal* project (2010-2018). The two projects were combined into a single project in 2019 to provide a more comprehensive picture of the ongoing contracted commercial fishing effort and results. Since 2010, contracted commercial fishers' effort in the upper Illinois Waterway below the Electric Dispersal Barrier includes 3,892 miles (6,264 km) of gill/trammel net; 19 miles (31 km) of commercial seine; 239 pound net nights; and 4,369 hoop net nights. A total of 97,849 Bighead Carp; 997,732 Silver Carp; and 9,373 Grass Carp have been removed. The estimated total weight of Asian carp removed is 4,528.6 tons (9,057,200 pounds). Contracted commercial fishing effort indicates a decreasing abundance trend of Asian carp moving upriver from Starved Rock Pool to

Dresden Island Pool with no Asian carp captured in Lockport or Brandon Road pools during contracted commercial fishing. One adult Bighead Carp was observed in Brandon Road Pool by a netting crew in October 2011. For more detailed results, consult the 2019 Interim Summary Report.

Methods:

Contracted commercial netting will occur from February through December in Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock 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 (*i.e. Part 830: Commercial Fishing and Musseling in Certain Waters of the State, Section 830.10(b): Waters Open to Commercial Harvest of Fish*); therefore, an agency biologist will be required to accompany contracted commercial fishing crews working in this portion of the river. Contracted commercial fishers with assisting agency biologists will fish four days per week during each week of the field season except for two weeks in June and two weeks in September when contracted commercial fishers will be sampling upstream of the Electric Dispersal Barrier for the Seasonal Intensive Monitoring project (Table 2).

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 Lockport, Brandon Road, Dresden Island, and Marseilles 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 agency biologist assigned to each boat.

Large mesh (2.5 - 5.0 inch; 63.5mm-127mm) gill and trammel nets set in 100- to 1,200-yard segments will be used and utilize fish herding (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors trimmed up) to drive fish into the net. Nets will typically be set for 20-30 minutes with overnight net sets occasionally occurring in off-channel habitat and in non-public backwaters with no boat traffic. Entangled fish will be removed from the net, identified, enumerated, and recorded. All 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, pet treats, food for injured animals, 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, Silver Carp, and Grass Carp) from each pool each day will be measured for total length, weighed, and sexed each week to gather morphometric data on harvested carp over time. All totes will be weighed with a pallet jack scale to determine total weight of Asian carp harvested.

Contracted Commercial Fishing Below the Electric Dispersal Barrier

Table 1. *Suggested Boat Launch Locations*

River Pool	Suggested Boat Launches for Contracted Commercial Fishing Sampling
Lockport Pool	Cargill Launch in Romeoville off W 9th St. (Inform Martin Castro (312) 401-9328)
Brandon Road Pool	Ruby Street Launch (767 N Bluff St., Joliet, IL 60435)
	Joliet Boat Store Launch (724 Railroad St., Joliet, IL 60436)
Dresden Island Pool	Big Basin Marina under the I-55 Bridge (24045 W Front St., Channahon, IL 60410)
Marseilles Pool	William G. Stratton State Park Launch (Griggs Dr., Morris, IL 60450)
	LST Memorial Public Boat Launch (E. South St., Seneca, IL 61360)
	Illini State Park Launch (2660 E. 2350th Rd., Marseilles, IL 61341)
Starved Rock Pool	Allen Park Launch off Route 71 (400 Courtney St., Ottawa, IL 61350)
	Starved Rock Marina off Dee Bennett Road (1130 N 27th Rd., Ottawa, IL 61350)

2020 Schedule:

Sampling will occur from February to December in 2020. The tentative distribution of 2020 contracted commercial fishers' effort is shown in Table 2.

Deliverables:

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

Table 2. *Tentative schedule for 2020 contract fishing below the Electric Dispersal Barrier.* Locations: LP=Lockport, BR=Brandon Road, DI=Dresden Island, MR=Marseilles, SR=Starved Rock.*

Week of	Location	Week of	Location	Week of	Location
24-Feb**	MR, SR	15-Jun	MR, SR	28-Sep	LP, BR, DI
3-Mar	MR, SR	22-Jun	LP, BR, DI	5-Oct	MR, SR
9-Mar	MR, SR	22-Jun	MR, SR	12-Oct	MR, SR
16-Mar	MR, SR	6-Jul	MR, SR	19-Oct	MR, SR
23-Mar	MR, SR	13-Jul	LP, BR, DI	26-Oct	MR, SR
30-Mar	LP, BR, DI	20-Jul	MR, SR	2-Nov	LP, BR, DI
6-Apr	MR, SR	27-Jul	MR, SR	9-Nov	MR, SR
13-Apr	LP, BR, DI	27-Jul	LP, BR, DI	16-Nov	MR, SR
20-Apr	MR, SR	3-Aug	MR, SR	30-Nov	LP, BR, DI
27-Apr	MR, SR	10-Aug	LP, BR, DI	7-Dec**	MR, SR
4-May	LP, BR, DI	17-Aug	LP, BR, DI	14-Dec**	MR, SR
11-May	MR, SR	24-Aug	MR, SR		
18-May	MR, SR	31-Aug	MR, SR		
25-May	MR, SR	28-Sep	MR, SR		

*Additional netting may occur during weeks not listed on this table.
**Weather permitting.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Participating Agencies: Leads: U.S. Fish and Wildlife Service Columbia Fish and Wildlife Conservation Office; U.S. Geological Survey Upper Midwest Environmental Sciences Center

Collaborators: Illinois Natural History Survey, Illinois Deprtment of Natural Resources, Southern Illinois University, U.S. Geological Survey Columbia Environmental Research Center

Location: Alton, LaGrange, Peoria, Starved Rock, Marseilles, and Dresden Island pools, Illinois River.

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

Introduction and Need:

Adaptive management is an interative process of decision making with the explicit goal of reducing uncertainty through time, thereby improving managment decisions over the long term (Walters 1986). Modeling is a critical component of the adaptive management framework. For example, population models applied to Asian carp control in the Illinois River are objective data-driven tools that can be used to simulate population effects of control strategies designed to maximize return (e.g., population reduction) on investment (e.g., control resources), identify key knowledge gaps that potentially limit or confound control effects, and evaluate control success.

The Asian carp population modeling to support an adaptive management framework monitoring and response plan (MRP) provided herein describes ongoing development of the Spatially Explicit Asian carp Population (SEAcarP) model. This model was developed to inform management decisions focused on reducing the abundance of Asian carp in the upper Illinois waterway (IWW), thereby reducing risk of population expansion toward the Great Lakes and to define research and monitoring priorities for Asian carp control. In addition, this MRP describes efforts to detail the monitoring data inputs needed to facilitate the development of statistical catch-at-age (e.g., Syslo et al. 2020) or statistical catch-at-length (e.g., Sullivan 1999; hereafter SCAA/L) models. Statistical catch-at-age or catch-at-length models are distinct from, but complementary to, forecasting simulation models such as the SEAcarP model. One advantage of the SCAA/L model framework is that they can be used to estimate the yield or the effort (e.g., fishing) required to achieve a given mortality benchmark, such as mortality benchmarks derived from the SEAcarP model.

Asian Carp Population Modeling to Support an Adaptive Management Framework

Objectives:

(1) Estimate demographic rates on a recurring annual basis using the current data available and incorporate results into the SEAcarP model.

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

(3) Subject the SEAcarP model to peer review by collecting critical feedback from three quantitative research groups with experience in population ecology. Guidelines describing the review process will be developed in collaboration with the Monitoring and Response Working Group MRWG co-chairs and attached to the formal review request along with the SEAcarP model code. The review will include both biological (e.g., the biological assumptions of the model) as well as technical (e.g., verification of model code) aspects of the modeling effort.

(4) Incorporate results from Action's 1 – 3 and prepare a manuscript for publication in a peer-reviewed journal using results from sensitivity analyses and population control (i.e., additive mortality, upstream movement deterrence) simulations.

(5) Explore the importance of fish immigration from the Mississippi River on the population dynamics within the Illinois River using the SEAcarP model and if warranted, transition the SEAcarP model to a multi-basin framework.

(6) Implement SCAA/L modeling to estimate vulnerability of carp to fishing as a function of fish size, exploitation rates, and immigration into the upper Illinois River Waterway.

(7) Develop the Modeling Work Group into a multi-institutional quantitative science team to guide the development and maintenance of future iterations of SEAcarP and other data-driven decision support tools.

(8) Hold an in-person meeting or virtual meeting of the Modeling Work Group and identify data needs and knowledge gaps.

(9) Develop a detailed communications strategy outlining how the Modeling Work Group will provide timely updates to MRWG chairs on progress and setbacks.

Status:

This effort is a continuing project from 2019. Achievements of this project to date include:

- Updated results were presented at the annual MRWG meeting in Peoria Illinois during January 2020 and various other ACRCC meetings.
- Model analysis, including sensitivity analysis, has been conducted to examine parameter uncertainty and model assumptions.
- The model has been placed into an R package (SEAcarP) for easier dissemination.
- A review of the model is currently underway.
- Efforts are underway to establish a modeling advisory group.

- Updated demographics based on most recent data (over 40,000 individual fish); manuscript under revisions (Erickson et al. *under revision).*
- Coordinated with MRWG sub-workgroups (i.e., Telemetry, Monitoring) to address identified data needs and knowledge gaps.

Methods:

SEAcarP model: Details about the SEAcarP model have been described in previous MRPs and Interim Summary Reports (ACRCC 2019). In summary, the SEAcarP model is a forecasting simulation model projecting the sizes and relative numbers of Asian carp in each of the lower six pools of the Illinois River over a 25-year time period under different control scenarios. Control scenarios are user-specified and include the location (i.e., pool) and magnitude of increased mortality (e.g., harvest, piscicide) and the effectiveness (i.e., percent reduction relative to baseline) of potential upstream movement deterrent(s) at Starved Rock, Marseilles, and Dresden Island pools locks and dams. Asian carp population dynamics are modeled in annual time steps using embedded sub-models that describe survival, growth, pool-to-pool movement, and reproduction. Embedded sub-models were parameterized using empirical results from published literature (i.e., Coulter et al. 2018, Erickson et al. 2020 *under revision*).

Each simulated control scenario is repeated 1,000 times to account for uncertainty in parameter estimates. For each iteration, new sets of growth, condition (i.e., length-weight), size-at-maturity, and pool-to-pool movement coefficients are randomly selected from a set of possible values (i.e., posterior distributions from Coulter et al. 2018, Erickson et al. 2020 *under revision*). The performance of different control scenarios is then evaluated based on projected changes in total abundance and biomass through time relative to the no-action scenario (i.e., no additional harvest, baseline movement).

Objectives 1 through 4 of our project relate to ongoing development of the SEAcarP model in the Illinois River sub-basin. Demographic rates will be updated using methods described in Erickson et al. (*under revision*) using the new data as more data become available. Results will be incorporated into the SEAcarP model analyses (Objective 1).

In addition to evaluating specific control scenarios, the SEAcarP model is being used to identify data gaps and provide data collection and research recommendations (Objective 2) aimed at advancing our general understanding of Asian carp population dynamics and hence success of control measures. To accomplish this objective, we will use two types of sensitivity analysis. The first type will examine how parameter uncertainty impacts model output whereas the second type will examine impacts associated with violations to underlying assumptions.

To evaluate impacts associated with parameter uncertainty, we will examine how variance from the different sub-models (e.g., growth, movement) contributes to the total variance in population size among pools. This examination will be accomplished using 1,000 iterations of the no-action scenario. However, instead of drawing new sets of coefficients for each sub-model as previously described, only values for one sub-model will be allowed to vary across iterations. Values for the remaining sub-models will be set to mean values. This process will be repeated for each sub-model. To complete the second type of sensitivity analysis we will examine how challenging our baseline assumptions impacts model results. For example, sensitivity to our baseline assumption that recruitment only occurs below Starved Rock Lock and Dam would be evaluated by comparing model results with and without recruitment above Starved Rock Lock and Dam. Similarly, we will evaluate other baseline assumptions including size-specific movement and the steepness and functional form of the stock-recruitment curve.

We will subject the SEAcarP model to peer-review to improve current modeling efforts and obtain recommendations concerning future modeling work aimed at achieving ACRCC Asian carp management goals. Specifically, we will collect critical feedback from three separate quantitative researchers using a “friendly review” (Objective 3). The review will include both biological (e.g., the biological assumptions of the model) as well as technical (e.g., verification of model code) aspects of the modeling effort. Next, we will engage with quantitative experts that have contributed to model development to prepare a manuscript for publication in a peer reviewed journal using results from sensitivity analyses and population control (i.e., additive mortality, upstream movement deterrence) simulations (Objective 4).

Objective 5 includes examining the importance of immigration of fish from the Mississippi River to the Illinois River. This examination will involve using telemetry modeling to account for complex source-sink dynamics thereby improving model predictions in the Illinois River. The spatial coverage of the SEAcarP model is determined by the underlying pool to pool movement model – currently the lower six pools of the Illinois River (Coulter et al. 2018). Thus, we will support ongoing efforts to better understand fish movement in the Mississippi River currently underway by USGS Upper Midwest Environmental Sciences Center and others. These efforts are not supported by GLRI funding but can be used to assist this project and ultimately determine if transitioning SEAcarP to a multi-basin framework (Objective 5) is warranted.

Objective 6 is to implement SCAA/L models to estimate yield or effort required to achieve a given mortality benchmark. Data inputs for SCAA/L’s are extensive, and it is unclear whether existing sampling and harvest data, which would be used to parametrize the model, are suitable and available in sufficient quantity to perform a robust analysis. Consequently, we will conduct a feasibility study to determine how successfully SCAA/L modeling could be completed given available data. This study will be accomplished in coordination with MRWG co-chairs and sub-workgroup leads. The first step will be to compile sampling and harvest data from all available sources, or alternatively, develop a suitable data summary (e.g., total catch, gear type and specifications, effort). Next, we will engage with quantitative experts that have experience developing and using SCAA/L models to implement a feasibility study. Results from the feasibility study will include:

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

2020 Schedule:

- February – April 2020: Multi-state movement modeling with MRWG Telemetry Technical Workgroup; Sent model out to reviewers/advisor members for feedback.[1]
- June 2020: Address reviewers' feedback; Finalize sensitivity analyses and report out on prioritized data needs
- July – August 2020: Statistical catch-at-length model development
- September – November 2020: 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 2020: Management scenario simulations
- December 2020 – January 2021: Prepare presentation and reports

Deliverables:

- Creation of quantitative science team to advise modeling efforts
- Comprehensive report and corresponding manuscript describing the SEACarp model and model findings
- Prioritized list of data and research needs
- Updated demographic rates using the most current data available
- Feasibility study for potential Statistical Catch at Age or Catch at Length modeling

Literature Cited:

Asian Carp Regional Coordinating Committee - Monitoring and Response Workgroup, (ACRCC). 2019. Monitoring and Response Plan for Asian carp in the Upper Illinois River and Chicago Area Waterway System. https://www.asiancarp.us/Documents/2019ActionPlan.pdf

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

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

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 total length [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 2020 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.

Status:

This project was started in 2018 and will continue in 2020. 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 workgroup. The total length of tagged fishes ranged from 391-635 mm. During 2019, 161 Silver Carp were tagged throughout Peoria Pool. The total lengths of tagged fish ranged from 374-776 mm. 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 2020, USFWS staff will tag an additional 150 Asian carp with total lengths between 300 – 500 mm with 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. This large-scale tagging of adult and immature 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 in Peoria and Starved Rock pools. 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.

2020 Schedule:

- May – June 2020: Gear preparation, planning field work, crew scheduling
- July – November 2020: Fish tagging, range testing, active tracking, data download, gear maintenance and relocations
- November – December 2020: Receiver removal, final data downloads
- December 2020 – January 2021: 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 MRWG summary report/presentation for the winter of 2020-2021.

Asian Carp Demographics

Participating Agencies: Lead: U.S. Fish and Wildlife Service (USFWS)-Columbia Fish and Wildlife Conservation Office (Columbia FWCO); Collaborators: Southern Illinois University (SIU)

Pools Involved: Dresden Island, Marseilles, Starved Rock, Peoria, LaGrange, 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, Marseilles Dresden pools) and lower IWW (Alton, La Grange, and Peoria pools; Figure 1). The demographic data collected from the project will help better understand what appropriate management actions are needed to protect the Great Lakes and how those management actions effect Asian carp populations within the Illinois River, Illinois.

Objectives:

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

(2) Use agreed upon methods to generate age and growth information for Illinois River Asian carp captures.

(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 hydroacoustics 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).

Asian Carp Demographics

Status:

This is a continuing project from 2018 and 2019. Following are highlights from this project and relationships to other GLRI-funded projects.

- In 2019, a standardized Silver Carp assessment was implemented in six pools of the Illinois River to collect demographic data. Collections included 2,131 Silver Carp; total effort was 450 5-minute trawls or 37.5 hours of active sampling; 348 Silver Carp were aged.
- 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 Silver Carp in the Illinois River.
- 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.
- Individual fish data collected under this project (e.g., sex, maturity status) are being considered for inclusion in the Multi-Agency Monitoring Program.

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

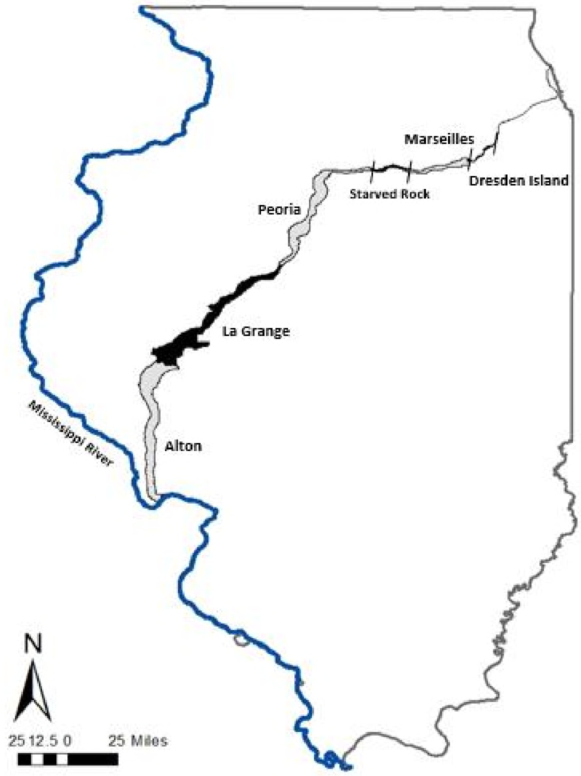

Figure 1. *The six lowest pools of the Illinois River, Illinois.*

Fall dozer trawl collections will be coordinated with fall SIU hydroacoustics sampling and paired capture gear sampling to ensure that comparisons among gear types are meaningful. All data will be summarized using methods described in MacNamara et al. (2016). Specifically, we will calculate proportional catch of Silver Carp for each 20-mm TL-class using dozer trawl data and compare results to summarized data from paired capture gear sampling.

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 six lowest pools of the Illinois River. Source populations in the three lowest pools will be sampled to evaluate length at maturity during spring sampling. 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. All data will be transferred to the modeling workgroup for demographic analyses associated with the SEAcarP model (e.g., growth, condition).

2020 Schedule:

- February – April 2020: Gear preparation, logistics, planning, and scheduling
- May – June 2020: Spring field sampling and data entry

- July – August 2020: Data entry, preliminary data analysis and protocol evaluation
- September – November 2020: Fall field sampling and data entry
- December 2020–January 2021: Data analysis, Annual report

Deliverables:

The Asian carp demographics project will provide updated demographic data for parameterizing the SEAcarP model and addresses data gaps identified by the modeling workgroup (i.e., stock-recruit data, length at maturity, length at age). 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:

Hammen J.J., Pherigo E., Doyle W., Finley J., Drews K., Goeckler J.M.. A comparison between conventional boat electrofishing and the electrified dozer trawl for capturing Silver Carp in tributaries of the Missouri River, Missouri. North American Journal of Fish Management. 2019; doi: 10.1002/nafm.10297.

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Walters, C.J. 1986. *Adaptive Management of Renewable Resources*. Macmillian, New York.

U.S. Army Corps of Engineers' Upper Mississippi River Restoration (UMRR) Program Long Term Resource Monitoring (LTRM) element. 2017, UMRR HNA-II Aquatic Areas: La Crosse, WI, https://doi.org/10.5066/F7VD6WH8.

Evaluation of a Modular Electric Deterrent Barrier

Participating Agencies: Illinois Natural History Survey (lead), US Geological Survey (field support)

Location: Locations for field trials will be selected among potential sites in Illinois Waterway tributaries, side channels, or backwaters.

Pools Involved: To be determined

Introduction:

Electric barriers have been used to impede or direct the movements 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 control purposes, such designs lack spatial flexibility and thus the capacity for adaptive management applications. Modular electric barriers may provide managers with the option to deploy control measures in a variety of locations to achieve various management objectives. 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, lock chambers), and directing fishes into entrapment or 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 project will evaluate the effectiveness of the modular electric barrier system at preventing passage of Asian carp, provide guidelines for the transport, deployment, and safe operation of the barrier, and offer cost estimates for barrier operation. 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 detection rates in the vicinity of the barrier could be reduced by > 99% when the barrier was in operation. Based on experimental findings, logistical issues, and experiences operating this barrier system, field-based assessments are needed to further evaluate the effectiveness of this technology at locations on the Illinois Waterway. Deployments planned during 2019 were disrupted by the widespread record flooding that occurred on the Illinois Waterway and the subsequent damage to roads and levees that prevented later access to planned study sites. Additional plans for field deployments at locations that will likely be less prone to disruption by flooding are being made for 2020. Further efforts are underway to identify effective operational settings, overcome system constraints in high conductivity environments, and provide cost estimates across a wide range of potential operational conditions.

Methods:

During 2020, experiments to assess the effectiveness of the mobile electric deterrent barrier for inhibiting passage of Asian carp and other fishes will be conducted 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 fish passage through the barrier using an ARIS sonar system during periods when the barrier is operational and when it is inactive. Fish passage and behavior when encountering the electric field will be observed both under passive conditions and when fish are compelled to pass the barrier zone through the use of driving methods. 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.

Evaluation of a Modular Electric Deterrent Barrier

2020 Schedule:

In 2020, field deployments of the modular electric deterrent barrier will occur during May through October, and as needed thereafter to assist agencies with management objectives. The COVID-19 pandemic may require modifications to the design and scheduling of field trials, but all efforts will be made to carry out at least one field deployment during 2020, while following all legal requirements and best practices to ensure the health and safety of all personnel and help stem the spread of the COVID-19 virus.

Deliverables:

Summaries of findings from field trials will be provided to MRWG partners as relevant results are produced. An operations manual will be developed by INHS, to complement the manual provided by Smith-Root by providing relevant guidelines for storage, planning, transportation, safe deployment, and cost breakdowns under a variety of scenarios that may be encountered in the field. Data will be summarized and project plans updated for annual revisions of the MRP.

Alternative Pathway Surveillance in Illinois – Law Enforcement

Participating Agencies: Illinois Department of Natural Resources (lead)

Location: Surveillance and enforcement operations will be conducted throughout Illinois and within other jurisdictions if multi-agency operations occur.

Pools Involved: Not applicable

Introduction and Need: The IDNR Invasive Species Unit (ISU) focuses on detecting illegal human activities that increase the likelihood of spreading aquatic invasive species. Proactive enforcement of the laws can reduce the spread of invasive species by educating those unaware of regulations and appropriately punishing those who knowingly disobey aquatic invasive species laws. Previous enforcement efforts exposed numerous people and businesses that prioritized financial profits over compliance with regulations. It is essential to identify, apprehend and penalize habitual offenders of aquatic invasive species regulations and detect and deter those initially contemplating whether the risk is worth the reward. ISU investigates all suspicious activities brought to its attention and responds to all law enforcement requests for assistance from MRWG members and other agencies. The work being done to protect the Great Lakes from Asian carp is a huge undertaking with many moving parts. All the removal, monitoring, research and deterrence efforts within the Asian carp project could be sabotaged without a law enforcement component mitigating the human introduction risk factor. ISU is the first fully dedicated aquatic invasive species law enforcement unit in North America and has served as a model to other agencies developing similar 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) Train Conservation Police Officers aquatic invasive species enforcement techniques to increase law enforcement capabilities within the aquatic life industry.

(2) Conduct commercial inspections of fish dealers selling, shipping, and transporting aquatic life in Illinois.

(3) Engage recreational fishermen through outreach efforts while simultaneously searching for illegal activities during AIS enforcement details.

(4) Respond to any requests, complaints, events, or suspicious activities that pose a threat to the Asian Carp Project.

(5) Participate in AIS conferences and related training to better equip the Unit with up to date information and tools to successfully complete its tasks.

Status: This project is on-going and has been extended into 2020. The Unit has active investigations pending and an overall strategy to proactively search for emerging threats.

Alternative Pathway Surveillance in Illinois – Law Enforcement

Methods:

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

2020 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.

2020 – 2021 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.

Asian Carp Enhanced Contract Removal Program

Participating Agencies: Illinois Department of Natural Resources (lead); U.S. Environmental Protection Agency and Great Lakes Fishery Commission (project support).

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

Pools Involved: Peoria

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 Starved 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 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:

Enhanced removal efforts which began in September of 2019 focused in the Peoria Pool. As of August 2020, nearly 2 million pounds have been removed under this program. The use of targeted contract fishing in the Illinois River is a key component of the multipronged strategy. In 2019 and early 2020, 26 contracts were entered into with Illinois-licensed commercial fishing. While it has been acknowledged that reducing abundance of Asian carp in the three lower IWW pools would be beneficial, initial contracts target Peoria Pool, with expectation that LaGrange and Alton pools will follow as fish landings and data evaluation suggest.

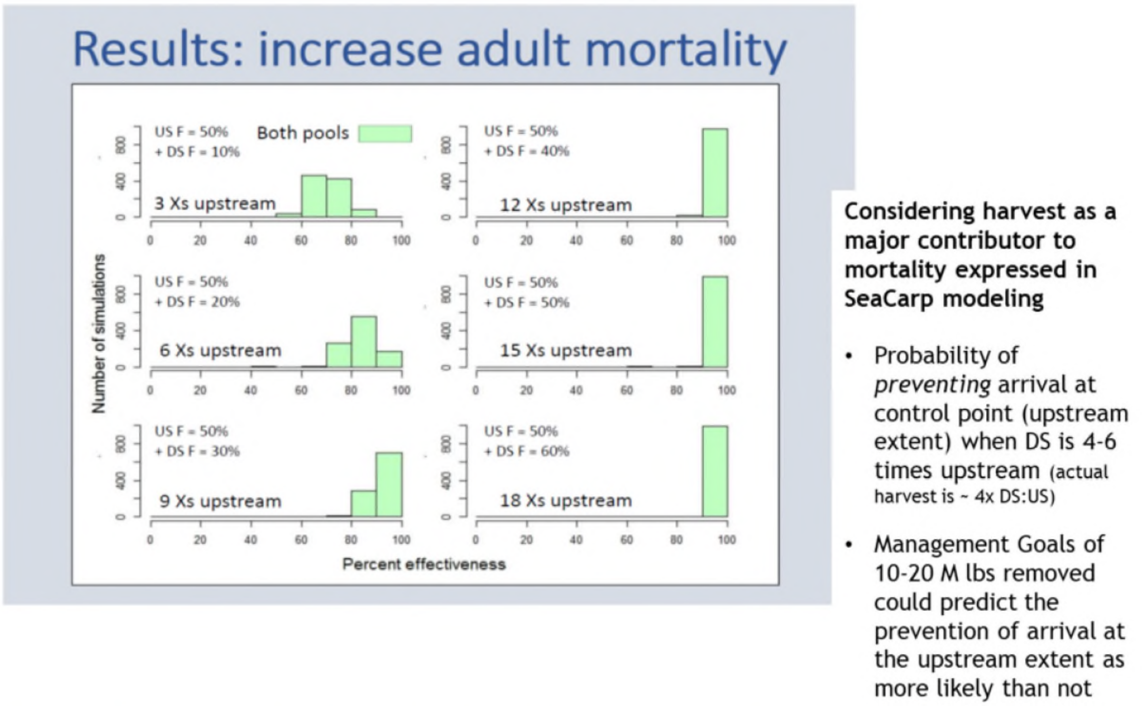


Figure 1: *Effects of increased harvest on likelihood of Asian carp migration; output from SEAcarP model*

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.

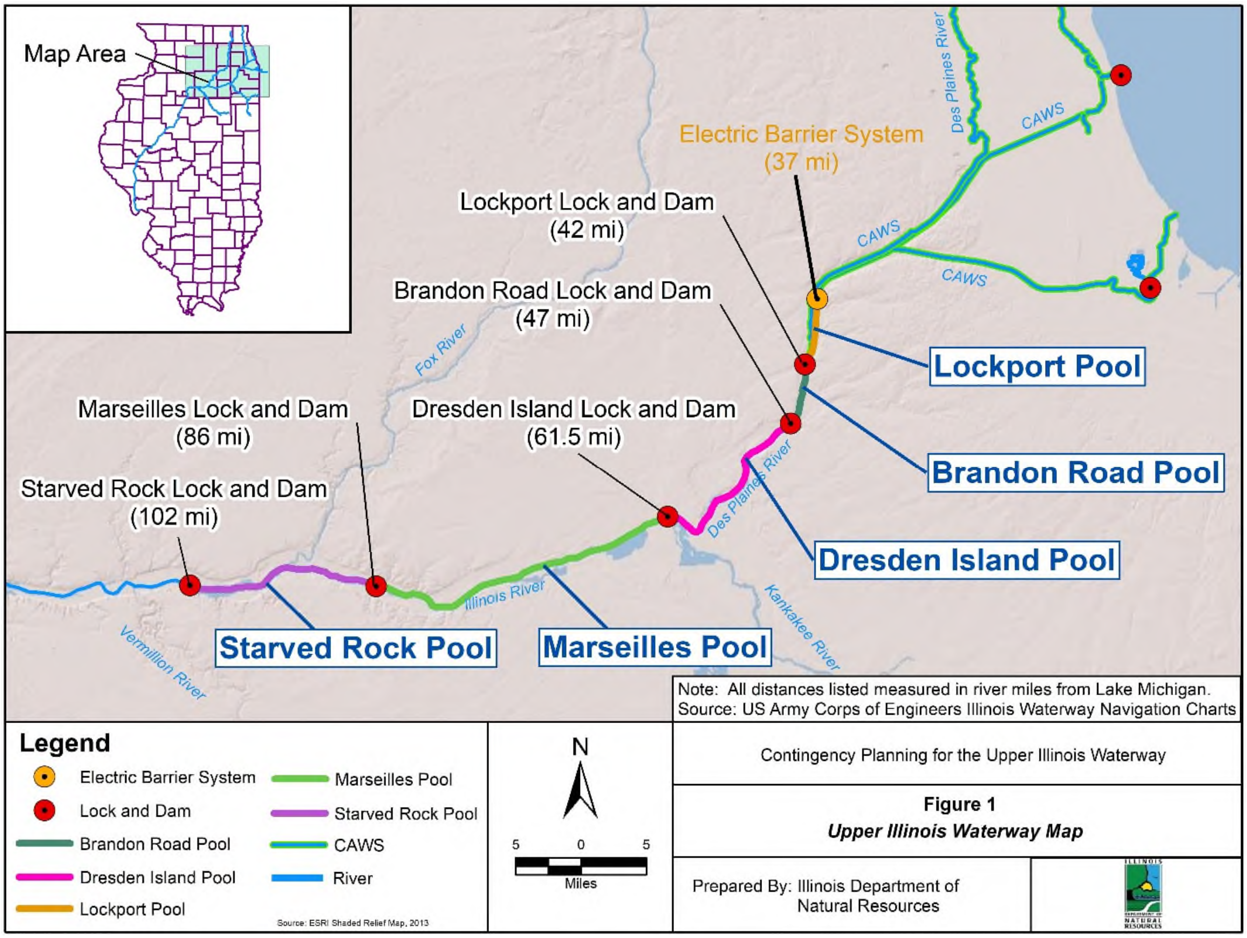


Figure 1. *Illinois Waterway Map and Profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.*

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 an 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 2019, 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.

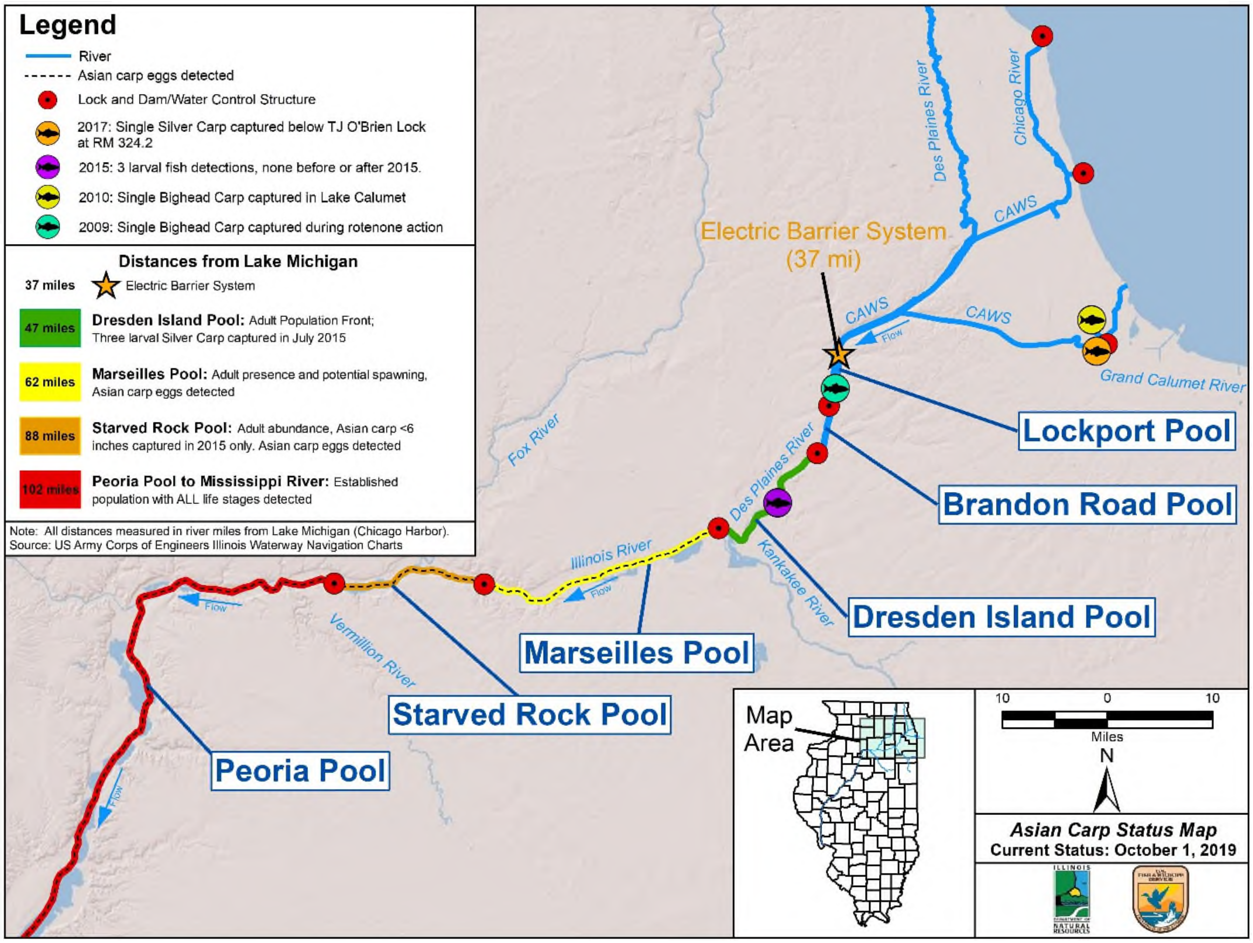


Figure 2. *Asian carp Status Map. Current Status: October 1, 2019.*

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 primarily refers to Bighead and Silver Carp, however, may also serve to inform potential response actions in the event a black carp was captured.

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.

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.

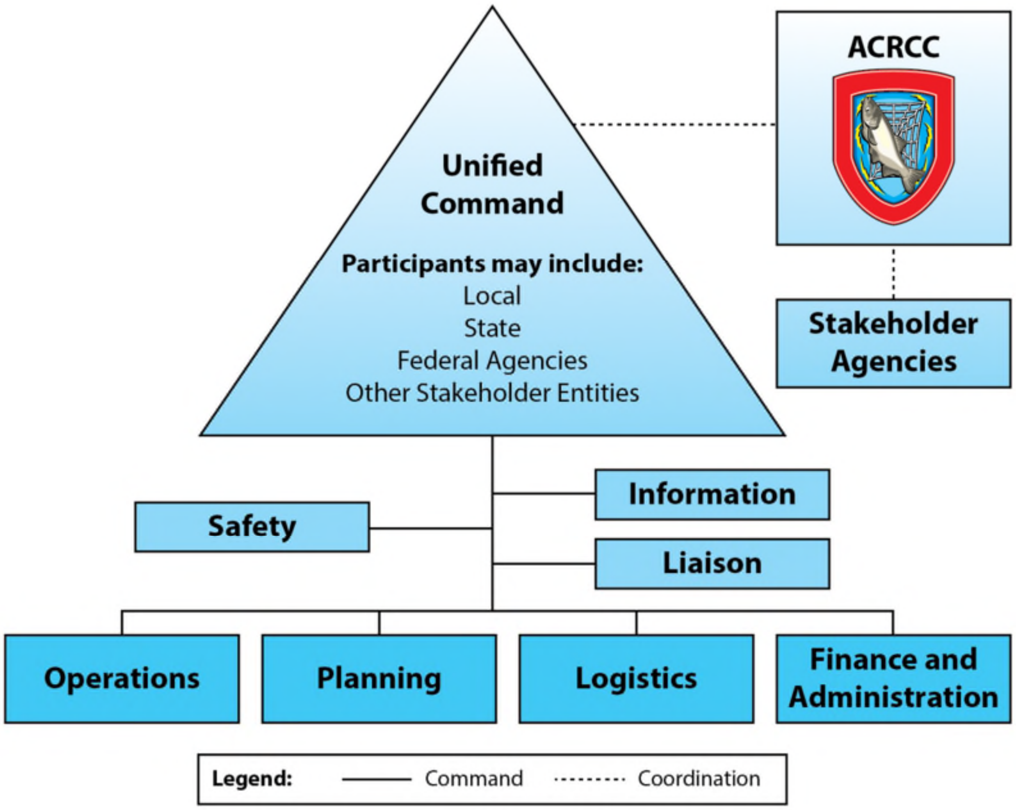


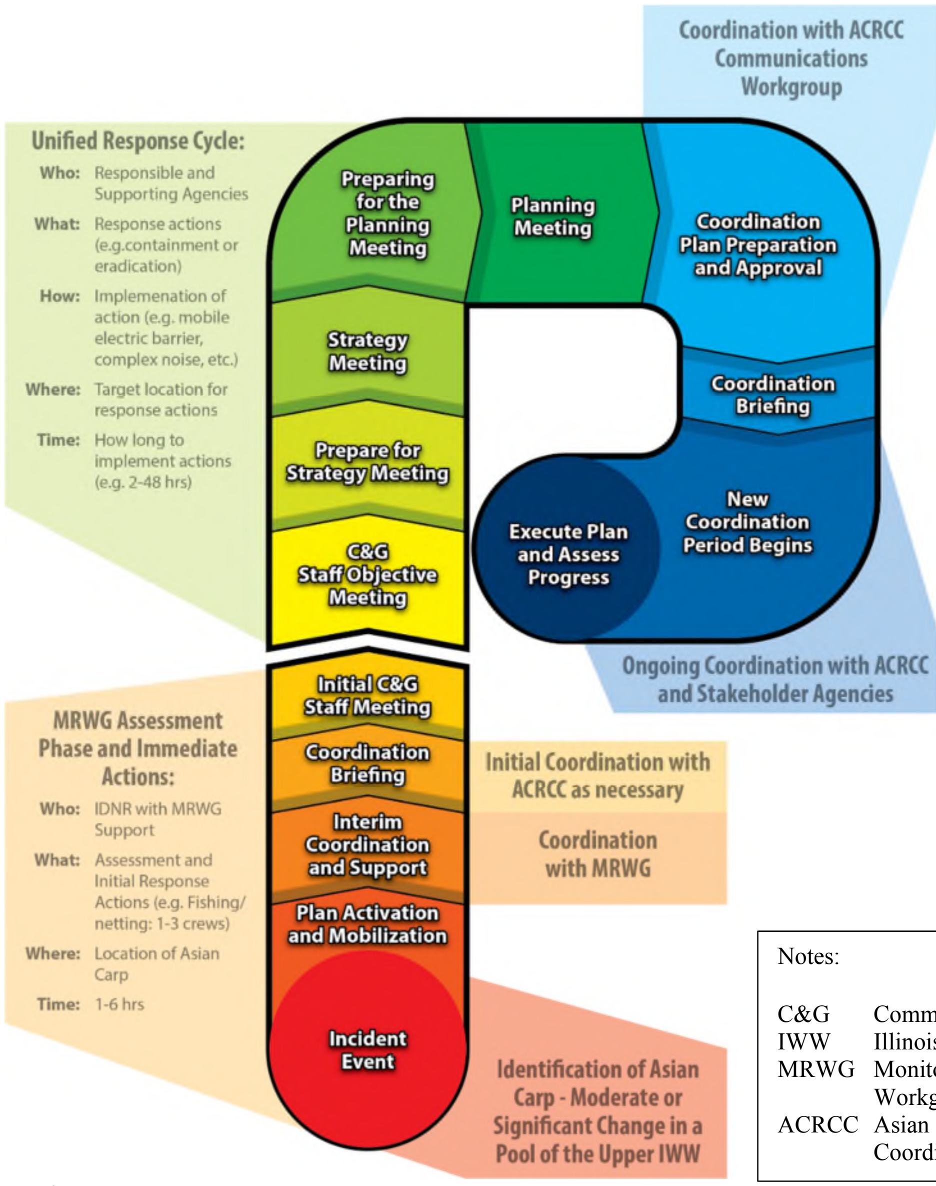
Figure 3. *Unified Command Organization Structure*

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.

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

Incident action planning extends farther than just preparation and distribution of the IAP. This planning includes the routine activities during each operational period of an incident response that provide a steady tempo and routine structure to incident management. The ICS Planning "P" is a guide to the steps, relative chronology, and basic elements for managing an incident. By incorporating the Planning "P" into planning efforts, overlaying anticipated daily operational and logistical chronologies, a local jurisdiction can establish a framework for incident management that provides a rough playbook for local, state, federal, and outside resources to manage 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.



Notes:

C&G	Command and General Staff
IWW	Illinois Water Way
MRWG	Monitoring and Response Workgroup
ACRCC	Asian Carp Regional Coordinating Committee

Figure 4. *ICS Planning "P"*

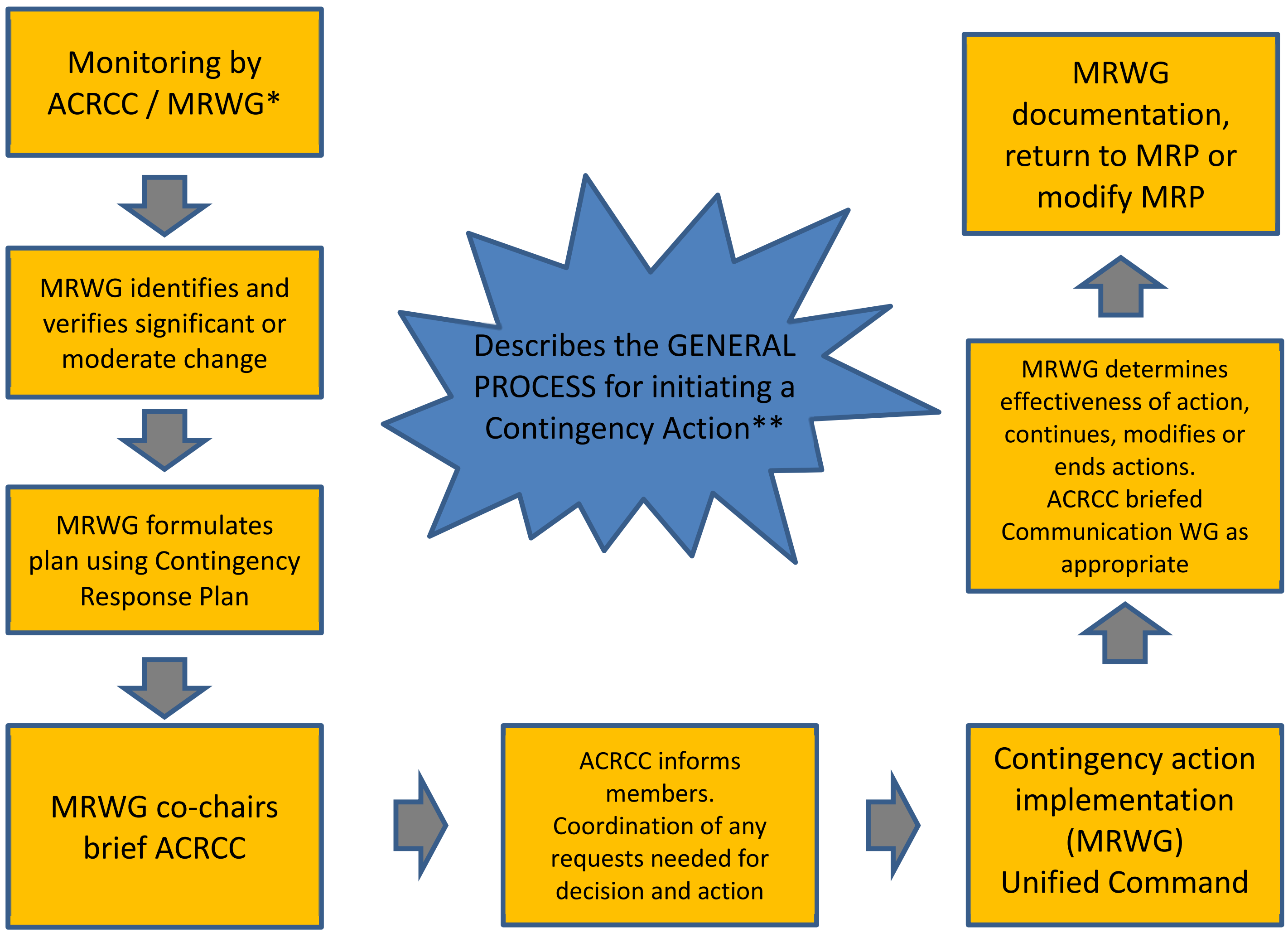
Response Decision Matrix

For the purposes of informing contingency response planning in the upper IWW, MRWG developed a 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.



* 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*

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

Level of Urgency (Action Response Level)	Potential Actions[2]	Applicable Locations	Responsible Agencies	Estimated Time to Implement	Regulatory or Other Requirements	Relative Cost ($-$$$$)
Significant Change						($$)
	Modify Barrier Operations	LP, BR	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents	All	USGS/USACE	1-7 days	Coordinate with local stakeholders	($$)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS/SIU/USGS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
	Temporary Flow Control	LP, BR	MWRD	1 day	Notice to navigation	($)
	Mobile Electric Array	All	INHS/IDNR	1-7 days	Coordinate with local stakeholders and Coast Guard	($$$)
Moderate Change	Increased Sampling Efforts	All	IDNR	1-7 days	Sampling permits	($$)
	Modify Barrier Operations	All	USACE	1 day	Coordinate with contractors	($)
	Acoustic Deterrents	All	USGSUSACE	1-7 days	Coordinate with stakeholders	($$)
	Commercial Contract Netting	All	IDNR	1-7 days	Sampling permits/contracts	($)
	Hydroacoustics	All	USFWS	1-7 days	None	($)
	Block Nets	All	IDNR	1-7 days	Notice to navigation	($$)
No Change	Maintain Current Level of Effort	N/A	All	Ongoing	N/A	($)

LP Lockport,
BR Brandon Road
* The implementation of some of these actions may require temporary lock closures or navigation restrictions, which fall under the authority of USACE and the US Coast Guard respectively. Temporary lock closures and navigation restrictions would be limited to the time necessary to carry out the supported measures. Such lock closures have supported previous barrier clearing events when electrofishing, water cannons, and/or nets were used to sample fish in and around the barrier system.
1 Additional Resource Considerations (page J-4) describes other measures that may be implemented as necessary and aligned with agency authorities.
2 The current monitoring and response activities are covered under existing federal budgets.
3 Response techniques encompassed by Increased Sampling Efforts under Potential Actions in above table

Technique	*Participating Agencies*
Electrofishing	USFWS, 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.

References:

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

Appendix A: Barrier Maintenance Fish Suppression

The USACE operates three Electric Dispersal Barriers (Demonstration Barrier, Barrier 2A and Barrier 2B) for aquatic invasive species in the Chicago 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.

In recent years, additional deterrents have been implemented to help mitigate the risk of Asian carp movement during winter annual maintenance activities. In the winter of 2017-2018 and 2018-2019 an acoustic deterrent system was deployed by USGS with assistance from USACE, Engineer Research and Development Center and Chicago District personnel. Up to 5 underwater speakers were temporarily welded to a moored tug boat approximately 0.8 miles downstream of the EDBS at the Hanson Material Service barge slip in Romeoville, Illinois. A recording of a 100-hp boat motor sound, a sound shown to deter Asian carp in previous lab studies, was played on loop during the maintenance operations. At the discretion of the MRWG and available resources, the deployment of an acoustic deterrent system will be discussed prior to any future winter barrier maintenance activities. Additional deterrent technologies will also be considered as they are developed, tested and feasible for field applications.

Fish suppression decisions should be made each time there is a planned or unplanned outage at the 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

Appendix A: Barrier Maintenance Fish Suppression

Barrier IIA	Barrier IIB	Demonstration	Required
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

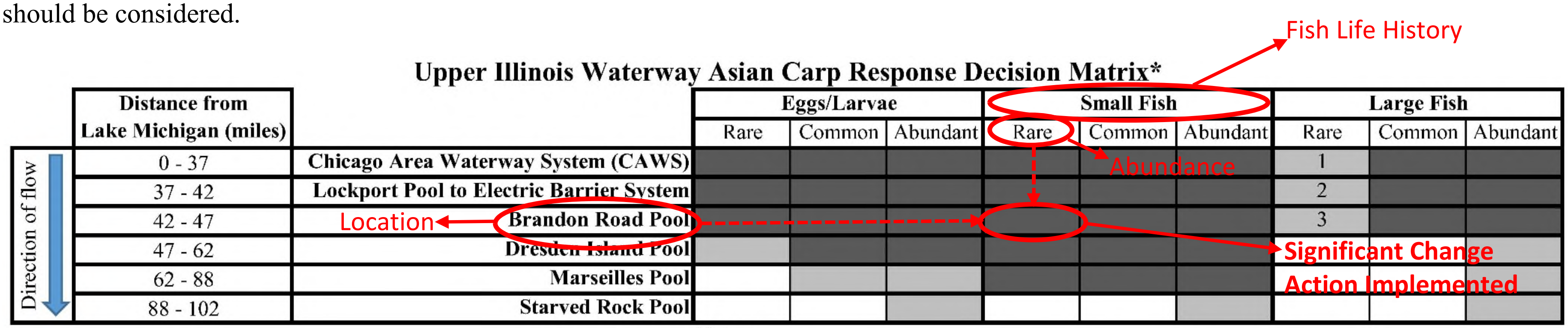
Table 2. *Operational changes anticipated from March 2020 – March 2021*

Barrier Operational Status				Clearing Decision	Activity	Season
Barrier IIA	Barrier IIB	Demonstration*	Permanent Barrier 1*			
On	On	Off	Off	No	Demonstration Connection to Permanent Barrier 1	2020 Fall
On	On	On	On	No	Permanent Barrier 1 Testing	2020 Fall
On	Off	Off	Off	No	2B Annual Maintenance	2020-21 Winter
Off	On	Off	Off	Yes	2A Annual Maintenance	2020-21 Winter
Off	Off	On	Off	Yes	Dive Operations	2021 Winter

*Permanent Barrier 1 will be connected to the current electrodes of the demonstration barrier. The demo will be powered down to make this connection in the Fall of 2020. Then Permanent barrier 1 will need to go through in water testing which is also expected to occur in Fall of 2020. Permanent Barrier 1 will not be turned back on until the Coast Guard gives USACE permission to operate full time, however the demonstration barrier will still be operable as its own barrier during this time. Permanent Barrier 1 is anticipated to be on by Spring of 2021.

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

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.

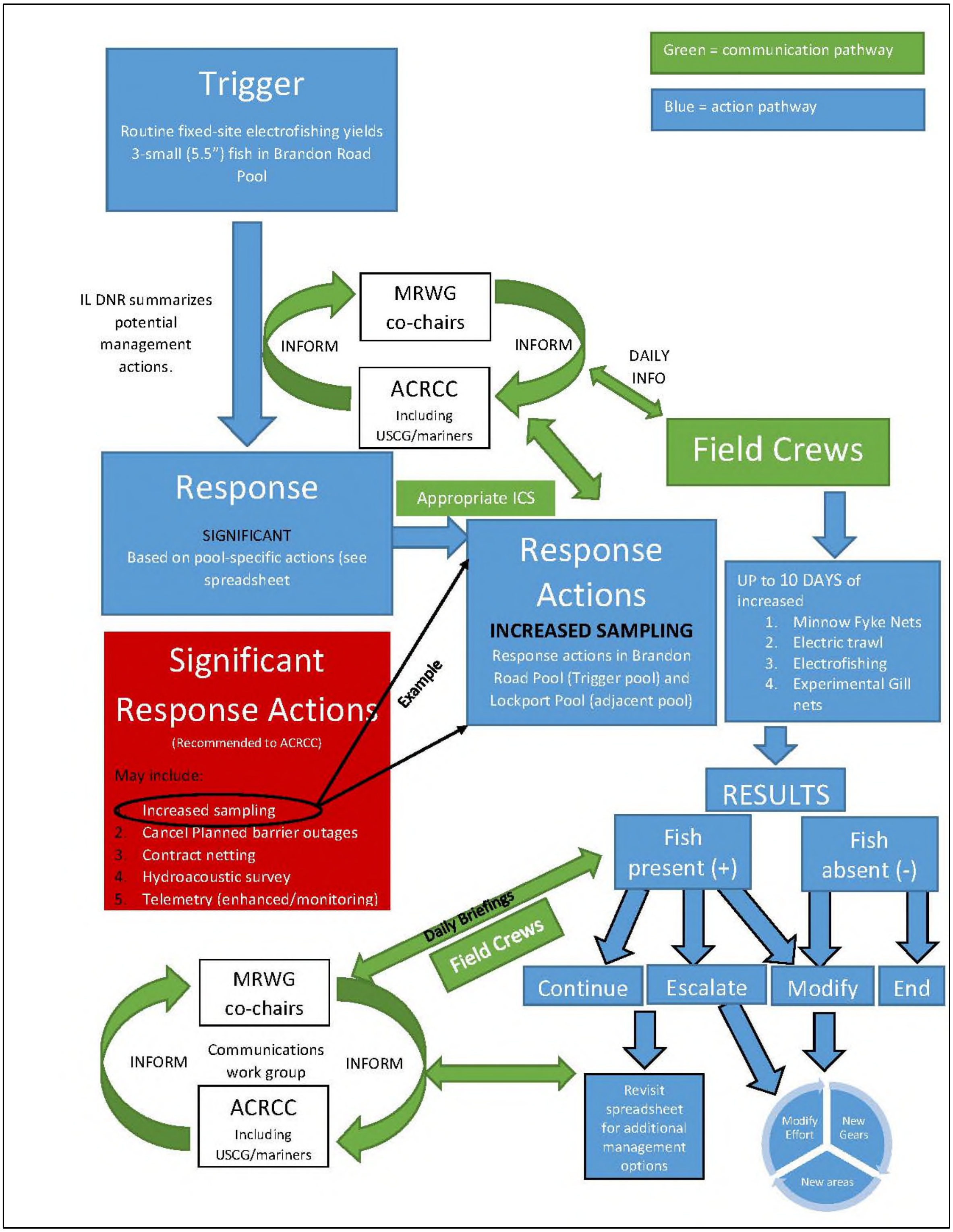
2 This status is based upon the collection of a single Bighead Carp during piscicides treatment in 2009.

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

Participating Agencies: Illinois Natural History Survey (lead), Southern Illinois University (lab support)

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 LaGrange

Introduction and Need:

Due to their ability to efficiently filter large volumes of water and capture small particle sizes, Bighead Carp and Silver Carp can deplete zooplankton densities and alter zooplankton community composition, potentially competing with native fishes for food resources and altering flows of organic matter. In the Illinois River, densities of large-bodied crustacean zooplankton have been substantially reduced, whereas rotifer densities have increased since the establishment of Asian carp. An aggressive Asian carp removal program has been implemented in the Illinois Waterway to limit further advances of Asian carp towards Lake Michigan. In addition to preventing the expansion of Asian carp into the Great Lakes, this removal program may also benefit native fish assemblages in the Illinois Waterway by mitigating some of the ecological impacts that Asian carp have had on this system. However, the extent and pace of ecosystem responses to such removals are uncertain. Zooplankton are known to be a rapid index of ecosystem response, as most riverine zooplankton taxa have relatively short generation times and high productivity rates. Additionally, zooplankton 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 develop specific zooplankton-based assessment metrics to quantitatively evaluate the extent to which the removal strategy is working to reverse ecosystem impacts from Asian carp. 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.

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

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

(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.

Status:

Zooplankton have been sampled from sites throughout the Illinois Waterway during 2011-2019. Comparison of zooplankton data collected during recent years with pre-invasion zooplankton collections indicate that zooplankton assemblages in the Illinois River have been substantially altered since the establishment of Asian carp. Considerable differences have also been found in zooplankton assemblages between the upper and lower Illinois Waterway (upstream and downstream of Starved Rock Lock and Dam) and between main channel and backwater habitats. Seasonal variation in density and biomass of various taxa also differs considerably across pools and habitats of the Illinois Waterway. Underlying environmentally-driven variability in zooplankton metrics must therefore be considered when evaluating the effects of planktivory by Asian carp and the responses of zooplankton to Asian carp removal. Zooplankton data collected from the Dresden Island, Marseilles, and Starved Rock pools, where known numbers and biomass of Asian carp have been removed, are being analyzed to understand how seasonal variation in temperature, water chemistry, and hydrology influence zooplankton assemblage composition, density, and biomass, and how harvest-driven changes in Asian carp densities have affected these relationships. To complement the shift in removal efforts into the Peoria Pool, analyses will be expanded to examine zooplankton responses within this navigation pool. 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 May and October of 2020 at established sites to maintain consistency and data comparability with past years (Figure 1). Zooplankton will be collected by obtaining vertically-integrated water samples using a diaphragmatic pump. At each site, 90 L of water will be filtered through a 55 μm mesh to obtain crustacean zooplankton, 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 USGS gages on the Illinois Waterway. Estimates of Asian carp abundance in each navigation pool will be obtained from hydroacoustic surveys conducted by Southern Illinois University.

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.

2020 Schedule:

During 2020, zooplankton sampling will occur at bi-weekly intervals at all sites from May to October. At most sites, zooplankton will be sampled concurrently with ichthyoplankton sampling (collected to monitor for Asian carp eggs and larvae). Changes to this proposed sampling schedule may arise from restrictions on travel due to the COVID-19 pandemic. All efforts will be expended to conduct all sampling that is possible during 2020 while following legal requirements and practicing all appropriate safety measures to protect the health of staff and the public.

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

Deliverables:

Results of 2020 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

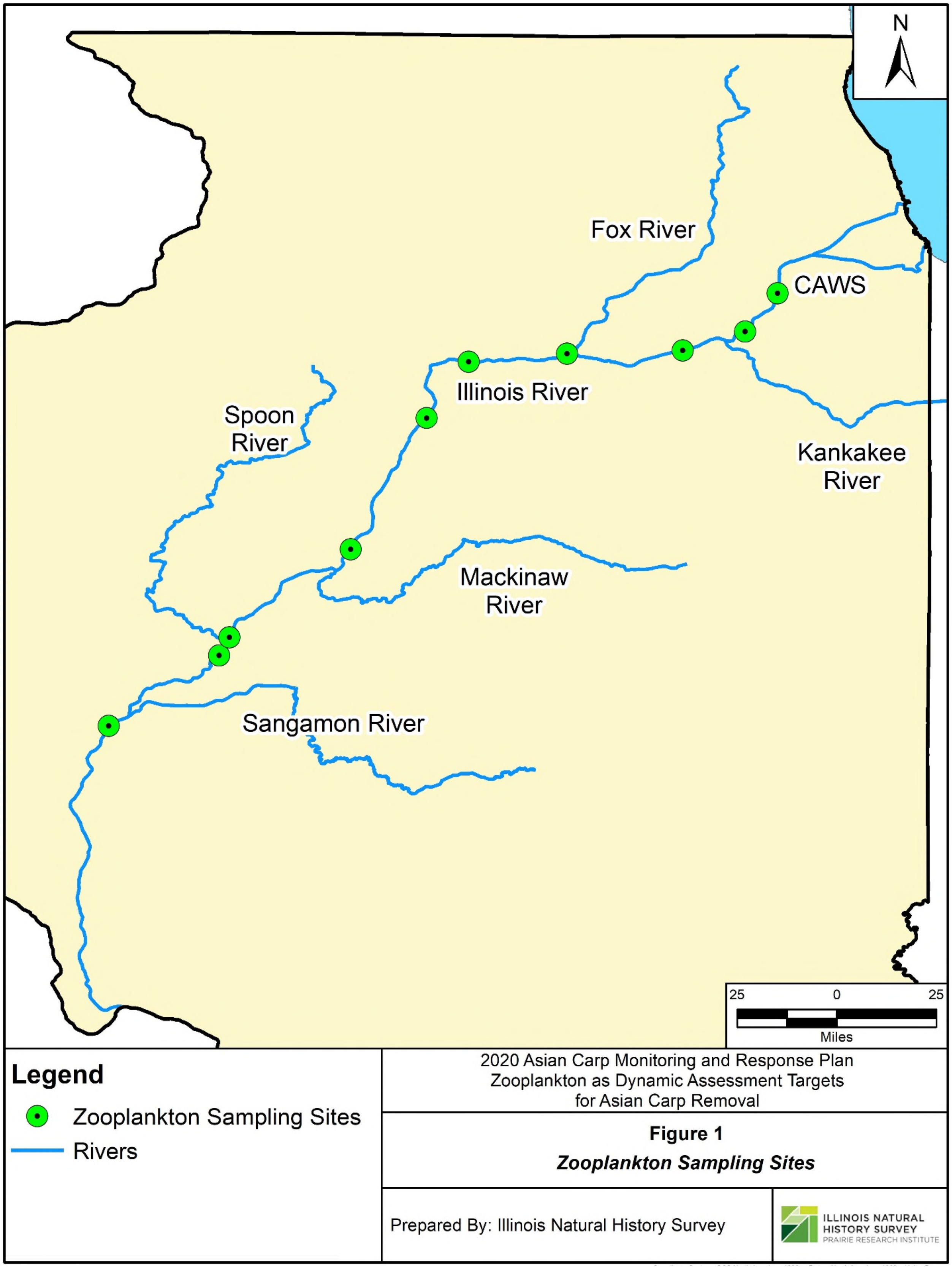


Figure 1. *Map of zooplankton sampling sites in the Illinois Waterway.*

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

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

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

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

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

BEST MANAGEMENT PRACTICES

BEFORE TRAVELING TO A SAMPLING LOCATION:

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

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

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

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

WHILE ON A WATERBODY:

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

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

Appendix C: 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.

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

ATTACHMENT A
DECONTAMINATION METHODS AND GEAR-SPECIFIC TIPS

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

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

Decontamination Methods

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

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

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

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

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

equipment being treated should be sprayed.[E]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7. *Freezing*

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

Gear-Specific Tips for Decontamination

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

Nets

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

Personal Gear and Clothing

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

Appendix C: 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.

Appendix C: 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.

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

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°C water, but 60°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°C for 2 weeks after blast freezing at-40°C) of in vitro VHSv shown a significant 99.9% reduction of the active virus post thaw.

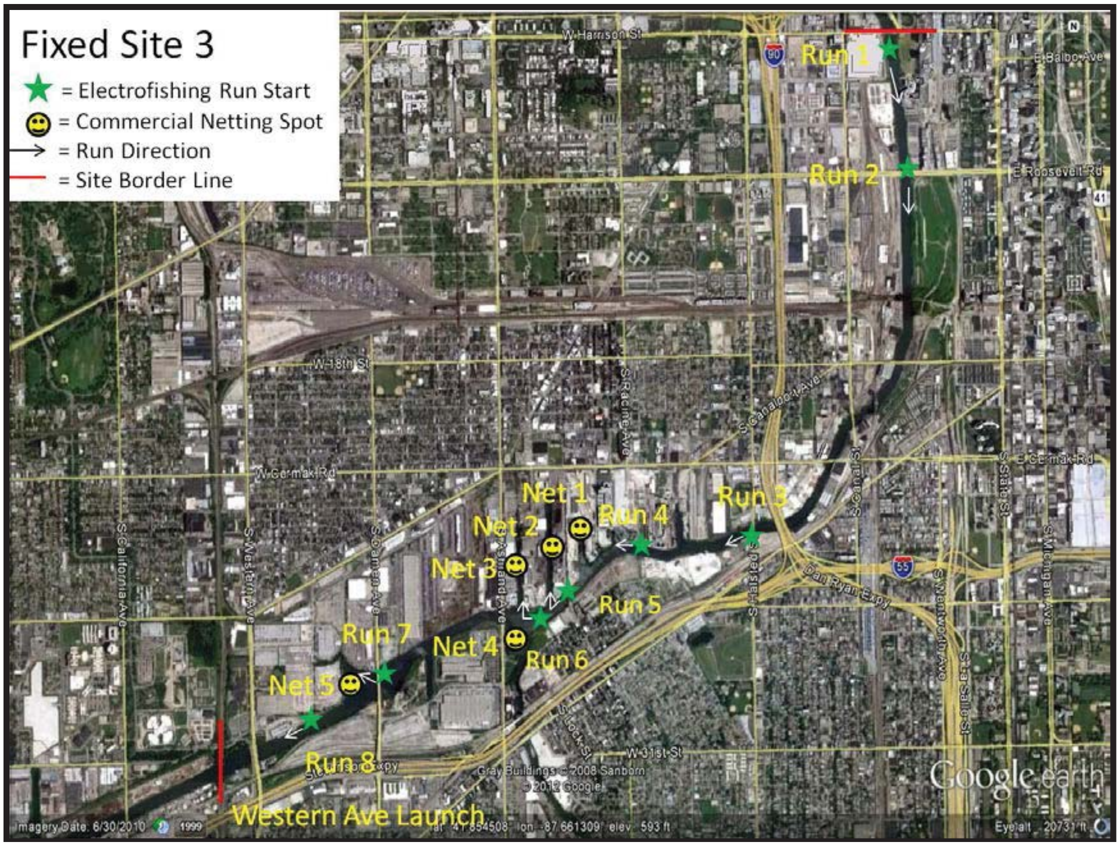
76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

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
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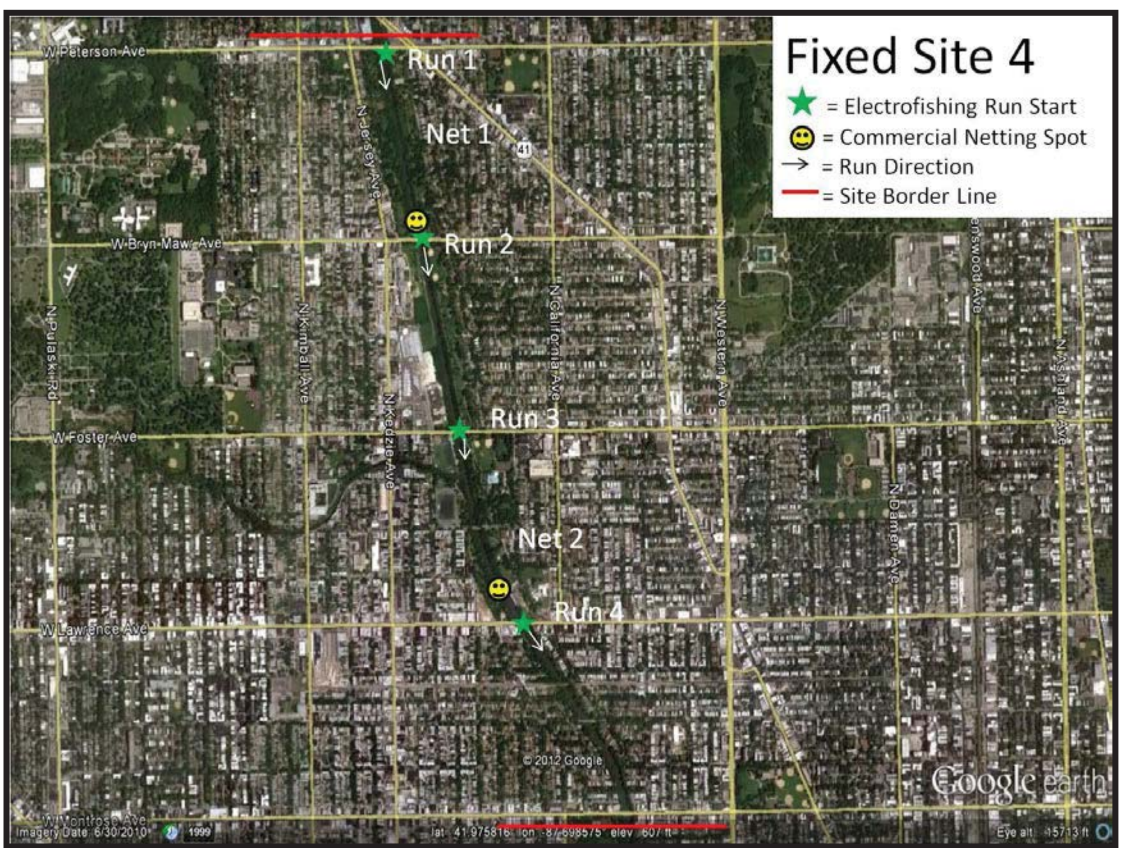
Net 3
Net 4
Net 5
Western Ave Launch
W Harrison St
E Balbo Ave
E Roosevelt Rd
W 18th St
W Cermak Rd
E Cermak Rd
S Racine Ave
S Canalport Ave
S Halsted St
S Ashland Ave
S California Ave
S Western Ave
S Damen Ave
S Wentworth Ave
S State St
S Michigan Ave
S La Salle St
W 31st St
Dan Ryan Expy
Google earth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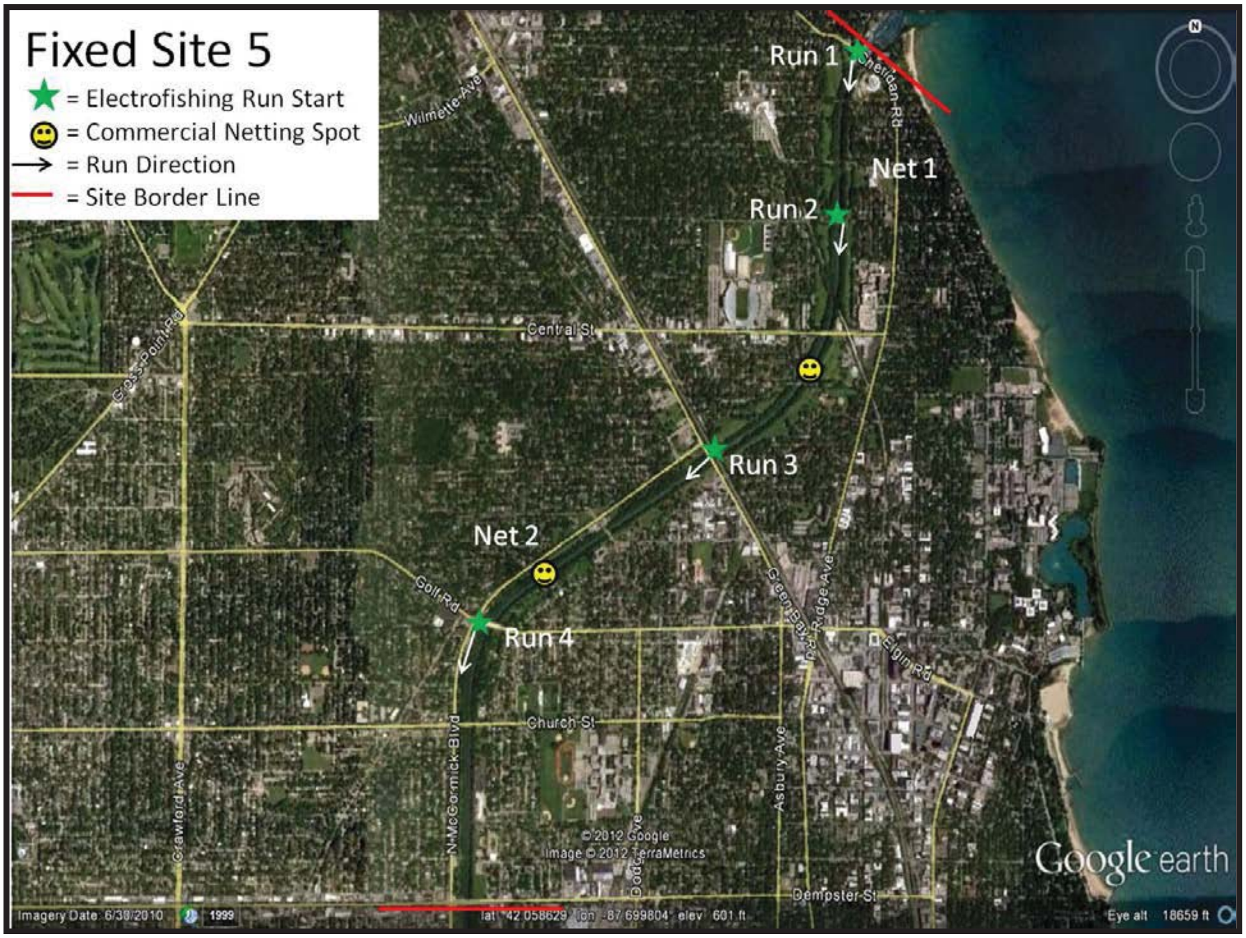
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
W Peterson Ave
W Bryn Mawr Ave
W Foster Ave
W Lawrence Ave
W Montrose Ave
N Pulaski Rd
N Kimball Ave
N Jersey Ave
N Kedzie Ave
N California Ave
N Western Ave
N Damen Ave
N Ashland Ave
© 2012 Google
Google earth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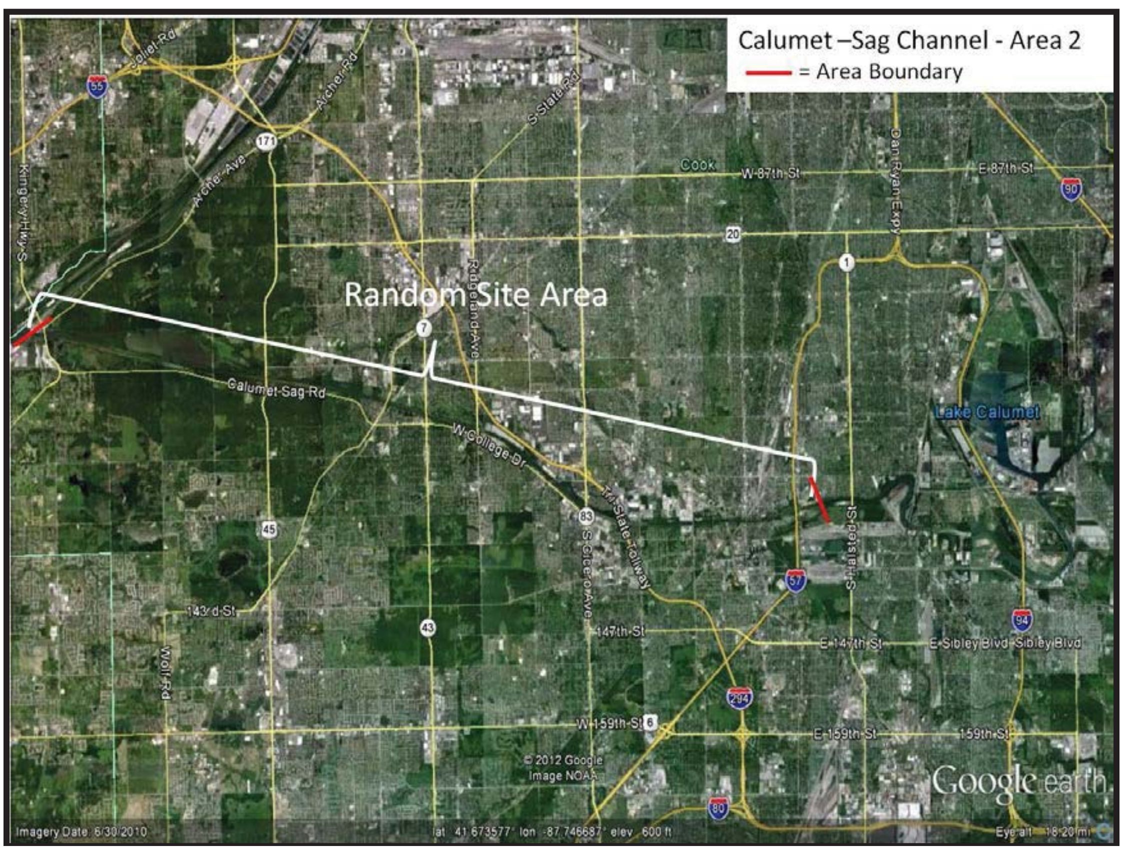
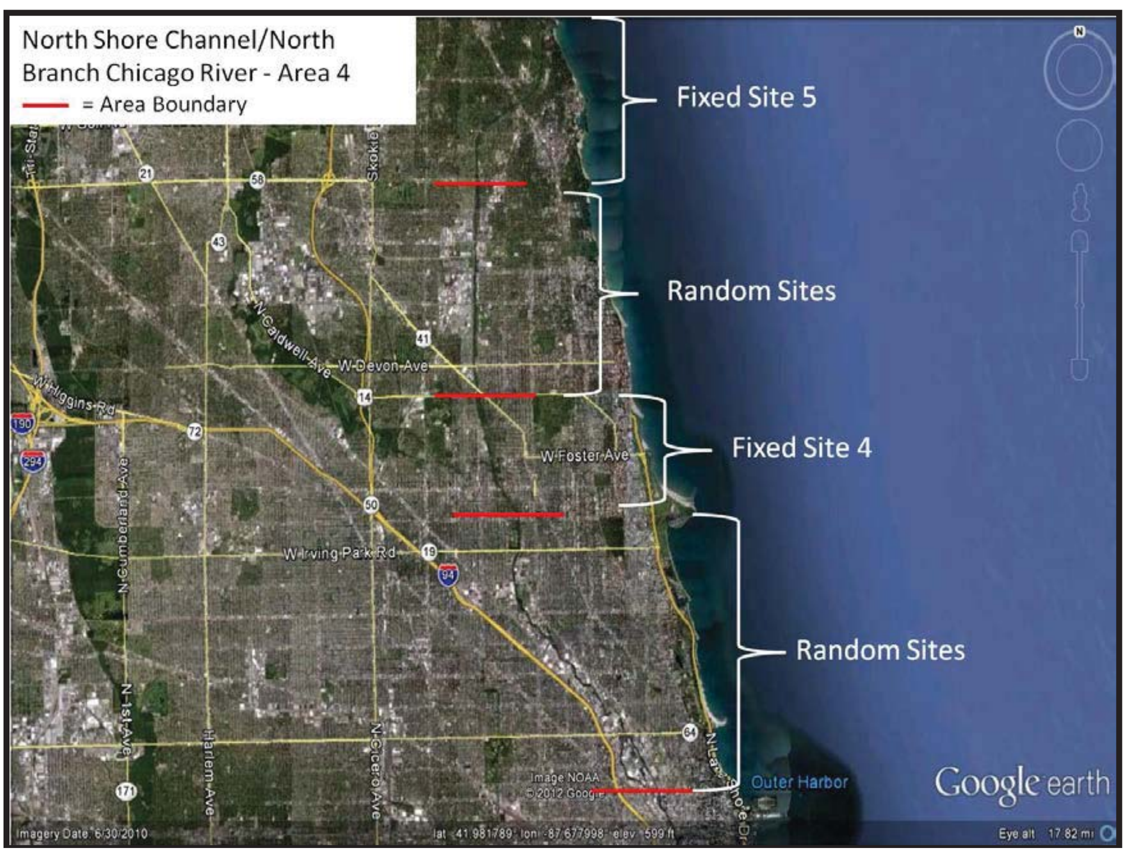
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
Wilmette Ave
Sheridan Rd
Central St
Gross Point Rd
Golf Rd
Church St
N McCormick Blvd
Crawford Ave
Asbury Ave
Ridge Ave
Green Bay Rd
Elgin Rd
Dodge Ave
Dempster St
© 2012 Google
Image © 2012 TerraMetrics
Imagery Date: 6/30/2010
1999
lat 42.058629 lon -87.699804 elev 601 ft
Eye alt 18659 ft
Google earth

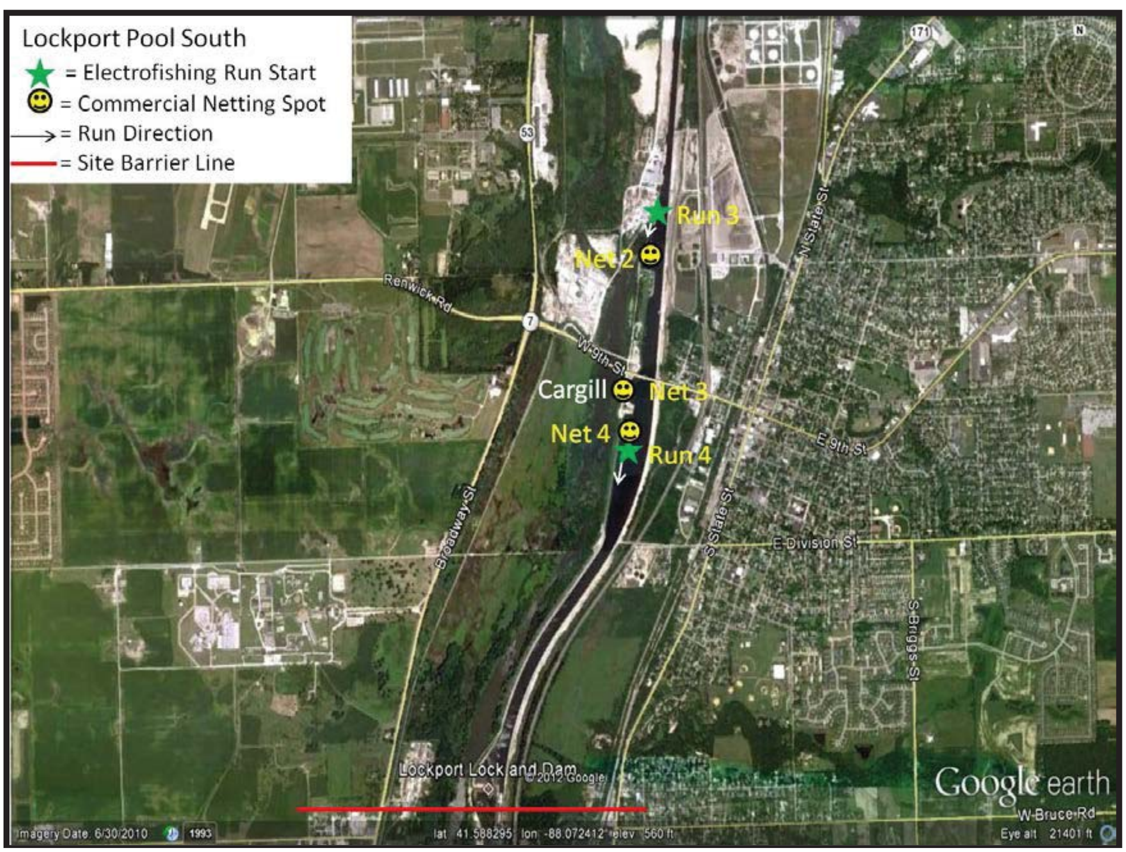

Calumet River - Area 1
= Area Boundary
Random Site Area
Lake Calumet
Wolf Lake
Highway 12
Chicago Skyway
Bishop Ford Fwy
S Halsted St
Calumet Ave
E 87th St
© 2012 Google
Image © 2012 TerraMetrics
Imagery Date 6/30/2010
1998
lat 41.697566° lon -87.564513° elev 586 ft
Eye alt 39389 ft
Google earth

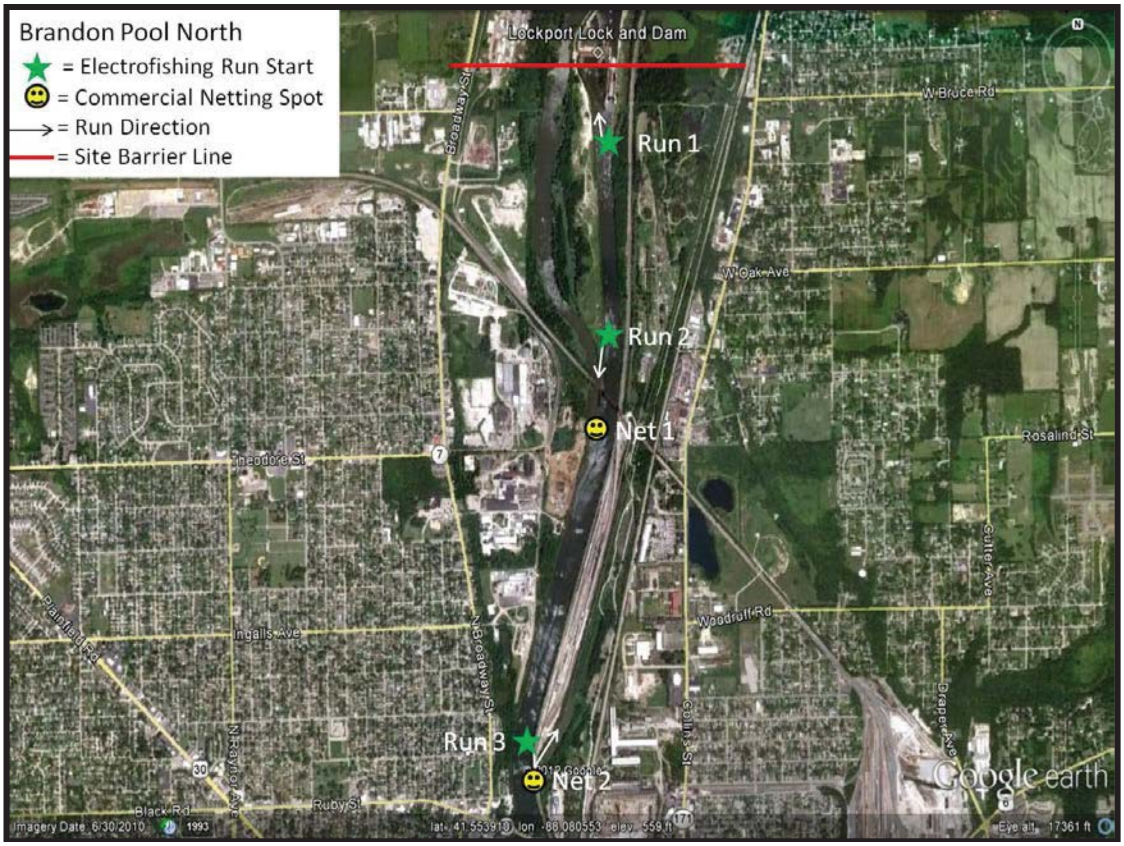

Calumet –Sag Channel - Area 2
= Area Boundary
Random Site Area
Lake Calumet
Joliet Rd
Archer Rd
Archer Ave
S State St
Cook
W 87th St
E 87th St
Dan Ryan Expy
Kingery Hwy S
Ridgeland Ave
Calumet-Sag Rd
W College Dr
Tri-State Tollway
S Cicero Ave
S Halsted St
143rd St
147th St
E 147th St
E Sibley Blvd
Sibley Blvd
Wolf Rd
W 159th St
E 159th St
159th St
© 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

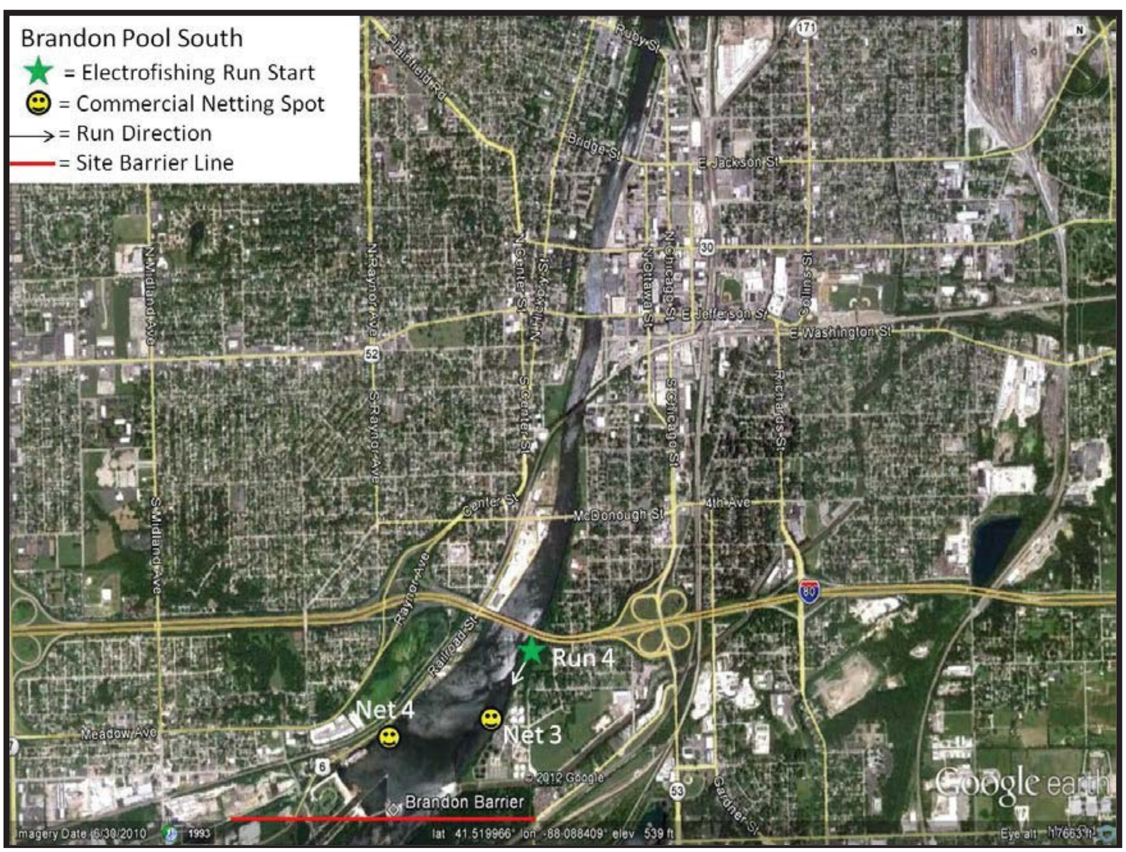

CSSC - Area 3
= Area Boundary
Random Sample Area
Roosevelt Rd
Butterfield Rd
DuPage
E Ogden Ave
W Ogden Ave
Stevenson Expy
Archer Rd
Archer Ave
Lincoln Ave
Main St
State Rd
Cook
W 87th St
Highway 12
Ridgeland Ave
S Harlem Ave
S Cicero Ave
S Halsted St
South La Grange Road
Veterans Memorial Tollway
© 2012 Google
Google earth
Imagery Date 6/30/2010

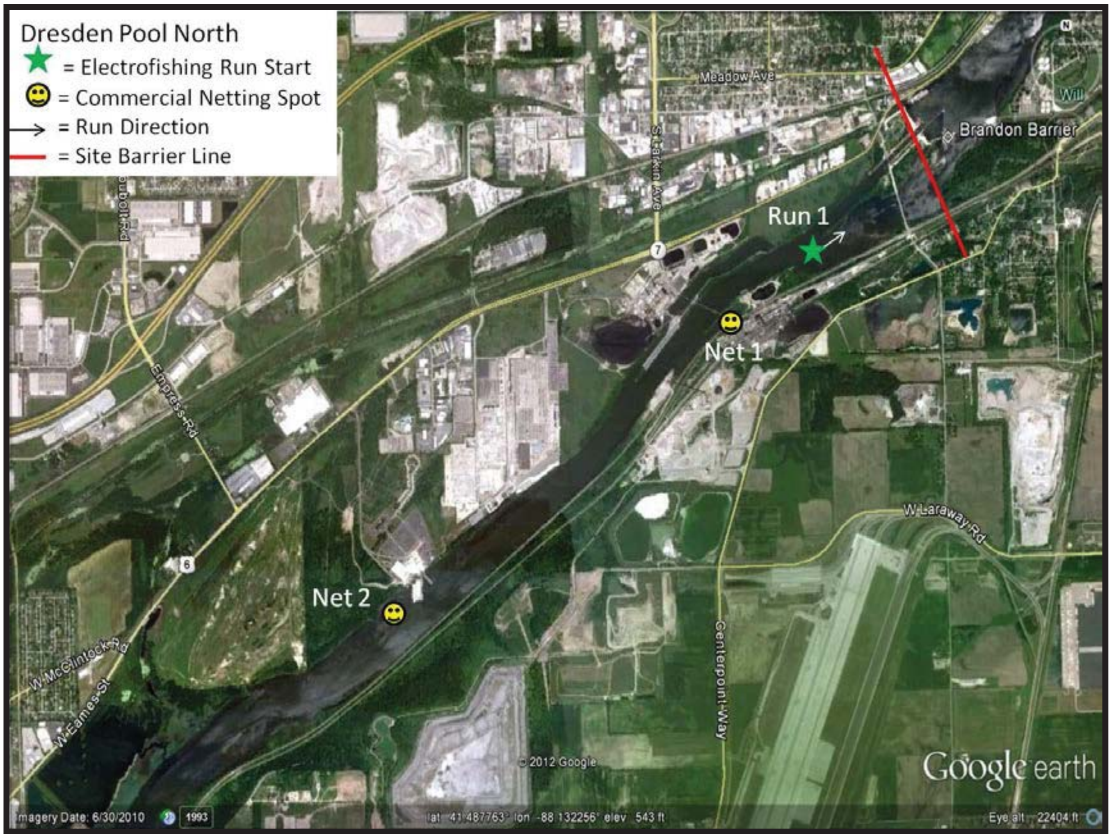

North Shore Channel/North Branch Chicago River - Area 4
= Area Boundary
Fixed Site 5
Random Sites
Fixed Site 4
Random Sites
N Caldwell Ave
W Devon Ave
W Higgins Rd
W Foster Ave
W Irving Park Rd
N Cumberland Ave
N 1st Ave
Harlem Ave
N Cicero Ave
Outer Harbor
Image NOAA
© 2012 Google
Google earth
Imagery Date 6/30/2010


Lockport Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Dispersal Barrier
W-135th St
E Romeoville Rd
Run 1
Run 2
Net 1
S Independence Blvd
Archer Ave
W 151st St
New Ave
Google earth
© 2012 Google
Imagery Date 6/30/2010
1993
lat 41.625414° lon -88.064803° elev 584 ft
Eye alt 18091 ft


Lockport Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 3
Net 2
Renwick Rd
W 9th St
Cargill
Net 3
Net 4
Run 4
E 9th St
N State St
S State St
E Division St
Broadway St
S Briggs St
Lockport Lock and Dam
© 2012 Google
Google earth
W Bruce Rd
Imagery Date 6/30/2010
1993
lat 41.588295° lon -88.072412° elev 560 ft
Eye alt 21401 ft

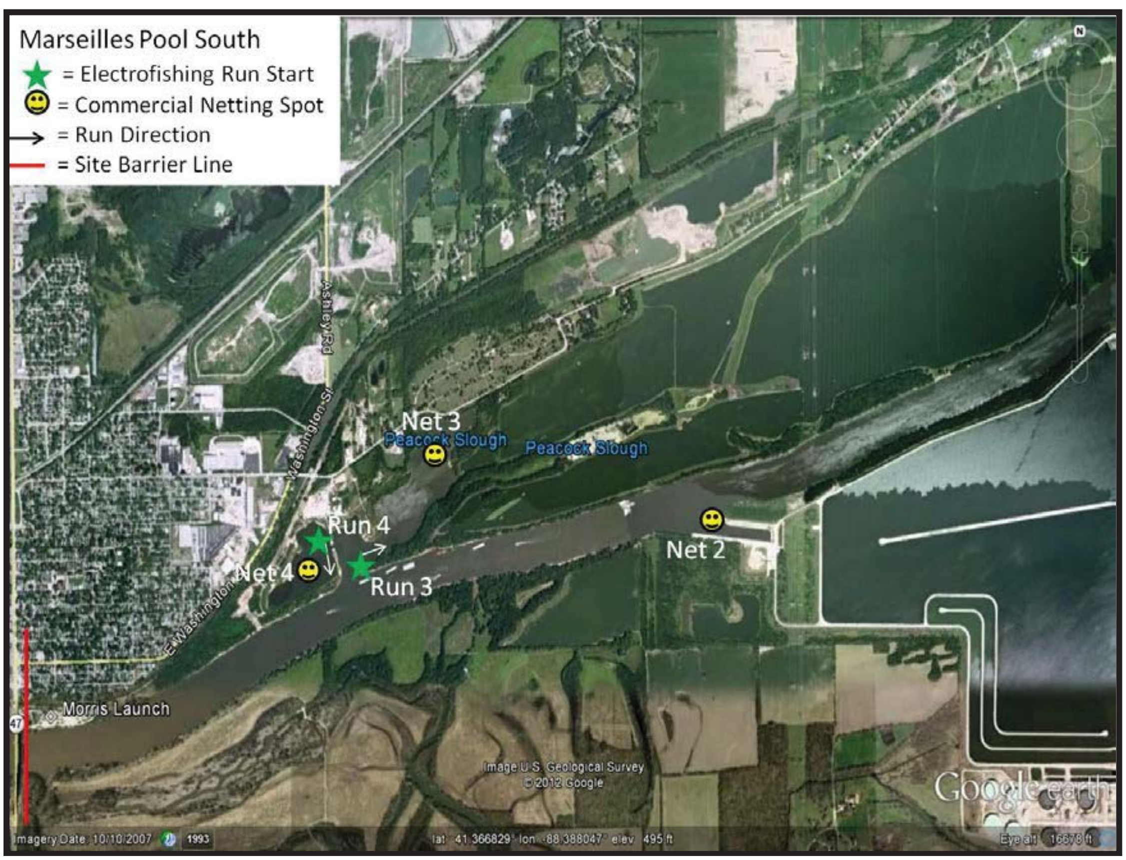

Brandon Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Lockport Lock and Dam
Run 1
Run 2
Net 1
Run 3
Net 2
W Bruce Rd
W Oak Ave
Rosalind St
Theodore St
Woodruff Rd
Ingalls Ave
Plainfield Rd
Black Rd
Ruby St
Broadway St
N Broadway St
Collins St
Draper Ave
Gutter Ave
N Raynor Ave
Google earth
Imagery Date 6/30/2010


Brandon Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 4
Net 4
Net 3
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
McDonough St
4th Ave
Center St
Raynor Ave
Railroad St
Meadow Ave
Richards St
S Chicago St
Gardner St
Google earth
Imagery Date 6/30/2010


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
E Eames St
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
Imagery Date: 4/30/2008
Eye alt 19308 ft


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

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):

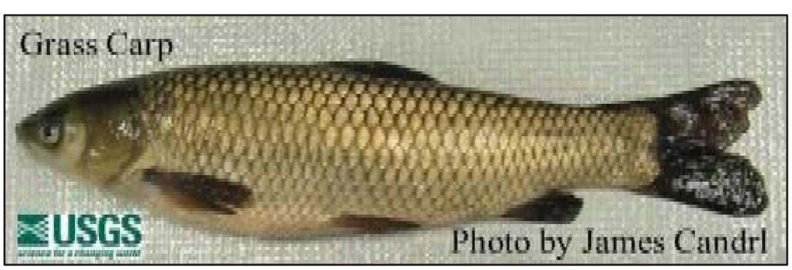
Collection No.	From: (Print Name, Agency) To: (Print Name, Agency)	Release Signature:	Release Date:	Delivered Via: □ U.S. Mail □ In Person □ Other:
Collection No.	From: (Print Name, Agency) To: (Print Name, Agency)	Release Signature:	Release Date:	Delivered Via: □ U.S. Mail □ In Person □ Other:
Collection 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.

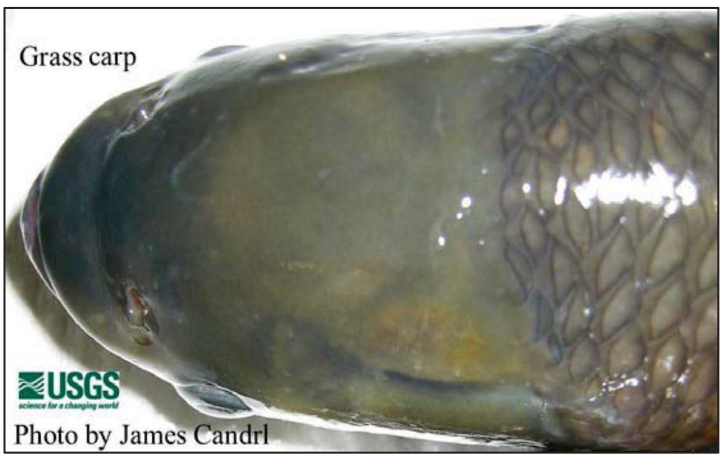
Step 1: Data Collection

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

Appendix G: List of Asian Carp fish species codes arranged in alphabetical order by fish common name. Four-digit species codes are the same as codes used by the Long Term Resource Monitoring Program (Ratcliff et al. 2014). Nomenclature follows the American Fisheries Society standard naming conventions (Nelson et al. 2004).

Common name	Scientific name	Code
Common carp x goldfish hybrid	*C. carpio x Carassius auratus*	CCGF
Common shiner	*Luxilus cornutus*	CMSN
Creek chub	*Semotilus atromaculatus*	CKCB
Creek chubsucker	*Erimyzon oblongus*	CKCS
Crystal darter	*Crystallaria asprella*	CLDR
Dusky darter	*Percina sciera*	DYDR
Emerald shiner	*Notropis atherinoides*	ERSN
Fantail darter	*Etheostoma flabellare*	FTDR
Fathead minnow	*Pimephales promelas*	FHMW
Flathead catfish	*Pylodictis olivaris*	FHCF
Flier	*Centrarchus macropterus*	FLER
Freckled madtom	*Noturus nocturnus*	FKMT
Freshwater drum	*Aplodinotus grunniens*	FWDM
Ghost shiner	*Notropis buchanani*	GTSN
Gizzard shad	*Dorosoma cepedianum*	GZSD
Golden redhorse	*Moxostoma erythrurum*	GDRH
Golden shiner	*Notemigonus crysoleucas*	GDSN
Goldeye	*Hiodon alosoides*	GDEY
Goldfish	*Carassius auratus*	GDFH
Grass carp	*Ctenopharyngodon idella*	GSCP
Grass pickerel	*Esox americanus vermiculatus*	GSPK
Green sunfish	*Lepomis cyanellus*	GNSF
Green sunfish x bluegill hybrid	*L. cyanellus x L. macrochirus*	GSBG
Green sunfish x orangespotted sunfish hybrid	*L. cyanellus x L. humilis*	GSOS
Green sunfish x pumpkinseed hybrid	*L. cyanellus x L. gibbosus*	GSPS
Green sunfish x redear hybrid	*L. cyanellus x L. microlophus*	GSRS
Green sunfish x warmouth hybrid	*L. cyanellus x L. gulosus*	GSWM
Greenside darter	*Etheostoma blennioides*	GSDR
Highfin carpsucker	*Carpiodes velifer*	HFCS
Hornyhead chub	*Nocomis biguttatus*	HHCB
Inland silverside	*Menidia beryllina*	IDSS
Iowa darter	*Etheostoma exile*	IODR
Johnny darter	*Etheostoma nigrum*	JYDR
Lake sturgeon	*Acipenser fulvescens*	LKSG
Largemouth bass	*Micropterus salmoides*	LMBS
Largescale stoneroller	*Campostoma oligolepis*	LSSR
Larval fish	Larval fish	LRVL
Least brook lamprey	*Lampetra aepyptera*	LBLP
Logperch	*Percina caprodes*	LGPH
Longear sunfish	*Lepomis megalotis*	LESF
Longnose gar	*Lepisosteus osseus*	LNGR
Longnose gar x spotted gar hybrid	*L. osseus x L. oculatus*	LNST

Appendix G: List of Asian Carp fish species codes arranged in alphabetical order by fish common name. Four-digit species codes are the same as codes used by the Long Term Resource Monitoring Program (Ratcliff et al. 2014). Nomenclature follows the American Fisheries Society standard naming conventions (Nelson et al. 2004).

Common name	Scientific name	Code
Mimic shiner	*Notropis volucellus*	MMSN
Mississippi silvery minnow	*Hybognathus nuchalis*	SVMW
Mooneye	*Hiodon tergisus*	MNEY
Mud darter	*Etheostoma asprigene*	MDDR
Muskellunge	*Esox masquinongy*	MSKG
New species	New species	NWSP
No fish caught	No fish caught	NFSH
Northern hog sucker	*Hypentelium nigricans*	NHSK
Northern pike	*Esox lucius*	NTPK
Northern studfish	*Fundulus catenatus*	NTSF
Orangespotted sunfish	*Lepomis humilis*	OSSF
Orangespotted sunfish x longear sunfish hybrid	*L. humilis x L. megalotis*	OSLE
Orangethroat darter	*Etheostoma spectabile*	OTDR
Ozark minnow	*Notropis nubilus*	OZMW
Paddlefish	*Polyodon spathula*	PDFH
Pallid shiner	*Hybopsis amnis*	PDSN
Pirate perch	*Aphredoderus sayanus*	PRPH
Plains minnow	*Hybognathus placitus*	PNMW
Pugnose minnow	*Opsopoeodus emiliae*	PGMW
Pumpkinseed	*Lepomis gibbosus*	PNSD
Pumpkinseed x bluegill hybrid	*L. gibbosus x L. macrochirus*	PSBG
Pumpkinseed x orangespotted sunfish hybrid	*L. gibbosus x L. humilis*	PSOS
Pumpkinseed x warmouth hybrid	*L. gibbosus x L. gulosus*	PSWM
Quillback	*Carpiodes cyprinus*	QLBK
Rainbow smelt	*Osmerus mordax*	RBST
Red shiner	*Cyprinella lutrensis*	RDSN
Redear sunfish	*Lepomis microlophus*	RESF
Redfin shiner	*Lythrurus umbratilis*	RFSN
Redspotted sunfish	*Lepomis miniatus*	RSSF
River carpsucker	*Carpiodes carpio*	RVCS
River chub	*Nocomis micropogon*	RVCB
River darter	*Percina shumardi*	RRDR
River redhorse	*Moxostoma carinatum*	RVRH
River shiner	*Notropis blennius*	RVSN
Rock bass	*Ambloplites rupestris*	RKBS
Round goby	*Neogobius melanostomus*	RDGY
Rudd	*Scardinius erythrophthalmus*	RUDD
Sand shiner	*Notropis stramineus*	SNSN
Sauger	*Sander canadensis*	SGER
Sauger x walleye hybrid	*S. canadensis x S. vitreus*	SGWE
Shorthead redhorse	*Moxostoma macrolepidotum*	SHRH

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Common name	Scientific name	Code
Shortnose gar	*Lepisosteus platostomus*	SNGR
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	SNSG
Shovelnose sturgeon x pallid sturgeon hybrid	*S. platorynchus x S. albus*	SNPD
Sicklefin chub	*Macrhybopsis meeki*	SFCB
Silver carp	*Hypophthalmichthys molitrix*	SVCP
Silver carp x bighead carp hybrid	*H. molitrix x H. nobilis*	SCBC
Silver chub	*Macrhybopsis storeriana*	SVCB
Silver lamprey	*Ichthyomyzon unicuspis*	SVLP
Silver redhorse	*Moxostoma anisurum*	SVRH
Silverband shiner	*Notropis shumardi*	SBSN
Skipjack herring	*Alosa chrysochloris*	SJHR
Slenderhead darter	*Percina phoxocephala*	SHDR
Slough darter	*Etheostoma gracile*	SLDR
Smallmouth bass	*Micropterus dolomieu*	SMBS
Smallmouth buffalo	*Ictiobus bubalus*	SMBF
Southern redbelly dace	*Phoxinus erythrogaster*	SRBD
Speckled chub	*Macrhybopsis aestivalis*	SKCB
Spotfin shiner	*Cyprinella spiloptera*	SFSN
Spottail shiner	*Notropis hudsonius*	STSN
Spotted bass	*Micropterus punctulatus*	STBS
Spotted gar	*Lepisosteus oculatus*	STGR
Spotted sucker	*Minytrema melanops*	SPSK
Starhead topminnow	*Fundulus dispar*	SHTM
Stonecat	*Noturus flavus*	STCT
Striped bass	*Morone saxatilis*	SDBS
Striped bass x white bass hybrid	*M. saxatilis x M. chrysops*	SBWB
Striped mullet	*Mugil cephalus*	SPMT
Striped shiner	*Luxilus chrysocephalus*	SPSN
Sturgeon chub	*Macrhybopsis gelida*	SGCB
Suckermouth minnow	*Phenacobius mirabilis*	SMMW
Tadpole madtom	*Noturus gyrinus*	TPMT
Threadfin shad	*Dorosoma petenense*	TFSD
Tiger muskellunge	*Esox masquinongy x E. lucius*	MGNP
Trout-perch	*Percopsis omiscomaycus*	TTPH
Unidentified	Unidentified	UNID
Unidentified sturgeons	Acipenseridae	U-SG
Unidentified suckers	Catostomidae	U-CT
Unidentified sunfishes	Centrarchidae	U-CN
Unidentified shads	Clupeidae	U-CL
Unidentified minnows	Cyprinidae	U-CY
Unidentified mooneyes	Hiodontidae	U-HI
Unidentified catfishes	Ictaluridae	U-IL

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Common name	**Scientific name**	**Code**
Unidentified perches	Percidae	U-PC
Unidentified lampreys	Petromyzontidae	U-LY
Walleye	*Sander vitreus*	WLYE
Warmouth	*Lepomis gulosus*	WRMH
Wedgespot shiner	*Notropis greenei*	WSSN
Weed shiner	*Notropis texanus*	WDSN
Western blacknose dace	*Rhinichthys obtusus*	BNDC
Western mosquitofish	*Gambusia affinis*	MQTF
Western sand darter	*Ammocrypta clara*	WSDR
Western silvery minnow	*Hybognathus argyritis*	WSMW
White bass	*Morone chrysops*	WTBS
White crappie	*Pomoxis annularis*	WTCP
White perch	*Morone americana*	WTPH
White perch x yellow bass hybrid	*M. americana x M. mississippiensis*	WPYB
White sucker	*Catostomus commersonii*	WTSK
Yellow bass	*Morone mississippiensis*	YWBS
Yellow bullhead	*Ameiurus natalis*	YLBH
Yellow perch	*Perca flavescens*	YWPH

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**
Alligator snapping turtle	*Macrochelys temminckii*	ASNT
Blanding's turtle*	*Emydoidea blandingii*	BLDT
Chinese Mystery Snails	*Cipangopaludina chinensis*	CMSN
Eastern musk turtle (formerly common musk turtle)	*Sternotherus odoratus*	CMKT
Eastern snapping turtle (formerly common snapping turtle)	*Chelydra serpentina*	CSNT
False map turtle	*Graptemys pseudogeographica*	FMPT
Midland painted turtle	*Chrysemys picta marginata*	MPTT
Midland smooth softshell	*Apalone mutica mutica*	SMSS
Mississippi map turtle	*Graptemys pseudogeographica kohnii*	MMPT
Northern map turtle (formerly common map turtle)	*Graptemys geographica*	CMPT
Ouachita map turtle	*Graptemys ouachitensis ouachitensis*	OMPT
Red Swamp Crayfish	*Procambarus clarkii*	RSCF
Red-eared slider	*Trachemys scripta elegans*	RESL
River cooter	*Pseudemys concinna*	RCOT
Rusty Crayfish	Orconectes rusticus	RUCF
Spiny softshell	*Apalone spinifera*	SPSS
Western painted turtle	*Chrysemys picta belli*	WPTT
Wood turtle*	*Glyptemys insculpta*	WODT
Yellow mud turtle* (formerly Illinois mud turtle)	*Kinosternon flavescens*	IMDT
Zebra Mussels	*Dreissena polymorpha*	ZEBR

*Rare species. Should be reported to respective state agencies if captured

Appendix H: Sample data sheets.

Asian Carp Monitoring Project - Electro

Date: ____________________

Area Surveyed: ____________________________ Biologist (Crew): _________________________________

Wisc Unit DC: Rate: ______ Duty:______ Range: High or Low Volts:_____ Amps:_________

Smith Root DC: Percent of Setting:________Pulse Per Second Setting:________Amps:________

Other (Describe): ____

Rate Gear Efficency (circle one): Good Moderate Poor

Air Temp: ________ Water Temp: _________ Conductivity: _________ Others: ________________

	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	Run No.___________ Lat.________________ Lon.________________ Start Time: __________ Shock Time: ________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total No. Fish
Gizzard shad >6 in.				
Gizzard shad juv.<6 in.				
Alewife				
Common carp				
Goldfish				
Carp x Goldfish hybrid				
Freshwater drum				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
White sucker				
Channel catfish				
Yellow bullhead				
Black bullhead				
Largemouth bass				
Smallmouth bass				
Bluegill				
Green sunfish				
Pumpkinseed				
Hybrid sunfish				
Rock bass				
White crappie				
Black crappie				
Golden shiner				
Bluntnose minnow				
Fathead minnow				
Spotfin shiner				
Emerald shiner				
Spottail shiner				
Round goby				
White perch				
White bass				
Yellow bass				

Asian Carp Monitoring Project - Nets

Date: ___________________

Area Surveyed: ____________________________ Biologist (Crew): ________________________________

Air Temp: ________ Water Temp: __________ Conductivity: __________ Others: _________________

Set No.___________ Lat.________________ Lon.______________ Total Yds.__________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total
Gizzard shad >6.0 in.				
Common carp				
Goldfish				
Carp x goldfish hybrid				
Freshwater drum				
Bighead carp				
Silver carp				
Grass carp				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
Channel catfish				

Set No.___________ Lat.________________ Lon.______________ Total Yds.__________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	Panel No.___________ Type (circle): Tra or Gill Length (yds.)_________ Height (ft.)___________ Mesh (in.)____________ Start Time: ___________ End Time: ___________	
Fish Species	No. of Fish	No. of Fish	No. of Fish	Total
Gizzard shad >6.0 in.				
Common carp				
Goldfish				
Carp x goldfish hybrid				
Freshwater drum				
Bighead carp				
Silver carp				
Grass carp				
Smallmouth buffalo				
Bigmouth buffalo				
Black buffalo				
River carpsucker				
Quillback				
Channel catfish				

Asian Carp Monitoring Project

Date: ____________________

Area Surveyed: ____________________ **Biologist (Crew):** ________________________________

Gear Type (circle one): DC, AC, Nets

Nets (Describe Nets): ____

Fish Species	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm	TL mm
Gizzard shad >6 in.										
Gizzard shad juv.<6 in.										
Alewife										
Common carp										
Goldfish										
Carp x Goldfish hybrid										
Freshwater drum										
Smallmouth buffalo										
Bigmouth buffalo										
Black buffalo										
Quillback										
White sucker										
Channel catfish										
Yellow bullhead										
Black bullhead										
Largemouth bass										
Smallmouth bass										
Bluegill										
Green sunfish										
Pumpkinseed										
Hybrid sunfish										
Rock bass										
White crappie										
Black crappie										
Golden shiner										
Bluntnose minnow										
Fathead minnow										
Spotfin shiner										
Emerald shiner										
Round goby										
White perch										
Yellow Bass										

eDNA Field Data Sheet

DATE______________ NAME________________________________ START TIME____________ SHEET _____of______

ID	Volume	Latitude	Longitude	Temp	Depth	Habitat	Collect Time	Filter Time

Notes/Comments:

Appendix I: Analysis of Bighead and Silver Carp Spawn Patches.

Spawn Patch Preservation/Analysis:

Bighead and Silver Carp males use their pectoral fins to irritate the vental margin of females during the spawning season (Figure 1). Recent spawning or prespawning interactions between males and females will leave an irritated patch on the breast of the female fish, and scales are often lost. Presence of regenerated scales is evidence that a female fish may have been courted by a male fish (although it is impossible to tell from this feature if spawning actually occurred). The number of annuli in regenerated scales may also be useful in determining the number of years since spawning activity occurred. It is as yet unclear how many scales are lost on average or if scales are lost each time the fish spawns. However, in order to preserve potential information on spawning activity or presence of male fish where a female fish is captured, it is prudent to preserve the breast of Bighead and Silver Carp caught from areas where the presence of Asian carps caught is being investigated if allowable by the state and regulatory bodies. For the 2013 Monitoring and Response Plan participants, fish collected in the CAWS or the Great Lakes should follow the chain of command and custody protocols is of primary importance with biological data being collected after securing the fish. Fish collected in Brandon Road Pool require a voucher per the 2013 MRP. Additional biological data will be processed after those protocols have been followed and likely in a lab setting. For fish collected below Brandon Road Lock and Dam, it is permissible to follow the procedures as long as it would not interfere with ongoing tracking/telemetry.

Figure 1. Spawn patch of a female Bighead Carp, located on the breast of the fish between the pelvic and pectoral fins.

If a Bighead or Silver Carp is caught from the Great Lakes or the CAWS, FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL; See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records**. If there is no conflict with existing protocol, the portion of the fish illustrated in Figure 2 should be photographed as soon as possible after capture, to document abrasions from recent sexual activity. In areas outside of the CAWS and the Great Lakes sections should be preserved from damage to ensure scale regeneration can be analyzed if required by state and regulatory agencies.

Protocols for analysis of scale regeneration in this area are not yet prepared, but care should be taken to preserve the scales and skin in this area. This technique is only useful when employed on female Bighead and Silver Carp. Although external features are useful in identifying the sex of a captured Bighead or Silver Carp, none of these features are 100% reliable in identification of sex. Therefore this portion of the fish should be preserved at least until the sex is determined by the examination of the gonads. When the gonads are examined, care should be taken to avoid cutting through the area of the spawn patch. Note that histological examination of gonads may also be useful in evaluating recent spawning activity.

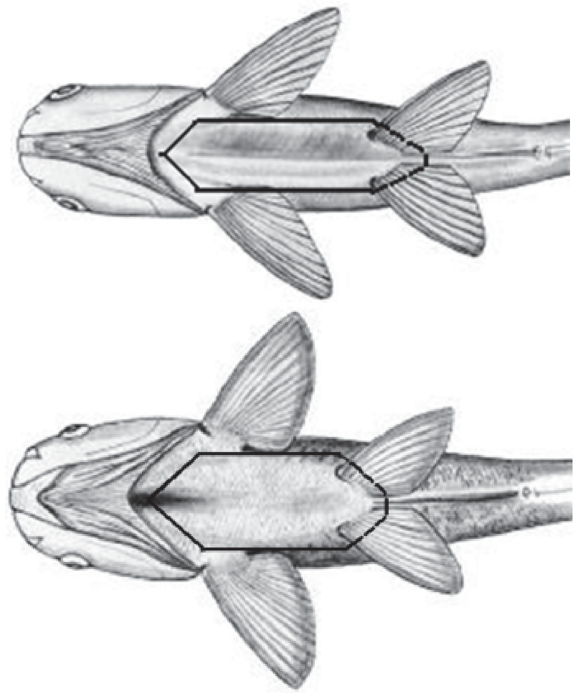

Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection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

Appendix J: Black and Grass Carp Identification

Black and grass carp are very similar in appearance. We do not have a reliable method to tell them apart based on external characteristics, but these photos and general characteristics might help. When in doubt, report the fish to the appropriate resource management agency.

Black carp


Photo: Greg Whitledge, SIU

Grass Carp


Photo: James Candrl, USGS

The mouth of **adult** black carp is more subterminal and the operculum is longer than in grass carp. The black carp's head is generally narrower, more cone-shaped, whereas the grass carp's tends to be rounder, blunter. However, the difference can be subtle.

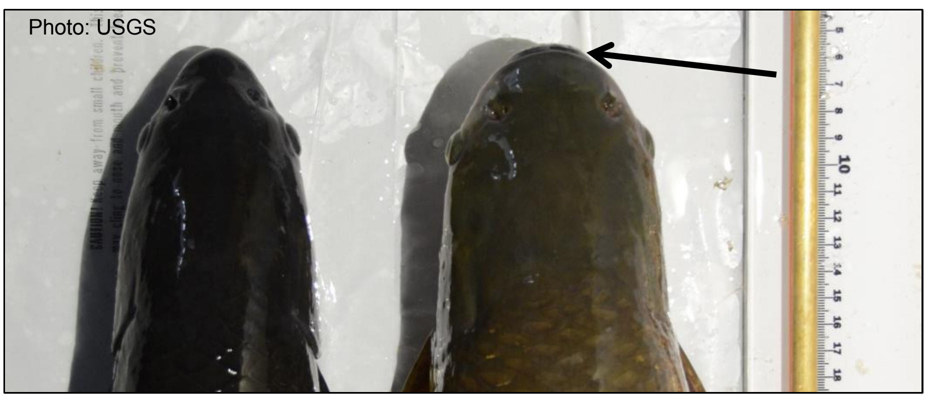
Photo: USGS

The upper lip of a grass carp is visible from above **when the mouth is fully closed.** Young black carp may also exhibit this feature, so it is only useful for **adults**.


Photo: USGS

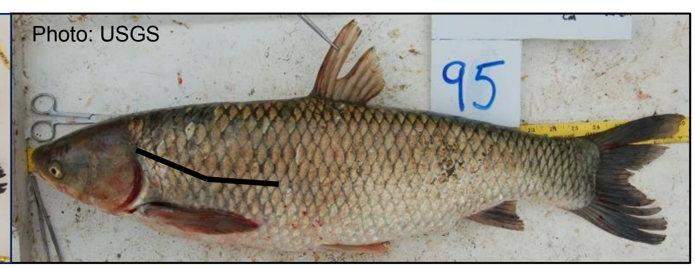

Photo: USGS

If the carcass is in good condition, you might be able to use the angle of the lateral line to ID the fish. "The lateral line of a black carp remains relatively straight moving from the operculum posterior, with a slight dip around the dorsal fin. On grass carp the lateral line takes an initial ventral dip for the first 6-8 scales (about 10°)" (Patrick Kroboth, USGS).

Black carp

Photo: Greg Whitledge, SIU

Photo: USGS

Photo: USFWS

Photo: USGS

Photo: Greg Whitledge, SIU

Grass Carp

Photo: USFWS

Photo: USGS

Photo: USGS

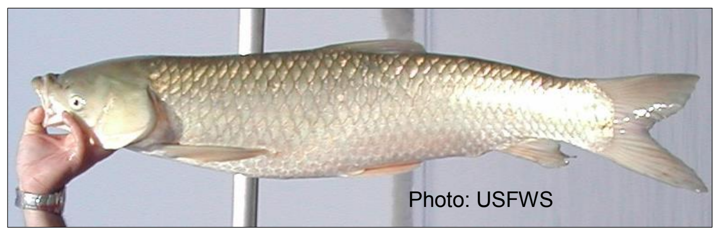

Photo: USFWS

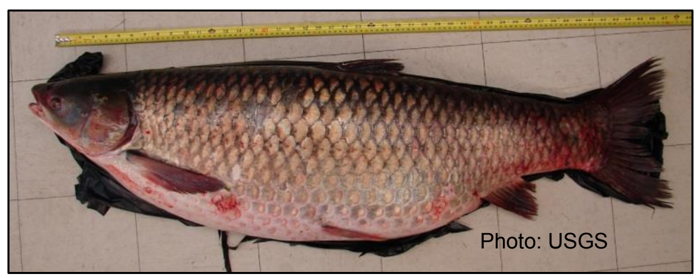

Photo: USGS

Photo: USGS

Black carp tend to have longer pectoral fins than grass carp. The coloration of black carp is described as, “Black, blue gray, or dark brown and the fins in particular are darkly pigmented. In contrast, coloration of grass carp is often described as olivaceous or silvery white, or as olive-brown above and silvery below, and most fins are dusky. Nevertheless, color may not always be reliable” (Nico et al. 2005).

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ORIGINAL PAPER

Bigheaded carps (*Hypophthalmichthys* spp.) at the edge of their invaded range: using hydroacoustics to assess population parameters and the efficacy of harvest as a control strategy in a large North American river

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K-2

Abstract The threat posed by bigheaded carps (*Hypophthalmichthys* spp.) to novel ecosystems has focused efforts on preventing further range expansion; upstream progression in the Illinois River is a major concern due to its connection with the uninvaded Great Lakes. In addition to an electric barrier system, commercial harvest of silver carp (*H. molitrix*) and bighead carp (*H. nobilis*) in the upper river is intended to reduce propagule pressure and prevent range expansion. To quantify demographics and evaluate harvest efficacy, the upper river was sampled between 2012 and 2015 using mobile hydroacoustic methods. Reach-specific densities, size structures and species compositions varied interannually but the advancing population was characterized longitudinally as small-bodied, silver carp-dominated at the highest densities downstream, shifting to large-bodied, bighead carp-dominated at the low-density population front. The use of hydroacoustic sampling for harvest evaluation was validated in backwater lakes; there was a significant positive correlation between density estimates and the corresponding harvest catch-per-unit-effort of bigheaded carps. Localized densities of bigheaded carps were reduced by up to 64.4 % immediately post-harvest but generally rebounded within weeks. However, annual sampling of the entire upper river indicated that density of bigheaded carps decreased by over 40 % (between 2012 and 2013) and subsequently remained stable (between 2013 and 2014). The annual harvest of bigheaded carps increased during this period (from 45,192 to 102,453 individuals), in years of contrasting discharge conditions. At this spatiotemporal scale, harvest appears to have contributed to initial reduction, and subsequent maintenance of, bigheaded carps density levels, but discharge likely plays an important role (e.g., through immigration) in determining the extent of its impact. Mobile hydroacoustic sampling enabled robust quantification of the population over varying spatial scales and density gradients, highlighting the potential of this approach as an assessment tool for invasive fishes in riverine environments.

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

Introduction

Aquatic invasive species can have negative ecological and socio-economic impacts in freshwater ecosystems where they are introduced (Vitule et al. 2009). As our understanding of these adverse effects increases, so too does vigilance regarding potential invaders (Van-der Zanden et al. 2010). In the central United States, preventing interbasin movement of non-native species between the Mississippi and Great Lakes is a key management objective (USACE 2014). Bigheaded carps (silver carp *Hypopthalmichthys molitrix* and bighead carp *H. nobilis*), large planktivores native to east Asia (Kolar et al. 2007; Garvey 2012), are among the fish species of highest concern. Since the early 2000s, many studies have focused on the ecology of bigheaded carps at the core of their North American range, specifically in the Middle Mississippi, Lower Missouri and Lower Illinois Rivers (e.g., Schrank and Guy 2002; Williamson and Garvey 2005; Sass et al. 2010; Cudmore et al 2012; Garvey et al. 2012; Norman and Whitledge 2015). Theoretical work has also examined the potential threat posed by the species to the uninvaded Great Lakes (Kocovsky et al. 2012; Cuddington et al. 2014; Zhang et al. 2016; see review by Cooke 2016). However, critical information on bigheaded carps adjacent to novel ecosystems is limited (see Hayer et al. 2014; Stuck et al. 2015; Coulter et al. 2016). These are the propagules most likely to be successful new invaders and, thus, their presence corresponds to locations at which immediate control measures need to be implemented.

The Illinois River is a major Mississippi River tributary that is hydrologically connected to the Great Lakes basin (Lake Michigan) via a network of canals and heavily modified rivers called the Chicago-Area Waterway System (CAWS). Bigheaded carps are established in the lower reaches of this river at high densities (Sass et al 2010; Garvey et al. 2012). In the upper river, the 'last line of defense' preventing dispersal into Lake Michigan is an electric barrier system located in the CAWS (Moy et al. 2011), although concerns exist about its effectiveness under certain conditions (Parker et al. 2015). Management agencies aim to reduce the population of bigheaded carps (and hence the likelihood of bigheaded carps reaching and challenging the barrier system) through contracted commercial harvest in the Starved Rock (river km (RKM) 372–394), Marseilles (RKM 394–437) and Dresden (RKM 437–460) reaches of the upper river (Fig. 1). The population front has remained in the Dresden reach for several years (ACRCC 2015), *c*. 17 RKM downstream of the electric barrier system.

As bigheaded carps in the Upper Illinois River represent an immediate threat to Lake Michigan, collection of accurate empirical data on this advancing population is needed to understand range expansion dynamics and develop effective management strategies (Cooke 2016). However, many sampling challenges exist: silver carp and bighead carp occupy a variety of habitat types (e.g., main channel, backwater lakes, side channels) over a relatively large spatial scale (three river reaches extending 88 RKM); both species may respond differently to capture sampling gears like electrofishing or netting (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014; Collins et al. 2015); and it is likely that a density gradient exists over the 88 RKM occupied by the advancing population, so sampling would have to be equally effective at a variety of densities. Mobile hydroacoustic sampling has begun to feature more prominently in fisheries research in riverine environments (e.g., Lucas and Baras 2000; CEN 2014) and, considering the constraints outlined above, this technology may represent the optimal approach in terms of spatial coverage and unbiased representation of the target species. We therefore initiated a program of mobile hydroacoustic surveys in the Upper Illinois River in 2012 with the objectives of (1) quantifying key demographics (density, size structure and species composition) of the advancing population of bigheaded carps, (2) ground-truthing hydroacoustic density estimates by reference to localized harvest metrics, and (3) evaluating the efficacy of harvest at suppressing overall population levels. We outline a unique sampling framework that can be applied in a variety of contexts (e.g., population assessment, control strategy evaluation, early detection) for management of invasive fish species.

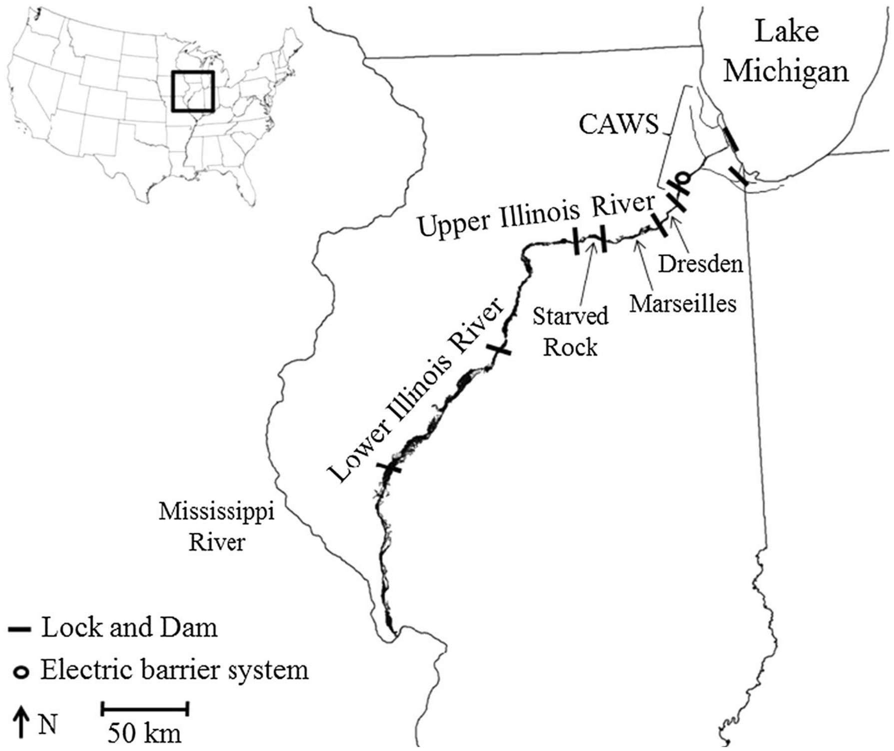

Fig. 1 The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM 372 and RKM 460. Also shown is the electric barrier system (RKM 477) located in the Chicago-Area Waterway System (CAWS)

Methods and materials

Harvest program

Commercial fishing is prohibited in the Upper Illinois River but fishing crews have been specially contracted by the Illinois Department of Natural Resources (IDNR) to harvest Asian carps (silver carp, bighead carp and grass carp *Ctenopharyngodon idella*) in the Marseilles and Dresden reaches since 2010 and in Starved Rock reach since 2011. Grass carp accounted for <1 % of the total harvest annually so were not considered further in this study. Each crew consisted of an experienced two-person team whose fishing location, effort, and catch was recorded by an onboard IDNR biologist. Suitable locations in the upper river were fished by up to five crews per day during the season, which extended from March to December (*c.* 340 crew-days per year). All bycatch was returned alive, while Asian carps were donated to a processor for conversion to liquid fertilizer (ACRCC 2015). The program goal was to maximize harvest, so a variety of gear types (e.g., gill and trammel nets, hoop nets, seine hauls) and fishing strategies (e.g. short-set, overnight set) were used, depending on river conditions and location. However, the mainstay of the harvest program has been the use of short-set (20–30 min), large-mesh (7.6–10.2 cm) gill and trammel nets. These accounted for 93.6–98.5 % of crew-days annually. As it was not possible to quantify effort for all gear types combined, we used gill and trammel net catch-per-unit-effort (CPUE; bigheaded carps/1000 m of net) as a relative indicator of harvest intensity and for comparison with hydroacoustic density estimates (see below).

Research vessel, hydroacoustic equipment and settings

The mobile hydroacoustic system (BioSonics DT-X) consisted of two horizontal-orientated split-beam transducers positioned on a stable, 9 m research vessel. The upper acoustic beam extended parallel to the water surface, and the lower beam was offset to ensonify the water column directly below the first beam (Fig. 2). Transducer pitch and horizontal plane was maintained by automatically adjusting dual-axis rotators. Data were collected out to a maximum distance of 50 m, at a ping rate of 5 pings/s and pulse duration of 0.40 ms. Transducers of frequencies

70 kHz (5° beam angle) and 200 kHz (6.6° beam angle) were deployed in various combinations (i.e. two 70 kHz, two 200 kHz, or 70 and 200 kHz) and each transducer was individually calibrated on-axis with the appropriate tungsten carbide sphere (Foote et al. 1987). This involved mooring the research vessel to a fixed object, in sufficiently deep water, with the transducers deployed as shown in Fig. 2 and aimed outward from the shore. The calibration sphere was attached to a 3 m pole using nylon fishing line and suspended in each acoustic beam.

Hydroacoustic sampling throughout the Upper Illinois River

As much boat-accessible habitat (>1–1.5 m depth) as possible within each reach was sampled annually (2012–2014) during September and October. The upper river consists of main channel (typically 150–250 m wide with a minimum depth of 2.7 m maintained over the thalweg for navigation) and connected backwaters. Backwater sites suitable for hydroacoustic sampling included backwater lakes ($N = 3$), side channels ($N = 5$), tributaries ($N = 2$), harbors ($N = 2$) and bays ($N = 1$) of varying size (0.1–1.8 km^2). In the main channel, transects consisted of a nearshore loop following the *c.* 1 m depth contour and a mid-channel loop. Only a single nearshore transect loop was generally required in side channels, bays, harbors and tributaries (Fig. 3). In the typically larger backwater lakes, transect loops were repeated progressively closer to the center, at intervals that would limit beam overlap while ensuring maximum possible coverage (Fig. 3). The acoustic beams were aimed outward from the nearest shoreline for all transects. Vessel speed was kept constant at approximately 6.5 km/h, and transects were as similar as possible to the previous year with some exceptions (e.g., allowing for boat traffic, debris, changes in water levels). River discharge data were obtained from a main channel gaging station at Seneca, IL in the Marseilles reach (http://waterdata.usgs.gov/nwis).

Hydroacoustic sampling of harvest events (ground-truthing of density estimates)

To test whether a relationship existed between localized hydroacoustic density estimates and harvest CPUE, three backwater lakes were sampled during summer 2014 and 2015, independent of the fall sampling outlined above. These lakes were created as gravel quarries that are now either active (East Pit, 1.8 km^2 surface area, 2.7 m mean depth, located at approx. RKM 422 in the Marseilles reach), inactive (West Pit, 1.3 km^2, 2.4 m, RKM 418 in the Marseilles reach), or converted to a nature preserve (Rock Run, 0.3 km^2, 4.4 m, RKM 453 in the Dresden reach) (Fig. 3). Hydroacoustic sampling was undertaken directly before and after harvest events (i.e. within a <24 h period), and subsample length and weight

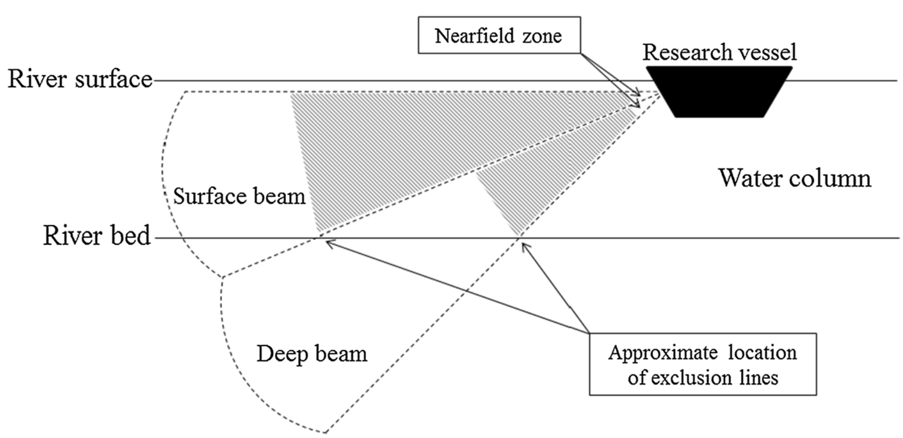

Fig. 2 Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in which acoustic targets were analyzed are indicated by the *gray shading* (no data analyzed in the nearfield zone or beyond the exclusion *line*). The surface beam typically accounted for *c.* 75 % of the volume of water sampled

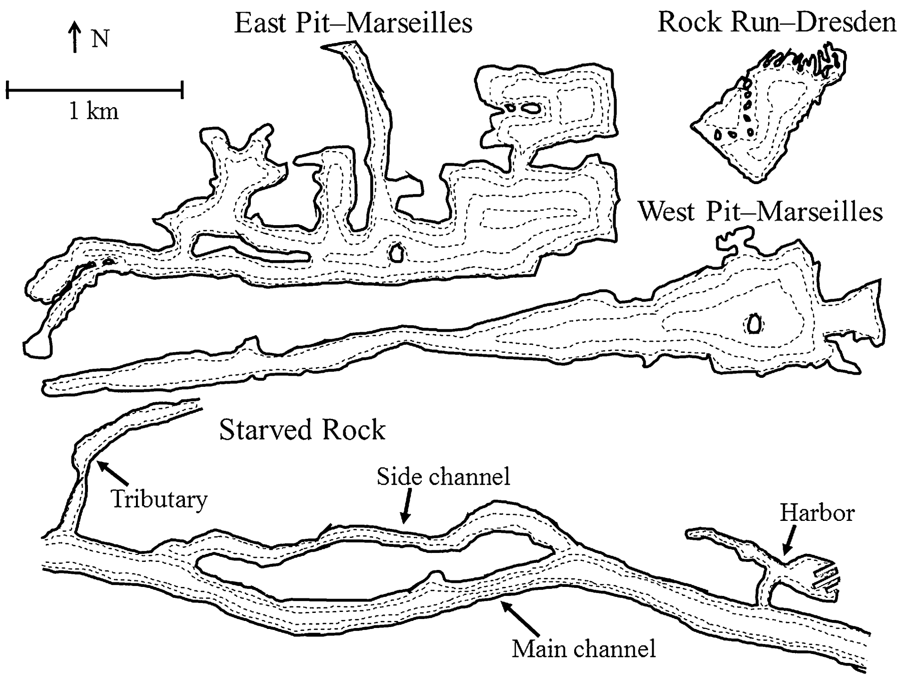

Fig. 3 Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after harvest events in the three backwater lakes consisted of a single nearshore loop only, rather the multiple loops undertaken as part of the river-wide surveys (as shown). For all surveys, the acoustic beams were aimed outward from the nearest shoreline

measurements of all species captured were taken. To minimize the time interval between hydroacoustic sampling and the harvest event (and thus the possibility of fish movement between the main channel), transects consisted of a single nearshore loop only (i.e. the area where harvest netting is focused) rather than multiple loops.

Hydroacoustic post-processing

Hydroacoustic data were processed using Echoview 5.4 software. An exclusion line was manually drawn at the point where the acoustic beams intersected the river bed (Fig. 2). Only data in the water column >1 m from the transducers (i.e. two times the near-field zone; Simmonds and MacLennan 2005; Rudstam et al. 2009) and before the exclusion line were analyzed. Areas of high interference (e.g., caused by passing boats or wind-generated waves) where acoustic targets could not be reliably distinguished were also excluded. Background noise was filtered by removing acoustic signals less than −60 decibels (dB). The volume of water sampled was calculated between the near-field and exclusion lines (Fig. 2) using the 'wedge volume sampled' method in Echoview.

Fish targets were identified using Echoview's 'split-beam single target detection (method 2)' algorithm following Parker-Stetter et al. (2009). Echoview's 'fish track detection' algorithm was then used to group targets originating from a single fish (Table 1). All fish tracks were manually inspected and edited to ensure accuracy. The mean compensated target strength (TS; in dB) of each fish track was then converted to fish total length (TL) using the side-aspect TL–TS equation given by Love (1971). Unlike most TL–TS equations, this multi-species equation is not frequency-specific and hence could be applied to the various transducer frequencies used. One shortcoming of using Love's (1971) equation is that it relates to maximum side-aspect target strength; this assumes that fish targets are ensonified near-perpendicular to the acoustic beam axis. Though likely in the main channel due to fish orientation relative to river flow and our parallel transect design, fish orientation may not be as uniform in lentic backwaters (i.e. acoustic ensonification may not always be exactly side-aspect). Adopting a TL–TS equation developed at multiple body aspects, for example 360° (Kubecka and Duncan 1998) could reduce this potential source of bias but, to our knowledge, such studies are all frequency-specific. Thus, for consistency across habitats and transducer frequencies, we opted to use the Love (1971) TL–TS equation and believe that using the mean TS of a fish track for conversion to TL

Table 1 Single target and fish track algorithm properties used for hydroacoustic post-processing

Split-beam single target detection (method 2)	
Min. and max. TS threshold (dB)	Dependent on transducer frequency used (Love 1971); corresponded to fish TL range of 30–120 cm
Pulse length determination level (dB)	6
Min. and max. normalized pulse length	0.6 and 1.5
Max. beam compensation	6
Max. standard deviations of minor and major axis angles	0.6
Fish track detection	
Min. number of single targets	1
Min. number of pings in track	1
Max. gap between single targets	3

adequately accounts for fish targets that may not have been ensonified exactly in the side aspect.

To further improve the accuracy of the fish track algorithms and manual editing, only acoustic targets corresponding to >30 cm TL were included in the analysis (the smallest silver carp or bighead carp captured in any year of the study was 48.8 cm).

Paired sampling

To interpret the acoustic data, we used information gathered annually in each reach during late summer/early autumn from a random site pulsed-DC electrofishing program (The Long-term Illinois, Mississippi, Ohio, and Wabash Rivers Fish Population Monitoring Program; http://wwx.inhs.illinois.edu/fieldstations/irbs/research/ltef-website/; see also McClelland et al. 2012) and the Asian carps harvest program (subsampling of target and bycatch species captured using short-set gill and trammel nets). Fish collected were identified, measured (TL; mm) and weighed (g). Both capture methods were combined to reduce selectivity biases (Williamson and Garvey 2005; Irons et al. 2011; Hayer et al. 2014) and all fish >30 cm TL were separated into three categories (i.e. silver carp, bighead carp, and other fish species). For each reach, proportional abundance of silver carp, bighead carp and other fish species was determined for each 2 cm TL-class (i.e. 30–32, 32–34 cm…) and then linearly interpolated for each 0.1 cm TL increment, up to a maximum of 120 cm TL; if the largest fish captured was less than this cut-off point, a 1.0 bighead carp proportion was assumed for the remaining length increments, which was corroborated with field observations.

Estimating bigheaded carps demographic parameters

Surveys were analyzed following the protocols developed by Scheaffer et al. (1996) and Parker-Stetter et al. (2009). Main channel transects were separated into two strata, the first stratum consisting of the nearshore loop and the second stratum consisting of the mid-channel loop (Fig. 3). Each 0.926 km (0.5 nautical mile) sampled along these strata represented replicates. Backwaters had one to four strata (depending on whether single or multiple transect loops were undertaken) (Fig. 3) and 0.463 km replicates were used. Initial density calculations were made based on all fish detected (i.e. converted acoustic targets equating to fish of 30–120 cm TL). Stratum-specific fish density $\bar{\rho}_h$ and within-stratum variance $Var(\bar{\rho}_h)$ were calculated as:

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

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

where n_h = number of replicates in stratum h and $\rho_{h,i}$ = mean fish density of replicate i within stratum h. For single stratum backwaters, this was the final mean fish density. For multi-strata survey sites, final mean fish density $\bar{\rho}$ and standard error ($SE(\bar{\rho})$) were calculated as:

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

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

where L = total number of strata, A = volume of water sampled for all strata combined, and A_h = volume of water sampled for stratum h (such that estimates were weighted by the sampled volume in each strata).

Silver carp and bighead carp densities (fish/1000 m^3 of sampled water) and associated 95 % confidence intervals were then calculated for each survey site by assigning the paired sampling proportional abundances to the size-specific densities. To obtain representative reach-specific and upper river density estimates, sampling sites were combined and calculated as above in Eqs. (3) and (4), except strata were substituted by sampling site.

To determine approximate size structure and numerical species composition of bigheaded carps, acoustic targets corresponding to fish TL with a >0.5 silver carp or bighead carp proportional abundance were classified accordingly.

Statistical analysis

Differences between annual hydroacoustic density estimates were assessed by pairwise interval estimation (i.e. whether the 95 % confidence interval of the difference in means contained zero). Changes in size structure were assessed using a non-parametric Kruskal–Wallis H-test, followed by Dunn's post hoc test. A χ^2 test of independence was used to determine whether species composition (silver carp vs. bighead carp) changed. Due to error in both the X and Y variables, the relationship between harvest CPUE and hydroacoustic density estimates of bigheaded carps was examined using reduced major axis (RMA) regression (Sokal and Rohlf 1995). A non-parametric repeated-measures approach (Wilcoxon signed-rank test) was used to determine if hydroacoustic density estimates differed between sampling undertaken before and after harvest events (i.e. for each identical 0.463 km replicate). The critical level of significance was set at $P = 0.05$. All statistical analyses were performed using IBM SPSS Statistics 21, except for RMA regressions performed using RMA for JAVA v. 1.21: Reduced Major Axis Regression software (Bohonak and van der Linde 2004).

Results

Characterizing the advancing population

Main channel and backwater sampling sites in the Upper Illinois River differed in terms of bigheaded carps density. Of the 45 total sampling occasions (15 sites × 3 years), six backwaters had lower densities than the corresponding main channel, whereas, the remaining backwater densities were on average 9.3 times (range = 1.5–23.3 times) higher than the main channel. However, to give a representative overall measure of the bigheaded carps population, and to account for the different number and type of backwaters within each reach, the advancing population was examined by combining main channel and backwater estimates for each reach.

Regardless of year, a significant decreasing bigheaded carps density gradient was apparent from the lowermost Starved Rock reach upstream to the population front (Dresden reach) (Fig. 4). Overall density was highest in Starved Rock, occurring in the range *c.* 0.4–1.6 bigheaded carps/1000 m^3. Annual mean densities of either species were consistently significantly higher in Starved Rock than Marseilles (*c.* 0.15–0.4 bigheaded carps/1000 m^3) and Dresden (<0.15 bigheaded carps/1000 m^3). Silver carp density followed this observed gradient each year (i.e. Starved Rock > Marseilles > Dresden). Bighead carp density was always highest in Starved Rock, while its density was comparable in Marseilles and Dresden during 2012 and 2013, but not 2014 (Fig. 4). Silver carp mean density in Dresden was <0.02/1000 m^3 in all years.

Significant longitudinal shifts in the size structure (H = 501–1319, all $P < 0.001$ (post hoc, all $P < 0.001$)) and species composition (χ^2 = 116–937, all $P < 0.001$) of bigheaded carps were observed from downstream to upstream in the Upper Illinois River during each year (Fig. 5). Within the highest density Starved Rock reach, bigheaded carps were significantly smaller and dominated by silver carp (71.6–83.8 % silver carp). In the lower density Marseilles reach, bigheaded carps were larger, and

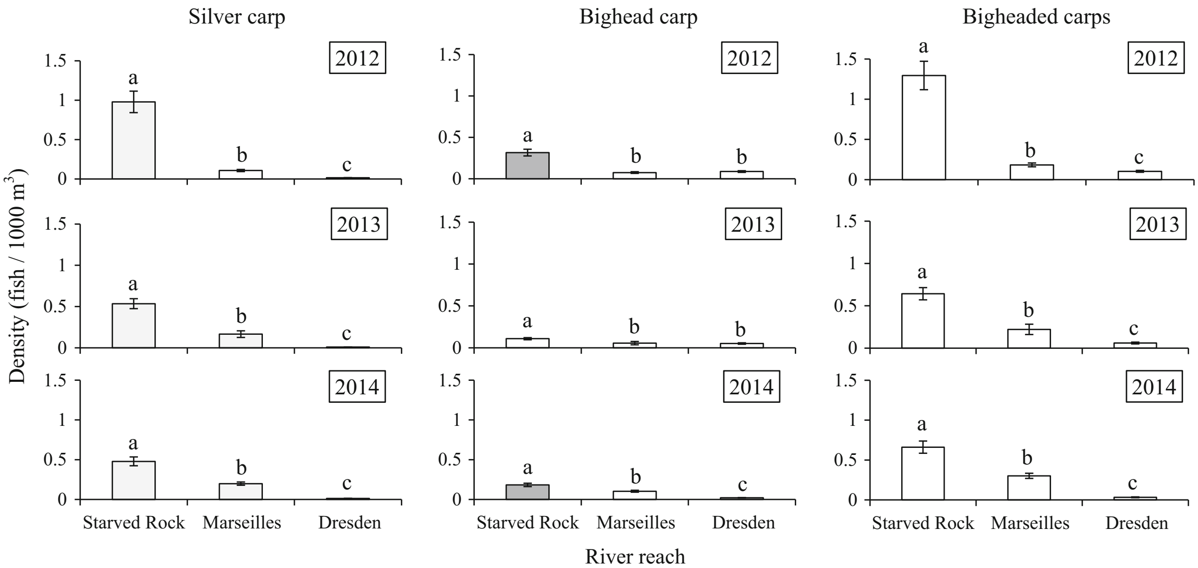

Fig. 4 Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated by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

though the proportion of bighead carp increased, there was still a silver carp predominance (59.4–74.2 % silver carp). At lowest density, in the Dresden reach (i.e. the population front), bigheaded carps were largest and species composition shifted in favor of bighead carp (15.1–38.2 % silver carp) (Fig. 5).

Validating hydroacoustic density estimates for harvest evaluation

Hydroacoustic sampling of backwater lakes was undertaken on ten occasions before harvest events, and on eight occasions after harvest events. Depending on the lake, one to five fishing crews operated, with effort (total m of net) ranging from 1829 to 14,905 m (mean ± SD = 6963 ± 4325 m). Harvest events captured 1–1301 bigheaded carps (mean ± SD = 589 ± 483 individuals). Hydroacoustic estimates of bigheaded carps density before harvest were significantly correlated with bigheaded carps harvest CPUE ($R^2 = 0.744$; Fig. 6a; Table 2). The density equivalent of harvested bigheaded carps (i.e. the difference in before–after hydroacoustic estimates) was also significantly correlated with bigheaded carps harvest CPUE ($R^2 = 0.823$; Fig. 6b; Table 2).

In nearly all cases, harvest significantly reduced bigheaded carps densities in the short term (i.e. within a <24 h period) by 32.0–64.4 % on average (Table 3). However, at backwater lakes with more than one before–after sequence, densities rebounded to initial levels (Rock Run 2014, East Pit 2015), or exceeded initial levels (East Pit 2014), in as little as 2 weeks (Table 3).

Bigheaded carps population changes throughout the upper Illinois River

Discharge conditions during the surveyed period in 2012 (mean ± SD = 70 ± 25 m^3/s) and 2013 (77 ± 24 m^3/s) were considerably lower than in 2014 (313 ± 142 m^3/s) but, in terms of the overall hydrograph, prolonged high discharge conditions occurred during 2013 and 2014 compared to the lower discharge in 2012, a drought year (Fig. 7 top). The total number of bigheaded carps harvested March–December increased annually from 45,192 in 2012, to 58,374 in 2013 and 102,453 in 2014. Monthly harvest (all gear types) of bigheaded carps within each reach was variable (Fig. 7) and, to a certain extent, harvested quantity (all gear types) and CPUE (gill and trammel nets) of bigheaded carps broadly reflected the advancing populations' density gradient (as described above).

Based on the annual hydroacoustic surveys, bigheaded carps density in the entire upper river (i.e. all

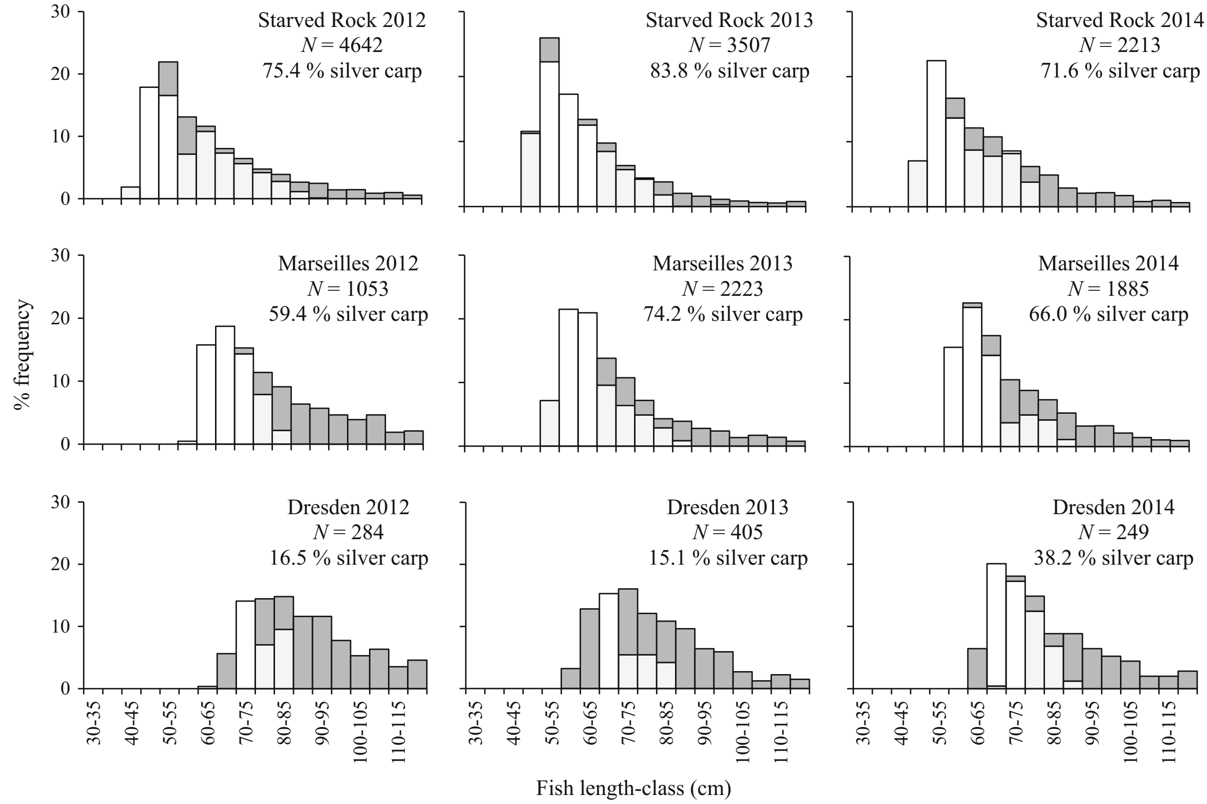

Fig. 5 Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding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

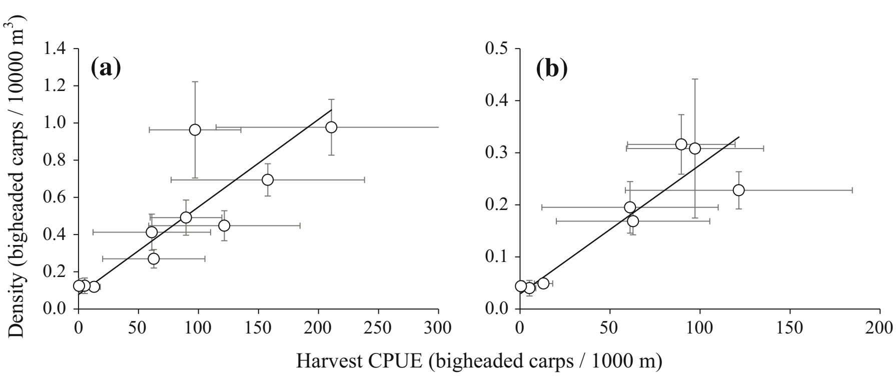

Fig. 6 Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence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

reaches combined) declined significantly, from $0.492 \pm 0.053/1000\ m^3$ in 2012 to $0.278 \pm 0.034/1000\ m^3$ in 2013, but remained stable between 2013 and 2014 ($0.254 \pm 0.024/1000\ m^3$). Annual density in Starved Rock mirrored that of the entire river, in contrast to Marseilles (where density did not change

Table 2 Reduced major axis regression estimates for (a) bigheaded carps density (before), and (b) before–after difference in bigheaded carps density, versus bigheaded carps harvest CPUE. Note that the primary statistics (*F* values and *P* values) are from linear least-squares regressions

Variable	Intercept ± SE	Slope ± SE (95 % CIs)	*F*	*df*	*P*	R^2
(a) Bigheaded carps density (before)	0.073 ± 0.090	0.005 ± 0.001 (0.003–0.007)	23.291	1, 8	0.001	0.744
(b) Before–after difference in bigheaded carps density	0.028 ± 0.030	0.003 ± 0.0004 (0.001–0.004)	27.807	1, 6	0.002	0.823

Table 3 Hydroacoustic estimates of bigheaded carps density (mean ± 95 % confidence intervals) before and after harvest events in three backwater lakes of the Upper Illinois River during 2014 and 2015. Bigheaded carps harvest metrics (CPUE and total number of individuals harvested) for the corresponding harvest event are given in parentheses under each pair of density estimates

2014						
East Pit (Marseilles)	6 May → 7 May		19 May → 20 May		7 July → 8 July	
	0.270 ± 0.049[a]	0.101 ± 0.023[b]	0.491 ± 0.095[a]	0.175 ± 0.037[b]	0.963 ± 0.259[a]	0.655 ± 0.126[b]
	(62.5 and 812)		(83.1 and 855)		(87.3 and 1301)	
West Pit (Marseilles)	20 May → 21 May					
	0.119 ± 0.020[a]	0.070 ± 0.023[b]				
	(13.4 and 66)					
Rock Run (Dresden)	8 July → 9 July		24 July → 25 July			
	0.125 ± 0.042[a]	0.078 ± 0.037[a]	0.124 ± 0.039[a]	0.069 ± 0.029[b]		
	(5.1 and 26)		(0.5 and 1)			
2015						
East Pit (Marseilles)	6 Aug → 7 Aug		7 Sep → 8 Sep			
	0.420 ± 0.099[a]	0.217 ± 0.048[b]	0.448 ± 0.081[a]	0.220 ± 0.045[b]		
	(56.6 and 150)		(116.2 and 701)			

Different superscript letters indicate a significant difference ($P < 0.01$) for each before and after sequence

year to year, but did increase significantly between 2012 and 2014) and Dresden (where consecutive annual declines in density occurred) (Fig. 7). At the scale of the entire upper river, the population response appears closely linked with the prevailing seasonal/annual discharge regime, as increasing annual harvest elicited an apparent 43.5 % decline after a drought year, but only maintenance of the reduced density levels following a flood year.

Discussion

The Upper Illinois River, as the conduit that links two major hydrological basins (one invaded and one not), is a critical location at which to investigate bigheaded carps invasion dynamics and the population response to control efforts (Cooke 2016). We adapted marine and large lake hydroacoustic protocols (Simmonds and MacLennan 2005; Parker-Stetter et al. 2009; Rudstam et al. 2009) for use in this shallow riverine environment, to estimate key demographic parameters of the advancing population at the edge of their range and, thus, by extension evaluate the efficacy of harvest in the Upper Illinois River.

Advancing population characteristics

Density of bigheaded carps was assessed on a volumetric basis, on the assumption that it is the most representative measure of population status (i.e. direct measurement rather than extrapolation). Annual fall surveys of the advancing populations' continuous longitudinal distribution confirmed that bigheaded carps were more prevalent downstream than upstream. The advancing population in each reach was

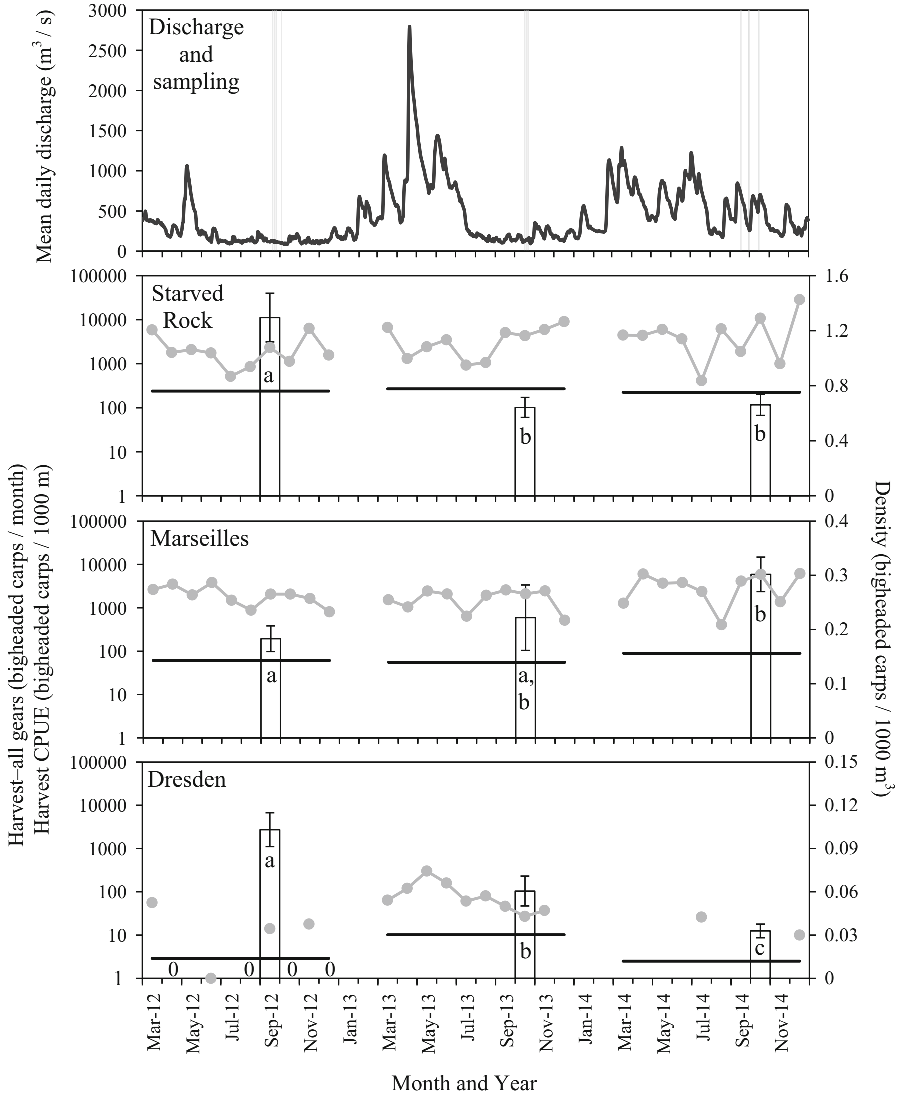

Fig. 7 *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks* indicate no fishing), annual bigheaded carps gill/trammel net CPUE (*horizontal black lines*) and bigheaded carps mean density ±95 % confidence intervals (*white bars*). Note y-axis logarithmic scale for harvest and CPUE, and the different scales for density in each reach. Significant differences ($P < 0.05$) in densities within a reach are indicated by *different letters*

categorized into distinct density components, ranging from the highest levels in Starved Rock to the lowest in Dresden. Site-specific densities within a reach may lie outside the observed ranges (reflecting habitat preferences of bigheaded carps e.g., DeGrandchamp et al. 2008), but these overall classifications provide an indication of the density gradient of this advancing population. Such information is useful where bigheaded carps are expanding their range, so as to quantify the invasion process and set appropriate removal targets (e.g., Tsehaye et al. 2013; Green et al. 2014).

Size structure and species composition also appear linked with each bigheaded carps density component, as body size (both species) and proportion of bighead carp increased from downstream to upstream. To what extent this is attributable to species-specific upstream dispersal or other density-dependent mechanisms is not clear. It also remains to be seen if the interannual variability in size structure and species composition observed within a particular reach reflects natural trends (e.g., a strong year-class) or is harvest-induced through gear selection for a particular species or size-class (Irons et al. 2011; Tsehaye et al. 2013).

Harvest evaluation (short-term, local scale)

The series of before–after harvest experiments in backwater lakes showed that in nearly all cases, density of bigheaded carps was reduced immediately post-harvest. It is probable that the large quantities of bigheaded carps removed by harvest caused most of the observed declines, but fish actively moving from the backwater to the main channel in response to the disturbance of the harvest event may also have contributed. This is especially likely in the smallest lake, Rock Run, which would help explain the somewhat less consistent results there.

Regardless of initial densities, recolonization of the backwater lakes occurred in as little as two weeks. Rebound rate is an important metric for evaluating targeted harvest (Frazer et al. 2012) and it appears that, in these locations at least, some features and/or conditions are continually re-attracting bigheaded carps (e.g. Cuddington et al. 2015). An integrated pest management approach (Koehn et al. 2000; ACRCC 2015), involving removal of individuals present (i.e. by harvest) and prevention of recolonization by new individuals (e.g., by behavioral barriers at strategic locations or manipulation of water levels), may be a rational approach to pursue, but the potential for altering upstream dispersal must also be carefully considered.

Hydroacoustic and capture gear comparisons can be highly variable, with the level of accuracy depending on the environment, gear type and characteristics of the species under consideration (e.g., Mehner and Schulz 2002; Dennerline et al. 2012; Guillard et al. 2012). Though the use of mobile hydroacoustic methods in shallow environments is increasing (e.g., Lucas and Baras 2000; CEN 2014), few studies have verified estimates against known relative abundance indices. The positive density–CPUE relationships obtained during the backwater lake experiments provided the basis upon which to use our river-wide hydroacoustic surveys as a tool to evaluate harvest on a broader spatiotemporal scale (i.e. throughout the upper river over three consecutive years).

Harvest evaluation (long-term, river-wide)

The river-wide fall surveys were not intended to directly correspond with harvest events, as sampling occurred during alternate weeks to harvest. Instead, we aimed to provide ‘snapshots’ of the population status in the entire upper river, at a comparable stage of each year (i.e. during suitable hydrological conditions, and when the harvest season had been underway for *c.* 6 months). Therefore, while harvested quantities and CPUE of bigheaded carps broadly reflected the density components estimated from the hydroacoustic surveys, they appear to lack the resolution of the hydroacoustic surveys to map fluctuations within these ranges (see Dennerline et al. 2012). The complexity of these reach-specific density trends likely reflects between-reach movement and differential harvest rates. Biases associated with the unstandardized, catch-maximizing approach of the harvest program further confound the interpretation of the capture statistics and highlight the need for the present fishery-independent evaluation.

Despite the large quantities of bigheaded carps removed from the Upper Illinois River annually, harvest alone is clearly not the only factor regulating population dynamics in the river (see also Tsehaye et al. 2013). Total harvest increased annually, yet density did not decline between 2013 and 2014. Instead, the prevailing discharge regime may play a key role. In situ reproduction is currently a negligible source of bigheaded carps in the upstream portion of the river (ACRCC 2015), thus Starved Rock Lock and Dam is the only immigration pathway to the Upper Illinois River from the high density reaches farther downstream (Sass et al. 2010; Garvey et al. 2012). Discharge is important for upstream fish passage at low-head dam structures (Zigler et al. 2004; Tripp et al. 2014) and it is likely that population densities were sustained by high immigration via Starved Rock Lock and Dam to the upper river in the latter two study years due to ‘open-river’ conditions (i.e. dam gates open to varying degrees to prevent flooding during high discharge). Both silver carp and bighead carp have shown increased movement rates during periods of high water levels (DeGrandchamp et al. 2008; Coulter et al. 2016).

The observed decline in bigheaded carps density in the Dresden reach (*c.* 68 % cumulative decline between 2012 and 2014) is interesting to note, suggesting that continued harvest at the low density population front may be effective (likely aided somewhat by the spatial isolation from higher densities downstream). From an invasion biology perspective, the ability to suppress at such low density has important management implications, both at the leading edge of well-established invasions and for rapid response to early detection of a new invasion (e.g., Taylor and Hastings 2004; Kadoya and Washitani 2010; Vander Zanden et al. 2010). Gear development for optimal harvest of bigheaded carps (Collins et al. 2015), coupled with fish-pinpointing technologies like mobile hydroacoustic surveys (this study) or 'Judas fish' telemetry (Bajer et al. 2011) are additional resources that can be applied at these low density (yet high priority) locations, to further improve detection probabilities and hence harvest rates.

Conclusions

When viewed in the context of other removal efforts in large rivers (Mueller 2005; Coggins et al. 2011; Franssen et al. 2014), the Asian carps harvest program in the Upper Illinois River compares quite favorably. During the 3 years of sampling, overall density declined to and remained at the lower level, and the population front has not expanded. However, hydrological variability (and possibly other environmental conditions) likely determine the extent of the population response in a particular year. Years with coinciding high discharge, strong year-class and/or successful recruitment are likely to put harvest resources under considerable pressure.

While there are still certain technological limitations associated with the use of hydroacoustic methods in shallow riverine environments (e.g., minimum depth and fish size, appropriate TL–TS equation relative to fish aspect, paired sampling required for species identification), this study nonetheless outlines a fishery-independent sampling framework that will be a valuable addition to management of invasive fishes in the Mississippi River basin and elsewhere. Integration of existing population estimates (Sass et al. 2010; Garvey et al. 2012; this study) with movement ecology (DeGrandchamp et al. 2008; Norman and Whitledge 2015) and simulation modeling (Tsehaye et al. 2013) is an important next step that will help disentangle the complex invasion processes and enable optimum control strategies to be developed.

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

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APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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

Introduction:

Various agencies (e.g., Illinois Department of Natural Resource, U.S. Army Core of Engineers, Illinois Natural History Survey, U.S. Fish and Wildlife), universities (e.g., Eastern Illinois University, Southern Illinois University, Western Illinois University) and personnel (e.g., contracted fisherman, volunteers) collaboratively monitor, remove, and research Invasive Carp (e.g., Bighead Carp [*Hypophthalmichthys nobilis*], Black Carp [*Mylopharyngodon piceus*], Grass Carp [*Ctenopharyngodon Idella*] and Silver Carp [*H. molitrix*]) in the Illinois River. Since numerous entities and personnel actively manage Invasive Carp populations in the Illinois River, standardizing sampling methods among groups and workers is critical. Standardized sampling efforts and methods ensure data collected by these entities and personnel can provide statistically valid interpretations that are comparable among agencies, locations and years. Long term comparisons of standardized sampling data will also allow managers to assess trends in Asian carp dynamics over time and the response of the Asian carp population to management actions.

Objective:

(1) Create a living document (i.e., a continually updated as new data becomes available) describing specifications of sampling gears utilized to deplete, detect, or monitor adult, juvenile, and larval Invasive Carp populations in the Illinois River watershed.

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Adult and juvenile fish capture gears

Active capture gears

Electrofishing (Figure 1):

Flat bottomed aluminum boats, 5.5 to 6.1 m (18.0 to 20.0 ft.) in length powered with 90-horsepower or greater outboard motors served as the boat for electrofishing. One, 3.4 m (11.0 ft.) fiberglass boom was attached to the port rail and starboard rail of the bow of the boat. Each fiberglass boom was created of hollow 3.8 cm (1.5 in.) outer-diameter, and 0.6 cm (0.3 in.) thick walled fiberglass poles and were spaced 3.1 m (10.0 ft.) apart (center to center at ends of booms). Each boom had a 0.9 m (3.0 ft.) diameter round stainless steel anode ring attached to the end of the pole. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode droppers cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 7,000-watt generator produced the electrical charge through an electrofishing box. Electrofishing boxes were either a MBS-1D "Wisconsin" style control box or Type VI-A smith-root control box with on foot pedal safety switch. Pulse rate of electrofishing boxes could be adjusted from 10 to 1,000 Hertz and duty cycles from 1% to 100%. Output voltage was adjustable from approximately 100 to 600 volts peak DC, depending on generator watt capacity and water conductivity. Electrofishers used a standardized pulse rate of 60 Hz with 25% duty with a uniform base power goal of 3,000 watts. Power goals (in watts) were calculated based off specific conductivity (micro siemens per centimeter) and temperature (in degrees Celsius) to ensure potential transfer of watt from water to fish was 3,000 watts. When operating at 3,000-watt power goal, an effective voltage gradient varying from 0.1 to 1.0 volts/centimeter was produced out to approximately 1.0 m from the boat hull and 2.0 m from the anode arrays. Dip nets used during electrofishing to capture stunned fish were 30.0 cm (12 in.) deep by 45.0 cm (17.6 in.) wide stitched to an approximately square frame mounted to a 2.4 m (8.0 ft.) fiberglass handle. Bar-measured mesh size in dip nets was 3.0 mm (0.1 in.).

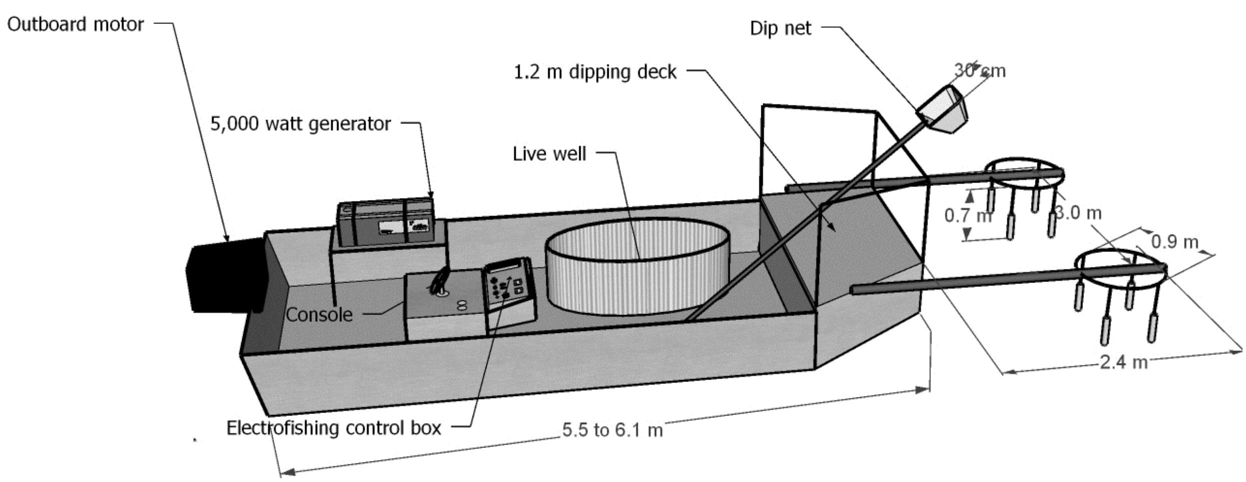

Figure 1. *Schematic of electrofishing boat.*

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Shallow drive electrofishing boat (Figure 2):
A flat-bottomed aluminum boat, 6.1 m (20.0 ft.) in length powered with two 37-horsepower EFI Gator Tail motors served as the shallow drive boat for electrofishing. One, 3.4 m (11.0 ft.) fiberglass boom was attached to the port rail and starboard rail of the bow of the boat. Hollow 3.8 cm (1.5 in.) outer-diameter by 0.6 cm (0.3 in.) thick walled fiberglass booms extended 2.4 m (8.0 ft.) in front of the boat and were spaced 2.7 m (9.0 ft.) apart (center to center at ends of booms) on the port and starboard sides of the bow. Each boom had a 0.8 m (2.5 ft.) diameter round anode ring attached to the end of the pole. Anode rings were constructed of a 1.3 cm (0.5 in.) stainless-steel rod bent and welded into a 76.2 cm (30 in.) outer-diameter circle. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode dropper cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 7,000-watt generator produced the electrical charge through an electrofishing box. Electrofishing box was a ETS 82A wave pulse DC (ETS Electrofishing Systems) control box with two dead man mat style safety switches. Pulse rate of electrofishing box could be adjusted from 10 to 1,000 Hertz and duty cycles from 1% to 100%. Output voltage was adjustable from approximately 100 to 600 volts peak DC, depending on generator watt capacity and water conductivity. Electrofishers used a standardized pulse rate of 60 Hz with 25% duty (15% - 20% duty if specific conductivity is over 900) with a uniform base power goal. A dedicated power goal strategy is currently being developed. Power goals (in watts) were calculated based off specific conductivity (micro siemens per centimeter) and temperature (in degrees Celsius) to ensure potential power transfer was great enough to achieve fish immobilization (narcosis) and electrotaxis but avoid tetany (full rigid, non-breathing) of small bodied (15.2 cm [6.0 in]) native species. Dip nets used during electrofishing to capture stunned fish were 30.0 cm (12 in.) deep by 45.0 cm (17.6 in.) wide stitched to an approximately square frame mounted to a 2.4 m (8.0 ft.) fiberglass handle. Bar-measured mesh size in dip nets was 3.0 mm (0.1 in.).

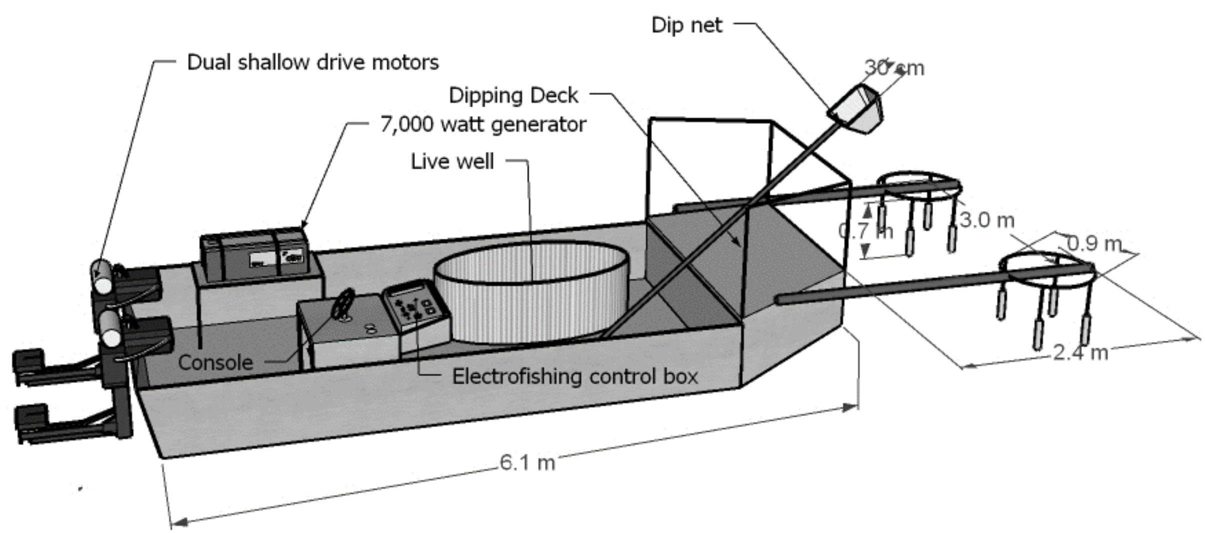

Figure 2. *Schematic of the shallow drive electrofishing boat.*

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Electrified dozer trawl (Figure 3):

A shallow drafting flat bottom aluminum boat 5.5 m (18.0 ft.) or 5.8 m (19.0 ft.) long, 2.4 m (8.0 ft.) wide with a semi-v bow, powered by a 105-horsepower outboard jet drive connected to a jack plate or a 36-horsepower tiller-steer outboard motor served as the boat for the dozer trawl. A 3.8 cm (1.5 in.) powered coated square steel tubing 2.1 m (7.0 ft) wide and 0.9 m (3.0 ft.) tall frame was secured to two 1.2 (4.0 ft.) booms that were attached to the port and starboard side of the bow with 1.3 cm (0.5 in.) a hinge pin. The net of attached to the frame was 1.83 m (6.0 ft.) or 4.6 m (15.0 ft.) long net was stitched to the frame with a combination of zip-ties and nylon cordage. The net was 4.6 m (15.0 ft.) long with a 3.7 m (12.0 ft.) long front portion was made of 35.0 mm (1.4 in.) bar measured mesh which tapered back in a funnel shape to a 0.9 m (3.0 ft.) cod end made of 4.0 mm (0.3 in.) bar measured mesh. The cod end of the net was tied securely closed using 10.2 mm (0.4 in.) nylon rope. The net-frame was held in fishing position (90 degrees to water surface with net opening forward) by double braided kevlar rope attached from the bottom of the frame to 90.7 kg (200.0 lb.) break away nylon cord at the top. Additionally, heavy duty 3.2 mm (0.1 in.) cord mesh with 5.8 cm (2.0 in.) bar measured netting was tied along the bottom of the fishing net to protect the fishing net from snagging on debris during shallow water fishing. A 1,360 kg (3,000.0 lb.) 12v electric winch fed with 4.8 mm (0.2 in.) steel cable was mounted to the deck of the boat. The steel cable was fed through pulleys on the boom arms to lift the boom-arms and subsequently the net-frame from the water when fishing was complete. A three-anode dropper configuration made of a polyvinyl chloride pipe frame was aligned 2.4 m (8.0 ft.) in front of the trawl frame with anode droppers spaced 457.2 mm (18.0 in.) apart. Alternatively, two anode booms space 1.8 m (6 ft.) apart each with an anode ring and four droppers were used occasionally. Anode rings of the booms were constructed of a 1.3 cm (0.5 in.) stainless-steel rod bent welded into a circle. Anode arrays consisted of four droppers attached equidistance around the ring using 3.1 mm (0.1 in.) diameter uncoated stainless-steel cable and U-bolt cable clamps. Anode droppers cable was 35.6 cm (14.0 in.) in length from the ring to the dropper. Cable-dropper arrangements were 66.0 cm (26.0 in.) in total length. A 42-amp Infinity control box produced by Midwest Lake Electrofishing System with a 7,000-watt or a 5,500-watt generator produced the electrical charge. A more detailed version of the electrified dozer trawl design is described in Hammen et al. (in review, USFWS-Columbia).

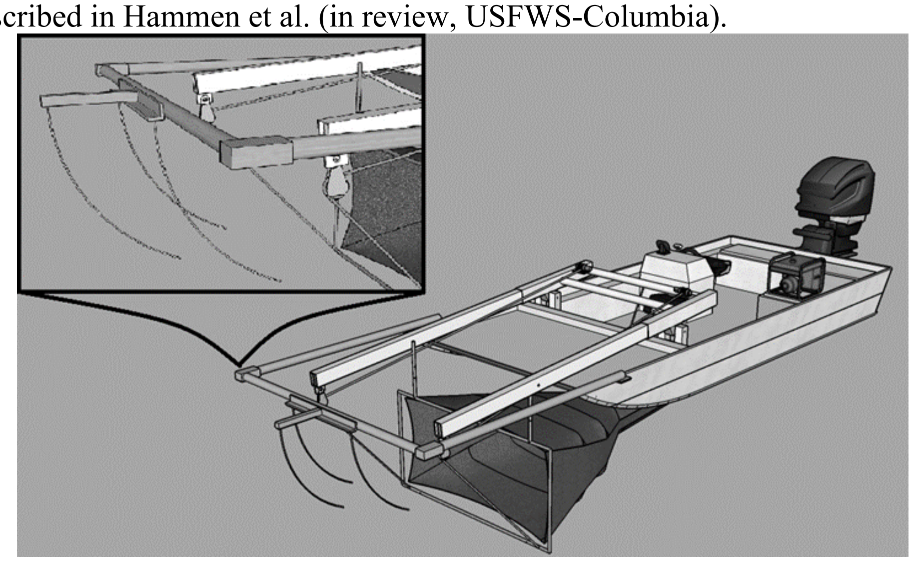

Figure 3. *Generalized schematic of the electrified dozer trawl.*

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Paupier trawl (Figure 4):

The paupier boat was a 7.3 m (24.0 ft.) long, 1.8 m (6.0 ft.) wide, semi-v bow, flat bottom boat powered with a 175-horsepower outboard motor. The bottom of the paupier was coated with a non-conductive abrasion resistant paint. A 4.0 m (13.0 ft.) wide by 1.5 m (5.0 ft.) deep rigid cathodic frame with a net consisting of 38.0 mm (1.5 in.) mesh in the body reducing to 6.0 mm (0.3 in.) mesh in the cod was attached on both sides of the hull of the boat. Three cable anodes droppers were affixed to booms 3.0-4.0m (10.0-13.0 ft.) in front of each frame. An 18.0 cm (7.0 in.) hemisphere anode was suspended in each frame approximately 1.0 m (3.3 ft.) back from the net opening. Cathodic frames were attached to an aluminum gantry which contained an electric winch allowing the frames to be raised and lowered within the water column during sampling. A Wisconsin ETS MBS-1D 72 amp high-output electrofishing box with 7,000-watt generator was used to produce the electrical charge. A more detailed version of the paupier design is described in Doyle et al. (in review, USFWS-Columbia).

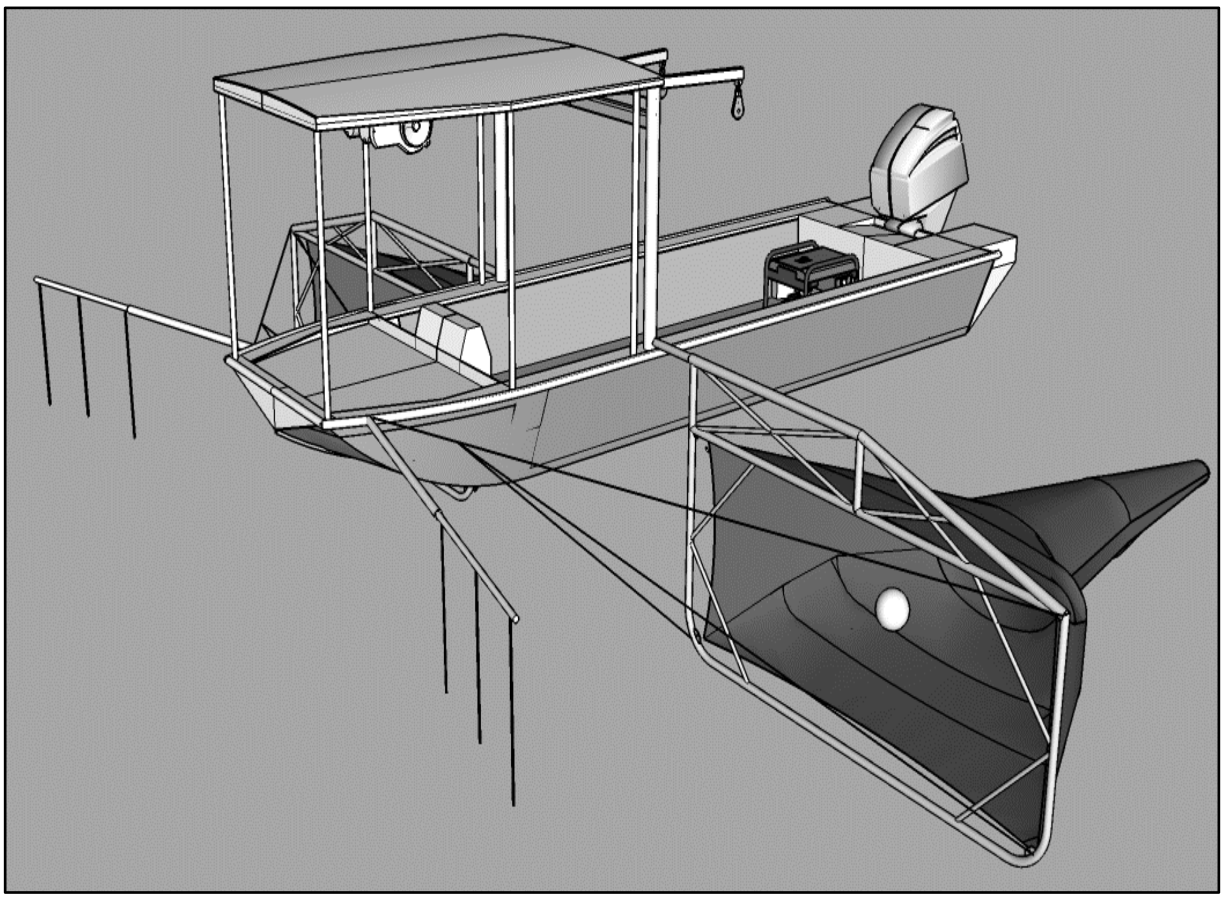

Figure 4. *Schematic of electrified Paupier trawl*

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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.).

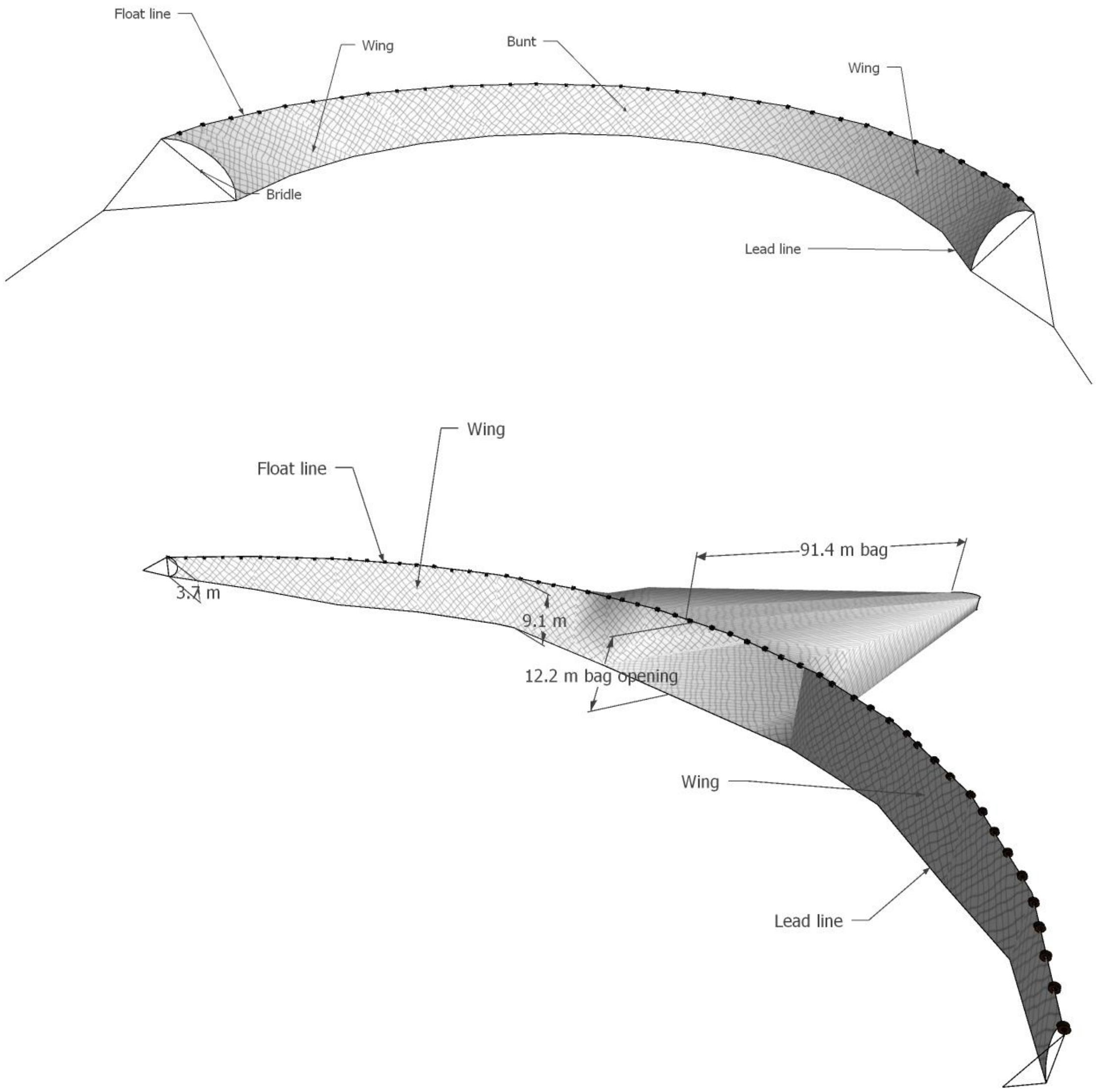

Figure 5. *Generalized schematic of a commercial seine without a bag (top) and with a bag (bottom).*

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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.

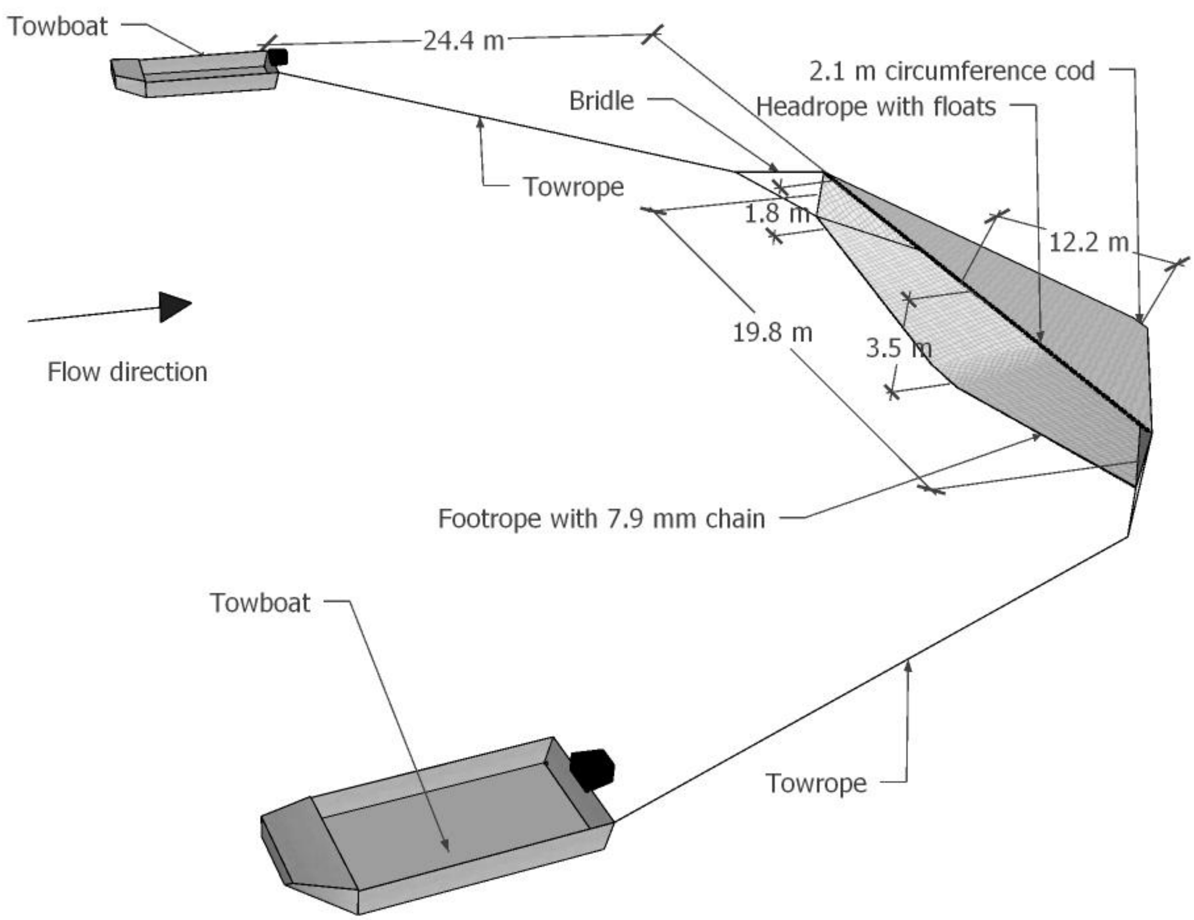

Figure 6. *Generalized schematic of a trawl.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Passive capture gears

Deep-water gill net (Figure 7):

Deep-water gill nets were constructed of three single walled panels made of clear monofilament webbing panels stitched vertically together. Each panel was 3.0 m (10.0 ft.) deep and 91.4 m (300 ft.) long. Stitched panels produced a 9.1 m (30.0 ft.) deep net. The multi-paneled net was tied to a single float line and single lead line. Float line was created from 127.0 mm (0.5 in.) foamcore float line producing 9071.0 g (320.0 oz.) of buoyancy. Lead line was created from #30 leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale; lower number meaning more webbing length per foot of float line) of each panel was 0.5. The bag created (depth of webbing versus the depth of the net) was 0.6 m (2.0 ft.). Bar-measured mesh size of webbing for each panel was 69.9 (2.8 in.), 82.6 mm (3.3) or 88.9 (3.5 in.) attached in a quasi-random experimental fashion (panels of different mesh size attached together to reduce effects of size selectivity). Two multi-panel deep-water gill nets were tied together increasing the total length of the net to 183.0 m (600.0 ft.).

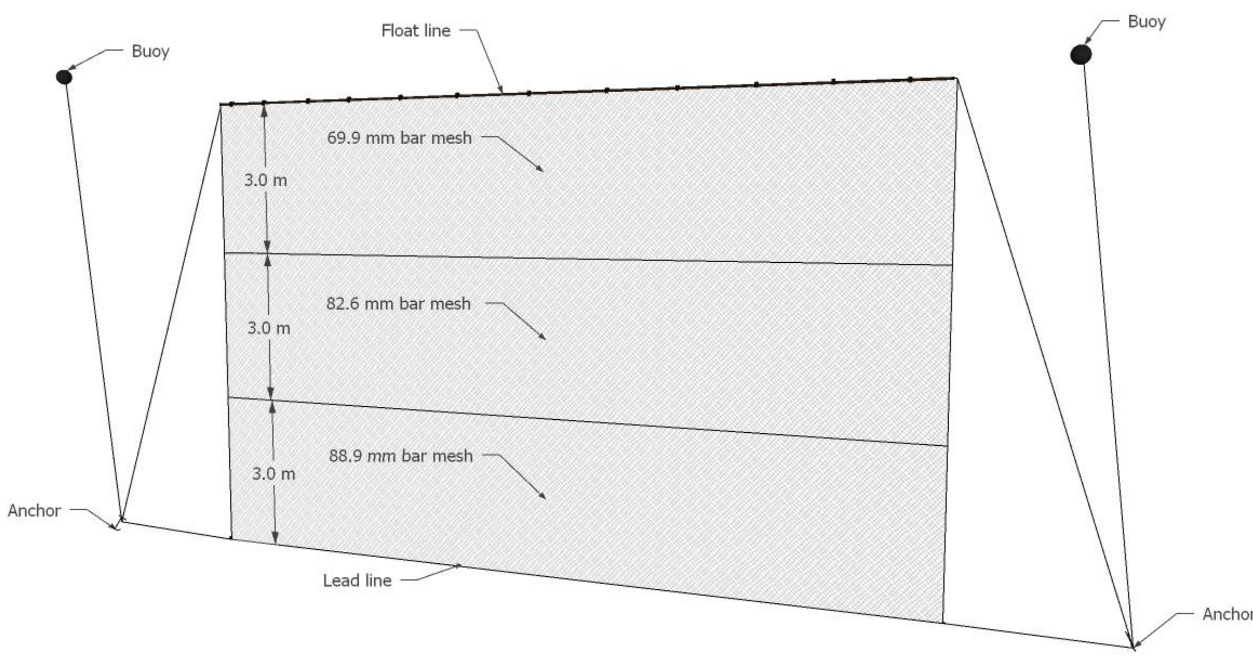

Figure 7. *Generalized schematic of a deep-water gill net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Shallow gill net (Figure 8):

Shallow gill nets were constructed of a panel of single walled monofilament, multi-strand monofilament or multifilament webbing stitched to a float line and a lead line in 91.4 m (300.0 ft.) increments. The float line was created from 95.0 mm (0.4 in.) or 127.0 mm (0.5 in.) foamcore float line producing 4,536.0 g (160.0 oz.) or 9,071.0 g (320.0 oz.) of buoyancy, respectfully. Lead line was created from #30 solid leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale with lower number meaning more webbing length per foot of float line) of each panel varied between 0.5 to 0.2. The bag created (depth of webbing versus the depth of the net) varied between 3.7 m (12.0 ft.) to 1.2 m (4.0 ft.). Color of panel webbing was black, clear, green, purple, red, or white depending on the net. Bar-measured mesh size of webbing varied from 63.5 mm to 127 mm (2.5 - 5.0-in.) depending on the panel. Depth of panel walling varied from 2.4 m (8.0 ft.) to 4.3 m (14.0 ft.) depending on the net. Multiple 91.4 m (300.0 ft.) panels could be tied together increasing the total length of a net to over 914.0 m (3,000.0 ft.).

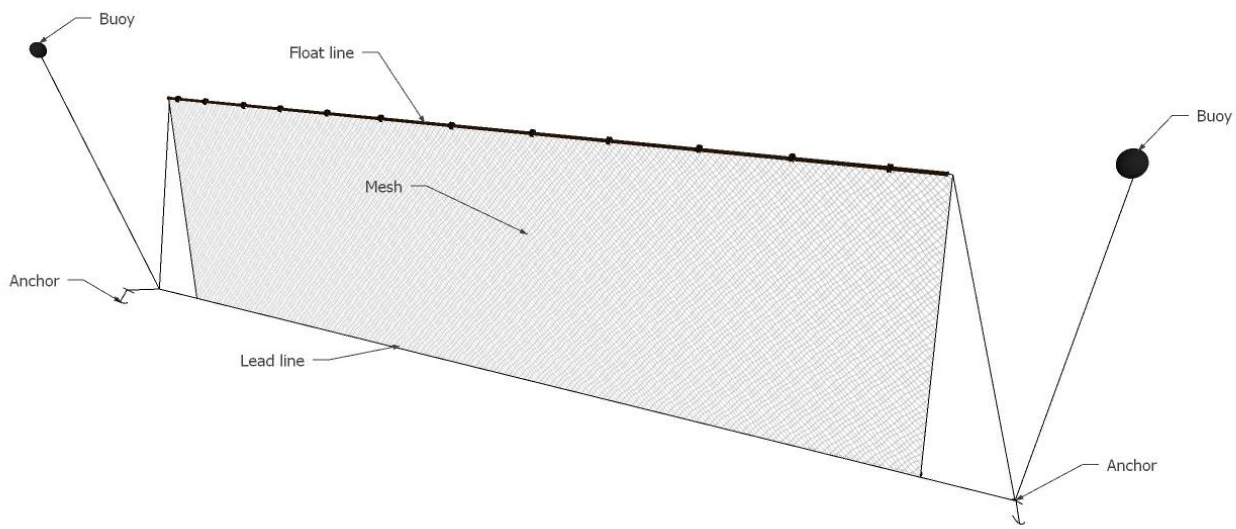

Figure 8. *Generalized schematic of a commercial shallow gill net.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Trammel net (Figure 9):

Trammel nets were constructed of three parallel mesh panels of monofilament, multi-strand monofilament or multifilament webbing stitched to a float line and a lead line in 91.4 m (300.0 ft.) increments. Float line was created from 95.0 mm (0.4 in.) or 127.0 mm (0.5 in.) foamcore float line producing 4,536.0 g (160.0 oz.) and 9,071.0 g (320.0 oz.) of buoyancy, respectfully. Lead line was created from #30 leadcore line. Hanging ratio (measure of how tightly the webbing is stretched along the float line and lead line on a 0-1 scale with lower number meaning more webbing length per foot of float line) of each panel varied between 0.5 to 0.2. The bag created (depth of webbing versus the depth of the net) was 1.2 m (4.0 ft.). Color of webbing included clear, green, red, and white depending on the panel. Bar-measured mesh webbing size of the outer panels were 457.0 mm (18.0 in.) with inner panel bar-measured mesh varying in size from 63.5 mm to 127.0 mm (2.5 to 5.0 in.) depending on the panel. Depth of panel walling varied from 2.4 m (8.0 ft.) to 3.7 m (12.0 ft.) depending on the net. Multiple 91.4 m (300.0 ft.) panels could be tied together increasing the total length of a net to over 914.0 m (3,000.0 ft.).

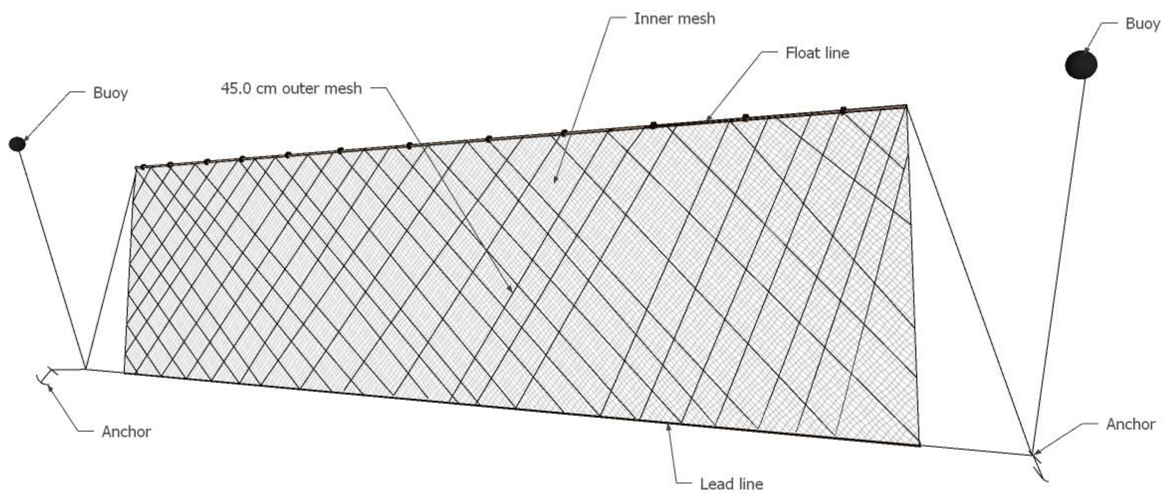

Figure 9. *Generalized schematic of a commercial trammel net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Hoop net (Figure 10):

Hoop nets were constructed of a series of six, 1.8 m (6.0 ft.) fiberglass or spring metal hoops covered in #15 nylon black asphalt coated mesh. Mesh was hung on each hoop with # 21 nylon twine. The first three sections from the mouth between hoops were covered in 8.9 cm (3.5 in.) bar measured mesh and spaced 44.5 cm (17.5 in.) or 5 meshes apart. The last two sections from the mouth between hoops were covered in 6.4 cm (2.5 in.) bar measured mesh and spaced 63.5 cm (25.0 in.) or 10 meshes apart. The cod end was covered in 6.4 cm (2.5 in.) bar measured mesh and 69.8 cm (27.5 in.) or 11 meshes in length. A sand anchor was attached was to tension strings of the cod and a weight plate secured the bridle with a rope 4.0 m to 6.0 m in length tied to the bridle on one end and a buoy on the other ensuring the net remained taught at a length of 6.7 m (22.0 ft.). The weight plate was 1.3 cm (0.5 in.) thick steel plate 30.5 cm (12.0 in.) in length by 20.3 cm (8.0 in.) weighing approximately 6.1 kg (13.6 lbs.). A finger style throat was directed inward from the second and fourth hoop from the mouth of the net and shaped with finger lines. The front finger-style throat hand tapered down to a 61.0 cm (24.0 in.) diameter opening (at rear) and was 53.3 cm (21.0 in.) long. The rear finger-style throat hand tapered down to a 17.8 cm (7.0 in.) diameter opening (at rear) and was 85.9 cm (33.3 in.) long. The front throat had two tension strings secured to the finger lines and tied to the fifth hoop from the mouth of the net. The rear throat had two tensions strings also attached to finger lines secured to the cod-end drawstring. Tension strings were made of #72 black nylon twine.

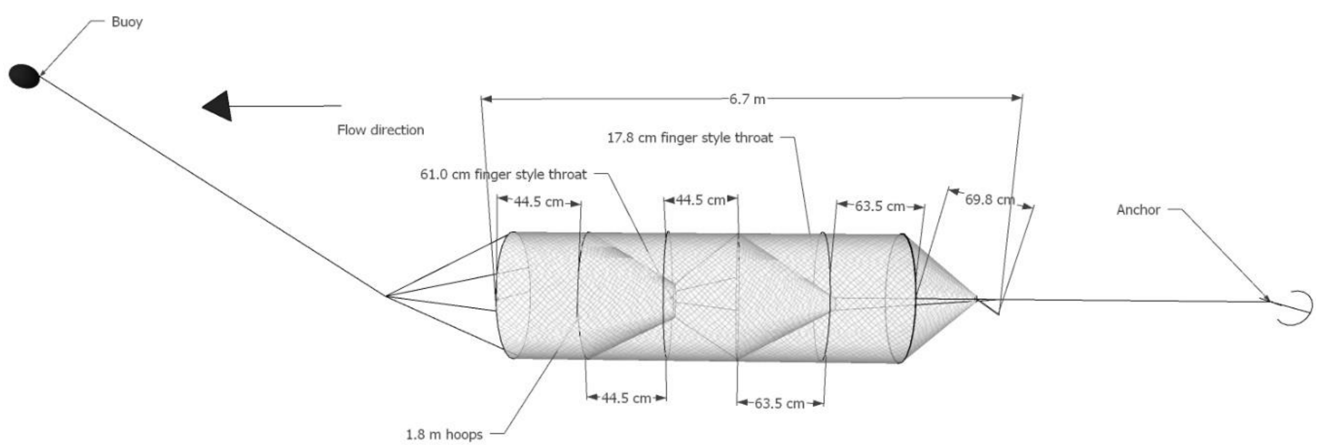

Figure 10. *Schematic of commercial hoop net*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Great lakes style pound net (Figure 11):

Pound nets had a single 100.0 m (328.0 ft.) long by 3.0 m (9.8 ft.) deep lead and two adjustable length wings that were longer than 150.0 m and 3.0 m (9.8 ft.) deep. Floats were attached every 91.4 cm (36.0 in.) on the float line of the lead and wings. Lead line of the lead and adjustable wings were created of solid core lead line. Floats were hard black plastic 127.0 mm (5.0 in.) in length by 51.0 mm (2.0 in.) in diameter which produced about 147.0 g (5.2 oz.) of buoyancy. The lead and adjustable wings were stitched to the heart joining the lead and wings to the mesh cab. The mesh cab or catch area, was a 6.1 m long by 3.0 m wide by 3.0 m deep (19.6 x 9.8 x 9.8 ft.) mesh square. The cab had two, 3.0 m (9.8 ft.) long by 2.5 cm (1.0 in.) diameter steel pipes sewn to the bottom of the horizontal panels of the cab as weights and one 3.0 m (9.8 ft.) long by 7.6 cm (3.0 in.) diameter capped polyvinyl chloride pipe stitched to the top of the rear horizontal cab panel for a float. Inner wings (wall throats) of the mesh cab, created a tunnel that extended from the outer corners of the heart to the middle of the rear rectangle mesh panel of the cab, with a 38.0 cm (15.0 in.) vertical gap between wings and either side of lead. Bar measured mesh size of webbing in pounds nets were either 3.8 cm (1.5 in.) or 6.4 cm (2.5 in.) black asphalt coated web depending on the pound net being used.

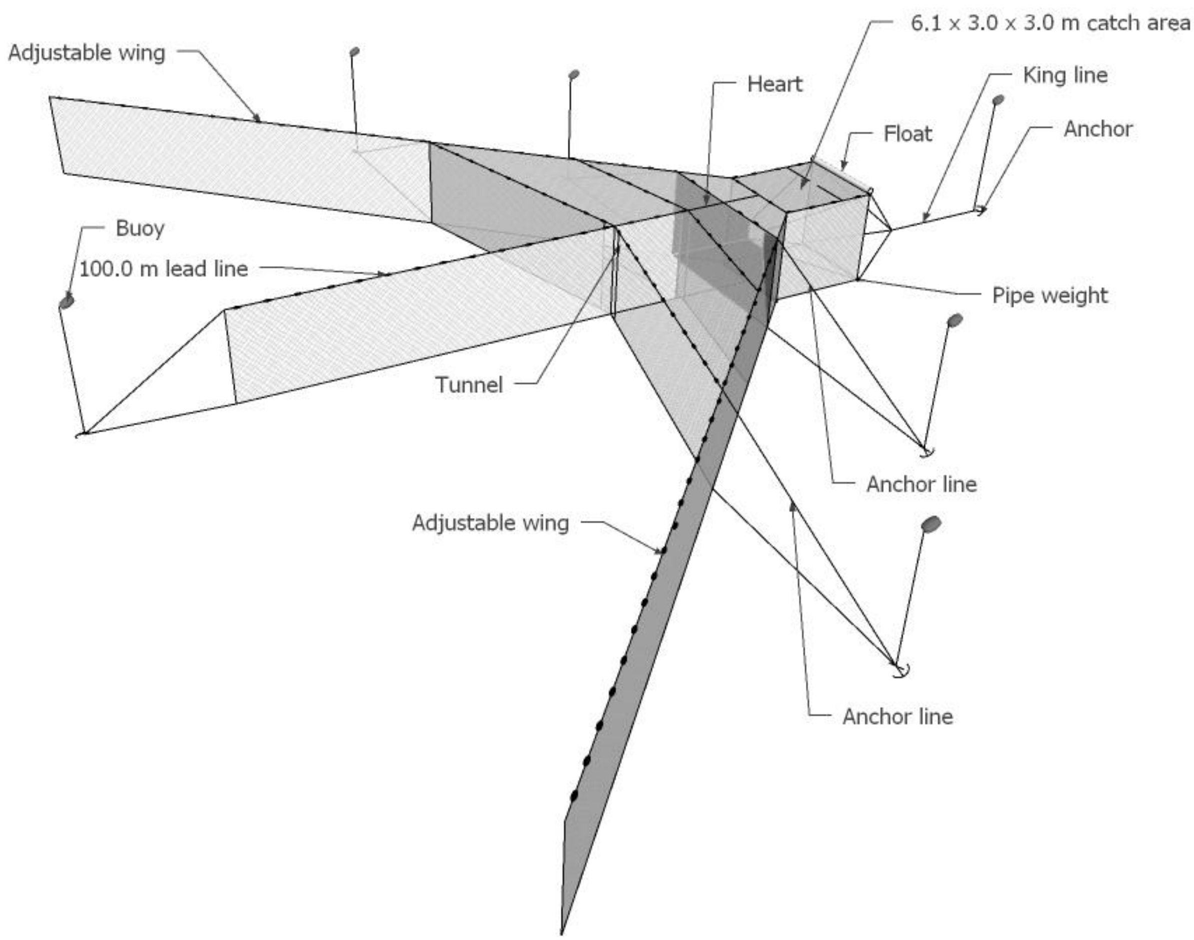

Figure 11. *Schematic of the great lakes style pound net*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Mini modified fyke net (Figure 12):

Mini modified fyke nets had a single, 5.0 m (16.4 ft.) long by 0.6 meter (2.0 ft.) deep lead. Floats were attached to the float line of the lead every 91.4 cm (36.0 in.) and lead weights attached every 45.7 cm (18.0 in.) along the lead line. Floats were made of 41.3 mm x 111.0 mm (1.6 in. by 4.4 in.) black hard foam that produced 85.0 g (3.0 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long, made from lead weighing approximately 28.3 g (1.0 oz.). The lead continued to the rear of the rectangular frame and was sewn to the vertical crossbar stitching the frame and lead together. The frame of the net was constructed of two, 0.6 m by 1.2 m (2.0 ft. by 4.0 ft.) rectangular bars made of 8.0 mm (0.3 in) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extend from outer corners of the front rectangle to middle of the rear rectangle. A 5.1 cm (2.0 in.) vertical gap existed between wings and either side of the lead at middle of rear rectangle. A 0.76 m (2.5 ft.) webbing covered gap connected the cab and frame together. The cab was constructed of two, 8 mm (0.3 in.) spring steel hoops that were 0.6 m (2.0 ft.) in diameter, spaced 0.6 m (2.0 ft.) apart. Cab and frame combined created a net that was 2.7 m (9.0 ft.) in total length. A single throat in the cab was attached to the first hoop from the mouth and tapered down to a 50.0 mm (2.0 in.) diameter hole at the rear. The throat was created with a 50.0 mm (2.0 in.) inner diameter by 6.4 mm thick (2.0 x 0.3 in.) stainless steel or nickel-plated ring sewn in the mesh. Four tension strings tied to the ring were secured to the rear hoop. A 1.8 m (6.0 ft.) long by 5.0 mm (0.2 in.) diameter braided nylon drawstring was sewn in a casing on the cod end secured the cod end closed. All webbing for the net was 3.0 mm (0.1 in.) ace type nylon netting coated with green latex type dip.

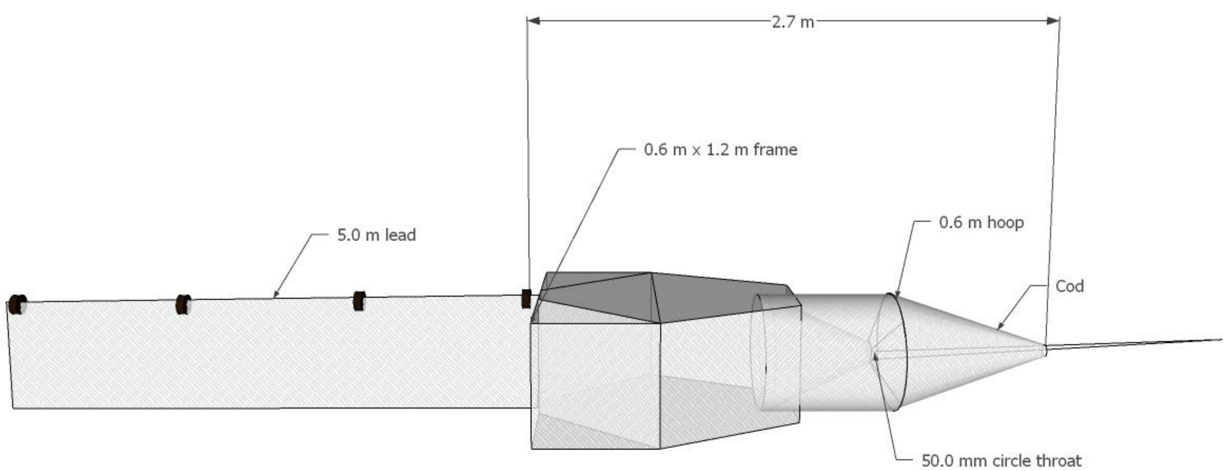

Figure 12. *Schematic of mini modified fyke net*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Modified fyke net (Figure 13):

Modified fyke nets had a single 15.2 m (50.0 ft.) long by 1.4 m (4.5 ft.) deep lead. Floats were attached every 91.4 cm (36.0 in.) on the float line of the lead, and lead weights every 30.5 cm (12.0 in.) along lead line of the lead. Floats were made from 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge producing about 156.0 g (5.5 oz.) of buoyancy. Weights were 38.0 mm (1.5 in.) long lead weighing approximately 28.3 g (1.0 oz.). Lead continued into the rear of the net frame and was sewn to the vertical crossbar joining the frame and lead. The frame of the net was constructed of two, 1.2 m (4.0 ft.) by 1.8 m (5.0 ft.) rectangular bars made of 8.0 mm (0.3 in.) black oil temper spring steel. Inner wings (vertical wall throats) of the frame extended from outer corners of the front rectangle to the middle of the rear rectangle. A 76.0 mm (3.0 in.) vertical gap existed on either side of lead at middle of rear rectangle. A 1.2 m (4.0 ft.) mesh covered gap connected the cab and frame together. The cab was constructed of six, 0.9 m (3.0 ft.) diameter spring steel hoops spaced 61.0 cm (24.0 in.) apart from each other and covered in webbing. Cab and frame together were 6.0 m (20.0 ft.) in total length. The front throat of the cab began at the first hoop from the mouth and was a 203.0 mm (8.0 in.) square style throat, 20 meshes long, and knitted to 40 meshes around (10 per side) at rear. The rear end of the front throat was attached to the third hoop with 4 tension strings. The rear throat of the cab began at the third hoop from the mouth and was a 102.0 mm (4.0 in.) crowfoot style throat 28 meshes long, knitted to 32 meshes around at rear. The rear end of the second throat was attached to cod end drawstring with 2 tension strings. A 2.4 m (8.0 ft.) long, 6.0 mm (0.3 in.) diameter asphalt coated braided nylon drawstring secured the cod end closed. All finger lines were made of #15 black nylon twine and tension strings were made of #72 black nylon twine. Webbing for the modified fyke net was 18.0 mm (0.8 in.) bar measured mesh coated with a black asphalt coating.

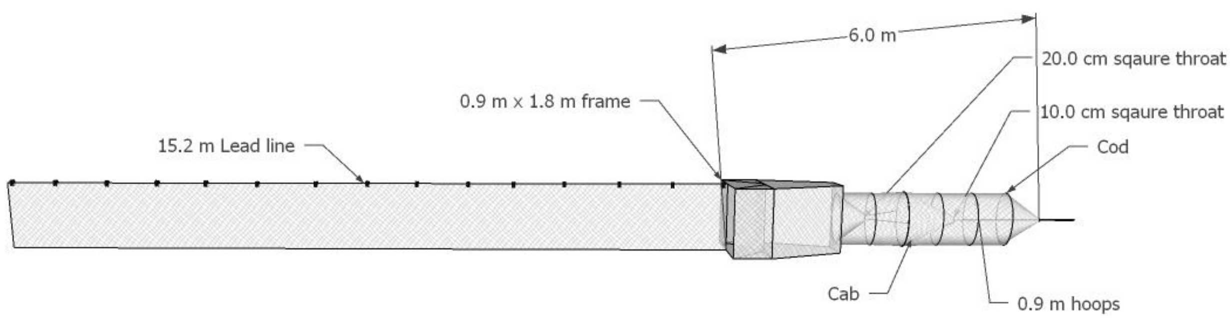

Figure 13. *Schematic of modified fyke net*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Larval fish capture gears

Active capture gears

Larval pushnet (Figure 14):

Larval pushnets were created from a nylon-mesh cone stitched to a steel rod cylinder secured to an aluminum frame. The nylon mesh cone was 500 µm mesh and was 3.0 m (9.8 ft.) in total length that tapered down to an 8.9 cm (3.5 in.) diameter circle at the distal end. The steel rod cylinder was made of 3.2 mm (0.1 in.) stainless steel rod bent and welded into a 0.5 (1.6 ft.) diameter circle. The distal end of the nylon mesh cone had an 8.9 cm (3.5 in.) adapter secured to it allowing a 1,000 ml hard-plastic plankton bucket to be attached. The plankton bucket had multiple rectangular sections removed and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. A flow meter or flow rocket was secured one-fourth the distance of the diameter of the steel cylinder in the net mouth (approximately the middle of the mouth) to estimate volume of water filtered. The pushnet was attached to an aluminum hexagon frame with industrial strength zip ties. The hexagonal frame was secured to the bow of the boat with 2.8 m (9.2 ft.) long aluminum bars.

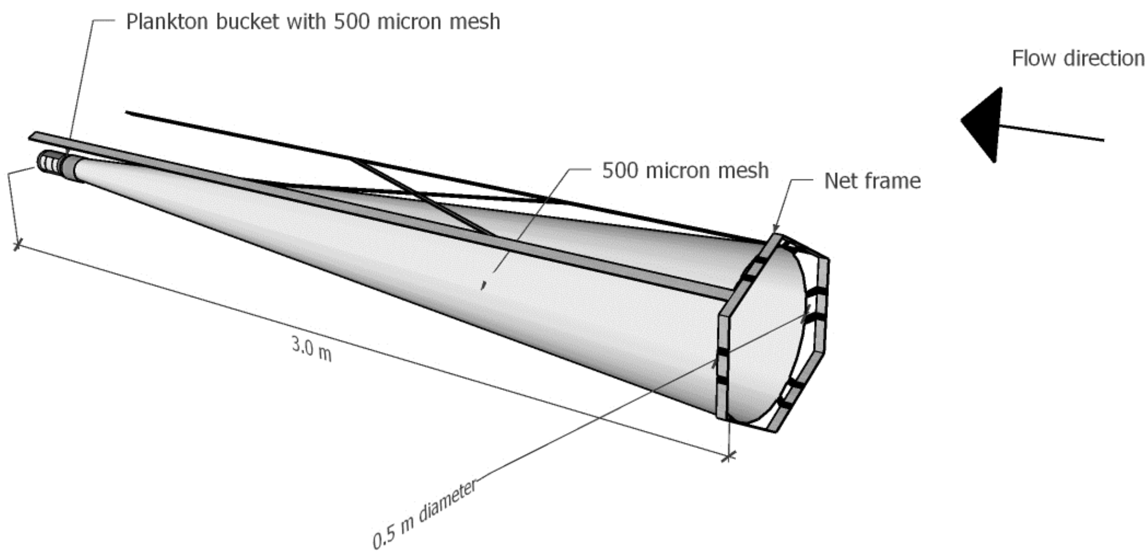

Figure 14. *Generalized schematic of a pushnet.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Passive capture gears

Larval driftnet (Figure 15):

Larval driftnets were created from 1.0 m (3.3 ft.) long plankton net stitched to a 0.3 m (0.8 ft.) by 0.5 m (1.5 ft.) rectangular made from 3.2 mm (0.1 in.) aluminum rod stock. Mesh pores of the plankton net were 500 µm. The plankton net tapered down to an 8.9 cm (3.5 in.) circumference circle on the distal end. An adapter was secured to the distal end of the plankton net allowing a 1,000 ml hard-plastic plankton bucket to be attached. The driftnet bucket had multiple sections cut out from the sides and covered with 504 µm stainless steel mesh facilitating the rinsing of the net and the collection of organisms after net retrieval. Flow was recorded prior to setting a driftnet with a flow meter for an estimate of the volume of water sampled. Drift nets were anchored to the river bottom using rebar stakes.

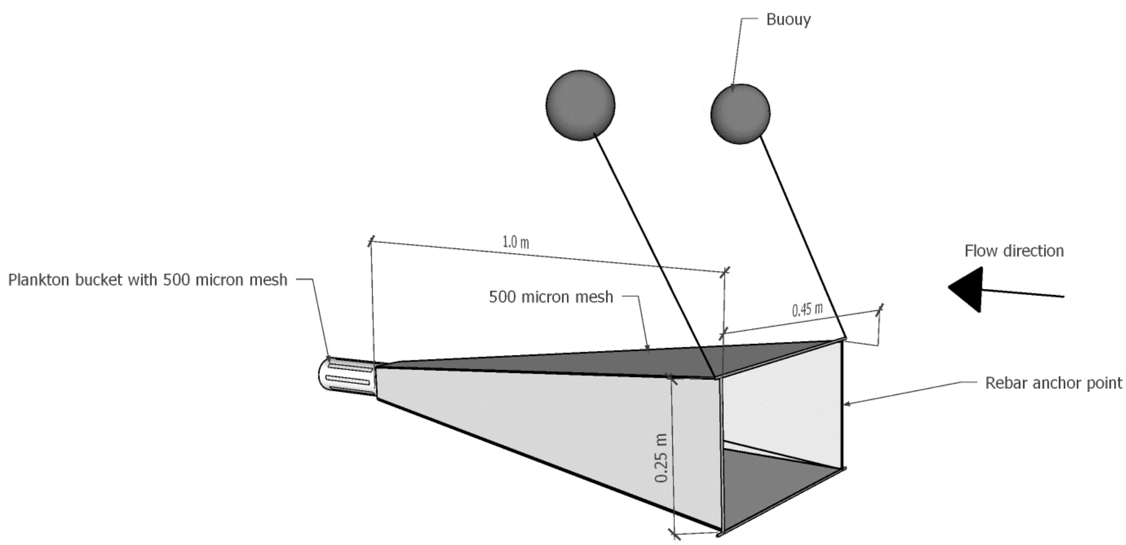

Figure 15. *Generalized schematic of a drift net.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Larval quadrafoil light trap (Figure 16):
Quadrafoil light traps consisted of a collection pan, a cloverleaf array and a closed cell floatation block. Collection pans were constructed of a 30.0 cm (11.8 in.) diameter aluminum pan with 5.1 cm (2.0 in.) tall sides. Six, 3.8 cm (1.5 in.) diameter drain holes were drilled into side of the collection pan and covered with 250 µm mesh allowing water to drained from the trap while retaining captured organisms upon retrieval. The cloverleaf array was created from four half circle polycarbonate tubes 10.2 cm (4.0 in.) in diameter with 6.4 mm (0.25 in.) thick polycarbonate cemented to a top and bottom 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick clear polycarbonate circles. The top polycarbonate circle of the cloverleaf array was secured to the closed cell floatation block with four, 4.8 mm (0.2 in.) by 25.4 mm (1.0 in.) stainless steel eye bolts. The closed cell floatation block consisted of the top polycarbonate circle of the cloverleaf array, a 30.0 cm (11.8 in.) diameter by 10.0 cm (3.9 in.) thick Styrofoam middle and a 30.0 cm (11.8 in.) diameter by 6.4 mm (0.3 in.) thick polyvinyl chloride top. The bottom polycarbonate circle was secured to aluminum collection pan with two paracord straps using four 3.2 mm (0.1 in.) zinc plated spring snap link carabiners on each end which were clipped to one of the rigging point eyebolts. A 20.0 mm diameter by 25.0 cm long capped central light tube at the center of the cloverleaf array stored the light source for light traps. Light sources for light traps were green photochemical light sticks. Rigging point eyebolts served as a point to tether the trap to a tree, the bank, or anchor at each sampling location.

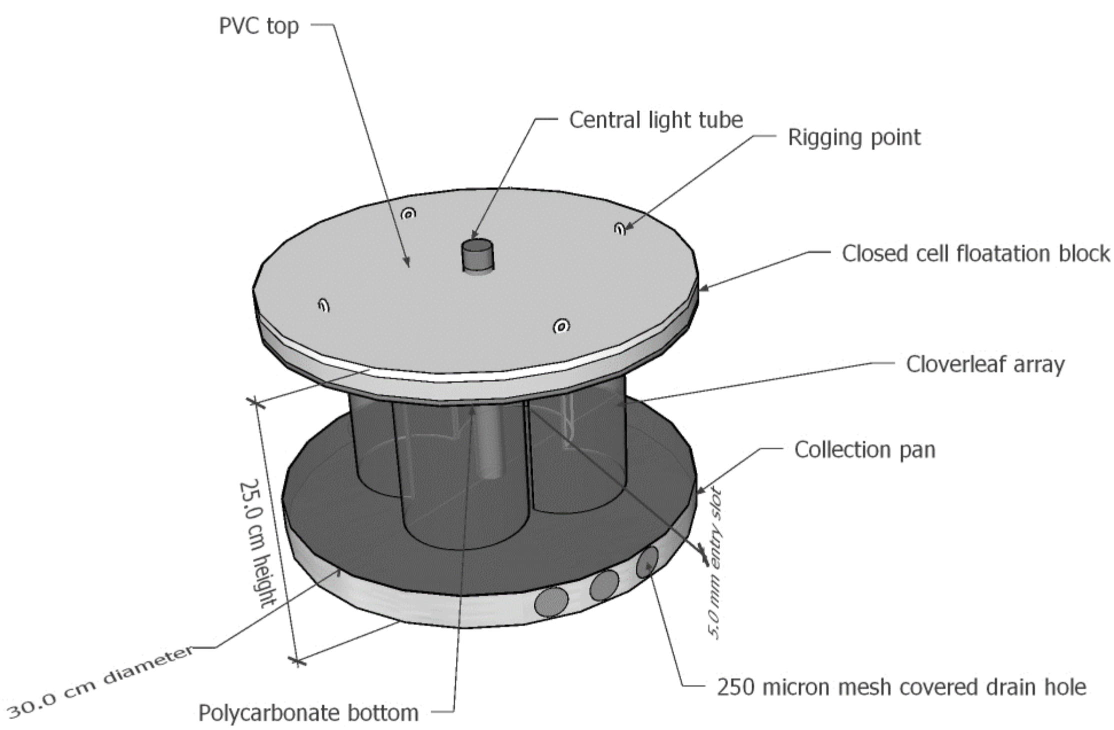

Figure 16. *Schematic of Quadrafoil light trap*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Non-capture gears

Nets

Block net (Figure 17):

Block nets consisted of nylon mesh webbing sewn to a float line and a lead line. Float lines had 7.6 cm (3.0 in.) by 3.8 cm (1.5 in.) polyvinyl chloride sponge floats attached every 30.5 cm (12.0 in.). Each float produced about 156.0 g (5.5 oz.) of buoyancy. Lead lines were 95.3 mm (0.3 in.) braided solid leadcore rope. Webbing of block nets was 7.9 mm (0.3 in.) bar measured nylon mesh covered in a black asphalt coating. Depth of block nets where either 9.1 m (30.0 ft.) or 6.1 (20.0 ft.) with webbing depths of 9.8 m (32.0 ft.) or 6.7 m (22.0 ft.), respectfully. Total lengths of block nets were either 152.4 m (500.0 ft.), 304.8 m (1,000.0 ft.) or 762.0 m (2,500.0 ft) with the webbing fully stretched to the same length as the total length of the block net (hanging ratio: 1.0 [measure of how tightly webbing is stretched along float and lead lines]). Block nets were used in conjunction with other sampling gears (e.g., electrofishing, gill/trammel nets) as they did not directly sample fish but prevented fish movement out of or into a new area.

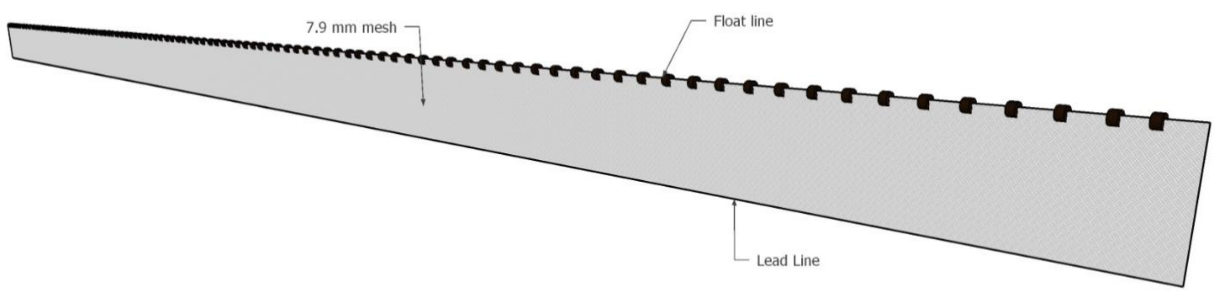

Figure 17. *Generalized schematic of a block net.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Sampling boats

Netting boat (Figure 18):

Flat bottomed aluminum boats, 4.9 m to 8.7 m (16.0 ft. to 28.0 ft.) in length powered with 90-horsepower or greater counsil or tiller controlled outboard motor set various active and passive capture gears. Outboard motors were controlled with a tiller handle or steering counsel. Netting boats had 2.3 m (7.5 ft.) wide hull with sides around 66.0 cm (25.0 in.) tall. Netting boats were made of 3.2 mm (0.1 in.) thick aluminum. A front 1.5 m to 2.3 m (5 ft. to 7.4 ft.) aluminum deck created a front platform with larger netting boats having a 1.0 m (3.2 ft) long step up to the deck. Under the step in larger netting boats was a 94.6-liter (25.0 gallon) fuel cell while smaller boats had a removable gas tank toward the stern. Two, 91.4 cm (36.0 in.) by 75.0 cm (29.5 in.) by 40.0 cm (16.0 in.) deep dry storage boxes were on the port and starboard freeboards in the stern of both the larger and smaller netting boats. Coupled with the outboard motor was a 3-blade stainless steel propeller.

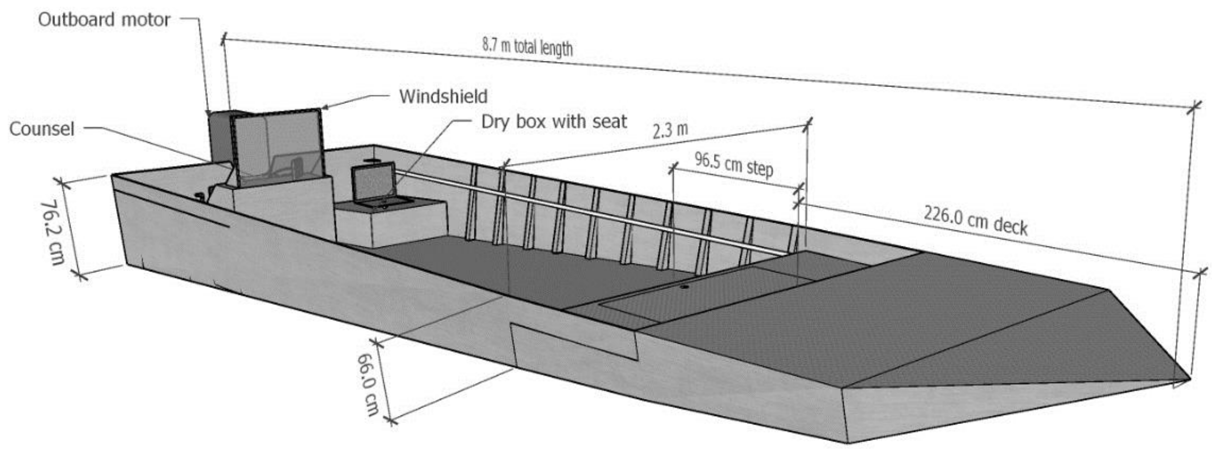

Figure 18. *Generalized schematic of netting boat.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Shallow drive boat (Figure 19):

The shallow drive boat used to drive fish and set gill/trammel net in shallow water was 5.5 m (18.0 ft.) long by 1.5 m (5.0 ft.) wide semi-v bottom with 61.0 cm (24.0 in.) tall sides of 3.2 mm (0.1 in.) thick aluminum. A front 1.4 m (4.6 ft.) aluminum deck coated in non-skid rubber created a front platform. Under the front deck was a 45.4-liter (12.0 gallon) fuel cell. The floor of the shallow drive boat was coated with non-skid rubber. Two, 91.0 cm (36.0 in.) by 73.6 cm (29.0 in.) dry storage boxes were on the port and starboard freeboards in the stern. A 38.1 cm by 58.4 cm by 38.1 cm (15.0 in. by 23.0 in. by 15.0 in.) aluminum float pod was welded to the starboard and port side of the transom. The hull of the shallow drive boat was coated with Gator Gilde. A 2017 Mudd Buddy HDR 44 tbd reverset power trim shallow drive motor with a V twin motor and 42 mm (16.5 in.) Mikuni carburetor was attached to the transom of the shallow drive boat. The shallow drive motor was made from cast aluminum and stainless steel with a 9.7 cm (3.8 in.) thick outdrive casting cover, an aluminum transmission cover and a stainless steel lower drive tube. An electric shift controller, allowed shifting of the shallow drive motor. A standard BPS "Q" performance muffler was attached to the shallow drive motor as well as a capacitor discharge ignition automatic advanced ignition with a 4650-rev limiter and a 50-amp charger. Coupled with the shallow drive motor was a 2-blade stainless steel hammer propeller.

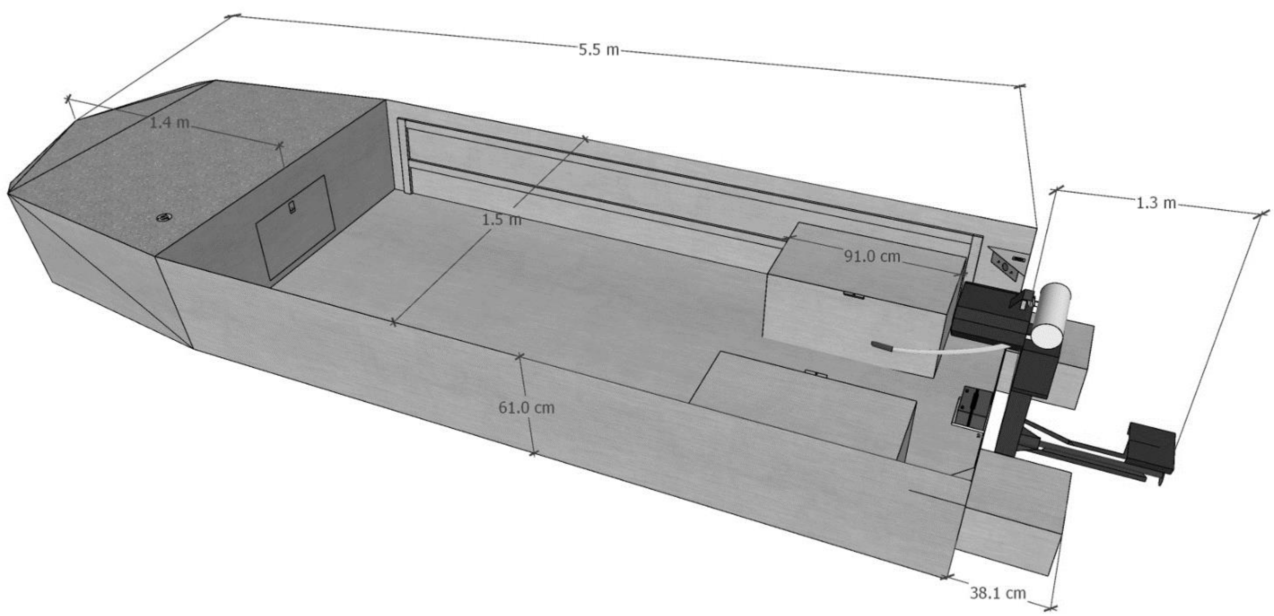

Figure 19. *Schematic of the shallow drive boat.*

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Table 1. *List of equipment vendors used during Asian Carp monitoring and response sampling. Use of trade names is for descriptive purpose and does not imply endorsement by an agency.*

Description	Vendor	Vendor contact
	Boats and Motors	
Electrofishing boat (aluminum, 5.5 + m)	Oquawka	www.oquawkaboats.com
Electrofishing boat trailer	Oquawka	www.oquawkaboats.com
Net boat (aluminum 5.5 + m)	Blue Ridge Custom boats, Oquawka, Kann, or AAD welding	https://www.facebook.com/pg/Blue-Ridge-Custom-Boats-1547565388875733/about/ www.oquawkaboats.com http://www.kannmfg.com/products/marine/ http://www.aadcustomboats.com/
Net boat trailer	Blue Ridge Custom boats, Oquawka, or Kann or AAD welding	https://www.facebook.com/pg/Blue-Ridge-Custom-Boats-1547565388875733/about/ www.oquawkaboats.com http://www.kannmfg.com/products/marine/ http://www.aadcustomboats.com/
Shallow drive boat (aluminum)	AAD welding	http://www.aadcustomboats.com/
Shallow drive boat trailer	AAD welding	http://www.aadcustomboats.com/
90 + HP outboard motors	Evinrude, Mercury, Yamaha	http://www.evinrude.com/en-US?redirect=false https://www.mercurymarine.com/en/de/engines/outboard/ https://yamahaoutboards.com/en-us/
Shallow drive motor	MudBuddy	http://www.mudbuddy.com/hdsport.htm
Miscellaneous: anchor, batteries, bilge pump, lights fuel tanks, rope, safety equipment		
	Electrofishing components	
MBS-1D Electrofishing control box	ETS Electrofishing	http://etselectrofishing.com/
Type VI-A Electrofishing control box	Smith-Root	https://store.smith-root.com/type-via-electrofisher-system-p-9.html
5,000 watt generator	Honda	http://powerequipment.honda.com/
Electrofishing boat booms	WS Hampshire	http://www.wshampshire.com/index.html
Electrofishing dip nets	Duraframe	http://www.duraframedipnet.com/
Holding tank fill pump	Rule	http://www.xylemflowcontrol.com/rule/
Holding tank (~379 liters)	Various suppliers	——
Miscellaneous: boots, gloves, life jacket, raingear, safety equipment, tank aeration, tank dip net		
	Net gear	
Mini Fyke net	Miller Net Company	http://www.millernets.com/
Fyke net	Duluth Nets Miller Net Company	http://duluthfishnets.com/ http://www.millernets.com/
Hoop net	Brown Fisheries Miller Net Company Memphis net	ronbrown.brownfisheries@gmail.com http://www.millernets.com/ http://www.memphisnet.net/
Gill/trammel nets	Brown Fisheries Memphis net	ronbrown.brownfisheries@gmail.com http://www.memphisnet.net/
Pushnet	Wildco	http://wildco.com/
Driftnet	Wildco	http://wildco.com/
Quadrafoil light trap	Aquatic Research Instruments	http://www.aquaticresearch.com/default.htm http://www.forestry-suppliers.com/

APPENDIX L
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Description	Vendor	Vendor contact
	Forestry Suppliers	
	Net get	
Pound net	Stuth Fishing	stuthfishing@charter.net
Seine	Commercial fisherman	——
Trawl	Commercial fisherman	——
Miscellaneous: anchors, floats, grapple, net preservative, rebar/stakes, rope, twine, webbing,		