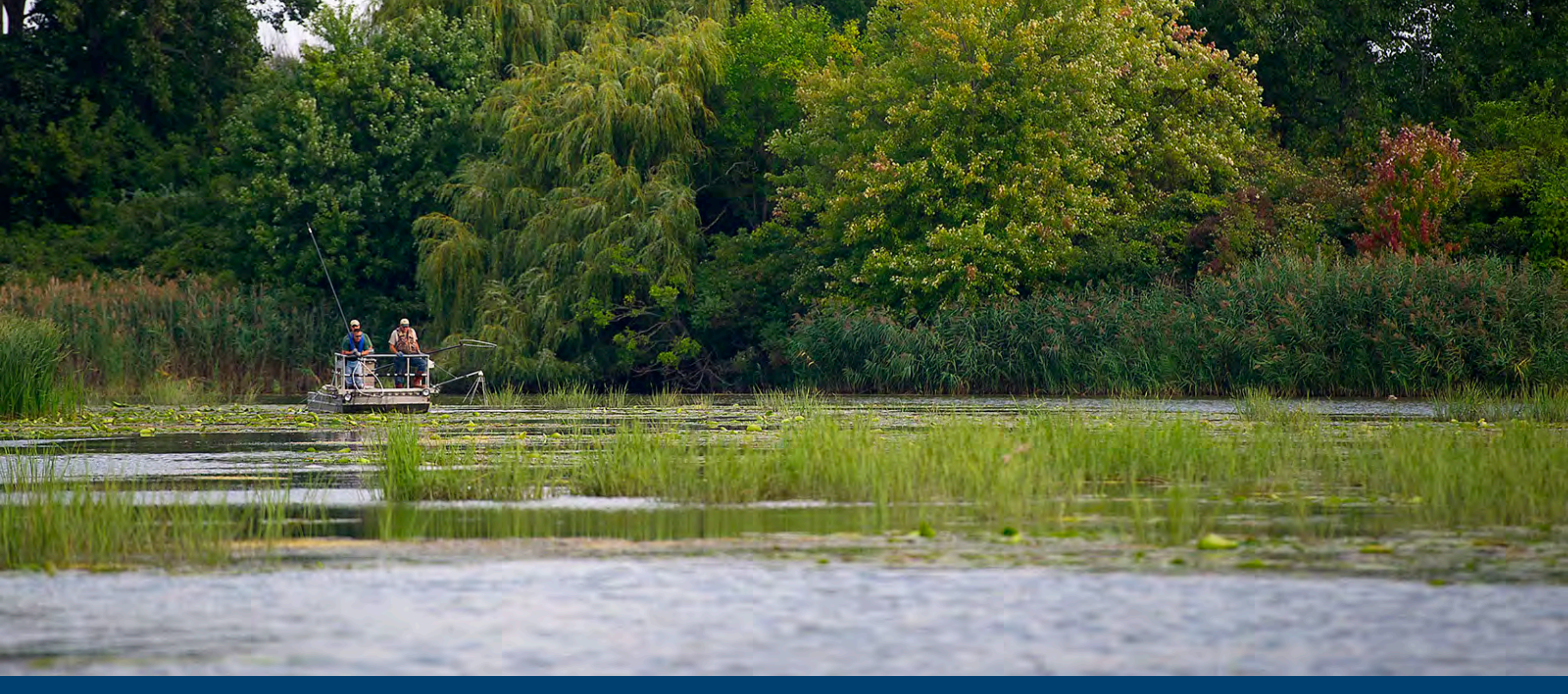

# 2017 Asian Carp Monitoring and Response Plan

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# ACKNOWLEDGEMENTS

The Asian Carp Monitoring and Response Plan was created by a team of biologists, scientists, managers, and administrators from state and federal agencies and includes technical input from government, university, and the private sector specialists. The original plan released in May 2010 was developed by S. Finney, R. Simmonds, S. Pescitelli, S. Shults, J. Mick, G. Sass, and R. Maher. This and earlier versions of the plan have benefitted from reviews by participants of the Monitoring and Response Work Group, Great Lakes state's natural resource agencies, nongovernmental organizations, and staff from the Illinois Department of Natural Resources Division of Fisheries, U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service. K. Irons, J. Dettmers, K. Baerwaldt, J. Davis M. Shanks, N. Barkowski, E.Monroe, R. Simmonds, S. Finney, J. Stewart, N. Bloomfield, E. Pherigo, R. Neeley, M. O'Hara, T. Widloe, B. Caputo, B. Bushman, J. Widloe, L. Nelson, J. R. Haun, R. Young, M. Brey, S. Butler, M. Diana, S. Collins, and D. Wahl contributed project write-ups for the plan. USFWS, IDNR, and INHS provided pictures for the cover.

# GLOSSARY

| TERM | DEFINITION |
|---|---|
| °C | Degrees centigrade |
| °F | Degrees Fahrenheit |
| µS/cm | microSiemen per centimeter |
| A | Amps |
| ACRCC | Asian Carp Regional Coordinating Committee |
| ANCOVA | Analysis of covariance |
| ANOVA | Analysis of variance |
| ANS | Aquatic Nuisance Species |
| CAWS | Chicago Area Waterway System |
| CERL | Construction Engineering and Research Laboratory |
| cm | Centimeter |
| $cm^2$ | Square centimeters |
| CPO | Conservation Police Officers |
| CPUE | Catch per unit effort |
| CSSC | Chicago Sanitary and Shipping Canal |
| dB | Decibels |
| DC | Direct current |
| DIDSON | Dual Frequency Identification Sonar |
| Diploid | Fish with the natural number of reproductive chromosomes; are capable of reproducing |
| ECALS | eDNA Calibration Study |
| eDNA | Environmental DNA |
| FWCO | Fish and Wildlife Conservation Office |
| g | Grams |
| GLFC | Great Lakes Fisheries Commission |
| GLMRIS | Great Lakes Mississippi River Interbasin Study |
| GPS | Global Positioning System |
| GSI | Gonadosomatic index |
| HACCP | Hazard Analysis and Critical Control Points |
| IDNR | Illinois Department of Natural Resources |
| INHS | Illinois Natural History Survey |
| IPC | Internal positive control |
| ISU | Invasive Species Unit |
| IWW | Illinois Waterway |
| kg | Kilogram |
| kHz | Kilohertz |
| km | Kilometer |
| km/hr | Kilometers per hour |
| LOQ | Limit of quantification |
| LTRMP | Long-Term Resource Monitoring Protocols |
| m | Meter |
| $m^2$ | Square meters |

# GLOSSARY

| TERM | DEFINITION |
|---|---|
| $m^3$ | Cubic meters |
| ml | Milliliter |
| mm | Millimeter |
| MRP | Asian Carp Monitoring and Response Plan |
| MRWG | Monitoring and Response Work Group |
| MVN | Multivariate Normal Distribution |
| MWRD | Chicago Metropolitan Water Reclamation District |
| Ploidy | Measurement of number of chromosomes, triploid fish are sterile |
| QAPP | Quality Assurance Project Plan |
| RM | River Mile |
| SD | Standard deviation |
| SIM | Seasonal Intensive Monitoring |
| SIUC | Southern Illinois University Carbondale |
| TL | Total length |
| Triploid | Fish that have been genetically modified to have an extra reproductive chromosome, rendering them sterile |
| -TS | Target Strength |
| UMESC | USGS Upper Midwest Environmental Sciences Center |
| USACE | U.S. Army Corps of Engineers |
| USCG | U.S. Coast Guard |
| USEPA | U.S. Environmental Protection Agency |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| V | Volts |
| v/cm | Volts per centimeter |
| V/in | Volts per inch |
| VHS | Viral Hemorrhagic Septicemia |
| W | Watts |
| WGL | Whitney Genetics Laboratory |
| yd | Yard |
| YOY | Young of year |

# 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 24 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 2017, 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 2017 MRP build upon considerable work completed during past years. 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 2016 Asian Carp Interim Summary Report, presented as a companion document to the 2017 MRP.

## HIGHLIGHTS OF PAST EFFORTS

### Detection Projects

- A total of 342,476 fish have been collected above the Electric Dispersal Barrier during seasonal intensive monitoring since 2011. No Asian carp have been observed since 2011, when a single Asian carp was captured in Lake Calumet.
- No small (< 6 inches) Asian carp were captured upstream of Peoria Pool in 2016.
- Asian carp eggs were collected in La Grange, Peoria, Starved Rock, and Marseilles Pools, but Asian carp larvae were only collected in La Grange and Peoria Pools in 2016. Asian carp appeared to have multiple spawning events in 2016.

- Fixed and random sampling below the Electric Dispersal Barrier has resulted in the collection of over 234,000 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 280, approximately 47 miles from Lake Michigan.
- There was one positive detection for Silver Carp eDNA and one positive detection for Bighead Carp eDNA above the Electric Dispersal Barrier during sampling in 2016.
- 32 Bighead Carp have been removed from urban ponds since 2011. 27 of the 28 ponds designated for investigation have either been sampled, emptied, or restored using rotenone to destroy existing fish.

**Manage and Control Projects**

- Over 2,504 tons of Asian carp have been removed from the IWW below the Electric Dispersal Barrier during commercial harvest efforts since 2010. This tonnage was comprised of 85,710 Bighead Carp and 474,264 Silver Carp.
- Telemetry study of tagged fish has observed no upstream passage past the Electric Dispersal Barrier. Only two lock passages were observed in the Upper IWW.
- 1,790 surrogate fish with behavior similar to Asian carp were tagged in 2016 to study movement across the Electric Dispersal Barrier and through locks and dams.
- Asian carp density in Dresden Island pool appears to have decreased by an estimated 59 – 75% (68% average). This is a likely result of commercial harvest.
- The efficacy of the Electric Dispersal Barrier in preventing upstream passage of small fish is compromised while tows are moving across the barrier in a downstream direction.
- No Asian carp have been captured during sampling in the Des Plaines River. This spans the collection of 6,656 fish since 2011.
- 35 Grass Carp were captured, including 4 from above the Electric Dispersal Barrier. 80% of captured Grass Carp were diploid. Fish were implanted with acoustic tags to monitor movement patterns and habitat preference.
- Modifications to the configuration and deployment of nets and electrofishing arrays were explored, resulting in new deployment techniques that increase the coverage of net deployments and electrofishing arrays.
- Pound nets were determined to be both the most effective gear for capturing Asian carp in backwater ponds and lakes, as well as the most cost-effective gear.
- Relationships between capture gear and Asian carp size class were determined, with specific gear determined to be optimal for targeting specific size classes and age ranges of Asian carp. This study also indicated that juvenile Asian carp tend to favor near-shore habitats, and gradually move to deeper water as they increase in size.
- Law enforcement conservation officers have completed inspections of multiple aquaculture facilities and numerous fish trucks. These and other efforts have resulted in citations and ongoing multi-agency, cross-jurisdictional investigations into the illegal trade of invasive aquatic species.

**Response Projects**

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

In addition to these highlights, a brief summary of work anticipated to be completed in 2017 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 2017.

## 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 (Week of June 12th and 19th) and the fall season (Week of September 18th and 25th). This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers at sites in the CAWS upstream of the electric 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 2010 one Bighead Carp was captured with commercial nets and had numerous Rapid Response actions due to positive Asian Carp eDNA samples. In this event pulsed-DC electrofishing, tandem trap nets, Lake Michigan pond nets and contracted commercial fishers will be utilized. 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 Barrier System.

### *Strategy for eDNA Sampling in the CAWS and Refining eDNA Interpretation Below the Electric Dispersal Barrier*

In 2017, the project will collect samples at four traditional sampling sites to maintain the historical data record. An additional comprehensive sampling event will take place prior to Seasonal Intensive Monitoring, to allow for the comparison of eDNA results with actual fish capture. Dresden Island Pool will be sampled twice in 2017 because there is a carp population gradient within the pool. This strategy will provide more comprehensive coverage of the pool, allowing for the determination of whether eDNA results correlate with known carp population trends within the pool.

***Larval Fish Monitoring in the Illinois Waterway***

Larval fish sampling will occur at approximately biweekly intervals at 12 sites located across the length of the Illinois Waterway (all navigation pools, including CAWS) from April to October. Additional sampling will occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee Rivers to assess potential Asian carp spawning in tributaries of the Illinois River. Sampling may occur more frequently during periods when Asian carp eggs and larvae are likely to be present (e.g., May - June, during periods of rising water levels, or shortly after peak flows). Observation of Asian carp eggs or larvae will help to inform other agencies of the upcoming likelihood of capturing young-of-year Asian carp. Analyses of the spatial and temporal distribution of Asian carp eggs and larvae will aid in identifying spawning locations, environmental factors associated with successful reproduction, and factors contributing to Asian carp recruitment.

***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 Illinois Waterway. 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 will be determined with acoustic telemetry. Sampling will occur during the months of April through October. Sampling effort will be distributed between Peoria, Starved Rock, Marseilles, and Dresden Island, Brandon Road, and Lockport pools.

***Fixed Site Monitoring Downstream of the Dispersal Barrier***

This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers at four fixed sites downstream of the Electric Dispersal Barrier system in Lockport pool, Brandon Road pool, and Dresden pool. Fixed and random site pulsed-DC electrofishing will take place bi-weekly from April through November, and will include 8 random sites in the Lockport, Brandon Road, and Dresden Island pools, respectively. Contracted commercial fishing will take place bi-weekly from March through November. Hoop and mini-fyke netting will occur bi-weekly from April through November. Results will provide information on the location of detectable Asian carp populations in the waterway (relative abundance and distribution) and their progression upstream over time. Population data may be compared among sites and across time.

***Telemetry Monitoring Plan***

This project uses ultrasonically tagged Asian carp and surrogate species to assess if fish are able to challenge and/or penetrate the Electric Dispersal Barrier and pass through navigation locks in the upper Illinois Waterway. An array of stationary acoustic receivers and mobile tracking will be used to collect information on Asian carp and surrogate species movements.

***Monitoring Fish Abundance, Behavior, and Barge Interactions at the Electric Dispersal Barrier, Chicago Sanitary and Ship Canal, Illinois***

This project continues to evaluate non-Asian carp fish behavior between the narrow arrays where the highest-voltage electrical field is located and determine the species of fish present in and directly adjacent to the barrier system. Other components of the project will evaluate behavior of fish near the barrier as barges traverse the barriers and their behavior near barges at the Brandon Road Lock and Dam and in downstream areas of high Asian carp abundance. This project will also evaluate the potential for transport of eggs and larvae by barges, and will evaluate potential operational protocols to avoid barge entrainment.

***Analysis of Feral Grass Carp in the CAWS and Upper Illinois River***

This project aims to evaluate the extent of Grass Carp populations through targeted sampling events in the Upper IWW. Grass Carp will be captured and tagged for telemetric tracking. Sampling will take place from April through October, as will tagging and tracking of fish movements. Following data collection, an analysis of fish movement trends will be completed.

***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). Elliot Lake will be sampled with DC electrofishing and trammel/gill nets.

***Young-of-year and Juvenile Asian Carp Monitoring***

This is a new project for 2017 that will perform sampling for young-of-year and juvenile Asian carp within the CAWS, lower Des Plaines River, and Illinois River with the intent to determine the uppermost waterway reaches where young Asian carp are successfully recruiting. Small fish will be collected by other detection projects, and the data provided by these projects will synthesized to meet project objectives.

***Illinois River Juvenile Asian Carp Telemetry***

This is a new project for 2017 that will collect juvenile Asian carp from La Grange and Peoria Pools, and implant them with acoustic telemetry tags. Telemetry will be used to observe juvenile Asian carp behavior, with a focus on (1) determining movement distance and direction; (2) determining macrohabitat selection; (3) determining whether movement is related to water temperature or flow conditions; (4) creating the home range estimate for juvenile Asian carp; (5) determining the age of tagged fish; and (6) performing genetic analysis to identify behavior differences between Bighead Carp, Silver Carp, and hybrids. Sampling and telemetry monitoring will take place from April through November.

***Des Plaines River and Overflow Monitoring***

This project performs monitoring for Asian carp within the Des Plaines River using electrofishing and gill netting. The Des Plaines River runs parallel to the CAWS, and represents a possible route for Asian carp to bypass the Electric Dispersal Barrier during overflow events. To prevent this bypass, a physical barrier was constructed between the Des Plaines River and the CAWS. This project continues to monitor for Asian carp in the Des Plaines River to determine the threat posed to the CAWS by Asian carp populations within the Des Plaines River. A minimum of two sampling events will be conducted in 2017, focusing on capturing the spawn and post-spawn time frames.

***USGS Support for Implementation of MRP***

This project aims to support the implementation of MRP goals and other projects by providing advanced analysis of existing data streams, including telemetry, fish capture, hydraulic/hydrologic, and climatic data. Databases and decision support tools will be developed to take full advantage of existing data to inform decision makers and help guide the efforts of other MRP projects.

## MANAGE AND CONTROL PROJECTS

***Barrier Maintenance Fish Suppression***

This project provides a fish suppression plan to support USACE maintenance operations at the electric dispersal barrier system. The plan includes clearing fish from between barriers with various fish driving and removal techniques and evaluating clearing success with split-beam hydroacoustics, side scan SONAR, and DIDSON imaging SONAR.

***Barrier Defense Asian Carp Removal Project***

This program was established to reduce the numbers of Asian carp downstream of the electric barrier system using targeted and contracted commercial fishing. Reducing Asian carp populations is anticipated to lower propagule pressure and the chances of Asian carp gaining access to waters upstream of the Electric Dispersal Barrier system. Primary areas that will be fished include Starved Rock and Marseilles pools.

***Spatiotemporal Changes in Asian Carp Abundance and Density to Target Management Actions and Control Strategies***

This project continues past efforts to develop, test, and utilize a model of Asian carp population characteristics, abundance, and movement within the IWW. In 2017, the model will continue to be refined using new data. The model will be used to quantify Asian carp densities and biomass from the Alton to Dresden Island Pools to assess trends in population trajectories, and evaluate relationships between Asian carp densities and control efforts (e.g., harvest) to determine the effectiveness of harvest at reducing Asian carp abundance. The model will also be used to quantify spatial and temporal variation in Asian carp densities in Marseilles and Dresden Island Pools throughout 2017 and relate densities to environmental conditions to inform harvest and control efforts. Efforts will continue to use the model to assess Asian carp movement throughout the Illinois River, and to evaluate the likely impact of various Asian carp removal scenarios.

***Understanding Surrogate Fish Movement with Barriers***

This project investigates the movements of tagged surrogate fish species in the Dresden Island, Brandon Road, and Lockport pools, along with specific areas such as Brandon Road Lock and Dam and below the Electric Dispersal Barrier Area in Lockport pool. The project will assess the movement of surrogate fish species between barriers and obtain recapture rates to help verify sampling success using multiple gears.

***Evaluation of Gear Efficiency and Asian Carp Detectability***

This project will continue to assess efficiency and detection probability of sampling gears used for Asian carp monitoring. Sampling in 2017 will continue to focus on evaluation of gears for capturing juvenile Asian carp. Sites in the LaGrange, Peoria, Starved Rock, Marseilles, and Dresden Island Pools will be sampled with a variety of gears including mini-fyke nets, beach seines, purse seines, gill nets, pulsed-DC electrofishing, push-frame nets, and hydroacoustics. Increased effort will be made in the upstream pools (Starved Rock, Marseilles, and Dresden Island Pools) to evaluate whether juvenile Asian carp are present. Analyses will continue to examine the ability of each gear to capture age-0 through age-2 Asian carp and for their effectiveness at capturing other species of small-bodied fishes. Detection probability modeling will continue to examine the probability of capturing Asian carp with various gears.

***Gear Evaluation for Removal and Monitoring of Asian Carp Species***

Two innovative trawling methods and traditional boat electrofishing will be deployed in backwater habitats of the Illinois River twice per month May through October 2017. Gears that will be evaluated include a dozer trawl, traditional boat electrofishing, and a paupier butterfly trawl. Gears will be evaluated and compared for their efficacy at capturing juvenile Asian carp.

***Unconventional Gear Development***

In 2017, the evaluation of the use of pound nets to capture Asian carp will continue. Past results have indicated the potential of pound nets to be an effective capture method in several habitat types. Work in 2017 will focus on evaluating the effectiveness of pound nets in capturing Asian carp in particularly difficult sampling habitats, including open-water areas where blocking the entire channel is not feasible. Pound nets will also be set at appropriate backwater habitats on the Illinois Waterway in continued collaboration with USGS personnel testing the effectiveness of feeding attractants and sound stimuli for attracting or deterring Asian carp. Experiments will involve comparisons of pound nets set with and without the feeding attractant or sound stimuli. All captured fish will be identified to species, and measured for total length and weight. Results of these trials will be reported by USGS. Pound nets will continue to be used to assist IDNR with monitoring and control efforts in the upper IWW. INHS will also help aid in the deployment of pound nets and training of personnel from other agencies that express interest in utilizing this gear type. Additional new gears and gear combinations may be incorporated into sampling efforts as they become available.

***Monitoring Asian Carp Using Netting with Supplemental Capture Techniques***

This project analyzes the use of supplemental techniques (electrofishing, complex sound, commercial technique) to increase the capture of Asian carp with netting. Based on previous results, catch data suggested there was no significant increase in catch effectiveness of Asian carp based on supplemental capture techniques. During 2017, electrofishing will be used as a supplemental technique as it demonstrated the greatest utility in past studies. Efforts will also focus on evaluating whether time of day has an impact on Asian carp capture rates, with multiple night sampling events planned. Sampling will take place from April to October.

***Barrier Defense Removal of Asian Carp Using Novel Gear***

This project will use the electrified paupier to supplement existing commercial netting efforts to remove Asian carp from the IWW below the Electric Dispersal Barrier. The electrified pauper will be evaluated as a tool for removing small and young Asian carp, as current commercial netting techniques are biased towards capturing large Asian carp. The efficacy of the electrified paupier will be evaluated, as will the demographics of the fish it captures in comparison to those captured by commercial netting.

***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.

## 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 have laid out a framework for taking response actions, including steps for coordinating between agencies and communicating with the general public. In 2017, efforts will be made to 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 and further reduce the risk of spread toward Lake Michigan. Specifically, this document is a compilation of 24 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 project outlines anticipated actions that will take place in 2017, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2017 Asian Carp Action Plan which outlines funding and actions taken through the USEPA's Great Lakes Restoration Initiative. The Fiscal Year 2017 Action Plan contains the portfolio of over 60 high-priority strategic activities planned for implementation in the coming year. The Action Plan serves as a foundation for the work of the ACRCC partnership — a collaboration of 27 U.S. and Canadian federal, state, provincial, and local agencies and organizations — 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 the 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 upon prior plans developed for 2011 - 2016. More specifically, it is intended to identify actions to be taken in 2017, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2017 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 2017 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 2017 MRP provides new information about project plans, as well as incorporates new information, technologies, and methods as they have been discovered, field tested, and implemented. A companion document, the 2016 Asian Carp Monitoring and Response Plan Interim Summary Report (ISR), has also been completed by the MRWG. The 2016 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 2017 MRP and 2016 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. Two projects were completed in 2016, and are not included in plans for 2017. Two new projects have replaced these completed projects, and plans are included in this MRP. These new projects are "Young-of-year and Juvenile Asian Carp Monitoring" and "Illinois River Juvenile Asian Carp Telemetry".

The projects included in the 2017 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 below.

| **Detection** |
|---|
| Seasonal Intensive Monitoring in the CAWS |
| Strategy for eDNA Sampling in the CAWS and Refining eDNA Interpretation Below the Electric Dispersal Barrier |
| Larval Fish Monitoring in the Illinois Waterway |
| Distribution and Movement of Small Asian Carp in the Illinois Waterway |
| Fixed Site Monitoring Downstream of the Dispersal Barrier |
| Telemetry Monitoring Plan |
| Monitoring Fish Abundance, Behavior, and Species Composition near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier |
| Analysis of Feral Grass Carp in the CAWS and Upper Illinois River |
| Alternative Pathway Surveillance: Urban Pond Monitoring |
| Young-of-year and Juvenile Asian Carp Monitoring |
| Illinois River Juvenile Asian Carp Telemetry |
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| USGS Support for Implementation of MRP |
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| Unconventional Gear Development |
| Monitoring Asian Carp using Netting with Supplemental Capture Techniques |
| Barrier Defense Using Novel Gear |
| Alternative Pathway Surveillance: Law Enforcement |
| **Response** |
| Upper Illinois Waterway Contingency Response Plan |

# CURRENT STATUS

Detection projects have informed agency actions and development of the 2017 MRP.

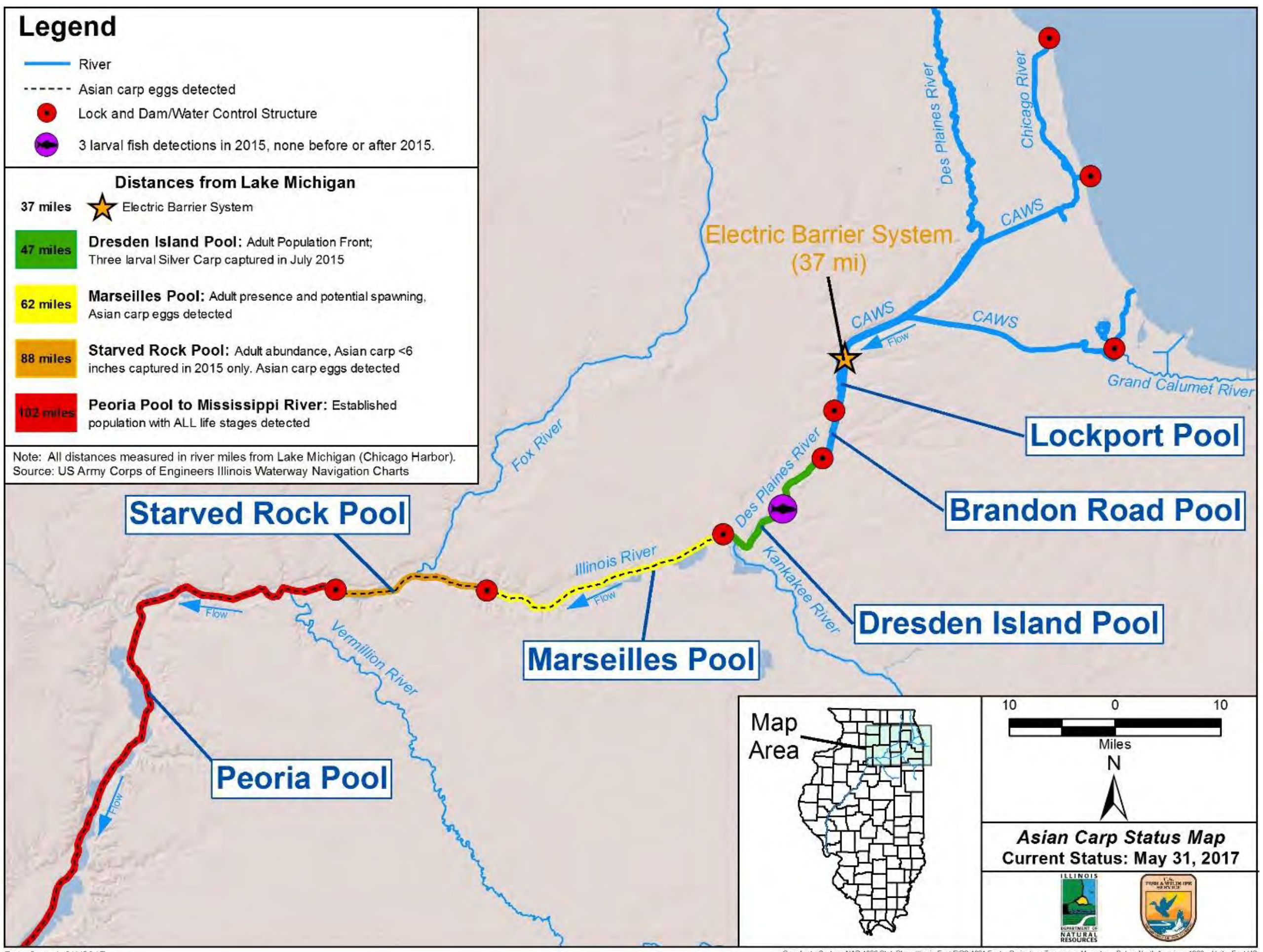
No Asian carp have been detected in Lake Michigan, and no Asian carp have been collected between Brandon Road Lock and Dam and the electric dispersal barrier since detection efforts were intensified in 2010. Acoustic-based surveys demonstrated that the relative abundance of adult Asian carp in the Dresden 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. To date, while spawning activity has been observed, 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 Pool, below the Starved Rock Lock and Dam. Larval and juvenile Asian carp are present in the Lower IWW, which acts as the source of Asian carp throughout the IWW. The MRWG believes that small Asian carp (< 6 inches) and those larger Asian carp found above the Starved Rock Lock and Dam have immigrated to the Upper IWW from the Lower IWW. Because Asian carp are produced only in the Lower Illinois River, the strategy of removal above Starved Rock Lock and Dam has increased efficacy for control. The MRP describes the suite of tools needed to successfully achieve its objectives. One of the tools demonstrating success within our Barrier Defense strategy is the Chinese Unified fishing method. This method of fishing has identified additional efficiencies to improve prescribed removal activities generally using existing harvest tools and techniques in more coordinated ways. To date this method has successfully removed nearly 100 tons of Asian carp and has only been used in Marseilles Pool, but will be applied more broadly in the Upper IWW during 2017. Understanding how other technical solutions (e.g. underwater speakers, electricity) increase capture rates will be further investigated in 2017 as well.

Data collected since 2011 have heightened 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) MRWG 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 May 2017, 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 (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:** 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.




Specific highlights from the 2016 field season include:

- No Asian carp collected or observed in Lake Michigan, CAWS, or Brandon Road Pool.
- No small fish detected in Upper IWW.
- 1.1 million pounds of Asian carp removed from Upper IWW.

- Demonstrated use of Chinese Unified Fishing Method, which allowed for up to an estimated 80% removal of all Asian carp from a 500 acre lake near Morris, Illinois.

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 takes into account what we know about the biology of Asian carp species. The model will serve to assist in informing management of the efforts over the short term (next 5 years) and long term (> 5 years). Initial results support the MWRG's existing management strategy that focuses localized and intense Asian carp removal efforts in the upper river. However, a long term strategy bolstered by market-driven forces that lead to much greater removal than can be accomplished in the Upper Illinois Waterway 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 efforts upstream may see some inefficiencies when downstream harvest efforts begin, it is likely 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, assuming that effective commercial markets for Asian carp can be established and sustained in the relatively near future.

Despite current activities, it is understood that 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. 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***

| 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
2 This status is based upon the collection of a single Bighead carp during piscicide treatment in 2009
3 This status is based upon sightings of 1 Bighead Carp and 1 Silver Carp by MRWG efforts in 2010-2011. No 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.

# 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 Carps in the Upper IWW pools of Starved Rock, Marseilles, and Dresden Island however, 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 May 2017 seven individual fish have been documented in the Illinois River. Commercial fishermen have reported the catch of two immature/young adult Black Carp in Spring 2017, with one fish caught in LaGrange Pool, and the second fish caught in Peoria Pool. These captures demonstrate the presence of immature/young adult Black Carp 160 miles further upstream than any previous

reports. Reproduction has been documented in the middle-Mississippi river, but little is known about its success or the general distribution of the species. Illinois DNR 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. Black Carp are considered rare in the Illinois River, but increasing catches in the Mississippi River suggests 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 2017 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 2017 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, Chicago Area Waterways, 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, Chicago Area Waterways, or further threaten the Great Lakes.
3. Continue to evaluate and review the Contingency Plan to assure efficacy and appropriate response. In 2017, 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 Plan and the 2018 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 2017.
5. Establish 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 (2018 and beyond).
7. Assess/review technology development (tools) for field deployment in 2018 as a pilot (e.g. algal attractants, complex noise, and carbon dioxide). 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 reviewed for possible implementation in the 2019 MRP. Discipline-specific workgroups, agencies, and researchers will recommend findings to MRWG co-chairs. Co-chairs will work with ACRCC representatives for concurrence and further review of potential tools.
8. Encourage business development to increase harvest of Asian carp in the Lower IWW from approximately 4 million pounds in 2016 to 8 million pounds by 2019. Business evaluation to be completed in 2017 should help inform development inquiries and responses in 2018.
9. To remain diligent with outreach and law enforcement activities to discourage other pathways of movement and introduction of Asian Carp.

## MRWG Work Groups

Discipline-specific work groups will be formed to assist in developing the most informed Monitoring and Response Plans in the future. Work groups may also be useful to focus expertise for further evaluation, assist in decision making, or otherwise provide MRWG Co-chairs, agencies, and ACRCC with insights as technical experts on a range of subjects. Expected work groups for 2017 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.

| 2017 Work Group | Lead/Agency |
|---|---|
| Contingency Planning | Matt Shanks/USACE |
| Removal | Matt O'Hara/ILDNR |
| Hydroacoustic Assessments | Dave Coulter/SIU |
| Telemetry | Mary Beth Brey/USGS |
| Modeling | David Glover/USFWS |
| Behavioral Deterrent Technologies | Aaron Cupp/USGS |

### *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 2016 funding levels. It is crucial that the necessary funds are available to continue aggressive removal efforts to reduce the risk of range expansion, as well as to continue focused surveillance to ensure that management agencies have an accurate understanding of changes to Asian carp range, population dynamics, and behavior.

**Detection**

- Ensure sufficient surveillance effort is deployed throughout Upper 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 Illinois Waterway below Brandon Road Lock and Dam.
  - Evaluate new methods for characterizing Asian carp populations based on improving technology, and implement where appropriate.

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

**Response**

- Ensure that response readiness is maintained and responsive to detected changes as noted in Contingency 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 USACE and MRWG members.

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

**Detection**

- Implement an effective, efficient, and sustainable 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.

# 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).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Introduction and Need:** Detections of Asian carp eDNA upstream of the Electric Dispersal Barrier in 2009 initiated the development of a monitoring plan using boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the barrier. In addition, random area sampling began in 2012 in order to increase the chance of encountering Asian carp in the CAWS beyond the designated fixed sites. Based on the extensive sampling performed upstream of the Electric Dispersal Barrier from 2010 through 2013 (682 hours of electrofishing, 445.8 km [277 mi] of gill/trammel net, 2.2 km [1.4 mi] of commercial seine hauls) and only one Bighead Carp being collected in Lake Calumet in 2010, fixed site and random area sampling effort was reduced upstream of the barrier to two Seasonal Intensive Monitoring (SIM) events from 2014 – 2016. The reduction of effort upstream of the Electric Dispersal Barrier will allow for increased monitoring efforts downstream of the barrier. The increase in sampling downstream of the Electric Dispersal Barrier will focus sampling efforts on the leading edge of the Asian carp population, which will serve to reduce their numbers in this area thus mitigating the risk of individuals moving upstream towards the Electric Dispersal Barrier and Lake Michigan by way of the CAWS. Results from SIM upstream of the Electric Dispersal Barrier will contribute to our understanding of Asian carp abundances in the CAWS and guide conventional gear or rotenone rapid response actions designed to remove Asian carp from areas where they have been captured or observed.

**Objectives:**

1) Remove Asian carp from the CAWS upstream of the Electric Dispersal Barrier when warranted.
2) Determine Asian carp population abundance through intense targeted sampling efforts at locations deemed likely to hold fish.

**Status:** Seasonal intensive monitoring is a modified continuation of Fixed and Random Site Monitoring Upstream of the Electric Dispersal Barrier and Planned Intensive Surveillance in the CAWS.

**Seasonal Intensive Monitoring in the CAWS**
**2017 Plan**

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

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

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

**Fixed and Random Area Sites Upstream of the Electric Dispersal Barrier -** *(weeks of June 12th and September 18th)*
The sampling design includes intensive electrofishing and netting at five fixed sites and four random site sampling areas (Figure 1). Random area sampling will exclude areas of the

waterway designated as fixed sites. Random sites will be generated with GIS software from shape files of designated random site areas and will be labeled with Lat-Lon coordinates in decimal degrees.

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

> 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).

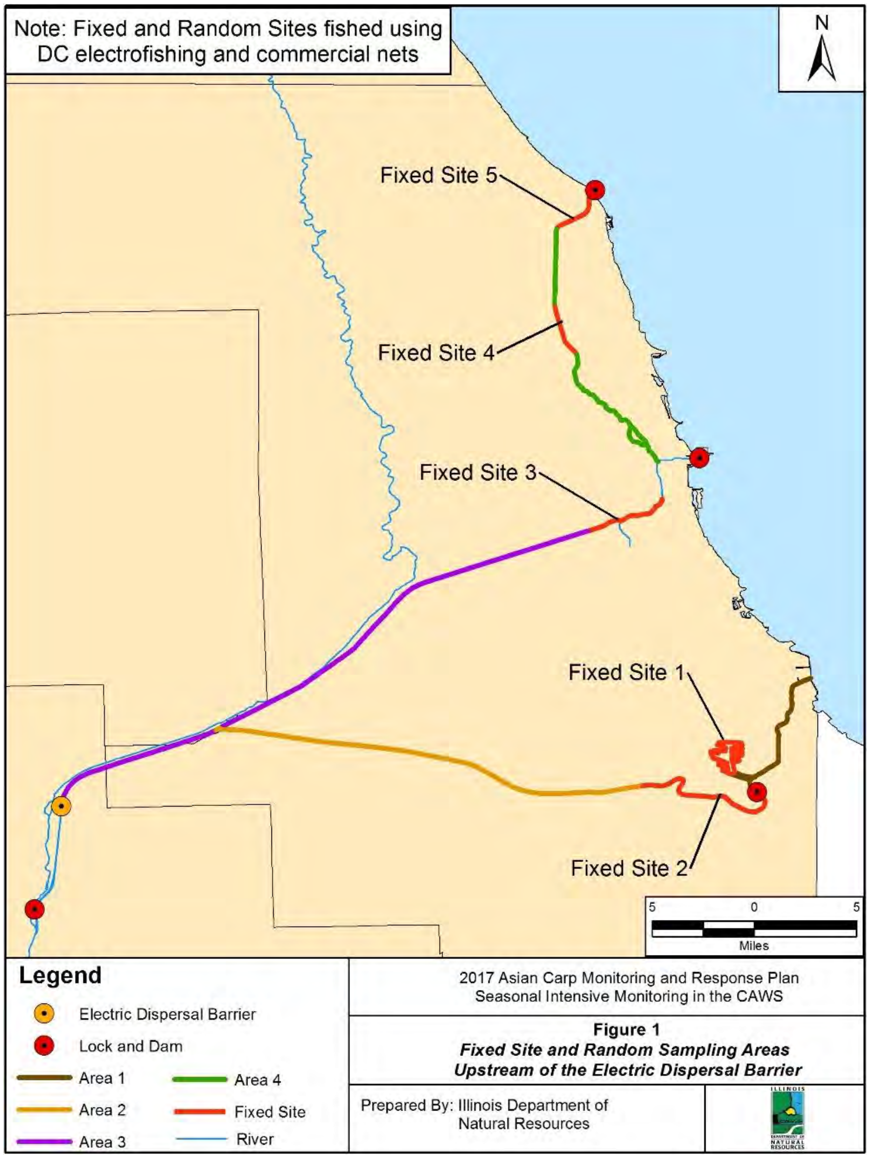



**Figure 1.** *Fixed site and random site sampling areas for electrofishing and commercial netting upstream of the Electric Dispersal Barrier.*

*Upstream Random Site Sampling Area Descriptions and Effort* - A description of random sampling areas and sampling effort targets is summarized below. As with fixed sites, the duration of each electrofishing run will be 15 minutes and length of each net set will be 182.9 m (600 ft). Four random areas have been identified to facilitate coordination with fixed site sampling (Figure 1).

Area 1 – Lake Calumet Connecting Channel and Calumet River

Area 2 – Cal-Sag Channel from its confluence with the CSSC to the Little Calumet River

Area 3 – CSSC from Western Avenue downstream to the Electric Dispersal Barrier

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

**Lake Calumet, Calumet River and Random Area Sites Upstream of the Electric Dispersal Barrier -** *(week of June 19th)*
*Lake Calumet* - Prior to sampling, crews will set Great Lake pound nets at the entrance to Lake Calumet to prevent fish immigration/emigration (Figure 2). This will, however, be contingent on water conditions as flows in and out of Lake Calumet prevented pound nets from being set in 2014. Commercial seining will occur in the North section for two days, then in the South section for one day (Figure 2).

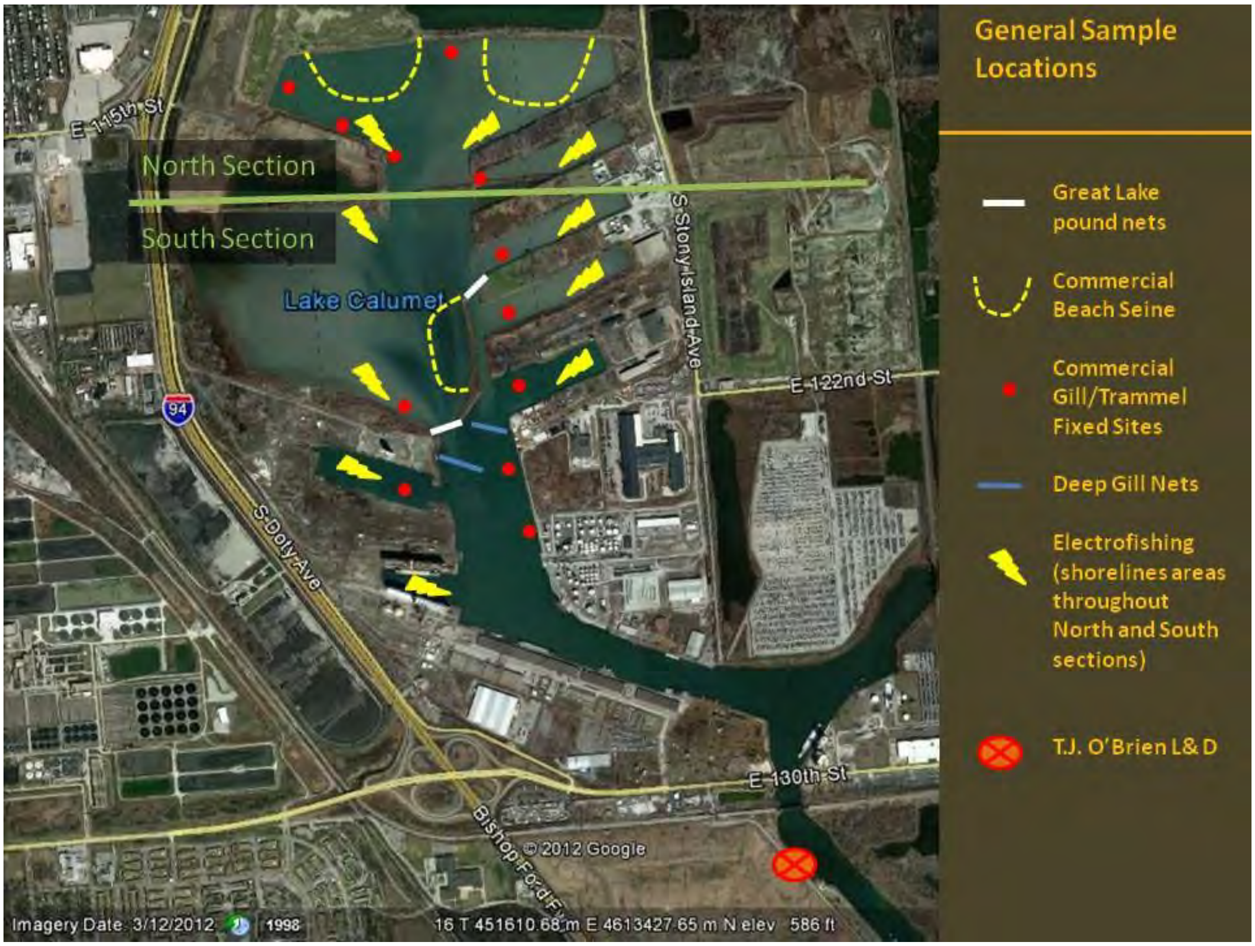


**Figure 2.** *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

Commercial gill/trammel nets and deep water gill nets will be fished in Lake Calumet, Calumet Connecting Channel and Calumet River. Gill and trammel nets will be set for short duration and will have fish driven into the nets with noise as described above. Deep water gill nets may be set for longer duration. They will be well marked with buoys when left unattended, with IDNR law enforcement officers securing the area. Agency electrofishing crews will operate throughout the monitoring event. Samples will be collected 15 minutes at a time, enumerating catches of fish netted. Electrofishing may also be used in conjunction with commercial fishers to move fish into nets.

In conjunction with sampling efforts in Lake Calumet and the Calumet River, electrofishing and gill/trammel netting will also take place at four random site sampling areas throughout the CAWS upstream of the Electric Dispersal Barrier as mentioned above (Figure 1).

**North Shore Channel, Chicago River and Random Area Sites Upstream of the Electric Dispersal Barrier -** *(week of September 25th)*

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

*Chicago River and South Branch Chicago River/Bubbly Creek* - Electrofishing will occur around the entire shoreline of the basin between Lake Shore Drive and Chicago Lock and near Wolf Point (confluence of the North Branch Chicago River and Chicago River) (Figure 3). During this time net boats will set deep water gill nets (IDNR will provide one 9.1 m (30 ft) deep gill net for each net boat) in areas off of the main navigation channel. Nets will be set for short duration and attended at all times. Noise from "pounding" on the hull of boats and revving trimmed up motors will be used to drive fish into the nets. Electrofishing boats will also be used to drive fish into the nets. When sampling in these areas is complete crews will travel down river and sample eight barge slips and backwater areas in the South Branch Chicago River near Bubbly Creek (Figure 3). Barge slip sampling will have a block net set at the entrance of each slip. Electrofishing boats will then shock from the back of the slip out towards the main channel, driving fish into the block net while collecting stunned fish along the way. A second net may be set midway within longer slips to sample them more effectively.


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

In conjunction with sampling efforts in the North Shore Channel and Chicago River, electrofishing and gill/trammel netting will take place at four random site sampling areas throughout the CAWS upstream of the Electric Dispersal Barrier as mentioned above (Figure 1). For all SIM activities accurate sampling time will be recorded with all fish identified to species. GPS coordinates (decimal degrees) will be taken at the location of all net sets and at the beginning of electrofishing runs. Grass Carp will be kept and put on ice for transfer to Dr. Greg

Whitledge (SIU) for ploidy analysis. Any Bighead Carp or Silver Carp collected will immediately be reported to the Operations Coordinator and/or Law Enforcement who will bring a cooler to secure fish. GPS location, time, and specific gear will be recorded as accurately as possible (mesh size, type, depth). Any Asian carp will be transferred to Dr. John Epifanio, with tissues shared among research agencies as per the 2017 MRP. Furthermore, capture of a Bighead Carp or Silver Carp would initiate a level two rapid response upon conferring with MRWG members, additional effort or time frame could change.

**2017 Sampling Schedule:**
*Spring Event*
Week of June 12th
Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of June 19th
Lake Calumet, Calumet River and random area sites upstream of the Electric Dispersal Barrier

*Fall Event*

Week of September 18th
Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of September 25th
North Shore Channel, Chicago River and random area sites upstream of the Electric Dispersal Barrier

**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 plans updated for annual revisions of the MRP.

# Strategy for eDNA Sampling in the CAWS and Refining eDNA Interpretation Below the Electric Dispersal Barrier

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

**Location:** CAWS and Dresden Island Pool

| ADDITIONAL INFORMATION |
| --- |
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**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 monitor for genetic presence of Bighead Carp and Silver Carp in the Chicago Area Waterway System (CAWS) since 2009. To maintain vigilence above the electric dispersal barrier, eDNA has been collected annually at four regular monitoring sites. In 2014, many of the projects, including use of eDNA moved work to below the electric dispersal barrier to better describe the active invasive front. eDNA results were no longer consdidered a trigger for any kind of response beginning in 2013.

**Objectives:**

1) Sample Asian carp DNA in historica locations in the CAWS to maintain vigilence in areas above the electric dispersal barrier, an area believed to be free of live Bighead Carp and Silver Carp.
2) Improve the interpretation of eDNA results along an active invasion front by collecting eDNA samples in Dresden Island Pool of the Illinois Waterway below the electric dispersal barrier. Dresden Island has an Asian carp gradient with few fish collected at the upper part of the pool and heavy harvest rates in the lower part of the pool, eDNA samples may reflect this carp gradient within a single pool.

**Status:** **S**ampling for eDNA in the CAWS above the electric dispersal barrier has been conducted since 2009. In 2013, equipment decontamination and separation protocols were implemented and in 2014, improved DNA markers were also implemented. Together, these improvements have made for more sensitive and specific eDNA results. For example, in 2015, there were zero positive eDNA samples in the CAWS. Since 2014, 960 eDNA samples have been collected (including blanks for quality assurance). Of these, 31 have been positive for Silver Carp DNA and 2 have been positive for Bighead Carp DNA. These low detection rates reflect no Bighead Carp or Silver Carp have been captured alive in the CAWS since 2010 when a single Bighead Carp was removed. As of 2013, all response to eDNA results were terminated, and there will not be any reaction to eDNA results this year as well.

eDNA sampling below the electric dispersal barrier began in 2014 simultaneous with movement of other surveillance and fishing efforts below the electric dispersal barrier. During 2014 and

2015, eDNA samples were collected along a gradient of Asian carp densities across several pools to see if the eDNA results reflected the 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 in pools with low or zero carp density; Lockport, Brandon Road, and the upper portion of Dresden Island and part of the Kankakee River above the Wilmington Dam. Only a single eDNA sample was positive in Brandon Road Pool, which was in agreement with other fish detection efforts that indicated there were no changes in Asian carp populations in Lockport and Brandon Road Pools. The lack of detections in Dresden Island pool are likely due to the fact that samples were only collected in the upper portion of the pool, where there are very few fish collected, and water flow is dominated by water coming from the pool above, which is devoid of carp and their eDNA.

**Methods:**
In 2017, to maintain the historical record, the CAWS will be sampled for Bighead Carp and Silver Carp eDNA at four traditional sites: Chicago River, North Shore Channel, Little Calumet River, and Lake Calumet. One comprehensive eDNA sampling event will take place prior to the Seasonal Intensive Monitoring event in June as a way of comparing observed eDNA and observed fishing results over a relatively short time frame.

Dresden Island Pool will be sampled twice in 2017 because there is a carp gradient within the pool. In 2014 and 2015, eDNA samples were collected along evenly spaced transects running bank-to-bank, across the thalweg to determine if DNA could be detected equally across the channel. In pools with higher carp densities, eDNA was detected relatively evenly across the transects, however, in pools with low or no carp densities, our results have shown that eDNA is unlikely to be detected in the thalweg (2014-2016 results). Other USFWS eDNA efforts utilize a targeted sampling approach, collecting water where eDNA may be retained in the system, such as eddies or back water slack areas. Due to the relatively channelized configuration of the Illinois system, there are not many of these types of collection sites, but shoreline may harbor eDNA for longer time periods, thus samples will be collected along the shore. This may lead to eDNA results that are more in line with known fish occupancy in this pool, with few or no detections in the upper half and more detections in the lower half of the pool. If this is this case, these results can guide eDNA sampling designs in other highly channelized systems, such as the mainstem Ohio River. Alternatively, even the shoreline may be subjected to high, streamlined flows and eDNA released from a few fish in the upper portion of the pool may be transported downstream before it can be detected with current eDNA methods. The upper portion of the pool may also lack a strong eDNA signal since the water there has entered from the pools above that contain few or no Asian carp, thus there may not be any signal in the upper half of the pool, even if there are some fish captured there via other monitoring efforts.

# Strategy for eDNA Sampling in the CAWS and Refining eDNA Interpretation Below the Electric Dispersal Barrier
# 2017 Plan

Similar to previous years, sample collection and processing methods will follow the Quality Assurance Project Plan (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 (http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf) after sample processing is complete. Results (CAWS) will then be posted online. Results from Dresden Island Pool will be made available to the MRWG in the 2017 Interim Summary Report.

**2017 Schedule:**
eDNA monitoring in the CAWS: Week of June 5$^{th}$
eDNA sampling in Dresden Island Pool: Weeks of May 30$^{th}$ and September 11$^{th}$

**Deliverables:**
Results of the CAWS sampling event will be reported as positive/negative for sampling summaries. Data will be summarized for an annual interim report and project plans will be updated for annual revisions to the MRP. Results from the events below the electric dispersal barrier will be reported as positive/negative and will be summarized for the annual interim report, but will not be posted online.

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

# Larval Fish Monitoring in the Illinois Waterway

Steven E. Butler, Scott F. Collins, David H. Wahl (Illinois Natural History Survey), Daniel R. Roth, Robert E. Colombo (Eastern Illinois University)

EASTERN ILLINOIS UNIVERSITY

**Participating Agencies:** INHS (lead), Eastern Illinois University (field and lab support)

**ADDITIONAL INFORMATION**

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Location:** Larval fish sampling will take place at 10 sites in the Illinois and Des Plaines River downstream of the electric dispersal barrier (LaGrange, Peoria, Starved Rock, Marseilles, Dresden Island, and Brandon Road Pools), and at two sites in the CAWS upstream 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.

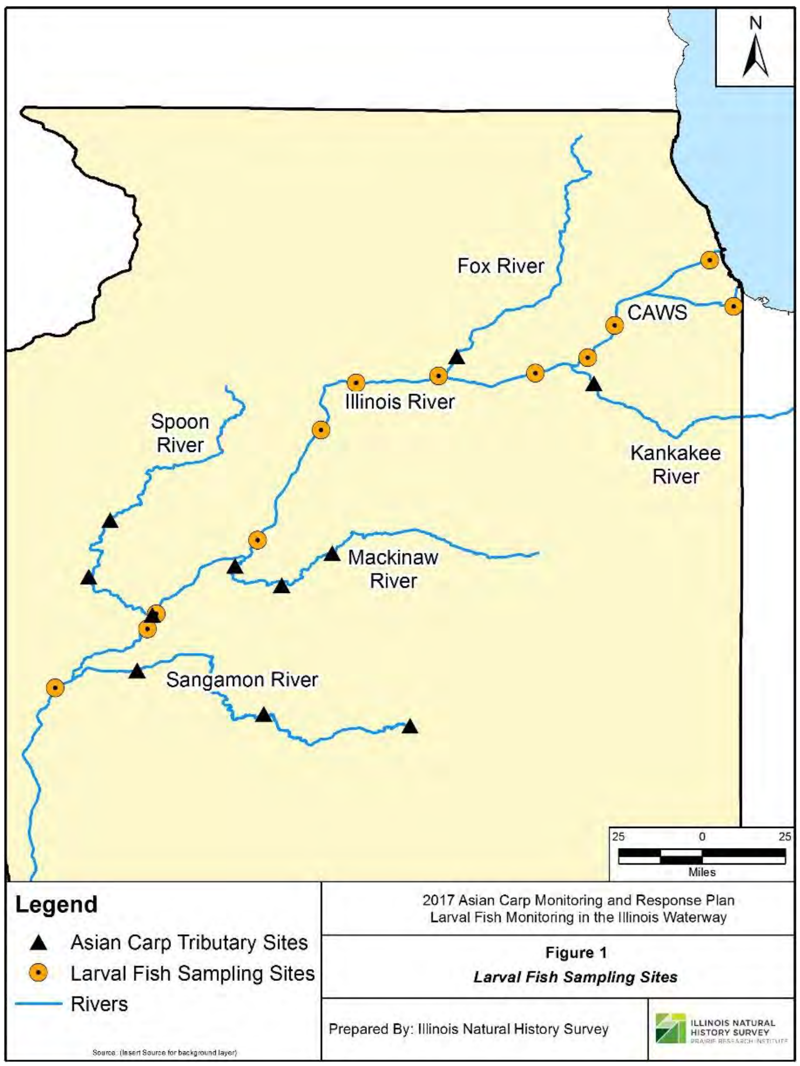



**Figure 1.** *Map of larval fish sampling sites in the Illinois Waterway (circles) and in tributary rivers (triangles).*

# Larval Fish Monitoring in the Illinois Waterway

**Introduction and Need:** Factors affecting the early life stages of fish strongly influence recruitment to adult populations. An evaluation of Asian carp reproduction and recruitment in different sections of the Illinois Waterway is needed to better understand Asian carp population dynamics and the spatial distribution of various life stages within this system. Asian carp eggs are semibuoyant and drift in river currents for approximately a day before hatching. Larvae settle in backwaters, creeks, and flooded areas outside of the main channel, which serve as nursery areas. Prior to 2015, larval and juvenile Asian carp had only been collected in the Alton, La Grange and Peoria Pools of the Illinois River, and the potential for Asian carp reproduction in upstream reaches of the Illinois Waterway was unknown. Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2016 indicate that some reproduction and potential recruitment 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. Reproduction and recruitment are known to be highly variable among years in the Illinois Waterway, but factors influencing this variation are still poorly understood. Asian carp spawning also appears to occur in smaller tributary rivers, but the frequency of spawning in these systems, or the contribution of these rivers to basin-wide Asian carp populations is not known. Information on the spatial and temporal distribution of Asian carp eggs and larvae will help to identify adult spawning areas, determine reproductive cues, and characterize relationships between environmental variables and survival of young Asian carp. This understanding will aid in evaluating the potential for these species to further expand their range in the Illinois Waterway, and may also be useful for designing future control strategies that target Asian carp spawning and exploit the early life history of these species.

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

1) Identify locations and timing of Asian carp reproduction in the Illinois Waterway;
2) Monitor for Asian carp reproduction in the CAWS; and
3) Determine relationships between environmental variables (e.g., temperature, discharge, habitat type) and Asian carp reproduction and recruitment.

**Status:** Low numbers of Asian carp larvae were collected from main channel and backwater sites of the Illinois Waterway during 2010 – 2013, but large spawning events in 2014 and 2015 resulted in the collection of high numbers of Asian carp eggs and larvae. The number of eggs and larvae collected in 2016 was lower than in 2014 – 2015, but still considerably higher than in 2010 – 2013. In several years, Asian carp appear to have had multiple spawning events within a single year, as indicated by the timing and location of eggs and larvae. The highest densities of Asian carp eggs and larvae have typically been observed when water temperatures were above 20°C and river discharge was steadily increasing, although some eggs and larvae have also been collected when water levels were falling. Prior to 2015, Asian carp larvae had only been collected at sites in the La Grange and Peoria Pools. However, during 2015 and 2016 sampling, numerous Asian carp eggs were collected in the Starved Rock and Marseilles Pools, and three Asian carp larvae were identified in a sample collected on June 2015 from the Dresden Island

Pool. During 2016, Asian carp eggs were also collected in the Sangamon, Spool, Mackinaw, and Fox Rivers, and Asian carp larvae were collected in the lower Spoon River, indicating that some Asian carp spawning does occur in these smaller tributaries, at least during some years.

**Methods:** At all Illinois Waterway sampling sites, larval fish samples will be collected using a 0.5 m-diameter ichthyoplankton push net with 500 µm mesh. To obtain each sample, the net will be pushed upstream using an aluminum frame mounted to the front of the boat. Boat speed will be adjusted to obtain 1.0 – 1.5 m/s water velocity through the net. Flow will be measured using a flow meter mounted in the center of the net mouth and will be used to calculate the volume of water sampled. Fish eggs and larvae will be collected in a meshed tube at the tail end of the net, transferred to sample jars, and preserved in 90% ethanol. Four larval fish samples will be collected at each mainstem and backwater 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 backwater sites, both backwater and main channel samples will be collected. At tributary sites (Sangamon, Spoon, Mackinaw, Fox, and Kankakee Rivers), three samples will be collected at each site on each sampling date, one near each bank and another in the center of the channel. Boat-mounted push nets will be used at boatable locations, whereas passive drift nets (0.45 x 0.25 m, 500 µm mesh) will be used at sites where boat access is restricted. Push net sampling will be conducted as for main channel sites, whereas passive drift nets will be deployed for 30 – 180 minute durations, depending on stream flow. Additional gear configurations may be tested to improve sampling success during periods of low discharge in tributaries. 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.

**Sampling Schedule:** In 2017 and subsequent years, larval fish sampling will occur at approximately biweekly intervals at all sites from April to October. Sampling will occur more frequently during periods when Asian carp eggs and larvae are likely to be present (e.g., during May – June, during periods of rising water levels, or shortly after peak flows).

**Deliverables:** Results of each sampling event will be reported within monthly sampling summaries. Observations of large-diameter eggs or any identification of Asian carp larvae upstream of the Starved Rock Lock and Dam will be immediately reported to MRWG members. Data will be summarized and project plans updated for annual revisions of the MRP.

# Distribution and Movement of Small Asian Carp in the Illinois Waterway

Kjetil Henderson, Emily Pherigo, Jeff Stewart, and Rebecca Neeley
U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL

**Participating Agencies**:
U.S. Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office, Columbia, MO

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**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 2016, USFWS personnel surveyed for small Asian carp within the Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools. Four small (85 - 110 mm TL) Silver Carp were captured in Depue Lake of Peoria Pool during 2016. As of February 2017, the farthest upstream juvenile Asian carp (≤300 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 and Need:**
Populations of Bighead and Silver Carp have become established in the middle IWW. Natural resource professionals remain concerned about the potential invasion of these species into the Great Lakes via the upper IWW. These fish may pose a significant threat to established Great Lakes fisheries by competing with economically and recreationally important species for limited plankton resources. Kolar et al. (2007) noted the Chicago Sanitary and Shipping Canal (CSSC) as the most probable pathway for Asian carp entry into the Great Lakes. Therefore, the CSSC is critical to stopping Asian carp from expanding their range into Lake Michigan and the Great Lakes.

An Electric Dispersal Barrier System (EDBS) operated by the U.S. Army Corps of Engineers (USACE) in Lockport Pool is intended to block the upstream passage of Asian carp through the CSSC. Laboratory tests have shown the operational parameters used at the EDBS are sufficient for stopping large-bodied fish from passing through. However, testing of operational parameters using small Bighead Carp (51 - 76 mm TL) revealed these parameters may be inadequate for blocking small fish passage. U.S. Fish and Wildlife Service (USFWS) research showed that Golden Shiner can be entrained in barge junction gaps upstream through the EDBS. Recent evidence has also highlighted passive entrainment of small fishes by barge traffic as a vulnerability of the EDBS. If Asian carp are present near the EDBS, these species may be capable of breaching the EDBS. As such, it is critical to determine the small Asian carp (≤ 153 mm) distribution and demographic characteristics below the EDBS. Additionally, understanding the reproduction of these species in the IWW is helpful to better target small fish for eradication or other future management actions.

The purpose of this study is to establish the spatial distribution of small Asian carp in the IWW through intensive, directed sampling. These efforts also serve to detect and remove the leading edge of IWW juvenile Asian carp source populations. This project involves traditional and novel gears developed for potentially improving small Asian carp capture efficiency in specific habitats. Irons et al. (2011) evaluated daytime electrofishing and mini-fyke nets to be effective for collecting small Asian carp. These gears, in addition to several rigid-frame trawls and otter trawls, were used to determine the distribution and abundance of small Asian carp in 2016.

**Objectives:**

1) Determine the distribution, abundance, and age structure of small Asian carp in the middle and upper IWW.
2) Use distribution and abundance information to characterize the risk of small Asian carp entry into the Great Lakes via the Chicago Area Waterway System.

**Status:**
This is a continued MRP project for 2017. Sampling conducted in 2016 using boat electrofishing, dozer trawl, paupier trawl, and mini-fyke nets caught four Silver Carp (85 - 110 mm TL) in Peoria Pool of the IWW. No small Asian carp were captured above Peoria Pool during the 2016 field season.

**Methods**:
IWW sampling for Asian carp (≤ 153 mm) will proceed from April through October 2017. Sampling effort will be distributed between Peoria, Starved Rock, Marseilles, and Dresden Island, Brandon Road, and Lockport pools. Beginning in Peoria Pool, sampling will proceed upstream after the capture of small Asian carp. In addition to Peoria Pool, sampling should include Sheehan Island (SR), Gobblers Knob (SR), Heritage Harbor Marina (SR), and Moody Bayou (MA) based on the historic captures of small Asian carp at these locations.

Sampling sites will be identified as backwaters, isolated pools, main channel border, side channels, side channel borders, marinas, or tributary mouths. Physical, water quality, and habitat measurements will be recorded at the time of each sampling event. Physical measurements include: water depth and Secchi depth. Water quality measurements include: temperature, salinity, specific conductance, dissolved oxygen, and pH (taken with YSI Professional Series multi-meter). Global Positioning System (GPS) coordinates will be recorded for all net sets, beginning and end of electrofishing runs, and trawl hauls.

Up to 10 Bighead Carp, Silver Carp, Grass Carp, and Gizzard Shad will be measured and weighed per sampling event. All Bighead Carp, Silver Carp, and Grass Carp will be harvested after capture, and all Asian carp (≤300 mm) will be labeled and frozen for future analysis. Fish not easily identified in the field will be fixed in ethanol (DNA analysis) or Excel Plus for laboratory identification to the lowest possible taxonomic level. All other fish will be counted and released. Uncommon fish species will be photographed to inform Illinois Natural History Survey fish distribution data, and disseminated to relevant stakeholders. Sampling effort will be quantified as minutes sampled (boat electrofishing, paupier and dozer trawls), or net nights for mini-fyke nets.

Electrofishing – Electrofishing conducted for 15 minute periods in water depths <2 m deep. Pulsed DC (60 pulses/s) will be used for all electrofishing sampling.

Fyke netting – Wisconsin type mini-fyke nets will be set 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.

Otter trawl – Standard two seam slingshot trawl capable of sampling throughout the water column. Sampling depth is based on rope length and otter board size. Trawl length will be five minutes.

Dozer trawl – Dozer trawls sample water depths between 0.5 and 2 m. A 35 mm mesh net at the opening reduces to 4 mm mesh in the cod end, attached to a 2x1 m rigid frame which is mechanically raised and lowered to fish depths of up to 1 m. The net extends approximately 2.5 m back as it is pushed off the front of the boat. Trawl length will be five minutes.

Paupier trawl – Paupier trawls sample water depths between 0.5 and 3 m. This trawl contains one 3.7x1.5 m rigid frame on both sides of a flat bottomed boat with 35 mm mesh in the body reducing to 4 mm mesh in the cod. Trawl length will be five minutes.

**2017 Schedule:**

February – March 2017
    Gear preparation, planning field logistics, and crew scheduling

March – October 2017
    Fish sampling, fish aging, fish identification, and data entry

October – December 2017
    Complete fish identification and aging, data entry, and verification

December 2017 – January 2018
    Data analyses, prepare report and presentation

**Deliverables:**

## Distribution and movement of small Asian carp in the Illinois Waterway

Any small Asian carp captured upstream of Starved Rock Pool will be reported immediately to Todd Turner (USFWS Assistant Regional Director – Fisheries) or Charlie Wooley (USFWS Deputy Regional Director – Region 3) and MRWG. An annual MRWG report and presentation will be provided during the winter of 2017 – 2018.

# Fixed Site Monitoring Downstream of the Dispersal Barrier

**Participating Agencies:** IDNR (lead); INHS, USACE, and USFWS (field support)

**Location:** Monitoring will take place in the CSSC, lower Des Plaines River, and upper Illinois River. Specifically, we will sample the Lockport Pool downstream of the Dispersal Barrier and the Brandon Road, Dresden Island, and Marseilles pools.

| ADDITIONAL INFORMATION |
| --- |
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**Introduction and Need:** Standardized sampling can provide useful information to managers tracking population growth and range expansion of aquatic invasive species. Information gained from regular monitoring (for example, presence, distribution, and population abundance of target species) is essential to understanding the threat of possible invasion upstream of the Electric Dispersal Barrier. For this project, we use pulsed-DC electrofishing, hoop and mini-fyke netting, and contracted commercial fishers to sample for Asian carp in the four pools below the Electric Dispersal Barrier. A goal of this monitoring effort is to identify the location of the detectable population front of advancing Asian carp in the Illinois Waterway and track changes in distribution and relative abundance of leading populations over time. The detectable population front is defined as the farthest upstream location where multiple Bighead 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. Monitoring data from 2010 to 2016 have contributed to our understanding of Asian carp abundance and distribution downstream of the Electric Dispersal Barrier and the potential threat of upstream movement toward the CAWS. Based on data collections from 2010 to 2016, sampling efforts upstream of the Electric Dispersal Barrier will continue with the two seasonal intensive monitoring (SIM) events in June and September to allow an increase in sampling efforts downstream of the Electric Dispersal Barrier. This plan of effort will allow the opportunity to better assess Asian carp abundances and distributions downstream of the Electric Dispersal Barrier.

**Objectives:** Standardized sampling will consist of DC electrofishing, hoop and mini-fyke netting, and contracted commercial netting to:

1) Monitor for the presence of Asian carp in the four pools below the Electric Dispersal Barrier;
2) Determine relative abundance of Asian carp in locations and habitats where they are likely to congregate;
3) Supplement Asian carp distribution data obtained through other projects (such as the Asian Carp Barrier Defense Project); and

4) Obtain information on the non-target fish community to help verify sampling success, guide modifications to sample locations, and assist with detection probability modeling and gear evaluation studies

**Status:** This project began in 2010 and is ongoing. Samples have been collected at four fixed sites in each of the four pools once monthly from April through November 2010 and from March through November 2011, 2012, and 2013, and twice monthly in 2014 and 2015 with pulsed-DC electrofishing gear. In 2016 sampling occurred twice monthly from April to November. Samples were also collected from July through September 2010, April through November 2011, March through November 2012, March through December 2013, April through December 2014, and March through December 2015 and 2016 with trammel and gill nets. In total, 17,501 estimated person-hours of labor were expended to complete 700.5 hours of electrofishing, deploy 1,092.7 kilometers of trammel/gill net from 2010 to 2016, and 588 hoop nets and 552 min-fykes from 2012 to 2016. No Bighead or Silver Carp have been captured by electrofishing or netting in Lockport and Brandon Road pools, although one adult Bighead Carp was observed in Brandon Road Pool by a net crew in October 2011. Monitoring indicated higher abundance of Bighead and Silver Carp in Marseilles pool than Dresden Island pool. For more detailed results, see the 2016 Interim Summary Report document.

**Methods:** The 2017 sample design includes intensive electrofishing and hoop/mini-fyke netting in each of the four pools below the Electric Dispersal Barrier (Figure 1). Similar to the previous year, commercial netting efforts will be focused in Lockport, Brandon Road, and Dresden Island pools. Fixed and random site electrofishing will take place bi-weekly from April through November. Contracted commercial netting will take place bi-weekly from March through December, except during June and September seasonal intensive monitoring events when contracted fishers will be sampling upstream of the Electric Dispersal Barrier in the CAWS. Hoop and mini-fyke netting will take place monthly from April to December. No sampling at fixed sites is planned for January or February because several of the sites are typically covered by ice during these months.

The fixed sites in each of the four pools are located primarily in the upper ends below lock and dam structures and in habitats where Asian carp are likely to be located (backwaters and side-channels). Targeted electrofishing and contracted commercial fishing sites could occur anywhere within their respected pool, including the lower portion of each pool. The Kankakee River, from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River, are included in the Dresden Island pool random electrofishing sites.

*Fixed Sites Downstream of the Dispersal Barrier Description and Effort*: A description of fixed site locations and sampling effort targets is summarized below. There are four 15-minute electrofishing runs, eight hoop net nights with 6-foot diameter hoop nets, and four mini-fyke net nights planned for each of the four pools. Additionally, there are four fixed contractual netting sites in Lockport, Brandon Road, and Dresden Island pools.

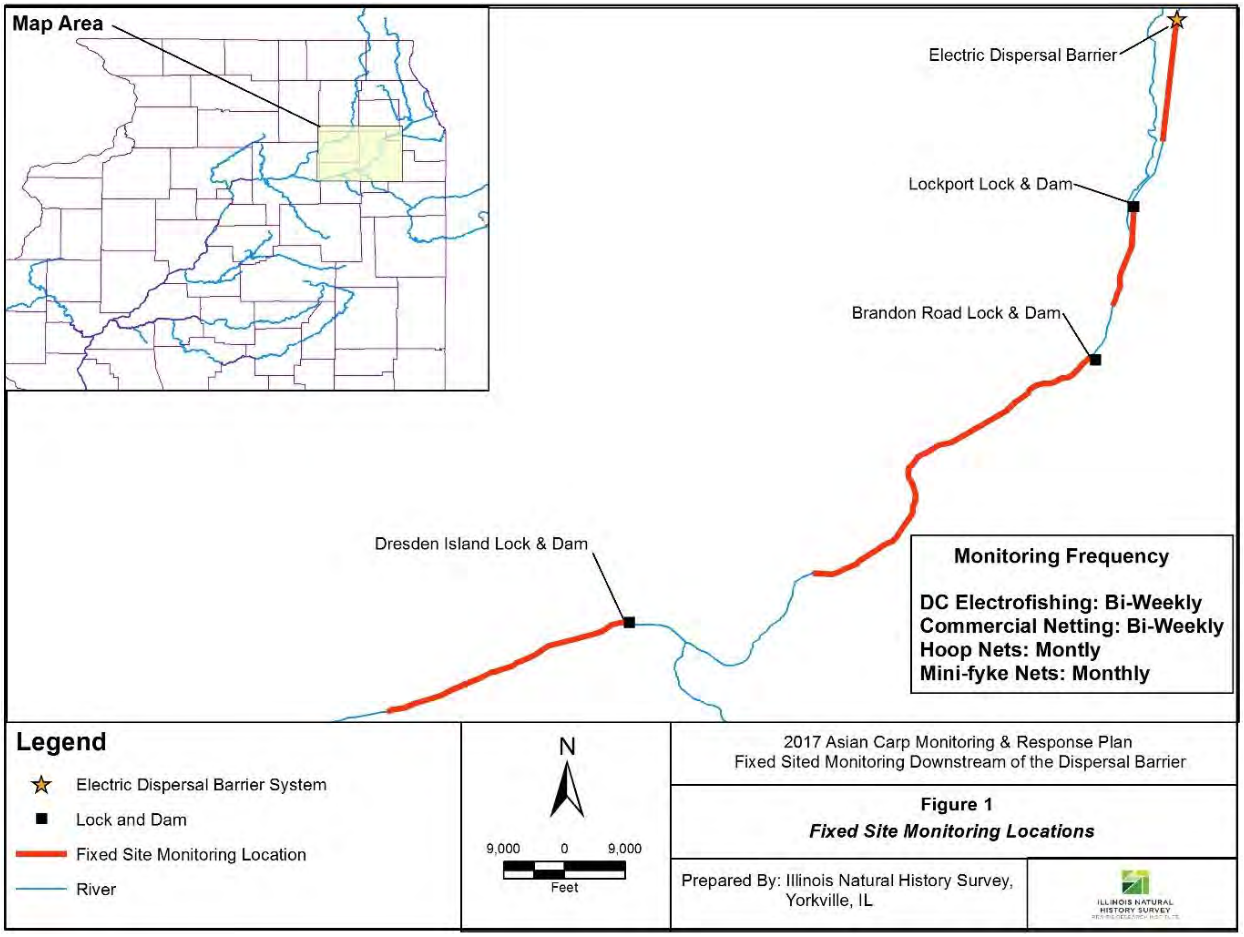



**Figure 1.** *Map of fixed sites for electrofishing and commercial net sampling for Asian carp downstream of the Electric Dispersal Barrier.*

Lockport Pool (1):

- (1) Fixed Electrofishing Site 1 starts at the Romeo Road Bridge on the east side of the canal and goes downstream.
- (1) Fixed Electrofishing Site 2 starts at the north end of the large haul slip of Hanson Material Services on the west side of the canal and goes downstream.
- (1) Fixed Electrofishing Site 3 starts at the upstream end of the MWRD Controlling Works and goes downstream.
- (1) Fixed Electrofishing Site 4 starts at the Rt. 7 Bridge on the west shore and goes downstream.
- (1) Fixed Commercial Fishing Site 1 is in the large haul slip of Hanson Material Services.
- (1) Fixed Commercial Fishing Site 2 is upstream of the Rt. 7 Bridge on the west side of the canal.
- (1) Fixed Commercial Fishing Site 3 is just downstream of the Rt. 7 bridge on the west side of the canal.

- (1) Fixed Commercial Fishing Site 4 is just downstream of Cargill Grain Elevator on the west side of the canal.
- (1) Hoop and Mini-Fyke Site 1 is in the large haul slip of Hanson Material Services.
- (1) Hoop and Mini-Fyke Site 2 is upstream of Rt. 7 Bridge on the west side of the canal.
- (1) Hoop and Mini-Fyke Site 3 is just downstream of the Rt. 7 Bridge on the west side of the canal.
- (1) Hoop and Mini-Fyke Site 4 is just downstream of Cargill Grain Elevator on the west side of the canal.

Brandon Road Pool (2):

- (2) Fixed Electrofishing Site 1 is in the bay below the Lockport Hydropower Plant.
- (2) Fixed Electrofishing Site 2 starts just above the confluence of the CSSC and Des Plaines River and goes downstream.
- (2) Fixed Electrofishing Site 3 starts just above the confluence of the Des Plaines River and the Illinois Michigan Canal and goes up the canal.
- (2) Fixed Electrofishing Site 4 starts at the I-80 Bridge and goes downstream along the east shore.
- (2) Fixed Commercial Fishing Site 1 is just downstream of the Des Plaines River confluence.
- (2) Fixed Commercial Fishing Site 2 is at the confluence of the Illinois Michigan Canal.
- (2) Fixed Commercial Fishing Site 3 is just downstream of I-80 on the east shoreline.
- (2) Fixed Commercial Fishing Site 4 is between I-80 and the Brandon Road Lock & Dam.
- (2) Hoop and Mini-Fyke Site 1 is just downstream of the Des Plaines River confluence.
- (2) Hoop and Mini-Fyke Site 2 is at the confluence of the Illinois Michigan Canal.
- (2) Hoop and Mini-Fyke Site 3 is just downstream of I-80 on the east shoreline.
- (2) Hoop and Mini-Fyke Site 4 is between I-80 and the Brandon Road Lock & Dam.

Dresden Island Pool (3):

- (3) Fixed Electrofishing Site 1 is in the bay on east side of river below the Brandon Road Dam.
- (3) Fixed Electrofishing Site 2 starts at the lower end of Treats Island and goes up into the side channel.
- (3) Fixed Electrofishing Site 3 is in Mobil Oil Corporation Cove.
- (3) Fixed Electrofishing Site 4 starts at I-55 Bridge on southeast shoreline and goes downstream.
- (3) Fixed Commercial Fishing Site 1 is in the bay on the east side of the river below the Brandon Road Lock & Dam.

- (3) Fixed Commercial Fishing Site 2 is downstream of the casino on the west side of the river.
- (3) Fixed Commercial Fishing Site 3 is in the lower end of the Treats Island side channel.
- (3) Fixed Commercial Fishing Site 4 is in Mobil Oil Corporation Cove.
- (3) Hoop and Mini-Fyke Site 1 is in the bay on east side of river below the Brandon Road Lock & Dam.
- (3) Hoop and Mini-Fyke Site 2 is downstream of the casino on the west side of the river.
- (3) Hoop and Mini-Fyke Site 3 is in the lower end of the Treats Island side channel.
- (3) Hoop and Mini-Fyke Site 4 is in Mobil Oil Corporation Cove.

Marseilles Pool (4):

- (4) Fixed Electrofishing Site 1 is along the west side of Big Dresden Island.
- (4) Fixed Electrofishing Site 2 is along the east shoreline across form Big Dresden Island.
- (4) Fixed Electrofishing Site 3 is at the back end of the north portion of Peacock Slough.
- (4) Fixed Electrofishing Site 4 is in the south portion of Peacock Slough.
- (4) Hoop and Mini-Fyke Site 1 is just upstream of the mouth of Aux Sable Creek.
- (4) Hoop and Mini-Fyke Site 2 is at the mouth of the Commonwealth Edison Co. Cove.
- (4) Hoop and Mini-Fyke Site 3 is just inside the north portion of Peacock Slough.
- (4) Hoop and Mini-Fyke Site 4 is in the back of the south portion of Peacock Slough.

*Electrofishing Protocol* -All electrofishing will use DC current and include one to two netters (two netters preferred). Locations for each electrofishing transect will be identified with GPS coordinates. Electrofishing transects should begin at each coordinate and continue for 15 minutes in a downstream direction in waterway channels (including following the shoreline into off-channel areas) or in a clockwise direction in backwater sloughs. Fixed site sampling locations will remain the same throughout the year and should be sampled with each site visit. Additionally, electrofishing will take place at random sites which will be computer generated in main-channel habitats.

While electrofishing, operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat and increasing the chances of catching an Asian carp. All fish will be netted and placed in a tank where they will be identified, counted, and checked for floy tags, after which they will be returned live to the water. Periodically, a subsample of 10 fish of each species per site will be measured in total length and weighed to provide length-frequency data for gear evaluations. Schools of young-of-year gizzard shad <6 inches (152.4 mm) long will be subsampled by netting a portion of each school encountered and placing them in a holding tank along with other captured fish. Young-of-year shad will be examined closely for the presence of Asian carp and counted to provide an assessment of young Asian carp in the waterway. We will count all captured Asian carp, as well as those observed but not netted. We may observe more Asian carp than we net because of the difficulty in capturing these fish with electrofishing gear. Sample data sheets are included in Appendix F. Crew leaders should fill in as much information on the data sheets as possible for each station/transect and record the location for the start of each run either with GPS coordinates (decimal degrees preferred) or by marking on attached maps.

*Gill and Trammel Netting Protocol* – Contracted commercial fishers will be used for gill and trammel net sampling at fixed and targeted sites. Large mesh (3.0 to 4.0 inches (76.2 to 101.6 mm)) trammel or gill nets 8 to 10 feet (2 to 4-3 meters) high and in lengths of 200 yards (182.9 meters) will be used for sampling efforts. Targeted locations for each net set will be selected by the commercial fisher and the attending IDNR/INHS biologist will mark the location with a GPS coordinate. Sets will be of short duration and include driving fish into the nets with noise (plungers on the water surface, pounding on boat hulls, or racing tipped up motors). Fisherman will fish for a predetermined number of hours with no minimum yardage; each fisherman will fish in a different pool each day.

In an effort to standardize netting effort, sets will be 15 to 20 minutes long and fish "driving" will extend no further than 150 yards (137.2 meters) from the net. Nets will be attended at all times. Captured fish will be identified to species and tallied on standard data sheets. Periodically, a subsample of 10 fish of each species per site will be measured in total length and weighed. An IDNR/INHS biologist will be assigned to each commercial net boat to monitor operations and record data.

*Hoop and Mini-Fyke Netting Protocol*- Single hoop nets will be deployed for two net-nights by IDNR/INHS biologists at four locations in the Lockport, Brandon Road, Dresden Island, and Marseilles pools. Specific set locations will vary, but nets typically will be set off shore, in current, and parallel to the navigation channel. Single mini-fyke nets will be set at four locations in each of the four pools and fished for one net-night per month. Mini-fyke nets will be set in shallow off-channel areas with leads affixed to the shoreline and running perpendicular to shore. Though hoop and mini- fyke nets will be left unattended, care will be taken to set them in locations that will not interfere with commercial navigation or recreational boat traffic.

*Suggested boat launches for fixed site sampling*:

Lockport Pool – Cargill Launch – Inform Martin Castro of MWRD.

Brandon Road Pool –Ruby Street Launch in Joliet on the west side of the river.

Dresden Island Pool – Big Basin Marina under the I-55 Bridge on north side of the river.

Marseilles Pool – Stratton State Park Launch in Morris on the north side of the river

# Fixed Site Monitoring Downstream of the Dispersal Barrier

**Sampling Schedule:** A tentative sampling schedule for electrofishing and netting for 2017 is shown in the table below. Hoop and mini-fyke netting will occur monthly, either the week before or after the week of scheduled electrofishing and netting.

**Table 1.** *2017 Fixed Site Monitoring Schedule*

| Electrofishing Below Barrier | |
|---|---|
| **Week** | **Agency** |
| 3-Apr | IDNR/USACE |
| 17-Apr | USFWS/USACE |
| 1-May | IDNR/USACE |
| 15-May | USFWS/USACE |
| 5-Jun | IDNR/USACE |
| 26-Jun | USFWS/USACE |
| 10-Jul | IDNR/USACE |
| 24-Jul | USFWS/USACE |
| 14-Aug | IDNR/USACE |
| 28-Aug | USFWS/USACE |
| 11-Sep | USFWS/USACE |
| 16-Oct | IDNR/USACE |
| 20-Nov | IDNR/USACE |

| Contracted Netting Below Barrier | |
|---|---|
| **Week** | **Agency** |
| 13-Mar | IDNR/INHS |
| 3-Apr | IDNR/INHS |
| 24-Apr | IDNR/INHS |
| 22-May | IDNR/INHS |
| 5-Jun | IDNR/INHS |
| 12-Jun | IDNR (SIMS) |
| 19-Jun | IDNR (SIMS) |
| 10-Jul | IDNR/INHS |
| 17-Jul | IDNR/INHS |
| 24-Jul | IDNR/INHS |
| 31-Jul | IDNR/INHS |
| 14-Aug | IDNR/INHS |
| 28-Aug | IDNR/INHS |
| 4-Sep | IDNR/INHS |
| 18-Sep | IDNR (SIMS) |
| 25-Sep | IDNR (SIMS) |
| 2-Oct | IDNR/INHS |
| 16-Oct | IDNR/INHS |
| 30_Oct | IDNR/INHS |
| 27-Nov | IDNR/INHS |

| Hoop and Mini-Fyke Netting Below Barrier | |
|---|---|
| **Week** | **Agency** |
| 24-Apr | IDNR |
| 22-May | IDNR |
| 12-Jun | IDNR |
| 24-Jul | IDNR |
| 28-Aug | IDNR |
| 18-Sep | IDNR |
| 30-Oct | IDNR |
| 27-Nov | IDNR |

**Deliverables:** Results of each sampling event will be reported for weekly sampling summaries. Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRP.

# Telemetry Monitoring Plan

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

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Overview:**
The Asian Carp Regional Coordinating Committee (ACRCC) developed the Asian Carp Control Strategy Framework 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 Framework, the ACRCC formed a sub-committee, the Asian Carp Monitoring and Response Work Group (MRWG), to develop and implement a Monitoring and Response Plan (MRP) for these invasive species. The plan consists of a series of scientific studies to detect, monitor, and respond to the invasion before reproducing populations of Silver and Bighead Carp become established in Lake Michigan. Telemetry has been identified as one of the primary tools to assess the efficacy of the Electric Dispersal Barrier System as well as investigating inter-pool movements and invasion front habitat use.

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

**Introduction:**
The telemetry monitoring plan includes the tagging of fish with individually coded ultrasonic transmitters in the Upper IWW. The acoustic network proposed is comprised of stationary receivers and supplemented by a mobile hydrophone unit to collect information from acoustic transmitters (tags) implanted into free-swimming Bighead Carp, Silver Carp and surrogate species. Acoustic receiver coverage within the Upper IWW is primarily focused at the electric dispersal barriers with secondary coverage surrounding lock and dams and emigration routes such as tributaries and backwater areas. In 2015 a total of 31 stationary receivers were placed from the confluence of the Cal-Sag to Dresden Island Lock and Dam and up the Kankakee River near the Wilmington Dam. In 2016, receiver coverage was added to the Dresden Island Pool (n=2) and Kankakee River (n=3) while a positioning receiver array within the electric dispersal barriers was removed (n=8). Additionally, SIUC, USGS and USFWS deployed a total of nine

receivers to the Dresden Island Pool and one receiver to the Brandon Road Pool in support of alternative projects. The data from these receivers were collated with the USACE database to supplement our understanding of fish movements within the study area. Figure 1 at the end of this report displays the full receiver network inclusive of partner agency receivers within the USACE study area.

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

However, as more research is conducted on Bighead and Silver Carp and the Upper IWW ecosystem; information gaps are being identified and monitoring plans continue to be refined. Acoustic telemetry monitoring was the only continuous monitoring project for the Electric Dispersal Barrier System in 2016. Additional barrier efficacy studies have been completed using alternative monitoring tools such as mark/release and hydroacoustic surveys. These studies have helped to address the deficiencies of acoustic telemetry but cannot be deployed every day throughout the year. Acoustic telemetry can also be used to address several information gaps that have been identified at the leading edge of the invasion front. Specific habitat use by Bighead and Silver Carp has not been detailed by existing monitoring projects for locations difficult to access by boat such as wetland shelves. Additionally, movement patterns and habitat use have not been characterized in relation to water quality parameters that may vary both spatially and temporally within the system. Acoustic telemetry can be used to help address these issues by modifying the goals and objectives of the plan in coordination with other MRWG activities. Finally, the USACE telemetry plan can also be adjusted to incorporate advancements in technology with the goal of streamlining data collection and reporting results. The following goals and objectives have been revised from previous years to focus future efforts on identified knowledge gaps and improving the efficiency of data collection and reporting.

**Goals and Objectives:**

The overall goal of this telemetry monitoring plan is to assess the effect and efficacy of the Barrier on tagged fish in the Chicago Area Waterways (CAWS) and Upper IWW using ultrasonic telemetry. The goals and objectives for the 2017 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** Establish real-time receiver locations upstream of strategic control points and develop a reporting protocol to provide quality controlled information to resource managers in an efficient and timely manner.
- **Objective** Support barrier efficacy and mitigation studies through supplemental data collection of tagged fish in the vicinity during controlled experimental trials.

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

- **Objective** Monitor the movements of tagged fish at Dresden Island, Brandon Road, and Lockport Locks and Dams using stationary receivers (N=8) placed above and below and within each lock.
- **Objective** Review and compare standard operating protocols and vessel lockage statistics for Lockport, Brandon Road and Dresden Island Locks.
- **Objective** Support Brandon Road acoustic deterrent trial through an acoustic telemetry positioning system within the downstream approach channel.

**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.

**Work Plan:**
*Sample size and distribution* – Sample size was selected through review of similar studies, past catch data and expert opinion from the MRWG. In 2010, the workgroup decided that a baseline minimum of 200 transmitters be implanted for telemetry monitoring in the vicinity of the electric dispersal barriers and that this level of tags be maintained as battery life expires or specimens exit the study area. At the conclusion of the 2016 sampling season there were 98 live, tagged fish within the study area with varying expiration dates. It is expected that 9 of these transmitters will expire by July 2016. 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. Twenty five tags implanted into surrogate fish species within the Lower Lockport pool will remain active throughout the 2017 calendar year. Previous data suggests that the highest emigration rates occur from the Lower Lockport Pool due to lock passage and water draw down events that entrain fishes through water control structures at the dam and Lockport Controlling Works spillway. The Lower Lockport Pool is also a critical area for telemetry monitoring efforts. The primary monitoring goal of assessing efficacy of the Electric Dispersal Barrier System is dependent on tag density immediately below the barriers. Increasing the number of deployed tags at this location is warranted to help maintain a minimum level of tag density. An additional 70 tags (Vemco V16-4x-069k-1) are planned for implantation and release within the Lower Lockport Pool. Deployment of these tags will be split between spring and fall to assist in even distribution of the transmitters across the year.

Twenty four of the tags released in the Brandon Road Pool will remain active through the 2017 sampling season. An additional 20 transmitters (V16-4x-069k-1) are planned for implantation and release in the fall to bring the total up to 44 tagged fish (Table 1). Immigration from the Lockport and Dresden Island Pools is expected and will also assist in maintaining elevated transmitter density in the spring and summer months.

There are 47 transmitters within the Dresden Island Pool that will remain active through the 2017 calendar year. Nine transmitters are expected to expire late winter through early summer.

USACE is targeting a total of 50 Bighead Carp and/or Silver Carp to remain active within the pool. In an effort to maintain this target goal, ten transmitters (V13TP-1x-069k-0017m) will be implanted in the spring and another ten (V16-4x-069k-1) released in the fall. The ten transmitters released in the spring will include both depth and temperature sensors to assist in mapping habitat use of Bighead and Silver Carp with greater precision. A small number of surrogate species (Common Carp) are also being maintained within Dresden Island Pool to help assess differences in behavior and movement patterns with Bighead Carp and Silver Carp. Surrogate species are also beneficial for use in studying interactions with the Brandon Road Lock and Dam as release of Bighead and Silver Carp upstream of the known invasion front is prohibited. Ten transmitters will be implanted into Common Carp in the spring and another five transmitters will be added in the fall.

**Table 1:** *Recommended transmitter implementation for the 2016 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 *10 depth/temp sensor tags into Bighead and Silver Carp plus 10 standard transmitters into surrogate species.*

| Release Pool/Location | Species | Spring Supplement tags | Fall Supplement tags | Total estimated tag distribution (1 Jan 2018) |
|---|---|---|---|---|
| **Upper Lockport/RM300** | Common Carp | 0 | 0 | 0 |
| **Lower Lockport/RM292.7** | Common Carp | 40 | 20 | 85 |
| **Brandon Road/RM286.5** | Common Carp | 0 | 20 | 44 |
| **Dresden Island/RM276** | Bighead, Silver and Common Carp | 20* | 15 | 73 |
| **Total** | - | 60 | 45 | 202 |

*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 Barriers. Therefore, in order to test the direct response of fish and maintain target density levels within all pools, surrogate species have been tagged and monitored within the Dresden Island, Brandon Road and Lockport pools. Dettmers and Creque (2004) cited the use of Common Carp (*Cyprinus carpio*) as a surrogate species for use in telemetry in the CSSC because "Common Carp are naturalized and widespread throughout the CSSC and Illinois water bodies in general. Common Carp are known to migrate relatively long distances and they grow to large sizes that approximate those achieved by invasive carps. Based on these characteristics, tracking of Common Carp should provide a good indicator of how Asian carp would respond to the dispersal barrier if they were in close proximity to this deterrent." These characteristics could also justify the use of other species such as Smallmouth and Black Buffalo (*Ictiobus bubalus* and *I. niger*), Grass Carp (*Ctenopharyngodon idella*), and Freshwater Drum (*Aplodinotus grunniens*).

Tagging efforts will continue to utilize fish site fidelity to increase the probability of attempted fish passage through the Electric Dispersal Barrier as well as lock and dams. Previous results along with published literature (ACRCC, 2013; Jones and Stuart, 2009) indicate that captured fish display high site fidelity upon release and tend to return to the area of capture. For example, fishes to be released in Lower Lockport pool will be captured upstream of the electric dispersal barriers and tagged and released downstream. These fishes will have a greater propensity to return to their capture site, hence, challenging the barriers more often. This same technique will be employed at the Dresden Island pool with a subset of surrogate fishes captured in the Brandon Road pool. When this technique was first implemented in the 2014 sampling season there had been 176 barrier challenges made between May 2011 and 31-Dec, 2013. During 2014, the first year of the modified release, there were 525 barrier challenges between 1-Jan and 31-Oct alone. This practice will continue in 2017 in order to gain a higher resolution of data to support barrier effectiveness and lock passage mechanisms. While this technique is encouraged with surrogate species to increase the sample size of barrier challenges, Bighead Carp and Silver Carp will be tagged and released near their capture location. It is important to remove any bias in experimental design when attempting to describe patterns of habitat use and movement.

*Tag specifications and Implantation procedure* – Tagging efforts will be focused during spring (March-May) and fall (October-November) and will follow the surgical and recovery procedures outlined in *Telemetry Master Plan Summary of Findings* by Baerwaldt and Shanks (2012). Adult Bighead and Silver Carp will be collected from the IWW; in the Dresden Island (RM 271.5 to 286) pool. Surrogate species will be collected from the Lockport Pool and the Brandon Road pools (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 attempt to reduce the amount of tagged fish losses due to harvesting, all Bighead and Silver Carp undergoing surgery will also be fitted with a single jaw tag (provided by SIUC) or external floy tag (provided by IDNR). 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 Bighead and Silver Carp if they are suitable for release, otherwise they will be requested to save the fish and return it to USACE so we can save the transmitter and tag a replacement fish. No

Bighead and Silver Carp caught in Lockport or Brandon Road pools will be tagged and returned as these areas are upstream of the known invasion front. Any Bighead and Silver Carp captured in Lockport or Brandon Road will be turned over to the IL DNR for species voucher.

**Acoustic Network Array:**

*Stationary Receivers* – A system of passive, stationary receivers (Vemco VR2W and VR2C) are placed throughout the IWW in order to monitor movement of tagged fishes. The receivers log data from tagged fish when they swim within the detection range of the receiver (typically at least one quarter mile from the receiver). Test transmitters will be used to test the detection range of each receiver. VR2W's will be placed from the Dresden Island Lock and Dam (RM 245 of Dresden Island Pool, Illinois Waterway) to the confluence of the Cal-Sag Channel with the CSSC upstream of the Electric Dispersal Barrier System within the Lockport Pool (RM 303.5 of Lockport Pool, Illinois Waterway). 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. The receiver network is re-established to its full capacity at the commencement of the following season, typically late March.

The receiver network underwent modifications around the Brandon Road Lock to increase the efficiency of inter-pool pathway detection in 2014. Additional receivers were deployed within the lock chamber, below the dam and within connecting tributaries nearby. Hickory Creek provides an alternate route for fishes attempting to continue upstream once they encounter the lock and dam impediment. Expanded receiver coverage around the Brandon Road Lock is helping to identify the basis for a lack of upstream passage by tagged fish as well as improve the understanding of Bighead and Silver Carp habitat use in the area. This expanded coverage will be continued into the 2017 sampling season. Additionally, a positioning system consisting of 12 receivers will be established within the approach channel to the Brandon Road Lock in April 2017. This positioning array will monitor fine scale fish movements near the lock in support of an acoustic deterrent trial being conducted in that location. The trial will be active for seven days in April. The telemetry monitoring program will support this effort by monitoring tagged fish populations in the vicinity of the lock for a period of one month utilizing the positioning array.

Figure 1 shows the general strategy of VR2W placement for 2017 (N=46 receivers) with permanent receivers displayed in red (N=35) and temporary deployments for the acoustic deterrent trial shown in green (N=11). The priority is to achieve the most coverage (detection capacity) in the immediate vicinity of the Barriers with VR2W receivers. To accomplish this, receivers immediately downstream and upstream of the Electric Dispersal Barriers will provide a system that will help USACE biologists monitor and track any fish movement through the Barriers. The network will expand throughout the system to track overall movement, and to determine what type of movement occurs from fish negotiating lock structures. Receivers will also be deployed at possible escape routes from the telemetry network such as tributary confluences. Movement through lock structures will be compared to USACE lockage data from Dresden Island, Brandon Road, and Lockport Locks. Leading edge movements will be monitored by the receiver network within the Dresden Island Pool, Brandon Road Pool and 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 the Dresden Island Pool between normally scheduled downloads to increase sampling frequency during spring spawning. All receivers will be downloaded via Bluetooth-USB capability. The software is available free online from the Vemco website (http://www.vemco.com/support/vue_dload_form.php). Water quality parameters (DO, pH, conductivity, and temperature) will be recorded at each station during downloads.

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

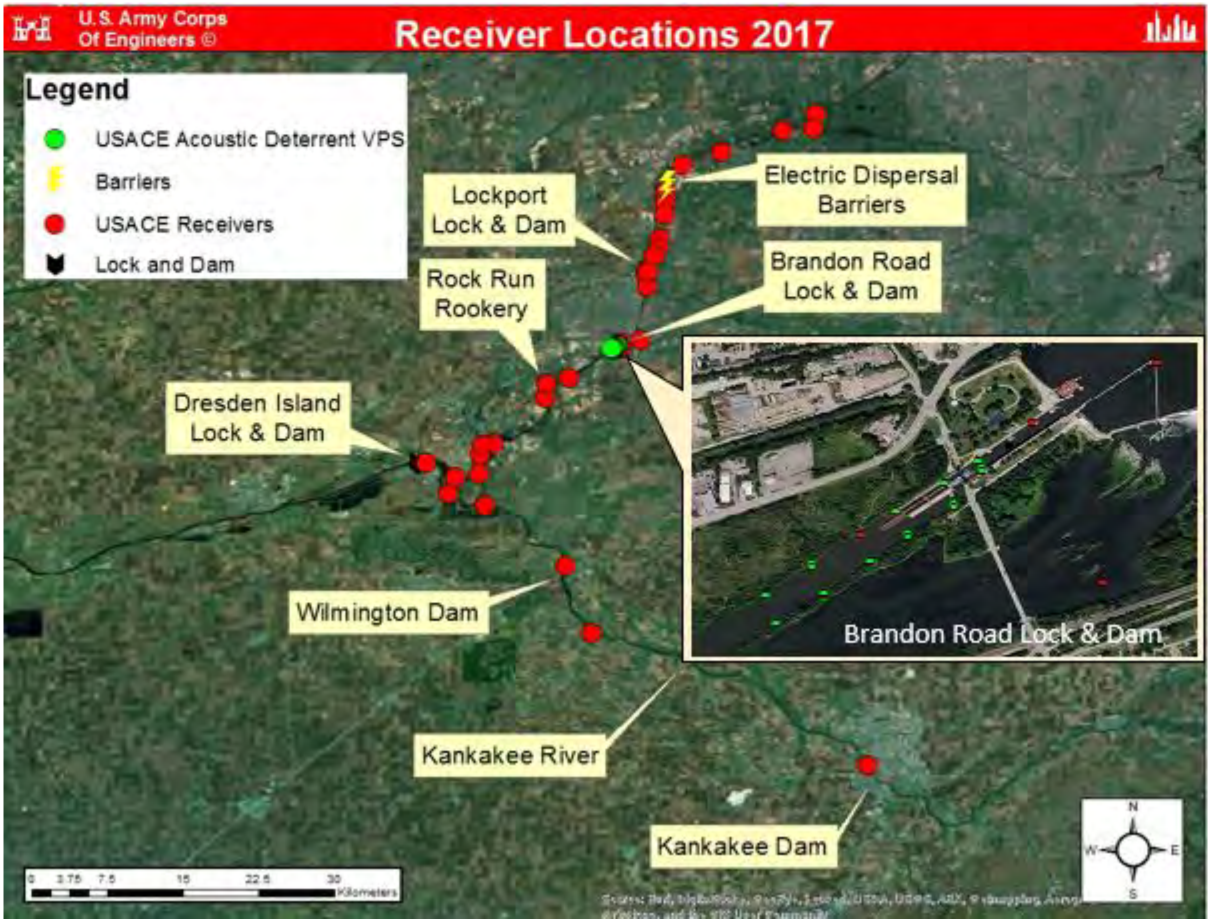



**Figure 1:** *VR2W receiver network within the Upper IWW and CAWS*

*Mobile Tracking* – In the past, mobile tracking has been used by USACE biologists using a mobile unit (Vemco VR-100 unit with a portable directional and omni-directional hydrophone operated out of a boat) that enabled crews to manually locate any tagged fish using the signal emitted from the transmitter inside the fish. The VR-100 mobile tracking unit will be used as a supplemental tool to help locate congregations of Bighead and Silver Carp in coordination with IDNR contracted commercial fishermen. In doing so, increased harvest of Bighead and Silver Carp may occur. In addition, the VR-100 will be used to further investigate tags that may cross the Electric Dispersal Barrier or Locks and Dams.

**Contingency Measures:**
*Tagged fish crossing Electric Dispersal Barrier System* – As described above, any suspicion (indicated by stationary receiver data) of any tagged fish crossing the Electric Dispersal Barrier System can be confirmed by the mobile tracking unit. This will enable crews to locate the exact

location of a fish, instead of the approximation detected by a stationary receiver. All agency leads involved with the telemetry plan, as well as the MRWG, will be notified immediately of any suspected barrier breach. In some cases, it may be necessary to implement a 24-hr 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 the 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 upstream of the Brandon Road Lock and Dam will trigger immediate notification to 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 agencies 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. 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.
- Trevor Cyphers and Rebecca Neeley, USFWS Region 5, Carterville Field Office. Species to be tagged in middle IWW include: Grass Carp. This study will begin summer of 2016 and will focus on the movement patterns and habitat use of adult Grass Carp.

**Sampling Schedule:** A tentative work schedule is presented below.

| | |
|---|---|
| March – May 2017 | VR2W network inspected and new receivers installed and range tested. Tagging efforts of Bighead and Silver Carp in the Dresden Island Pool and surrogate fish in Lockport and Brandon Road pools at Barriers. |
| ONGOING | VR2W network maintenance, downloads and mobile tracking |
| Oct – Nov 2017 | Tagging efforts of Bighead and Silver Carp with depth sensor tags in the Dresden Island Pool and surrogate fish in Lockport and Brandon Road Pools |
| December 2017 | Prepare receiver array within the IWW and CAWS for winter months |

**Reporting of Results**

All agency leads involved with the telemetry plan, as well as the MRWG, will be notified immediately of any suspected barrier breach or detection of Bighead and Silver Carp above the Brandon Road Lock. Periodic updates will be given to the MRWG in the form of briefings at regular meetings, and the year-end summary report will be compiled after the 2017 sampling season.

# Monitoring Fish Abundance, Behavior, and Species Composition near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier

Lead Agency: U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL

**Participating Agencies:** U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL (lead); U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Marion, Illinois (lead); U.S. Geological Survey, Illinois Water Science Center, Urbana, IL (field support); USACE, Chicago District (field support)**,** U.S. Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office, Columbia MO. (field support)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

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

**Introduction and Need:**

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

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.

## Monitoring Fish Abundance, Behavior, and Species Composition near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier

**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.

**Status:** Since 2012, the U.S. Fish and Wildlife Service 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 system 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 Barrier IIB which has the greatest electrical field strength (Parker and Finney 2013). Since 2015, hydroacoustic surveys have been completed on a bi-weekly to monthly basis to gain greater temporal resolution on fish community dynamics. An additional component to this work was 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 (U.S. Fish and Wildlife Service 2016).

Interim reports for this work can be found in the 2012-2016 ACRCC MRWG Interim Summary Reports and on the USFWS Carterville FWCO website at http://www.fws.gov/midwest/fisheries/carterville/didson-barge.html.

**Methods:**

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

Side-looking split beam hydroacoustic and side scan sonar surveys will be conducted below the CSSC Electric Dispersal Barrier to assess fish abundance, density, and distribution patterns near the Electric Dispersal Barrier on a fine temporal scale. Surveys below the Electric Dispersal Barrier will take place on a bi-weekly (barrier surveys) to seasonal basis (pool surveys) beginning in January 2017. The hydroacoustic survey equipment utilized for these surveys consists of a pair of Biosonics® 200 kHz split-beam transducers. 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 rotators orient the transducers to preset positions every 45 seconds. This approach will allow a large portion of the water column to be ensonified by the survey vessel during each survey. These surveys will provide information on size frequency distributions of fish targets as well as spatial orientation information. Results of biweekly surveys will be communicated to the ACRCC as rapid communications if changes in fish abundance or behavioral status are detected.

*Stationary hydroacoustic deployment at the Electric Dispersal Barrier- Pilot study*
A stationary acoustic remote sensing system utilizing two split beam transducers will be temporarily deployed approximately 100 meters downstream from the Electric Dispersal Barrier concurrent with barge entrainment studies scheduled for July and August 2017. The system will utilize two transducers (420 kHz) that will be aimed across the navigation channel. This configuration will provided adequate acoustic coverage to estimate fish abundance continuously during the deployment period. The transducers will be powered by a Biosonics DTX® echo sounder operating at 5.0 pings per second with a 0.40 ms pulse width. The echo sounder data will be routed into a control module running Visual Acquisition v.6® and Auto Track® data acquisition and automated fish tracking software. Data from this phase of the project will provide real time estimates of fish community size structure and abundance before and after barge vessel transits. This deployment will also provide fine scale information on fish density and "barrier challenging" behavior of wild fish in response to a variety of environmental and anthropogenic variables.

*Shore based stationary multi-beam imaging sonar observations of fish behavior at the Electric Dispersal Barrier*
A pair of multi-beam imaging sonar systems (DIDSON) will be utilized to make direct observations of fish behavior directly over the high field array structure of Barrier IIB concurrently with barge entrainment trials. The imaging sonar units utilize a series of 96 separate acoustic cones that are integrated to produce video quality acoustic images. This sampling system will produce real time observations of fish behavior in the canal under ambient conditions and during barge tow vessel transits. The two DIDSON units will be deployed into the canal from the western canal wall with a mobile telescopic boom lift. The DIDSON units will be deployed ≈ 6.0 m from the western canal wall, 0.5 m below the water surface, and will be aimed towards the western wall. This technique allows real time observations of wild fish behavior at the Electric Dispersal Barrier in response to a variety of environmental and anthropogenic variables.

*Fish community species composition sampling*
The community of small pelagic fishes present within the Brandon Road and Lockport pools will be physically sampled by utilizing newly developed surface and midwater trawls deployed within the respective navigation channels of each reach on a monthly basis. Comprehensive sampling of the fish community within the Brandon Road and Lockport pools is currently

conducted using electrofishing, gillnetting, hoop netting, and mini-fyke nets. However, physical sampling of the pelagic fish community within the navigation channel of these study reaches is currently not conducted due to a variety of challenges and gear limitations (deep water, commercial traffic, etc.). Recent advances in gear development will now allow this habitat to be effectively sampled. The physical data obtained through this monitoring effort on fish species composition and size structure changes over time will allow for validation of hydroacoustic data collections and provide identification of changes in species composition and size structure throughout the season.

**2017 Schedule:**

Winter 2017-Fall 2017

Seasonal mobile hydroacoustic fish surveys; Brandon Road and Lockport Pools

January – December 2017

Biweekly mobile hydroacoustic fish surveys at the Electric Dispersal Barrier

July – August 2017

Stationary hydroacoustic deployment at the Electric Dispersal Barrier

Shore based multi-beam imaging sonar at the Electric Dispersal Barrier

May 2017-November 2017

Monthly fish community species composition sampling

**Deliverables:**

Any bigheaded carp captured upstream of Dresden Island Pool will be reported immediately to Todd Turner (USFWS Assistant Regional Director – Fisheries) or Charlie Wooley (USFWS Deputy Regional Director – Region 3) and MRWG. An annual MRWG report and presentation will be provided during the winter of 2017 – 2018. Biweekly reports will be supplied on fish density and spatial distribution near the Electric Dispersal Barrier to the ACRCC following barrier scans. Annual reports, presentations, and peer reviewed articles outlining significant findings of all program study areas will be prepared.

# Analysis of Feral Grass Carp in the CAWS and Upper Illinois River

Lead Agency: U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL

**Participating Agencies:**
USFWS La Crosse Fish Health Center (laboratory support), USGS - Columbia Environmental Research Center (laboratory support), USACE-Chicago District (project support), Southern Illinois University (project support), USGS – Upper Midwest Environmental Sciences Center (project support), and Illinois DNR (project support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Location:**
Targeted sampling for Grass Carp using electrofishing will take place in the Upper Illinois Waterway (IWW) in Dresden Island Pool with the objective of tagging captured fish with acoustic telemetry tags below the Brandon Road Lock and Dam. Tagged fish will be monitored via the existing acoustic telemetry array currently being maintained by the U.S. Army Corps of Engineers (USACE), Southern Illinois University (SIU) and U.S. Geological Survey (USGS). Grass Carp captured in the Chicago Area Waterway System (CAWS) during sampling events will be processed through the Grass Carp protocol and analyzed for life history traits.

**Introduction and Need:**
Grass Carp are large, herbivorous fish that were first introduced in the United States in 1963 because of their ability to control aquatic vegetation and importance as a food fish (Kolar et al., 2007; Mitchell and Kelly, 2006; Allen and Wattendorf, 1987). As early as the 1970s, Grass Carp escaped stocking areas and distributed themselves throughout the Mississippi River Basin (Baerwaldt et al., 2013; Kelley et al., 2011). In 1983, triploid Grass Carp became commercially available in the Unites States to reduce reproductive success and establishment in the wild (Allen et al. 1986), however; many states in the Mississippi River Basin do not restrict the stocking of diploid Grass Carp (MICRA 2015). Grass Carp reach maturation at about 4-5 years of age or approximately 560-860 mm in total length, but can fluctuate based on temperature and water condition (Cudmore and Mandrak, 2004; Chilton and Muoneke, 1992). For this reason determining ploidy in feral specimens is important to understanding the population. The rapid expansion of Grass Carp and other Asian carp have caused concerns about their potential to invade the Great Lakes and negatively affect the fishery (Kocovsky et al., 2012). This has resulted in a growing need for agencies, committees and work groups to determine the current status of Grass Carp within the Great Lakes Basin.

# Analysis of Feral Grass Carp in the CAWS and Upper Illinois River

The Great Lakes Panel (GLP) on Aquatic Nuisance Species (GLP, April 2015) and Fisheries and Oceans Canada (Cudmore et al. 2017) have suggested that actions need to be implemented to better understand the current status of Grass Carp in the Great Lakes Basin. An ecological risk assessment by DFO suggests that the most likely arrival point for Grass Carp to Lake Michigan is through the Chicago Area Waterway System (CAWS). Grass Carp are currently at the 'arrival' stage in Lake Michigan, as there have been repeat detections within the basin on a continuous basis over the past five years (Cudmore et al 2017). The GLP (2015) also determined that movement studies to examine preferred habitat, home range and seasonal movement patterns of Grass Carp could be useful in future management strategies. Whitledge (2015) stated that a surveillance program to gather life history traits of feral Grass Carp in the Great Lakes region would be a vital tool to assessing short-term risk of introduction from areas not currently known to have self-sustaining populations.

In 2016, the U.S. Fish and Wildlife Service (USFWS) Carterville Fish and Wildlife Conservation Office Wilmington Substation started a monitoring project to analyze Grass Carp populations in the Upper Illinois Water Way (IWW) and CAWS. The primary goal of this project is to analyze Grass Carp within the IWW and CAWS through a protocol to determine life history traits and population dynamics. Historic Grass Carp captures were analyzed to determine potential high density areas, which then could be targeted for sampling. Due to the interest in Grass Carp movement, Grass Carp captured below the USACE Electric Dispersal Barrier were implanted with Vemco acoustic telemetry tags to monitor barrier effectiveness at Brandon Road Lock and Dam, large-scale movement patterns and habitat preference using the telemetry array established within the Upper IWW.

**Objectives:**

1) Tag Grass Carp below the Brandon Road Lock and Dam to determine barrier effectiveness, seasonal movements and habitat preferences as a surrogate for Bighead and Silver Carp through the use of acoustic telemetry.
2) Determine life history traits (e.g., age, ploidy, otolith microchemistry, gonad histology and gonadosomatic index) of Grass Carp in the CAWS through processing any wild captured through the Grass Carp protocol.

**Status:** This project began in 2016 and is funded through GLRI. The goals of this project are to better understand the Grass Carp population in the CAWS and to determine barrier effectiveness, seasonal movements and habitat preference of Grass Carp in the Upper IWW using acoustic telemetry.

**Methods:**

**Historical Data Analysis**

Prior to the 2017 field season, historical Grass Carp captures in the CAWS and Upper IWW from 2011 to 2016 were requested from the Illinois Department of Natural Resources (ILDNR).

## Analysis of Feral Grass Carp in the CAWS and Upper Illinois River

These data were used to generate kernel density maps to estimate relative abundance and potentially high distribution areas that could be used during targeted sampling of Grass Carp. Maps were generated for the CAWS and Dresden Island Pool based on project objectives (Figures 1 and 2).

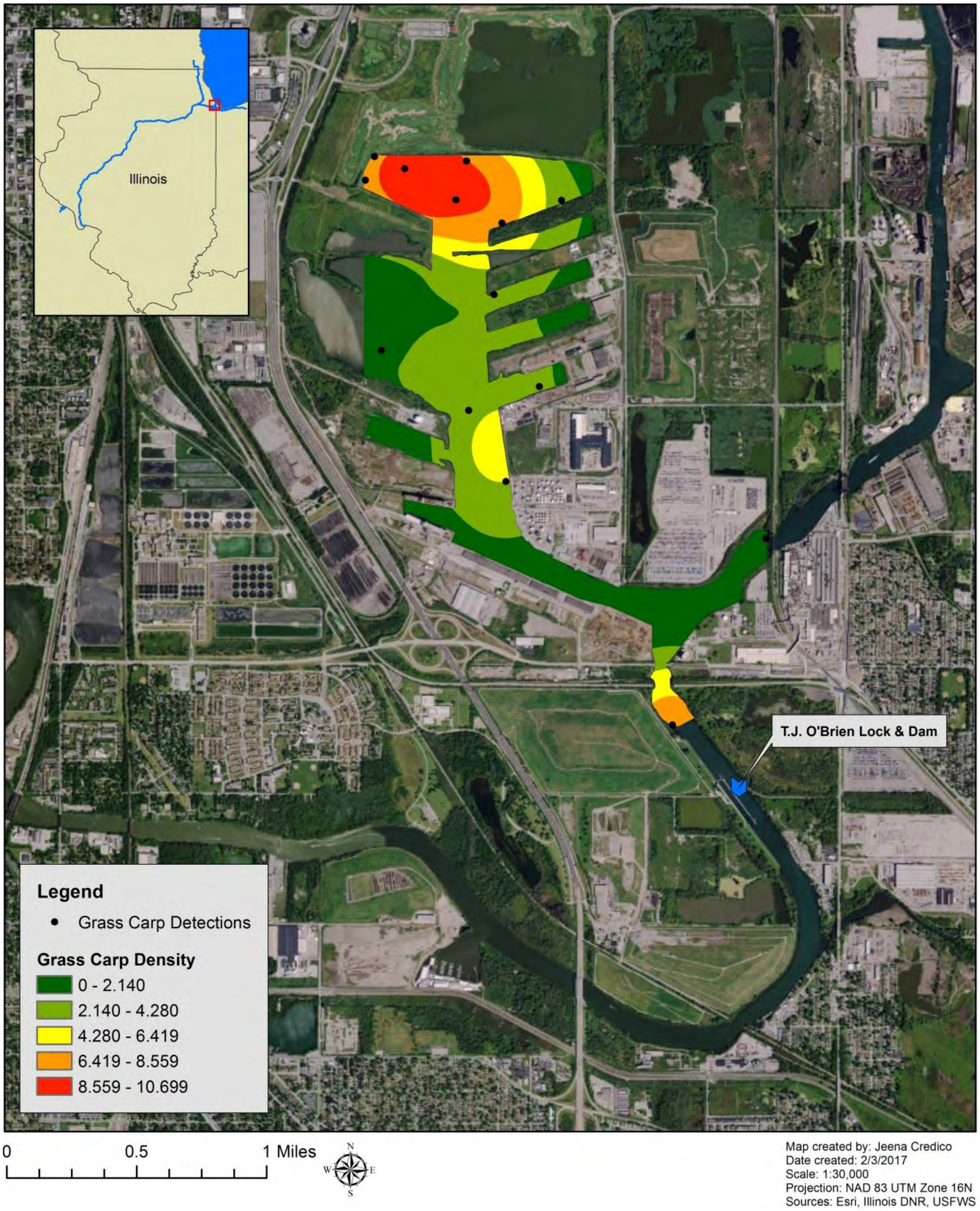



**Figure 1.** *Kernel density of Grass Carp within Lake Calumet and connecting Calumet River based on capture data from 2010-2016.*

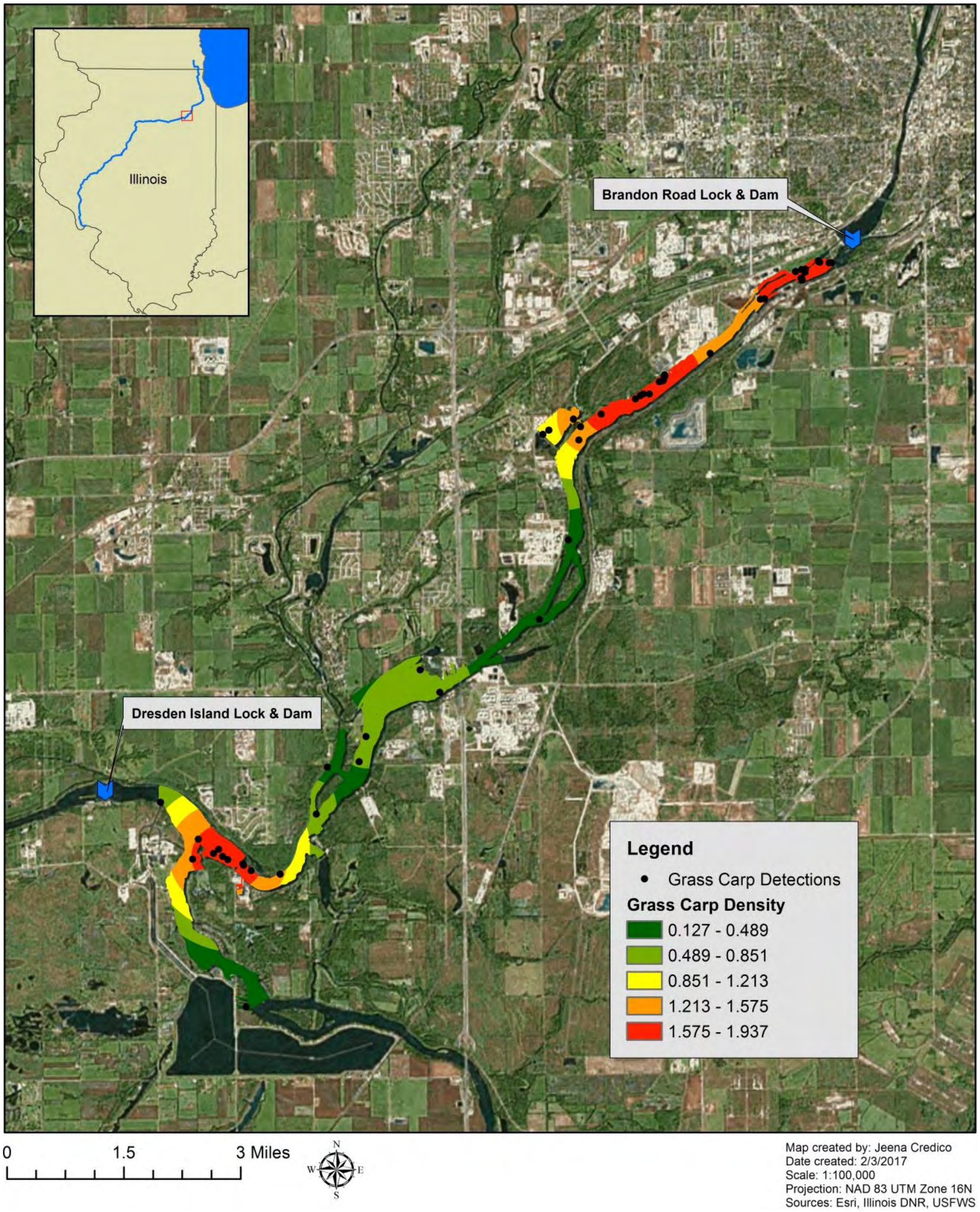



**Figure 2.** *Kernel density of Grass Carp for Dresden Island Pool based on capture data from 2011-2016.*

## Targeted Sampling

Targeted sampling with the intent of capturing fish for telemetry purposes will begin in April 2017, once telemetry gear is deployed. Targeted sampling will involve using pulsed-DC electrofishing in predetermined areas by past Grass Carp captures below the Electric Dispersal Barrier system. Targeted sampling will continue until the remaining telemetry tags are used.

**Incidental Grass Carp Collection**
During the 2017 field season, any Grass Carp captured in the CAWS by USFWS personnel and other partner agencies will be analyzed for life history traits according to protocol. This will predominantly be done during Season Intensive Monitoring (SIM) events coordinated by the IDNR. Upon collection, total length, fork length, girth and weight will be recorded. Eyeballs and whole gonads will be removed, stored in saline solution, and shipped to the La Crosse Fish Health Center (FHC) within eight days after capture. Eyeballs will be used to determine ploidy, while gonads will be transferred to formalin to analyze histology and determine a gonadostomatic index at a later date. Grass Carp heads will be removed just in front of the pectoral fins to include the first vertebrae. Whole heads will be sent to the USGS - Columbia Environmental Research Center (CERC) for age analysis and otoliths will be shipped out for microchemistry analysis. Any Grass Carp captured during incidental collections within the Upper IWW will be implanted with acoustic telemetry tags when applicable. If tagging is not possible, length, and weight will be recorded and eyeballs will be removed for ploidy analysis.

**Determination of Life History Traits**
*Ploidy Analysis* - Grass Carp captured during targeted sampling for telemetry purposes will be sampled non-lethally by collection of 1-2 ml of whole blood from the caudal vein in acid citrate dextrose (ACD) and shipped cold to the FHC for ploidy analysis using methods for erythrocyte nuclei analysis (Jenkins and Thomas, 2007). Grass Carp collected within the CAWS will be euthanized and both eyes will be extracted, covered in saline, and shipped cold to the FHC for ploidy analysis using methods for vitreous humor cell analysis (Jenkins and Thomas, 2007).

*Aging* - Aging structures will be collected from Grass Carp within the CAWS, but will not be collected from Grass Carp used for telemetry. Age structures (whole heads) will be shipped to partners at CERC to be processed for analysis. Aging will be determined by using vertebral sections with scales and whole vertebrae as reference structures.

*Gonadosomatic Index* - Gonads will be collected from Grass Carp captured within the CAWS, removed and covered in saline, and shipped cold for pre-processed along with eyeball or blood samples for ploidy analysis.

**Grass Carp Telemetry**
*Telemetry Array* – This project will utilize the current acoustic telemetry array in the Upper IWW being maintained through a partnership between the; USACE, USFWS, Metropolitan Water Reclamation District, Southern Illinois University Carbondale and the IDNR developed by the Asian Carp Regional Coordinating Committee as part of the Monitoring and Response Work

Group (MRWG). Implemented in 2010, it was developed to determine the efficacy of barriers within the Upper IWW and monitor inter-pool movements and potential invasion of bigheaded carps. Additional receivers will be placed in areas by USFWS personnel within the IWW to supplement the current array where partners deem necessary.

*Grass Carp Telemetry* – Grass Carp will initially be targeted within Dresden Island Pool for telemetry reasons in April in order to determine barrier effectiveness at the Brandon Road Lock and Dam. Captured Grass Carp will be anesthetized and implanted with Vemco V16 (6H) tags set to a varying 30-90 second ping frequency. Following tag implantation, blood will be drawn from the caudal fin for ploidy analysis and fish will be jaw tagged. Once fish recover from surgery, they will be released near where they were captured. Grass Carp movement will be monitored through the use of stationary Vemco receivers (VR2Ws) and a Vemco mobile acoustic receiver (VR100). Stationary receivers will be downloaded every other month and analyzed using Vemco VUE software. Manual tracking using a VR100 will be done within the Upper IWW when deemed necessary. Detections of non-USFWS fish from stationary downloads and active tracking will be disseminated to their proper agency.

**2017 Schedule:**
February – March 2017
Gear preparation, field logistics planning, crew scheduling

April - October 2017
Targeted sampling events, acoustic tagging, data entry, fish movement analysis, analysis of CAWS captured fish through the Grass Carp protocol

November 2017
Compile data and fish movement analysis

December 2017 – January 2018
Annual report generation

**Deliverables:**
Annual report to the MRWG in winter 2017-2018, as requested. Results of ploidy analyses will be compiled and presented after each field season. A final report and presentation depicting Grass Carp telemetry and life history traits will be given to the MRWG upon completion of this project. Capture data, locations, and ploidy results will be provided to Amy Benson at USGS-FL for mapping and submission to the USGS Non-indigenous Aquatic Species Database: http://nas.er.usgs.gov/

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# Alternative Pathway Surveillance – Urban Pond Monitoring

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

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

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

**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, eight 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 the Lake or CAWS upstream of the 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 transfers of Asian carp between waters within close proximity to one another.

## Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring 2017 Plan

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, 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) they should be 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 41 Bighead Carp and one Silver Carp have been removed from nine ponds. Fifty hours of electrofishing and 11 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 32 Bighead Carp removed from five ponds since 2011. Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. One Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have both had Bighead Carp removed following natural die-offs and sampling. All ponds yielding positive eDNA detections and 18 of the 21 IDNR urban fishing ponds have been sampled. Lincoln Park South was not sampled because it was drained in 2008, resulting in three Bighead carp being removed, and is no longer a source of Asian carp as a result. Auburn Park was too shallow for boat access but had extremely high visibility. Therefore, the pond was visually inspected with no large bodied fish observed. Elliot Lake had banks too steep to back a boat in on a trailer. Lastly, Jackson Park and Garfield Park were drained in 2015 and, similar to Lincoln Park South, are no longer a source of Asian carp. A map of all the Chicago area fishing ponds that were sampled or inspected as part of this project can be found in Figure 1. For more detailed results *see* 2016 interim summary report document (MRWG 2016).

**Methods:**

*Sampling Protocol* - Trammel and gill nets used are approximately 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). 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 Microanalysis 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.

**2017 Schedule:**
Pulsed DC-electrofishing and trammel/gill nets will be used to sample Elliott Lake in 2017. We will investigate reports of Asian carp sightings in other Chicago area ponds solely based on photographic evidence or reports from credible sources.


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

**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.

# Young-of-year and Juvenile Asian Carp Monitoring Plan

Scott F. Collins, Steven E. Butler, and David H. Wahl; Illinois Natural History Survey
Brennan Caputo, Tristan Widloe, Justin Widloe, Luke Nelson, Blake Bushman, Matt O'Hara and Kevin Irons; Illinois Department of Natural Resources

**ADDITIONAL INFORMATION**

- Link to mapping tool
- Link to 2016 Interim Summary Report

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

**Location**: Monitoring of young-of-year and juvenile Asian carp will take place through targeted sampling by participating agencies at sites throughout the Illinois and Des Plaines Rivers, and the Chicago Area Waterway System (CAWS). These efforts will occur as part of the following projects: Larval Fish Monitoring in the Illinois Waterway (INHS), Fixed Site Monitoring Downstream of the Dispersal Barrier (IDNR), Evaluation of Gear Efficiency and Asian Carp Detectability (INHS), and Seasonal Intensive Monitoring in the CAWS (IDNR). See individual project plans in the 2017 MRRP for specific locations of sampling stations.

**Introduction**: Successful reproduction is considered an important factor in the establishment and long term viability of Asian carp populations. The northward expansion of Asian carp through the Illinois River and connected waterways increases the likelihood of these species challenging or circumventing measures taken to block their access to Lake Michigan. Moreover, the risk that Asian carp will establish viable populations in the Great Lakes increases if either species is able to successfully spawn in the upper sections of the Illinois River. Therefore, it is important to understand where young-of-year and juvenile Asian carp are within the river network and how patterns change across years. Targeting young-of-year and juvenile Asian carp in monitoring efforts is needed because these life stages are not detected in gears that capture adults (e.g., Collins et al. 2015, 2017).

**Objectives**: Multiple gears suitable for sampling small fish will be used to:

1) Determine whether Asian carp young-of-year or juveniles are present in the CAWS, lower Des Plaines River, and Illinois River; and
2) Determine the uppermost waterway reaches where young Asian carp are successfully recruiting.

**Status**: Since 2010, multiple gears have been deployed by participating agencies to monitor young-of-year and juvenile Asian carp along the Illinois Waterway. Small Asian carp were targeted with both active and passive gears (six gears in 2010, eight gears in 2011, ten gears in 2012, six gears in 2013, seven gears in 2014, eleven gears in 2015, and six gears in 2016). DC-

electrofishing has been conducted in all segments of the Illinois River, upper Des Plaines River and CAWS. Mini-fyke nets, trawling (multiple trawl designs), and seining have been used in locations downstream of the electric barrier from Lockport to the LaGrange Pools.
Active sampling effort has been high across all pools, although effort varies among yearly among projects with various objectives. Since 2010, agencies have completed 2,017 hours of electrofishing across all years and sites. In 2016, DC-electrofishing accounted for 361.5 effort hours and trawling accounted for 65.5 effort hours across all pools. Likewise, participating agencies conducted 165 net-nights of mini-fyke nets and 44 seine hauls.

No juvenile Asian carp <305 mm long were captured in 2010 (note: La Grange, Peoria, and Starved Rock Pools were not sampled in 2010) and 2013, and low catches were reported in 2011 and 2012, which may reflect poor Asian carp recruitment. During 2014, sampling across agencies detected the first year of substantial abundances of young-of-year Asian carp since monitoring started in 2010. In 2016, total catch of Asian carp (<12 inch) was low (n = 912) when compared to 2015 (n = 1,934) and especially to 2014 (n = 71,632). In 2016, Asian carp <6 inches were detected in the LaGrange Pool (n =462) and reduced numbers were found in the Peoria Pool (n = 4), and none in or above the Starved Rock Pool (n = 0). Asian carp between 6-12 inches were collected in the Starved Rock Pool (n = 16) and the Marseilles Pool (n = 4). These patterns of small (<6 and 6-12 inch) Asian carp among the Illinois River pools are consistent with patterns observed in 2015. The farthest upstream catch of juvenile Asian carp in 2015 and 2016 were several Silver carp (6-12 inches) in the Marseilles Pool near Morris, IL, (river mile 263).

**Methods**: As in the past, 2017 sampling for young-of-year and juvenile Asian carp will occur through other projects of the MRP. Young fish will be targeted in the following projects: Larval Fish Monitoring in the Illinois Waterway (INHS), Fixed Site Monitoring Downstream of the Dispersal Barrier (IDNR), Evaluation of Gear Efficiency and Asian Carp Detectability (INHS), and Seasonal Intensive Monitoring (SIM) in the CAWS (IDNR). See individual project plans and the 2017 MRRP for specific locations, the active and passive gears used, sampling frequency, and effort.

**Sampling Schedule**: In 2017, sampling will occur along the Illinois River and relevant connected waterways starting in the spring and ending in the winter. Start and end dates vary by project. Additional sampling may occur at other sites on an as-needed basis in cooperation with other sampling and monitoring efforts. Sampling will be conducted as required to meet future research and monitoring objectives.

**Deliverables**: At the conclusion of the 2017 sampling season, data will be collected from participating agencies and summarized as part of an ongoing synthesis of young-of-year and juvenile Asian carp monitoring. Findings will update agencies about the current status of young-of-year and juvenile Asian carp in the Illinois River and be used to refine individual project plans and annual revisions of the MRP.

**Literature Cited:**

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## Illinois River Juvenile Asian Carp Telemetry

Kjetil Henderson, Cory Anderson, and Rebecca Neeley
Lead Agency: U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL

**ADDITIONAL INFORMATION**

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Location:**
The study will be conducted in La Grange or Peoria Pool of the Illinois River.

**Introduction and Need:**
Relative to large individuals, small Asian carp represent a greater risk for breaching the Electric Dispersal Barrier due to the negative relationship between body size and electrical immobilization. Recent evidence has also highlighted passive entrainment of small fishes by barge traffic as a vulnerability of the Electric Dispersal Barrier. Indeed, several state and federal agencies have devoted substantial resources to sampling in the upper Illinois River to gather greater insight into the potential risk that juvenile Asian carp pose. The use of traditional sampling gears does have limitations, however, including habitat-specific gear efficiency and associated detection probabilities, dynamic environmental conditions, and patchy species distributions. Identifying habitats used by juvenile Asian carp may cast light on the effectiveness of past sampling efforts by the U.S. Fish and Wildlife Service (USFWS) and Illinois Department of Natural Resources (IDNR) thereby providing guidance for future monitoring. Additionally, understanding habitat use and environmental factors related to movement are valuable for future monitoring regimes.

**Objectives:**

1) Quantify movement distance and direction of juvenile Asian carp
2) Identify macrohabitat selection by juvenile Asian carp
3) Determine if juvenile Asian carp movement is related to temperature or flow
4) Determine a home range estimate for juvenile Silver Carp
5) Determine the age of tagged fish by taking calcified structures from a sample of fish
6) Perform genetic analysis to identify differences in movement and habitat use between Bighead Carp, Silver Carp, and hybrids

**Methods:**
Boat electrofishing will be used to collect fish for tagging. Fish will be placed in a hard foam jig during surgery, with a wet towel placed over the head and cool river water circulating over the gills. Transmitters, scalpels, sutures, and forceps will be soaked in 70% isopropyl alcohol prior to each surgery. Scales will be removed from the ventral left side of each fish anterior to the pelvic fin. A drop of betadine will be placed on the affected area prior to surgery. A 1-cm incision will be made in the ventral left side of the fish, anterior to the pelvic fin, taking care not to cut the inner peritoneum. Transmitters will be inserted through the incision into the musculature of the

body. Ultrasonic transmitters (180kHz, 0.65 g in air, 12.7 mm long, <2% body weight; Vemco Ltd., Halifax, Nova Scotia; Model V5) and radio transmitters (166 Mhz, 1.6 g in air, 15 mm long, <2% body weight; Lotek Wireless Inc., Newmarket, Ontario; Model NTQ-6-1) will be tested for recognition prior to surgery. Each transmitter provides a unique identification number when detected by the receiver. Vemco V5 acoustic have a minimum life expectancy of 113 days at a ping rate of one per minute, and NTQ-6-1 radio tags have a minimum life expectancy of 357 days at a ping rate of six per minute. Small nylon Oasis Brand (Mettawa, IL) non-absorbable sutures will be used to place a single suture in each fish after placing the activated transmitters. Fish will be placed into a small holding tank with river water until equilibrium was reestablished then promptly returned to the river. All water temperature and river discharge data will be collected from U.S. Geological Survey stream gauge #05558300 in Henry, IL.

Fish will be tracked throughout the study area by boat using both an omnidirectional portable hydrophone and receiver (Vemco Model VH180 Hydrophone and VR100), and radio receiver and Yagi antenna (Lotek Model SRX800) to quantify movement and habitat selection. Transects will be driven at idle speed parallel to river flow while an observer listens for tag detections. Shallow areas will be tracked by conducting transects roughly 500 m apart. Stationary hydrophones will be attached to navigation buoys via a 4 m section of 3/16 inch steel cable using two screw-tighten hose clamps. The steel cable will be swaged to have a loop at the ends and attached to the buoy ribs using a 5/16 inch steel quick-link.

**2017 Schedule:**

February – March 2016
- Gear preparation, planning field logistics, and crew scheduling

April – November 2016
- Fish sampling and tagging, telemetry array placement, active tracking, receiver downloads, genetic analysis, fish aging, and array maintenance

October – December 2016
- Collect telemetry gear and complete data analysis

December 2016 – January 2016
- Data analyses, prepare manuscript, and presentation

**Deliverables:**

Results will be incorporated in a MRWG presentation and peer reviewed publication.

# Des Plaines River and Overflow Monitoring

**Participating Agencies:** US Fish and Wildlife Service-La Crosse Fish and Wildlife Conservation Office (FWCO) (lead); US Fish and Wildlife Service-Carterville FWCO Wilmington Substation; Metropolitan Water Reclamation District of Greater Chicago, US Army Corps of Engineers, and Illinois Department of Natural Resources (field support)

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

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Introduction and Need:**
The upper Des Plaines River rises in Southeast Wisconsin and joins the CSSC in the Brandon Road Pool immediately below the Lockport Lock and Dam. Asian carp have been observed in this pool up to the confluence 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 samples were taken in 2012-2016). 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 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 the US Army Corps of Engineers (USACE) and consists of concrete barriers and 0.25 inch mesh fencing built along 13.5 miles of the upper Des Plaines River where it runs adjacent to the CSSC. It is designed to stop adult and juvenile Asian carp from infiltrating the CSSC, but it will likely allow Asian carp eggs and fry in the drift to pass. Opportunites for fish to pass occurred during high discharge events in 2011 and 2013 when water breached the physical barrier. USACE reinforced these and other low lying areas to prevent scouring during future lateral water transfers. It is important to understand the Asian carp population status, monitor for any potential spawning events, and determine the effectiveness of the physical barrier to inform management decisions and help assess risk of Asian carp bypassing the electric dispersal barrier.

**Objectives:**

1) Monitor Bighead Carp and Silver Carp populations and potential spawning activities in the Des Plaines River above the confluence with the CSSC.
2) Monitor for Bighead Carp and Silver Carp eggs and larvae around the physical barrier and monitor the effectiveness of the barrier during high flow events when water moves laterally from the Des Plaines River into the CSSC.

**Status:** This project began in 2011 and is ongoing. Between 2011 – 2016 9,696 fish have been collected via electrofishing (51.19 hours) and gill netting (134 sets; 17,584 yards). No Bighead or Silver Carp have been collected or observed. Seven Grass Carp have been collected. Six of these were submitted for ploidy analysis. All were determined to be triploid (sterile).

# Des Plaines River and Overflow Monitoring

**Methods:**

*Population Monitoring*

Population monitoring will include electrofishing and gill netting. The project will utilize pulsed-DC electrofishing. One or two dippers will dip all visible fish, with the exception of Common Carp. Incapacitated Common Carp will be counted. Gill netting will consist of short-term top to bottom sets. Mesh sizes will be 3 – 5 inch bar mesh. 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 Carp 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 two sampling events will be planned for 2017. These will encompass the potential spawning time frame and post-spawn. A water temperature threshold of 18˚C and elevated water levels will be used to determine the spawning time frame and sampling event.

Three backwater areas will be considered fixed sites and will be sampled during each sampling event, if accessible (Figure 1). All accessible shoreline will be sampled with electrofishing gear. Each fixed site will also include 600 yards of gill net during each sampling event. During the spawning time period, main channel habitats will be targeted with electrofishing.

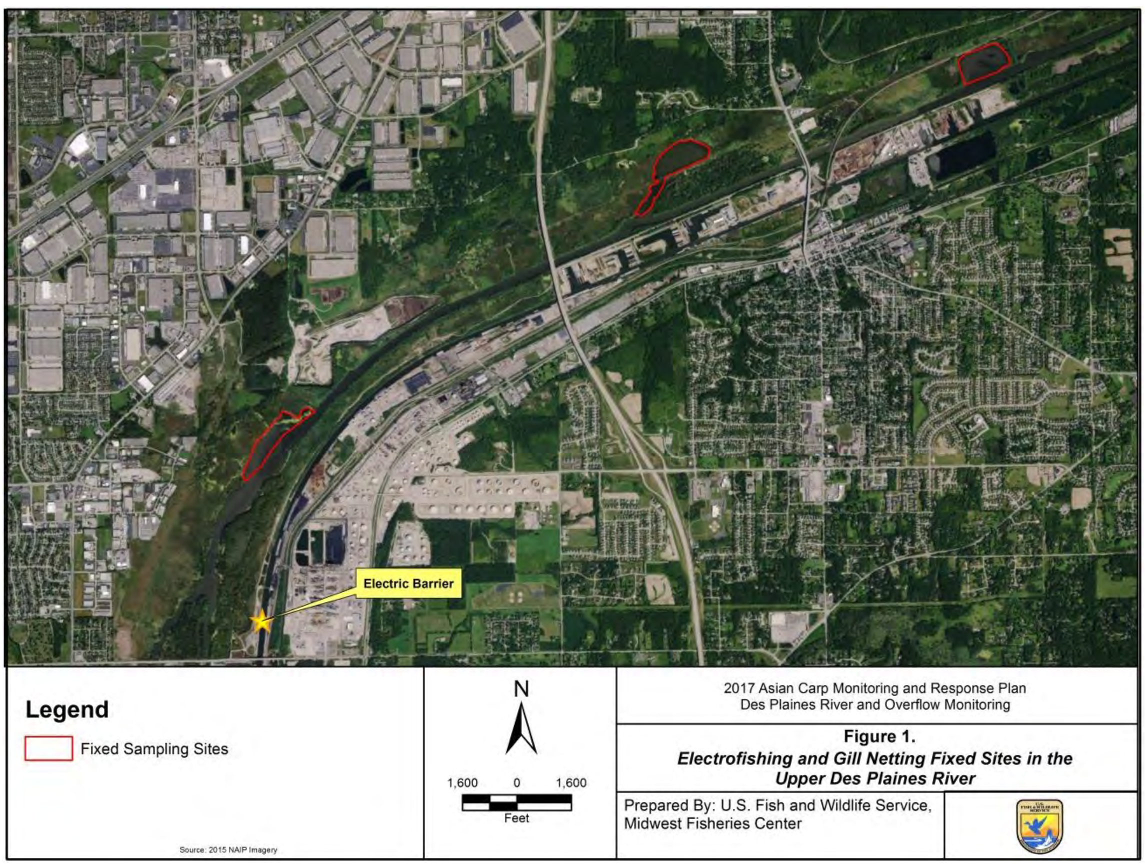


**Figure 1.** *Fixed site areas for electrofishing and gill netting in the upper Des Plaines River.*

## Des Plaines River and Overflow Monitoring

*Overflow Monitoring*
USACE personnel will monitor water levels for potential overtopping events. La Crosse FWCO will be notified of potential overtopping events and location. When it is safe and practical to do so, block nets may be used to temporarily close any breeches. Small mesh seines and ichthyoplankton trawls will be fished on the floodplain on both sides of the barrier fence near areas where water is flowing through the fence or where breeches have occurred, provided it can be done safely.

**2017 Schedule:**
Fixed sites will be sampled once each during spawn and post-spawn time frames. Additional sampling will be scheduled if: 1) Population status in Brandon Road pool significantly increases or 2) There are credible reports of Asian carp sightings in the upper Des Plaines River.

**Deliverables:**
Results of each sampling event will be reported for monthly sampling summaries. Captures of Bighead Carp or Silver Carp will be reported to MRWG immediately. Data will be summarized for an annual interim report and presented at the annual MRWG winter meeting.

# USGS Support for Implementation of MRP

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**Participating Agencies:**
USGS, IL DNR, USACE, USFWS, Southern Illinois University,Western Illinois University

**Location:** Illinois River

| ADDITIONAL INFORMATION |
|---|
| - Link to mapping tool |

**Introduction and Need:**
Intensified surveillance in the Upper Illinois River between Starved Rock Lock and Dam and the electric dispersal barrier using advanced and traditional telemetry methods (e.g., transmitting data from passive receivers in near real-time, enhanced acoustic arrays, manual tracking, and satellite-capable transmitters) will provide a greater understanding of the movements, habitats, and behaviors of Asian carp in areas of intense management that will allow for better application of control and containment tools. An abundance of data have been and are currently being collected in the Upper Illinois River, however, limited support exists to bring this information together to support management objectives and to inform further research and data collection. There is a need for development of databases, decision support tools, and targeted analyses of existing data to help maximize data and information usefulness for adaptive and integrated management of Asian carp in the intensive management zone.

**Objectives:**

1) Implementation and evaluation of new strategies for monitoring, surveillance, control and containment.
2) Development and evaluation of databases and decision support tools.

**Status:**
In 2016, five real-time telemetry receivers were deployed in the Upper Illinois River. Sites included Utica, IL, (below Starved Rock LD), Seneca, IL (Marseilles pool), Joliet, IL (Brandon Roads lock approach), Minooka, IL, (just upstream of Dresden Island LD), and at Lemont (above the electric dispersal barrier). The real-time receiver data stream was incorporated into the AC Telemetry database and visualization tool and on a USGS website. Development of an Asian carp database was initiated to house monitoring and assessment data for the upper Illinois River. Three additional receivers are scheduled to be deployed in summer 2017. Information from these receivers will be used to provide near real-time alerts to management agencies. In addition,

commercial catch data and Asian carp sampling data are currently being incorporated into an Asian Carp data portal (a database from which decision support tools can be developed).

**Methods:**

1) Real time telemetry, and telemetry database and visualization tool to inform removal and contingency actions:
   - Continue to add real-time receiver data to the Fish Telemetry website (http://il.water.usgs.gov/data/Fish_Tracks_Real_Time/)
   - Release a beta version of the telemetry database and visualization tool to collaborating management and research agencies (https://my-beta.usgs.gov/fishtracks/index)
   - Continuously incorporate the data stream from the additional real-time receivers into the AC telemetry database and visualization tool.
   - With management agencies, identify additional sites for placement of automated real-time receivers.
   - Deploy real-time telemetry receivers in the Upper Illinois River at a minimum of 3 of the following sites: Wilmington Dam on Kankakee River, downstream of the electric barrier, in Dresden Island Pool upstream of Rock Run Rookery, upstream of Brandon Road Lock and Dam, in Rock Run Rookery in Dresden Island Pool, or in Hansen Material Pit in Marseilles Pool.
   - Complete field testing of satellite-capable geotags for tracking AC to inform removal efforts in Dresden Pool.
   - Continue email summaries of river discharge, temperature, and "real-time" telemetry detections at key locations on the Illinois River to inform monitoring efforts.
   - Finalize the "real-time" telemetry alert system to management agencies and partners.

2) Database and decision support tools actions:
   - Continue the development of an AC database to house monitoring and assessment data for the Upper Illinois River.
   - Continue the development of a decision support tool to inform mitigation measures to minimize the entrainment of AC eggs and larvae by barge traffic.
   - Provide support, as requested, for the development of annual and contingency monitoring and response plans for the Illinois River including tabletop exercises of the contingency plans
   - Initiate the development of a habitat suitability decision support tool for AC using 2D hydrologic and water quality data.

**2017 Schedule:**

- Three additional "real-time" telemetry receivers will be deployed throughout the 2017 field season between May and October 2017.

- Finalizing telemetry database will be completed by October 2017.
- Real-time alert system will be available in Summer 2017.

**Deliverables:**

- Placement/deployment of real-time telemetry receivers in the Upper Illinois River at sites recommended by management agencies.
- Release of a beta version of the telemetry database and visualization tool to collaborating agencies/organizations

# MANAGE AND CONTROL PROJECTS

# Barrier Maintenance Fish Suppression

| ADDITIONAL INFORMATION |
|---|
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**Participating Agencies:** IDNR (lead); INHS, USFWS, USACE and USGS (field support); USCG, USEPA and MWRD (project support)

**Location:** Sampling to assess abundance of Asian carp may take place in the Lockport Pool of the CSSC between Lockport Lock and Power Station and the Electric Dispersal Barrier System (RM 291.0-296.1). Surveillance methods utilizing both hydroacoustic and sonar based surveys will occur between the Demonstration Barrier and Barrier 2A to assess initial abundances between the Electric Dispersal Barrier System. Traditional and novel techniques will then be deployed in cooperation or after the aforementioned surveillance technologies to clear fish from between the Barriers. The work area will be extended about 0.25 miles (0.4 km) in both upstream and downstream directions if a backup rotenone action is necessary to allow for chemical application and detoxification stations.

**Introduction and Need:** The USACE operates three electric dispersal barriers (Demonstration Barrier, Barrier 2A and Barrier 2B) for aquatic invasive species in the CSSC at approximate river mile 296.1 near Romeoville, Illinois. 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 Electric Dispersal Barrier System received approval to operate all three barriers concurrently to increase redundancy in the event of an unplanned shutdown. With this barrier operation protocol, IDNR will lead fish surveillance and suppression at the barrier whenever the barrier's system experiences a planned or unplanned shutdown that creates an opportunity for fish passage in the upstream direction. Based on 4 years of conventional fish sampling and eDNA monitoring in the CAWS upstream and downstream of the Dispersal

## Barrier Maintenance Fish Suppression

Barrier, fish suppression is necessary because there is a possibility that Asian carp could be present throughout this reach of the waterway. 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.

The Following is a generalized plan to provide fish suppression at the barriers in support of Barrier maintenance. Operations to clear fish may take from 1-5 days and may include any combination of traditional and novel collecting and driving techniques and, if necessary, a small-scale rotenone action. A plan is also included for intensive fish sampling to detect presence and assess abundance of Asian carp that may be in the canal immediately downstream of the barrier.

By selecting a cut-off of 300 mm in total length for physical fish removal, sub adult and adult Asian carp are targeted. Excluding young-of-year Asian carp from the requirement of physical removal is based on over four years of sampling in the Lockport Pool with no indication of any young of the year Asian carp being present or any known location of spawning. However, continued monitoring in the lower reaches of the Illinois Waterway in the spring of 2015 indicated that small Asian carp less than 153 mm were being collected progressively upstream over time. Juvenile Silver Carp were reported from the Starved Rock Pool beginning in April in substantial numbers with several individual captures of similar sized juvenile Silver Carp reported from the Marseilles Pool by October. These new records prompted resource managers to take a more conservative approach at the barriers by sampling all sizes of fishes between the barriers during a clearing event. It was determined that all fishes over 300 mm still be physically removed from the area and that fishes less than 300 mm be sub-sampled to ensure no juvenile or young of year Asian carp are present. While 2016 sampling results did not capture small Bighead Carp or Silver Carp upstream of the Starved Rock Lock and Dam, the same precautions will remain in place for 2017 to identify the species of small fishes at the barriers during a clearing event.

A key factor to any response is risk of invasive bigheaded carps being at or between the barriers. The MRWG (Monitoring and Response Workgroup) has taken a conservative approach to barrier responses in that there is little evidence that bigheaded carps are directly below the barrier, but with the understanding that continued work and surveillance below the electric barriers is necessary to maintain appropriate response measures. With budgetary costs, responders safety and surveillance findings in mind the MRWG will direct response needs based on best professional judgment. A barrier maintenance clearing event will be deemed successful when all fish >300 mm in total length are removed from the barrier or until MRWG deems the remaining fish in the barrier as a low risk and physical capture and identification has been made on an appropriate number of fishes <300mm in total length.

**Objectives:** The IDNR will work with federal and local partners to:

1) Remove fish >300 mm (12 inches) in total length between Barrier 2A and 2B before maintenance operations are initiated at 2B or after maintenance is completed at 2A by collecting or driving fish into nets from the area with mechanical technologies (surface noise, surface pulsed-DC electrofishing and surface to bottom gill nets) or, if needed, a small-scale rotenone action.
2) Assess fish assemblage <300 mm (12 inches) in total length between Barrier 2A and 2B for species composition to ensure Bighead Carp and Silver Carp juvenile or young of year individuals are not present. Physical capture gears focused on small bodied fishes such as electrified paupier surface trawls and surface pulsed-DC electrofishing could be utilized in support of this effort.
3) Assess the results of fish clearing operations by reviewing the physical captures and surveying the area between Barrier 2A and 2B with remote sensing gear (split-beam hydroacoustics and side-scan sonar). The goal of fish clearing operations is to remove as many fish (>300 mm in total length) as possible between the barriers, as determined with remote sensing gear or until the Monitoring and Response Workgroup (MRWG) deems the remaining fish in the barrier as a low risk. Fishes <300 mm in total length at the Barriers are deemed a low risk to be Bighead Carp or Silver Carp until further evidence from downstream monitoring suggests the presence of this size class upstream of Brandon Road Lock and Dam.

**Status:** Fish suppression in support of barrier maintenance began in 2009 and is on-going. There were eight occasions in 2016 in which the primary barrier (furthest downstream active barrier) experienced a loss of power to the water for an extended duration (ranging from 37 minutes to 18 days). The MRWG determined physical clearing actions between the barriers were not required due to a very low risk of Asian carp presence. There were two occasions in which additional monitoring actions were taken at the Electric Dispersal Barrier System to further support the MRWG decision.

The two monitoring actions performed at the Electric Dispersal Barrier System utilized either DC electrofishing or hydroacoustic sonar scans. The first monitoring response occurred 28-30 June in response to the 20 and 21 June Barrier 2A outages. USACE completed two 15 minute electrofishing runs on Tuesday and Wednesday (28-29 June; total of two runs one each day) to help assess the risk for Asian carp presence. No fish were observed or captured. USFWS Wilmington sub-office completed three replicate sonar runs between the barriers (30 June). Results from these scans indicated fish abundance in general was low between the barriers and no large fish were observed. USFWS completed another sonar scan of the area between the barriers on 14 September 2016. While this scan was not specifically requested by the MRWG it helped further assess the risk for fish presence between Barriers 2A and 2B following the outages in late August and early September. Results from this scan indicated no large fish and low abundance of small fish between Barriers 2A and 2B.

For more detailed results of fish clearing and sampling relative to barrier maintenance see the 2016 interim summary report document (MRWG 2017) and the Monitoring Asian carp Population Metrics and Control Efforts plan.

**Methods:**
*Project Overview* – The current approach to fish suppression at the barrier 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 mechanical collection or driving techniques will be used to move fish downstream out of the target area. A request for no flow conditions will be made to MWRD for a 2-hour period during surveillance and clearing operations. If mechanical clearing fails and there is a high risk for Asian carp to be in the barrier, response actions may be elevated to a small-scale rotenone to clear fish from the area. Finally, a plan is included for intensive sampling in the Lockport Pool downstream of the barrier to further measure the risk of an Asian carp presence at the barrier during maintenance. If downstream sampling suggests an increased risk for juvenile or young-of-year Asian carp presence at the Barriers, clearing and driving methods will be used for all sizes of fish if present between the barriers.

*Remote Sensing and Mechanical Clearing Operations* - Surveys will be conducted with split beam hydroacoustics and side scan sonar to determine if fish are present in the target area and to evaluate the success of mechanical fish clearing actions. Clearing will be considered successful when no fish larger than 300 mm are observed between the barriers or the MRWG deems the remaining fish in the Barriers as a low risk. By selecting a cut-off of 300 mm, fish targets will be limited to sub adult and adult Asian carp while excluding young-of-year. Excluding young-of-year Asian carp from the assessment is appropriate because there is no indication of their presence in the Lockport Pool based on over three years of intensive monitoring. Continued monitoring in the lower reaches of the Illinois Waterway in the spring of 2015 indicated that small Asian carp less than 153 mm were being collected progressively upstream over time as far north as RM 256.5 within the Marseilles Pool near Seneca, IL. This new data was reviewed in 2015 by the MRWG and it was suggested to continue with a clearing action if fish of any size were detected between the Barriers by remote sensing methods. Fish less than 300 mm would need to be confirmed as non-Asian carp species to be considered a successful clearing event. This same protocol will be maintained in 2017 even though 2016 sampling results found no small Bighead Carp or Silver Carp (<153mm) upstream of the Starved Rock Lock and Dam.

Multiple surveys are necessary to enhance confidence in results that fish are either present or absent from the area between the barriers. The principal remote sensing tools are split-beam hydroacoustics and side scan sonar. These gears are operated simultaneously and provide about 98% coverage of the waterway with just three passes of the barrier area (10- to 15-minute survey duration; see 2014 Barrier Maintenance Fish Suppression final report in MRWG 2014).

During a typical maintenance shutdown, a request will be sent to the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) to reduce or halt canal flows and then remote sensing gears will be deployed to survey the target area. The detection of fish of any size within the target area will initiate mechanical suppression actions. Mechanical suppression will target removal of all fishes greater than 300 mm and identify an appropriate sub-sample of fishes less than 300 mm. Activities will begin with surface pulsed-DC electrofishing in conjunction with noise generation to drive fish from the area and may include additional clearing techniques such as electrified paupier trawls, complex noise or other experimental fishing gear in the designated safety zone area. Figure 1 provides a map and description of a mechanical fish clearing operation at the Dispersal Barrier.

A second set of surveys will occur after mechanical removal operations have taken place with both barriers operational to assess the effectiveness of mechanical removal efforts. It is beneficial to have low flow conditions during remote sensing surveys to reduce interference with hydroacoustics scans caused by air bubbles entrained in the water column. Operators at MWRDGC have been helpful in modifying flows to assist with fish clearing operations. The presence of any large juveniles or adult fish (>300 mm) between the barriers that have been determined to be a high risk for Bighead Carp and Silver Carp by the MRWG, signifies that a rotenone action will likely be necessary to eliminate fish from the area. In contrast, a pre-planned rotenone action may be cancelled if mechanical suppression is shown to be successful.

Canal navigation closures may not be necessary for remote sensing surveys when one barrier is operating (2A or 2B); however, they will be needed for mechanical fish suppression activities. Typically, IDNR will make a request to USCG for safety zone closures to navigation in the vicinity of the barriers for 5 hours each morning (7:00 a.m. to 12:00 p.m.) on 4-5 days during the week of barrier maintenance fish clearing. A contingency week should also be planned in case equipment failure or inclement weather precludes operations. All closure requests will be made 45 days prior to a planned event.

# Barrier Maintenance Fish Suppression

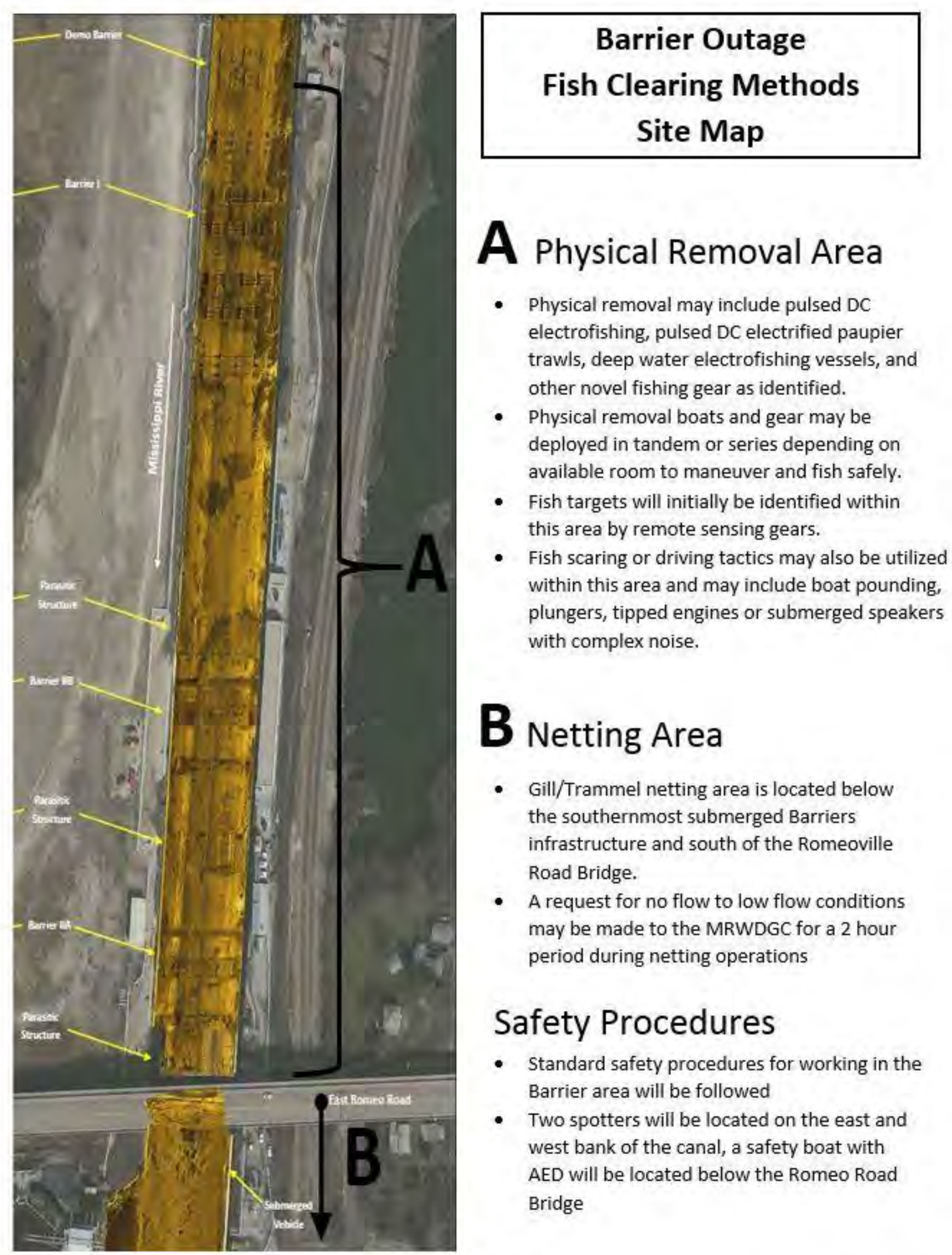


**Figure 1.** *Map and descriptions of a fish clearing operation at the Dispersal Barrier.*

## Barrier Maintenance Fish Suppression

*Small Scale Rotenone Action* - Rotenone is considered the fallback method for fish suppression should other clearing efforts prove to be unsuccessful. If necessary, rotenone will be applied from boats at a location just upstream of the arched overhead pipe that designates the upstream boundary of the barrier Regulated Navigation Area (RNA) Safety Zone enforced by the USCG (Figure 2). This will create a rotenone slug that will travel downstream and mix throughout the water column driving fish from the target area between barriers or killing them. The rotenone slug will be detoxified with liquid sodium permanganate pumped from boats at a location south of the Romeo Road Bridge (Figure 2). Unlike fish clearing methods discussed above, the effect of rotenone on fish is well known and has been documented, precluding the need for on-site evaluation. Barrier 2B will be turned down for maintenance once stable operation of Barrier 2A has been confirmed.

Although rotenone is an effective technique for controlling fish populations, there are several reasons for attempting physical removal of fish prior to rotenone application. Even the proposed small-scale rotenone action will be costly (estimated 150-250K), require extensive labor and permitting (minimum 40-50 persons; NEPA, NPDES, IDNR CERP, and Special Local Needs labeling), and require a longer duration canal closure than physical fish clearing (estimated 8-10 hours vs. 0-5 hours). In addition, barrier maintenance must occur regularly at approximately 6 month intervals. Developing methods that are less expensive and disruptive to canal users is beneficial to all involved stakeholders. In contrast to rotenone, physical clearing methods will not pollute waters or kill fish. Fish killed with rotenone must be collected and disposed of in an EPA approved toxic waste landfill. Perceptions that rotenone actions “poison” the water have been expressed by potential purchasers of commercially harvested Bighead Carp and Silver Carp from down river locations. These perceptions may adversely affect the success of Bighead Carp and Silver Carp commercial market development projects. Furthermore, while rotenone is used and neutralized successfully in most cases, there is the possibility that mechanical or environmental factors could allow rotenone to travel outside of the treatment area where additional aquatic resources could be unintentionally harmed. Finally, the USACE telemetry program to assess effectiveness of the barriers will be adversely impacted should tagged fish in the vicinity of the barriers be eradicated by rotenone.

A small-scale rotenone action will take place if remote sensing surveys indicate fish >300 mm long may be present between Barriers 2A and 2B and mechanical suppression measures fail to collect or drive fish from the area unless MRWG deems the remaining fish in the barrier as a low risk. All operations will occur between Hanson Material Service’s large barge slip (~RM 295.2) and a point approximately 0.25 miles (0.4 km) upstream of the arched pipeline (up to RM 297). No work is planned in the designated RNA, although it will be necessary for some boats to pass through the RNA to get to upstream chemical application stations (see Safety and Communication section below for RNA restrictions). IDNR will stand up an Incident Commend Structure (ICS) for a rotenone action and will work closely with USCG and USACE (possibly in

Unified Command) during all phases of project planning and implementation to ensure a safe and successful event. Detailed plans for a rotenone action will be prepared by IC staff, but a general overview of possible operations is presented here. In all, we anticipate a 3-4 day operation with 12-15 boats, 45-50 field crew, and 15-20 IC staff and support crew. This estimate does not include security and safety zone enforcement boats and crews. Day 1 will include travel to the site, gear preparation, and the collection of sentinel fish for detoxification monitoring.

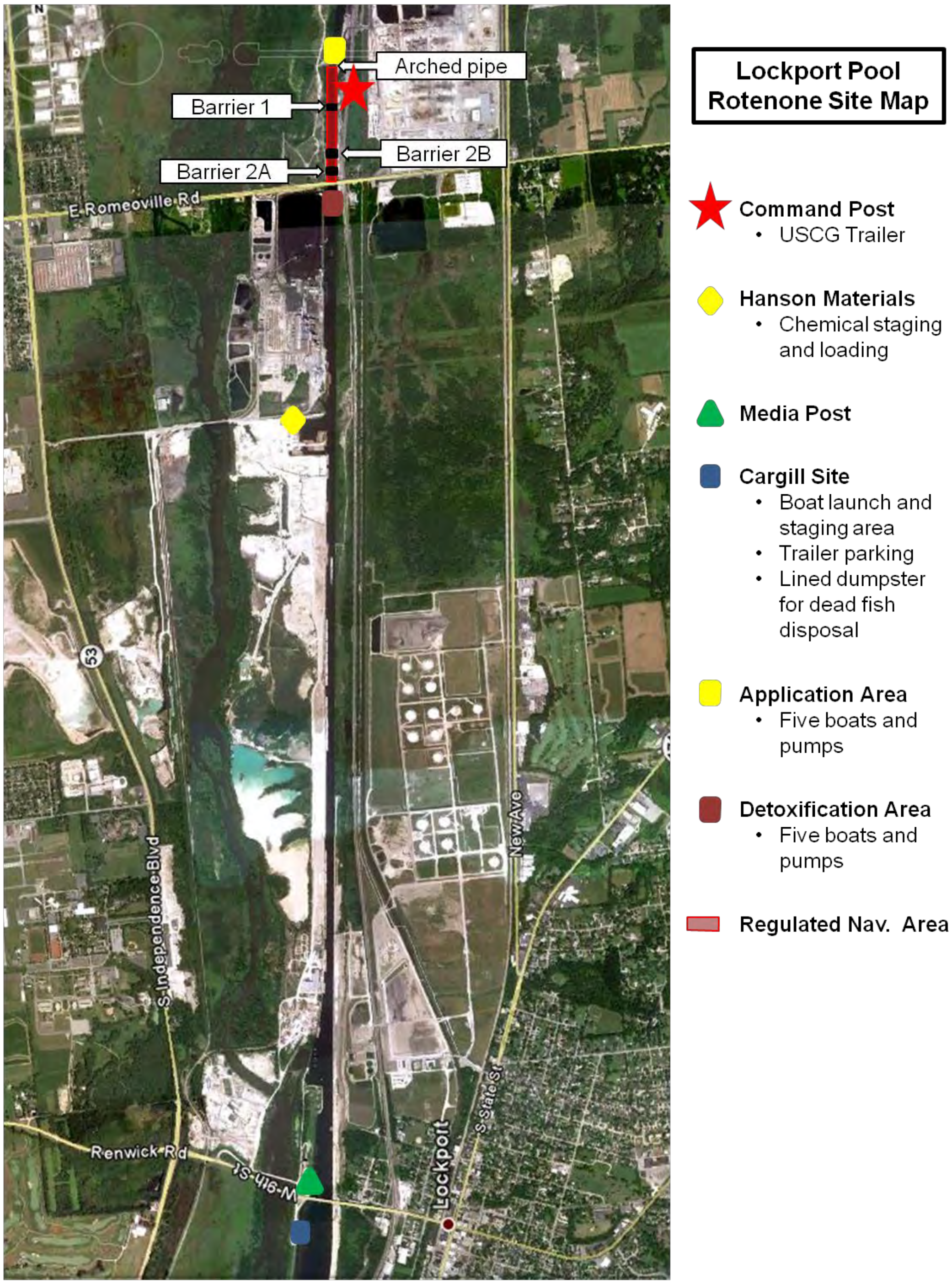


**Figure 2.** *A map of a small-scale rotenone operation to clear from the Dispersal Barrier.*

The bulk of the work will occur on the second day of operations and a 10-hour daytime canal closure will be necessary on this day. During Day 2, we will apply approximately 125 gallons of rotenone from boats (*N* = 5) located at a station upstream of the RNA. The chemical will be allowed to mix and flow downstream over the barriers killing fish or forcing them out of the area. Dye will be used to track the leading and trailing boundaries of the rotenone slug. Reactivation of Barrier 2A must be synchronized with the passing of the tail end of the rotenone slug through the barrier area to prevent movement of fish back into the treatment zone. Detoxification with approximately 750 gallons of sodium permanganate applied from boats (N = 3-4) will take place downstream of the barrier RNA. The exact location of the detoxification station will be based on consultations with personnel from the Midwest Generation power plant and their level of concern over permanganate entrainment through the plant cooling system. Cages with sentinel fish will be placed at several downstream locations in the Lockport Pool to ensure that detoxification was successful. Although a large kill is not anticipated, we will have 2-3 recovery boats and crews and one dumpster on hand for the collection and disposal of dead fish. Fish recovery will continue on the third and fourth day of the event, as needed.

*Lockport Pool Sampling* - Fish sampling may take place in the CSSC from Lockport Lock and Power Station to the downstream boundary of the barrier RNA (Figure 3) when deemed necessary by the MRWG. Sampling has been shown to be effective without waterway closures, but closures can be requested if sampling is to take place in the main navigation channel for extended periods of time. An example of sampling gears and anticipated effort from a fall 2010 multi-gear operation is included in the following table and text. All captured fish will be identified to species, counted, and a subsample of 20 fish per species per gear type will be measured (mm total length). Except for Asian carp, all captured fish will be returned live to the waterway. Any captured Asian carp will be held and immediately reported to the operations coordinator.

| Methods | Boat/crew | Number of sets, runs, or samples | Duration |
|---|---|---|---|
| | | | |
| Pulsed DC-electrofishing | 2 boats; 6 crew** | 6 hours total; 12 runs @ 30 min. per run | 2 partial days; three 30-min. runs/boat/day |
| Commercial fishers - trammel/gill nets @ 8’ x 600’; 3-5 in. mesh | 2 boats; 4 crew, and 2 IDNR observers | 1,000 yards (914.4 m) of net set and run/boat/day | 2 nights; 13-14 hour set |
| Experimental gill nets<br>6 @ 6’ x 300’; 0.75-5.0 in. mesh<br>3 @ 10’ x 150’; 0.75-2.0 in. mesh | 1 boat, 3 crew* | 6 nets set overnight in off channel areas | 1-2 nights; 13-14 hour set |
| Mini fyke nets (10) | 1 IDNR boat, 3 crew** | 10 nets set overnight | 2 partial days; 13-14 hour set |
| Telemetry | 1 boat, 4 crew | NA | 1-2 days |

*Same boat doing different sampling.

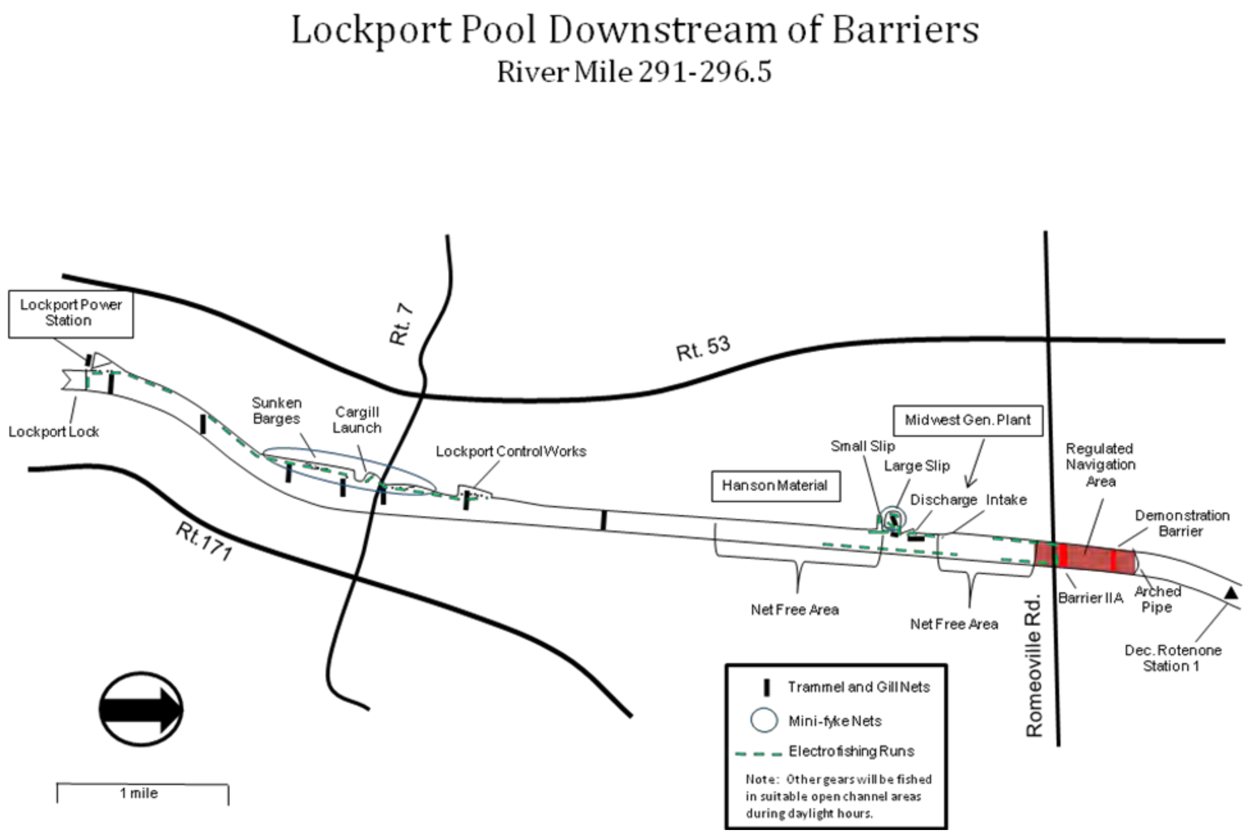


**Figure 3.** *Lockport Pool downstream of the Dispersal Barrier showing target areas for fish sampling operations.*

Sampling will require eight open deck aluminum boats that range in size from 18-24 feet (5.5 – 7.3 m) long. The staging, boat launch, and overnight boat storage area will be located at the Cargill Launch site on the west bank of the canal just south of the Route 7 (9th Avenue) Bridge (a.k.a. Carp Camp 1). Mini-fyke nets and experimental gill nets will be fished in shallower, near shore areas away from the navigation channel and in a portion of Hanson Material Services large slip during day and night hours. Daytime trammel net sets will be of short duration (15-20 minutes) and will have fish driven into the nets by “pounding,” a method commonly used by commercial netters. Short term sets will always be attended by a net boat crew and target areas throughout the reach known to hold concentrations of fish. Trammel nets may be set overnight in backwater and off channel areas to increase chances of catching fish.

*Safety and Communication* - Safety is a primary objective when operating in the electric field created by the barrier. Boats will be equipped with required safety equipment and floatation devices. Operators and crews will wear personal flotation devices while working on the water. For fish sampling operations, no work is scheduled to take place in or upstream of the barrier RNA. However, all requirements of the RNA will be adhered to should a crossing be necessary. The RNA extends from the arched pipe downstream to a point 450 feet (137.2 m) below the Romeo Road Bridge (designated by Sampson post #2 on the west bank).

First, any vessel crossing the Dispersal Barrier or entering the RNA will provide advance notification to the Coast Guard Captain of the Port Representative on scene at (630) 336-0296 or VHF-16. Additional RNA requirements include:

a) The vessel cannot be less in than 20 feet (6.1 m) in length.
b) The vessel must proceed directly through the RNA, and may not conduct any fishing operations, loiter, or moor within the RNA boundaries. Special permits will be requested for remote sensing surveys and mechanical fish suppression operations planned to take place within the RNA (see below).
c) All personnel must remain inside the cabin, or as far inboard as practicable. If personnel must be on open decks, they must wear a Coast Guard approved Type II personal floatation device.

The CSSC is a working ship canal and sampling crews should be aware of potential hazards in the waterway. Note that no boats should operate near barges that are being loaded. In addition to the hazard of being hit by material that misses the target, there are cables that move barges along the wall during loading. These cables may be under the water surface when slack, but can rapidly rise 4-5 feet (1.2-1.5 m) above the water when tightened. A rising cable could cause severe bodily injury or catch and easily flip a sampling boat. Crews should be aware of their surroundings and avoid potential safety hazards while sampling.

Communication among boats, staff, security, and shore command will be by marine radio or cell phone. A briefing before any crew enters the water will be held and will include a handout of crew leaders and cell phone numbers for each participating boat/crew. This handout will include a map of the sample reach. All boats will be equipped with numbered flags for identification on the water and hand-held marine radios operating on Channel 12 for the operation, unless emergency communication with USCG or Lockmaster is necessary (Channel 16, 14). Emergency contact numbers (local ambulance, fire/rescue service, Lockmaster, USGC contact information, and MWRD) will be included on the handout if needed for unforeseen reasons, yet the primary communicator to these services will be the operations coordinator or Incident Commander.

**Sampling Schedule**: Barrier maintenance may be required every six months to a year. The USACE determines the need for barrier maintenance and when maintenance will occur. The IDNR has requested that USACE provide a notice of maintenance dates 60 days in advance to allow time for planning and preparation. The USCG requires that Safety Zone applications be submitted 45 days prior to requested canal closure dates. By law, mariners must be informed about any non-emergency canal closures 30 days before the closure is to occur. Canal closures are required for the safety of mariners and operation crews.

**Deliverables:** Results of fish sampling events will be compiled for monthly sampling summaries. Fish suppression updates will be provided daily during operations. Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRP.

# Barrier Defense Asian Carp Removal Project
# 2017 Plan

**Participating Agencies**: IDNR (lead)

| ADDITIONAL INFORMATION |
|---|
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**Location:** The Barrier Defense Project will target the area between the Starved Rock Lock and Dam up to the Dispersal Barrier at Romeoville. The primary focus area will be the Starved Rock and Marseilles Pools.

**Introduction and Need:** This project uses controlled commercial fishing to reduce the numbers of Asian carp in the upper Illinois and lower Des Plaines rivers downstream of the Dispersal Barrier. By decreasing Asian carp numbers, we anticipate decreased migration pressure towards the barrier and reduced chances of carp gaining access to upstream waters in the CAWS and Lake Michigan. Trends in harvest data over time may also contribute to our understanding of Asian carp population abundance and movement between pools of the Illinois Waterway. The project was initiated in 2010 and is ongoing using nine contracted commercial fishing crews to remove Asian carp with large mesh (3.0 - 5.0 inch; 76.2 – 127mm) trammel nets, gill nets and other gears on occasion (e.g., seines, pound nets, and hoop nets).

**Objectives:** Nine commercial fishers will be employed to:

1) Harvest as many Asian carp as possible in the Starved Rock and Marseilles Pools. Harvested fish will be picked up and utilized by private industry for purposes other than human consumption; and
2) Gather information on Asian carp population abundance and movement in the Illinois Waterway downstream of the Electric Dispersal Barrier as a supplement to fixed site monitoring.

**Status:** Contracted commercial fishers and assisting IDNR biologists deployed 1,848 miles (2,974.1km) of gill and trammel net, 15.5 miles (24.9 km) of commercial seine, 88 pound net nights and 1,354.2 hoop net nights in the upper Illinois Waterway since 2010. A total of 85,710 Bighead Carp; 474,381 Silver Carp; and 3,226 Grass Carp were removed by contracted netting. The total weight of Asian carp removed was 2,504 tons. For more detailed results see the 2016 Interim Summary Report (MRRWG 2016).

**Methods:** Contract commercial fishing will take place from March through December. Contract commercial fishing will occur in the target area of Marseilles and Starved Rock Pools. This target area is closed to commercial fishing by Illinois Administrative Rule; therefore an IDNR biologist will be required to accompany commercial fishing crews working in this portion of the river. Six commercial fishing crews per week with assisting IDNR biologists will fish Tuesday through Friday of each week, 1-3 weeks each month of the field season. Fishing will occur in backwater areas known to hold Asian carp, main channel, and side channel habitats. Specific netting locations will be at the discretion of the commercial fishing crew with input from the IDNR biologist assigned to each boat. Large mesh (2.5 - 5.0 inch; 63.5mm-127mm) trammel and gill net will be used and typically set for 20 – 30 minutes with fish being driven to the nets with noise (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors tipped up). Nets will be occasionally set overnight off the main channel, and in non-public backwaters with no boat traffic. Biologists will enumerate and record the catch of Asian carp and identify the by-catch to species. Asian carp and common carp will be checked for ultrasonic tags and ultrasonic tagged fish and by-catch will be returned live to the water. All harvested Asian carp will be removed and transferred to a refrigerated truck and taken to a processing plant where they will be used for non-consumptive purposes (e.g. converted to liquid fertilizer). During each harvest event a representative sample of up to 30 of each Asian carp species (Bighead, Silver, and Grass Carp) from each pool will be measured in total length and weighed in grams to provide estimates of total weight harvested.

*Suggested Boat Launches for Barrier Defense Harvesting:*

Marseilles Pool – Stratton State Park Launch in Morris on the north side of the river.

Starved Rock Pool – Allen Park Launch in Ottawa off Route 71 on the south side of the river or Starved Rock Marina off of Dee Bennett Road on the north side of the river.

**Sampling Schedule**: A tentative sampling schedule for 2017 is shown in the table below.

| Week of | Agency | Week of | Agency | Week of | Agency |
|---|---|---|---|---|---|
| Feb 27* | IDNR | May 8 | IDNR | Sept 11 | IDNR |
| Mar 6 | IDNR | May 15 | IDNR | Oct 9 | IDNR |
| Mar 27 | IDNR | May 29 | IDNR | Oct 23 | IDNR |
| Apr 10 | IDNR | Jun 26 | IDNR | Nov 13 | IDNR |
| Apr 17 | IDNR | Aug 7 | IDNR | Dec 4* | IDNR |
| May 1 | IDNR | Aug 21 | IDNR | | |

* Weather permitting.

**Deliverables:** Results of each sampling event will be reported for weekly sampling summaries. Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRP.

# Spatiotemporal Changes in Asian Carp Abundance and Density to Target Management Actions and Control Strategies

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

**Location:** Illinois River from Dresden Island Pool to Alton Pool, along with associated backwaters, side channels, and tributaries.

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to interim summary

**Introduction and Need:**

Assessments of Asian carp population characteristics, abundance, and movements help to both refine and plan control and management efforts. Estimates of annual pool-wide densities determine whether population trajectories are decreasing through time and whether these patterns correspond with harvest (both commercial and contracted). Assessing densities in the upper river is necessary to determine the effectiveness of contracted harvest and deterrent efforts at keeping abundances low, thus minimizing the chance of the invasion front spreading upstream. Assessing densities in the lower river is needed to inform decisions about deterrent use at existing barriers and for informing contracted harvest efforts in the upper river. It is currently unclear whether Asian carp display density-dependent movement among pools. An observed increase in lower river Asian carp densities could indicate that increased movement into the upper river is soon possible and warrants the use of deterrent technologies (e.g., sound or $CO_2$) at existing barriers (e.g., Starved Rock Lock & Dam). Additional annual pool-wide density estimates will also reduce the amount of uncertainty in the Asian carp population model (see 2016 Monitoring and Response Working Group Interim Summary Report) which will improve predictions of how different harvest strategies affect the number of Asian carp at the invasion front.

In addition to annual density estimates, understanding how Asian carp densities change throughout the year, particularly near the invasion front, can help target efforts to key locations, with the goal of maximizing removal effectiveness while minimizing costs. Asian carp abundances in the upper pools (Starved Rock–Dresden Island) remain low and have decreased through time, especially at the invasion front in the Dresden Island Pool. As abundances decrease it will become increasingly necessary to identify key locations where Asian carp aggregate and to determine whether these high-density locations change throughout the year. It is also necessary to relate the environmental conditions at these locations to Asian carp densities in order to predict where and when Asian carp abundances are high. Determining these relationships will allow managers to take simple habitat measurements and decide which habitats should be harvested with contracted fishing.

# Spatiotemporal Changes in Asian Carp Abundance and Density to Target Management Actions and Control Strategies

While Asian carp abundances in the upper Illinois River can be reduced by harvest, individuals may immigrate from downstream, driving population dynamics in the system and ultimately influencing the numbers of Asian carp approaching the electric barriers. Therefore, it is important to monitor the numbers, direction (upstream vs. downstream), timing, and route (lock vs. dam) with which Asian carp move among river pools. Upstream passages through some dams are very rare and the rarity of these events makes them difficult to predict. For example, upstream passages through Starved Rock Lock & Dam occurred in 2013 and 2015 but not in 2014 or 2016. Additionally, most upper Illinois River dams have not previously been monitored closely enough to determine whether individuals pass through the dam gates or the lock chamber (with the exception of Starved Rock Lock & Dam in 2015 and 2016). Additional years of monitoring passages will improve the predictability of when Asian carp may approach and/or pass through dams and the route they use to pass through. Control measures (e.g., complex sound) are likely to be deployed at lock and dam structures to further limit Asian carp passage through locks and dams. Documentation of additional passages will help refine statistical models which have the potential to provide temporal and spatial (e.g., lock chamber vs. gates) targets for the deployment of control measures which will ultimately reduce costs.

Prospects for harvest-induced collapse of invasive Asian carp in the Illinois River is considered to be extremely poor and efforts have shifted toward reducing population size and minimizing the likelihood of Asian carp breaching the Electric Dispersal Barrier in the CAWS. Estimates of abundance and movement rates for Asian carp are vital to determine the location and degree of harvest needed. Abundance, movement rates, and other population information were recently used to develop a spatially-explicit stochastic length-structured Asian carp population model to inform management decisions about the spatial allocation of harvest, harvest intensity, and fish passage barriers (see 2016 Monitoring and Response Working Group Interim Summary Report). In 2017, this model will be improved and used to run harvest scenarios developed through discussions with the Illinois DNR.

**Objectives:**

1) Quantify Asian carp densities and biomass from the Alton to Dresden Island Pools to assess trends in population trajectories, and evaluate relationships between Asian carp densities and control efforts (e.g., harvest) to determine the effectiveness of harvest at reducing Asian carp abundance.
2) Quantify spatial and temporal variation in Asian carp densities in Marseilles and Dresden Island Pools throughout 2017 and relate densities to environmental conditions to inform harvest and control efforts.
3) Assess Asian carp movement throughout the Illinois River, especially in determining number and timing of passages through lock and dam structures to refine the timing and location of future control measures that may be deployed at dams, which are already existing pinch points.

4) Use the newly developed spatially-explicit stochastic length-structured population model to predict the number of Asian carp that would reach the vicinity of the CAWS under various harvest and movement scenarios in relation to a no-fishing scenario.

**Status:** Continues previous work by SIU that has intensivly monitored movement and density of Asian carp in the Illinois River since 2012. Data from these efforts has also been used to parameterize an Asian carp population model that has assessed a set of baseline harvest scenarios, with further simulations being determined through discussions with the Illinois Department of Natural Resources

**Methods:**

*Quantifying Asian carp density and relationships relative to habitat conditions*

To quantify fish densities, a combination of side-looking and down-looking hydroacoustic and side-scan sonar techniques will be used. To identify high-density areas to target with contracted harvest near the invasion front, hydroacoustic sampling will be conducted in main channel, tributaries, side channels, and backwater lakes in the Dresden Island and Marseilles Pools every other month between March and November. In order to inform hydroacoustic data, catch from ongoing efforts (e.g., contracted removal) in the Dresden Island and Marseilles Pools will be sampled for species identification and measured for length and weight. Density information will be relayed to the IDNR and MRWG within 30 days of sampling to inform harvest strategies.

Hydroacoustic surveys will also be conducted in the fall of 2017 throughout the Illinois River from Alton to Dresden Island Pools following the same protocol outlined above. Survey sites will be the same standardized locations sampled previously by SIU in order to add to the existing long-term (6 years as of 2016) dataset. Asian carp harvest data will be obtained from IDNR to determine whether population trends are related to harvest efforts.

Environmental conditions will be sampled during hydroacoustic surveys using a multi-parameter water quality sonde that will measure chlorophyll-*a* concentrations, blue-green algae concentrations, turbidity, water temperature, and dissolved oxygen at 1-minute intervals. Potential relationships between these environmental conditions and Asian carp densities will be evaluated with the goal of developing a statistical model to predict densities based on all or a subset of these habitat conditions.

*Movement data to identify pinch points and harvest areas*

SIU will also continue to maintain a network of acoustic telemetry stationary receivers in the river and in locks throughout the Illinois River and collaborate with other researchers involved in telemetry studies. 20 additional Asian carp will be implanted with acoustic telemetry tags as part of this study and 50 additional individuals will be tagged as part of another SIU/USGS study to increase numbers of tagged individuals present in the upper Illinois River (primarily Starved Rock and Marseilles Pools).

50 tags will be distributed among lateral habitats (e.g., tributaries, backwaters, side channels) in Starved Rock Pool as part of a USGS funded study to examine the environmental traits that drive Asian carp to use particular lateral habitats. Stationary receivers will be placed inside and just outside selected lateral habitats to determine residency in each lateral habitat. Residency will be compared among lateral habitat types and among lateral and main channel habitat. Residency will be related to environmental characteristics (e.g., chlorophyll, temperature, dissolved oxygen) to determine which environmental variables may contribute to Asian carp using a particular habitat, which can in turn be used to predict where Asian carp aggregations may occur. Ultimately these results will lead to more effective harvest and be used to validate findings from ongoing hydroacoustic density-environmental characteristic linkages.

*Simulation model to inform harvest*

The spatially explicit length-structured population model that tracks size- and pool-specific abundance through time (initially developed in 2016) will be improved and used to evaluate different harvest and movement scenarios of invasive Asian carp. The model will use updated Asian carp demographic parameters (i.e., growth, maturity, length-weight, movement) derived using data from all possible sources (state and federal agencies and universities) as they become available. The model will also be modified to incorporate variability in movement probabilities among river pools where, in 2016, it utilized fixed movement rates. This will be done by generating Markov Chain Monte Carlo (MCMC) estimates (10,000 iterations, 1,000 burn in, 4,000 tuning) for each movement probability.

Previous harvest scenarios evaluated include four levels of exploitation (0 to 0.9 by 0.3 increments) in the upper- (i.e., Starved Rock, Marseilles, Dresden Island) and lower pools (i.e., Alton, La Grange, Peoria). All possible combinations of upper and lower pool harvest were evaluated, resulting in a total of 16 different harvest scenarios, which includes the no-harvest scenario (see 2016 Monitoring and Response Working Group Interim Summary Report). However, these simulations will be performed again once variation in movement probabilities is incorporated. In addition, the model will be used to evaluate how the different harvest scenarios interact with reductions (e.g., 10%) in lower to upper pool movement rates. Other reasonable harvest scenarios will be obtained through discussions with the Illinois Department of Natural Resources. Under each harvest strategy, the abundance of Asian carp located in the Dresden Island Pool at the end of the simulation period will be estimated with confidence bounds based on parameter uncertainty. Finally, to examine the relative improvement of one strategy relative to others, abundance in the Dresden Island pool will be expressed relative to a no fishing scenario.

## Spatiotemporal Changes in Asian Carp Abundance and Density to Target Management Actions and Control Strategies

**2017 Schedule:**

Hydroacoustic surveys of Dresden Island and Marseilles Pools will begin in March and occur every other month until November. New acoustic telemetry tags will be deployed by May of 2017 and fish will be tagged prior to spawning. Stationary receiver downloads will occur three times and will likely occur in April, July and November. Fall hydroacoustic surveys of all Illinois River pools (Alton–Dresden Island) will occur in October and November. Model refinement and simulations will be on-going throughout 2017.

**Deliverables:**

Coupled hydroacoustic and environmental data will be used to more accurately determine environmental conditions that contribute to Asian carp density and biomass and how Asian carp density and biomass vary spatially and temporally at the edge of their invasion front. Results will consist of mean (and associated error) density estimates at each site and heat maps visually displaying Asian carp densities and environmental conditions in the Marseilles and Dresden Island Pools throughout the year. These data will also be used to create a statistical model predicting Asian carp density from environmental conditions. Fall density data will provide an estimate of the percent change in Asian carp densities throughout the Illinois River in 2017 compared to 2016, as well as to the previous five years.

Telemetry data will be used to determine the passage route (number of passages through lock vs. dam gates) as well as the environmental conditions and timing associated with upstream passages. These results will provide a spatial and temporal context for the deployment of control measures which will increase the efficiency (both costs and in preventing movement) of the control measures. Lateral habitat work will help determine what environmental conditions lead to Asian carp using a particular habitat which can help identify aggregations for harvest and make recommendations for the restoration of lateral habitats to limit their use by Asian carp. The simulation model will ultimately be used to inform management decisions and will be used to test a variety of management scenarios. Specifically, the model will provide recommendations for where and at what rates harvest should occur and where barrier technologies should be deployed to cause the greatest reduction in Asian carp approaching the CAWS.

# Understanding Surrogate Fish Movement with Barriers

**ADDITIONAL INFORMATION**

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Participating Agencies:** IDNR (lead); USACE and USFWS (field support)

**Location:** Sampling will take place in the Lockport Pool downstream of the Electric Dispersal Barrier, Brandon Road Pool, Dresden Island Pool, and Rock Run Rookery.

**Introduction and Need:** Based on the results of extensive monitoring using traditional fishery sampling techniques (electrofishing, trammel nets, gill nets, hoop nets and fyke nets), Asian carp are rare to absent in the area between the Electrical Dispersal Barrier and the Brandon Road Lock and Dam. Brandon Road Lock and Dam is a crucial pinch point to stop Asian carp from moving upstream to the Electric Dispersal Barrier. More effort will be placed in the lower Brandon Road Pool and the upper Dresden Island Pool to gain a better understanding of fish movement and passage around Brandon Road Lock and Dam. Based on monitoring data, the furthest upstream an Asian carp has been caught or observed is in Dresden Island Pool near river mile 278, which is 18 river miles downstream of the Electric Dispersal Barrier. Given the close proximity, Asian carp pose a real threat to the Electric Dispersal Barrier. The goal of this project is to use surrogate species to assess the potential risk of Asian carp movement through barriers (i.e. lock chambers and the Electric Dispersal Barrier). In addition, recapture rates of surrogate species will be used to determine sampling efficiency in the area between the Electric Dispersal Barrier and the Dresden Island Lock and Dam. In order to test the potential risk of Asian carp movement through barriers, surrogate species will be tagged in Dresden Island, Brandon Road, and Lockport Pools, and in Rock Run Rookery. Common Carp (*Cyprinus carpio*), Black Buffalo (*Ictiobus niger*), Smallmouth Buffalo (*Ictiobus bubalus*) and Bigmouth Buffalo (*Ictiobus cyprinellus*) will be used as surrogate species because they are naturalized and widespread throughout the Chicago Sanitary Ship Canal (CSSC) and the upper Illinois River. Common Carp are known to migrate relatively long distances and grow to large sizes that are approximate to those achieved by invasive carps (Dettmers and Creque 2004). Based on these characteristics, Common Carp should provide a good indicator of how Asian carp would respond to the various barriers if they were present. Similarly, *Ictiobus* spp. (Smallmouth, Bigmouth and Black) make good surrogates due to their migration pattern and large body sizes (Becker 1983).

**Objectives:** The IDNR will work with federal and local partners to:

1) Monitor the movements of tagged surrogate species in Dresden Island, Brandon Road and Lockport Pools and Rock Run Rookery to assess fish movement between barrier structures; and
2) Obtain information on recapture rates of surrogate species to help verify sampling success using multiple gear types.

## Understanding Surrogate Fish Movement with Barriers

**Status:** Sampling and fish tagging for 2017 will begin in March and end in December.

**Methods:** Sampling for Common Carp, Bigmouth Buffalo, Smallmouth Buffalo and Black Buffalo will be obtained through Fixed and Random Site Monitoring Downstream of the Barrier and Barrier Maintenance Fish Suppression projects (see Monitoring and Response Plan for Asian Carp in the Upper Illinois River of Chicago Area Waterway 2016). The sample design includes electrofishing at four fixed sites and twelve random sites in each of the three pools below the Electric Dispersal Barrier. Contracted commercial netting will include four fixed sites in each pool along with targeted sites of the commercial fishermen's choosing in Dresden Island, Brandon Road, and Lockport Pools each week sampled. Contracted commercial netting will also include targeted sets in Rock Run Rookery two times per month from March to December. Hoop and minnow fyke netting will take place at four fixed sites in each pool once per month. The fixed sites in each of the three pools are located primarily in the upper end of each pool below lock and dam structures, in habitats where Asian carp are likely to be located (backwaters and side-channels). Random electrofishing and contracted commercial fishing sites occur throughout each pool, including the lower portions of each pool as well as in the Kankakee River, from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River.

*Floy tagging and external marking procedure* – Floy tags will be anchored to all Common Carp, Bigmouth Buffalo, Smallmouth Buffalo and Black Buffalo collected. The length of each fish will be recorded in millimeters along with date, location, coordinates and an individual tag reference number. Floy tags will be anchored by inserting the tag gun needle into a fleshy area below the dorsal fin on the left side of the fish. The needle should be inserted at an acute angle to the body, angling the needle towards the anterior portion of the fish to allow the tag to lie along the side of the fish. The needle should pass the midline of the body but not penetrate the opposite side of the fish. If the T-bar is only held in by the fish's skin, the tag will be removed and the fish will be retagged. A secondary mark on the dorsal fin will be given to all fish collected in case of a floy tag malfunction. A fin clip will be given to all fish parallel to the body on the anterior portion of the dorsal fin to increase recognition upon recapture. In the event of a recapture, fish species and tag number will be recorded. If a floy tag is missing from a recaptured fish possessing a fin clip, a new tag will be inserted and the new number will be recorded.

**2017 Schedule**: Fixed and random site electrofishing in Dresden Island, Brandon Road and Lockport Pools will take place bi-weekly from March through November. Contracted commercial netting in Dresden Island Pool, Brandon Road Pool, Lockport Pool and Rock Run Rookery will take place bi-weekly from March through December. Hoop and minnow fyke netting will take once per month from March through November.

**Deliverables:** Results of fish sampling events will be compiled for monthly sampling summaries. Data will be summarized for an annual interim report and project plans updated for annual revisions of the MRRP.

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# Evaluation of Gear Efficiency and Asian Carp Detectability

Scott F. Collins, Steven E. Butler, David H. Wahl (Illinois Natural History Survey)

**Participating Agencies:** Illinois Natural History Survey (lead)

**Location:** Evaluation of sampling gears will take place through targeted sampling at multiple sites in the Illinois and Des Plaines Rivers, and the Chicago Area Waterway System (CAWS). Sites may be dropped, or additional sites added as needed in order to complete study objectives.

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Introduction and Need:** Multi-agency sampling and removal efforts using a variety of sampling gears are currently ongoing in the Illinois River and the CAWS to monitor and control populations of Asian carp. Sampling gears may vary widely in their ability to capture fish in proportion to their abundance, and may select for different sizes of fish. Evaluating the relative ability of traditional and alternative sampling gears to capture juvenile and adult Asian carp will help improve the efficiency of monitoring programs and allow managers to more effectively assess Asian carp relative abundance. Data gathered from effective gears can also be used to calculate detection probabilities for Asian carp, which would allow for determination of appropriate levels of sampling effort, and help improve the design of existing monitoring regimes. Results of this gear evaluation study will help improve Asian carp monitoring and control efforts in the Illinois River and the CAWS, and will contribute to a better understanding of the biology of these invasive species in North America.

**Objectives:** We are using a variety of sampling gears to:

1) Evaluate the effectiveness of traditional and alternative sampling gears at capturing juvenile and adult Asian carp;
2) Determine site characteristics and sampling gears that are likely to maximize the probability of capturing Asian carp;
3) Estimate the amount of effort required to detect Asian carp at varying densities with different gears;
4) Supplement Asian carp sampling data being collected by other agencies; and
5) Gather data on abundances of other fish species found in the Illinois River and CAWS to further assess gear efficiency, and examine potential associations between Asian carp and native fishes.

**Status:** Evaluation of sampling gears during 2011 – 2013 was only possible for adult Asian carp, as juvenile Asian carp were scarce or absent in the Illinois Waterway during these years. These efforts determined that pulsed-DC electrofishing was the most effective gear for capturing adult Silver Carp, whereas hoop nets and trammel nets were the most effective methods for capturing adult Bighead Carp. Hybrid Asian carp appeared to be vulnerable to both electrofishing and passive gears. Detection probability was found to be highly correlated with Asian carp catch per unit effort, with substantially lower probabilities of detecting both Silver Carp and Bighead Carp at upstream sites. Modelling exercises suggest that extremely large sampling efforts would be required to detect either Asian carp species in areas of very low abundance.

Successful spawning and recruitment to juvenile life stages allowed for evaluation of sampling gears targeting juvenile Asian carp during 2014 – 2015. Pulsed-DC electrofishing monitoring was conducted in the La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island Pools during summer months of 2014 and 2015. Juvenile Asian carp were only captured in the La Grange and Peoria Pools during these efforts. Subsequent sampling using all sampling gears occurred during summer and fall at multiple sites along the Illinois Waterway, resulting in the capture of 140,552 fish, including 67,991 Silver Carp and 3 Bighead Carp. Substantially more fish were collected in 2014 (n = 101,191) than 2015 (n = 39,358). In 2014, most juvenile Silver Carp were captured during sampling in late July or early August (n = 67,714), with substantially lower numbers being collected during late September (n = 167), despite equivalent sampling effort. High and rapidly declining water levels during the 2015 summer sampling period increased the difficulty of sampling and impacted gear effectiveness. Consequently, during 2015, the fewest Silver Carp were captured during July and early August (n = 10), whereas higher numbers were captured during September (n = 99). Mini-fyke nets captured the highest numbers of juvenile Silver Carp in both 2014 (n = 56,054) and 2015 (n = 60), and captured all three Bighead Carp in 2015. Beach seines were the second most effective gear for age-0 Silver Carp in 2014 (n = 7,211), but only captured a single individual in 2015. Electrofishing (n = 419 in 2014; n = 39 in 2015), purse seines (n = 4,063 in 2014; n = 1 in 2015) and cast nets (n = 135 in 2014; n = 0 in 2015) captured fewer numbers of juvenile Silver Carp, and were considerably less effective during 2015 than in 2014. Gill nets failed to capture any age-0 Asian carp in either year, but did collect age-1 Silver Carp in backwater lake habitats (n = 8) during 2015. In general, average catches for all gears, except gill nets, were higher in main channel habitats than in backwater lakes.

Only small numbers of age-0 and age-1 Asian carp were captured in 2016. Evaluation of mini-fyke nets and beach seines during 2016 resulted in the capture of 8,613 fish, including 336 age-0 Silver Carp. A total of 328 age-0 Silver Carp were captured in mini-fyke nets (65 in August; 263 in October) and 8 age-0 Silver Carp were captured in beach seine hauls (7 in August; 1 in October). Silver Carp body lengths were similar between mini-fyke nets and beach seines during August sampling. Average lengths of Silver Carp increased from 31 mm in August to 50 mm in October. Because only 1 Silver Carp was collected in the beach seine sampling during October, confident comparisons could not be made between gears for the fall sampling period.

## Evaluation of Gear Efficiency and Asian Carp Detectability

Pulsed-DC electrofishing primarily captured age-1 and older Silver Carp (≥ 215 mm; n = 201). Only a single age-0 Silver Carp (23 mm) was captured by pulsed-DC boat electrofishing during 2016.

**Methods:** During 2017, sampling efforts will continue to focus on juvenile Asian carp. Sampling will occur opportunistically during summer and fall at multiple sites throughout the Illinois Waterway. Whereas sampling for juvenile Asian carp focused on the lower Illinois River during 2016, sampling in 2017 will shift upstream to also include locations in the Starved Rock, Marseilles, and Dresden Island Pools where juvenile Asian carp may be rare or absent. Gears targeting juvenile Asian carp will be employed at select sites during appropriate times when juvenile Asian carp are considered likely to be present due to the presence of larval fish or due to observation of juvenile Asian carp by multi-agency sampling activities. Based on results of previous years, nearshore sampling will focus on the use of mini-fyke nets and beach seines to target age-0 Asian carp. Offshore sampling will employ pulsed-DC electrofishing, push frame nets, and hydroacoustic surveys to target larger age-0 to age-2 Asian carp. All captured fish will be identified to species and measured for total length and weight. Analyses will examine the ability of each gear to capture age-0 through age-2 Asian carp, and for their effectiveness at capturing other species of small-bodied fishes.

Detection probability modeling will continue to examine the probability of capturing Asian carp with various gears. Previous work has estimated the probability of detecting adult Silver Carp using pulsed-DC electrofishing and adult Bighead Carp using hoop nets at different sites throughout the Illinois Waterway. Future work will incorporate other sources of sampling data, examine additional gear types, assess multi-gear models, and explore detection probability for various native species. These analyses will be used to determine site characteristics and sampling gears that are likely to maximize the probability of capturing Asian carp, estimate the amount of effort required to detect Asian carp at varying densities, and use native species with similar traits as Asian carp to estimate potential differences in detection probabilities between the Illinois River and the CAWS. All analyses will be performed with PRESENCE and GENPRES software. Results will be reported to management agencies to inform them on gear choices and appropriate levels of sampling effort.

**Sampling Schedule**: In 2017, gear evaluation sampling will occur during summer and fall, as conditions permit, throughout the Illinois Waterway. Additional sampling may occur on an as-needed basis in cooperation with other sampling and monitoring efforts.

**Deliverables:** Preliminary results will be reported for monthly sampling summaries. Data will be summarized and project plans updated for annual revisions of the MRP.

# Gear Evaluation for Removal and Monitoring of Asian Carp Species

**Participating Agencies:** US Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office; Illinois Natural History Survey

| ADDITIONAL INFORMATION |
| --- |
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**Introduction and Need:**
Techniques to effectively capture all sizes of Asian carp at varying densities are integral to addressing management of these nuisance fish in Midwestern waters. The Columbia Fish and Wildlife Conservation Office (Columbia FWCO) have developed two trawling methods designed to target invasive carp: paupier and dozer trawl. When electrified, the paupier and dozer trawl can catch all sizes of invasive carp. Longitudinal differences in the densities of invasive carp populations in the Illinois River provide opportunity to evaluate novel gears. Determining the ability of novel trawling techniques to capture various sizes of Asian carp will contribute knowledge for developing monitoring protocols to guide and assess management actions.

**Objectives:**

1) Determine the ability for the electrified paupier, electrified dozer trawl, and traditional boat electrofishing to detect Asian carp in the Illinois River.
2) Evaluate the ability of the electrified paupier, electrified dozer trawl, and traditional boat electrofishing to estimate relative abundances and size structure of Asian carp.
3) Develop sample size efforts needed to determine detection and monitoring of Asian carp in the Illnois River.
4) Gain a better understanding of the population dynamics of Asian carp in the Illinois River.
5) Collaborate with Illinois Natural History Survey to identify sampling techniques best suited for detection and monitoring of juvenile Asian carp in the Illinois waterway.

**Methods:**
**<u>Sampling Sites</u>:** Sampling will be conducted from May–October 2017. Two innovative trawling methods and traditional boat electrofishing will be deployed twice per month in the Illinois River where one week will be spent downstream of Starved Rock Lock and Dam in the LaGrange Pool and the second week will be spent upstream of Starved Rock Lock and Dam in the Marseilles and/or Starved Rock pools. Sites in the LaGrange Pool will include but not be limited to: Chautauqua National Wildlife Refuge (RM 128), Quiver Lake (RM 122), Lake Matanzas (RM 114), and Lily Lake (RM 83). Sites upstream of Starved Rock Lock and Dam will include but not be limited to Hanson Material Service East and West Pits in the Marseilles Pool (RM 260).

# Gear Evaluation for Removal and Monitoring of Asian Carp Species

All sites are known to have persistent populations of Silver Carp but size classes and densities differ longitudinally along the Illinois River.

**Gears:** A suite of gears will be utilized to capture Asian carp in Illinois River backwaters. Following is a list of sampling techniques and specifications for the Columbia FWCO.

*Dozer trawl*: The dozer trawl is a trawl that is pushed in front of the boat. It has a 2 meter (m) wide by 1 m tall rigid frame attached to a net with 38 millimeter (mm) mesh at the opening reducing to 6 mm at the cod end. The net extends under the boat and is 2.5 m long. A modified boom with three cable anode droppers extends 3 – 4 m in front of the dozer frame, similar to a traditional electrofishing boat. Electrofishing settings are 30 hertz and 15% duty cycle.

*Traditional electrofishing*: Standard boat electrofishing set-up consists of two spider array anodes each attached to a boom extending approximately 1.5 meters in front of boat. Two crew members on the bow of the boat use 6 mm mesh dip nets to capture fish. Electrofishing settings will be set at 30 hertz and 15% duty cycle.

*Paupier*: The paupier is an electrified butterfly trawl that consists of a 4.0 m wide by 1.5 m deep rigid frame on either side of the boat with the nets consisting of 38 mm mesh in the body reducing to 6 mm mesh in the cod. Three cable dropper anodes are affixed to booms 3-4 m in front of the paupier frames. An 18 centimeter (cm) hemisphere anode is suspended in each paupier frame approximately 1 m back from the net opening. Electrofishing settings will be 30 hertz and 15% duty cycle.

**Collaborations:** Collaborations with Illinois Natural History Survey will take place three weeks throughout the year in the LaGrange Pool. Data will be compared using daily labor estimates ($LD_i$) as described by Collins et al. (2015, 2017). Additional analysis of catch rates, size distributions, and other measures will be compared where appropriate.

**Data Collection:** The full suite of gears (dozer trawl, traditional electrofishing, and paupier) will be deployed in both the near shore (<10 m from bank) and open water zones (>10 m from bank) in each sampling location. Random starting points for all gears for both the near shore and open water zones will be generated in ArcGIS. For near shore transects, a random direction (i.e., left or right) will be determined and each gear will fish for five minutes running parallel to shore for the entire duration. For open water transects, a random direction (i.e., 360 degrees) will be determined and each gear will be fished in a straight line in that direction for five minutes. Gear order will be randomized to minimize influences of time of day.

Four transects for each gear will run in both the near shore and open water zones. Sampling technique, total time and whether the transect is near shore or open water will be recorded for each deployment. All fish will be identified to species and enumerated for each run. The total length (mm) and weight (gram) of all Asian carp will be recorded for four random samples using each gear for each day. The total length (mm) of up to 10 Gizzard Shad and total length (mm) and weight (g) of Asian carp at each 100mm length group will be collected from the remaining four transects of each gear. All Asian carp less than 200mm will be measured for total length (mm) and kept frozen. All unknown specimens will be preserved and identified at a later date. A subsample of 30 Silver Carp per month in each pool (N = 360) will be frozen and taken back to the lab for age, growth and fecundity estimation.

**Gear Evaluation Data Analysis:** Catch rate (fish/5 min) and size distributions of Silver Carp will be evaluated for each gear. Catch rate data will be $\log_{10}(x + 1)$ transformed to correct for proportionality between the standard deviations and means and compared via repeated-measures analysis of variance (ANOVA) with a Tukey's test for multiple comparisons. Differences in length-frequency distributions will be determined among gears using nonparametric Kolmogorov-Smirnov tests. All analyses will be performed in R (R Development Core Team, 2013) and statistical significance for all analyses is declared at $\alpha = 0.05$.

Sample size estimates for monitoring efforts will be obtained using two methods. A targeted sampling of 125 stock size individuals is suggested by Quist et al. (2009) to appropriately assess a population. Therefore, sample sizes needed to obtain 125 stock size (250–450mm; Phelps and Willis 2013) Silver Carp will be calculated for each gear. Sample sizes will also be calculated for each gear using a resampling procedure to determine the number of deployments needed to achieve a relative standard error of 25% or less around the mean catch rate of stock size Silver Carp for 80% of the samples based on Koch et al. (2014).

Naive occupancy values of targeted invasive carp species/life stage combinations will be calculated for each gear by dividing the number of sites where they were detected by the total number of sites surveyed. Naive occupancy values will then be used to determine the probability of detecting a single species/life stage with a particular number of samples ($P_{detection}$).The $P_{detection}$ values generated can then be used to determine the amount of effort needed for 95% confidence of presence-absence at each site (Pellet and Schmidt 2005; MacKenzie et al. 2005).

**Silver Carp Population Dynamics Analysis:**

Fulton condition factor (K; Pope and Kruse 2007) will be used to assess the overall condition of Asian carp at different sizes and pools. Differences between size classes and reaches will be assessed using an ANOVA with a Tukey's test for multiple comparisons.

Length-weight relationships of Asian carp will be $\log_{10}$ transformed for linearity. Differences in length-weight regression between pools will be tested using an analysis of covariance (ANCOVA) with discharge as the covariate (Pope and Kruse 2007).

Lapilli otoliths from the frozen subsamples will be used for aging. Removal and setup methods will be as described by Seibert and Phelps (2013). Silver Carp growth will be estimated using a von Bertalanffy growth curve (Isley and Grabowski 2007). Age- and length-of-maturity and sex ratios will be determined for Asian carp in each pool. Instantaneous mortality will be estimated using a catch-curve model (Miranda and Bettoli 2009).

Fecundity estimation will be determined on frozen subsamples collected. Oocytes in 1-g samples from each mature ovary will be counted and the mean will be multiplied by the weight of both ovaries for an estimation of fecundity (Crim and Blebe 1990; Williamson and Garvey 2005). Spawning periodicity will be analyzed with the Gonadosomatic Index (GSI; Crim and Glebe 1990). Linear least-squares regression will be used to determine associations between total length and GSI and weight and GSI. An ANOVA with Tukey-Kramer honestly significant difference (HSD) will be used to test differences in mean GSI between months and pools.

**Project Schedule**:
March–April 2017
Gear preparation, field logistics planning, crew scheduling

May–October 2017
Field sampling, data entry

Novemeber 2017
Data entry, data analysis

December 2017–February 2018
Annual report generation

**Deliverables:**
Project updates and preliminary results will be reported in monthly summaries to MRWG. Annual report to the MRWG in winter 2017–2018. Oral presentation will be given to fellow workgroup members and at the annual 2017 MRWG meeting.

**Literature Cited**:
Collins, S. F., S. E. Butler, M. J. Diana, and D. H. Wahl. 2015. Comparison of pound nets, hoop nets, and fyke nets in backwater lakes of the Illinois River. North American Journal of Fisheries Management 35:1219-1225.

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# Unconventional Gear Development

Scott F. Collins, Steven E. Butler, David H. Wahl
(Illinois Natural History Survey)

**Participating Agencies:** INHS (lead), USGS and IDNR (project support)

| ADDITIONAL INFORMATION |
| --- |
| - Link to mapping tool<br>- Link to 2016 Interim Summary Report |

**Location:** Great Lakes trap (pound) nets will be deployed at select sites in Illinois River backwaters and other off-channel habitats to collect adult Asian carp for various research, monitoring, and control purposes. Additional new gears or combination systems may be evaluated at appropriate sites as needed. Additional sites may be added as necessary in order to complete study objectives.

**Introduction:** Traditional sampling gears vary widely in their ability to capture Asian carp. Many of these gears may have limited effectiveness for detecting Asian carp in areas of low population density without expending extremely high levels of sampling effort. Evaluation of novel sampling gears and capture methods is warranted to enhance the efficiency of monitoring programs and increase capture rates of Asian carp for control efforts. Capture efficiency and size selectivity of these new methods is being evaluated and compared with selected traditional gears to determine the utility of these techniques for monitoring and controlling juvenile and adult Asian carp.

**Objectives:** To enhance sampling success for low density Asian carp populations, and increase harvest of Asian carp for control efforts, we will:

1) Investigate alternative techniques to enhance capture of Asian carp in deep-draft channels, backwater lakes, and other areas of interest for Asian carp monitoring and control purposes; and
2) Evaluate unconventional gears, capture methods, and combination system prototypes in areas with varying Asian carp population densities.

**Status:** During 2011 – 2013, large (2 m) hoop nets were found to capture fewer fish of all species, as well as fewer numbers of all Asian carp taxa compared to standard (1 m) hoop nets. We therefore recommended against the use of large hoop nets for Asian carp monitoring purposes. Surface-to-bottom gill nets were found to capture higher numbers of all Asian carp taxa than standard gill net configurations during four-hour sets, and experiments testing the effectiveness of driving fish into surface-to-bottom gill nets suggested that drives using pulsed-DC electrofishing captured higher numbers of Silver Carp and Bighead Carp than either control sets or drives using traditional pounding. During 2014, additional experiments were conducted to test the effectiveness of driving Asian carp into surface-to-bottom gill nets. Analysis of combined 2013 and 2014 data indicates that drives using pulsed-DC electrofishing captured more total fish (all taxa) than drives using traditional pounding or control sets. Catch rates of Silver Carp were highest in electrofishing treatments, which were nearly 4 times higher than control sets, but similar to traditional pounding treatments. Bighead Carp catch rates were highest in traditional pounding treatments, although these were not significantly different than control or electrofishing treatments. A majority of all fish and of Silver Carp captured in surface-to-bottom gill nets were captured in the smaller mesh panels, particularly the 6.4 cm mesh size. However, Bighead Carp appear to be more vulnerable to larger mesh sizes, and drives using pounding in particular captured higher numbers of Bighead Carp in the 10.2 cm mesh panel. Driving fish into surface-to-bottom gill nets therefore appears to be an effective method for capturing Asian carp and other fishes.

Pound nets were set at Lake Calumet, the Hanson Material Service Pit, and Lily Lake during 2012 – 2015. Pound nets captured large numbers of fish at all sites, including large catches of Asian carp at the Hanson Material Service Pit and Lily Lake. No Asian carp were captured at Lake Calumet, and pound nets were repeatedly vandalized or became twisted and unfishable from wave action at this location. During 2015 and 2016, pound nets were deployed for multiple two-week periods in collaboration with USGS to test the effectiveness of feeding attractants and sound stimuli for capturing/deterring Asian carp. During these trials, attractants were tested by deploying the attractant at one net, and using a second net as a control. Pound nets were checked daily during each set, at which times all captured fish were removed from the pots for identification and measurement. INHS also assisted ILDNR personnel using pound nets at the Hanson Material Service pit (Marseilles Pool) for monitoring and removal of Asian carp.

Analysis of 2012 - 2014 data from Lily Lake and the Hanson Material Service Pit indicated that catch rates of fishes, including Asian carp taxa, were consistently higher in pound nets in comparison to traditional entrapment gears set in backwater habitats (Collins et al. 2015). Average nightly catch of all fish species was, on average, 134 times higher in pound nets than in hoop nets and 5-6 times higher than in fyke nets. Overnight catch rates of Bighead Carp were 113 times higher in pound nets than in hoop nets, and 41 times higher than in fyke nets. Average Silver Carp catch rates were 3,200 times higher in pound nets than in hoop nets, and 360 times higher in pound nets than in fyke nets. Pound nets tended to capture larger Bighead Carp (mean ± SD = 829 ± 103 mm) than hoop nets (619 ± 99 mm) or fyke nets (681 ± 140 mm). However, sizes of Silver Carp did not differ significantly among pound nets (582 ± 62 mm), hoop nets (572 ± 75 mm), and fyke nets (557 ± 78 mm). Estimation of the labor hours required to deploy, maintain, and retrieve various entrapment gears indicates that pound nets are considerably more cost effective for capturing Asian carp than fyke nets or hoop nets due to the high catch rates relative to the labor hours invested (Collins et al. 2015). These data suggest that the use of pound nets in backwater habitats is an effective means of capturing large numbers of Asian carp relative to conventional approaches.

## Unconventional Gear Development

**Methods:** During 2017, alternative pound net configurations will be tested to evaluate methods to maximize the effectiveness of this gear type, particularly in open-water areas where blocking entire channels is not feasible. Potential configurations that may be tested include sets perpendicular to shore, parallel to shore facing both upstream and downstream, and tandem pound net sets. Pound nets will also be set at appropriate backwater habitats on the Illinois Waterway in continued collaboration with USGS personnel testing the effectiveness of feeding attractants and sound stimuli for attracting/deterring Asian carp. Experiments will involve comparisons of pound nets set with and without the feeding attractant or sound stimuli. All captured fish will be identified to species, and measured for total length and weight. Results of these trials will be reported by USGS. INHS will also deploy pound nets as needed to assist other agencies with Asian carp monitoring and control activities, and help to train personnel from other agencies in the deployment, maintenance, and retrieval of pound nets.

**Sampling Schedule**: In 2017, pound nets will be set opportunistically at appropriate backwater lake areas during spring through fall. Additional sampling may occur at other sites on an as-needed basis in cooperation with other sampling and monitoring efforts. Sampling in subsequent years will be conducted as required to meet future research and monitoring objectives.

**Deliverables:** Preliminary results will be reported for monthly sampling summaries. Data will be summarized and project plans updated for annual revisions of the MRP.

**Literature Cited:**

Collins, S.C., S.E. Butler, M.J. Diana, and D.H. Wahl. 2015. Catch rates and cost effectiveness of entrapment gears for Asian carp: a comparison of pound nets, hoop nets, and fyke nets in backwater lakes of the Illinois River. North American Journal of Fisheries Management 36:1219-1225.

Collins S.F., M.J. Diana, S.E. Butler, and D.H. Wahl. 2017. A comparison of sampling gears for capturing juvenile Silver Carp in river-floodplain ecosystems. North American Journal of Fisheries Management 37:94–100.

# Monitoring Asian Carp Using Netting with Supplemental Capture Techniques

Trevor Cyphers and Rebecca Neeley; U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Participating Agencies:** U.S. Geological Survey Columbia Environmental Research Center (field and technical support)

**Location:** Monitoring effort to determine the presence front of the adult Asian carp population will take place in Brandon Road and Lockport Pools.

**Introduction and Need:**
Asian carp are highly invasive species that have been expanding their range in the U.S. due to rapid growth rates, short generation times, and dispersal capabilities (DeGrandchamp 2003; Peters et al. 2006; DeGrandchamp et al. 2008). Large populations of Asian carp reside in the lower and middle reaches of the Illinois River. Natural resource managers are concerned about the potential invasion of Asian carp into the Great Lakes due to the connection of the Upper Illinois Waterway (IWW) to Lake Michigan, (Conover et al. 2007). If Asian carp gain entry into Lake Michigan they could pose a significant threat to fisheries by competing with established, economically and recreationally important species for limited plankton resources (Sparks et al. 2011). Kolar et al. (2007) noted that the most probable pathway for gaining access to the Great Lakes is through the Chicago Sanitary and Shipping Canal (CSSC). Therefore, the CSSC may be the key to stopping large numbers of Asian carp from expanding their range into Lake Michigan and the Great Lakes (Conover et al. 2007). The Electric Dispersal Barrier, operated by the U.S. Army Corps of Engineers (USACE), is in place to block the upstream passage of Asian carp through the CSSC. However, the Electric Dispersal Barrier is subject to unexpected mechanical failures or other unplanned outages. This highlights the need to better define the distribution and demographic characteristics of Asian carp in the upper IWW.

With established Asian carp populations in the lower and middle Pools of the Illinois River, increased monitoring efforts have been implemented by federal, state and private agencies within the Upper Illinois River and the Chicago Area Waterway System (CAWS). The current monitoring effort by federal and state agencies has included using traditional gears (gill netting, electrofishing, hoop nets, pound nets, etc.) in an attempt to capture Asian carp. This project was established to aid current sampling efforts and to increase the probability of detecting Asian carp in Pools closest to the Electric Dispersal Barrier via the use supplemental capture techniques.

## Monitoring Asian Carp Using Netting with Supplemental Capture Techniques

**Objectives:**

1) Determine (in conjunction with ongoing projects) the distribution, abundance and presence front of adult Asian carp in the upper Illinois River.
2) Utilize mobile split-beam hydroacoustic surveys to determine target areas that appear to contain larger fish.
3) Determine the effectiveness of night netting for adult Asian carp in Brandon Road and Lockport Pools.

**Status:**
Netting for adult Asian carp with the addition of supplemental capture techniques (electrofishing, complex sound, and commercial technique) was first implemented and analyzed for efficiency during the 2015 field season. In 2015, field crews collected 802 total fish, 451 of which were adult Asian carp. Electrofishing was the most efficient technique at driving fish into nets, with a catch per unit effort (CPUE) of 6.12 fish/100 yards of net. No adult Asian carp were captured above RM 276 in Dresden Island Pool.

During the 2016 field season, increased effort was applied to standardize supplemental capture techniques to determine which techniques were most effective at herding Asian carp into nets, thus increasing harvest rates. Technique effectiveness was assessed in Marseilles and Starved Rock Pools at 7 standardized fixed sites. In total, 55 net sets were deployed totaling 17,400 yards of gill and trammel nets resulting in the capture of 1,394 total fish, 1,229 of which were Asian carp or 88.2%. Of the three capture techniques that were used, electrofishing had the highest CPUE based on 100 yards of net for Asian carp captured (9.8 ± 4.1), followed by complex sound (8.1 ± 1.8) and commercial technique (5.4 ± 1.3), respectively. Analysis of catch data suggested there was no significant increase in catch effectiveness of Asian carp based on the supplemental capture technique that is utilized.

Moving forward, we intend to move away from the analysis of supplemental capture techniques and focus on implementing nets with capture techniques, particularly those that were effective, in Brandon Road and Lockport Pools with the intent of capturing adult Asian carp.

**Methods:**
Gill and trammel nets will be deployed throughout Brandon Road and Lockport Pools in predetermined areas based on river current, topography and suggestions from commercial fisherman contracted by the Illinois DNR. Upon net deployment, GPS coordinates will be recorded and a supplemental capture technique will be implemented for 10 minutes throughout the study site and used to drive fish into nets. Electrofishing will be given preference over other capture techniques as it yielded the highest CPUE over the past two years of analysis. Other supplemental capture techniques will be utilized if electrofishing is not available based personal and equipment availability. Floating trammel nets of 150 feet long by 8 feet deep with varying square bar mesh sizes will be used to target main channel habitats in Brandon Road and Lockport

Pools when applicable. Asian carp captured within Brandon Road Pool and above will be measured for length (mm), weight (g), sexed and lapilli otoliths will be taken for microchemistry and aging. Personnel from the Illinois Department of Natural Resources will be contacted and informed of any Asian carp captures. Native fish captured during sampling events will be enumerated and released.

**Supplemental Capture Techniques**

*Electrofishing* – Electrofishing as a supplemental capture technique will involve using pulsed-DC with the intent of driving fish into nets. Electrofishing runs will be standardized for 10 minutes and stunned fish will be collected by dip-netters with priority given to Asian carp over native species when time and personnel allow.

*Complex Sound* – In the past, complex sound as a herding technique was completed with the assistance of field personnel from U.S. Geological Survey Columbia Environmental Research Center (CERC). Moving forward, this technique will be used based on collaboration and availability of crews from USGS- CERC. Two acoustic underwater transducers (Lubell LL9162T) will be mounted to the boat bow and lowered into the water column. Transducers will be plugged into an amplifier employed with a complex tone audio file of a 100 HP boat motor. Complex sound will be standardized and implemented for 10 minute increments at sample sites.

*Non-directional Sound (Commercial Technique)* - A technique frequently employed by commercial fishermen, will involve driving fish into nets by noise created from pounding on boat hulls with rubber mallets and revving tilted boat motors. Non-directional sound will be standardized and implemented for 10 minute increments at sample sites.

**Targeted Sampling using Hydroacoustic Surveys**

Mobile split-beam hydroacoustic surveys used to analyze fish density and distribution in Brandon Road and Lockport Pools are completed monthly by USFWS personnel at the Carterville FWCO Wilmington substation. Using a holistic approach, real-time data from surveys will be observed and conveyed to USFWS personnel with netting gear to target areas that appear to contain larger fish. Captures from nets will be compared to split-beam data in order to determine effectiveness.

**Night Sampling**

In 2017, netting with supplemental capture techniques for Asian carp will be implemented at night in an attempt to increase capture efficiency. This will be done in Brandon Road and Lockport Pools in areas that are primarily targeted during day sampling events.

## Monitoring Asian Carp Using Netting with Supplemental Capture Techniques

**Fish Sampling Frequency and Effort**

Sampling will begin in April 2017 and go through October 2017, with one week per month dedicated to sampling the adult Asian carp presence front in Brandon Road and Lockport Pools. Effort will be completed in conjunction with hydroacoustic pool surveys. Night sampling will be implemented for two weeks during the 2017 sampling season and increased based on success.

**2017 Schedule:**

March 2016
Gear preparation, field logistics planning, crew scheduling

April - October 2016
Field sampling, data entry, data analysis

November 2016
Complete data analysis

December 2016 - January 2017
Annual report generation

**Deliverables:**

An annual report to the MRWG in winter 2017-2018, as requested. Any findings of Asian carp in areas significantly upstream towards the electric barrier will be reported immediately to Todd Turner, USFWS Assistant Regional Director-Fisheries or Charley Wooley, USFWS Deputy Regional Director - Region 3, and the MRWG.

# Barrier Defense Using Novel Gear

**Participating Agencies:** US Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office (lead), and Illinois Department of Natural Resources (field support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Introduction and Need:**
Since 2015, the Columbia FWCO electrified paupier has contributed to monthly mass removal of Asian carp from the Starved Rock and Marseilles pools of the upper Illinois River. This ongoing effort, referred to as Barrier Defense, was established to reduce the number of Asian carp downstream of the electric dispersal barrier. Contracted commercial fishermen routinely deploy gill nets in backwater habitats and other areas with low to no flow targeting concentrations of Asian carp for removal. Gill nets are generally 3–4" mesh and inherently capture large Asian carp. The electrified paupier contributes to Barrier Defense by removing a wide size range of Asian carp in a variety of habitat types. In 2017, Barrier Defense with the electrified paupier will entail two protocols: (1) mass removal and (2) diel sampling.

**Objectives:**

1) Remove adult and juvenile Asian carp from the Starved Rock Pool of the upper Illinois River with the paupier and a tender boat.
2) Determine paupier cost-effectiveness as a removal tool in terms of labor hours.
3) Determine optimal diel period for Asian carp removal using the paupier.

**Methods:**

**<u>Gears</u>:**
The following are the Columbia FWCO specifications for the electrified paupier technique to be used in 2017 Barrier Defense efforts.

*Electrified paupier:* Modeled after shrimp trawlers in the Gulf of Mexico, the paupier has metal frames measuring 3.7 meters (m) wide by 1.5 m tall extending off the port and starboard with 52 millimeter (mm) bar mesh nets attached to the frames tapering back approximately 7 m towards the stern to a 20 mm bar mesh cod end. Three cable dropper anodes are affixed to booms 3–4 m in front of the paupier frames. An 18 centimeter (cm) diameter hemisphere anode is suspended in each paupier frame approximately 1 m back from the net opening. Anodes are powered with an 82-amp ETS box.

*Tender boat:* A heavy duty all welded aluminum john boat, measuring 7.3 m long, 183 cm wide at floor width, and 63.5 cm deep will assist with removal efforts in 2017.

**Data collection:** Sampling will be conducted one week per month May–December, 2017. The following are two distinct protocols to be used in those efforts.

*Mass removal:* One week each in June, August, September, October, and December will be committed to mass removal efforts upstream of the Starved Rock Lock and Dam, targeting a variety of habitats (backwater, tributary, and channel boarder) with known aggregations of Asian carp. Electrofishing time will vary depending on habitat length and/or when nets reach maximum capacity of fish. A tender boat will accompany the paupier to retrieve catch, process fish, and record data. All fish will be identified to species and enumerated. The first fifty Silver Carp collected each day will be measured in total length (TL; mm) and weight (g). All Bighead and Grass Carp TL and weights will be recorded. Electrofishing time, boat preparation (e.g., set up of electrical equipment), and crew size will also be recorded.

*Diel sampling:* One week each in late spring, summer, and fall will be committed to diel sampling in backwater areas. A paupier crew will sample two hours before and seven hours after sunset. A minimum of 16, five minute transects will be deployed per sample event. Transect location and direction will be random, generated using ArcGIS.

All fish will be identified to species and enumerated. Following each sample, the first ten Silver Carp in each 100 mm length group will be measured in TL and weight. Additional Silver Carp will be assigned to 100 mm length groups. All Bighead and Grass Carp TL and weight will be recorded. Additionally, diel hour, season, backwater, transect depth, water temperature, turbidity, conductivity, and electrofishing pedal time will be recorded.

**Data analysis:**
*Mass removal:* Silver Carp biomass will be estimated by extrapolating average weights to the number collected. Bighead and Grass Carp biomass will be calculated using known weights. Bycatch (percent Silver Carp) will be assessed.

Daily labor hour estimation, *LD*, will be calculated as

$$LD = \frac{\sum[(E_i * C_i) + P_i]}{n}$$

where $E_i$ is the daily electrofishing pedal time, $C_i$ is the field crew size, $P_i$ is time to prepare electrofishing equipment at the start of the day, and $n$ is the number of days sampled. Cost-effectiveness will be calculated as the ratio of average daily catch and *LD*. Travel time between sites is dependent on locating aggregations of Asian carp and the time required to handle individual fish for data collection is dependent on the protocol. Because neither of those factors are dependent on the gear, they will be excluded from evaluating the paupier as a removal tool (Collins et al. 2015 & 2017).

*Diel sampling:* Silver Carp catch rate (fish per 5 min sample), size distribution, and bycatch (percent Silver Carp) will be evaluated. Silver carp catch rates will be modeled using generalized linear regression.

**Project Schedule:**
March 2017
Gear preparation, technique refinement, field logistics planning, crew scheduling

May–December 2017
Field sampling, data entry

November 2017
Data entry, data analysis

December 2017–February 2018
Annual report generation

**Deliverables:**
Project updates and preliminary results will be reported in monthly summaries to MRWG. Annual report to the MRWG in winter 2017–2018. Oral presentation will be given to fellow workgroup members at the annual 2017 MRWG meeting.

**Literature Cited:**

Collins, S.F., S.E. Butler, M.J. Diana, and D.H. Wahl. 2015. Catch rates and cost effectiveness of entrapment gears for Asian carp: A comparison of pound nets, hoop nets, and fyke nets in backwater lakes of the Illinois River. North American Journal of Fisheries Management 35:1219–1225.

Collins, S.F., S.E. Butler, M.J. Diana, and D.H. Wahl. 2017. A comparison of sampling gears for capturing juvenile Silver Carp in river–floodplain ecosystems. North American Journal of Fisheries Management 37:94–100.

# Alternative Pathway Surveillance in Illinois – Law Enforcement

Brandon Fehrenbacher & Heath Tepovich
Illinois Department of Natural Resources

**Participating Agencies:** Illinois Department of Natural Resources (lead)

**Location:** Surveillance and enforcement efforts will focus in the Chicago Metropolitan area and areas throughout Illinois.

**Introduction and Need:** There is a substantial risk of invasive species being introduced into the Great Lakes basin and other waterway systems through the illegal trade and transportation of aquatic species. The Invasive Species Unit (ISU) is the Illinois Department of Natural Resources' specialized law enforcement unit that works directly with the Division of Fisheries to detect and apprehend anyone involved with possessing or transporting prohibited aquatic species. The unit consists of two officers with over twenty-six years of combined law enforcement experience with the Illinois Conservation Police. Past arrests and discoveries made by the Unit related to invasive species law violations show the need for such a unit.

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2016 Interim Summary Report

**Objectives:** Build upon the capabilities of the IDNR Invasive Species Unit. Collaborate with other agencies and Department personnel to prevent the spread of invasive species by human means we propose to:

1) Continue to educate and assist Conservation Police Officers regarding invasive species regulations and enforcement techniques.
2) Monitor the Internet for advertisements of illegal invasive species.
3) Look for illegal sales or importation of invasive species within the bait industry.
4) Use the portable environmental DNA testing machines to detect any traces of Asian Carp during bait shop and bait truck inspections.
5) Conduct surveillance operations and random checks of live fish markets.
6) Carry out fish truck inspections for all live shipments we encounter.
7) Enforce importation regulations of live aquatic life coming into Illinois.
8) Complete training relevant towards invasive species investigations.
9) Represent our agency and Unit at relevant conferences and joint operations related to invasive species issues.

**Status:** This project is on-going and has been extended into 2017. The Unit investigates all matters of concern brought to their attention or discovered while performing their duties. ISU is constantly on the lookout for new threats to our environment and continues to work closely with other agencies to share information and resources.

**Methods:**
*Intelligence gathering and Surveillance* - Being sensitive in nature, surveillance activities, operations and specific arrest details may be omitted from this document. The ISU utilized Internet searches, leads provided by other agencies and the public, surveillance, on-site observations, record reviews, and information provided by those within the aquatic life industry to successfully meet objectives.

**Sampling Schedule**: Surveillance and enforcement activities will take place at yet to be determined times 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.

**2017 – 2018 ISU Work Activities:** Investigations into illegal activities associated with any invasive species will be conducted as they are encountered. The Unit will build upon any newly developed information to guide future project planning.

# RESPONSE PROJECTS

# Upper Illinois Waterway Contingency Response Plan

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

**Introduction and Need:**
This Contingency Response Plan 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 Contingency Response Plan 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 Contingency Response Plan 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 barrier system and in the CAWS, upstream of the Lockport Lock and Dam (River Mile, RM 291). The ACRCC relies on electric barriers 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. As a result, this Contingency Response Plan reduces pressure by Asian carp on the electric barriers.

Previous response operations have been successfully conducted by the ACRCC in response to detections of potential Asian carp above the electric dispersal barriers, including the 2010 response in the Little Calumet River where piscicide was applied to over two miles of waterway.

In addition a response was conducted in 2009 to protect the electric barrier system during scheduled maintenance in which five miles of the CSSC was treated with a piscicide.

This enhanced Contingency Response Plan expands the geographic scope of existing contingency planning efforts, as well as the scope of potential tools to be utilized in such an event. This plan also considers barrier operations and status and is complementary and additive to the existing response plan in the MRP.

Asian carp distribution has not changed significantly in either abundance or location in the upper IWW since individuals were discovered in the Dresden Island Pool in 2006. This 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 the electric barrier or that they may become inadvertently entrained in areas between barge tows and propelled through locks. Such entrainment has not been observed or demonstrated for either Bighead or Silver Carp.

**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 waterbody. Each pool is defined as the body of water between two structures; such as a series of lock and dams. 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 electric dispersal barrier are as follows: Lockport- N/A, Brandon Road-5.5, Dresden Island-10.5, Marseilles- 26, and Starved Rock-49.5.

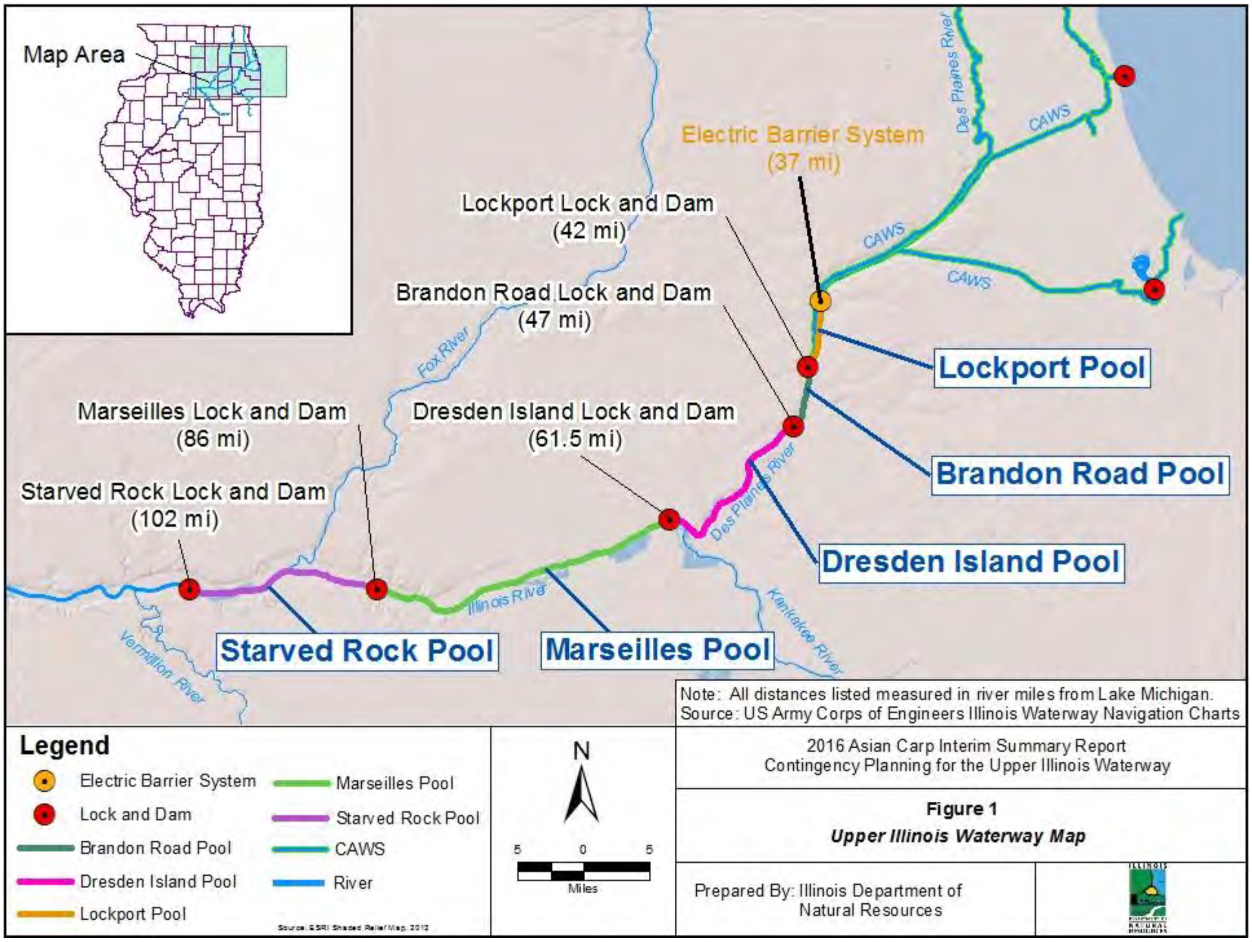



**Figure 1.** *Illinois Waterway Map and Profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.*

**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, predict future Asian carp scenarios, and develop a plan to direct appropriate, prudent, and contingency response actions as needed in the upper Illinois Waterway. 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.*

To meet this goal of the contingency plan 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 agreed-to terms, and is designed to be effective and transparent. This plan will also provide for open and transparent communication with the public and special stakeholder groups.

This is a living document that will evolve over time as information changes and additional tools are developed e.g., ozone, hot water, microparticles, water jets, pheromones/other attractants, $CO_2$, or other unspecified tools).

**Additional Resources Considerations:**
This contingency plan allows for deployment of aggressive monitoring or control tools deemed most appropriate by the MRWG, the ACRCC, and the governmental agency holding locational or operational jurisdictional authority. For example, one of the most aggressive responses in Asian carp prevention occurred in 2009, when approximately 6 miles of the Chicago Sanitary and Ship Canal was treated with a fish piscicide (Rotenone) in support of a barrier 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 Contingency Response Plan for the MRWG to consider, the Illinois DNR reserves the right to authorize the use of piscicide in the CSSC or other developing technologies such as $CO_2$ or complex noise via speaker installation, when it determines the need is prudent. These technologies may be considered if convincing evidence is provided that suggests effective Asian carp control may be obtained.

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. 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 Contingency Response Plan will be operational in spring 2016, building upon and complementing existing response plans, and will be updated, as needed, based on new scientific information and available technical capacity for Asian carp control.

Data collected since 2011 have heightened 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 benchmark year 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 benchmark 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 May 2017, 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 (source unknown)
- **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.

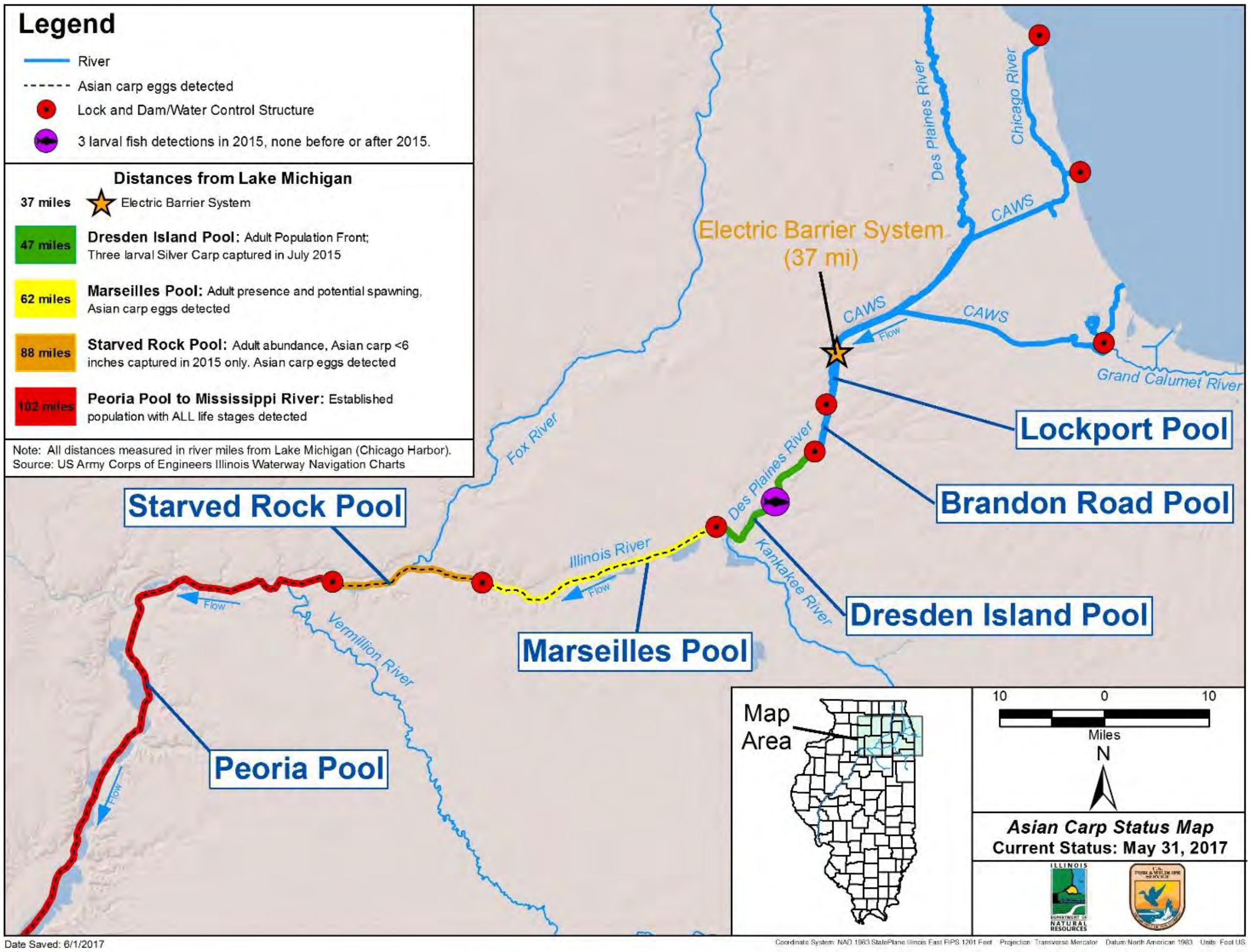



**Figure 2.** *Asian Carp Status Map. Current Status: May 31, 2017.*

**Planning Assumptions:**

These planning assumptions anticipate potential realistic situations and constraints on ACRCC and 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 Contingency Response Plan Asian Carp refers to Bighead and Silver Carp.

*Command, Control, and Coordination Assumptions*

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

*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 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 respons, 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 electric dispersal barrier). 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 electric barriers (barrier functionality), directly impact to 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. Such an event could also trigger a response action.

*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. Additionally, the group recognized that identified response options are recommendations only. An action(s) could be more or less intense based upon the nature 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 a response.

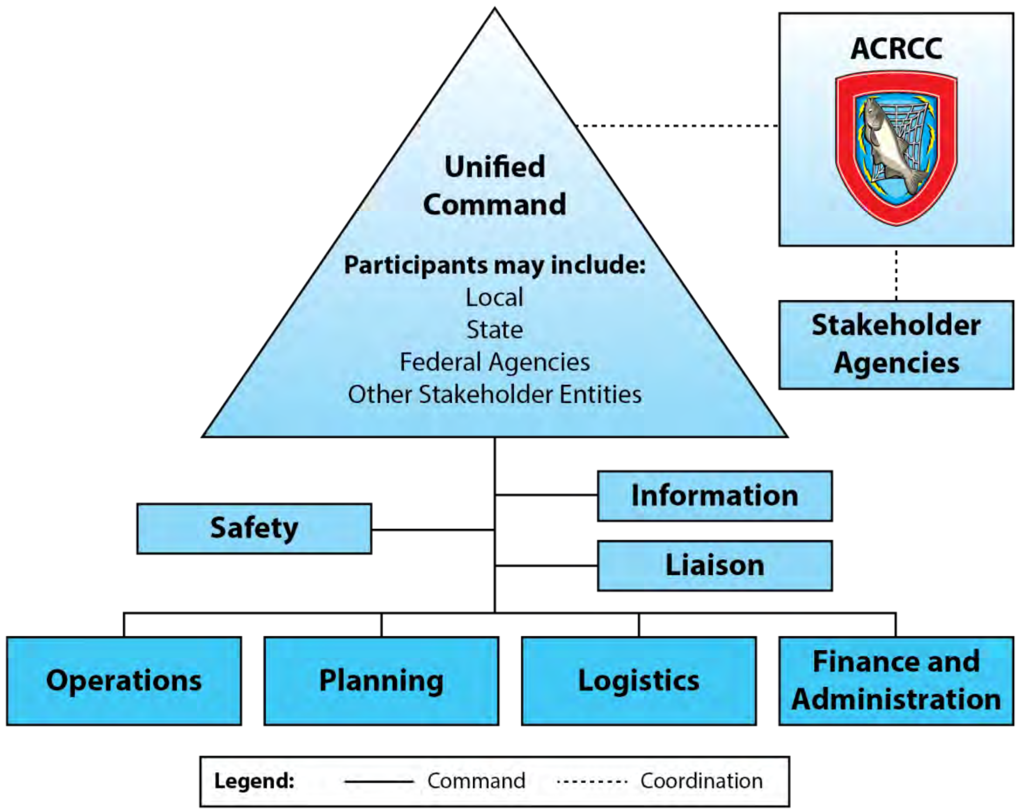


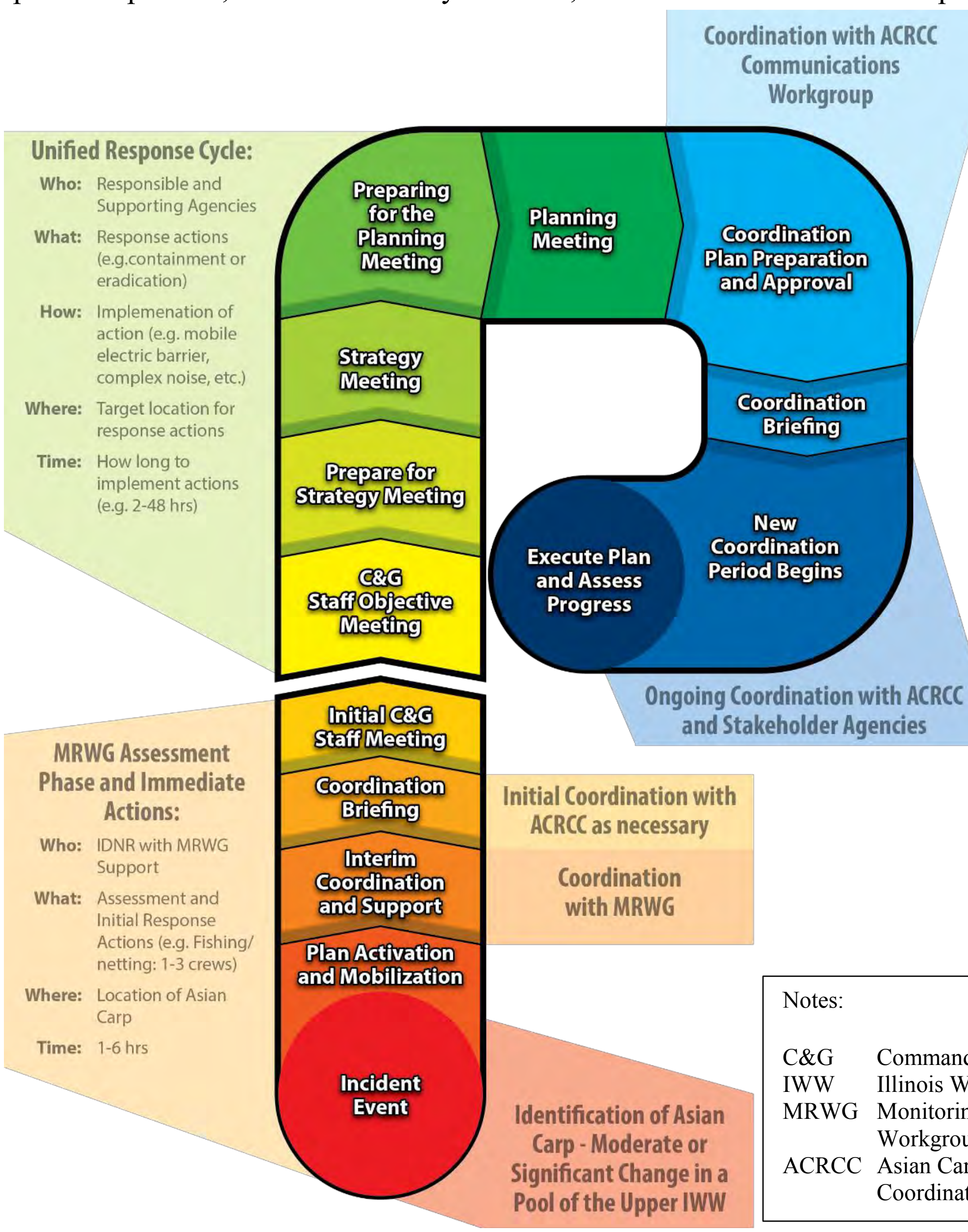

**Figure 3.** *Unified Command Organization Structure*

**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 |

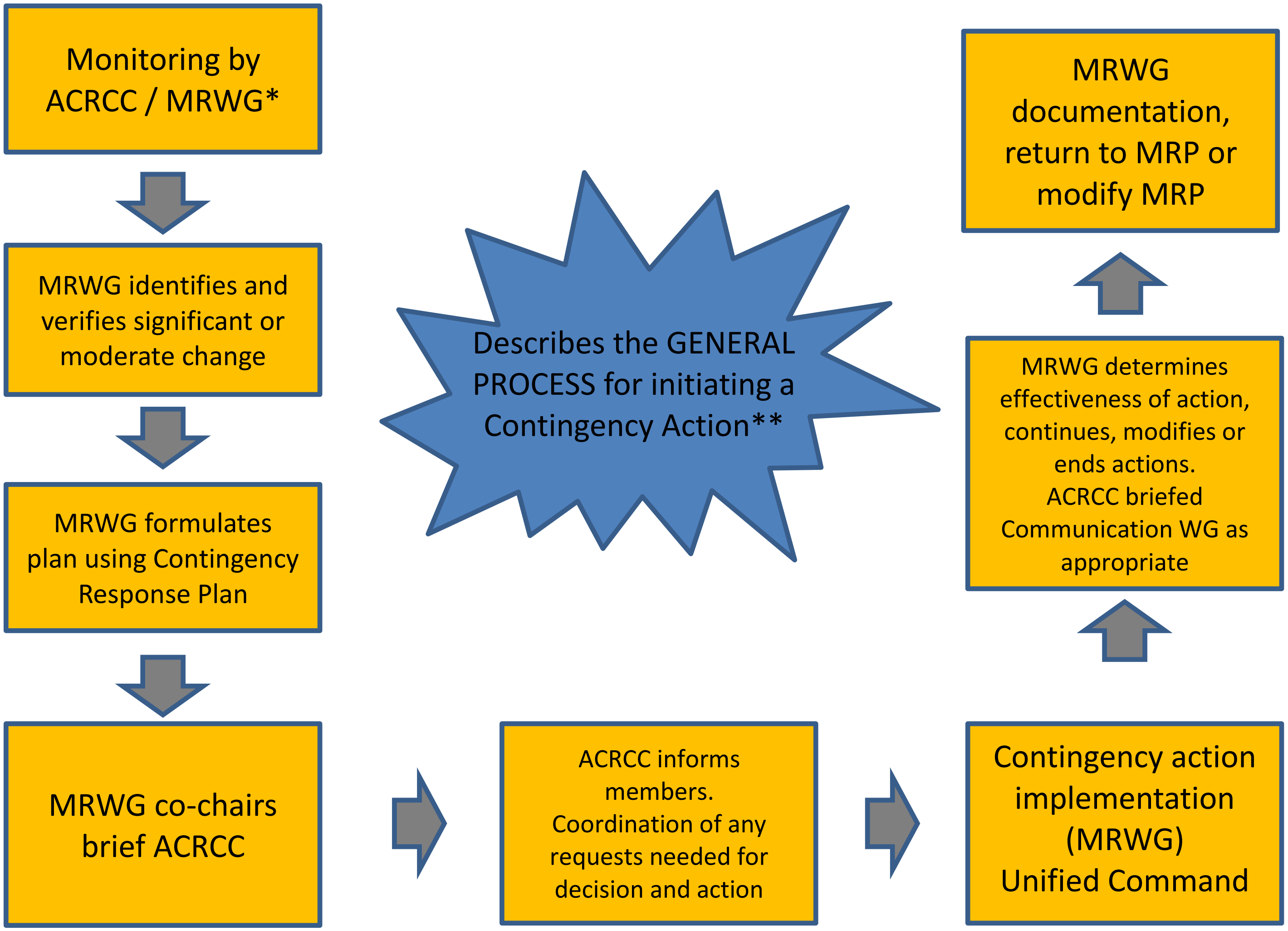
**Figure 4.** *ICS Planning "P"*

*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 (verified by agency personnel) or observed during the sampling event in question, and 3) identifying whether the sampling result is Rare, Common, or Abundant relative to a baseline measurement.

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 of these 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

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.

**Figure 2.** *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 ($-$$$$) |
|---|---|---|---|---|---|---|
| **Significant Change** | Increased Sampling Efforts[3] | All | IDNR/USFWS | 1-7 days | Sampling permits | ($$) |
| | Modify Barrier Operations | LP, BR | USACE | 1 day | Coordinate with contractors | ($) |
| | Complex Noise | All | USFWS/IDNR | 1-7 days | Unknown | ($$) |
| | Commercial Contract Netting | All | IDNR | 1-7 days | Sampling permits/contracts | ($) |
| | Hydroacoustics | All | USFWS/SIU/USGS | 1-7 days | None | ($) |
| | Block Nets | All | IDNR | 1-7 days | Notice to navigation | ($$) |
| | Temporary Flow Control | LP, BR | MWRD | 1 day | Notice to navigation | ($) |
| | Mobile Electric Array | All | INHS/IDNR | Months | Finalize contracting, construction | ($$$) |
| **Moderate Change** | Increased Sampling Efforts | All | IDNR | 1-7 days | Sampling permits | ($$) |
| | Modify Barrier Operations | All | USACE | 1 day | Coordinate with contractors | ($) |
| | Complex Noise | All | USFWS/IDNR | 1-7 days | Unknown | ($$) |
| | Commercial Contract Netting | All | IDNR | 1-7 days | Sampling permits/contracts | ($) |
| | Hydroacoustics | All | USFWS | 1-7 days | None | ($) |
| | Block Nets | All | IDNR | 1-7 days | Notice to navigation | ($$) |
| **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 brought to bare as necessary and aligned with agency authorities.

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

3 Response techniques encompassed by Increased Sampling Efforts under Potential Actions in above table

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

*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.

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.

Fish Life History

**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 | | | | | | | | | |

Location

Abundance

Significant Change

Action Implemented

Notes:

- = Significant change from baseline requiring further response action
- = Moderate change from baseline requiring further response action
- = No chage/Status Quo from baseline. No further action

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

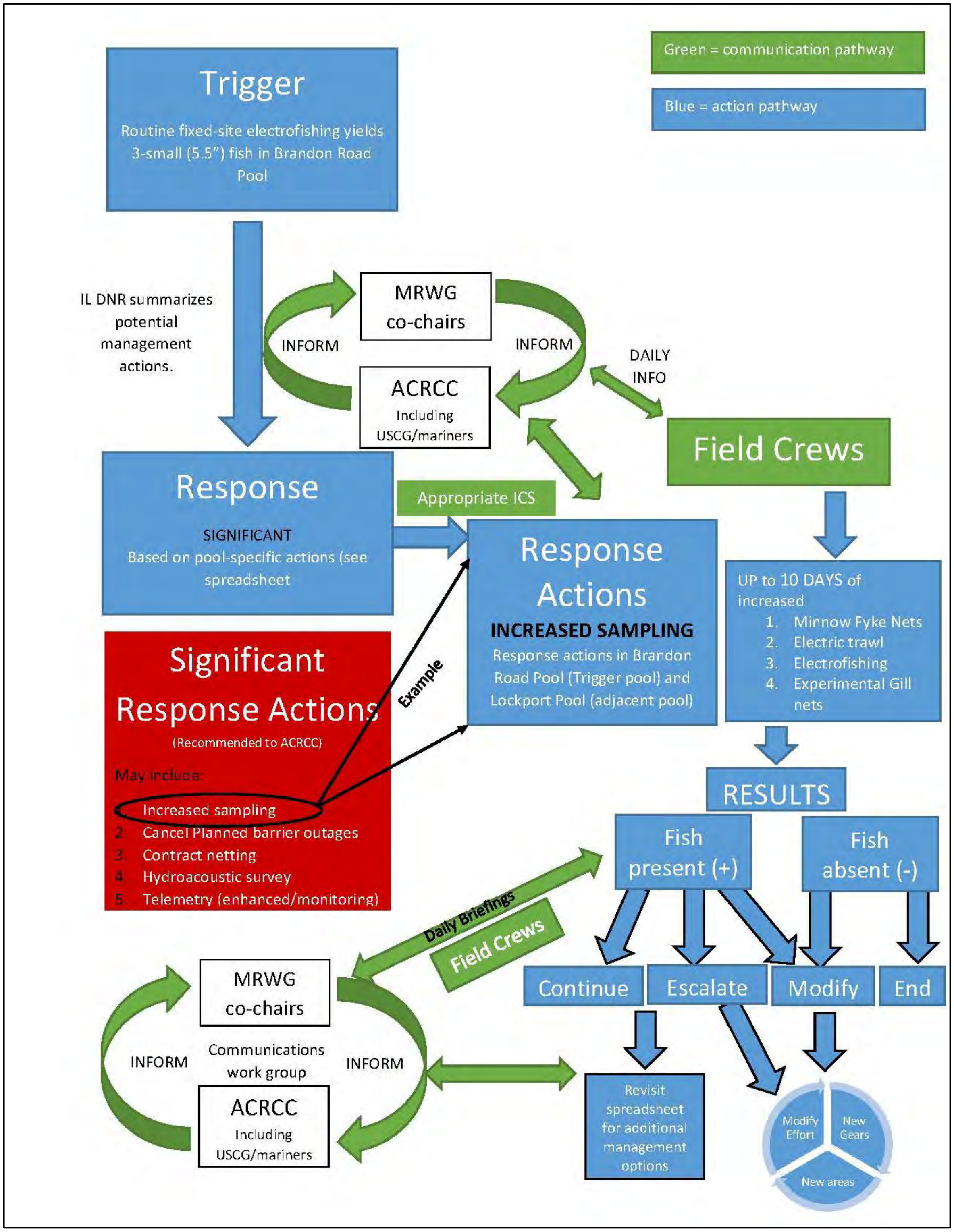
2 This status is based onpon the collection of a single Bighead carp during piscicide treatment in 2009

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.

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 as ones between 2-3 inches). |
| 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. |
| Complex Noise | 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. |

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

# Integration of New Science and Technology

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[2]U.S. Geological Survey, Columbia Environmental Research Center; Columbia, MO
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**Participating Agencies:** USGS, IL DNR, USACE, USFWS, Southern Illinois University, Western Illinois University

**Location:** Illinois River

**Introduction and Need:**
The integration of new science and technology will be needed to keep Asian carp from invading the Great Lakes. The work conducted by USGS in collaboration with other research organizations and management agencies from the funding provided by GLRI and USGS supports adaptive and integrated management of Asian carp with the following primary objectives: (1) evaluation of new tactics for monitoring, surveillance, control and containment; (2) understanding the movements, behaviors, species interactions and population dynamics of Asian carp; and (3) the development of databases, decision support tools and performance measures.

Intensive efforts are currently being directed towards preventing Asian carp invasion of the Great Lakes from the established population in the lower Illinois River. Two primary management tactics being employed are operation of electric dispersal barriers and targeted removal through intensive, contracted commercial harvest. These tactics target a portion of the Upper Illinois River between Starved Rock Lock and Dam and the electric dispersal barrier referred to as the Intensive Management Zone (IMZ). This area is characterized by relatively low Asian carp abundance and limited recruitment compared to downstream reaches, and thus acts as a buffer between the high density Asian carp population established downstream of Starved Rock Lock and Dam and the electric dispersal barrier. Targeted removal combined with documented low recruitment within the IMZ results in reduced Asian carp densities because the primary source of Asian carp is thought to be immigration from downstream of Starved Rock Lock and Dam rather than local recruitment. Minimizing the number of Asian carp in this zone reduces the likelihood of Asian carp challenging the electric dispersal barrier and the potential for propagules of Asian carp reaching the Great Lakes.

New deterrents, monitoring, surveillance and decision support tools to increase the efficacy of these two primary tactics (i.e., electric dispersal barrier and targeted removal) in the IMZ would further minimize the risk of introducing Asian carp propagules into the Great Lakes. Redundant deterrent technologies like sound or $CO_2$ might work better than a single technology because the efficacy of individual technologies is known to vary with environmental conditions and life stage of Asian carp. Tandem and redundant operations allow for protection across a greater range of conditions and life stages, and allow for backup in the case of failure of a single deterrent technology. For example, few Asian carp have been detected upstream of Brandon Road Lock and Dam, located in the upstream portion of the IMZ. Studies at this location are being conducted to deter Asian carp movement upstream towards the electric dispersal barrier, thereby providing a buffer for the electric dispersal barrier. Additionally, deployment of $CO_2$ or sound at locks and dams between Brandon Road Lock and Dam and Starved Rock Lock and Dam might limit passage of Asian carp to upstream reaches, allowing fishing to reduce Asian carp abundances in that stretch of river in the short term and may act in a cummulative fashion to reduce propegule pressure at the electric barriers over time. As well, deterrents (e.g., $CO_2$, and sound) and algal attractants might be integrated with targeted removal, and eventually other control technologies like piscicide laced microparticles, to further reduce Asian carp abundance in the IMZ.

Intensified surveillance in this zone with advanced and traditional telemetry methods (e.g., transmitting data from passive receivers in near real-time, enhanced acoustic arrays and manual tracking, and satellite-capable transmitters) will provide greater understanding of the movements, habitats, and behaviors of Asian carp in areas of intense management that will allow for better application of control and containment tools.

**Objectives:**

1) Development, implementation, and evaluation of new tactics for monitoring, surveillance, control and containment.
2) Understanding behavior and reproduction of Asian carp in established and emerging populations to inform deterrent deployment, rapid response, and removal efforts..

**Status:** Ongoing.

**Methods:**
The USGS and its partners including IDNR, SIU, WIU, USFWS, USACE, and others will implement new technologies (e.g., underwater sound, $CO_2$, feeding attractants, advanced surveillance techniques) to evaluate behavioral information, and develop databases and associated decision support tools to maximize the efficacy of targeted removal and minimize immigration of Asian carp into the Upper Illinois River to protect the Great Lakes. Actions planned for 2017 under the 3 major objectives of this work are listed below.

(1) Implementation and evaluation of new tactics for monitoring, surveillance, control and containment.

- Complex sound and $CO_2$ as deterrents at dams and other strategic locations
  - Complete analysis and reports (e.g., manuscript) of 2015 field trials using sound and $CO_2$.

  - Complete analysis and summary of initial sound mapping to establish complex noise baselines around Illinois River sites selected for control technologies.
  - Apply and evaluate the use of complex sound at Brandon Road Lock and Dam.
  - Continue planning for the application of $CO_2$ at a lock chamber in the Upper Illinois River or Upper Mississippi River.
- Microparticle application
  - Coordinate and collaborate with state and federal natural resource management agencies to deploy antimycin-latent microparticles in a field setting to accomplish a specific management action.
  - Evaluate the potential use of microparticles as a passive and unique fish marker for differentiation of discrete fish populations.
- Advanced monitoring techniques
  - Use genetic tools to verify the identity of morphometrically identified bigheaded carp eggs and larvae collected in standardized monitoring in of the Upper Illinois River.
  - Finalize and disseminate protocols to use genetic tools (i.e., Next Generation Sequencing and qPCR) to efficiently screen ichthyoplankton tows for the presence of Asian carp eggs and larvae.
  - Disseminate protocols for light trapping to assess movement rates and habitat selection of bigheaded carp and grass carp larvae.
- Assessments of Unified Method
  - Prepare and submit manuscript describing the Chinese Unified Method and its potential use in the USA, and work with the ILDNR to perform second trial of the method.
  - Complete analysis and report on telemetry study during the application of the Unified Method in Hansen Material Pit in the Marseilles Pool of the Illinois River.
  - Deploy sound as a driving mechanism in the conduct of the Unified Fishing method in Hansen Material Pit in the Marseilles Pool of the Illinois River.
- Algal attractants and complex sound to aid in removal efforts
  - Continue to conduct field trials and reconnaissance to assess the usefulness of algal attractants and complex sound to enhance monitoring and control tactics.

(2) Behavior and reproduction of Asian carp in established and emerging populations to inform deterrent deployment, contengency actions, and removal efforts

## Integration of New Science and Technology

- Complete analyses and reports on Asian carp movement, habitat and behavior associated with removal efforts.
- Complete analysis and reports on field and pond studies assessing native predators to control Asian carp.
- Present findings and initiate discussions (e.g., workshops) with managers on the feasibility of stocking or enhancing habitat for native predators to control Asian carp.
- Continue/initiate detailed active and passive telemetry studies in the Upper Illinois River and Upper Mississippi River to assess longitudinal and lateral movements of Asian carp to inform removal and deterrents.
- Continue/initiate studies on otolith microchemistry to determine movements through strategic dams and sources of recruitment to emerging and established populations of Asian carp.
- Continue/initiate evaluations of the efficacy of removal efforts in reaches with emerging and established populations of Asian carp.
- Develop an Integral Projection Model to evaluate alternate management strategies, namely use of YY-males, for ACs.
- Initiate evaluation of performance measures associated with tactical objectives established by managers as part of adaptive management for Asian carp.

**2017 Schedule:** All studies are ongoing, and individual project schedules will vary.

**Deliverables:** As described above in Methods section.

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

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

**Agency Representatives**
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**Independent Technical Experts**
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**Agency Participants**

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Jennifer Jeffrey
Jeremiah Davis, USFWS
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John Goss, IWF
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Matt Lubejko, SIU
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Mike Weimer, USFWS
Nathan Jensen , USGS
Neal Jackson, KDNR
Luke Nelson, IDNR
Nick Barkowski, USACE
Nick Bloomfield, USFWS
Matt O'Hara, IDNR
Rob Simmonds, USFWS
Robin Calfee, USFWS
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Ryan Manning, USCG
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Skyler Schlick , UFWS
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Widloe, Justin , IDNR

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

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

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

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

**BEST MANAGEMENT PRACTICES**

*BEFORE TRAVELING TO A SAMPLING LOCATION:*

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

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

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

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

*WHILE ON A WATERBODY:*

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

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

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

*AFTER FIELD WORK ON WATERBODY IS COMPLETE:*

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

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

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

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

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

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

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

- ***KEEP RECORDS.***

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

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

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

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

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

## ATTACHMENT A
## DECONTAMINATION METHODS AND GEAR-SPECIFIC TIPS

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

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

**Decontamination Methods**

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

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

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

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

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

[C] Wisconsin Department of Natural Resources. 2015. Boat, Gear, and Equipment Decontamination Protocol. Manual Code #9183.1.

[D] United States Geological Survey. Movement of field equipment (boats, trucks, nets, seines, etc.) between two separate waterbodies for field sampling. Columbia Environmental Research Center. HACCP Plan. Accessed 4 Nov 2015.

equipment being treated should be sprayed.[E]

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

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

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

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

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

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[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).

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

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

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

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

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

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

7. *Freezing*

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

**Gear-Specific Tips for Decontamination**

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

*Nets*

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

*Personal Gear and Clothing*

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

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

*Dip nets, measuring boards, and other gear*

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

*Boats, trailers, and live wells*

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

*Motors*

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

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

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

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

**Key:**
☑ = Effective
⊗ = Not Effective
® = Additional Research Needed
**?** = Literature Review Needed

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

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

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

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

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

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

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

| ANS | Steam Cleaning (212°F) | Hot Water (140°F) | Drying (5 days) | Chlorine (500 ppm) | Virkon® (2:100 solution) | Freezing (-3°C) |
|---|---|---|---|---|---|---|
| Spring Viremia of Carp Virus (SVCv) | ☑ | ☑[29,30,31,6,4] | ⊗[4*] | ☑[28,29,30,64] | ☑[28] | ⊗[29] |
| Largemouth Bass Virus (LMBv) | ® | ® | ® | ☑[24,28] | ☑[24,28] | ⊗[32] |
| Viral Hemorrhagic Septicemia Virus (VHSv) | ☑ | ☑[4,72,73] | ☑[4,72,74] | ☑[28] | ☑[28,72] | ☑[26,29,63] ⊗[75] |
| Lymphosarcoma | ® | ® | ® | ☑ | ® | ® |
| Whirling Disease | ☑[33] | ⊗[20,33,71] | ☑[5,33] | ☑[5,20,28,33] | ® | ☑[5,33] |
| Heterosporis | ® | ® | ☑[34] | ☑[34] | ® | ☑[34] |

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## References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

*Recommends 10% bleach/water solution.*

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

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

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

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

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

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

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

    *Direct quotes:*

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

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

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

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

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

    *Direct Quote:*

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

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

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

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

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

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

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

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

    *Direct Quote:*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

*Two weeks needed for mortality.*

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

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

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

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

*>38°C (100°F) for 12 hours.*

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

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

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

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

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

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

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

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

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

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

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

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

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

*EWM seeds are viable to excessive periods of desiccation.*

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

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

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

*EWM seeds likely experience increased viability after freezing.*

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

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

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

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

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

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

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

*N. peltata seeds show high tolerance to desiccation.*

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

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

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

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

*>50°C (122°F) for 15 seconds*

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

*Dry in full sunlight for >50 hours.*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

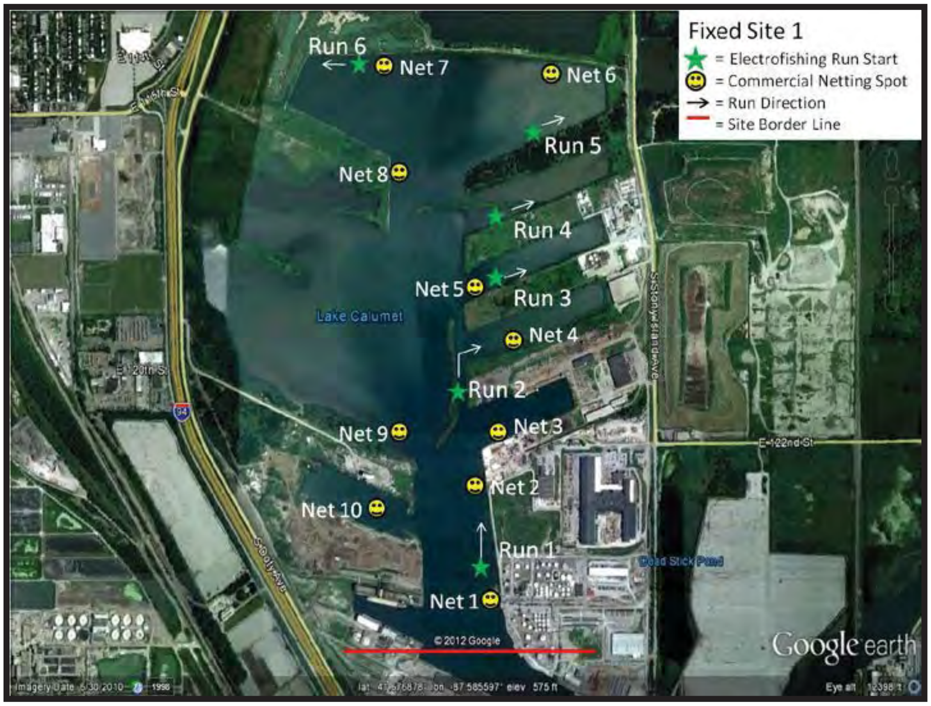
76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

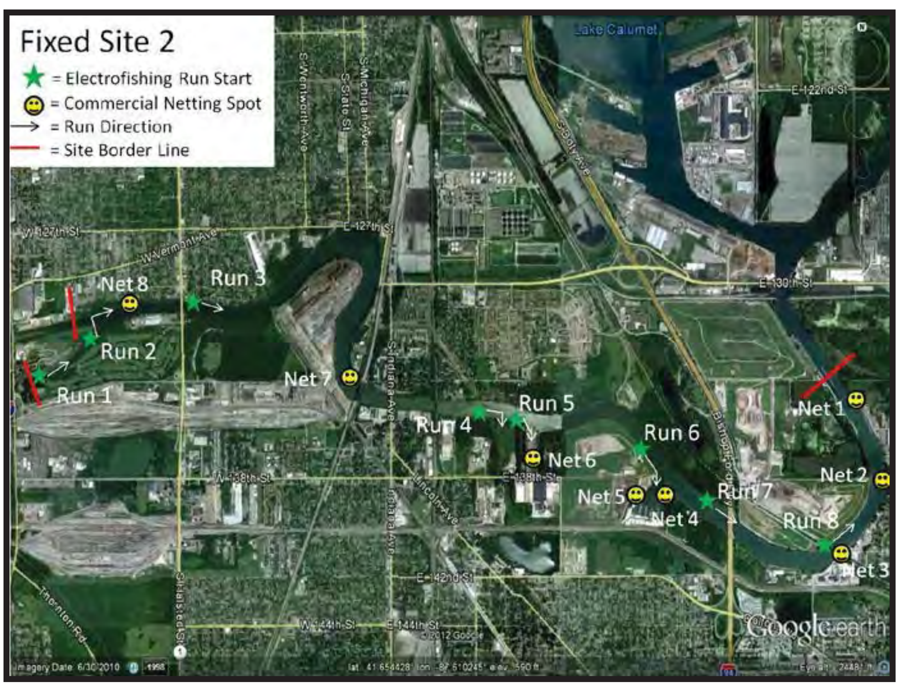
*Virkon® was found to be effective after trials of 1, 5, and 10 minute exposures to a 2% solution. Bleach and 409 were also tested. Bleach was found to be effective at 5, 10, and 20 minute exposures to a 400 ppm solution.*

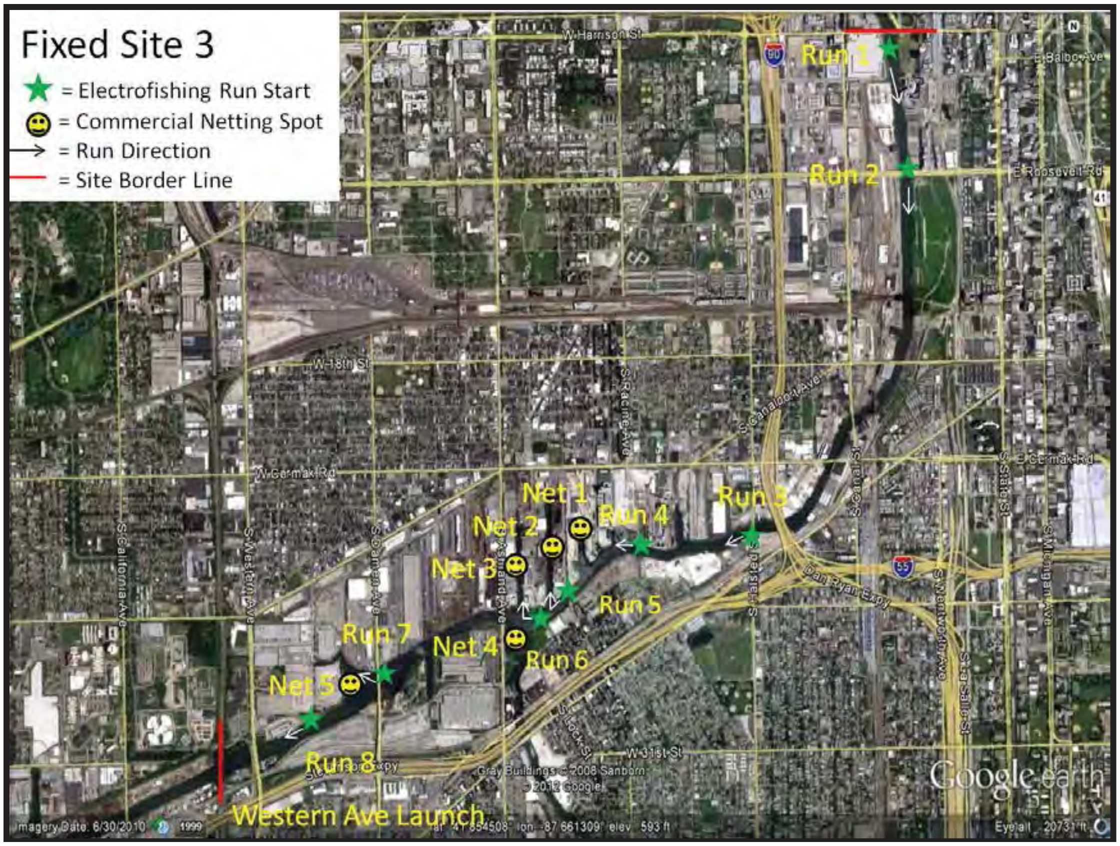
77. DiVittorio, J., M. Grodowitz, and J. Snow. 2010. Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species [2010 Edition]. U.S. Department of the Interior Bureau of Reclamation. Technical Memorandum No. 86-68220-07-05.

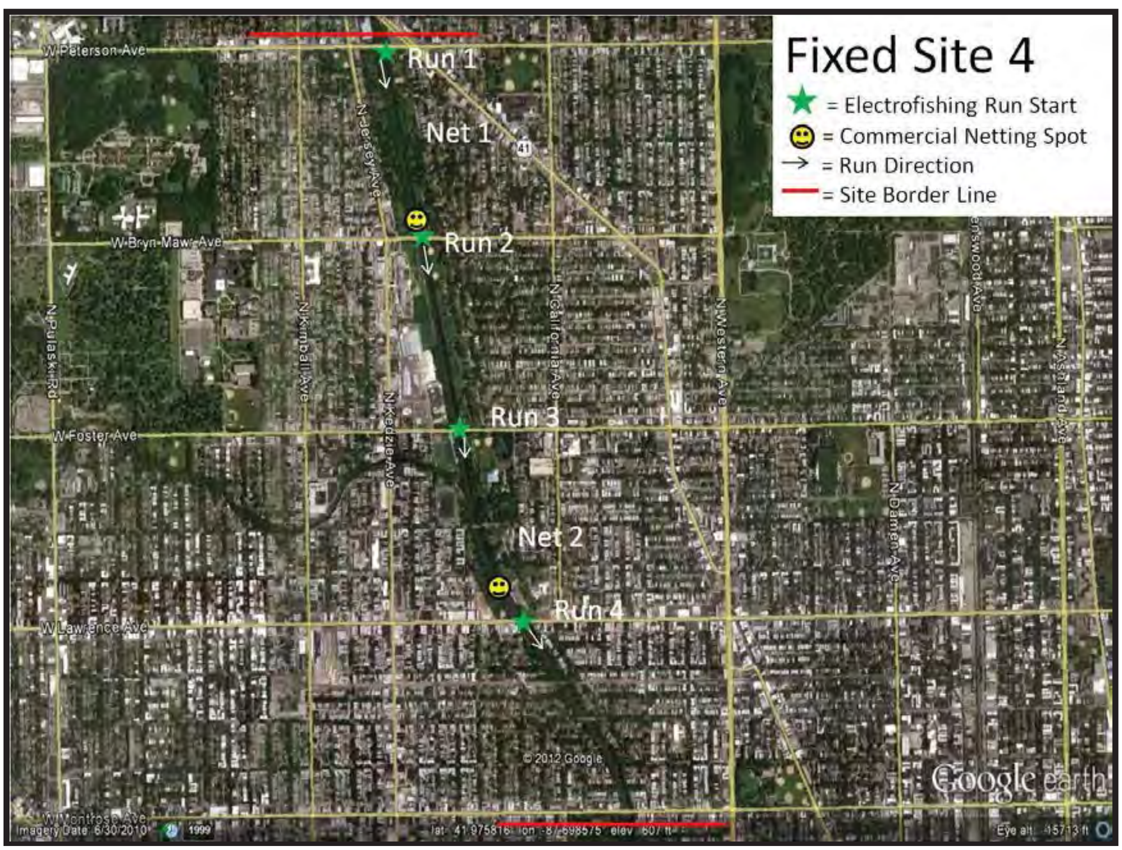
*Mentioned steam cleaning as effective, however, no reference or study provided to validate claim.*

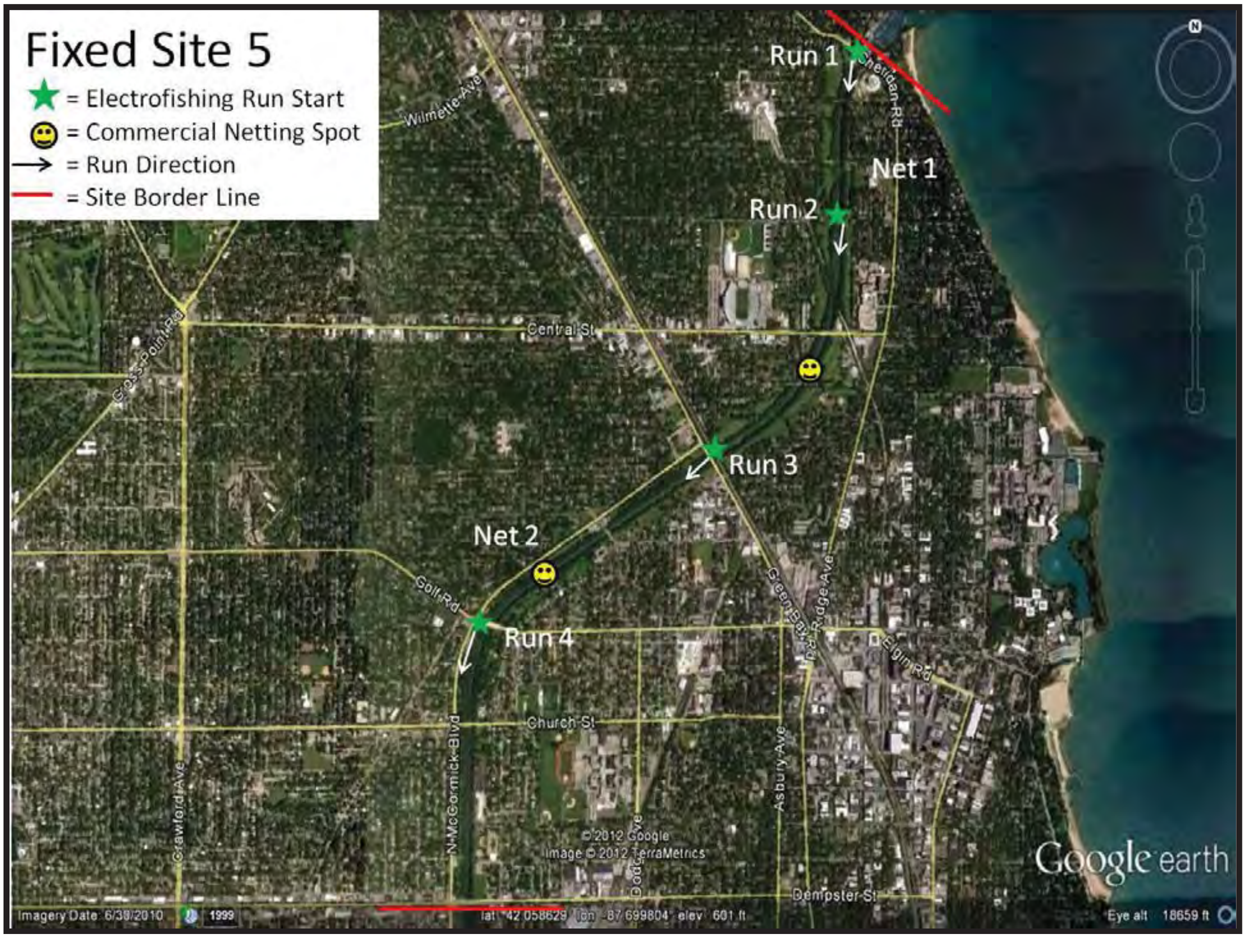
**Appendix D.** Detailed Maps of Fixed and Random Site Sampling Locations.



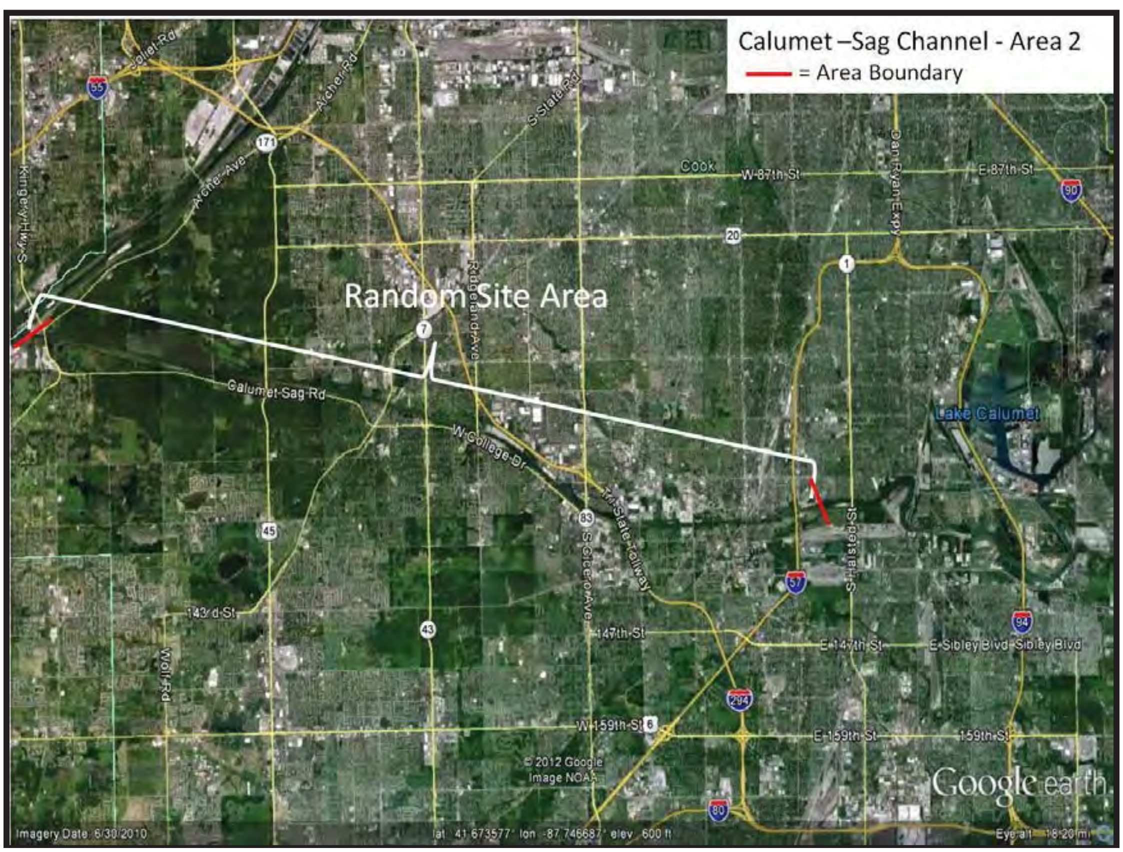




Fixed Site 3
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Run 5
Run 6
Run 7
Run 8
Net 1
Net 2
Net 3
Net 4
Net 5
Western Ave Launch
W Harrison St
W 18th St
W Cermak Rd
S Western Ave
S California Ave
S Racine Ave
Dan Ryan Expy
W 31st St
Google earth

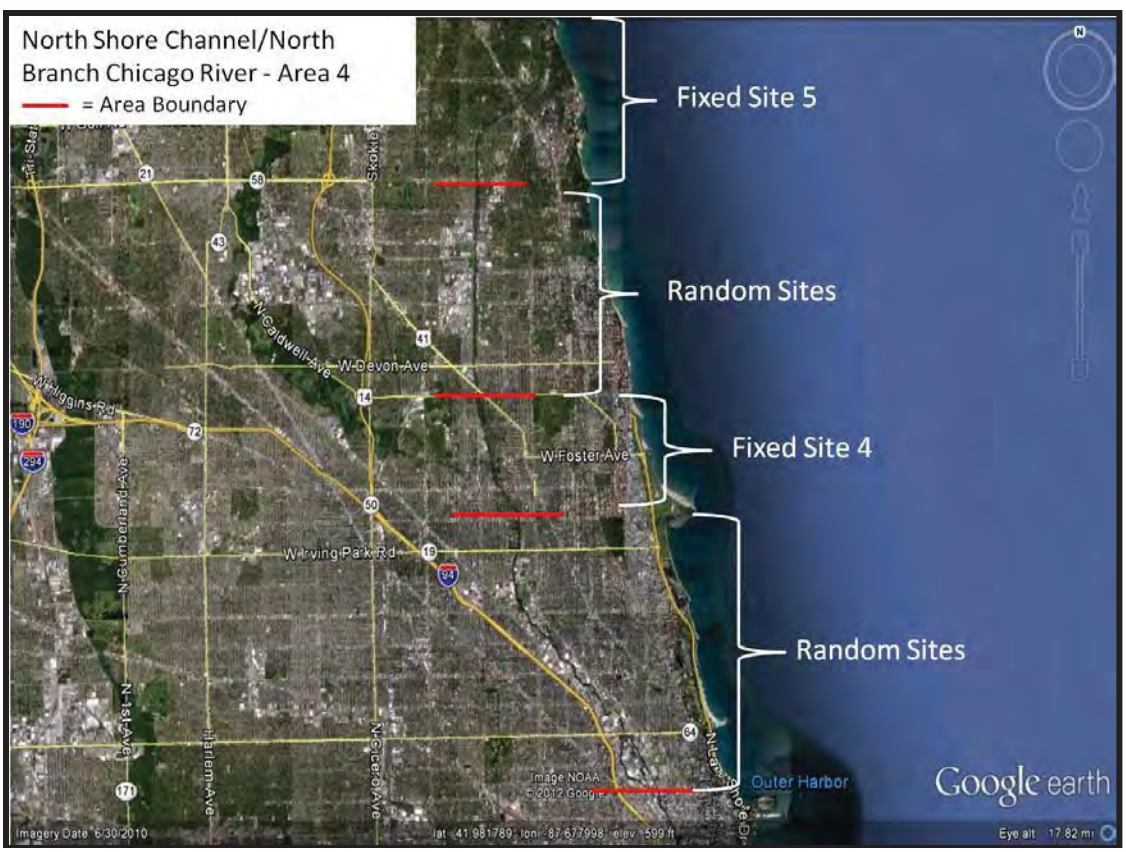

Fixed Site 4
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
W Peterson Ave
W Bryn Mawr Ave
W Foster Ave
W Lawrence Ave
W Montrose Ave
N Pulaski Rd
N Kimball Ave
N Kedzie Ave
N California Ave
N Western Ave
N Damen Ave
N Ashland Ave
© 2012 Google
Google earth


Fixed Site 5
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Net 1
Run 3
Net 2
Run 4
Wilmette Ave
Central St
Golf Rd
Church St
Dempster St
Sheridan Rd
Crawford Ave
Asbury Ave
Ridge Ave
Elgin Rd
N McCormick Blvd
© 2012 Google
Image © 2012 TerraMetrics
Google earth
Imagery Date: 6/30/2010
Eye alt 18659 ft


Calumet River - Area 1
= Area Boundary
Random Site Area
Lake Calumet
Wolf Lake
Highway 12
Chicago Skyway
Bishop Ford Fwy
S Halsted St
Calumet Ave
© 2012 Google
Image © 2012 TerraMetrics
Imagery Date 6/30/2010
Google earth

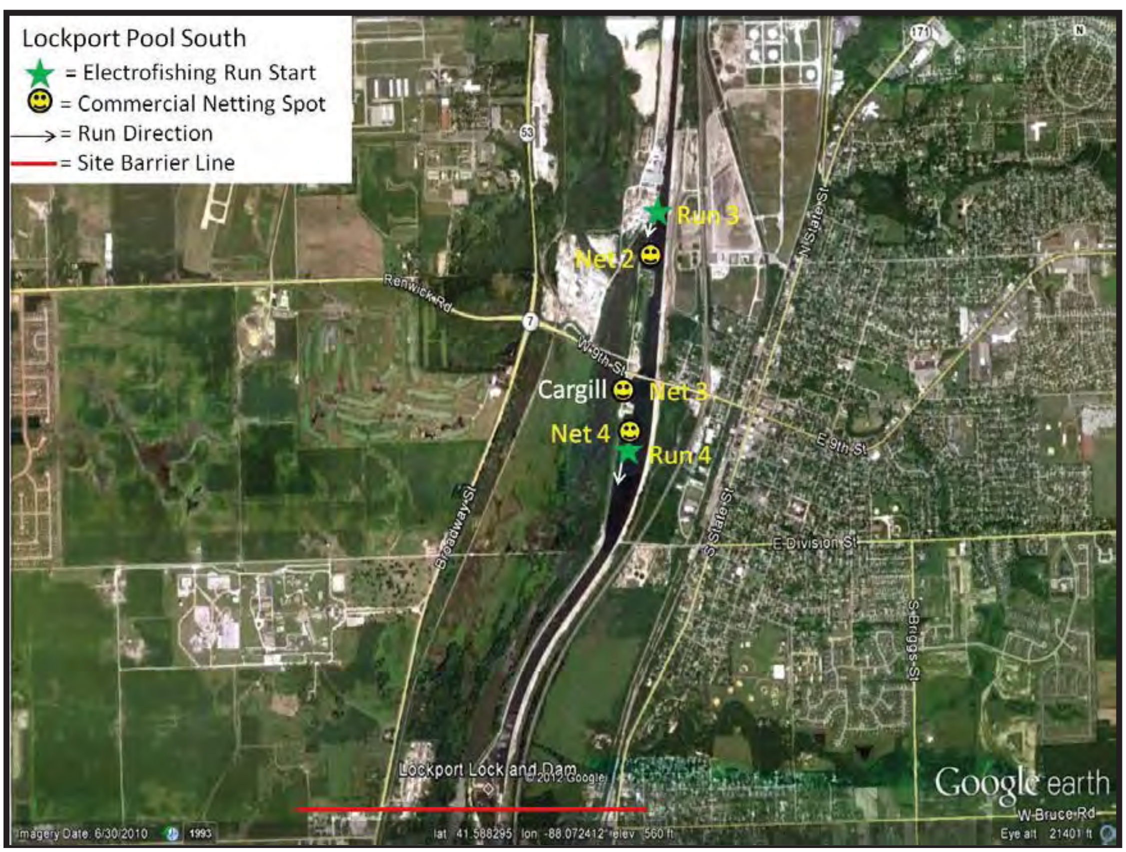

Calumet –Sag Channel - Area 2
= Area Boundary
Random Site Area
Lake Calumet
Calumet-Sag Rd
W College Dr
Archer Ave
Dan Ryan Expy
W 87th St
E 87th St
143rd St
147th St
E 147th St
E Sibley Blvd
Sibley Blvd
W 159th St
E 159th St
159th St
Wolf Rd
Tri-State Tollway
S Halsted St
© 2012 Google
Image NOAA
Imagery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

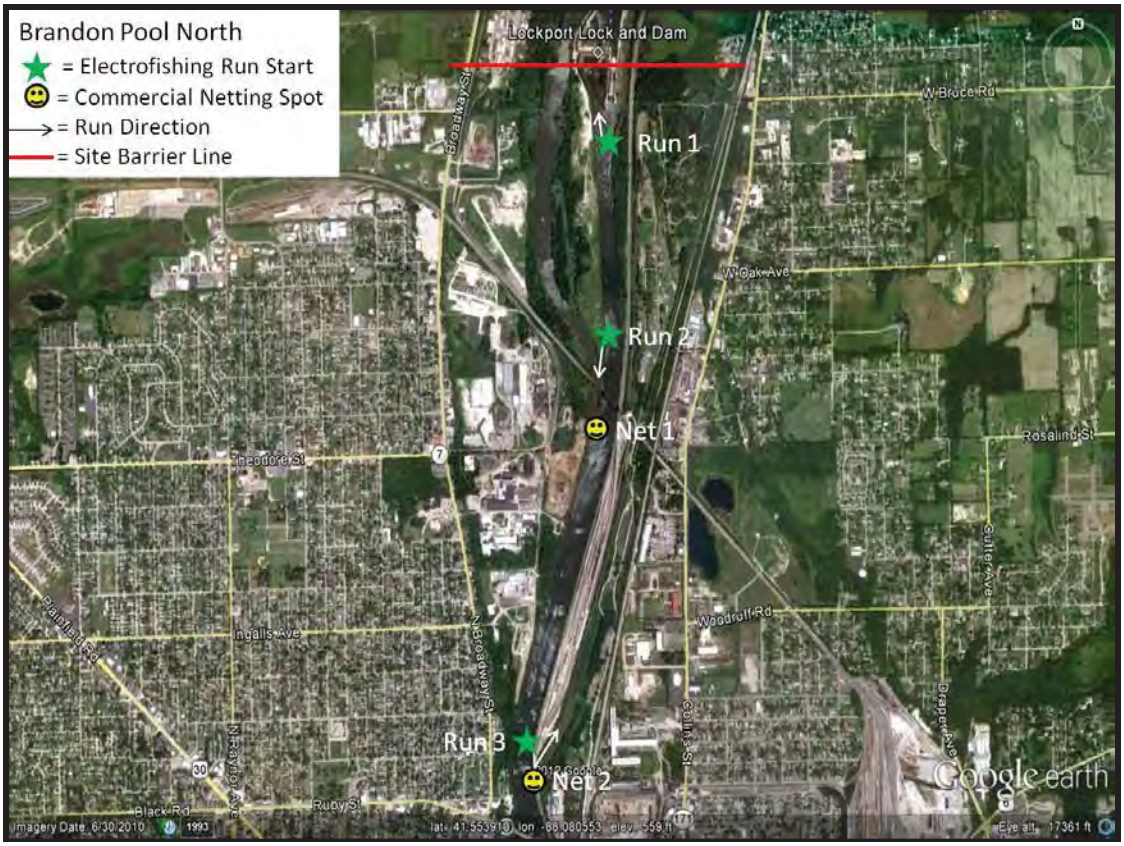
CSSC - Area 3
= Area Boundary
Random Sample Area

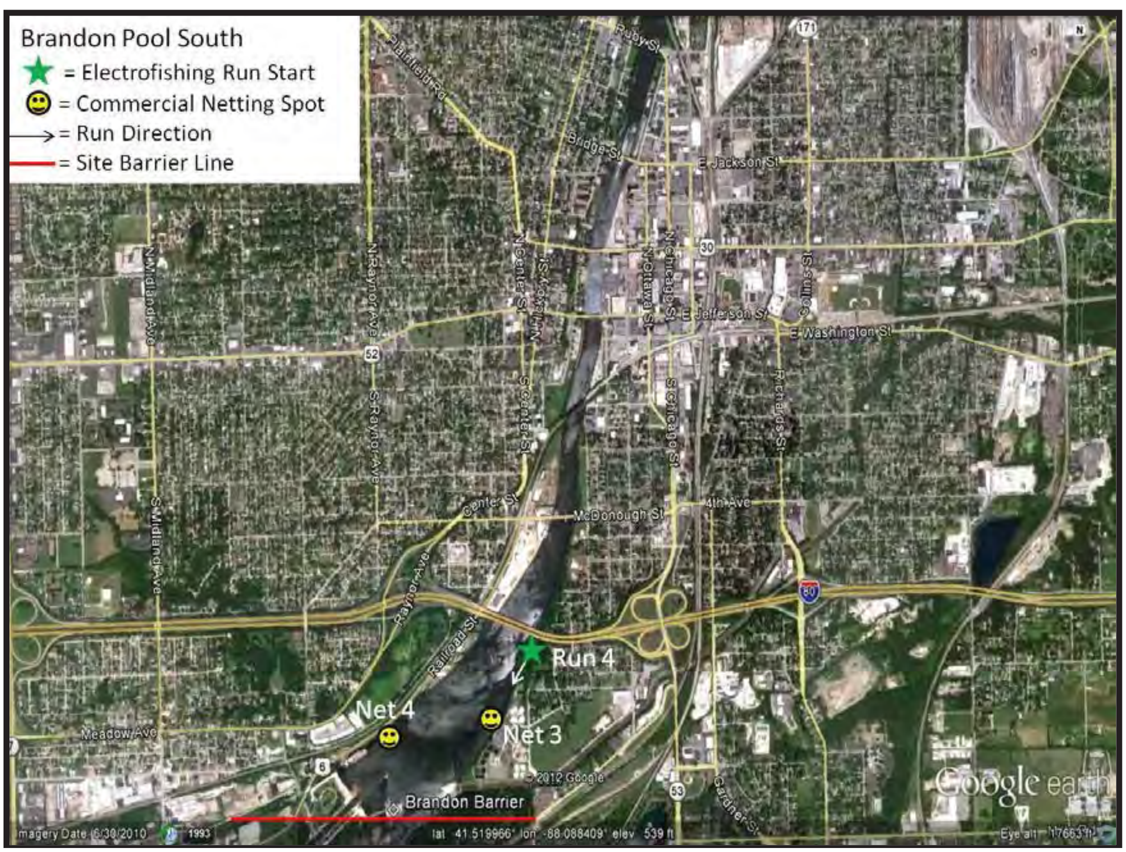



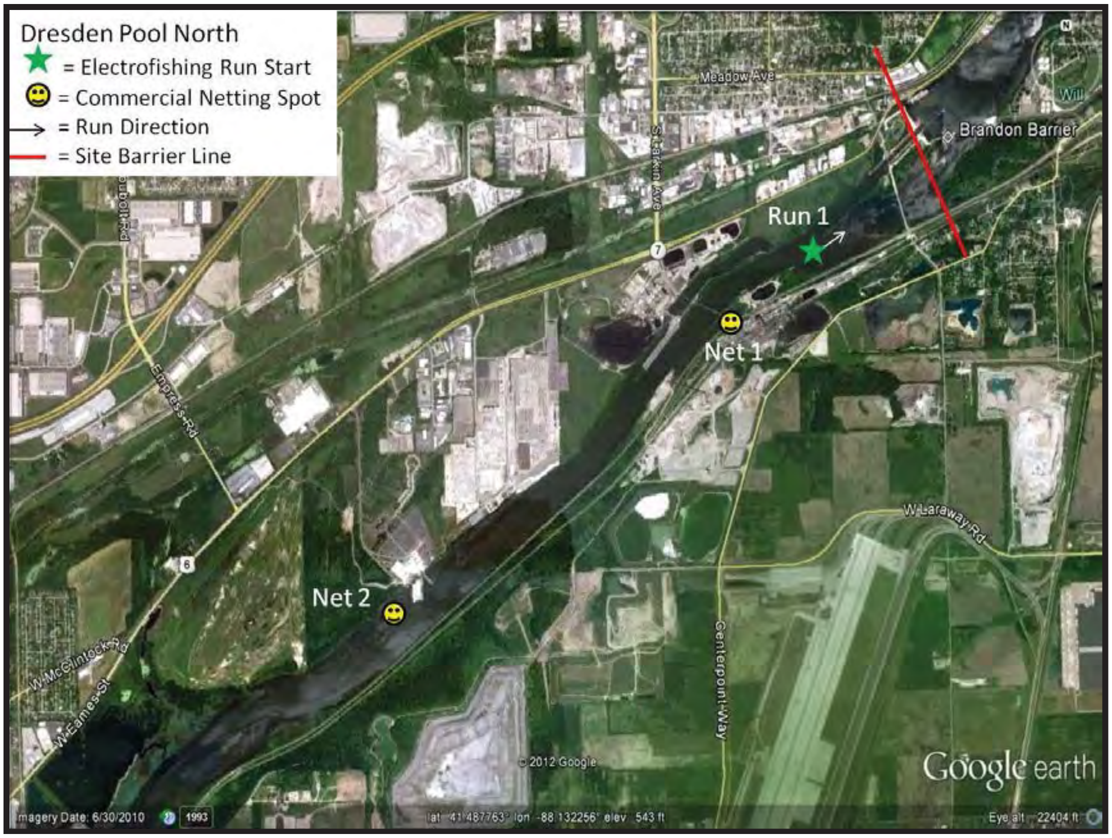
North Shore Channel/North
Branch Chicago River - Area 4
= Area Boundary
Fixed Site 5
Random Sites
Fixed Site 4
Random Sites


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


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


Brandon Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Lockport Lock and Dam
Run 1
Run 2
Run 3
Net 1
Net 2


Brandon Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 4
Net 3
Net 4
Brandon Barrier


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
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
W Bluff Rd
S Frontage Rd
E Frontage Rd
E Eames St
Craig Rd
W Manhattan Rd
Co Hwy 17
S Brandon Rd
Centerpoint Way
Image U.S. Geological Survey
© 2012 Google
Google earth
Imagery Date: 6/30/2010
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
1998
lat 41.386214° lon -88.314243° elev 498 ft
Eye alt 19308 ft


Marseilles Pool South
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Net 3
Peacock Slough
Peacock Slough
Run 4
Net 4
Run 3
Net 2
Ashley Rd
Washington St
E Washington
Morris Launch
Image U.S. Geological Survey
© 2012 Google
Imagery Date 10/10/2007
1993
lat 41.366829 lon -88.388047 elev 495 ft

**Appendix E.** Handling Captured Asian Carp and Maintaining Chain-of-Custody Records

Chain-of-custody is a legal term that refers to the ability to guarantee the identity and integrity of a sample from collection through reporting of the test results. The following are general guidelines to keep chain-of-custody intact throughout the fish collection process.

These procedures should be followed when any Bighead or Silver carp is collected in the Chicago Area Waterway (from Lockport Lock and Dam to Lake Michigan, but also areas where they have not previously been collected (e.g. Brandon Road Pool, Des Plaines River, or Lake Michigan).

1. Keep the number of people involved in collecting and handling samples and data to a minimum.

2. Only allow authorized people associated with the project to handle samples and data. Always document the transfer of samples and data from one person to another on chain-of-custody forms. No one who has signed the chain-of-custody form shall relinquish custody without first having the chain-of-custody form signed by the next recipient.

3. Always accompany samples and data with their chain-of-custody forms. The chain-of - custody form must accompany the sample.

4. Ensure that sample identification and data collected are legible and written with permanent ink.

**Specific Instructions for Handling Asian Carp:**

1. A. If the boat crew believes they have collected an Asian carp, they should cease further collection and take a GPS reading of the location at which the Asian carp was found or mark the location on a map provided.

   B. The boat crew leader should immediately notify a lead operations coordinator or chief, who will immediately notify the Incident Commander and the Conservation Police Commander, if present. If a command structure is not in place, then immediately contact an Illinois Conservation Police Officer (CPO) by contacting the IDNR Region 2 law office at 847-608-3100 x 2056.

   C. The boat crew will then take the fish to a staging area for identification by the fish biologist stationed at the site. If a staging area has not been designated, the boat crew should proceed to a predetermined meeting location and await the arrival of the CPO. The boat crew will not leave until the CPO arrives and they have recorded the GPS reading on a chain-of-custody form and signed the form over to the CPO. The CPO is to remain with the fish at all times.

   D. Once a fish biologist at the staging area makes a positive visual identification, he/she will identify the fish with a fish tag; take pictures of the tagged fish (See spawn patch preservation and analysis appendix for photo request, Appendix H); measure its total length (mm) and weight (g); determine the fish's gender; identify reproductive status and gonad development as immature, mature – green, mature – ripe, mature - running ripe, and mature – spent; place the fish in a plastic bag; and seal the fish in a cooler with wet ice. The fish biologist at the staging area will place evidence tape across the opening of the cooler and initial it. The fish biologist at the staging area or when no staging area has been designated, the boat crew leader will give the sealed cooler to the IDNR CPO. The fish is to remain under IDNR control at all times.

E. The CPO will then deliver the sealed fish and chain-of-custody form to the sampling laboratory on site or make arrangements for transport to the genetics laboratory at the University of Illinois (contact: Dr. John Epifanio). Soft tissue for genetic testing and hard tissue for aging and/or chemical analysis will be removed at the UIUC laboratory. Additional soft tissue samples will be collected for other cooperating genetics laboratories (e.g., ERDC), as needed. Hard tissue will be transported to SIUC for analysis (contact: Dr. Jim Garvey). Chain-of-custody will be maintained when transporting hard tissue between university laboratories.

2. Only authorized IDNR tissue samplers or persons designated by an operations coordinator or chief will unseal the fish and remove the tissue samples from the fish for preservation and delivery to the lab. The lab samples will maintain the same sample ID as the subject fish but will also include an additional sequential letter (AC 001a, AC001b, AC002a, AC002b, etc) for multiple tissue samples from one fish. While sampling is occurring, the fish and samples will remain under supervision of the IDNR CPO who will maintain the chain-of-custody form.

3. All Asian carp captured during rapid response actions should be treated with care, handled minimally (no photo ops prior to tissue sampling), and transported to the staging area where they will be stored on ice in a cooler (no plastic bags). Captured fish cannot be frozen or preserved with chemicals, as these techniques distort the DNA. The USACE Engineer Research and Development Center (ERDC) has been designated to obtain a tissue sample from any Bighead Carp or Silver Carp collected during a rapid response action. The preferred tissue for DNA analysis is a pectoral fin (the entire fin) removed with a deep cut in order to include flesh and tissue of the fin base. The fin and tissue sample will be stored in a vial containing ethanol preservative (USACE will provide vials and preservative). Samples will be transported to ERDC for sequencing and comparison to the eDNA found in the pool.

| | CHAIN OF CUSTODY RECORD | File No.<br>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)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |
|---|---|---|---|---|
| Collection No. | From: (Print Name, Agency)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |
| Collection No. | From: (Print Name, Agency)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |
| Collection No. | From: (Print Name, Agency)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |
| Collection No. | From: (Print Name, Agency)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |
| Collection No. | From: (Print Name, Agency)<br>To: (Print Name, Agency) | Release Signature: | Release Date: | Delivered Via:<br>□ U.S. Mail<br>□ In Person<br>□ Other: |

**Appendix F.** Shipping, Handling, and Data Protocols for Wild Captured Black Carp and Grass Carp.

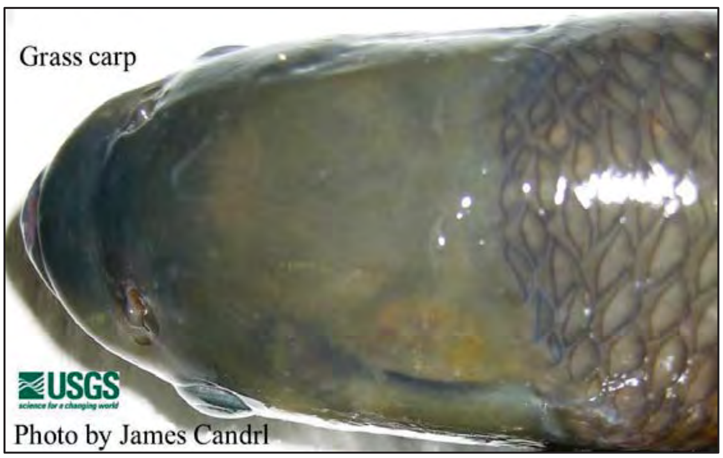
Any suspect black carp collected in the wild in the United States and grass carp collected in the Great Lakes Basin, or other novel locations in the U.S., should be immediately reported to the appropriate resource management agency in the state where the fish was collected. Do ***not*** release suspect 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 head**




**Example of 4.c: Dorsal view of head with mouth fully closed**

***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.** Fish Species Computer Codes.

## Species Codes Asian Carp Monitoring

| | | | | | |
|---|---|---|---|---|---|
| Alewife | ALE | Highfin Carpsucker | HFC | Spotted Sucker | SDS |
| | | | | Spring Chinook Salmon | SCS |
| Banded Darter | BAD | Lake Trout | LAT | Suckermouth Minnow | SUM |
| Banded Killifish | BAK | Largemouth Bass | LMB | | |
| Bigeye Chub | BGC | Logperch | LOP | Threadfin Shad | THS |
| Bighead Carp | BHC | Longear Sunfish | LOS | Trout Perch | TRP |
| Bigmouth Buffalo | BGB | Longnose Gar | LOG | | |
| Black Buffalo | BKB | | | Walleye | WAE |
| Black Bullhead | BLB | Mosquitofish | MOF | Warmouth | WAM |
| Black Carp | BCP | | | White Bass | WHB |
| Black Crappie | BLC | Northern Hog Sucker | NHS | White Crappie | WHC |
| Blackside Darter | BLD | Northern Pike | NOP | White Perch | WHP |
| Blackstripe Topminnow | BLT | | | White Sucker | WHS |
| Bluegill | BLG | Orangespotted Sunfish | ORS | | |
| Bluntnose Minnow | BLS | Oriental Weatherfish | OWF | Yellow Bass | YLB |
| Bowfin | BOW | | | Yellow Bullhead | YEB |
| Brook Silverside | BRS | Paddlefish | PAH | Yellow Perch | YEP |
| Brown Bullhead | BRB | Pumpkinseed | PUD | | |
| Brown Trout | BRT | | | | |
| Bullhead Minnow | BUM | Quillback | ULL | | |
| | | | | | |
| Central Mudminnow | CEM | Rainbow Smelt | RAS | | |
| Channel Catfish | CCF | Rainbow Trout | RBT | | |
| Coho Salmon | CHO | Redear Sunfish | RSF | | |
| Common Carp | CAP | Redfin Shiner | RDS | | |
| Common Shiner | CMS | River Carpsucker | RVC | | |
| Creek Chub | CRC | River Redhorse | RVR | | |
| | | River Shiner | RVS | | |
| Emerald Shiner | EMS | Rock Bass | ROB | | |
| | | Round Goby | ROG | | |
| Fall Chinook Salmon | FCS | | | | |
| Fathead Minnow | FHM | Sand Shiner | SAS | **Hybrid Codes** | |
| Flathead Catfish | FCF | Sauger | SAR | Bluegill x Green Sunfish | BGH |
| Freshwater Drum | FRD | Shorthead Redhorse | SHR | Bighead x Silver Carp | BSH |
| | | Shortnose Gar | SHG | Common Carp x Goldfish | CGH |
| Ghost Shiner | GHS | Silver Carp | SCP | Striped Bass x White Bass | SBH |
| Gizzard Shad | GZS | Silver Chub | SVC | Yellow Perch x White Bass | YWH |
| Golden Redhorse | GOR | Silver Redhorse | SVR | White Perch x Yellow Perch | WYH |
| Golden Shiner | GOS | Skipjack Herring | SKH | | |
| Goldeye | GOL | Smallmouth Bass | SMB | **Other Codes** | |
| Goldfish | GOF | Smallmouth Buffalo | SAB | Unidentified Sunfish | SUN |
| Grass Carp | GRC | Spotfin Shiner | SFS | Unidentified Minnow | MIN |
| Grass Pickerel | GRP | Spottail Shiner | SPS | Unidentified Fish | UID |
| Green Sunfish | GSF | Spotted Gar | SPG | No Fish Code | NFH |

**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.___________<br>Lat.________________<br>Lon.________________<br>Start Time: __________<br>Shock Time: ________ | Run No.___________<br>Lat.________________<br>Lon.________________<br>Start Time: __________<br>Shock Time: ________ | Run No.___________<br>Lat.________________<br>Lon.________________<br>Start Time: __________<br>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 | | | | |
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# Asian Carp Monitoring Project - Nets

Date: ___________________

Area Surveyed: ____________________________ Biologist (Crew): _________________________________

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

| Set No.___________<br>Lat.________________<br>Lon._______________<br>Total Yds.__________ | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>End Time: ___________ | | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>End Time: ___________ | | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>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 | | | | | | | |
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| Set No.___________<br>Lat.________________<br>Lon._______________<br>Total Yds.__________ | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>End Time: ___________ | | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>End Time: ___________ | | Panel No.___________<br>Type (circle): Tra or Gill<br>Length (yds.)_________<br>Height (ft.)___________<br>Mesh (in.)_____________<br>Start Time: ___________<br>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 | | | | | | | |
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# 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 | | | | | | | | | | |
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eDNA Field Data Sheet

DATE______________ NAME________________________________ START TIME____________ SHEET _____of______

| ID | Volume | Latitude | Longitude | Temp | Depth | Habitat | Collect Time | Filter Time |
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Notes/Comments:

**Appendix I.** Understanding Surrogate Fish Movement with Barriers Floy tagging data sheet.

| Asian Carp Monitoring - Floy Tag Data Sheet | | | | | | | Date:______________ | | |
|---|---|---|---|---|---|---|---|---|---|
| Area Surveyed:______________________ | | | | | | Biologist (Crew):____________________________ | | | |
| | Species | Length(mm) | Time | Tag # | Recap. | Clip Loc. | Latitude(Dec. Deg.) | Longitude(Dec. Deg.) | Gear | Comments(dead/alive) |
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**Appendix J.** 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.

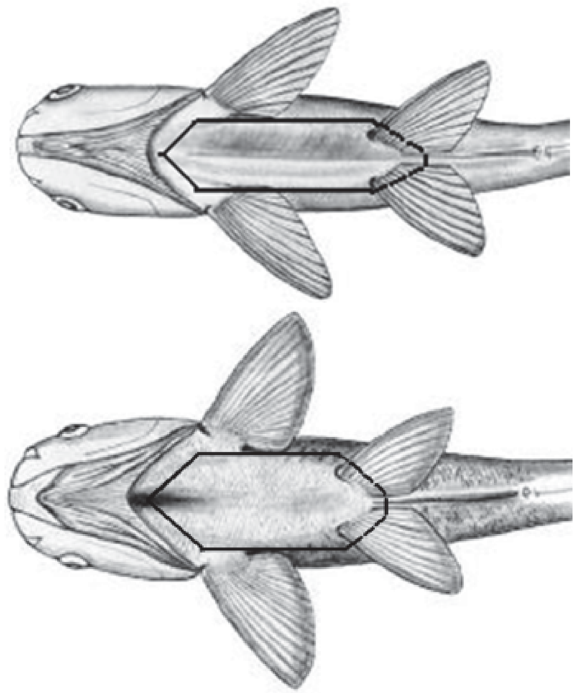

Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection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

# Appendix K: 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.

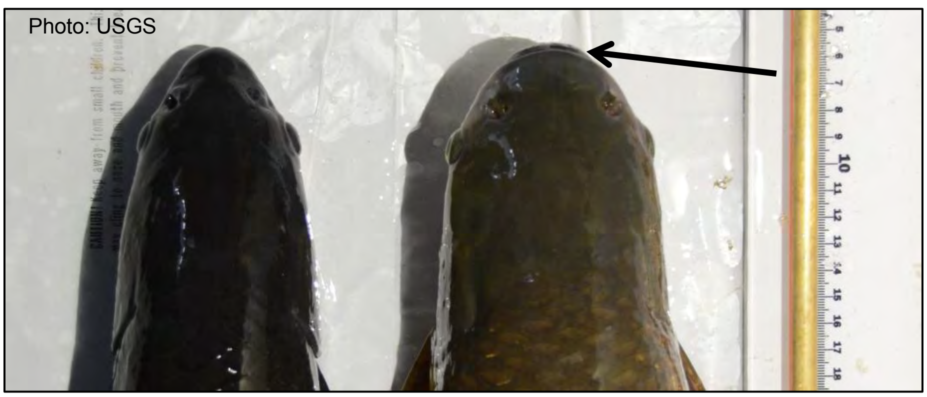

Photo: USGS

The upper lip of a grass carp is visible from above but that of a black carp is generally not **when the mouth is fully closed.** Young black carp may also exhibit this feature, so it is only useful for **adults**.

Photo: USGS

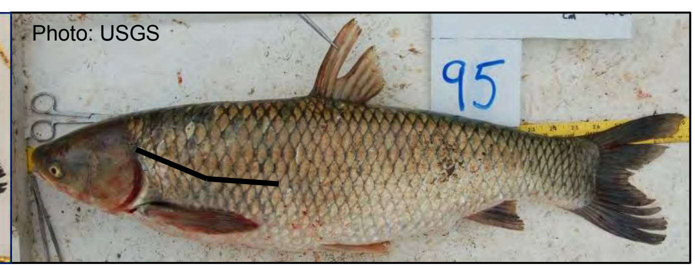


Photo: USGS

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 | Grass Carp |
| --- | --- |

## 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


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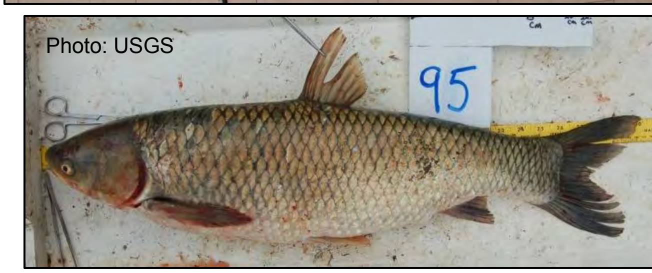

Photo: USGS

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

**Ruairí MacNamara · David Glover · James Garvey · Wesley Bouska · Kevin Irons**

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

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## Introduction

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

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

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

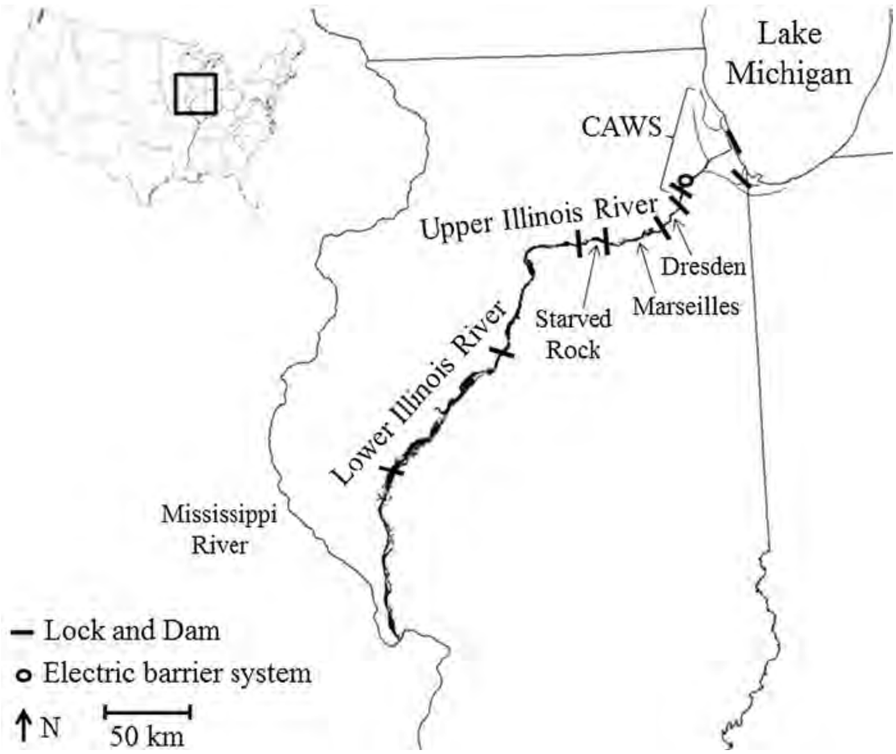


**Fig. 1** The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM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

## Methods and materials

### Harvest program

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

### Research vessel, hydroacoustic equipment and settings

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

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

## Hydroacoustic sampling throughout the Upper Illinois River

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

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

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

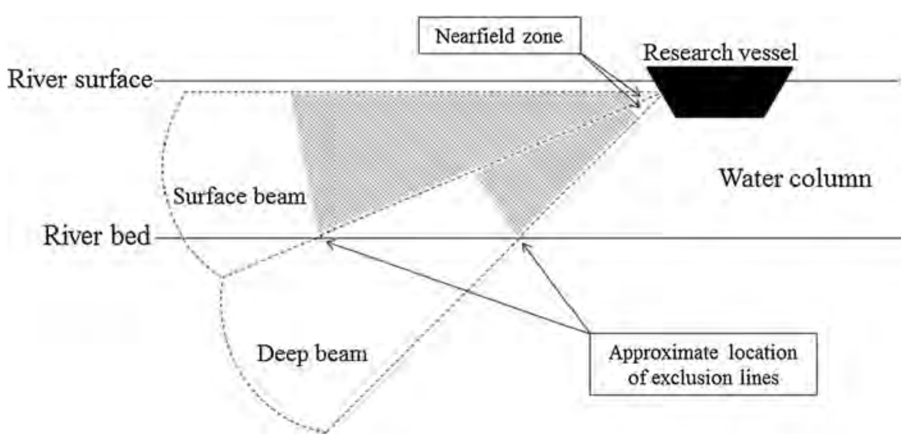


**Fig. 2** Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in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

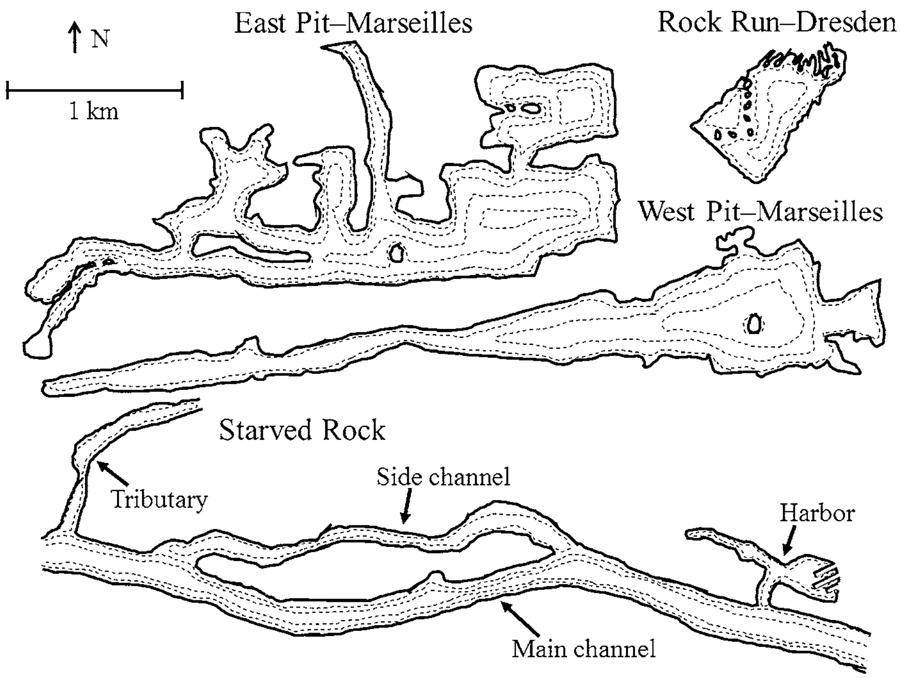


**Fig. 3** Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after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

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

Hydroacoustic post-processing

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

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

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

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

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

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

## Paired sampling

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

## Estimating bigheaded carps demographic parameters

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

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

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

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

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

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

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 $\chi^2$ 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 ($\chi^2 = 116–937$, all $P < 0.001$) of bigheaded carps were observed from downstream to upstream in the Upper Illinois River during each year (Fig. 5). Within the highest density Starved Rock reach, bigheaded carps were significantly smaller and dominated by silver carp (71.6–83.8 % silver carp). In the lower density Marseilles reach, bigheaded carps were larger, and

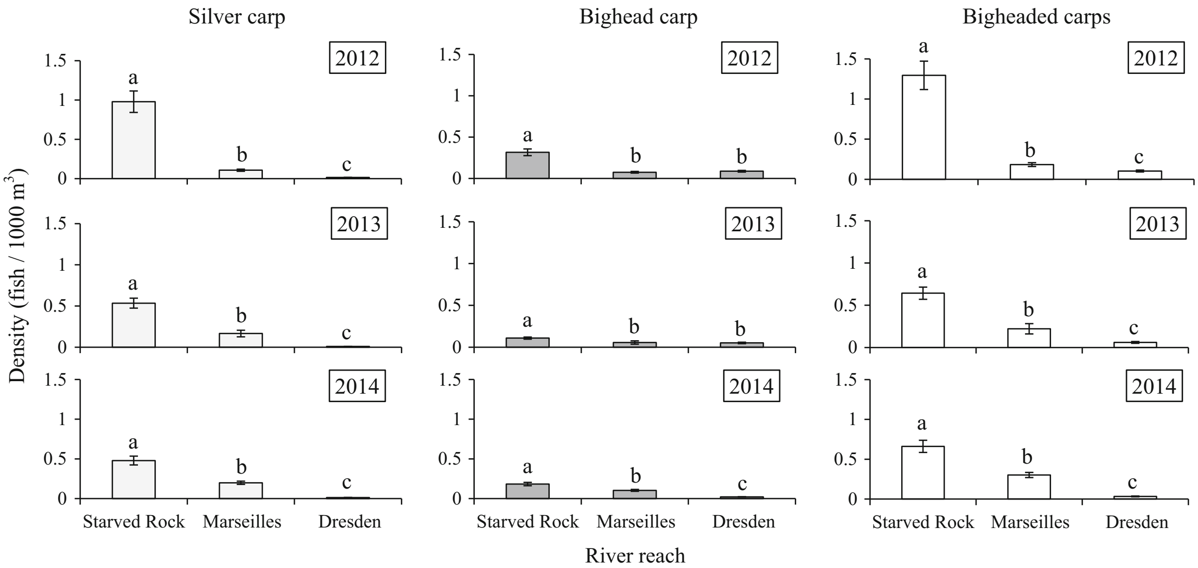


**Fig. 4** Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated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

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

## Validating hydroacoustic density estimates for harvest evaluation

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

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

## Bigheaded carps population changes throughout the upper Illinois River

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

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

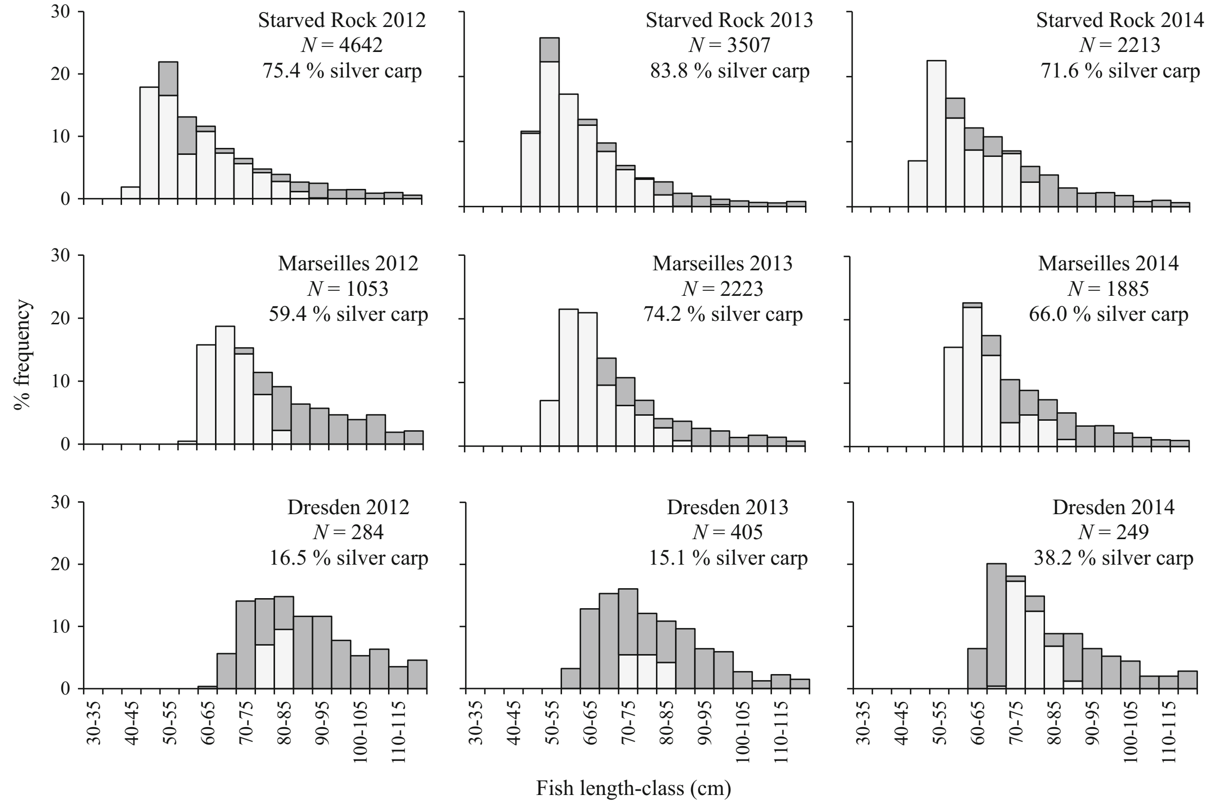


**Fig. 5** Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding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

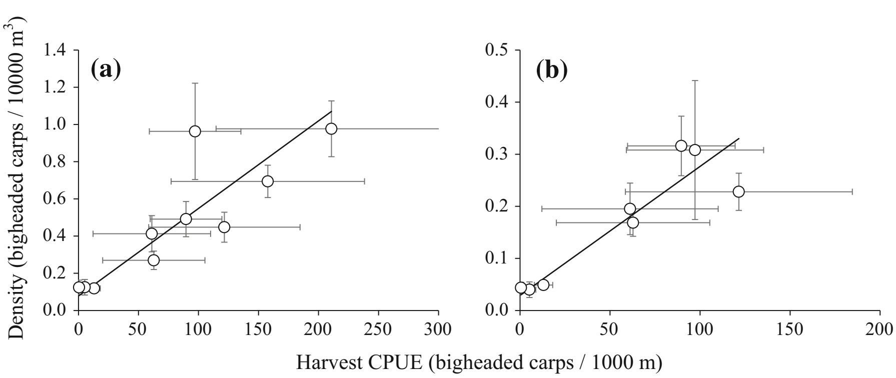


**Fig. 6** Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence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

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

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

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

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

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

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

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

## Discussion

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

### Advancing population characteristics

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

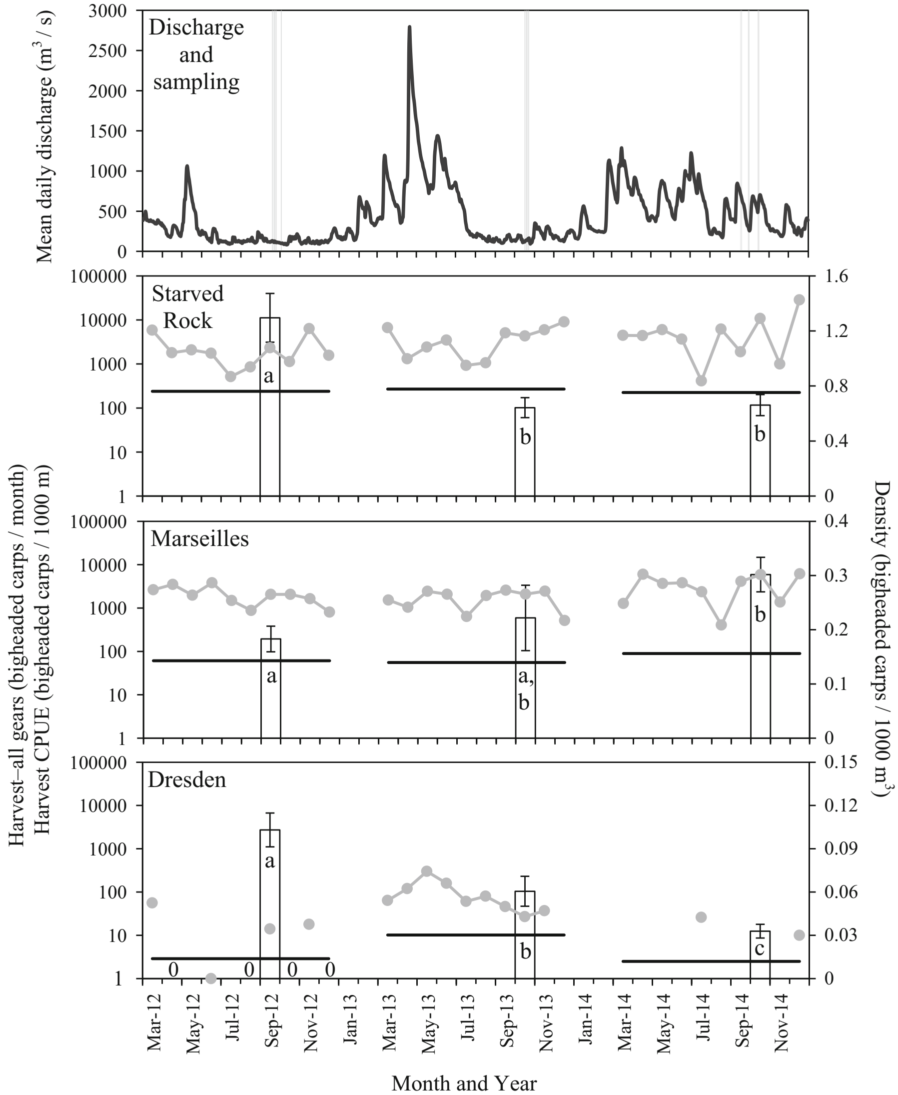


**Fig. 7** *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks*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

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

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

Harvest evaluation (short-term, local scale)

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

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

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

Harvest evaluation (long-term, river-wide)

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

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

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

## Conclusions

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

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

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