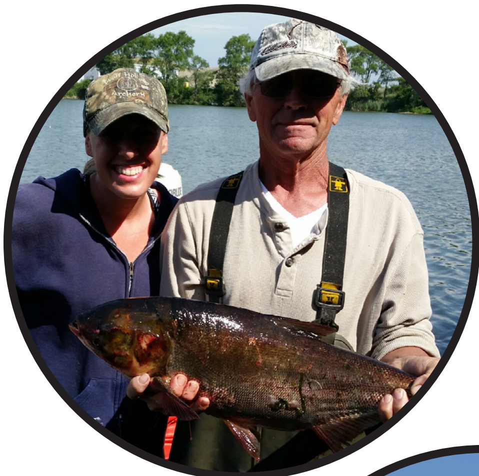
Asian Carp Monitoring and Response Plan





2018

Asian Carp Regional Coordinating Committee

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

ILLINOIS
DEPARTMENT OF NATURAL RESOURCES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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

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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, J. Merry, R. Simmonds, S. Finney, J. Stewart, N. Bloomfield, A. Coulter, D. Coulter, E. Pherigo, R. Neeley, R. Anderson, J. Kallis, M. O'Hara, T. Widloe, B. Caputo, B. Bushman, J. Widloe, L. Nelson, N. Bloomfield, B. Fehrenbacher, S. Morrison, B. Knights, 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 26 individual project plans, each of which plays an important role in preventing the expansion of the range of Asian carp, and in furthering the understanding of Asian carp location, population dynamics, behavior, and the efficacy of control and capture methods. Each individual plan outlines anticipated actions that will take place in 2018, 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 2018 MRP build upon considerable work completed since 2010. Selected highlights of past efforts are presented below, grouped by primary objective. For a more detailed accounting of the results and findings of previously completed work, please refer to the 2017 Asian Carp Interim Summary Report, presented as a companion document to the 2018 MRP.

HIGHLIGHTS OF PAST EFFORTS

Detection Projects

- A total of 374,288 fish representing 73 species and six hybrid groups were sampled above the Electric Dispersal Barrier, including 2,020 Banded Killifish (state threatened species) from 2010-2017. From 2011 – 2016 no Bighead or Silver Carp were captured or observed.
- One Silver Carp was captured above the Electric Dispersal Barrier in the Little Calumet River in 2017.
- No small (< 6 inches) Asian carp were captured upstream of Peoria Pool in 2017. Three small Asian carp were caught in Peoria Pool.
- Observations of eggs, larvae, and juveniles in the upper Illinois River during 2015 - 2017 indicate that some reproduction occurs above Starved Rock Lock and Dam in some years,

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

- Fixed and random sampling below the Electric Dispersal Barrier has resulted in the collection of over 291,000 fish to date. No Asian carp have been captured in Brandon Road or Lockport Pools. The detectable Asian carp population front is near River Mile 281, approximately 46 miles from Lake Michigan.
- 72 juvenile Silver Carp in LaGrange and Peoria pools were collected and tagged for acoustic telemetry studies in 2017.
- There were no positive detections for Asian carp eDNA above the Electric Dispersal Barrier during sampling in 2017. eDNA sampling in Dresden Island Pool was analyzed to compare eDNA detection frequencies with known trends in Asian carp populations.
- 34 Bighead Carp have been removed from urban ponds since 2011.

Manage and Control Projects

- Through IDNR and USFWS harvest efforts, over 3,193 tons of Asian carp have been removed from the IWW below the Electric Dispersal Barrier since 2010. This tonnage was comprised of 90,469 Bighead Carp, 681,743 Silver Carp, and 4,668 Grass 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.
- 542 surrogate fish with behavior similar to Asian carp were tagged in 2017 to study movement across the Electric Dispersal Barrier and through locks and dams. One tagged Common Carp showed downstream movement through Brandon Road Lock and Dam.
- The estimated mean density of Asian carp in Dresden Island Pool has declined by 93% between 2012 and 2017. Ongoing MRWG removal efforts through contracted commercial fishing in the upper IWW likely play an important role in this observed decline.
- No Asian carp have been captured during sampling in the Des Plaines River. This spans the collection of 11,082 fish since 2011.
- 61 Grass Carp were captured in 2017, including 13 from above the Electric Dispersal Barrier. 59% 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, and the most cost-effective gear.
- 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 2018 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 2018.

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 4th and 11th) and the fall season (Week of September 10th and 17th). This project includes standardized monitoring with pulsed-DC electrofishing gear and contracted commercial fishers at sites in the CAWS upstream of the Electric Dispersal Barrier system. Monitoring also will include five fixed sites with additional random electrofishing transects and net sets at locations outside of fixed sites to maintain spatial coverage of the waterway. Along with maintaining the spatial coverage upstream of the Electric Dispersal Barrier, each seasonal intensive monitoring event will provide extra sampling focus on a unique location in the CAWS. The two-week event in the spring will focus on the Lake Calumet/Cal-Sag area of the CAWS. In 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 pound 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 Dispersal Barrier System.

Strategy for eDNA Sampling in the CAWS

In 2018, the project will collect samples at four traditional sampling sites in the CAWS above the Electric Dispersal Barrier to maintain the historical data record. Based on the results of other recent eDNA studies, samples will be biased to side channel and backwater areas that have longer retention times for eDNA.

Larval Fish Monitoring in the Illinois Waterway

Larval fish sampling will occur at approximately biweekly intervals at 10 sites located in the Illinois and Des Plaines rivers below the Electric Dispersal Barrier from April to October. Additional sampling will occur at sites in the Sangamon, Spoon, Mackinaw, Fox, and Kankakee rivers to assess potential Asian carp spawning in tributaries of the Illinois River. Sampling may occur more frequently during periods when Asian carp eggs and larvae are likely to be present (e.g., May - June, during periods of rising water levels, or shortly after peak flows). Observation of Asian carp eggs or larvae will help to inform other agencies of the upcoming likelihood of capturing young-of-year Asian carp. Analyses of the spatial and temporal distribution of Asian carp eggs and larvae will aid in identifying spawning locations, environmental factors associated with successful reproduction, and factors contributing to Asian carp recruitment.

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 Asian carp 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. During 2018 a total of 108 random sites in Marseilles and Dresden Island pools will be sampled in an effort to sample areas that aren't routinely visited.

Distribution and Movement of Small Asian Carp in the Illinois Waterway Using Telemetry

During 2018 this project will focus on collecting juvenile Asian carp from Peoria Pool, and implant them with acoustic telemetry tags. A subset of juvenile Asian carp will be implanted with radio tracking 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.

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 December, except in June and September when commercial fishers will be sampling for the Seasonal Intensive Monitoring event above the Electric Dispersal Barrier. Hoop and mini-fyke netting will occur bi-weekly from April through December. 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 Species Composition Near the Chicago Sanitary and Ship Canal Electric Dispersal Barrier

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

Alternative Pathway Surveillance – Urban Pond Monitoring

This project provides monitoring and removal efforts for Asian carp that may have been unintentionally stocked in urban fishing ponds in the Chicago Metropolitan Area. Monitoring with eDNA technology and conventional gears (electrofishing and netting) has previously occurred in local fishing ponds and has detected and removed Asian carp (possibly introduced as contaminants in shipments of stocked sport fish). During 2018, urban pond sampling will be based upon photographic evidence of Asian carp or reports from credible sources.

Young-of-year and Juvenile Asian Carp Monitoring

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

Des Plaines River and Overflow Monitoring

This project performs monitoring for Asian carp within the Des Plaines River using electrofishing and gill netting. The Des Plaines River runs parallel to the CAWS, and represents a possible route for Asian carp to bypass the Electric Dispersal Barrier during overflow events. To prevent this bypass, a physical barrier was constructed between the Des Plaines River and the CAWS. This project continues to monitor for Asian carp in the Des Plaines River to determine the threat posed to the CAWS by Asian carp populations within the Des Plaines River. A minimum of three sampling events will be conducted in 2018, 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.

Barrier Defense 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. Additional processing techniques will be employed in 2018 and evaluated for their ability to speed up fish collection and processing. The efficacy of the electrified paupier will continue to be evaluated, as will the demographics of the fish it captures in comparison to those captured by commercial netting.

Optimization of Mass Removal Techniques

This project will use a variety of methods to evaluate the efficacy of mass harvest techniques for removing Asian carp, including the Unified Fishing Method. This project will develop and evaluate herding and containment methods tailored to Asian carp and local conditions to improve the efficiency of mass harvest efforts. It will also aim to identify locations where aggregations of Silver Carp are common based on environmental conditions. The project will also develop cost effective methods for estimating the number of Asian carp in a particular area to both identify target areas for mass removal, and to evaluate the impacts of mass removal to local Asian carp populations.

Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions

This project continues past efforts to develop, test, and utilize a model of Asian carp population characteristics, abundance, and movement within the IWW. In 2018, 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. 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.

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 2018 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. 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. Multi-gear sampling models will also be deployed and evaluated.

Unconventional Gear Development

In 2018, the evaluation of the use of pound nets to capture Asian carp will continue. Past results have demonstrated the potential of pound nets to be an effective capture method in several habitat types. Work in 2018 will focus on evaluating the effectiveness of pound nets in a variety of locations to increase the robustness of the efficacy evaluation of pound nets. Work will also be conducted to deploy and evaluate alternative pound net configurations to determine optimal set conditions for capturing Asian carp. Configurations that will be tested include perpendicular to shore, parallel to shore facing both upstream and downstream, and tandem sets. 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.

Barge Entrainment and Asian Carp Interaction Study and Monitoring Barge Entrainment Dynamics and Assessment of Mitigation Protocols

In 2018, this project will build upon past work involving the effect of barges on the Electric Dispersal Barrier, and the ability of barges to entrain relatively small fish and transport them across barriers. While past work has primarily focused on evaluating barge interactions with the Electric Dispersal Barrier using surrogate fish, in 2018 the project will focus on experimenting with several size classes of Asian carp in downstream portions of the Illinois River where Asian carp are well established. The interaction between Asian carp and barges will be studied, with a focus on the entrainment of smaller size classes. This project will also perform an analysis correlating historical Asian carp spawning events with commercial ship tracking data to analyze whether there were time periods and locations where the entrainment and upstream transport of Asian carp eggs and/or larvae were possible.

Asian Carp Population Modeling to Support an Adaptive Management Framework
This project continues to build upon past efforts to develop a Spatially Explicit Asian carp Population (SEAcarP) model that includes spatial components (i.e., river pools) of the Illinois River system. During 2018, the model will be updated with the most recent available data, and will be modified to use integral projection models to model Asian carp populations continuously, rather than as discrete size classes. Sensitivity analyses will be performed on the model to determine which model inputs require additional data and research. Statistical catch models will be used to estimate vulnerability to fishing based on fish size, exploitation rates, and immigration to the upper Illinois River. The model will be used to inform adaptive management efforts to control Asian carp populations in the Illinois River.

Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEACarP)
This project aims to provide a more robust telemetry dataset to inform Asian carp movement within the SEACarP model. During 2018, this project will focus on tagging small and juvenile Asian carp to better understand their movement tendencies, including interactions with dams and macro-habitat selection. Tagging efforts will focus on Starved Rock Pool. The results of this study will be incorporated in the SEACarP model to better evaluate the risk posed by movement of small and juvenile Asian carp, and to better understand the habitat selection of juvenile Asian carp as they mature.

Asian Carp Demographics
This project aims to establish a consensus standard for determining the age of captured Asian carp. To date, there is no agreed-upon method for aging Asian carp, which are particularly difficult species to age due to a variety of factors, including wide-ranging growth rates and the ability to spawn multiple times in a single year. This project aims to collect a representative subset of Asian carp from varied sizes and age groups, and convene a group of subject matter experts to establish a consensus standard for determining the age of Asian carp. This standard will then be promulgated to multiple agencies for use in future aging studies. This project will also aim to quantify demographics for each of the lower five pools of the Illinois River, develop spawner and cohort abundance indices to evaluate relationships between spring and fall juvenile recruitment classes, and establish methods for determining the strength of an annual recruitment class.

Asian Carp Enhanced Contract Removal Program
This new program will reduce the abundance of Asian carp in the Illinois River Peoria Pool through controlled and contracted fishing efforts. This program will be implemented through the issuing of fishing contracts to those willing to target Asian carp in Peoria Pool and fulfilling contractual obligations of selling, reporting, transporting, and fishing in the identified area. This project will also provide critical information on population densities of Asian carp over time in

the Peoria Pool as well as the Illinois River system to guide management efforts. This project will also identify and use mechanisms for use of the harvested fish through private industry for purposes including human consumption. Through a cooperative relationship of agency and fisher along with end users/markets, advice and support will be provided as necessary to further inform fishers on the delivery of quality and quantity of fish to the end user/markets through this interaction.

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 2018, 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 26 individual project plans, each of which plays an important role in preventing the expansion of the range of Asian carp, and in furthering the understanding of Asian carp location, population dynamics, behavior, and the efficacy of control and capture methods. Each project outlines anticipated actions that will take place in 2018, including project objectives, methodology, and highlights of previous work.

This MRP is the operational extension of the 2018 Asian Carp Action Plan which outlines funding and actions taken through the USEPA's Great Lakes Restoration Initiative. The Fiscal Year 2018 Action Plan contains the portfolio of more than 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 – 2017. More specifically, it is intended to identify actions to be taken in 2018, consistent with the multiyear, 2015 – 2017 MRP that was developed in 2015. This 2018 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 2018

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 2018 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 2017 Asian Carp Monitoring and Response Plan Interim Summary Report (ISR), has also been completed by the MRWG. The 2017 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 2018 MRP and 2017 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. Four projects were completed in 2017, consisting of "Analysis of Feral Grass Carp in the CAWS and Upper Illinois River", "Illinois River Juvenile Asian Carp Telemetry", "Understanding Surrogate Fish Movement with Barriers" and "Monitoring Asian Carp using Netting with Supplemental Techniques". The final reports for each of these projects can be found in the 2017 Interim Summary Report. In 2018, five new projects have been added, and plans are included in this MRP. These new projects are "Optimization of Mass Removal Techniques", "Asian Carp Population Modeling to Support an Adaptive Management Framework", "Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEACarP)", "Asian Carp Demographics", and "Asian Carp Enhanced Contract Removal Program".

The projects included in the 2018 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
Larval Fish Monitoring in the Illinois Waterway
Distribution and Movement of Small Asian Carp in the Illinois Waterway
Distribution and Movement of Small Asian Carp in the Illinois Waterway using Telemetry
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
Alternative Pathway Surveillance: Urban Pond Monitoring
Young-of-year and Juvenile Asian Carp Monitoring
Des Plaines River and Overflow Monitoring
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Optimization of Mass Removal Techniques
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Telemetry Support for the Spatially Explicit Asian Carp Population Model (SEACarP)
Asian Carp Demographics
Asian Carp Enhanced Contract Removal Program
Alternative Pathway Surveillance: Law Enforcement
Response
Upper Illinois Waterway Contingency Response Plan

In addition to these project plans that directly address the primary objectives of the MRWG, additional key information is provided in this MRP as appendices. Additional project plans for 2018 are provided in the following locations:

- Appendix A: “Integration of New Science and Technology”
- Appendix M: “Using zooplankton to measure ecosystem responses to Asian carp barrier defense and removal in the Illinois River”
- Appendix N: “Detection using Novel Gear”

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

CURRENT STATUS

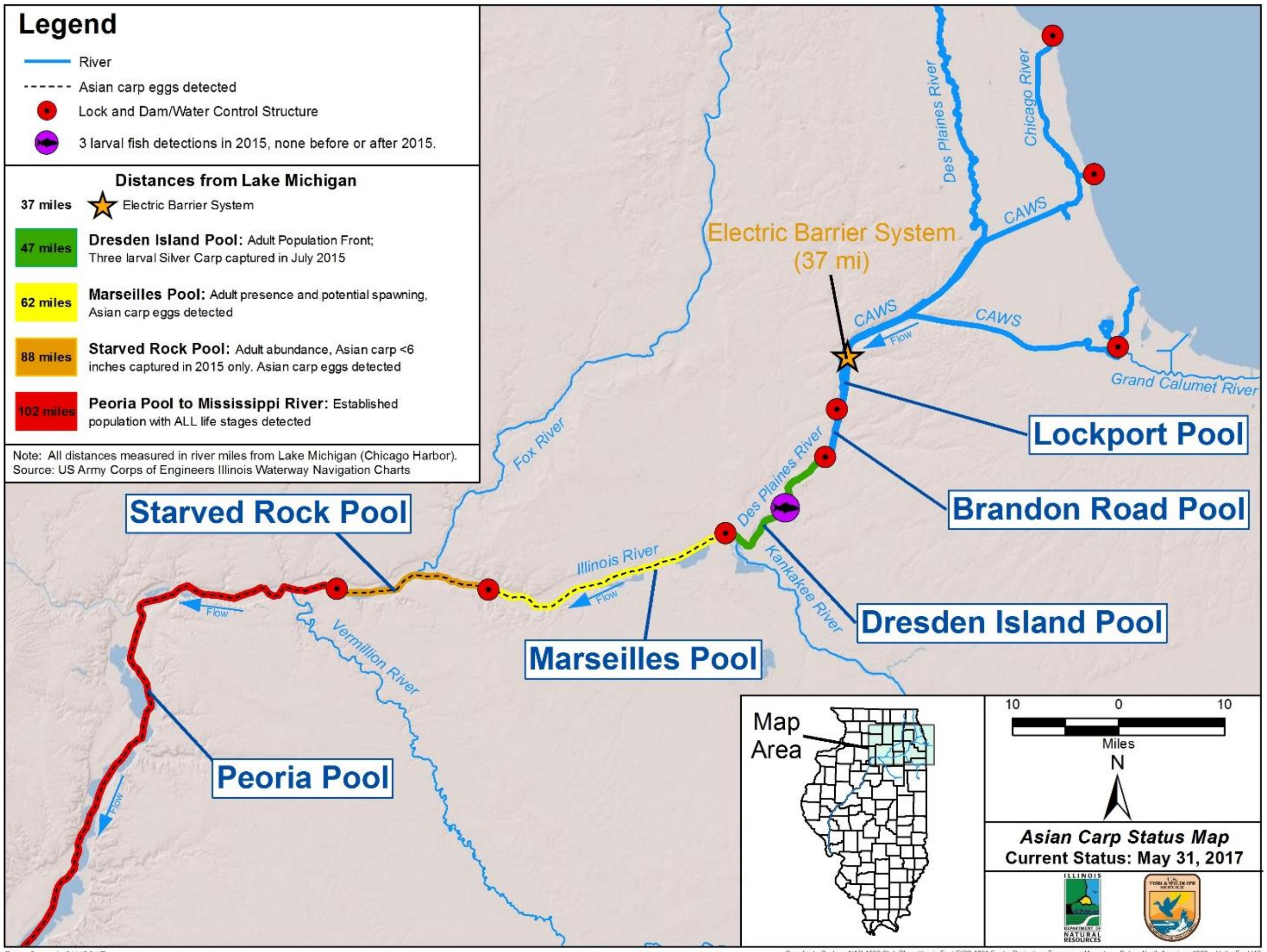
Detection projects have informed agency actions and development of the 2018 MRP.

No Asian carp have been detected in Lake Michigan, and no Asian carp have been collected between Brandon Road Lock and Dam and the Electric Dispersal Barrier since detection efforts were intensified in 2010. Acoustic-based surveys performed in 2017 suggest relative abundance (measured as mean Asian carp density based on hydroacoustic surveys) has been reduced by an estimated 93% from 2012 levels. This is an improvement on prior estimates demonstrating relative abundances of adult Asian carp in the Dresden Island Pool decreased between an estimated 59% and 75% from 2012 to 2014 (a 68% average, see MacNamara et al. 2016 contained in Appendix L). This reduction was facilitated, in part, by the mass removal of Asian carp through the strategic use of contract commercial fishing, as well as other factors such as fish migration within the waterway and the degree of reproductive success during those years. These acoustic survey techniques allow for assessment of the Asian carp population on a pool-by-pool basis and evaluation of potential change of risk of Asian carp approaching the electric barrier system, in addition to traditional techniques.

The management and control aspects of this MRP have also contributed to observations of reduced populations (up to 50% declines as noted by MacNamara et al [Appendix L]) in Marseilles and Starved Rock pools, as well as reduced populations (up to 93% decline) in Dresden Island Pool. While spawning activity has been observed in Marseilles and Starved Rock pools, the resulting eggs travel downstream with prevailing flow direction, away from Lake Michigan. Data suggest that any eggs produced in these pools experience mortality or drift downstream to hatch in the Peoria and LaGrange pools, below the Starved Rock Lock and Dam. Larval and juvenile Asian carp are present in the Lower IWW, which acts as the source of Asian carp throughout the IWW. The MRWG believes that small Asian carp (< 6 inches) and those larger Asian carp found above the Starved Rock Lock and Dam have immigrated to the Upper IWW from the Lower IWW. Because Asian carp are produced only in the Lower Illinois River, the strategy of removal above Starved Rock Lock and Dam has increased efficacy for control until such time as much larger commercial harvest of Asian carp further downstream in the lower Illinois River can be effectively accomplished. The 2018 Asian Carp Action Plan recognizes management based contracts that can be issued to increase removal efforts in the lower Illinois River. 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 been used in Marseilles and Dresden Island pools, and will be applied more broadly in the Upper IWW during 2018. Understanding how other technical solutions (e.g. underwater speakers, electricity) increase capture rates will continue to be explored in 2018.

Data collected since 2011 have improved knowledge of where fish are and where fish are not in the IWW. The graphic below summarizes our current knowledge of the status of Bighead Carp and Silver Carp developed through ongoing monitoring and historical accounts. This graphic also denotes 2015 as the baseline year to evaluate progress in future years. 2015 was selected as a baseline year for two primary reasons: (1) 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 2018, have been used to establish the current status of Asian carp populations in each pool of the IWW, as described below:

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



Specific highlights from the 2017 field season include:

- No Asian carp collected or observed in Lake Michigan or Brandon Road Pool.
- A single Silver Carp collected in the Illinois Waterway below T.J. O'Brien Lock and Dam, approximately 9 miles from Lake Michigan.
- No small Asian carp detected in Upper IWW.
- 1.25 million pounds of Asian carp removed from Upper IWW.
- Successfully implemented Chinese Unified Fishing Method, at multiple locations in Marseilles and Dresden Island pools.

The capture of a single Silver Carp below T.J. O'Brien Lock and Dam, above the Electric Dispersal Barrier, triggered a two-week intensive sampling event. Crews from the U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACE), Illinois Department of Natural Resources (IDNR), Illinois Natural History Survey and contracted commercial fishers conducted the monitoring operation. The U.S. Coast Guard provided notice to mariners of increased activity in the areas above and below the T.J. O'Brien Lock and Dam. The field portion of the operation exceeded 1,950 person-hours. In addition, commercial fishers working with IDNR biologists set more than 43 miles of gill net, while crews with IDNR, USACE and USFWS conducted 365 electro-fishing runs for a total of more than 91 hours of effort.

Four electrofishing crews, three contracted commercial fishers, and a specially outfitted netting boat were deployed daily below the T.J. O'Brien Lock and Dam, in Lake Calumet, and in an area from the T.J. O'Brien Lock and Dam to Calumet Harbor. The operation covered a 13-mile section of the waterway and Calumet Harbor with intensive monitoring. No Asian carp were captured or observed during this response.

The single Silver Carp that was collected and was submitted for a detailed autopsy, performed by Southern Illinois University, USFWS, and the U.S. Geological Survey (USGS). The autopsy found that the fish originated in the Illinois/Middle Mississippi watershed. Analysis showed the 4-year-old male Silver Carp spent a quarter of its life in the Des Plaines River watershed before being caught and removed from the Little Calumet River above the USACE' electric dispersal barrier system (EDBS). Though it is not known how the fish was able to arrive above the barrier defense system, analysis showed that the fish spent no more than a few weeks to a few months in the stretch of river where it was found.
Detailed results of the autopsy can be accessed online (http://www.asiancarp.us/documents/SIUSummaryofSilverCarpData.pdf).

In addition to these direct findings, data collected via surveillance and management projects have been used to develop a model that combines the propensity of Asian carp to move, the effects of harvest, and basic biological parameters such as age, growth, and condition of Asian carp. The model will serve as a decision support tool to help inform management efforts and strategy over the short term (next 5 years) and long term (> 5 years). Initial results support the MWRG's existing management strategy that focuses localized and intense Asian carp removal efforts in the upper river. However, a long term strategy bolstered by market-driven forces to remove Asian carp in the lower Illinois Waterway 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 the upstream removal strategy may have less impact on the Asian carp population after downstream harvest efforts begin, the MRWG expects that population suppression above Starved Rock Lock and Dam, and detection above Brandon Road Lock and Dam, will continue for at least the next 10 years. This timeline would likely be extended if effective commercial markets for Asian carp cannot be established and sustained in the relatively near future.

Despite current activities, 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. The contingency plan has proven useful and is suitable to guide other actions and inter-agency activities even when an emergency action is not observed. The contingency plan was successfully implemented on June 24 2017 with the capture of a Silver carp 9 miles from Lake Michigan The event "Operation Silver Bullet" applied the framework of the contingency plan, which continued for 2 weeks until actions were ceased following the guidelines set forth, in the contingency response plan.

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, but Grass Carp are found in Brandon Road Pool and the CAWS. Since Grass Carp is a large-bodied cyprinid species similar to Silver Carp and Bighead Carp, MRWG believes methodologies included in this MRP and developed based on past work will also provide sufficient gears, methods for detection, and removal techniques for Grass Carp. Most of the Grass Carp detected by MRWG efforts in the CAWS are triploid individuals, which means that they are infertile. However, diploid (fertile) Grass Carp have been detected. There is no record of reproducing Grass Carp in Lake Michigan, but reproducing populations have been noted in Lake Erie. Grass Carp are removed by monitoring and removal crews when encountered unless tagged and identified for further research. The USGS Nonindigenous Aquatic Species (NAS) website provides a fact sheet and references to supplement this plan and can be found at: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=514

Black Carp

Black Carp have not been detected in the Upper IWW, however through 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. http://www.asiancarp.us/documents/KeepCoolCallHandout.pdf 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 2018 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 2018 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 2018, 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 2019 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 2018.

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 (2019 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. A business evaluation was completed in 2017, and the results are being used to develop techniques for targeted outreach and market development during 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 2018 are listed below with leads identified to assist in communication and structure. Co-leads may also be identified to assist with managing these work groups as appropriate and helpful. Workgroups may be added or deleted to serve MRWG and ACRCC needs.

2018 Work Group	Lead/Agency
Contingency Planning	Matt Shanks/USACE
Removal	Matt O'Hara/ILDNR
Hydroacoustic Assessments	Dave Coulter/SIU
Telemetry	Brent Knights /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 2017 funding received. It is crucial that the necessary funds are available to continue aggressive removal efforts to reduce the risk of range expansion, as well as to continue focused surveillance to ensure that management agencies have an accurate understanding of changes to Asian carp range, population dynamics, and behavior.

Detection

- Ensure sufficient surveillance effort 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 CO_2 to herd fish can be effectively incorporated into MRWG actions.
  - If the answer is no or is ambiguous, consider removing techniques that show limited demonstrable effectiveness from future MRPs and MRWG actions.
  - Develop standardized methods for evaluating ongoing research efforts, including set decision points for continuing or stopping research efforts, and recommended timelines for including regulatory input and evaluations.
- Evaluate ongoing management efforts to measure the effectiveness of management actions, adjust activities to improve effectiveness and adapt to future changes.
  - Hydroacoustic surveys to provide reliable estimates of abundance in each of the pools of the 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).

Introduction and Need:

Detections of Asian carp eDNA upstream of the Electric Dispersal Barrier in 2009 initiated the development of a monitoring plan using boat electrofishing and contracted commercial fishers to sample for Asian carp at five fixed sites upstream of the barrier. In addition, random area sampling began in 2012 in order to increase the chance of encountering Asian carp in the CAWS beyond the designated fixed sites. Based on the extensive sampling performed upstream of the Electric Dispersal Barrier from 2010 through 2013 (682 hours of electrofishing, 445.8 km (277 mi) of gill/trammel net, 2.2 km (1.4 mi) of commercial seine hauls) and only one Bighead Carp being collected in Lake Calumet in 2010, fixed site and random area sampling effort was reduced upstream of the barrier to two Seasonal Intensive Monitoring (SIM) events from 2014- 2017. 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.

Methods:

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

Electrofishing Protocol:

All electrofishing will use pulsed DC current and include 1-2 netters (two netters preferred). Locations for each electrofishing transect will be identified with GPS coordinates. Electrofishing transects should begin at each coordinate and continue for 15 minutes in a downstream direction in waterway main channels (including following shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Electrofishing boat operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat. Common Carp will be counted without capture and all other fish will be netted and placed in a tank where they will be identified and counted, after which they will be returned live to the water. Schools of young-of-year (YOY) Gizzard Shad < 152.4 mm (6 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 4th and September 10th)*

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).

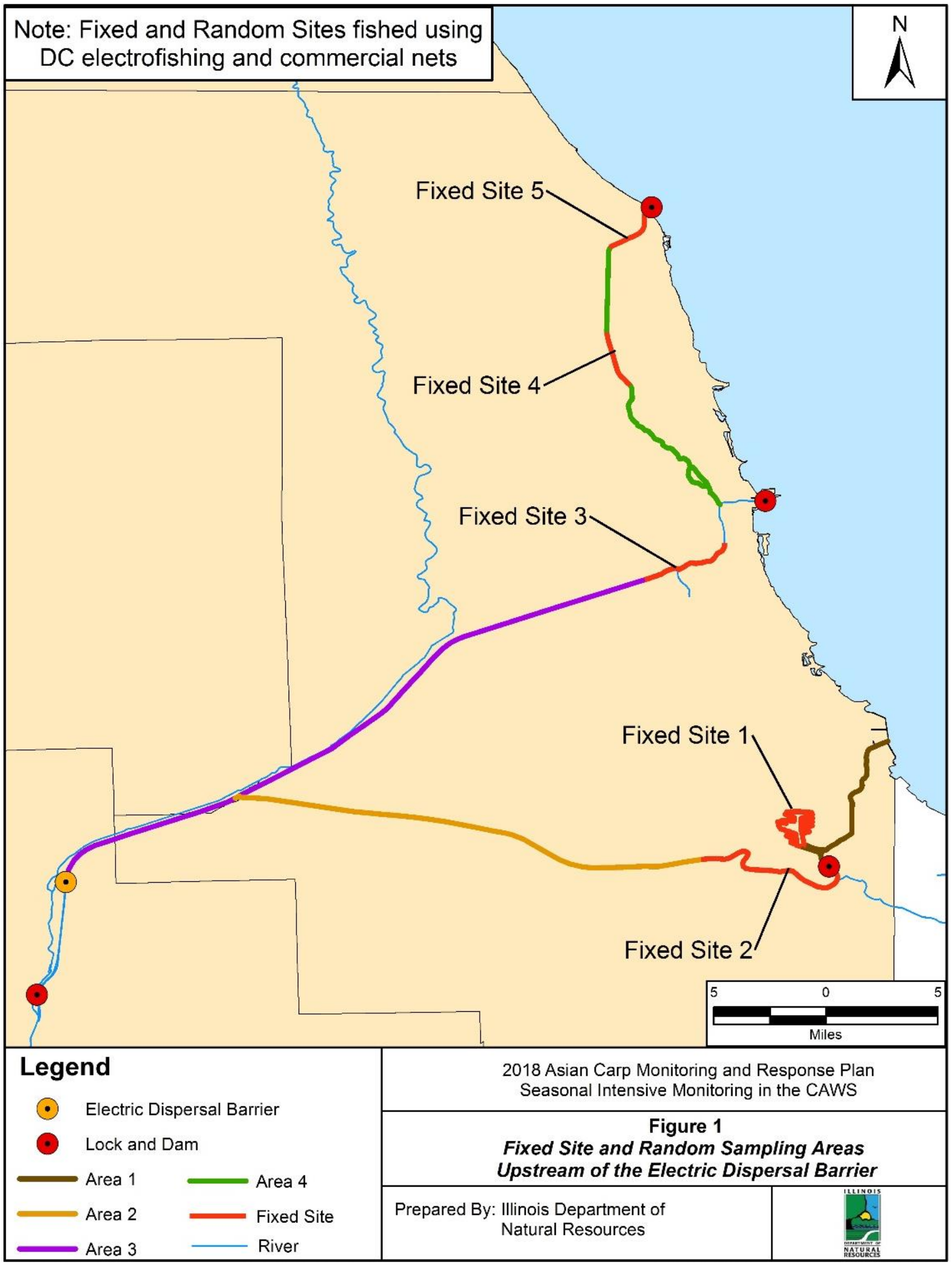


Figure 1. *Fixed site and random site sampling areas for electrofishing and commercial netting upstream of the Electric Dispersal Barrier.*

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 11th)*

Lake Calumet

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

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

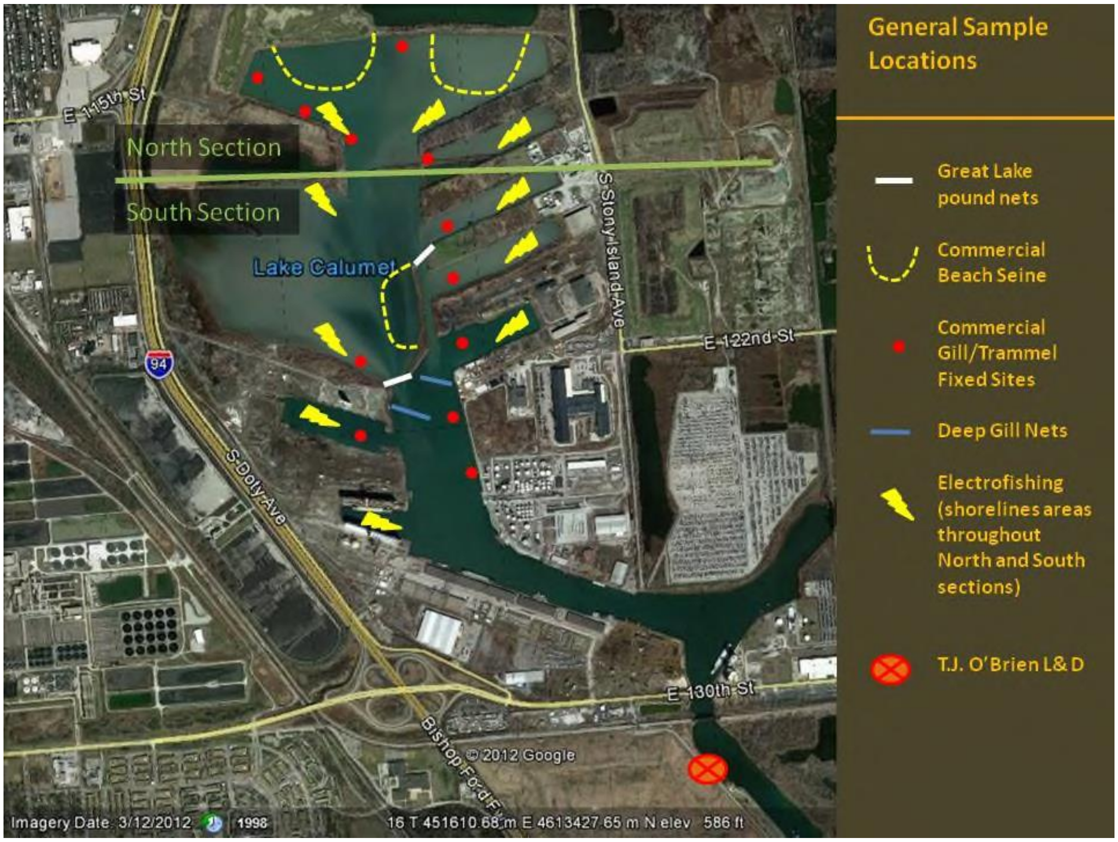


Figure 2. *Sampling locations in Lake Calumet. Sample locations are approximate and subject to change.*

North Shore Channel, Chicago River and Random Area Sites Upstream of the Electric Dispersal Barrier - *(week of September 17th)*

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. In conjunction with sampling efforts in the North Shore Channel and Chicago River, electrofishing and gill/trammel netting will take place at four random site sampling areas throughout the CAWS upstream of the Electric Dispersal Barrier as mentioned above (Figure 1). For all SIM activities accurate sampling time will be recorded with all fish identified to species. GPS coordinates (decimal degrees) will be taken at the location of all net sets and at the beginning of electrofishing runs. Grass Carp will be kept and put on ice for transfer to Dr. Greg Whitledge (SIU) for ploidy analysis. Any Bighead Carp or Silver Carp collected will immediately be reported to the Operations Coordinator and/or Law Enforcement who will bring a cooler to secure fish. GPS location, time, and specific gear will be recorded as accurately as possible (mesh size, type, depth). Any Asian carp will be transferred to Dr. John Epifanio, with tissues shared among research agencies as per the 2018 MRP. Furthermore, capture of a Bighead Carp or Silver Carp would initiate a level two rapid response upon conferring with MRWG members, additional effort or time frame could change.

2018 Sampling Schedule:

Spring Event

Week of June 4: Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of June 11: Lake Calumet, Calumet River and random area sites upstream of the Electric Dispersal Barrier

Fall Event

Week of September 10: Fixed and random area sites upstream of the Electric Dispersal Barrier

Week of September 17: North Shore Channel, Chicago River and random area sites upstream of the Electric Dispersal Barrier

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

Deliverables:

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

Strategy for eDNA Sampling in the CAWS
2018 Plan

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

Location: Chicago Area Waterway System (CAWS)

Introduction and Need:

Monitoring with multiple gears in the CAWS has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of Asian carp from establishing in the Great Lakes. Environmental DNA (eDNA) has been used as a surveillance tool to sample for the genetic presence of Bighead Carp and Silver Carp in the CAWS since 2009. The goal of using eDNA in the CAWS was and still is to apply a monitoring tool that has a much lower false negative (fail to detect eDNA that is present) rate than other monitoring methods, such as electroshocking and gill netting, which have a very high false negative rate when animals are present in very low abundance (Darling and Mahon 2011). Using multiple detection methods provides a balanced and complete monitoring program in the CAWS, because all monitoring methods have difficulty detecting very low abundance organisms. To maintain vigilence above the Electric Dispersal Barrier, eDNA has been collected at four regular monitoring sites. Sampling was deployed twice per year 2014-2015, and was reduced to once per year in 2016 and 2017. Since 2014, eDNA results are no longer consdidered a trigger for any kind of response, which will continue this year.

Objective:

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

Status:

Sampling for eDNA in the CAWS above the Electric Dispersal Barrier has been conducted since 2009. In 2013, equipment decontamination and separation protocols were implemented and in 2014, improved DNA markers were deployed. Together, these improvements have made for more sensitive and specific eDNA results. For example, in 2015 and 2017, there were zero positive eDNA samples in the CAWS, and in 2016 there was a single sample positive for both species' DNA. Since 2014, 1,394 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. While improvements to the field and lab methods have improved sensitivity, this method should not ever be expected to find the proverbial "needle in the haystack" or a single fish, but it has been shown to provide detection of rare species when other methods have failed. The low eDNA detection rates observed in the CAWS reflect that only one Silver Carp was captured alive in 2017, and one Bighead Carp was captured alive in the CAWS in 2010. As of 2013, all response actions to eDNA results were terminated, and there will not be any response actions based on eDNA results this year. In September 2017, changes were made to the distribution of eDNA samples collected in the CAWS based on lessons learned deploying eDNA in other carp-infested rivers such as the Wabash and Upper Mississippi. Extra emphasis is put on slack-water and off-channel areas, which have been demonstrated to be more effective in recent eDNA studies. Most notably, changes were made to add samples in the areas of Bubbly Creek and Goose Island, and near the Chicago Lock. Additionally, more barge slips were sampled and all thalweg samples were relocated to shorelines or other off-channel areas, based on results of eDNA studies in other rivers where DNA has been shown to be moved quickly downstream in the thalweg.

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

In 2017, efforts below the Electric Dispersal Barrier were expanded to the entire Dresden Island Pool, but limited to that single pool. In 2017, eDNA results closely reflected the carp density gradient present in the pool. Hotspots of positive eDNA detections consistently reflected the areas where the most Asian carp were captured by traditional gears in the months surrounding eDNA sampling events. The habitat location of eDNA detections also shifted noticeably between sampling events and were consistent with the movment of Asian carp responding to changing water level conditions observed in systems where their movements are tracked through telemetry.

Strategy for eDNA Sampling in the CAWS
2018 Plan

Methods:

In 2018, to maintain vigilance within the CAWS and enhance other ongoing monitoring effots, the CAWS will be sampled for Bighead Carp and Silver Carp eDNA in a method similar to the September 2017 event, which was modified based on recent eDNA studies and results in other river systems. Specifically, samples are now targeted shoreline and off-channel areas, where fish and their DNA may collect, and all thalweg samples are removed, since DNA shed in this high flow area will be rapidly transported downstream. The goal of using eDNA in the CAWS is to apply a monitoring tool that has been shown in literature to have a much lower false negative (fail to detect eDNA that is present) rate than other fishing methods when animal abundance is low. Use of more than one observation method increases monitoring strength in any system, including the CAWS. The modified sampling regime will encompass areas of the Chicago Sanitary and Ship Canal (CSSC), North and South Branches of the Chicago River, the Chicago River, the Little Calumet River, the Calumet River, and Lake Calumet that have less flow, or bank areas where eDNA may accumulate. Highly channelized areas such as the North Shore Channel will not be sampled, since any eDNA is quickly moved downstream. Sampling will occur in June and September in the week prior to the Seasonal Intensive Monitoring events. There will be no eDNA sampling conducted below the Electric Dispersal Barrier in 2018.

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 and made available to the MRWG in the 2018 Interim Summary Report.

2018 Schedule:

Week 1: May 29-June 1 (Alternate dates: May 21-25) – 280 samples

Week 2: September 4-7 (Alternate dates: August 27-31) – 280 samples

Deliverables:

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

References:

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

Larval Fish Monitoring in the Illinois Waterway

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

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

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; 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.

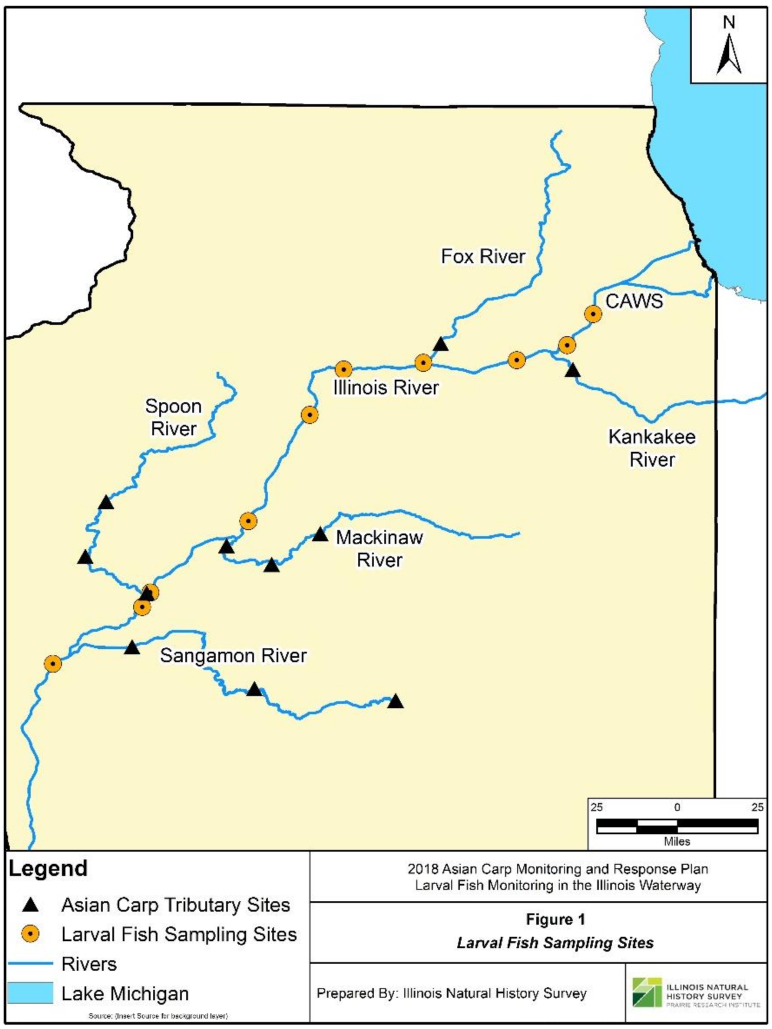


Figure 1. *Map of larval fish sampling sites in the Illinois Waterway (circles) and in tributary rivers (triangles).*

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, LaGrange 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 - 2017 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 some years in smaller tributary rivers, but the frequency of spawning in these systems, or the contribution of these rivers to basin-wide Asian carp populations is not known. 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.

(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, suggesting very limited reproduction during these years. Much larger spawning events during 2014 – 2017, particularly in 2015 and 2017, resulted in the collection of very large numbers of Asian carp eggs and larvae. Asian carp often have 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 increasing, although some eggs and larvae have also been collected when water levels were stable or falling. Prior to 2015, Asian carp larvae had only been collected at sites in the LaGrange and Peoria Pools. However, during

2015 - 2017 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, Spoon, 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 needed 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. Analyses examining relationships between environmental factors and Asian carp reproduction and recruitment will be completed and reported during 2018. Collaborative modeling of Asian carp egg drift (FluEgg model) with USGS partners, using a hydrodynamic model of the Illinois Waterway and a reverse-time particle tracking algorithm, will be used to back-calculate spawning locations of Asian carp eggs collected by ichthyoplankton sampling efforts.

Larval Fish Monitoring in the Illinois Waterway

Sampling Schedule:

In 2018 and subsequent years, larval fish sampling will occur at weekly intervals at all sites from April to early July, and biweekly intervals from late July to October. Additional sampling will occur during periods when Asian carp eggs and larvae are likely to be present (e.g., during periods of rising water levels, or shortly after peak flows).

Deliverables:

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

Distribution and Movement of Small Asian Carp in the Illinois Waterway

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

Location: Known populations of adult Asian carp exist in all pools of the Illinois River Waterway (IWW) downstream of Brandon Road Lock and Dam. In 2016, USFWS personnel surveyed for small Asian carp within the Lockport, Brandon Road, Dresden Island, Marseilles, and Starved Rock pools. Three small (109 - 115 mm total length [TL]) Silver Carp were captured near Henry, IL (RM 194) in the Peoria Pool during 2017. As of February 2018, the farthest upstream juvenile Asian carp (≤400 mm TL) have been recorded was in Moody Bayou (Gundy County) at Illinois River Mile 256.4. These two Silver Carp (168 and 171 mm) were collected on October 22, 2015.

Introduction:

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

Laboratory tests have shown the Electric Dispersal Barrier System is sufficient at stopping large-bodied fish from passage, however, testing using small Bighead Carp (51 to 76 mm TL) indicated that the operational parameters of the barrier may be inadequate for blocking small fish passage (Holliman et al. 2011). U.S. Fish and Wildlife Service (USFWS) research indicated that Golden Shiners (*Notemigonus chrysoleucas*) can be entrained in barge junction gaps and transported through the Electric Dispersal Barrier System. Other research by USFWS using Dual Frequency Identification Sonar (DIDSON) indicated that small fish (non-Asian carp species; suspected to be Gizzard Shad) are transported upstream through the barrier by return water current during downstream barge movement. These studies show that if Asian carp are present near the Electric Dispersal Barrier System these fish may able to breach the barrier through multiple methods. For this reason, there is a critical need to monitor the distribution of juvenile Asian carp below the Electric Dispersal Barrier System. Additionally, a need is present to understand the reproduction, demographics, and habitat usage of these fish in the IWW so small fish may be targeted for eradication or other management actions.

Distribution and Movement of Small Asian Carp in the Illinois Waterway

The purpose of this study is to determine the spatial distribution of small Asian carp in the IWW through intensive, targeted sampling. Silver and Bighead Carp specimens ≤153 mm TL (6 inches) are considered "small fish" based on discussions within the Monitoring and Response Working Group and will be the primary focus of this monitoring due to the operational weaknesses of the Electric Dispersal Barrier System. Any Asian carp found smaller than 400 mm are considered "juvenile" in this document based on previously published research on growth and maturity (Williamson and Garvey 2005). A variety of techniques were used in 2017, including: traditional boat electrofishing, tandem and single mini-fyke nets, and dozer trawl.

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 2018. Sampling conducted in 2017 using boat electrofishing, dozer trawl, paupier trawl, and mini-fyke nets caught three Silver Carp (109 - 115 mm TL) in Peoria Pool of the IWW. No small Asian carp were captured above Peoria Pool during the 2017 field season.

Methods:

Sampling site selection will be conducted in two ways: stratified-random generated sites and "general" sites chosen at crew leader's discretion. Starting this year, in an effort to sample non-routinely visited areas, a series of 18 random sites will be generated for Marseilles and Starved Rock pools, during spring, summer, and fall seasons (54 total random sites in each pool). Six random sites will be generated in each season for each habitat strata: backwater, side channel, and main channel habitats (18 total). The ratio of sites in each habitat area is subject to change based on data gathered on habitat usage of juvenile Silver Carp studied with telemetry. These random sites will be fished using boat electrofishing for 15 minutes, similar to general sampling procedures. During general sampling, locations will be chosen at the crew leader's discretion based on best area to deploy gear, water quality conditions, and historically captured small Silver/Bighead Carp.

Physical characteristics and water quality measurements are to be made at each collection site and will include: Secchi depth, depth, substrate type (i.e, boulder, cobble, gravel, sand, silt, and clay), temperature, specific conductivity, and dissolved oxygen. Water quality measurements will be taken using a YSI Professional Series multi-meter. Additionally, GPS coordinates and time stamps will be recorded at the start and end of each electrofishing event, trawl run, and mini-fyke net set.

During random site sampling all fish over 100 mm TL will have their length recorded and weighed to the nearest gram. During general sampling all Bighead, Silver, and Grass Carp will be measured for TL (mm) and weighed (g). Any other species will be tallied and released to increase processing speed. If a small Silver or Bighead Carp is captured, all fish at that site will be measured for TL (mm) and weighed (g) to provide bycatch information. Any fish not easily identified in the field will be preserved in Excel Plus or 70% ethanol for laboratory identification to the lowest possible taxonomic level. Effort will be quantified as net nights (mini-fykes) or minutes of electrofishing (boat electrofishing and dozer trawl).

Individual gear descriptions for 2018:

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

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

Dozer trawl – A 35 mm mesh net at the mouth reducing to 4 mm mesh at the cod end tied to a 2 m by 1 m rigid frame mechanically raised and lowered to fish depths <1 m. The net extends approximately 2.5 m back as it is pulled forward. The target habitat is open water >0.6 m deep. Length and duration of trawl will be dependent on site characteristics and fish catch rate.

2018 Schedule:

February – March 2018: Gear preparation, planning field logistics, and crew scheduling

April – November 2018: Fish sampling, identification, and data entry

November – December 2018: Complete fish identification (preserved specimens), data entry, and verification

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

Deliverables:

Any small Asian carp captured upstream of Starved Rock Pool will be reported immediately to Todd Turner (USFWS Assistant Regional Director – Fisheries), Charlie Wooley (USFWS Deputy Regional Director – Region 3) and MRWG. An annual MRWG report and presentation will be provided during the winter of 2018 – 2019.

Distribution and Movement of Small Asian Carp in the Illinois Waterway Using Telemetry

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

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

Introduction:

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

Objectives:

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

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

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

Status:

This project is a continuation of an MRP conducted in 2017. Field efforts in 2017 resulted in the tagging of 72 juvenile Silver Carp tracked using nine radio monitoring stations and 26 hydroacoustic receivers. All of the 72 tagged juvenile Silver Carp had acoustic transmitters implanted and 12 of the 72 had both acoustic and radio transmitters implanted. To date telemetered fish have demonstrated movement and habitat-specific residencies correlated to water flow velocity and temperature, though the sample size is still small. This project is continuing in 2018, however, radio tags will be used more extensively and the goal is to tag more total fish than in 2017.

Methods:

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

Juvenile Asian carp will be captured using boat electrofishing and electrified dozer trawl from the Illinois River near Henry, Illinois and Lacon, Illinois. Marinas, backwaters, and side channels will be fished primarily due to the morphology of the river in these areas and gear effectiveness in this part of the river. Following tagging, fish will be released in proximity to their capture location. Fish tags used will be Vemco V5 ultrasonic transmitters (180 kHz, 0.38 g in water, Vemco Ltd.) and Lotek NTQ-4 radio transmitters (168 mHz, 0.65 g in water, Lotek Wireless).

Immediately after capture, fish will be held for no more than 1 hour in an aerated 60 gallon holding tank covered with ¼ inch mesh. In order to maintain as close to sterile conditions as possible, one crew member as the dedicated “surgeon” will wear gloves and only handle fish for the process of the incision, tag implantation, and suturing. Another crew member will be responsible for weighing and measuring the fish and recording data. All surgical tools, fish tags, and sutures will be soaked in 70% isopropyl alcohol between surgeries. Only active, healthy looking fish will be selected for surgery. Each fish will be measured for total length (mm) and weight (g), assigned a number, then placed into a foam board with a fish-shaped cut out for surgery. A surgical rubber hose connected to a slow siphon of fresh aerated river water will be placed in the mouth of fish to allow them to breathe during surgery. A wet microfiber towel will be placed over the head of the fish to keep them calm.

The surgery site will be gently washed with several drops of betadine prior to making an incision. Using a #12 hook blade scalpel, a 1 cm (acoustic tags) or 2 cm (radio tags) incision will be made in the left ventral side of the body, just behind the pelvic fins, anterior to the anus, taking care not to damage the intestines. Next, the tag will be inserted through the incision and gently pushed towards the anterior of the body cavity. In the case of radio tags, the antenna will be positioned to exit at the posterior corner of the incision. Two non-absorbable nylon Oasis Brand (Mettawa, Illinois) sutures will be used to close the incision site for acoustic tags and a third suture will be placed to secure the antenna for radio tags. Immediately following suture closure, the incision site will be washed with betadine a second time and rinsed using deionized water. The fish will then be placed into an aerated, salted holding tank for recovery. Once fish equilibrium has been reestablished and tags are tested, fish will be returned to the river. Total holding time for fish will generally be less than 2 hours.

Acoustic telemetry equipment will be deployed prior to tagging fish. A sum of 18 Vemco VR2-W 180kHz (Vemco Ltd) hydrophone receivers will be placed from Hennepin, Illinois to Chillicothe, Illinois. Main channel receivers will typically be deployed by attaching the hydrophone to a 5 foot section of 3/16 inch galvanized steel cable and attaching the assembly to navigational buoys. In some main channel areas and side channel sets, hydrophones will be attached to 3/16 inch cable that dangles from a float and is tethered to a concrete anchor. The anchor will then be either tethered to a tree on shore and padlocked, or attached to an 800 lb holding force Danforth style river anchor. Similar deployment methods are to be used for backwater sets.

Radio telemetry gear deployment was started in September 2017 and is ongoing. Nine passive monitoring stations are currently constructed from the Peoria Lock and Dam to Hennepin, Illinois at key constriction points and entrances to backwater lakes or side channels. Four more stations will be constructed in the spring of 2018. Fish tagging will occur simultaneously with the remainder of tracking equipment deployment throughout 2018. Each monitoring station consists of: a Lotek Wireless SRX800D (Lotek Wireless) datalogging radio receiver, deep cycle 150 AH battery, and a solar charge controller placed inside a weatherproof storage box. The equipment will be placed a minimum of 15 feet above any flood plain habitat, usually within tree branches to keep it safe from flooding. A solar panel will be mounted at similar height, facing south, at 41 degrees to the ground and connected to the solar charge controller with 12 gauge wire. Two to three 7-element (1.5 meter) Yagi antennas will be mounted a minimum of 25 feet above the ground using aluminum antenna mast poles, or strapped to trees, then attached to the SRX800D using coaxial cable. Generally, each site will have one antenna pointed upstream or downstream in the river channel and one antenna pointed into a backwater or side channel habitat so fish position can be differentiated depending on which habitat they enter.

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

Active tracking via boat will be conducted in 2018 shortly after tagging fish and monthly following fish tagging, as time allows. Acoustic active tracking will be conducted using a Vemco

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

2018 Schedule:

February – March 2018: Gear preparation, planning field work, crew scheduling, hydrophone deployment, remainder of radio gear deployment

April – November 2018: Fish tagging, range testing, active tracking, data download, gear maintenance and relocations

November – December 2018: Hydrophone removal, final data downloads, radio gear winter maintenance

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

Deliverables:

Results from this study will be used to inform small Silver/Bighead Carp monitoring efforts throughout 2018 and for future years. Habitat usage and movement data is critical to improving knowledge of juvenile stages of Silver/Bighead carp and subsequently will make monitoring efforts more efficient. Data will be analyzed and results summarized into a MWRG summary report/presentation for the winter of 2018 – 2019, as well a scientific paper publication and presentation at the conclusion of this study.

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 downstream of the Electric Dispersal Barrier in Lockport, Brandon Road, Dresden Island, and Marseilles pools.

Introduction and Need:

Standardized sampling is essential to managers monitoring population growth and range expansion of aquatic invasive species. Information learned from consistent and long-term monitoring (i.e., presence/absence, distribution, and abundance of target species) is imperative to understanding the threat of possible invasion upstream of the Electric Dispersal Barrier. We use pulsed-DC boat electrofishing, hoop and mini-fyke netting, and contracted commercial fishers to sample for invasive Asian carp in the four reaches below the Electric Dispersal Barrier: Lockport, Brandon Road, Dresden Island, and Marseilles pools. These efforts are useful to monitor changes in the leading edge, distribution, and relative abundance of Asian carp in the Illinois Waterway over time. The “leading edge” 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. Our eight years of data (2010-2017) provide a working knowledge of Asian carp abundance and distribution downstream of the Electric Dispersal Barrier and the potential threat of upstream movement to the CAWS. Sampling efforts upstream of the Electric Dispersal Barrier will continue in 2018 with two seasonal intensive monitoring (SIM) events in June and September, providing sufficient time to sample downstream of the Electric Dispersal Barrier using the previously mentioned gear types. This will allow continued success monitoring Asian carp distribution and abundance downstream of the Electric Dispersal Barrier.

Objectives:

(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 (i.e., Asian Carp Barrier Defense project, Telemetry master plan).

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

Fixed Site Monitoring Downstream of the Dispersal Barrier

Status:

This project began in 2010 and is ongoing. Pulsed-DC boat electrofishing occurred at four fixed sites in each of the four pools monthly from April to November (2010) and March to November (2011 – 2013), and twice monthly from April to November (2014 – 2017). Contracted commercial fishers used gill/trammel nets at four fixed sites in each of the four pools from July to September (2010), April to November (2011), March to November (2012), March to December (2013), April to December (2014), and March to December (2015 – 2017). Hoop/mini-fyke netting occurred at four fixed sites in each of the four pools once monthly from August to December (2012), May to November (2013), April to November (2014 – 2016) and May to December (2017). In total, 19,085 estimated person-hours were expended completing 744.5 hours of electrofishing (2010 – 2017); 1,123.9 kilometers of trammel/gill net sets (2010 – 2017); 856 hoop net sets; and 676 mini-fyke net sets (2012 – 2017). No Bighead or Silver Carp were captured in Lockport or Brandon Road pools, but one adult Bighead Carp was observed in Brandon Road Pool by a netting crew in October 2011. Also, our efforts indicate a greater abundance of Bighead and Silver Carp in Marseilles Pool than Dresden Island Pool. For more detailed results, consult the 2017 Interim Summary Report.

Methods:

Similar to previous years, the 2018 sampling design includes pulsed-DC boat electrofishing, hoop/mini-fyke netting, and commercial netting to monitor Asian carp populations below the Electric Dispersal Barrier (Figure 1). 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 to November. Contracted commercial netting will take place bi-weekly from March to December, except in June and September when contracted fishers will be sampling upstream of the Electric Dispersal Barrier for the SIM event. Hoop and mini-fyke netting will take place monthly from April to December. No sampling is planned for January or February because sampling locations are typically covered by ice during these months.

Fixed sites (four sites per pool) in each of the four pools are located primarily below lock and dam structures and in habitats where Asian carp are likely to congregate (backwaters and side channel habitats). Random site electrofishing and targeted commercial netting occur anywhere accessible within the four pools for the respected gear types. The section of the Kankakee River from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River is included in the Dresden Island Pool for random site electrofishing and targeted commercial netting.

Fixed Site Monitoring Downstream of the Dispersal Barrier

Fixed Sites Downstream of the Dispersal Barrier Description and Effort

A description of fixed sampling locations (Table 1) and gear types is summarized below. There are four 15-minute electrofishing runs, eight 6-foot diameter hoop net nights, and four mini-fyke net nights for each of the four pools. Additionally, there are four fixed sites for contracted commercial netting in each Lockport, Brandon Road, and Dresden Island pools.

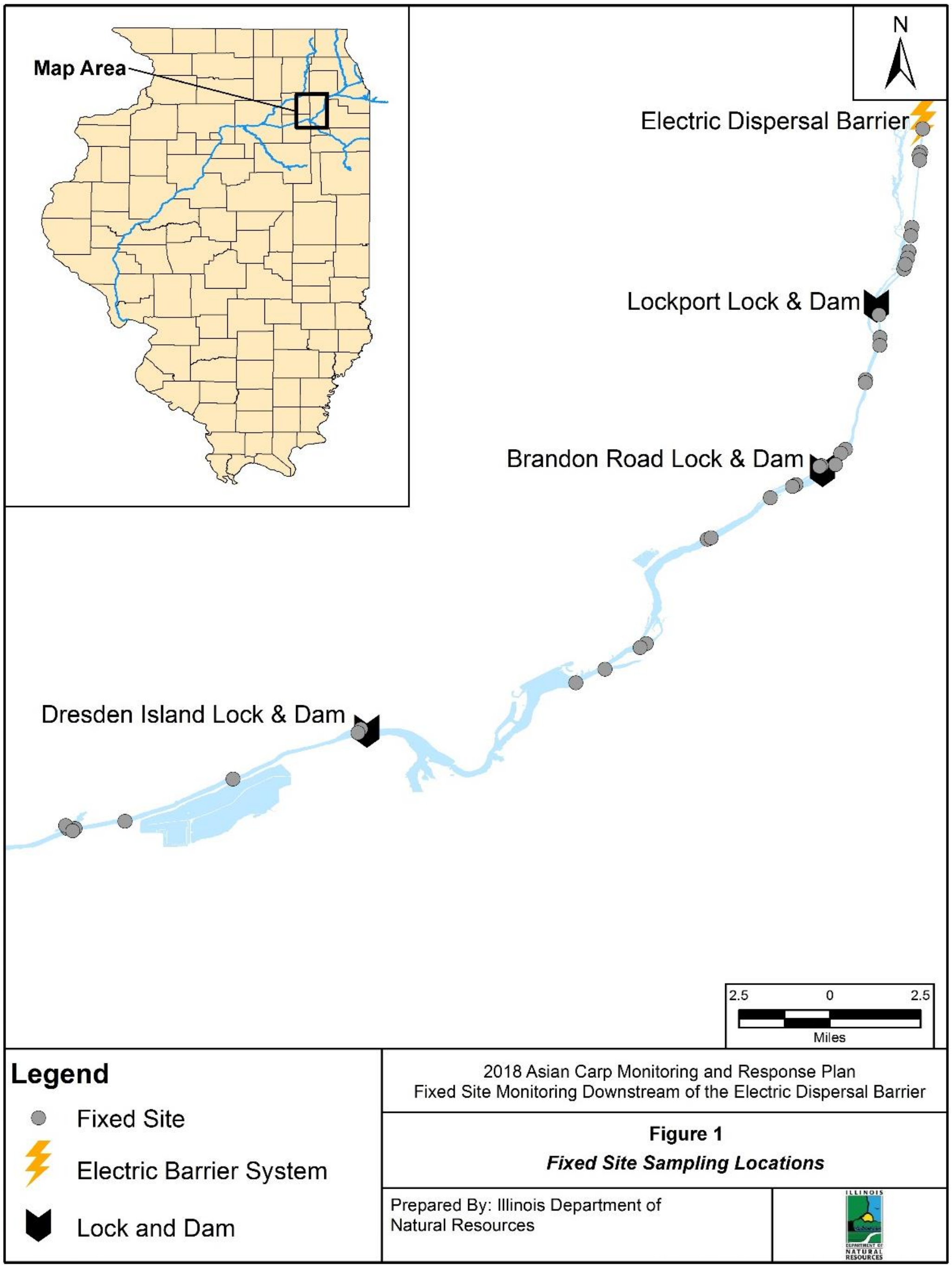


Figure 1. *Map of pulsed-DC boat electrofishing, hoop & mini fyke netting, and contracted commercial netting fixed site sampling locations used to monitor Asian carp populations downstream the Electric Dispersal Barrier.*

Fixed Site Monitoring Downstream of the Dispersal Barrier

Table 1. *Description of fixed site sampling locations downstream the Electric Dispersal Barrier using pulsed-DC boat electrofishing, hoop & mini fyke netting, and contracted commercial netting.*

Pool	Gear	Site	Site Description	Coordinates	
Lockport	Electrofishing	Site 1	Romeo Road Bridge, east side of canal heading downstream	41.63942	-88.06019
Lockport	Electrofishing	Site 2	North end of the Hanson Material Services' large haul slip, west side of canal heading downstream	41.62988	-88.06144
Lockport	Electrofishing	Site 3	Upstream end of MWRD Controlling Works heading downstream	41.60028	-88.06474
Lockport	Electrofishing	Site 4	Rt. 7 Bridge, west shore heading downstream	41.58814	-88.06732
Lockport	Commercial Netting	Site 1	Hanson Material Services' large haul slip	41.62843	-88.06318
Lockport	Commercial Netting	Site 2	Upstream Rt. 7 Bridge, west side of canal	41.59740	-88.06565
Lockport	Commercial Netting	Site 3	Immediately downstream Rt. 7 Bridge, west side of canal	41.59033	-88.06723
Lockport	Commercial Netting	Site 4	Immediately downstream Cargill Grain Elevator, west side of canal	41.58673	-88.06789
Lockport	Hoop and Mini-Fyke	Site 1	Hanson Material Services' large haul slip	41.62894	-88.06184
Lockport	Hoop and Mini-Fyke	Site 2	Upstream Rt. 7 Bridge, west side of canal	41.59721	-88.06544
Lockport	Hoop and Mini-Fyke	Site 3	Immediately downstream Rt. 7 Bridge, west side of canal	41.58833	-88.06739
Lockport	Hoop and Mini-Fyke	Site 4	Immediately downstream Cargill Grain Elevator, west side of canal	41.58376	-88.06862
Brandon Road	Electrofishing	Site 1	Bay below the Lockport Hydropower Plant	41.56596	-88.07826
Brandon Road	Electrofishing	Site 2	Immediately above the confluence of the CSSC and Des Plaines River heading downstream	41.55612	-88.07787
Brandon Road	Electrofishing	Site 3	Immediately above the confluence of the Des Plaines River and the Illinois Michigan (I&M) canal heading into the canal	41.53971	-88.08253
Brandon Road	Electrofishing	Site 4	I-80 Bridge heading downstream along east shoreline	41.51188	-88.09066
Brandon Road	Commercial Netting	Site 1	Immediately downstream the Des Plaines River confluence	41.55424	-88.07832
Brandon Road	Commercial Netting	Site 2	Confluence of the I&M canal	41.53926	-88.08218
Brandon Road	Commercial Netting	Site 3	Immediately downstream I-80 along east shoreline	41.50655	-88.09391
Brandon Road	Commercial Netting	Site 4	Between I-80 and the Brandon Road Lock & Dam	41.50634	-88.09986
Brandon Road	Hoop and Mini-Fyke	Site 1	Immediately downstream the Des Plaines River confluence	41.55380	-88.07829
Brandon Road	Hoop and Mini-Fyke	Site 2	Confluence of the I&M canal	41.54004	-88.08270
Brandon Road	Hoop and Mini-Fyke	Site 3	Immediately downstream I-80 along east shoreline	41.51088	-88.09142
Brandon Road	Hoop and Mini-Fyke	Site 4	Between I-80 and the Brandon Road Lock & Dam	41.50680	-88.09991
Dresden Island	Electrofishing	Site 1	Bay on east side of the river below Brandon Road Lock & Dam	41.49791	-88.11005
Dresden Island	Electrofishing	Site 2	Lower end of Treats Island heading into the side channel	41.43433	-88.17310
Dresden Island	Electrofishing	Site 3	Mobil Oil Corporation Cove	41.42524	-88.18708
Dresden Island	Electrofishing	Site 4	I-55 Bridge along southeast shoreline heading downstream	41.41883	-88.19858
Dresden Island	Commercial Netting	Site 1	Bay along east side of the river below the Brandon Road Lock & Dam	41.49273	-88.11941
Dresden Island	Commercial Netting	Site 2	Downstream the casino, west side of the river	41.47763	-88.14484
Dresden Island	Commercial Netting	Site 3	Lower end of Treats Island side channel	41.43507	-88.17060
Dresden Island	Commercial Netting	Site 4	Mobil Oil Corporation Cove	41.42503	-88.18591
Dresden Island	Hoop and Mini-Fyke	Site 1	Bay on east side of the river below Brandon Road Lock & Dam	41.49714	-88.11125
Dresden Island	Hoop and Mini-Fyke	Site 2	Downstream the casino, west side of the river	41.47751	-88.14581
Dresden Island	Hoop and Mini-Fyke	Site 3	Lower end of Treats Island side channel	41.43313	-88.17292
Dresden Island	Hoop and Mini-Fyke	Site 4	Mobil Oil Corporation Cove	41.42492	-88.18633
Marseilles	Electrofishing	Site 1	Along west side Big Dresden Island	41.39922	-88.28602
Marseilles	Electrofishing	Site 2	Along east shoreline across from Big Dresden Island	41.40078	-88.28479
Marseilles	Electrofishing	Site 3	Back of the north portion of Peacock Slough	41.36101	-88.40042
Marseilles	Electrofishing	Site 4	South portion of Peacock Slough	41.36214	-88.40329
Marseilles	Hoop and Mini-Fyke	Site 1	Immediately upstream the mouth of Aux Cable creek	41.38101	-88.33689
Marseilles	Hoop and Mini-Fyke	Site 2	Mouth of the Commonwealth Edison Co. Cove	41.36341	-88.37937
Marseilles	Hoop and Mini-Fyke	Site 3	Immediately inside the north portion of Peacock Slough	41.36173	-88.39998
Marseilles	Hoop and Mini-Fyke	Site 4	Back of the south portion of Peacock Slough	41.36057	-88.40329

Electrofishing Protocol

All electrofishing will use pulsed-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 have remained the same since 2010 and should continue to be sampled bi-weekly from April to November 2018. Additionally, electrofishing will take place at computer generated random sampling locations for main channel habitats in each pool (112 computer generated random sampling locations per pool for 2018).

While electrofishing, operators may switch the safety pedal on and off at times to prevent pushing fish in front of the boat and to increase the chances of catching an Asian carp. All fish will be netted and placed in a tank to be identified, counted, and checked for a floy tag, after which they will be returned live to the water (native fish only). 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 the electrofishing gear type. 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 including the location for the start of each run using GPS coordinates (decimal degrees preferred).

Gill and Trammel Netting Protocol

Contracted commercial fishers will use gill and/or trammel nets at fixed and targeted sampling locations. Large mesh (3-4 inches [76.2-101.6 millimeters]) gill/trammel nets, 8-10 feet (2-3 meters) high, and 200 yards (182.9 meters) in length will be used for netting efforts. Targeted sampling locations are selected by the commercial fisher, and are locations where Asian carp capture could be likely. The attending IDNR/INHS biologist will record coordinates of targeted locations with a GPS unit. Net sets will be of short duration and include driving fish into the nets using noise (i.e., “pounding” with plungers on the water surface, banging on boat hulls or revving trimmed-up motors). Contracted fishers will fish for a predetermined number of hours with no minimum yardage.

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

Sampling Schedule:

The tentative 2018 sampling schedule for electrofishing, hoop/mini-fyke netting, and electrofishing is shown in Table 2. Hoop and mini-fyke netting will occur monthly, either the week before or after the week of scheduled electrofishing and netting.

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.

Table 2. *Tentative 2018 Fixed Site Monitoring Downstream the Electric Dispersal Barrier Schedule*

Electrofishing

Week	Agency
26-Mar	IDNR/USACE
16-Apr	USFWS/USACE
7-May	IDNR/USACE
21-May	USFWS/USACE
28-May	IDNR/USACE
18-Jun	USFWS/USACE
2-Jul	IDNR/USACE
23-Jul	USFWS/USACE
13-Aug	IDNR/USACE
27-Aug	USFWS/USACE
24-Sep	USFWS/USACE
15-Oct	IDNR/USACE
5-Nov	IDNR/USACE

Contracted Netting

Week	Agency
26-Feb	All Agencies (Dresden Unified)
12-Mar	IDNR/INHS
26-Mar	IDNR/INHS
16-Apr	IDNR/INHS
7-May	IDNR/INHS
14-May	IDNR/INHS
29-May	IDNR/INHS
4-Jun	IDNR (SIMS)
11-Jun	IDNR(SIMS)
25-Jun	IDNR/INHS
16-Jul	IDNR/INHS
30-Jul	IDNR/INHS
13-Aug	IDNR/INHS
20-Aug	IDNR/INHS
10-Sep	IDNR(SIMS)
17-Sep	IDNR (SIMS)
1-Oct	IDNR/INHS
15-Oct	All Agencies (Dresden Unified)
29-Oct	IDNR/INHS
5-Nov	IDNR/INHS

Hoop and Mini-Fyke

Week	Agency
16-Apr	IDNR
14-May	IDNR
4-Jun	IDNR
30-Jul	IDNR
20-Aug	IDNR
10-Sep	IDNR
29-Oct	IDNR
26-Nov	IDNR

Telemetry Monitoring Plan

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

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 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 locks and dams and emigration routes such as tributaries and backwater areas. In 2015 a total of 31 stationary receivers were placed from the confluence of the Cal-Sag to Dresden Island Lock and Dam and up the Kankakee River near the Wilmington Dam. In 2016, receiver coverage was added to the Dresden Island Pool (n = 2) and Kankakee River (n = 3) while a positioning receiver array within the Electric Dispersal Barriers was removed (n = 8). In 2017 the network was similar to the 2016 network, except the receivers upstream of the Wilmington Dam on the Kankakee River were removed. Additionally, SIUC, USGS and USFWS deployed a total of nine receivers to the Dresden Island Pool and one receiver to the Brandon Road Pool in support of alternative projects. The data from these receivers were collated with the USACE database to supplement our understanding of fish movements within the study area. Figure 1 at the end of this report displays the full receiver network inclusive of partner agency receivers within the USACE study area.

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 2017. 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 2018 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.

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

- **Objective:** Determine if the leading edge of the Bighead and Silver Carp invasion (currently RM 286.0) has changed in either the up or downstream direction.
- **Objective:** Describe habitat use and seasonal movement in the areas of the Upper IWW and tributaries where Bighead and Silver Carp have been captured and relay information to the population reduction program undertaken by IDNR and commercial fishermen.

Additional objectives of the telemetry monitoring plan:

- **Objective:** Integrate information between agencies conducting related acoustic telemetry studies.
- **Objective:** Download, analyze, and post telemetry data for information sharing.
- **Objective:** Maintain existing acoustic network and rapidly expand to areas of interest in response to new information.

- **Objective:** Support the modeling efforts by USFWS with supportive data and adjust network accordingly in consultation with telemetry working group.
- **Objective:** Work with SIUC on an expanded surrogate comparison study in the middle IWW.
- **Objective:** Active participant in the telemetry working group.

Work Plan:

Sample size and distribution

Sample size was selected through review of similar studies, past catch data and expert opinion from the MRWG. In 2010, the workgroup decided that a baseline minimum of 200 transmitters be implanted for telemetry monitoring in the vicinity of the Electric Dispersal Barriers and that this level of tags be maintained as battery life expires or specimens exit the study area. At the conclusion of the 2017 sampling season there were 127 live, tagged fish within the study area with varying expiration dates. Tag implantations will be required in the spring to achieve recommended minimum levels of the sampling size. As in previous years, surrogate species will be used throughout the study area while Bighead and Silver Carp will only be released downstream of the known population front to reduce the risk of assisting any upstream advance of the invasive species.

The proposed distribution of tags across the study area is influenced by several factors including the carrying capacity for the receiver network per pool, the increasing focus and attention on the Brandon Road Lock and available source populations of the target species. Fifty-two tags implanted into surrogate fish species within the Lower Lockport Pool will remain active throughout the 2018 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 36 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 tags released in the Brandon Road Pool will remain active through the 2018 sampling season. However, 12 tagged surrogates emigrated from Lockport Pool in 2017 and 20 additional tags are anticipated for 2018 (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 56 transmitters within the Dresden Island Pool that will remain active during the 2018 calendar year. In an effort to maintain this target goal, 17 transmitters (V13TP-1x-069k-0017m) will be implanted into Asian Carp in 2018.

Table 1: *Recommended transmitter implementation for the 2018 sampling season. Supplemental tags are required to maintain existing level of coverage within the study area while exact ratios per pool may be changed slightly to account for new focus areas.*

Release Pool/Location	Species	Spring Supplement tags	Fall Supplement tags	Total estimated tag distribution
Upper Lockport/RM300	Common Carp	0	0	0
Lower Lockport/RM292.7	Common Carp	18	18	75
Brandon Road/RM286.5	Common Carp	10	10	52
Dresden Island/RM276	Bighead and Silver	17	0	73
Total	-	45	28	200

Species selection (primary and surrogate)

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

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. 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 Pool (RM 271.5 to 286). 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 fishes undergoing surgery will also be fitted with an external tag for other agencies. Commercial fishermen and action agencies working with the MRWG will be made aware of the project and will be requested to release any externally marked fishes including Bighead and Silver Carp if they are suitable for release, otherwise they will be requested to save the fish and return it to USACE so we can save the transmitter and tag a replacement fish. No Bighead and Silver Carp caught in Lockport or Brandon Road pools will be tagged and returned as these areas are upstream of the known invasion front. Any Bighead and Silver Carp captured in Lockport or Brandon Road will be turned over to 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 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 Electric Dispersal 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 is 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.

Figure 1 shows the general strategy of VR2W placement for 2018 (n = 28 receivers) with USACE receivers displayed in red, USFWS receivers displayed in orange, and USGS receivers displayed in green. The priority is to achieve the most coverage (detection capacity) in the immediate vicinity of the Electric Dispersal Barriers with VR2W receivers. To accomplish this, receivers immediately downstream and upstream of the Electric Dispersal Barriers will provide a system that will help USACE biologists monitor and track any fish movement through the 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 USACE. USFWS, SIUC and USGS all maintain a number of receivers throughout the study area outlined here. Data sharing will occur across all agencies to leverage the resources of each agency for a greater benefit to each individual study. The USGS receivers are specifically set up to provide real-time data to a centralized online database. The deployment of these receivers is being coordinated to track fish movements above known invasion fronts and upstream of barriers to fish passage. These locations include the CSSC upstream and downstream of the Electric Dispersal Barriers in Lemont, the Des Plaines River up and downstream of Brandon Road Lock and Dam, and within the Kankakee River. This data will supplement the bi-monthly downloads. These receivers allow for reporting and response actions to be completed faster in the event of a fish passage occurrence across a barrier or beyond the known invasion front.

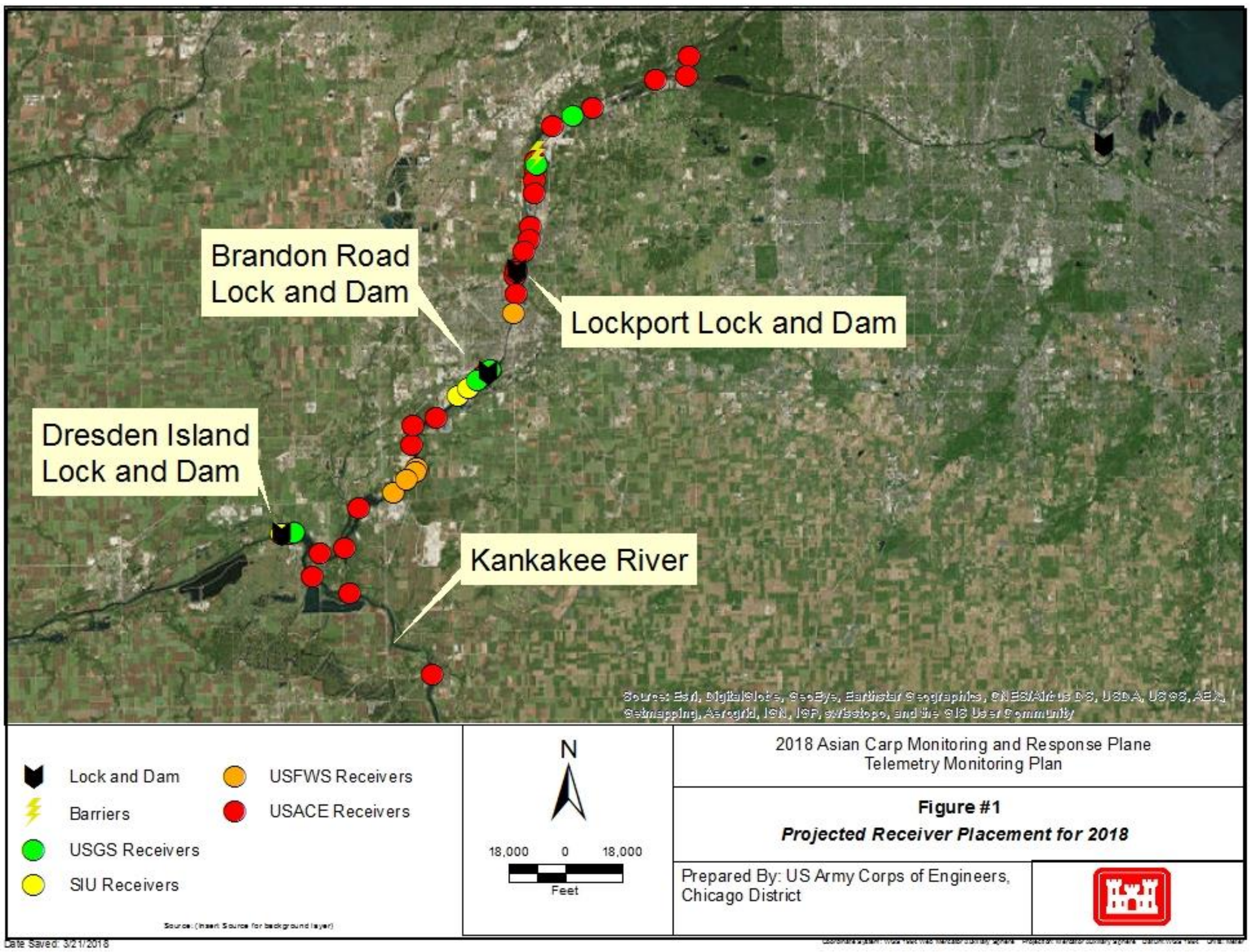


Figure 1. *VR2W receiver network within the Upper IWW and CAWS.*

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. Corps leadership, all agency leads involved with the telemetry plan, as well as the MRWG, will be notified immediately of any suspected barrier breach. In some cases, it may be necessary to implement a 24-hour track to confirm if the fish of interest is 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 upstream of the Brandon Road Lock and Dam will trigger immediate notification to USACE leadership, agency leads involved with the telemetry plan, as well as the MRWG co-chairs.

Other Relevant Studies:

An ancillary benefit of this project will be the enhancement of the regional capability of fish tracking at a basin scale. This project will complete the IWW basin acoustic receiver network which extends from the Mississippi River to Lake Michigan and will enable cooperating researchers to document large scale movements of Bighead and Silver Carp and other fish species within the system. The information gathered from this system will enhance the understanding of systemic movement in the basin. Additionally, any fish tagged from this effort that disperse outside of the USACE telemetry network detection area have the probability of being detected on another researcher or 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.
- 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.
- Jim Lamer, Western Illinois University. Species tagged include Bighead Carp in the Illinois River. The study is evaluating emerging technology in the field of telemetry.

Sampling Schedule:

A tentative work schedule is presented below.

March – May 2018	VR2W network inspected and new receivers installed and range tested. Tagging efforts of Bighead and Silver Carp in the Dresden Island Pool and Common Carp in Lockport Pool
ONGOING	VR2W network maintenance, downloads and mobile tracking
Oct – Nov 2018	Tagging of surrogate fish in Lockport Pool
December 2018	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 2018 sampling season.

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

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 (field support)

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

Introduction and Need:

The Electric Dispersal Barrier System located within the Chicago Sanitary and Ship Canal (CSSC) operates with the purpose of preventing dispersal of invasive fishes between the Mississippi River and the Great Lakes basins while maintaining continuity of this important shipping route. Numerous field and laboratory studies have examined the complexities associated with operations of the Electric Dispersal Barrier System 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 System 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 System; especially with regard to small size classes of fish. This project will provide insights on fish behavioral responses to biological, abiotic, and anthropogenic changes within the system. Additionally, fish surveys supporting barrier clearing operations will be performed “as necessary” to support barrier maintenance needs or requests from the ACRCC.

Objectives:

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

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

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

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 the portion of Barrier IIB with the greatest electric field strength (Parker and Finney 2013). Since 2015, hydroacoustic surveys have been completed on a biweekly to monthly basis to gain greater temporal resolution on fish community dynamics. An additional component to this work has been furthering the understanding of complexities introduced at the Electric Dispersal Barrier System 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 System 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 System in return current flows associated with downstream barge transits at the Electric Dispersal Barrier System (U.S. Fish and Wildlife Service 2016).

Methods:

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

Side-looking split beam hydroacoustic and side scan sonar surveys will be conducted above and below the CSSC Electric Dispersal Barrier System to assess fish abundance, density, and distribution patterns near the Electric Dispersal Barrier System on a fine temporal scale. Surveys at the Electric Dispersal Barrier System will take place on a biweekly (barrier surveys) to bimonthly (pool surveys) beginning in January 2018. The hydroacoustic survey equipment utilized for these surveys consists of a pair of Biosonics® 200 kHz split-beam transducers as well as a 4125 Edge Tech ultra-high resolution side scan unit. The two split-beam transducers are mounted in parallel on the starboard side of the research vessel 0.15 m below the water surface on Biosonics® dual axis automatic rotators. The side scan unit is attached to a davit at the bow of the boat and is lowered less than a meter into the water. This approach, using both systems, 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.

In addition, several scans will be conducted in conjunction with SIU throughout the summer to ensure that both agencies are collecting data in the proper manner and comparable.

Stationary hydroacoustic deployment at the Electric Dispersal Barrier System- Pilot study

A stationary acoustic remote sensing system utilizing two split beam transducers will be temporarily deployed at or near the Electric Dispersal Barrier System during FY 2018. The system will utilize two transducers (430 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 10.0 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 throughout the deployment. 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.

2018 Schedule:

- Mobile hydroacoustic fish surveys at the Electric Dispersal Barrier System: Biweekly- January 2018-December 2018
- Mobile hydroacoustic fish surveys in Brandon Road and Lockport pools: Seasonally Winter 2018-Fall 2018
- Stationary hydroacoustic deployment at the Electric Dispersal Barrier System: July- August 2018

Deliverables:

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

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

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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 Electric Dispersal Barrier. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively. Gompers Park never had a report of Asian carp, nor have any been captured or observed during past sampling events. Nevertheless, examining all urban fishing ponds close to the CAWS or Lake Michigan continues to be of importance due to the potential of human transfers of Asian carp between waters within close proximity to one another.

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) all ponds with positive detections were examined for the presence of live Asian carp given the proximity to the CAWS.

Objectives:

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

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

Status:

This project began in 2011 and is on-going. A total of 43 Bighead Carp and one Silver Carp have been removed from nine ponds. 57 hours of electrofishing and 12 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 34 Bighead Carp removed from five ponds since 2011. Additionally, eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. Lastly, one Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have both had Bighead Carp removed following natural die-offs and sampling. All ponds yielding positive eDNA detections and 18 of the 21 IDNR urban fishing ponds have been sampled. Lincoln Park South was not sampled because it was drained in 2008, resulting in three Bighead Carp being removed, and is no longer a source of Asian carp as a result. Auburn Park was too shallow for boat access but had extremely high visibility. Therefore, the pond was visually inspected with no large bodied fish observed. Elliot Lake had banks too steep to back a boat in on a trailer. Lastly, Jackson Park and Garfield Park were drained in 2015 and, similar to Lincoln Park South, are no longer a source of Asian carp. A map of all the Chicago area fishing ponds that were sampled or inspected as part of this project can be found in Figure 1. For more detailed results see 2017 interim summary report document (MRWG 2017).

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring 2018 Plan

Methods:

Sampling Protocol

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

Otolith 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.

2018 Schedule:

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

Deliverables:

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

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring
2018 Plan

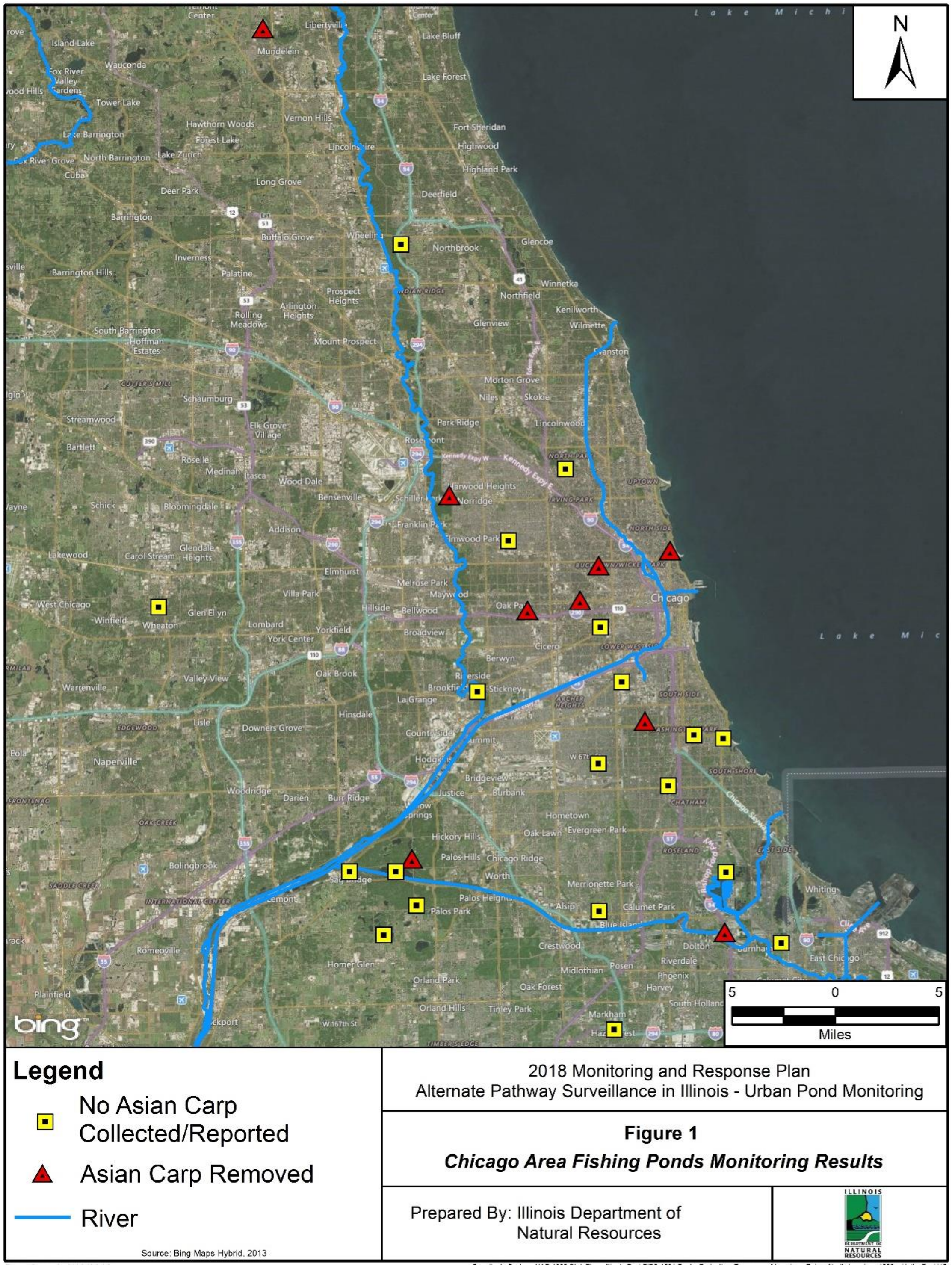


Figure 1. *Chicago area fishing ponds from which Asian carp have been removed (red) and those from which no Asian carp have been collected or reported (yellow).*

Young-of-year and Juvenile Asian Carp Monitoring

Brennan Caputo, David Wyffels, Tristan Widloe, John Zeigler, Blake Ruebush, Matt O'Hara and Kevin Irons (Illinois Department of Natural Resources)
Scott F. Collins, Steven E. Butler, Joseph J. Parkos III, and David H. Wahl (Illinois Natural History Survey)

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

Location: Monitoring for young-of-year and juvenile Asian carp will take place through targeted sampling by multiple participating agencies at multiple sites along the Illinois and Des Plaines rivers, and the Chicago Area Waterway System (CAWS). These efforts will occur as part of the following projects: Larval Fish and Productivity Monitoring, Fixed Site Monitoring Downstream of the Dispersal Barrier, Gear Efficiency and Detection Probability Study, Seasonal Intensive Monitoring (SIM) in the CAWS, Des Plaines River and Overflow Monitoring Project, and Barrier Maintenance Fish Suppression Project. See individual project plans in the 2018 MRP for specific details.

Introduction:

Bighead Carp and Silver Carp are known to successfully spawn in larger river systems where continuous flow and moderate current velocities transport their semi-buoyant eggs during early development. Spawning typically occurs at water temperatures between 18 – 30ºC during periods of rising water levels. Environmental conditions suitable for Asian carp spawning may be available in the CAWS and nearby Des Plaines River, particularly during increasingly frequent flooding events. The northward expansion of Asian carp through the Illinois River and connected waterways increases the likelihood of challenging or circumventing measures taken to block their access to Lake Michigan.

Successful reproduction and recruitment are considered important factors for the establishment and long-term viability of Asian carp populations. The risk that Asian carp will establish viable populations in Lake Michigan increases if either species is able to successfully spawn in the CAWS. Although there has been no evidence of successful Asian carp reproduction in the CAWS or Des Plaines River, targeting young-of-year and juvenile Asian carp in monitoring efforts is needed to evaluate the spatial distribution of early life stages across years and their potential advancement towards the Great Lakes.

Young-of-year and Juvenile Asian Carp Monitoring

Objectives:

Multiple gears suitable for sampling small fish were 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 captured.

Status:

Since 2010, multiple gears have been deployed by participating agencies to quantify the abundances of young-of-year and juvenile Asian carp along the Illinois River and other connected waterways. DC-electrofishing has been conducted in all segments of the Illinois River, upper Des Plaines River and CAWS. Mini-fyke nets, trawling (multiple gears), and seining have been used at numerous locations downstream of the Electric Dispersal Barrier. Annual sampling effort has been high across all pools, although effort varies yearly among projects. To date, a total of 2,448 hours of electrofishing have been conducted across all years (2010 – 2017) and navigation pools. Since 2010, numbers of small Asian carp, primarily Silver Carp, have varied by orders of magnitude among years. During 2014, sampling across agencies detected the first year of substantial abundances of young-of-year Asian carp since monitoring started in 2010. From 2015 to 2017, total catches of juvenile Asian carp were generally low (2015: n = 1934; 2016: n = 912; 2017: n = 2,967) when compared to 2014 (n = 71,632). In 2016, Asian carp <6 inches were detected in the LaGrange Pool (n = 462), lower 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). The farthest upstream catch of juvenile Asian carp in 2015 and 2016 consisted of several Silver Carp (6 – 12 inches) in the Marseilles Pool near Morris, Illinois (river mile 263). However, in 2017, only a single Asian carp was captured in the Starved Rock Pool (6 – 12 inches; n = 1), and no small Asian carp were detected in the Marseilles Pool (n = 0).

Methods:

As in the past, 2018 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 and Productivity Monitoring, Fixed Site Monitoring Downstream of the Dispersal Barrier, Gear Efficiency and Detection Probability Study, Seasonal Intensive Monitoring (SIM) in the CAWS, Des Plaines River and Overflow Monitoring Project, and Barrier Maintenance Fish Suppression Project. See individual project summary reports and the 2018 MRP for specific locations, the active and passive gears used, sampling frequency, and effort.

Young-of-year and Juvenile Asian Carp Monitoring

Sampling Schedule:

In 2018, sampling will occur along the Illinois River and 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 2018 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.

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, Southern Illinois University, and Illinois Department of Natural Resources (field support)

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

Introduction and Need:

The upper Des Plaines River rises in southeast Wisconsin and joins the CSSC in the Brandon Road Pool immediately below the Lockport Lock and Dam. Asian carp have been observed in this pool up to the confluence with the Des Plaines River, and have free access to enter the upper Des Plaines River. In 2010 and 2011, Asian carp eDNA was detected in the upper Des Plaines River. No Asian carp eDNA sampling has been conducted in the Des Plaines River since 2011. It is possible that Asian carp present in the upper Des Plaines River could gain access to the CSSC upstream of the Electric Dispersal Barrier 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. These reinforcements withstood hish flow events in 2017. Understanding the population status of Asian carp in the Des Plaines River, monitoring for potential spawning events, and determining the effectiveness of the physical barrier are all necessary to inform management decisions and assess risk of Asian carp bypassing the dispersal barrier.

Objectives:

(1) Monitor Bighead Carp and Silver Carp populations and in the Des Plaines River above the confluence with the CSSC.

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

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

Status:

This project began in 2011 and is ongoing. Between 2011 – 2017, 11,082 fish have been collected via electrofishing (57.69 hours) and gill netting (140 sets; 20,384 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 and all six were determined to be triploid (sterile).

Methods:

Population Monitoring

Population monitoring will include electrofishing and gill netting. The project will utilize pulsed-DC electrofishing. One or two dippers will attempt to dip all visible fish, with the exception of Common Carp. The number of Common Carp observed to be incapacitated in the electrical field will be recorded. Gill netting will consist of short-term top to bottom sets. Mesh sizes will be 3 – 5 inch bar mesh. Backwater areas will be blocked off with the net and fish will be driven towards the net via pounding or electrofishing. All non-Asian carp will be identified and released. Any Bighead 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 three sampling events will be planned for 2018 that will span from pre-spawn to post-spawn time frames. Three backwater areas will be considered fixed sites and will be sampled during each sampling event, if accessible (Figure 1). All accessible shoreline in the backwaters will be sampled with electrofishing gear. Each fixed site will also be sampled with 600 yards of gill net during the spring and fall events. In addition to the fixed backwater sites, main channel habitats will be targeted with electrofishing as time and access allow.

Des Plaines River and Overflow Monitoring

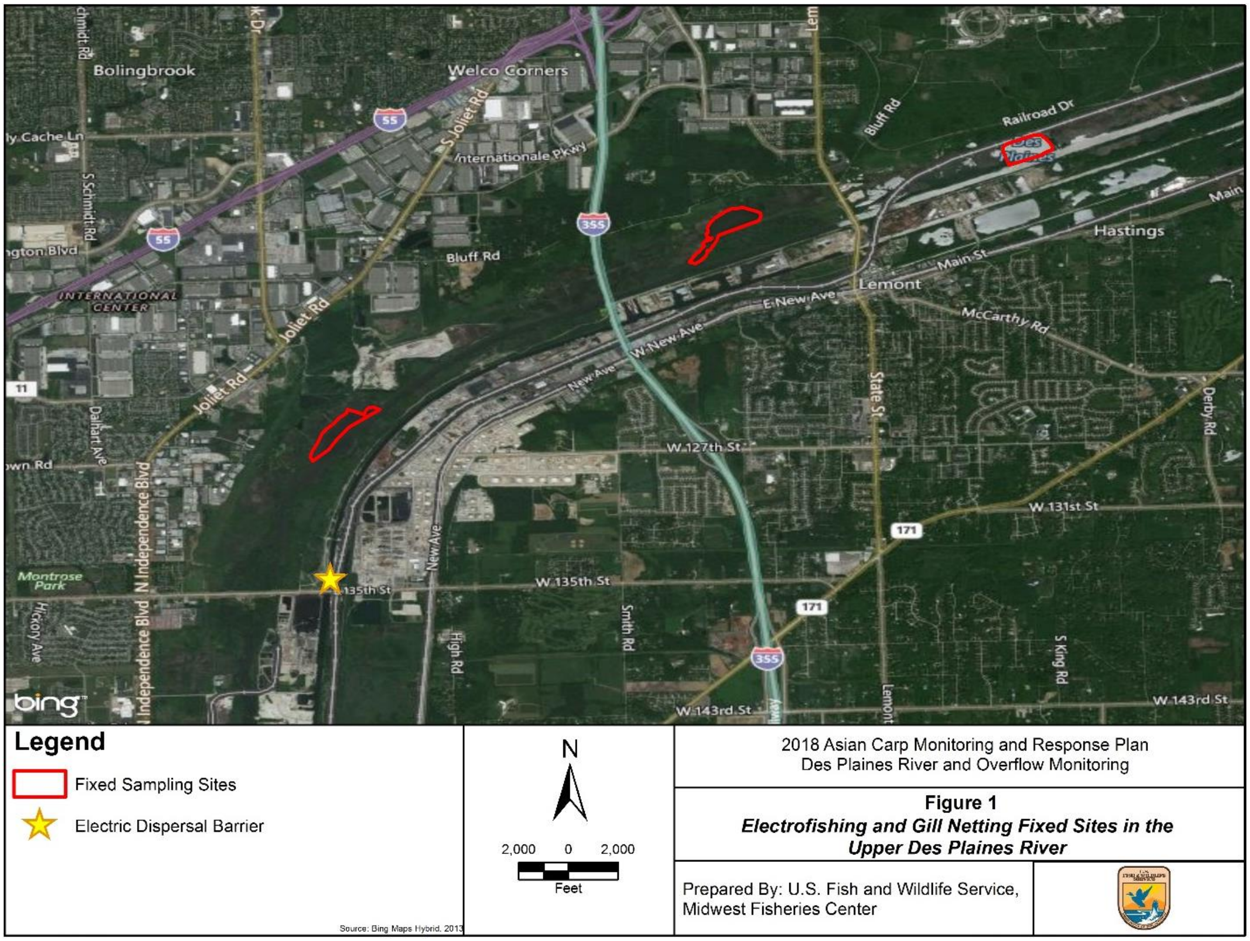


Figure 1. *Fixed site areas for electrofishing and gill netting in the upper Des Plaines River.*

Overflow Monitoring

USACE personnel will monitor water levels for potential overtopping events. La Crosse FWCO will be notified of potential overtopping events and location. Biologists will inspect the fence for areas of flow-through and potential breaches. When it is safe and practical to do so, block nets may be used to temporarily close any breaches until repairs can be made by USACE. Depending on conditions, multiple gears may be used to document fish species and sizes moving through the physical barrier.

During an overflow event in which the water temperature exceeds 18°C and provided it is practical and safe to do so, ichthyoplankton trawls will be fished on the floodplain on both sides of the barrier fence near areas where water is flowing through the fence and/or where breaches have occurred. Three additional sites will be sampled as well: 1) Willow Springs Road 2) CSSC and Des Plaines River confluence and 3) below Lockport Lock. Three replicates will be taken at each sample site for five minutes each.

Des Plaines River and Overflow Monitoring

2018 Schedule:

Fixed sites will be sampled three times throughout the field season for population monitoring. 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. Physical barrier inspections and ichthoplankton sampling will occur when USACE personnel indicate overflow conditions are likely or occuring.

Deliverables:

Results of each sampling event will be reported for monthly sampling summaries. Asian carp captures (excluding Grass 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

Marybeth K. Brey, Brent Knights, Aaron Cupp, Jon Amberg (U.S. Geological Survey, Upper Midwest Environmental Sciences Center)

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

Jim Duncker, Elizabeth Murphy (U.S. Geological Survey, Illinois Water Science Center)

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

Location: Illinois River

Introduction and Need:

Intensified surveillance in the Upper Illinois River between Starved Rock Lock and Dam and the Electric Dispersal Barriers 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 has been and is 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.

Mass harvest of Silver Carp and Bighead Carp is challenging primarily due to their strong net avoidance behaviors. Evaluation of innovative capture gears and techniques across a variety of habitat types is important to identify the most effective methods to removing large quantities of carps. Herding techniques such as underwater sound are also being tested and assessed. The FluEgg model is a multi-purpose risk assessment tool that is being used to assess Asian carp spawning and recruitment success, as well as to help identify high risk locations for barge entrainment of small fish. There is also a continuous need for hydraulic data and information to support control and containment efforts, assessment of barrier locations such as Brandon Road Lock and Dam, and other waterway actions.

Objectives:

1) Implementation and evaluation of new strategies for monitoring, surveillance, risk assessment, control and containment.

2) Development and evaluation of databases and decision support tools.

USGS Support for Implementation of MRP

Status:

In 2017, three additional "real-time" telemetry receivers were deployed in the Illinois River between May and October 2017 and brought online. An automated alert system was established for detections of tagged Asian carp in strategic locations to alert management agencies and inform contingency actions. USGS monitored, maintained and downloaded data from real time receivers and provided timely summaries to removal crews and other partners. Lateral and longitudinal movements of tagged Asian carp were assessed to inform removal and control efforts. USGS also conducted range testing of receivers under high and low water conditions to establish detection capabilities and limitations. The beta telemetry database was transferred to a new USGS system, additional commercial catch data and Asian carp sampling data was incorporated into the database, and the associated visualization tool was further developed. This database will provide critical data and information for the development of decision support tools. An operational hydraulic model of IWW was created to generate input for the FluEgg model for use in real time predictions. Two field trials were conducted for underwater sound to herd Asian carp and to determine efficacy of sound and other techniques to increase catch.

Methods:

1) Real time telemetry, and telemetry database and visualization tool to inform removal and contingency actions:
   - Install 3 additional real time receivers in the upper Illinois River at key removal areas and bring them online for use by IDNR removal crews.
   - Monitor, maintain, test and download data from real time receivers and provide timely summaries and alerts to removal crews and key decision makers (http://il.water.usgs.gov/data/Fish_Tracks_Real_Time/).
   - With management agencies, identify additional sites for placement of automated real-time receivers.
   - A beta version of the telemetry database and visualization tool will be released to collaborating management and research agencies. Release was delayed due to changes related to the platform and development (https://my-beta.usgs.gov/fishtracks/index).
   - Complete field testing of satellite-capable geotags for tracking Asian carp to inform removal efforts in Dresden Island Pool in 2018. Delay in 2017 due to defective tags and delivery issues.
   - Continue email summaries of river discharge, temperature, and "real-time" telemetry detections at key locations on the Illinois River to inform monitoring efforts.
2) Bigheaded carp habitat mapping, modeling and removal dashboard:
   - Collect high resolution bathymetry in off-channel areas of Starved Rock and Marseilles pools, including Morris pits, Dresden Island and Brandon Road pools and serve data as

GIS layers for use in management action planning and Bighead/Silver Carp habitat modeling with fish hydroacoustic data from Southern Illinois University.

- Work with IDNR and USFWS to build a conceptual model of an Asian carp removal dashboard (i.e., GIS visualization and decision support tool) and habitat models to inform fish removal actions.

3) Database and decision support tools actions:
   - Continue the development of an Asian carp commercial catch and monitoring database to house monitoring and assessment data for the Upper Illinois River. Includes data from IDNR, USACE, and USFWS.
   - Completing development of a decision support tool to inform mitigation measures to minimize the entrainment of Asian carp 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.
   - Continue development of a habitat suitability decision support tool for Asian carp using 2D hydrologic and water quality data that will support the Glover-Kallis population model.

4) Mass Harvest and Unified Method
   - Identify site-appropriate mass removal gears (Lampara Seine, tributary Iruka Trap, Paupier, Purse Seine, effluent trap) and refine prototype gear to minimize limitations and maximize efficiency.
   - Use above techniques with the unified method to maximize harvest of Asian carp in a 2-week event in Creve Coeur Lake in Missouri (January or February 2018). Conduct hydroacoustic surveys, use DIDSON, and tag and implant transmitters in Silver Carp to observe fish behavior. Gamefish population and growth will be assessed following removal operations.

5) Underwater Sound Technology (USGS/USACE)
   - In response to the planned winter maintenance of the Electric Dispersal Barrier, IDNR requested, through the ACRCC, operation of a temporary acoustic deterrent in the CAWS (February 2018 through the end of Electric Dispersal Barrier maintenance) to serve as a risk reduction measure.
   - Pond testing of newly screened potential sounds specifically designed to deter Asian carp and limit impacts on native fishes, in ponds.
   - Select a set of non-proprietary sounds to be used in the field to deter Asian carp (based on pond trials (see above) and project in a field setting test on wild fish in Wabash River, and parameterize sound propagation model at Brandon Road lock approach with new sounds.

- Initiate installation of 1-3 deterrent systems that have varying tested or developing operating parameters with multi-agency science team. Barkley Dam, Kentucky Dam, Lock & Dam 19, and Starved Rock Lock and Dam are potential sites for deployment, but additional or alternative site selection may occur.
- Refine sound propagation model for designing acoustic deterrent systems in locks and navigation channels.
- Reports on fish hearing damage, potential for sound habituation, and effectiveness of herding strategies in tributaries with high Bighead and Silver Carp densities.

6) Barge Entrainment
   - Entrainment mitigation technology refinement with USFWS, USACE, USGS, and USCG builds on previous research and will include risk assessment modeling using the FluEgg simulation model and ship tracking data to identify high entrainment risk locations and time periods.
7) FluEgg Model to assess spawning and recruitment
   - Complete a USGS software release of FluEgg including a user’s manual.
   - Conduct phase 2 lab flume experiments to characterize swim speeds and mortality in flowing water (USACE/USGS).
   - Present a webinar targeted toward managers to explain capabilities of FluEgg which simulates egg and larvae transport from spawning grounds.
   - Work with MRWG to use the IWW forecasted hydraulic conditions and the FluEgg model to predict where eggs and larvae will be after spawning.
8) Assessment of hydraulic and water quality influences on waterways
   - Publish continuous 2017 water year water quality data for Illinois River main channel and backwater sites and continue velocity and bathymetry mapping of selected river reaches and spawning documentation activities in coordination with Illinois DNR and other agencies.
   - Analyze 2015 fish tissue for ABCs (USGS/U of IL), review historic INHS data for fish tissue analyses, and coordinate fish tissue sampling with Illinois DNR and commercial fishers.
   - Draft a USGS manuscript on results of study relating the Asian carp movement and water-quality data.

2018 Schedule:

- A fully functional telemetry database and visualization system for archiving bigheaded carp telemetry by end of FY2018.

USGS Support for Implementation of MRP

- USGS and WIU will tag additional fish in Starved Rock Pool and geotags will be deployed in Dresden Island Pool to inform IDNR removal efforts.
- Deployment of underwater sound technology to support USACE Electric Dispersal Barrier maintenance from February 2018 until maintenance is completed.

Deliverables:

- Placement/deployment of real-time telemetry receivers in the Upper Illinois River at sites recommended by management agencies.
- Present database functionality to MRWG telemetry working group and release Version 1.0 of the telemetry database and visualization tool to collaborating agencies/organizations.
- High resolution bathymetry data from upper pools in Illinois River as GIS layers for use in management action planning and bigheaded carp habitat modeling, initial removal dashboard (GIS visualization and decision support tool), and Asian carp habitat model from LTRM data in LaGrange Pool of the Illinois River.
- Complete a USGS software release of FluEgg including a user's manual.
- Operation of a temporary acoustic deterrent (underwater sound) in the CAWS (February 2018 through the end of Electric Dispersal Barrier maintenance) to serve as a risk reduction measure.
- Implement unified method and other mass removal gear to maximize harvest of Asian carp in a 2-week event in Creve Coeur Lake near St. Louis, Missouri (January or February 2018).

MANAGE AND CONTROL PROJECTS

Barrier Maintenance Fish Suppression

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 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 Electric Dispersal 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 eight years of sampling in the Lockport Pool with no indication of any young-of-year Asian carp being present or any known location of spawning. However, juvenile Silver Carp have been reported from the Starved Rock Pool up to the Marseilles Pool. These 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. These precautions will remain in place for 2018 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 Dispersal 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 Barrier 2B or after maintenance is completed at

Barrier 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 eleven occasions in 2017 in which the primary barrier (furthest downstream active barrier), in this case Barrier 2A, experienced a loss of power to the water for an extended duration (ranging from nine minutes to 24 days). In addition, Barrier 2B went down five times for a duration of 1 minute to 5 days. However, in the instances Barrier 2A went down, Barrier 2B was active and similarly the Demo Barrier was active when Barrier 2B went down. The MRWG determined physical clearing actions between the barriers were not required due to a very low risk of Asian carp presence. There were three occasions in which additional monitoring actions were taken at the Electric Dispersal Barrier System to further support the MRWG decision.

The three monitoring actions performed at the Electric Dispersal Barrier System utilized either DC electrofishing or hydroacoustic sonar scans. The first two monitoring responses were hydroacoustic sonar scans and occurred September 14 and September 27, 2017 in response to the August 14 and August 21 – September 1, 2017 Barrier 2A planned outages. Results from these scans indicated fish abundance in general was low between the barriers and no large fish were observed. USFWS completed bi-weekly sonar scans of the area between the barriers through the end of December. While these scans were 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. USACE also completed one 15 minute electrofishing run the week of Nov 27th to help assess the risk for Asian carp presence. No fish were observed or captured.

Methods:

Project Overview

The current approach to fish suppression at the Electric Dispersal 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 the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) 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 Electric Dispersal 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 2018 even though previous 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

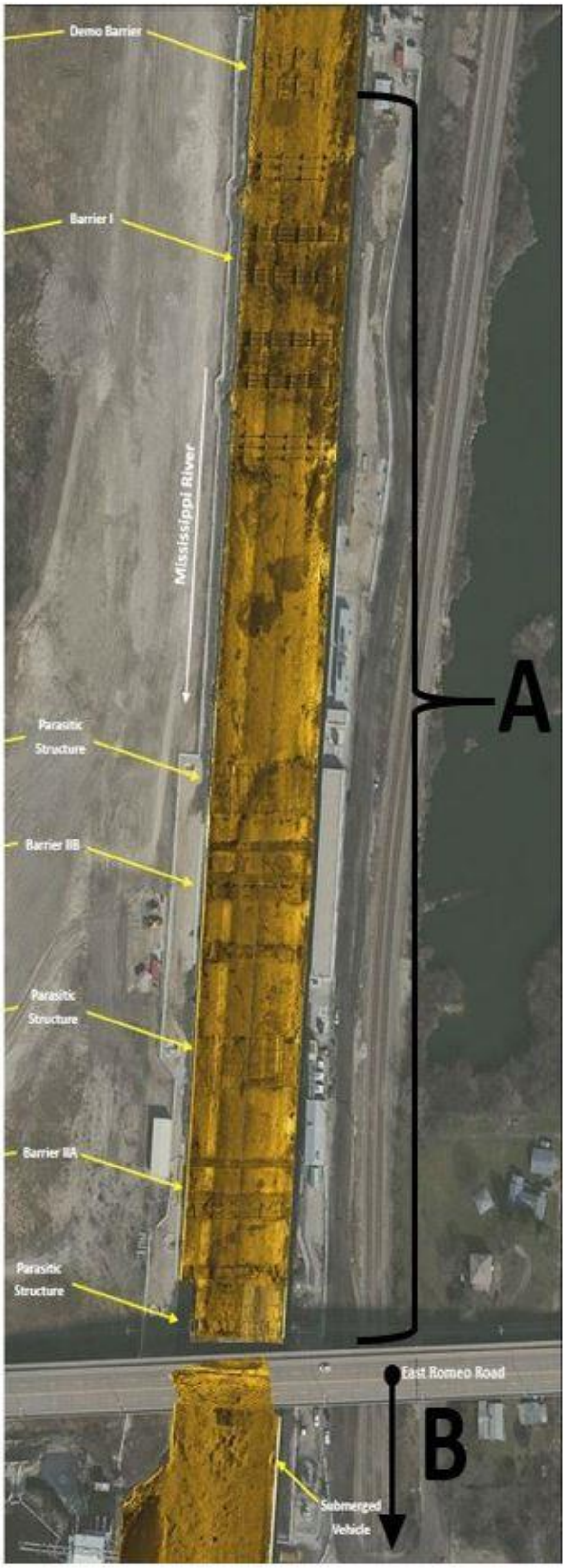
98% coverage of the waterway with just three passes of the barrier area (10- to 15-minute survey duration; see 2014 Barrier Maintenance Fish Suppression final report in MRWG 2014).

During a typical maintenance shutdown, a request will be sent to 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 hydroacoustic 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



Barrier Outage
Fish Clearing Methods
Site Map

A Physical Removal Area

- Physical removal may include pulsed DC electrofishing, pulsed DC electrified paupier trawls, deep water electrofishing vessels, and other novel fishing gear as identified.
- Physical removal boats and gear may be deployed in tandem or series depending on available room to maneuver and fish safely.
- Fish targets will initially be identified within this area by remote sensing gears.
- Fish scaring or driving tactics may also be utilized within this area and may include boat pounding, plungers, tipped engines or submerged speakers with complex noise.

B Netting Area

- Gill/Trammel netting area is located below the southernmost submerged Barriers infrastructure and south of the Romeoville Road Bridge.
- A request for no flow to low flow conditions may be made to the MRWDGC for a 2 hour period during netting operations

Safety Procedures

- Standard safety procedures for working in the Barrier area will be followed
- Two spotters will be located on the east and west bank of the canal, a safety boat with AED will be located below the Romeo Road Bridge

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 cost of $150,000-$250,000), 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 Services’ 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.

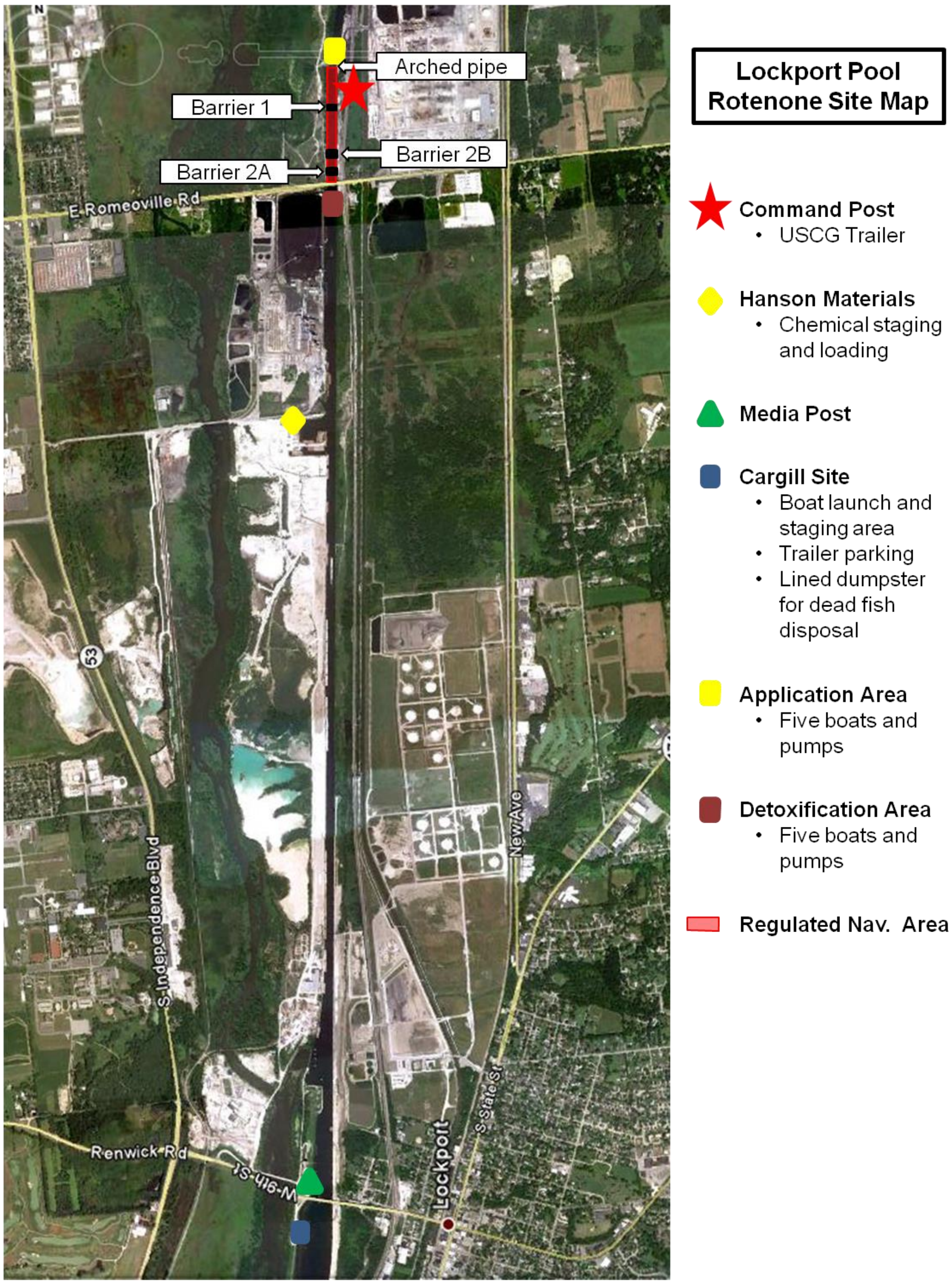


Figure 2. *A map of a small-scale rotenone operation to clear from the Dispersal Barrier.*

Barrier Maintenance Fish Suppression

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 6 @ 6' x 300'; 0.75-5.0 in. mesh 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.

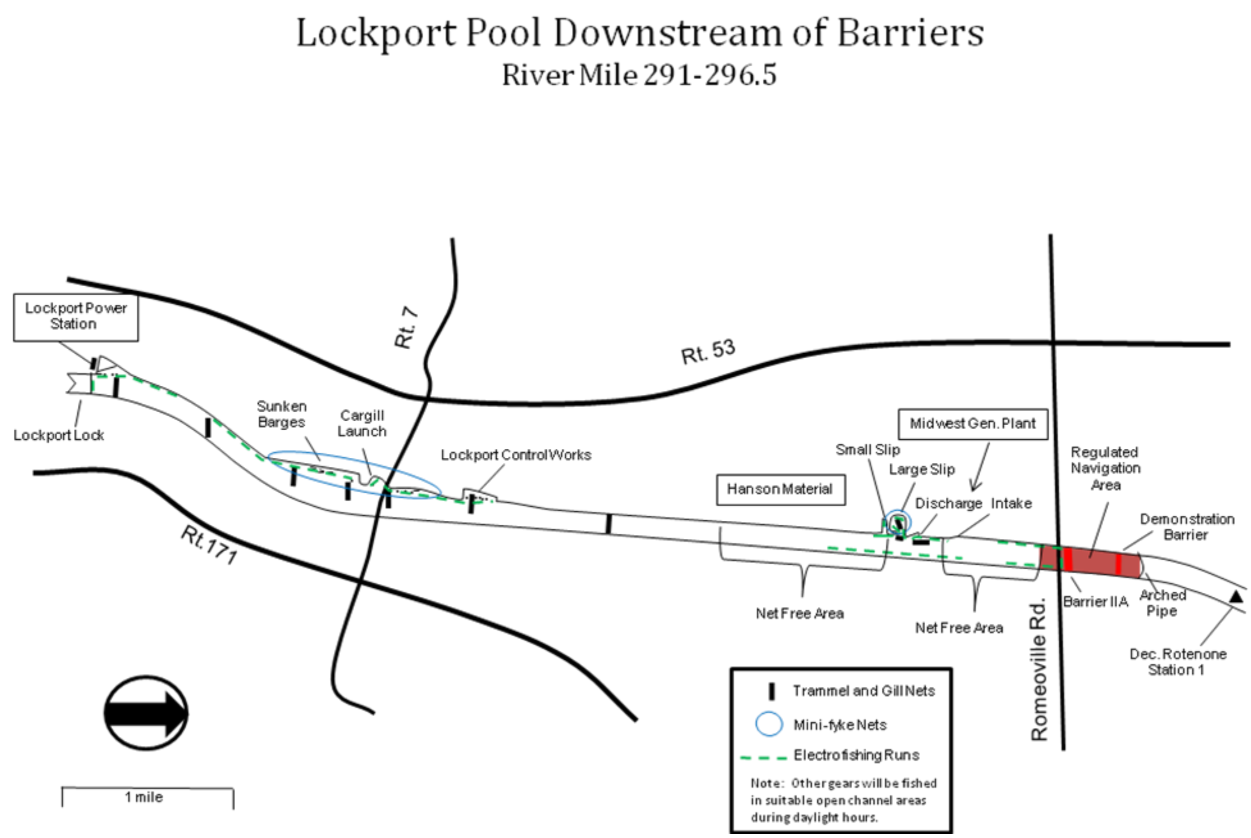


Figure 3. *Lockport Pool downstream of the Dispersal Barrier showing target areas for fish sampling operations.*

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 Electric Dispersal 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 Electric 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
2018 Plan

Participating Agencies: IDNR (lead), Illinois Natural History Survey

Location: The Barrier Defense Project will target the area between the Starved Rock Lock and Dam up to the Electric 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 (2.5 - 5.0 inch; 63.5 – 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.

(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 deployed 2,056 miles (3,308km) of gill/trammel net, 20 miles (32.1km) of commercial seine, 162 pound net nights and 2,342 hoop net nights in the upper Illinois Waterway since 2010. A total of 88,159 Bighead Carp, 638,186 Silver Carp, and 4,558 Grass Carp were removed by contracted commercial fisherman from 2010-2017. The total weight of Asian carp removed was 3,078 tons. For more detailed results see the 2017 Interim Summary Report (MRRWG 2017).

Barrier Defense Asian Carp Removal Project
2018 Plan

Methods:

Contract commercial fishing will take place from February 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, main channel, and side channel habitats known to hold Asian carp. 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 used for non-consumptive purposes (e.g. converted to liquid fertilizer, chum, etc.). 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 2018 is shown in the table below**.

Week of	Agency	Week of	Agency	Week of	Agency
Mar 5*	IDNR	May 21	IDNR	Sept 24	IDNR
Mar 19	IDNR	June 18	IDNR	Oct 8	IDNR
Apr 2	IDNR	July 9	IDNR	Oct 22	IDNR
Apr 9	IDNR	July 23	IDNR	Nov 26	IDNR
Apr 23	IDNR	Aug 6	IDNR	Dec 3*	IDNR
Apr 30	IDNR	Aug 27	IDNR		
	IDNR	Sept 3	IDNR		

* Weather permitting.

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

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.

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).

Introduction and Need:

Barrier Defense was initiated in 2010 to reduce the number of Asian carp downstream of the Electric Dispersal Barrier and thereby decrease risk of invasion into the Great Lakes. Since 2015, the Columbia FWCO has contributed to this effort using an electrified butterfly frame trawl (paupier), removing several tons of Asian carp from the Starved Rock and Marseilles pools of the upper Illinois River. The paupier is a unique mass removal tool because it is an active gear utilizing electrofishing technology, it catches all sizes of bigheaded carps, and it is capable of fishing in a variety of habitats. Silver Carp daily removal increased in 2017 as a result of handling fish more efficiently. For instance, mechanical winch improvements assisted with moving heavy loads of fish thereby reducing crew fatigue, the addition of a tender boat and crew freed the paupier to continue fishing operations, and a trailer with totes increased the amount of fish that could be hauled to the processing/disposal location. Additionally, standardized sampling with the paupier in spring, summer, and fall of 2017 suggested Silver Carp catch rates peaked in summer. Therefore, Barrier Defense with the paupier in 2018 will concentrate efforts in the summer season with the addition of a tender boat and hauling trailer.

Objectives:

(1) Remove adult and juvenile Asian carp from the Starved Rock Pool of the upper Illinois River with the paupier, tender boat, and carp hauling trailer.

(2) Track and assess cost effectiveness in terms of Asian carp biomass per labor hour to inform future harvest.

Methods:

Gears

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

Harvest will occur in the Starved Rock Pool of the upper Illinois River during the summer season (late June to early September 2018). Electrical settings, electrotrawling time, crew size, and time expended on the water will be recorded daily. Silver Carp aggregations will be located using fish finders (i.e., Humminbird 1100 Series, and Humminbird 360ssi) in a variety of habitat types (slack or backwater and flowing water) and targeted during variable length transects. Transect length will depend on habitat availability or net capacity. Winches will lift loaded paupier nets into the tender boat. Native fish will be identified to species, enumerated and be immediately released. When the tender boat reaches capacity, Asian carp will be transported to the hauling trailer with large plastic totes stationed at a nearby boat ramp. All Asian carp will be identified to species and enumerated while offloading into the hauling trailer. Concurrently, the paupier will continue harvesting carp independently until the tender boat returns. At the end of a day's effort, all carp will be hauled to the processing/disposal station located offsite. There, total length and weight will be collected for all Grass Carp and Bighead Carp, and a 10% subsample of Silver Carp selected at random to calculate size structure and biomass.

Data analysis

Data will be summarized in terms of effort (days, labor hours, and electrotrawling hours), catch (Asian carp counts and biomass), catch per unit of effort (Asian carp tons per day, lbs per labor hour, and counts per electrotrawl hour), bycatch (percent Asian carp catch), and size structure. Biomass will be calculated by extrapolating average weights (Silver Carp) or known weights (Grass Carp and Bighead Carp) to the number harvested. Labor hours will be the number of crew members multiplied by hours spent on the water. Percent Asian carp catch will be the proportion of Asian carp relative to the total number fish collected.

Project Schedule:

March – May 2018: Gear preparation and field logistic planning

June – September 2018: Field sampling

October – November 2018: Data entry and analysis

December 2018 – February 2019: Produce annual report and presentation

Deliverables:

Project updates and preliminary results will be reported in monthly summaries to MRWG. Annual report to the MRWG in winter 2018–2019. Oral presentation will be given to fellow workgroup members at the annual 2018 MRWG meeting, and state and regional conferences.

Optimization of Mass Removal Techniques
2018 Plan

Participating Agencies: USFWS-Columbia Fish and Wildlife Conservation Office (USFWS-CFWCO), USGS-Columbia Environmental Research Center (USGS-CERC; Collaborator)

Location: Alton Pool, Illinois River; Illinois River tributaries and backwaters; Missouri River tributaries and backwaters; Kentucky Lake

Introduction and Need:

Efficacy of a mass harvest event can be somewhat pre-determined by the availability of fish present and relative success of the removal action. Since mass harvest generally demands a higher investment, it is important to verify that a large number of fish are present, predict when the fish will be present, condense those fish to a smaller area, and remove the fish with a discrete large effort. A proactive "optimized" methodology is needed to prescribe how mass harvest events could be conducted in the future over a wider geographic area, in more habitats, with lower cost, higher efficiency and greater success on a repeatable framework.

Mass harvest fishing methodologies exist throughout the world for a variety of species and these methods can be adapted to harvesting Asian carp from Midwestern U.S. waters. Mass harvest technique development incorporates global expertise in net design, existing proven methods and innovative methods in condensing fish to a point of capture. Experimental approaches can be used to test the effectiveness of methods to identify the most efficient mass-removal strategies for reducing Asian carp populations. To date, preliminary evaluations by the USFWS-CFWCO and USGS-CERC have shown the success of several herding methods like deep-water electricity combined with sound. Mass harvest methods like encirclement seine gear and the paupier are having success as well. Barriers to current mass harvest strategies involve fish avoidance to the action and escapement (jumping). Although the Unified Method has experienced great success, there is a very small window of time related to temperature where fish can be contained. Methods need to be developed to extend this temperature time-frame when the method can be used or expedite the timeline of the event (net hoods, herding, and containment nets). Paupier mass harvest has been highly successful when Silver Carp are at high densities. Further optimization of herding methods to create this harvest scenario and better net design to handle large numbers of fish would provide a needed method for removing fish in discrete locations without the use of larger gears.

Sonar technologies can be integrated into net design and population assessment. High tech DIDSON technology in addition to new low-tech side imaging technology (Humminbird MegaImaging) can be used to understand behavioral responses such as herding and avoidance and inform how to build appropriate gear. These technologies as well as Humminbird 360 may be used as a method for determining the relative success of an action and accelerate the learning process.

Optimization of Mass Removal Techniques
2018 Plan

Use of the Humminbird 360 is at least a good measure of categorical abundance (high,medium,low) that can be used to describe the use of an area that may be well suited for mass harvest (harvest basin). Abiotic or biotic (i.e., chlorophyll) factors may prove important for understanding when fish abundance will be high to optimize timing of the harvest effort. Tools like the paupier make it possible to validate the demographic of the sonar image. Understanding the frequency of population replenishment of a harvest basin is important to understanding sustainable yield within harvest basin. Using waterfowl survey strategies, whereby readers are trained by pictures of known numbers of animals to estimate abundance, it is possible create a rapid visual assessment skillset for Asian carp biologists which will provide a more refined way to describe population availability during an assessment.

Objectives:

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

(2) Validate low-cost methods using the Humminbird 360 sonar to identify and measure Silver Carp aggregations.

(3) Validate environmental variables predicting Silver Carp aggregations in tributaries to identify prime "Harvest Basins."

Status:

Gear evaluation and optimization of mass harvest are parts of past and ongoing research efforts conducted under the following GLRI funded projects: Barrier Defense Using Novel Gear (FWS), Mass Removal and Monitoring of Juvenile Asian carp (FWS), Use of Acoustic Technology to Determine Behavior (USGS), and Integrated Pest Management Program (USGS).

Methods:

Tributaries (USFWS in collaboration with USGS)

Herding will be systematically conducted with multiple methods in net-blocked portions of three tributaries of the Missouri (2) and Illinois rivers (1) throughout 2018. Herding methods will drive the fish down the blocked portion through two containment weirs and into a final catch trap. The relative proportion of fish driven will be qualitatively evaluated between methods to determine relative effectiveness of moving fish to a contained area for harvest. Three types of harvest fyke nets will be used to determine fish avoidance behavior and optimized design. Anti-jumping hoods will be affixed to block nets during the study to determine an effective design.

Optimization of Mass Removal Techniques
2018 Plan

Backwaters (USFWS; collaboration with USGS passive capture methods on an opportunistic basis)

Herding, containment, and capture methods in backwater habitats will be similar to methods deployed in tributaries but with more expansive gears. Backwaters and impoundments with high and low concentrations of Silver Carp will be sampled throughout 2018 (Alton Pool of the Illinois River, Kentucky Lake, Hanson Material Services Pits in Morris, Illinois, and Creve Coure Lake, Missouri). Fish will be driven across a large (100 acre) area using deep water electricity, “scare” gillnets, and Chinese flasher boards from a large area through containment weirs and finally into a smaller corral where they will be harvested. Three removal methods including: paupier bumper cod extensions, purse seining, and passive fykes will be used to capture fish in the containment corral. Supplemental hood attachments on block nets will be evaluated for their ability in preventing surface escapement over the block net. Qualitative 360 sonar surveys will be used to evaluate the success of the action.

Humminbird 360 sonar (USFWS in collaboration with USGS)

The utility of the low-tech Humminbird 360 sonar will be evaluated for its use in qualitatively assigning Asian carp presence and abundance. Collaboratively collected 360 sonar surveys within tributaries, backwaters, and reservoirs will be evaluated for their use as a rapid assessment tool. Images collected may be qualitatively described by multiple readers and used to create an image analysis program. Paupier fish surveys conducted at the time sonar images were collected will be used to validate species and size of fish present.

Environmental Indicators (USFWS in collaboration with USGS)

Information on environmental variables that correlate to aggregations of Silver Carp in tributaries will be compiled and then validated on the landscape. Validation will collect pertinent biotic and abiotic parameters as well as qualitative fish presence and abundance. Biotic parameters may enlist the use of data loggers to describe depth, light, temperature, or water level and water quality meters recording chlorophyll and turbidity. Fish presence and abundance surveys may be conducted with Humminbird 360 sonar and the paupier to validate species and size of fish present. Ad hoc sonar surveys in the Missouri River tributaries will be done when extreme weather or rain events occur. Information gained from this will be used to identify potential harvest basins in the Illinois River.

2018 Schedule:

February – April 2018: Project planning in collaboration with USGS-CERC; Gear preparation; Field logistics

May – December 2018: Site surveys; Field sampling; Evaluate Humminbird 360 sonar images

December 2018 – February 2019: Data synthesis; Annual report preparation

Optimization of Mass Removal Techniques
2018 Plan

Deliverables:

Project updates and preliminary results will be reported to MRWG when fieldwork occurs. Annual report and oral presentation delivered to the MRWG in winter 2019. Summary report and associated publication will describe:

- Hood containment system that can be used on block or seine nets to prevent airborne escapement
- 360 sonar as a tool for estimating percentage of fish reduced by sampling event
- Relative efficiency of herding methods
- Effectiveness of weir as a containment and reduction technique
- Species composition relative to potential Asian carp biomass in mass harvest efforts and the importance for assessing risk of bycatch since most States currently do not allow commercial fishing in tributaries.
- Paupier as a tool for species validation of sonar surveys and biomass estimation.
- Evaluation of paupier harvest using floating retrievable bumper cods
- Efficacy of using purse/cod seining for mass harvest
- Relative categorical description of fish abundance as correlated to environmental variables
- Species demographic of survey area

Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions

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

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

Introduction and Need:

Because Asian carp continue to advance upstream through the Illinois River towards the Laurentian Great Lakes, management goals have focused on limiting upstream dispersal through monitoring, assessing and possibly enhancing movement barriers, and reducing abundance through contracted harvest. Asian carp spatial distributions vary both seasonally and annually, therefore, quantifying how spatial distributions change through time will help target contracted harvest efforts to maximize removal efforts and minimize costs. Additionally, long-term information on Asian carp population characteristics, distributions, and movements, especially along the population front in the upper Illinois River, can provide data to parameterize population models. These models simulate the effects of various management actions (e.g., harvest scenarios, locations of enhanced deterrent technologies) to determine which options are most likely to achieve management goals.

Monitoring of Asian carp densities via hydroacoustic sampling throughout the Illinois River (Alton to Dresden Island pools) by Southern Illinois University (SIU) has been ongoing since 2012 and is a useful metric to evaluate long-term changes in Asian carp abundance. By monitoring densities across multiple years throughout the river, long-term trends can be identified and related to environmental conditions, reproduction, or management actions such as commercial harvest (lower Illinois River) or contracted removal (upper Illinois River) to understand the variables most strongly affecting abundance. Broad-scale density estimates also help inform management actions in the upper river near the invasion front. Annual densities, particularly in the lower Illinois River, have displayed relatively large fluctuations among years (Coulter et al. 2016), necessitating the need for continued assessments of Asian carp densities throughout the river. This will identify whether lower river population size has increased from the previous year and help determine whether harvest or surveillance in the upper river should be altered in anticipation of increased immigration from downstream pools. It is currently unclear whether, or the extent to which, Asian carp in the Illinois River exhibit density-dependent impacts on reproduction, condition, growth, and movement. Collecting long-term data, particularly density and movement data, can be used to help quantify these patterns which will better inform management decisions and improve models predicting population response to management actions.

Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions

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

Locations of Asian carp aggregations have previously been linked to chlorophyll-*a* levels (Calkins et al. 2012) but the relationship between Asian cap abundances and chlorophyll-*a* as well as the spatial and temporal distributions of chlorophyll-*a* in the Illinois River where Asian carp are present have yet to be fully investigated. Other environmental variables, such as temperature, conductivity and water depth, also warrant investigation for links with Asian carp abundance. Mapping and comparing a suite of environmental variables to Asian carp abundances may allow for predictions of where abundances may be high and when particular areas should be targeted for removal.

A spatially-explicit population model of Asian carp in the Illinois River was recently developed to assess how Asian carp populations respond to a variety of management actions (e.g., location and intensity of harvest; location and effectiveness of deterrent technologies). This model draws on a wide variety of data mostly collected from 2012 – 2015. However, updating the model with additional years of data (2016 – 2018) and including additional input variables could greatly reduce uncertainty in model predictions. For example, previous telemetry work by SIU has shown that passages of Asian carp through existing lock and dam structures can be rather variable among years (e.g., 0 passages in 2014 and >10 passages in 2015 at Starved Rock Lock and Dam). Including three additional years of data to parameterize the model will better account for such annual variability in movement behavior, densities, and life history characteristics. Including additional input variables into the model can also help reduce model uncertainty. Specifically, no estimates were available to initially parameterize mortality rates in the current iteration of the model, nor were mortality rates able to be differentiated by type of mortality, which contributes to uncertainty in model output. Currently, mortality is estimated from growth rates and is not separated by cause (e.g., natural vs. harvest) but using SIU's telemetry data, it may be possible to estimate both the current harvest mortality rate as well as natural mortality rates to reduce uncertainty in model output. Additionally, estimated harvest mortality rates from telemetry data would provide an estimate of the current exploitation levels for Asian carp in the Illinois River which has not previously been quantified.

Objectives:

(1) Quantify Asian carp densities every other month in Dresden Island and Marseilles pools in 2018 using mobile hydroacoustic surveys to pinpoint high density areas that can be targeted during contracted removal. Water quality (chlorophyll-*a* concentrations, blue-

green algae concentrations, turbidity, conductivity, water temperature, dissolved oxygen, and water depth) will be measured during surveys to examine possible environmental predictors of Asian carp densities throughout the year.

(2) Conduct hydroacoustic surveys at standardized sites in fall 2018 from Alton – Dresden Island pools to assess long-term trends in density, biomass, and size structure.

(3) Maintain SIU's extensive acoustic telemetry array currently in place in the Illinois River. Quality check data and merge with existing telemetry database to determine distance moved by Silver Carp, Bighead Carp, and their hybrids, and determine the number and timing of passages through dams.

(4) Use telemetry data, including known reported mortalities, to estimate natural and harvest mortality rates, if possible, which will then be updated in the population model. Continue collaboration with USGS to determine environmental factors influencing lateral habitat use of bigheaded carps to provide managers with estimates of when and where harvest should occur to maximize effort.

Status:

Continues previous work by SIU that has intensivly monitored movement and density of Asian carp in the Illinois River since 2012. One year of environmental data has been collected in conjunction with the hydroacoustic surveys and will be continued for a second year. Hydroacoustic and standardized sampling surveys will yield information on trends in density, biomass, and population information such as size structure, CPUE, length-weight relationships of Asian carp in the Illinois River. Because these surveys have been ongoing since 2012, long-term temporal trends can now be evaluated.

Methods:

Spatial and temporal variation in Asian carp densities in Marseilles and Dresden Island pools: relationships with environmental characteristics

Mobile hydroacoustic surveys will occur in main channel, tributaries, side channels, and connected backwater lakes using horizontally oriented split-beam transducers. Surveys will be conducted every other month in Dresden Island and Marseilles pools from March to November in 2018, given appropriate sampling conditions. In order to inform hydroacoustic data, catch from ongoing efforts (e.g., contracted removal) in the Dresden Island and Marseilles pools will be sampled throughout the year for species relative abundance and measured for length and weight.

Environmental conditions will be sampled during hydroacoustic surveys using a multiparameter water quality sonde that will continuously measure chlorophyll-*a* concentrations, blue-green algae concentrations, turbidity, water temperature, and dissolved oxygen concentrations. Potential relationships between these variables and Asian carp densities will be evaluated with the goal of developing a statistical model to predict Asian carp densities based on all or a subset of these environmental conditions. These results will build on data collected in 2017 surveys.

Density estimates of Asian carp in the Illinois River

Hydroacoustic surveys will be conducted in the fall of 2018 throughout the Illinois River (Alton – Dresden Island pools) following the same protocol outlined above for the bi-monthly surveys of Marseilles and Dresden Island pools. Survey sites will be the same locations sampled previously by SIU in order to add to the existing long-term (6 years as of 2017) dataset. Such data are essential to fully understand population dynamics, especially when biotic (e.g., annual variability in recruitment success) and abiotic (e.g., drought, flood years) processes fluctuate through time. As with the bi-monthly sampling in Marseilles and Dresden Island pools, environmental conditions will be sampled during the hydroacoustic surveys to provide additional data across a variety of sites and environmental conditions for determining relationships between Asian carp density and water quality measurements.

Telemetry data to update pool-to-pool transition probabilities and estimate natural and harvest mortality rates

The existing acoustic telemetry array of 54+ stationary receivers will be maintained and downloaded on two occasions in 2018. Additional acoustic telemetry tags (~100 tags) will be deployed by SIU in LaGrange and Alton pools while bigheaded carp in other Illinois River pools will be tagged by USFWS and USACE such that numbers of tagged bigheaded carps remain high in all pools within the telemetry array. Stands holding the receivers and hardware will be replaced as necessary. Data from the telemetry array will provide information on numbers of tagged Asian carp moving upstream or downstream through each dam, which provides an indication of the relative numbers of individuals in the population that may be moving among pools. Telemetry data from 2016 and 2017 will be added to capture histories used to generate previous pool-to-pool transition probabilities. Capture histories from telemetry data will also be used to estimate both natural and harvest mortality levels in the Illinois River which will be used to update the population model (e.g., Hightower et al. 2001). Pool-to-pool transition probabilities and mortality estimates can be incorporated into the spatially-explicit bigheaded carp population model.

2018 Schedule:

Bi-monthly hydroacoustic surveys will be conducted in the Marseilles and Dresden Island pools from March through November 2018, weather permitting. In addition, annual hydroacoustic surveys will occur in the Alton, LaGrange, Peoria, and Starved Rock pools in fall 2018, between September and October. Telemetry stationary receivers will be downloaded two times during 2018.

Using Long-term Asian Carp Abundance and Movement Data to Reduce Uncertainty of Management Decisions

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 2018 compared to 2017, 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.

References:

Calkins HA, Tripp SJ, Garvey JE (2012) Linking silver carp habitat selection to flow and phytoplankton in the Mississippi River. Biological Invasions 14: 949-958.

Coulter DP, Coulter AA, MacNamara R, Brey MK, Kallis J, Glover D, Garvey JE, Whitledge GW, Lubejko M, Lubejko A, Seibert J (2016) Identifying movement bottlenecks and changes in population characteristics of Asian carp in the Illinois River. Final Report to Illinois Department of Natural Resources.

Hightower JE, Jackson JR, Pollock KH (2001) Use of telemetry methods to estimate natural and fishing mortality of striped bass in Lake Gaston, North Carolina. Transactions of the American Fisheries Society 130: 557-567.

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Evaluation of Gear Efficiency and Asian Carp Detectability

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

Participating Agencies: Illinois Natural History Survey (lead)

Location: Evaluation of sampling gears will take place opportunistically during summer and fall at multiple sites in the Illinois Waterway.

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 Waterway, 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.

(5) Gather data on abundances of other fish species found in the Illinois River to further assess gear efficiency, and examine potential associations between Asian carp and native fishes.

Evaluation of Gear Efficiency and Asian Carp Detectability

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 – 2017. Sampling occurred during summer and fall at main channel and backwater sites along the Illinois River, resulting in the capture of 168,606 fish, including 71,184 juvenile Silver Carp and 3 juvenile Bighead Carp. Catch rates of all fishes and of juvenile Asian carp varied widely among years, with considerably higher numbers of juvenile Silver Carp captured in 2014 (n = 67,881) and 2017 (n = 2,861) than in 2015 (n = 106) and 2016 (n = 336). Mini-fyke nets produced higher catch rates of age-0 Silver Carp than any other sampling gear in every study year, and appear to be among the most effective tools for targeting these fishes in near-shore habitats. Earlier years of this study suggested that beach seines may have some value for juvenile Asian carp sampling. However, this gear type has produced very low and inconsistent capture rates of juvenile Asian carp in more recent years, bringing its utility into question. Pulsed-DC electrofishing, purse seines, cast nets, and gill nets have also captured low and inconsistent numbers of juvenile Silver Carp, and do not appear to be preferable methods of sampling for these fish. Differences in size selectivity for juvenile Asian carp appears to exist among gear types, with beach seines typically capturing the smallest size groups of age-0 Silver Carp, and other gear types collecting broader length ranges. Larger size groups of age-0 and age-1 Asian carp do not appear to be vulnerable to nearshore sampling gears such as mini-fyke nets and beach seines, suggesting that a habitat shift occurs as these fishes increase in size, and that alternate offshore sampling gears may be necessary to target these larger juvenile size classes.

Juvenile Asian carp sampling in 2017 was conducted concurrently with USFWS trawling efforts in the LaGrange Pool. Comparison among established nearshore sampling gears and pelagic trawling methods is being conducted by USFWS (see Gear Evaluation for Removal and Monitoring of Asian Carp Species plan).

Methods:

During 2018, sampling efforts will continue to focus on juvenile Asian carp. Sampling will occur opportunistically during summer and fall at multiple sites in the Illinois Waterway, concurrent with efforts employing innovative pelagic trawling systems (see Gear Evaluation for Removal and Monitoring of Asian Carp Species plan). 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. Catch rates of juvenile Asian carp will be compared to those of innovative pelagic gears (paupier nets, surface trawls, dozer trawls, etc.) being tested by collaborating agencies.

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. Ongoing analyses are examining additional gear types, assessing multi-gear models, and exploring 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 2018, gear evaluation sampling will occur during summer and fall, as conditions permit. 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. Estimates of detection probabilities and sample size requirements for different life stages of Asian carp and select native fishes will be summarized and provided to MRWG partners as a separate report during 2018. All data will be summarized and project plans updated for annual revisions of the MRP.

Unconventional Gear Development

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

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

Location: Great Lakes trap (pound) nets will be deployed at select sites in Illinois River backwaters and other off-channel habitats to test alternative configurations of this gear type, and 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.

(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. During 2013 – 2014, experiments were conducted to test the effectiveness of driving Asian carp into surface-to-bottom gill nets. 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 four 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 Services 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 Services 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 - 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 IDNR personnel using pound nets at the Hanson Material Services pit (Marseilles Pool) for monitoring and removal of Asian carp.

Analysis of 2012 - 2014 data from Lily Lake and the Hanson Material Services 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 $\pm$ SD = 829 $\pm$ 103 mm) than hoop nets (619 $\pm$ 99 mm) or fyke nets (681 $\pm$ 140 mm). However, sizes of Silver Carp did not differ significantly among pound nets (582 $\pm$ 62 mm), hoop nets (572 $\pm$ 75 mm), and fyke nets (557 $\pm$ 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.

Previous deployments of pound nets involved angling the two wings from the net to opposite banks, blocking the entirety of a waterway. However, in larger floodplain lakes, blocking from bank to bank is not possible. During 2017, alternative configurations of pound nets were tested at the Hanson Material Services backwater. During this deployment, one net was set perpendicular to shore, and the other was set parallel to shore. Total catch rates during these trials were very low, likely due to the extensive removal efforts that were undertaken throughout the year at the Hanson Material Services pit. More fish were captured in the perpendicular set than in the parallel set, and all of the Asian carp (3 Bighead Carp, 2 Silver Carp, 1 Grass Carp) were captured by the perpendicular set. Additional deployments are needed to adequately evaluate alternative pound net configurations, particularly in areas where Asian carp densities are higher. However, low water levels prohibited testing pound nets at other potential study sites during 2017.

Methods:

During 2018, additional locations for pound net deployment will be pursued in order to provide a robust, replicated assessment of alternative pound net configurations. Backwater areas of the Alton, LaGrange, and Peoria pools will be scouted to evaluate their suitability for pound net deployment, particularly during periods of higher water levels. Alternative configurations will be tested at select sites 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 be set for 1-3 week periods, during which they will be checked every 1-7 days as needed based on catch rates. All captured fish will be identified to species, and measured for total length and weight. Species composition, catch rates, and size selectivity will be compared among the different pound net configurations. Pound nets will also be deployed as needed to assist other agencies with Asian carp research, monitoring, and control activities. INHS will also help to train personnel from other agencies on the deployment, maintenance, and retrieval of pound nets.

Sampling Schedule:

In 2018, 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.

References:

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.

Barge Entrainment and Asian Carp Interaction Study and Monitoring Barge Entrainment Dynamics and Assessment of Mitigation Protocols

Participating Agencies: U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office, Wilmington Substation, Wilmington, IL and U.S. Geological Survey, Central Midwest Water Science Center, Urbana, IL

Location: Field work will be conducted within the Illinois River LaGrange and Peoria pools

Introduction and Need:

The Electric Dispersal Barrier System located within the Chicago Sanitary and Ship Canal (CSSC) operates with the purpose of preventing dispersal of invasive fishes between the Mississippi River and the Great Lakes basins while maintaining continuity of this important shipping route. In an attempt to gain further understanding about the potential risk of fish passage associated with barge traffic at the Electric Dispersal Barrier System the U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey (USGS) conducted a series of experimental field trials during 2015-2017 that utilized a contracted commercial barge tow. Studies conducted during 2015-2016 investigated the potential for entrainment, retention, and transport of freely swimming fish within the rake to box junction gaps between barges and examined non-entrainment pathways for fish passage associated with barge traffic at the Electric Dispersal Barrier System. Results of the barge entrainment studies demonstrated that small fish can become entrained by barges, retained within junction gaps, and transported over distances of at least 9.6 miles including upstream across the Electric Dispersal Barrier System (Davis et al. 2016). Studies conducted during 2017 tested mitigation techniques to reduce or eliminate fish passage at the Electric Dispersal Barrier System associated with passing tows.

Currently, juvenile Asian carp (< 6”) are not believed to be present near the Electric Dispersal Barrier System or in the Illinois Waterway within 39.5 miles downstream from the Electric Dispersal Barrier System. This is based on extensive physical sampling efforts targeting juveniles. These observations highlight a need to understand the risks associated with barge entrainment and upstream transport of early life stages of Silver Carp in the Illinois Waterway. During FY 2018, a barge entrainment risk assessment tool will be developed using existing data and models to identify potential times and locations that may be “hotspots” for the inadvertent entrainment of early life stages of Asian carp.

Objectives:

(1) Gain further insights on barge entrainment, retention, and transport dynamics specifically regarding entrainment of juvenile Silver Carp.

(2) Determine potential upper size thresholds for entrainment of juvenile Silver Carp.

(3) Simulate the spatial characteristics of Asian carp ichthyoplankton drift events from known spawning events that occurred between 2012-2016 using lagrangian particle tracking models (Fluegg).

(4) Overlay historical ship track data from the Illinois River on egg plume models.

Methods:

The 2018 barge study is designed to empirically estimate size-selective entrainment probabilities for Asian carp. A modified mark recapture study utilizing juvenile Asian carp of varying sizes will be performed in a downstream location with abundant Asian carp populations. Nets will be used to physically recapture marked study specimens and document entrainment transport distances as well as locking through lock and dam systems. Additionally, multi-beam sonar systems and video cameras will be deployed around the barge tow. The images from the DIDSON and underwater cameras will be used to view and count fish in barge junctions over time, distance traveled, and after locking through a lock and dam. Additional data on temperature, flow, speed of the barges, and distances traveled by the barges will also be collected and compared to the sonar data collections.

Additionally, historical Asian carp spawning events and commercial ship track data on the Illinois River will be analyzed to determine if there were periods and/or reaches where entrainment and upstream transport of Asian carp eggs and/or larvae were possible. The analysis will be based on visualizing plumes of eggs and larvae after documented spawning events by using the FluEgg model along with historical commercial ship track data. This will allow the identification of high entrainment risk locations and temporal periods. Early life stages (eggs and larvae) of Asian carp passively drift downstream during the period before inflation of the gas bladder. If early life stages occupy the same time and space as northbound commercial traffic, there is a risk of entrainment and upstream transport. Hydrologic data from periods corresponding with historical spawning events (up to 6 events) occurring between 2012-2016 (river stage, discharge, etc.) will be used as input to the FluEgg model. This particle tracking model, developed especially for Asian carp eggs, will then be used to simulate historical spawning events at likely spawning locations within the Illinois Waterway. This will provide spatially explicit Asian carp egg density estimates within the Illinois Waterway during simulated spawning events. Ship track data from the National Automated Identification System (NAIS), used to track commercial vessels, will then be overlaid on egg location density data in a Geographic Information System (GIS). These products will allow the identification of locations where egg density is likely to be high and the incidence of spatial overlap with commercial traffic is also likely to occur. These potential zones of high entrainment risk are likely localized, only occur at specific discharge levels, and only occur for short windows of time after a spawning event occurs. Identification of these risk windows has the potential to offer opportunities for management and avoidance actions.

2018 Schedule:

- January 2018: Logistics, preparation, partner agency coordination, and obtain data permissions from USCG
- June 2018: Run models
- July 2018: GIS analysis
- August 2018: Field trials
- November 2018: Report generation

Deliverables:

Status reports covering any urgent and significant findings will be shared among partner agencies as soon as possible following the finding. An annual report summarizing all work conducted in 2018 will be produced by approximately January 2019.

References:

Davis, J.J., LeRoy, J.Z., Shanks, M.R., Jackson, P.R., Engel, F.L., Murphy, E.A., Baxter, C.L., Trovillion, J.C., McInerney, M.K. and Barkowski, N.A., (2017). Effects of tow transit on the efficacy of the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System. *Journal of Great Lakes Research*, *43*(6), pp.1119-1131.

Asian Carp Population Modeling to Support an Adaptive Management Framework 2018 Plan

Participating Agencies:

Leads: US Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office and Columbia Fish and Wildlife Conservation Office; US Geological Survey Upper Mississippi Environmental Science Center

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

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

Introduction and Need:

There is strong interest in maximizing harvest effectiveness for reducing Asian carp in the upper Illinois River waterway, particularly in combination with other tools such as deterrent barriers (ACRCC 2015). However, it remains uncertain how Asian carp popuations in the upper Illinois River waterway will respond to different management strategies. Adaptive management was conceived as a way of managing natural resources (Walters 1986), including invasive species (e.g., Shea et al. 2002) in the face of great uncertainty. The adaptive management framework calls for data driven tools, such as population models that describe current knowledege and include assumptions and predictions as the basis for decision making and further learning. In response to this need, a Spatially Explicit Asian carp Population (SEAcarP) model that includes spatial components (i.e., river pools) of the Illinois River system was developed to inform management decisions concerning harvest strategies (i.e., harvest location and intensity) and upstream movement deterrents (i.e., deterrent location and efficacy). Although the SEAcarP model is an appropriate adaptive management support tool, important needs remain including addressing model assumptions and limitations, updating model predictions using the most current data available, and conducting sensitivity analyses to deterimine how uncertainty in the model output can be related to different sources of uncertainty in its inputs (i.e., demographic rates) and whether those uncertainties can be minimized by prioritizing future research and data collections. Further, opportunities exist for other model improvements and should be undertaken where possible. The work described herein will focus on model implementation and development such as sensitivity analyses and annually updated management recommendations based on contemporary data, improvements that reflect current advancements in population modeling (i.e., integral projection models; Merow et al. 2014) and addressing model limitations and assumptions, such as incorporating vulnerability to fishing as a function of fish size and field-based estimates of fishing mortality, and upstream movement.

Asian Carp Population Modeling to Support an Adaptive Management Framework 2018 Plan

Objectives:

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

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

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

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

(5) Modify the length-based structure of the model; use integral projection models to define populations by a continuous variable instead of discrete length classes.

Status:

A group of population modeling experts convened during 2013 to outline an Asian carp population model for the Illinois River waterway that includes spatially explict componentes. Development of the model was supported by Illinois DNR and Southern Illinois University (Project: Identifying Movement Bottlenecks and Changes in Population Characteristics of Asian Carp in the Illinois River, ACRCC-MWRG 2015). Preliminary results were presented at the annual MRWG meeting in Springfield, Illinois during January 2017. During early 2017, model development responsibilites were transfered to USFWS. Thus, this is a continuing project during 2018, but the first year that it will be formally managed by USFWS.

Methods:

Model parameterization updates

The SEAcarP model will be reparameterized using updated demographic rates estimated from all possible data sources (state and federal agencies and universities). Demographic rates (i.e., growth, mortality, condition, maturation schedule) for Bighead and Silver Carp will be estimated from data collected from the Mississippi River and its tributaries using Bayesian hierarchical models. In all models, river pool will be treated as the random effect. Inter-reach transition probabilities will be based on previous modeling (Project: Identifying Movement Bottlenecks and Changes in Population Characteristics of Asian Carp in the Illinois River, ACRCC-MWRG 2015).

Growth rate will be estimated by fitting a von Bertalanffy growth function to individual length at age data:

$$L_{i,j} = L_{\infty j}\left(1 - e^{-K_j(a_{ij} - t_{0j})}\right) + \varepsilon_{ij}$$

$$\varepsilon_{i,j} = N(0, \sigma^2)$$

$$log\begin{pmatrix} L_{\infty,j} \\ K_j \\ t_{0,j} + 10 \end{pmatrix} \sim MVN(\mu, \Sigma)$$

$$\mu = \log(\bar{L}_\infty, \bar{K}, \bar{t}_0)$$

where $L_{i,j}$ is the total length and $a_{i,j}$ is the estimated age for fish *i* from pool *j*. The model parameters $L_{\infty,j}$, K_j, and $t_{0,j}$ represent the asymptotic length, the growth coefficient, and the theoretical age at which size equals 0, respectively. Age- and pool-specific random errors representing individual variation in length at age are indicated by $\varepsilon_{i,j}$. The random errors will be assumed to be independently and identically distributed as $N(0, \sigma^2)$ whereas the natural log of the von Bertalanffy model parameters were assumed to follow a multivariate normal distribution (*MVN*) with a population mean μ and variance-covariance $\sum$. The population mean μ contains L_∞, K, and t_0 which are the population-average parameters that describe the mean growth curve among pools. Though estimates of t_0 are typically negative, the log of negative values is not possible. Thus, to facilitate with model fitting a value of 10 will be added to t_0, and subsequently subtracted before evaluating on the original scale (Kimura 2008).

Probability of maturity will be modelled as a function of female length using a binomial logit model:

$$logit(p_{ij}) = \beta_j L_{ij} + \alpha_j + \varepsilon_{ij}$$

$$\varepsilon_{i,j} = N(0, \sigma^2)$$

$$(\alpha_j, \beta_j) \sim MVN(\mu, \Sigma)$$

$$\mu = (\mu_\alpha, \mu_\beta)$$

where $p_{i,j}$ is the probability of maturity and $L_{i,j}$ is the total length for fish *i* from pool *j*. Parameters β_j and α_j are pool-specific slope and intercept parameters. The structure of random errors and correlations between parameters in the maturity models will be treated similarly to the approach used in growth models. Maturity status will be assigned using either macroscopic visual inspection or the gonadosomatic index (100 × ovary weight / somatic weight). Females that were not visually inspected will be considered mature when GSI is greater than 1% and immature otherwise (Tsehaye et al. 2013). We will limit our analysis to data collected during May – August when gonads are at their largest and thus most easily detected.

Condition will be estimated by fitting a linear regression to individual length at weight data:

$$Y_{ij} = \beta_j L_{ij} + \alpha_j + \varepsilon_{ij}$$

$$\varepsilon_{i,j} = N(0, \sigma^2)$$

$$(\alpha_j, \beta_j) \sim MVN(\mu, \Sigma)$$

$$\mu = (\mu_\alpha, \mu_\beta)$$

where $Y_{i,j}$ is the weight and $L_{i,j}$ is the length of fish *i* in pool *j*. Parameters β_j and α_j are the slope and intercept estimates for pool *j*.

For most models, the prior probability distributions for σ will use a diffuse uniform whereas the distributions for μ and $\sum$ will use a diffuse normal. However, because Asian carp grow rapidly during their first year of life and relatively few age-0 or age-1 fish were captured, length at age data provided poor estimates for t_0 which led to unrealistic estimates of L_∞ and *K* due to the strong correlation among parameters. Consequently, a prior probability distribution on t_0 using available data (Silver Carp: mean = -0.05; sd = 0.18; Bighead Carp: mean = -0.04, sd = 0.22; fishbase.org) will be included. Variance-covariance $\sum$ will be modelled using the scaled inverse-Wishart distribution (Gelman and Hill 2007). Posterior distributions will be compiled by running three concurrent Markov chains, beginning each chain with different values. Chains will be run for a total of 500,000 iterations with the first 200,000 discarded for burn in. The remaining data will thinned by retaining every third sample leaving a total of 100,000 values for analysis. Final posterior distributions will be assessed visually and using Brooks-Gelman-Rubin statistic R-hat (i.e., values <1.1 indicating convergence). All analyses will be implemented from within R (R Core Team, 2017), using JAGS (Version 4.2.0) and the rjags package (Plummer 2016).

Annual natural mortality will be estimated using indirect methods that relate mortality to demographic parameters (Jensen 1996). Uncertainty in natural mortality estimates will be derived from variation in the demographic parameters (i.e., *K*) used in the empirical relationship.

Inter-reach movement will be estimated using a multistate model (Project: Identifying Movement Bottlenecks and Changes in Population Characteristics of Asian Carp in the Illinois River, ACRCC-MWRG 2015) parameterized in program MARK. The model calculates annual probabilities of movement (ψ_{hk}) among the lower six Illinois River pools where *h* is the starting pool and *k* is the destination pool. Markov chain Monte Carlo (MCMC) estimation was used (in Program MARK) to estimate model parameters. We will explore the potential and appropriateness of using annual survival rates (*S*) generated from the multistate model as an estimate for natural mortality rate (i.e., 1-*S*).

Spatially explicit Asian carp Population model

The underlying simulation model characterizes the population dynamics of Asian carp in terms of pool- and length-specific abundance over time. Changes in numbers at one time step to the next will be estimated using a set of sub-models that describe Asian carp mortality, growth, inter-reach movement, and reproduction. Sub-models will be applied in a sequential fashion, beginning with survival. The number of fish surviving to the next time step will be estimated in the following way:

$$N_{s,p,t} = N_{s,p,t-1}e^{-M}(1 - v_s U_p)$$

where e^{-M} is size and location invariant survival in the absence of harvest mortality. The terms v_s and U_p are user defined terms representing size-specific vulnerability to harvest, and pool-specific annual exploitation rate respectively. After accounting for survival, the number of fish surviving to the next time step will be updated via matrix multiplication using an S by S growth matrix, where S is the number of size bins. Each element of the growth matrix is a 0 or 1 representing the transition probabilities among size classes. Inter-reach movement will be simulated by multiplying the number of fish surviving and growing into the next time step by a P by P movement matrix, where P is the number of pools. Each element of the movement matrix describes transition probabilities among pools. Numerical recruitment, the final step in the sequence, will be accomplished via addition. Consistent with field observations, recruitment will be limited to the lower-reaches of the Illinois River (i.e., Alton, LaGrange, Peoria pools). The number of recruits added to a given pool will be estimated using a stock-recruitment relationship scaled by pool length. Spawning stock biomass will be calculated using the product of abundance, probability of maturity, and mass summed over all size classes. Recruits will be assigned to a given size class using the Von Bertalanffy growth function solved for size at age zero.

Beverton-Holt and Ricker stock-recruit functions will be parameterized in terms of steepness (h). Stock-recruit functions parameterized in terms of steepness require estimates of average recruitment (R_0) and reproductive effort (S_0) under equilibrium conditions. Because we are not concerned with population scaling, R_0 will be set to an arbitrary value of 1.0 and used in association with mean demographic rates to estimate S_0 in terms of spawner biomass. Specifically, we will create a stable age distribution using R_0, longevity, and the mean mortality rate. Next, we will calculate age-specific length, mass, and probability of maturity. Lastly, we will compute S_0 as the product of age-specific abundance, mass, and probability of maturity, summed over all ages. Initial population abundance will be determined by setting the pool with highest density of Asian carp (Silver Carp: LaGrange Pool; Bighead Carp: Peoria Pool) to S_0 and scaling the remaining pools using hydroacoustics data thus preserving the relative differences in Asian carp abundance among pools.

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

Evaluating management scenarios

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

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

Sensitivity analysis

Sensitivity analysis is a technique that can be used to explore complex models to determine how variation in a given parameter or set of parameters impacts model results. Results of sensitivity analyses will be used to develop a prioritized list of data and research needs and ultimately, to reduce uncertainty associated with model predictions. Sensitivity analyses will be implemented using a one-factor-at-a-time (OAT, Saltelli 2008) approach and 1,000 simulations of the no action scenario. Demographic rates will be set to mean levels for all but one variable (e.g., growth), which will be allowed to vary across simulations as previously described. This process will be repeated for each set of demographic parameter estimates (i.e., growth, maturity schedule, condition) and for a range of plausible steepness values in the stock-recruitment function.

Addressing limitations and assumptions

Statistical catch-at-length models will be used to address limitations and assumptions associated with the SEAcarP model and provide a second source of demographic information for comparison and validation. Statistical catch-at-length models are based on the length structure of an exploited population. The model will use use proportional catch-at-length data from contracted commercial fisheres to estimate relative abundance, exploitation rates, vulnerability to fishing as a function of fish size, growth, and immigration into upper pools of the Illinois River waterway. Demographic rates estimated using the statstical-catch-at-length approach will be used to validate estimates from Bayesian heirarchial models and telemetery-based transition probabilites (Project: Identifying Movement Bottlenecks and Changes in Population Characteristics of Asian Carp in the Illinois River, ACRCC-MWRG 2015). Other results will be directly incorported into the simulation model. For example, the relationship between vulnerability to fishing and fish length will replace the assumption that only fish ≥500 mm total length are suseptible to harvest.

Model improvements

Advancements in population modeling have moved beyond discrete structured designs. Integral projection models (IPMs) are preferable because they better capture continuous processes such as fish growth (Ellner and Rees 2006, Merow et al. 2014). Consequently, the SEAcarP model will be improved to one that maintains the current spatial structure (i.e., discrete pools) but modifies the length-structure using an IPM framework.

2018 Schedule:

May 2018: Meet with stakeholders to finalize objectives

June – August 2018: Multi-state movement modeling with MRWG Telemetry Technical Workgroup; incorporation of integral projection submodel into SEAcarP model

September – October 2018: Data compilation from partners, QA/QC, and data standardization; Statistical catch-at-length model development

November 2018: Statistical catch-at-length parameterization and modeling; demographic data analyses and SEAcarP model reparameterization

November – December 2018: Management scenario simulations

December 2018 – January 2019: Finalize sensitivity analyses, prepare report, and presentation

Asian Carp Population Modeling to Support an Adaptive Management Framework 2018 Plan

Deliverables:

- Recommend mortality benchmarks and fish passage deterrent locations with efficacy requirements.
- Conduct sensitivity analyses and develop a prioritized list of data and research needs based on results thereof.
- Incorporate updated demographic rates using the most current data available.
- Parameterize a statistical catch at length model to estimate vulnerability to fishing as a function of fish size, exploitation rates, and immigration into the upper Illinois River.
- Modify the discrete length-structure of the SEAcarP model; use integral projection models to define populations by a continuous variable instead of discrete length classes.

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

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

Location: Peoria and Starved Rock pools within the Illinois Waterway

Introduction:

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

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

Asian carp demographic information will also be collected throughout 2018 to further bolster the SEACarP. For further information on this work please refer to the USFWS Asian carp demographics monitoring and response plan. For more information on small Asian carp telemetry please refer to the USFWS distribution and movement of small Asian carp in the Illinois Waterway using telemetry monitoring and response plan.

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

Objectives:

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

(2) Refine movement across locks and dams.

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

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

Status:

This is a new project in 2018. However, in 2017 as part of the USFWS juvenile Asian carp monitoring project a total of 72 juvenile Silver Carp were tagged with acoustic transmitters and 12 of the 72 had both acoustic and radio transmitters implanted. To date telemetered fish have demonstrated movement and habitat specific residencies correlated to water flow velocity and temperature, though the sample size is still small. This project is continuing in 2018, however, radio tags will be used more extensively and the goal is to tag more total fish than in 2017.

Methods:

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

USFWS crews will also tag an additional 150 Asian carp in and around the Starved Rock Pool using Vemco V-16 tags. This large-scale tagging of adult and juvenile Asian carp will provide more information for the model to better estimate current levels of exploitation and to bolster estimates of large-scale pool-to-pool movement.

Asian carp will be captured using boat electrofishing and electrified dozer trawl from the Illinois River. Immediately after capture, fish will be held for no more than 1 hour in an aerated 60 gallon holding tank covered with ¼ inch mesh. In order to maintain as close to sterile conditions as possible, one crew member as the dedicated “surgeon” will wear gloves and only handle fish for the process of the incision, tag implantation, and suturing. Another crew member will be responsible for weighing and measuring the fish and recording data. All surgical tools, fish tags, and sutures will be soaked in 70% isopropyl alcohol between surgeries. Only active, healthy looking fish will be selected for surgery. Each fish will be measured for total length (mm) and weight (g), assigned a number, then placed into a foam board with a fish-shaped cut out for surgery. A surgical rubber hose connected to a slow siphon of fresh aerated river water will be placed in the mouth of fish to allow them to breathe during surgery. A wet microfiber towel will be placed over the head of the fish to keep them calm.

The surgery site will be gently washed with several drops of betadine prior to making an incision. Using a #12 hook blade scalpel, a 1 cm (Vemco -5 acoustic tags) or 2.5 cm (Vemco-16 acoustic tags) incision will be made in the left ventral side of the body, just behind the pelvic fins, anterior to the anus, taking care not to damage the intestines. Next, the tag will be inserted through the incision and gently pushed towards the anterior of the body cavity. At least two non-absorbable nylon Oasis Brand (Mettawa, Illinois) sutures will be used to close the incision site for acoustic tags. Immediately following suture closure, the incision site will be washed with betadine a second time and rinsed using deionized water. The fish will then be placed into an aerated, salted holding tank for recovery. Once fish equilibrium has been re-established and tags are tested, fish will be returned to the river in proximity to their capture location. Total holding time for fish will generally be less than 2 hours.

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

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

2018 Schedule:

May – June 2018: Gear preparation, planning field work, crew scheduling

July – November 2018: Fish tagging, range testing, active tracking, data download, gear maintenance and relocations

November – December 2018: Receiver removal, final data downloads

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

Deliverables:

Results from this project will be used to support the SEACarP model. Data will be analyzed and results summarized into a MWRG summary report/presentation for the winter of 2018-2019.

Asian Carp Demographics
2018 Plan

Participating Agencies: Leads: US Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office; USGS Columbia Environmental Research Center

Collaborators: US Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office Wilmington substation; Illinois Natural History Survey

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

Introduction and Need:

Field collections

Management of invasive Asian carp in the IWW calls for an adaptive management approach (Walters 1986). Data driven tools are integral parts of the adaptive management framework. They describe existing understanding using systems models that include key assumptions and predictions, which form the basis for further learning and decision making. Although the SEAcarP model represents one such tool, there remains great need to address data gaps identified by the modeling workgroup. In the Illinois River there are two sources of data: fisheries-independent data collected through a standardized protocol and fishery-dependent data collected from commercial or recreational sources targeting fish. To address data gaps associated with the SEAcarP model, the USFWS Columbia FWCO will collect fisheries-independent data including spawner biomass, recruitment, age, and growth data from portions of the upper IWW (i.e., Starved Rock and Marseilles pools) and from the lower IWW (Alton, LaGrange, and Peoria pools) for which there is a paucity of data. In addition, the USFWS Carterville FWCO will coordinate with IDNR commercial fisheries to collect fisheries-dependent data which will be used to estimate vulnerabity to harvest as a function of total length and provide a secondary source of information regarding immigration and exploitation levels.

Laboratory efforts and aging workshop

Development of data-driven tools for control of Asian carp requires the best possible accuracy and precision of ages of captured Asian carps, but Asian carp can be difficult fish to age and opinions vary as to the best methods. Cyprinids as a whole are notoriously more difficult to age than some other families of fish. Asian carp growth rate can vary tremendously, depending resources available. A two-year-old silver carp can weigh several kilograms or 250 grams. Asian carp can spawn any time that the water is the right temperature, therefore the first annulus can vary substantially in its location relative to the focus. Because Asian carp can be incremental spawners, with more than one spawning effort in the same year, multiple spawn "checks" can occur at nearly any time during the warm months. Some of the more favored aging structures are prone to development of large lumens that obscure multiple annuli. Published opinions on the value of otoliths for aging silver carp are varied, and a variety of hard structures have been used to age silver carp. Publications that incorporate aging of Asian carp have had few or no "known-age" validations of aging techniques used. Obviously, there is a need for concensus and development of a "gold standard" aging method for these important invasive fishes, as well as a better understanding of the accuracy of that method. We describe here an effort to develop that gold standard and to define that accuracy.

Objectives:

Field collections

(1) Quantify size and sex structure, length at maturity, and relative abundance during spring and fall in the lower five pools of the Illinois River.

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

(3) Transfer Asian carp captured in the field to USGS for laboratory processing (e.g. aging) and inclusion in the USGS-led age and growth workshop during August 2018.

(4) Work with IDNR contracted fishers during a two week intensive data collection effort during October 2018.

Laboratory efforts and aging workshop

(1) Recruit team of acknowledged experts in aging fish, including but not limited to persons experienced with Asian carps.

(2) Extract, prepare, and image a suite of aging structures from available known-age fish and fish collected from the Illinois River.

(3) Convene workshop and generate a consensus "gold standard" methodology for aging Asian carps.

(4) Using that standard method, generate age and growth information for Illinois River Silver Carp.

Status:

Gear evaluation studies conducted from 2014-2017 under the Gear Evaluation for Removal and Monitoring of Juvenile Asian Carp template provided fundamental understanding of how electrified frame trawls can be used to survey all aspects of the Silver Carp population in the Illinois River. Mass removal projects such as the Barrier Defense Asian Carp Removal Projects have provided fishery-dependent and exploitation data collected by contracted commericial fishermen in the upper Illinois River since the early 2000s.

Asian Carp Demographics
2018 Plan

Methods:

Field collections

The USFWS Columbia FWCO will collect fisheries-independent data including age, size, sex structure, length at maturity, and relative abundance during spring (May – June) and fall (September – November) in each of the lower five pools of the Illinois River using a random design stratified by habitat type (i.e., backwaters, island side channels, main-channel borders). River pools will be classified by the three habitat types using satellite imagery to create layers in a geographic information system (GIS). Prior to each sampling event, collection sites will be identified by randomly selecting cells from an indexed 50 m by 50 m GIS layer. Collection sites will be sampled by conducting 5 minute trawls at 4.8 kilometers per hour (calculated by GPS tracking) using either the electrified dozer or paupier trawls – previous findings indicate that relative size distributions of the catch do not differ between the two gear types and that catch rates can be readily converted from one gear to the other using linear relationships fit using existing data. Trawl runs will not be allowed to overlap. Electrified dozer trawl will be used primarily; however paupier gear may be deployed in low density conditions owing to its ability to sample larger volumes of water. An initial sample size of 50 (5-minute trawls) per pool was selected because catch rate data from Illinois River backwaters (2014-2017 Template: Gear Evaluation for Removal and Monitoring of Juvenile Asian Carp) revealed that the precision associated with this amount of effort was within acceptable levels (i.e., 25% relative standard error; Koch et al. 2014). Fish length and weight will be measured for all captured Bighead and Silver carp. Subsamples consisting of 10 small (≤300 mm total length) or five large (>300 mm total length) individuals per 50 mm length class will be retained for laboratory analysis (i.e., age, sex, maturity status) by USGS. All by-catch will be identified to species and enumerated.

The USFWS Carterville FWCO will work with IDNR contracted commercial fishers during a two-week intensive data collection effort in October of 2018. During this time staff will collect fisheries-dependent data including length, weight, and sex on all Asian carp captured and aging structures from a subset of fish. Data collected during this event will be used to 1) inform the population model on Asian carp demographics in the upper IWW and their vulnerability to harvest as a function of total length, and 2) provide data to incorporate into a statistical catch-at-length model that will provide a secondary source of information regarding immigration into upper pools and exploitation levels. Aging structures will be collected following a standard operating procedure and will be sent to Western Illinois University for processing.

All data will be transferred to the modeling workgroup for analyses associated with the SEAcarP model. Results from these analyses will be used to determine if a single season sampling design sufficiently meets data needs regarding indices of spawner abundance and recruitment. A minimum of two years of data are suggested under this protocol before a determination is made for long-term field data collection and data workflow.

Asian Carp Demographics
2018 Plan

Laboratoy efforts and aging workshop

USFWS will capture 400 Illinois River fish. These fish will come from different pools of the Illinois River and include all size classes of fish that are available from each pool, as needed to develop the demographic data required for population modeling for those pools. USGS and USFWS will extract the following structures from all 400 fish: scales, pectoral spines, vertebrae, postcleithra, lapilli, dorsal spine, and asterisci otoliths. From at least 100 fish, chosen to cover a variety of sizes and locations within the Illinois River, within the pool of provided fish, USGS will prepare and digitally image all structures listed above.

In August 2018, USGS will host an aging workshop in which the 100 aging structures with multiple structures, and the existing known-age structures, plus a few additional structures from outside the Illinois River (for comparison and prediction of portability of the preferred methods) will be compared from digital images and if necessary from direct observation of the prepared structures. Digital images will be provided to all participants, in a blind format including only the length of the fish, from which they were taken (in 10 cm increments so that length of fish is not a clue to match up aging structures), before the workshop. Individual estimates of ages should be performed and provided to workshop organizers one week prior to the workshop. Organizers will graph the results of each fish, and develop summary data, for comparison and for discussion at the workshop. Using prepared electronic images on screen in a meeting room, as well as on participant laptops, and if necessary using original parts on microscope broadcast on the screen, the workshop will arrive at an aging consensus of enough of the provided images to provide for consensus on methods. Using insights gathered during this process, the workshop will develop consensus best practices for aging fish for demographic work. Note that a single method may not be appropriate for all fish – for example, it might be necessary to use a different structure or an additional structures for fish above a certain size. In addition, separate recommendations might be provided for fish not necessarily used in demographic work but of extreme importance, such as fish captured on the upstream side of the Electric Dispersal Barrier.

Preparation, imaging, and aging of the remaining 300 fish provided by the USFWS from the Illinois River will begin in completion of the aging workshop. Analysis will be completed by January of 2019.

2018 Schedule:

Field collections (USFWS Columbia FWCO)

- February – April 2018: Gear preparation, logistics, planning, and scheduling
- May – June 2018: Spring field sampling and data entry
- July – August 2018: Data entry, preliminary data analysis and protocol evaluation
- September – Novemeber 2018: Fall field sampling and data entry
- December 2018 – January 2018: Data analysis, Annual report

Asian Carp Demographics
2018 Plan

Field collections (USFWS Carterville FWCO)

- October 2018: Field work

Laboratoy efforts and aging workshop

- May 2018: Collect fish and extract parts
- June – July 2018: Prepare and image parts, provide parts to workshop members
- Late August or September 2018: Hold workshop
- September – December 2018: Age remaining structures, provide USFWS with data for use in modeling.
- January 2019: Submit publication on consensus method(s) for aging silver carp.

Deliverables:

An annual report and presentation summarizing sampling results will be provided to the MRWG, agency partners, and any other interested parties. Project plans will be updated for annual revisions of the MRP.

Field collections:

The Asian carp demographics project will provide updated demographic data for parameterizaing the SEAcarP model and addresses data gaps identified by the modeling workgroup (i.e., stock-recruit data, growth of small fish from the lower pools, vulnerability, exploitation, immigration levels). In addition, this project will deliver aging structures for the USGS-led age and growth workshop, which is scheduled for August 2018. Lastly, this project will develop a standardized Asian carp sampling protocol that is directly tranferable to other large river systems such as the Missouri and Mississippi River systems.

Laboratory efforts and aging workshop

Publication on consensus method for aging Asian carp. Data will be provided to the SEAcarP model in the Illinois River.

References:

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

Asian Carp Enhanced Contract Removal Program

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

Introduction and Need:

This new program will reduce the abundance of Asian carp in the Illinois River Peoria Pool through controlled and contracted fishing efforts. This program will be implemented through the issuing of fishing contracts to those willing to target Asian carp in Peoria Pool and fulfilling contractual obligations of selling, reporting, transporting, and fishing in the identified area. This project will also provide critical information on population densities of Asian carp over time in the Peoria Pool as well as the Illinois River system to guide management efforts. This project will also identify and use mechanisms for use of the harvested fish through private industry for purposes including human consumption. Through a cooperative relationship of agency and fisher along with end users/markets, advice and support will be provided as necessary to further inform fishers on the delivery of quality and quantity of fish to the end user/markets through this interaction.

Objectives:

(1) Remove Asian carp from the lower Illinois River via controlled and contracted fishing efforts.

(2) Remove a target of 8 million pounds of Asian carp from the lower Illinois River by 2019.

(3) Remove a target of 15 million pounds of Asian carp from the lower Illinois River by 2022.

Status:

Field implementation of this project will begin during 2018. Past efforts have included identifying prospective end users, analyzing key market variables to understand supply and demand of Asian carp as a commodity, and determining optimal methods to encourage the expansion of the Asian carp market. Previous fishing experiments suggest changing density of Asian carp through harvest is achievable and most recently models developed by Illinois, Southern Illinois University, and supported by USFWS have suggested heightened removal efforts downstream of contracted removal (Upper IWW) can further exacerbate reduction efforts, further protecting the Great Lakes. During 2018 and future years, contracts will be supplied to fishing crews to put the knowledge gained via market analysis to work. While it has been acknowledged reducing abundance of Asian carp in the three lower IWW pools would be beneficial, initial contracts will target Peoria Pool, followed by LaGrange and Alton pools as fisher landings and data evaluation suggest.

Methods:

This project will use financial support to contract with willing fishing crews based upon landings and ability to sell the fish to existing or developing markets. The project recognizes that increased commercial demand for Asian carp will support a more robust fishery, which in turn will result in increased removal rates of Asian carp in the Illinois River. In an effort to focus a burgeoning Asian carp market, IDNR will provide funding to contracted fishing crews to remove Asian carp from the Peoria Pool of the Illinois River. IDNR will not restrict any commercial harvest, but does hope efforts will be encouraged from Peoria Pool whenever practicable. IDNR will also administer grant funding to evaluate and further support quality measures that add value to existing markets. IDNR will develop a contract that assures targeted measures are indeed met, fish come from the target pool where increased mortality/removal is desired to meet management goals and add value to model development and reduce upstream movement of Asian carp into the Upper IWW. Evaluation of efforts will include inspection and recording of landings, scientific evaluation of carp populations, and any necessary accounting to assure heightened knowledge of fishing success. Contracted fishers may be asked to account for fishing, catch, gear, locations in more detail that IDNR commercial fishing regulations require to meet management goals and evaluation needs. An overarching branding exercise has been identified as important to Asian carp markets and will also be sought under this effort. Lastly, support of the business analysis steering committee and facilitating communication between agencies, fishers, and inquiries will further add value to these efforts and enable business contribution to common goals of increasing mortality/harvest in IWW. Such a program can serve as a pilot to addtional areas with similar management needs. While the ultimate goal of having business demand over-harvest Asian carp to meet management agency goals, the short-term goals will provide additional management leverage to maintain or reduce further the upstream populations below the level detected in 2017, being 93% reduced from 2012 levels. Long-term goals will seek to further protect rivers and lakes from and prevent the spread of Asian carp. A targeted management goal of this program is to contribute to targeted commercial demand in Peoria Pool (lower Illinois River) resulting in the removal of 8 million pounds of Asian carp by 2019, and 15 million pounds of Asian carp by 2022. While efforts in 2018 will focus on removing Asian carp from Peoria Pool, the program will likely need to expand to encompass other pools in the lower Illinois River in future years. As evaluation of these efforts progresses, an equal inquiry to other business based solutions should be evaluated and instituted when practicable and achievable.

Asian Carp Enhanced Contract Removal Program

2018 Schedule:

Upon securing Asian carp Action Plan for 2018 IDNR with assistance of potential contractors will:

- Agree to contractual language that assures management goal are met and sign up fishers to take advantage of a targeted $0.10 per pound contract for fish removed from Peoria Pool by Fall 2018.
- By Fall of 2018, Provide program support to account for landings and payments of enhanced contracted removal program.
- By Fall of 2018, Identify common goals and support staff to align fishers and willing markets by scheduling logistics and communications to meet common goals, including a public meeting to describe program to fishers and assist with signing them up if desired.
- By Spring of 2019, a goal of 50% of contract funds to be expended, with a goal of an additional 2.5 million pounds removed from Peoria Pool alone, remaining being removed by Fall of 2019.
- By Spring of 2019, Removal and Model Development Workgroup should evaluate data and data needs for next year and any further implementation plans.

Deliverables:

A summary of the results of the Enhanced Contract Removal Program will be provided in the 2018 Asian Carp Interim Summary Report. Key metrics will include:

- The amount of funds dispersed via both fishing contracts and grant awards.
- The weight of Asian carp removed from Peoria Pool.
- Provide demographic information of Asian carp from the Peoria pool to populate the USFWS SEAcarP Model, which will continue to advise managers on downstream fishing locations.
- Identified overarching branding methods and initiatives that have been developed and implemented.
- Key achievements in developing logistical networks to facilitate the transportation of Asian carp from capture through final processing, including efforts to maintain quality in these additional landings.

Challenges:

IDNR and management agencies will not desire to dispose of these fish, and only those fish being sold at markets will qualify for the contract expenditure. It is understandable that markets and fishers may need time to modify makets and demands, thus challenging our aggressive removal goals. Success of contracts may be slowed by markets ability to buy and further process or use fish.

Alternative Pathway Surveillance in Illinois – Law Enforcement

Brandon Fehrenbacher & Heath Tepovich (Illinois Department of Natural Resources)

Participating Agencies: Illinois Department of Natural Resources (lead)

Location: Surveillance and enforcement operations will be conducted in any areas of interest or concern throughout Illinois.

Introduction and Need:

When the IDNR Invasive Species Unit (ISU) was formed in 2012, it had limited experience dealing with the complex issues of aquatic invasive species (AIS). The experience and knowledge of the two-officer unit within the AIS field has grown exponentially since its inception. The ISU focuses on detecting and preventing intentional or unintentional activities within the human pathways that could spread aquatic invasive species. Illegal activities from mankind create substantial risks for spreading AIS, and it is imperative that we actively minimize those risks through proactive enforcement. Past enforcement efforts exposed numerous people and companies that prioritized financial profits and/or personal gratification over obeying environmental laws. Previous violators can change their behaviors, but new groups of offenders emerge each year. The ISU can investigate any AIS issues that arises and will respond to all requests for assistance.

Objectives:

Advance the abilities of the ISU to detect, dissuade, prevent and/or apprehend those involved with activities that could spread aquatic invasive species we propose to:

(1) Educate and train Conservation Police Officers in the field of aquatic invasive species enforcement

(2) Implement a strategy to inspect large shipments of live species being imported into Illinois through the Chicago O'Hare airport

(3) Conduct an advanced search for injurious species within the pet/aquarium trade

(4) Seek out training relevant to ISU enforcement priorities

(5) Conduct surveillance operations

(6) Widen the scope of commercial inspections within the aquatic life industry

(7) Actively participate in pertinent conferences and meetings associated with aquatic invasive species issues

(8) Utilize the GLDIATR web monitoring tool to monitor the Internet trade of AIS

Alternative Pathway Surveillance in Illinois – Law Enforcement

Status:
This project is on-going and has been extended into 2018. ISU has active investigations pending and is currently searching for emerging threats within the AIS field.

Methods:

Intelligence gathering and Surveillance

Being sensitive in nature, specific law enforcement details may be omitted from this document. The ISU utilized Internet searches; information provided by other agencies, the public and those within the aquatic life industry; surveillance; on-site observations; record reviews; 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.

2018 – 2019 ISU Work Activities:

Investigations into illegal activities associated with any aquatic invasive species will be conducted as they are encountered. ISU 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 contingency planning efforts prior to 2017, as well as the scope of potential tools to be utilized in such an event. This plan also considers barrier operations and status and is complementary and additive to the existing “Barrier Maintenance Fish Suppression” 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, as well as any tributaries connected to that pool. The body of water upstream of a lock and dam is given the name of that lock and dam. For instance, the Brandon Road Pool is the body of water upstream of the Brandon Road Lock and Dam. The distances (miles) from the upstream structure of a given pool to the electric dispersal barrier are as follows: Lockport- N/A, Brandon Road- 5.5, Dresden Island-10.5, Marseilles- 26, and Starved Rock-49.5.

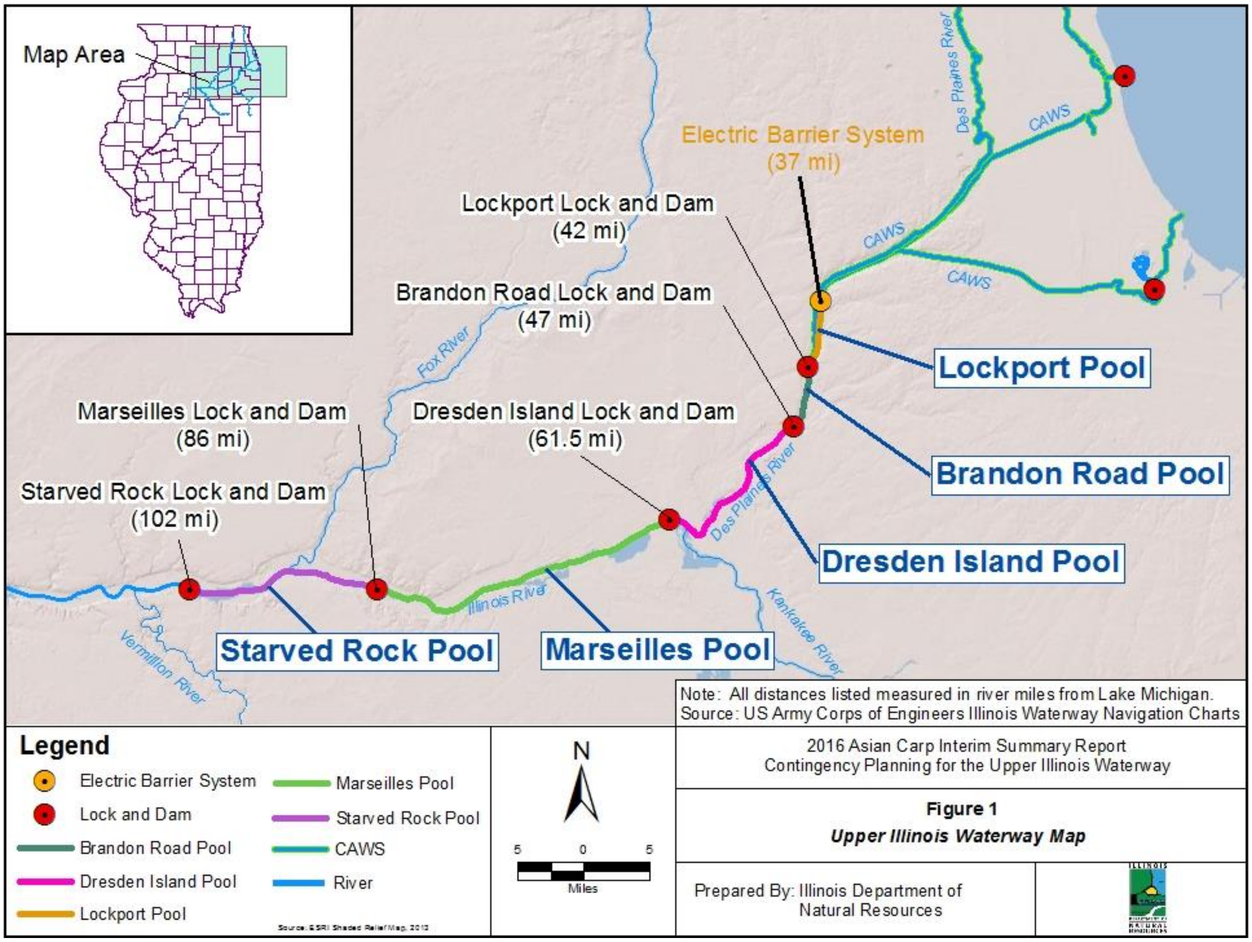


Figure 1. *Illinois Waterway Map and Profile. Note: For the purposes of this map, the Lockport Pool is only highlighted up to the electric barrier system.*

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 was placed into operation in spring 2016, building upon complementing existing response plans, and has been updated annually based on new scientific information and available technical capacity for Asian carp control.

Data collected since 2011 have 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.

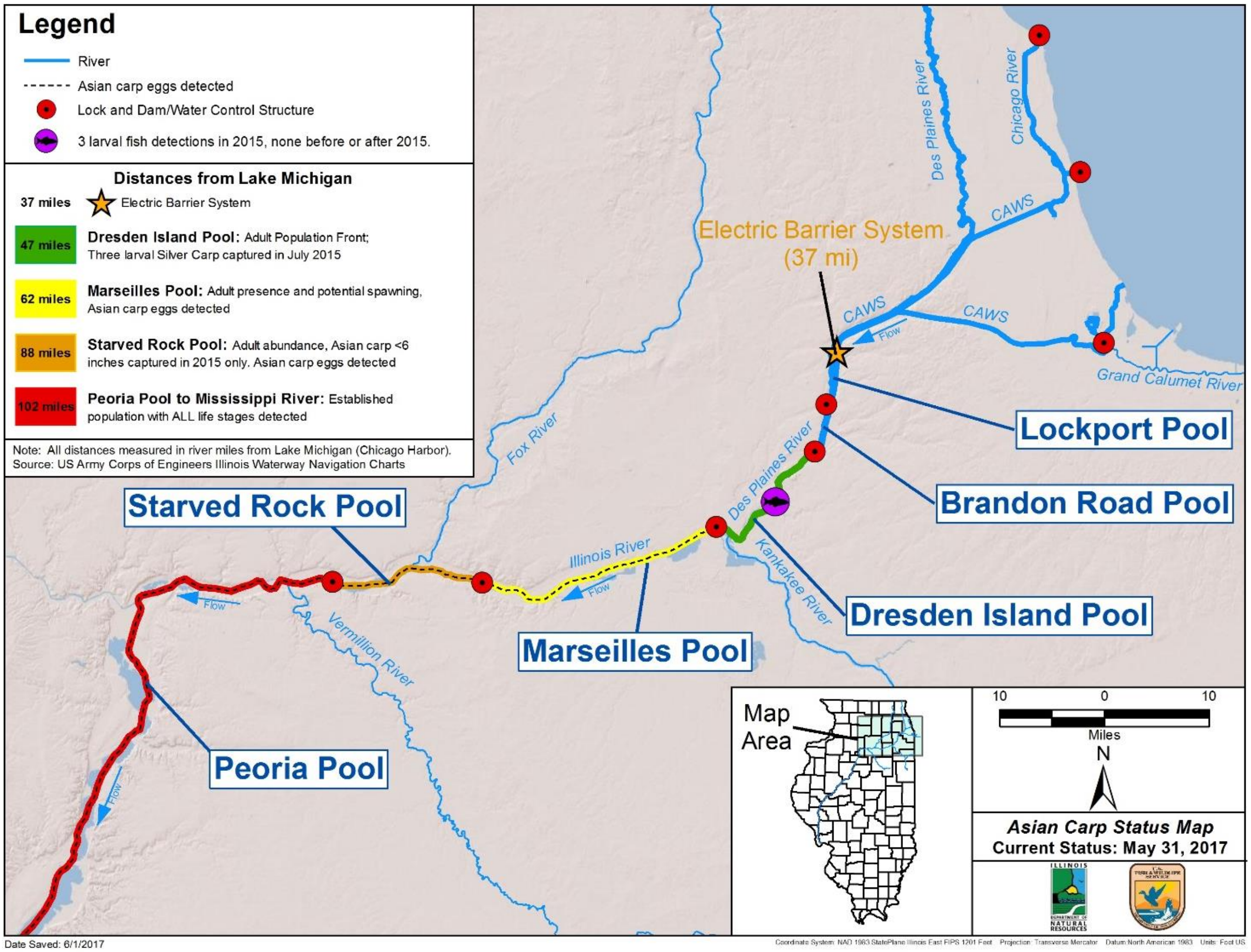


Figure 2. *Asian Carp Status Map. Current Status: May 31, 2017.*

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 response, the number of coordinating entities could increase along with the need for additional response operations. This expansion will trigger additional command, control, and coordination elements. The overall incident complexity and Incident Command System (ICS) span of control principles should guide the incident management organization.

Methods:
Subject matter experts from participating agencies discussed the importance of many factors within the IWW and the Asian carp populations that could potentially change and result in an increased invasion potential of the Great Lakes. The subject matter experts independently evaluated the extent of change each scenario warranted and then the group met jointly to discuss and develop a consistent opinion about the degree of change. Individuals then made independent assessments as to what level of response they would choose under the varying conditions within the decision support trees. These responses were then discussed and agreed upon by the group, which resulted in the contingency table described in Section 3.5.

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

Pool:
Navigation pool was determined to be the best and most appropriate scale for the location of Asian carp in a population (relation to distance from the 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 (see Barrier Maintenance Fish Suppression plan).

Additional Considerations for Actions and Decision Making Process:
This process will include a recommended set of response actions for decision makers to consider when a change to the baseline condition is identified. Changes may include, but are not limited to, changes in fish population abundance, life stage presence, or new geographical positions in upstream and/or downstream pools, the ongoing rate of change in Asian carp population characteristics, season and/or water temperature, the habitat where fish are sighted or collected, flow conditions, the amount of available data, and whether multiple lines of evidence exist to support changing conditions. The validity of evidence that a response trigger has been met will also be taken into consideration. Evidence of Asian carp presence to new locations within the IWW may come from physical captures, confirmed sightings by trained biologists, or via detections of telemetered specimens on active or passive receivers. 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.

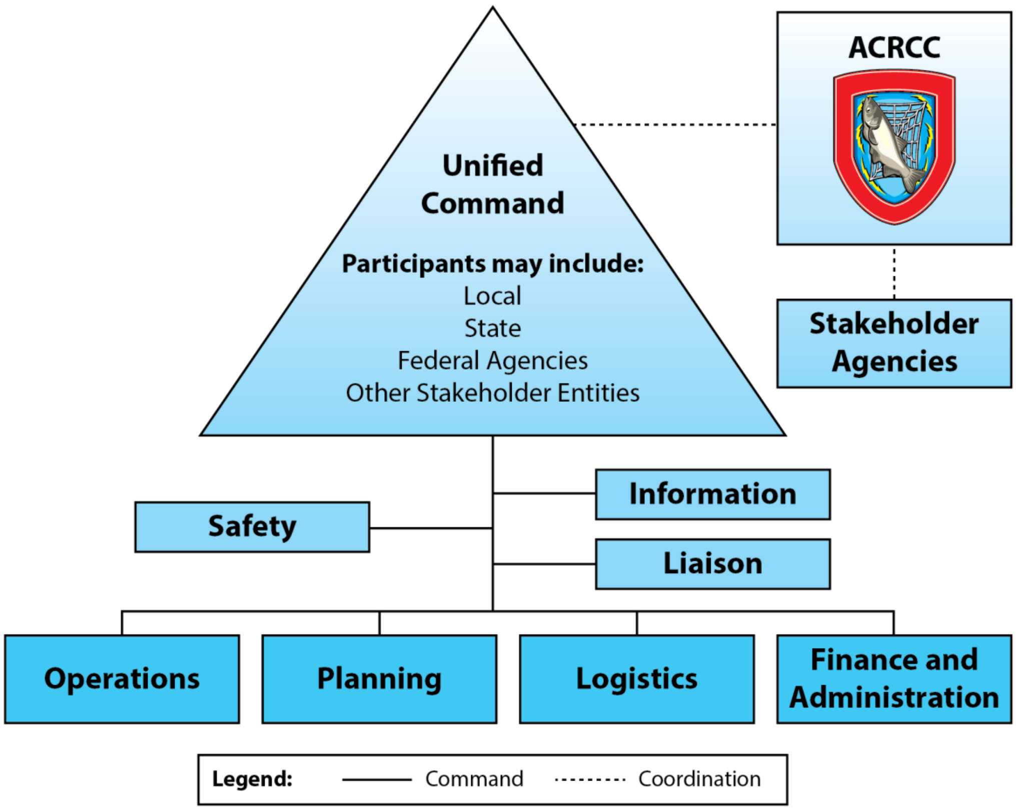


Figure 3. *Unified Command Organization Structure*

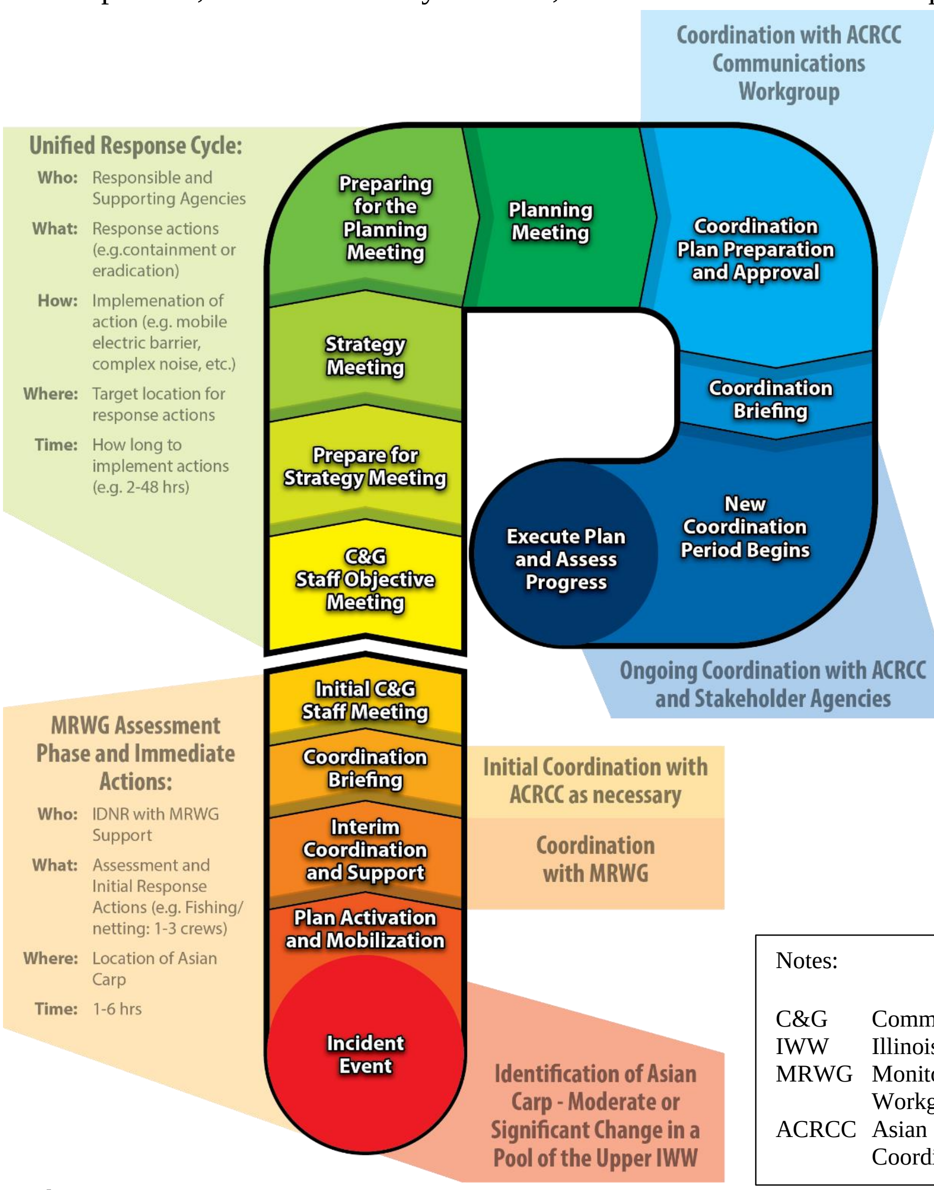
Incident Action Planning:

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

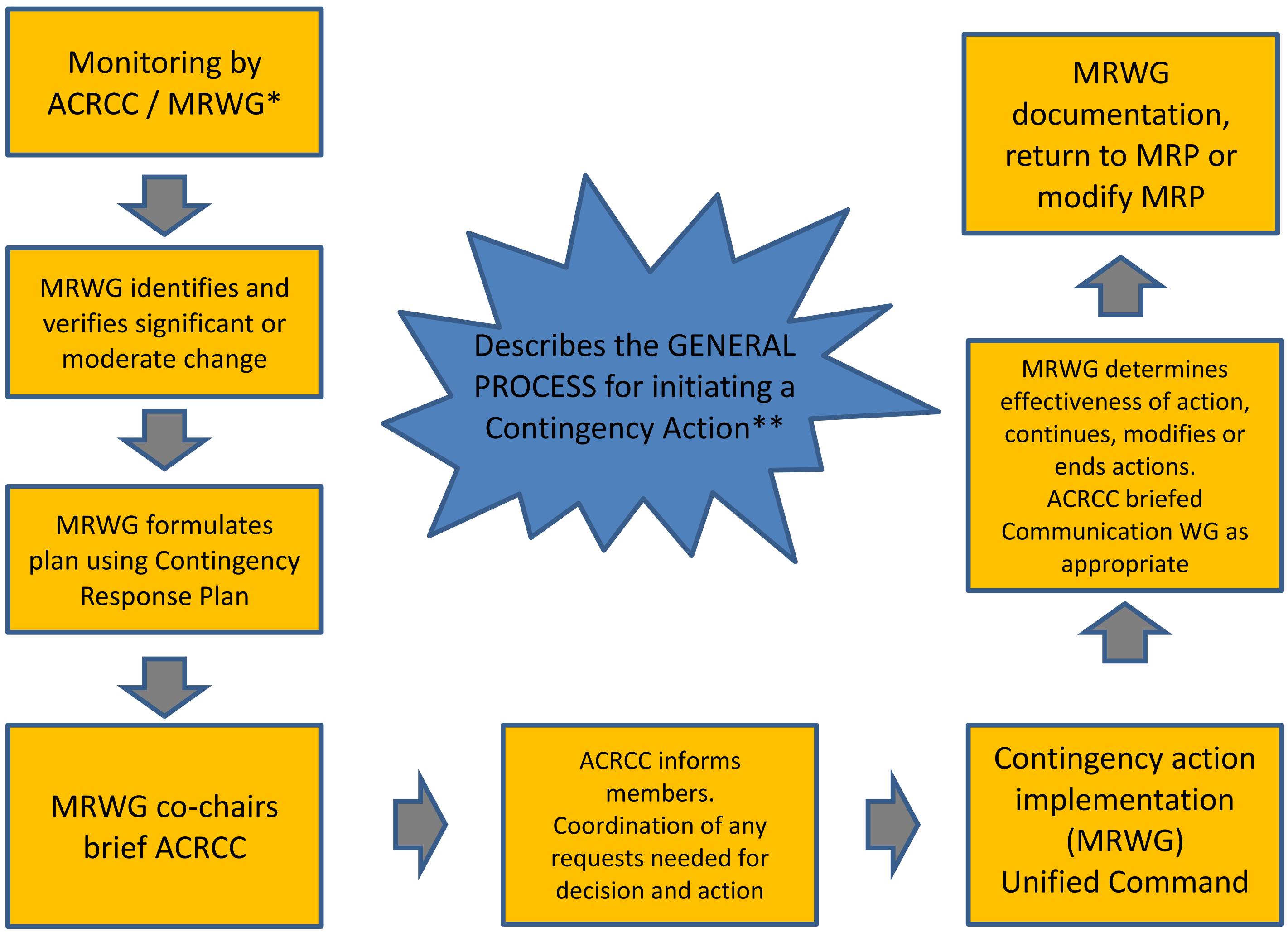
Figure 4. *ICS Planning "P"*

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, observed, or detected (verified physical observations by agency personnel or confirmed telemetry based detections), and 3) identifying whether the sampling result is Rare, Common, or Abundant relative to 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*

	Distance from Lake Michigan (miles)		Eggs/Larvae			Small Fish			Large Fish		
			Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of flow	0 - 37	**Chicago Area Waterway System (CAWS)**							1		
	37 - 42	**Lockport Pool to Electric Barrier System**							2		
	42 - 47	**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 6. *Upper IWW Asian Carp Response Decision Matrix*

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

Level of Urgency (Action Response Level)	Potential Actions[2]	Applicable Locations	Responsible Agencies	Estimated Time to Implement	Regulatory or Other Requirements	Relative Cost ($-$$$$)
Significant Change	Increased Sampling Efforts[3]	All	IDNR/USFWS	1-7 days	Sampling permits	($$)
	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*

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

Direction of flow

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

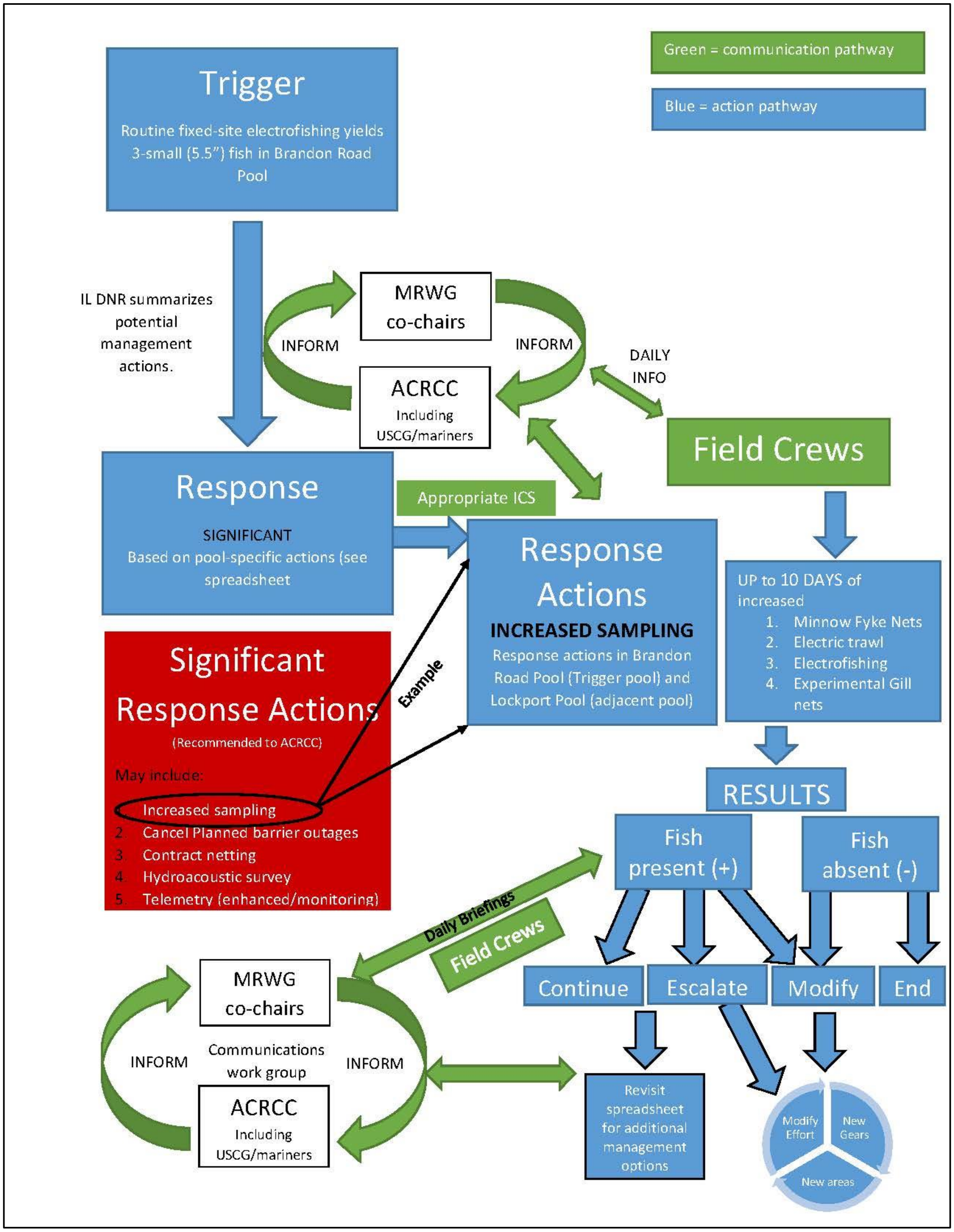
2 This status is based onpon the collection of a single Bighead carp during piscicide treatment in 2009

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

Appendix A
Integration of New Science and Technology

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Jim Duncker (U.S. Geological Survey, Illinois Water Science Center)

Participating Agencies: USGS**,** IDNR, USACE, USFWS, Southern Illinois University, Western Illinois University and other partners

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 Barriers 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 Barriers. Targeted removal combined with documented low recruitment within the IMZ results in reduced Asian carp densities because the primary source is thought to be through migration of Asian carp 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 them challenging the Electric Dispersal Barriers 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 Barriers 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 EB, 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 their abundances in that stretch of river in the short term and may act in a cummulative fashion to reduce propegule pressure at the Electric Dispersal 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 USFWS, USACE, IDNR, and others will implement and evaluate technologies for monitoring, surveillance, risk assessment, control and containment to maximize the efficacy of targeted removal and minimize further movement of Asian carp into the Upper Illinois River to protect the Great Lakes.

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

- CO_2 as deterrents at dams and other strategic locations
    - In 2018, the USGS and partners from USACE, USCG, USFWS, UW-Platteville, UIUC and IA DNR will demonstrate an operational CO_2 fish deterrent system in

the auxiliary lock at Lock and Dam 14 on the Upper Mississippi River near Bettendorf, IA. Data will be collected on water quality, air quality, fish behavior and various system operating parameters during simulated lock operating conditions to help determine the feasibility of CO_2 as an Asian carp control tool.

  - Develop CO_2 water quality model to assist with barrier performance analysis and receiving water body impacts. The model will quantify operational aspects of CO_2 barriers related to efficacy, safety and economics.
  - Outcomes from the engineering, architectural designs, and construction process are expected to result in conceptual procedures for implementing large-scale CO_2 injection systems at navigational locks under varying navigation scenarios.
  - Studies to address USFWS Section 7 ESA consultation data requirements of a CO_2 fish deterrent system will be completed and needed state/federal permits will be obtained. The effects of CO_2 infusion on non-target species will be evaluated.
  - Four reports are expected to be published characterizing (1) the effects of water temperature on Asian carp behavior in response to elevated CO_2; (2) the effects of CO_2 gradients in outdoor ponds; (3) toxicity of CO_2 to Asian carp; and (4) describing CO_2 injection devices and piping designs for navigational locks.

- Microparticle application
  - Publish results from laboratory, pond and two 2017 microparticle field trials, and conduct a webinar on the development and status of the microparticles and other species-specific control tools.
  - Conduct multiple field trials with toxic particles at a location with Bighead Carp to verify specificity of microparticles to them.
  - Conduct laboratory and pond trials to assess efficacy of a Grass Carp-specific bait.
  - Determine the effective range of the algal attractant and assess the use of bait to develop a protocol that maximizes the efficiency of microparticle delivery.
  - Registration activities will continue with EPA and USFWS to meet requirements for microparticle use.
- 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.

- Algal attractants to aid in removal efforts
  - Continue to conduct field trials and reconnaissance to assess the usefulness of algal attractants to enhance monitoring, and containment and control tactics.
- eDNA/molecular technologies
  - Technology will be transferred for the use of High Throughput Sequencing protocols to USFWS or other management agencies in analyzing individual or composite water samples to correlate with species composition/abundance.
  - Initiate eDNA analysis of habitat usage and effectiveness of a Unified Method fishing effort at Creve Coeur Lake, Missouri; and to evaluate effectiveness of a microparticle field trial.
  - Initiate mesocosm studies of degradation of eDNA naturally shed from Bighead Carp of known biomass.
  - Continue development of LAMP assays for Grass Carp and Black Carp.
- Grass Carp monitoring and response
  - Develop permanent monitoring/index stations for Grass Carp eggs in Sandusky and Maumee rivers and continue to monitor spawning events, refine egg sampling methods.
  - Use genetic analyses to estimate size of spawning population of Grass Carp in the Sandusky River.
  - Complete report on the mapping of aquatic vegetation in Lake Erie for Grass Carp risk assessment.
  - Update projections of potentially suitable Great Lakes tributaries for spawning of Grass Carp.
- Black Carp monitoring and control
  - Black Carp will be spawned and a developmental series on life history will be published, and conduct related biological studies.
  - Continue to work with collaborators on commercially-captured Black Carp, to provide aging and diet information from captured fish, and determine age at maturation and time of year that fish are spawning.
  - Perform trials of toxic bait, assess fish behavior, and determine minimum dosage.
  - Telemetry will be used to track Black Carp.

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

- Concluding life history studies on predation, light trapping, and triploidy including completing analysis and papers on predation of young of year Asian carp by native predators, larval carp dispersal studies, predation of Asian carp and Gizzard Shad, and testing ploidy and whether triploid bighead carp produce gametes.

- Collect, prepare and analyze larval Asian carp at different stages to determine structural development, likely utilizing scanning electron microscopes.
- Conduct preliminary investigations of Asian carp behavioral responses to sound and temperature (audiotaxis and thermotaxis) and continue studies Asian carp behavior in hydraulic flumes.
- Conduct a study to determine (1) the feasibility of using fin ray strontium:calcium (Sr:Ca) ratios to assess fish movement between areas in the Illinois, Kankakee, and Des Plaines rivers and (2) preliminarily assess whether fish are passing upstream from the Illinois and/or Kankakee rivers through Brandon Road Lock and Dam into the Des Plaines River.

2018 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
Matt O'Hara, IDNR
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Brandon Fehrenbacher, IDNR
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Jeremiah Davis, USFWS
Jim Bredin, IWF
Jim Duncker, USGS
Jim Garvey, SIU
John Dettmers, GLFC
John Goss, IWF
John Tix, U of I
Jon Amberg, USGS

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

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

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

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

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

BEST MANAGEMENT PRACTICES

BEFORE TRAVELING TO A SAMPLING LOCATION:

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

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

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

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

WHILE ON A WATERBODY:

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

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

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

AFTER FIELD WORK ON WATERBODY IS COMPLETE:

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

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

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

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

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

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

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

- ***KEEP RECORDS.***

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

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

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

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

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

ATTACHMENT A
DECONTAMINATION METHODS AND GEAR-SPECIFIC TIPS

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

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

Decontamination Methods

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

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

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

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

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

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

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

equipment being treated should be sprayed.[E]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7. *Freezing*

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

Gear-Specific Tips for Decontamination

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

Nets

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

Personal Gear and Clothing

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

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

Dip nets, measuring boards, and other gear

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

Boats, trailers, and live wells

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

Motors

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

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

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

Key:

☑ = Effective

⊗ = Not Effective

Ⓡ = Additional Research Needed

? = Literature Review Needed

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

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

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

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

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

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

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

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

References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Recommends 10% bleach/water solution.

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

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

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

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

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

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

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

    Direct quotes:

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

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

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

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

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

    Direct Quote:

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

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

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

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

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

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

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

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

    Direct Quote:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Two weeks needed for mortality.

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

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

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

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

>38°C (100°F) for 12 hours.

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

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

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

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

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

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

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

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

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

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

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

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

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

EWM seeds are viable to excessive periods of desiccation.

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

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

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

EWM seeds likely experience increased viability after freezing.

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

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

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

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

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

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

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

N. peltata seeds show high tolerance to desiccation.

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

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

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

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

>50°C (122°F) for 15 seconds

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

Dry in full sunlight for >50 hours.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

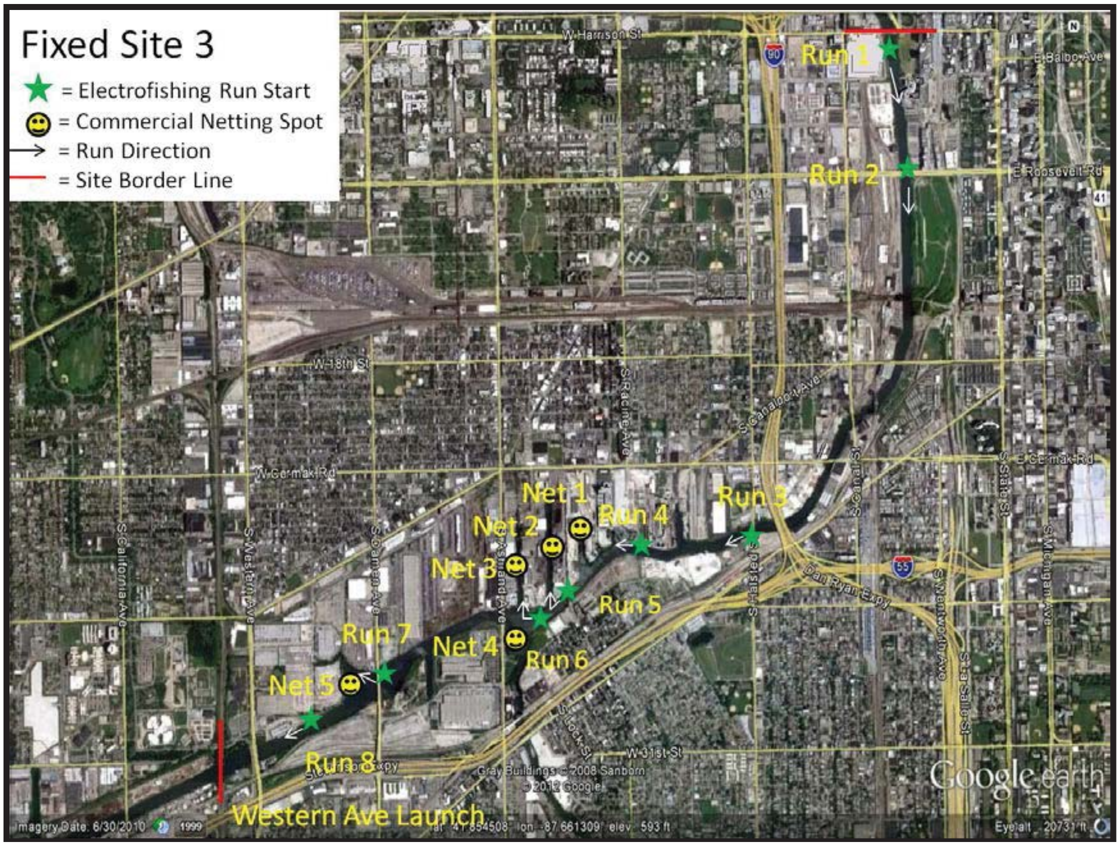
76. Acy, C.N. 2015. Tolerance of the invasive New Zealand mud snail to various decontamination procedures. Thesis submitted in candidacy for Honors at Lawrence University.

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

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

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

Appendix D. Detailed Maps of Fixed and Random Site Sampling Locations.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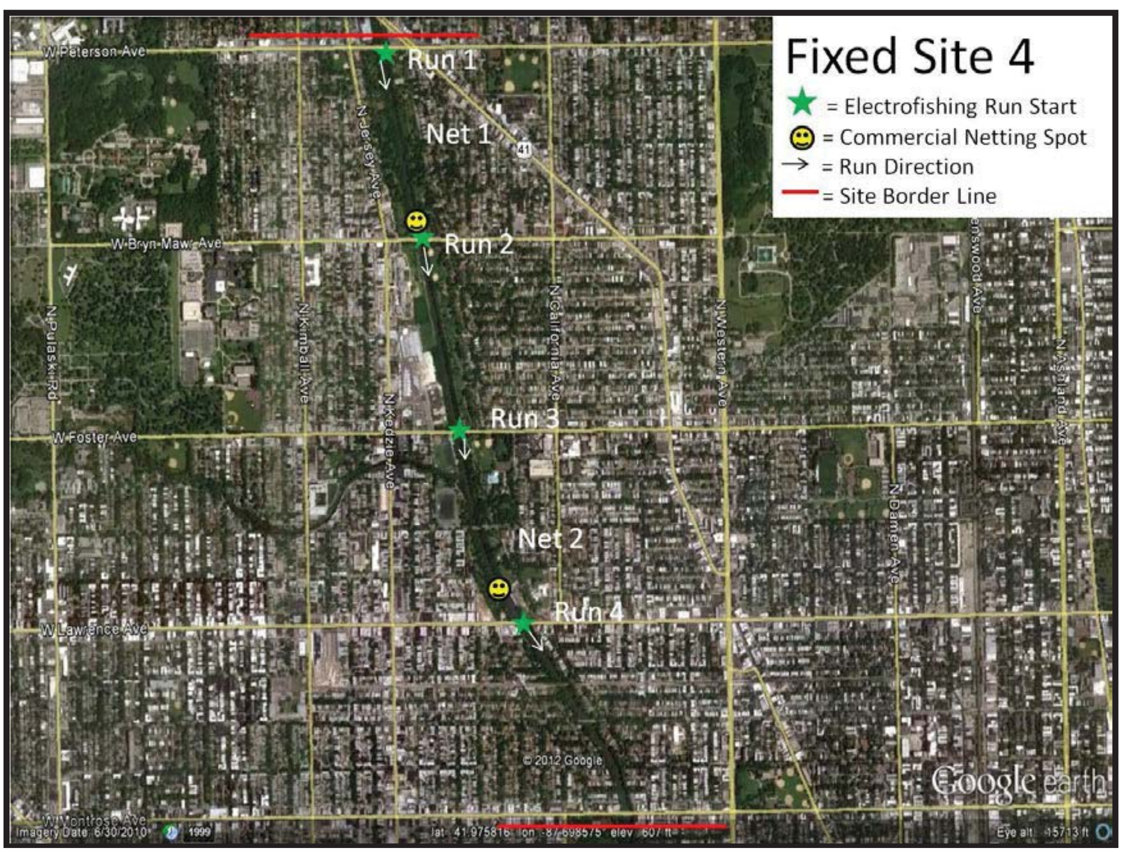
= Commercial Netting Spot
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Run 5
Run 6
Run 7
Run 8
Net 1
Net 2
Net 3
Net 4
Net 5
Western Ave Launch
W Harrison St
E Balbo Ave
E Roosevelt Rd
W 18th St
W Cermak Rd
S Western Ave
S California Ave
S Racine Ave
Dan Ryan Expy
Google earth


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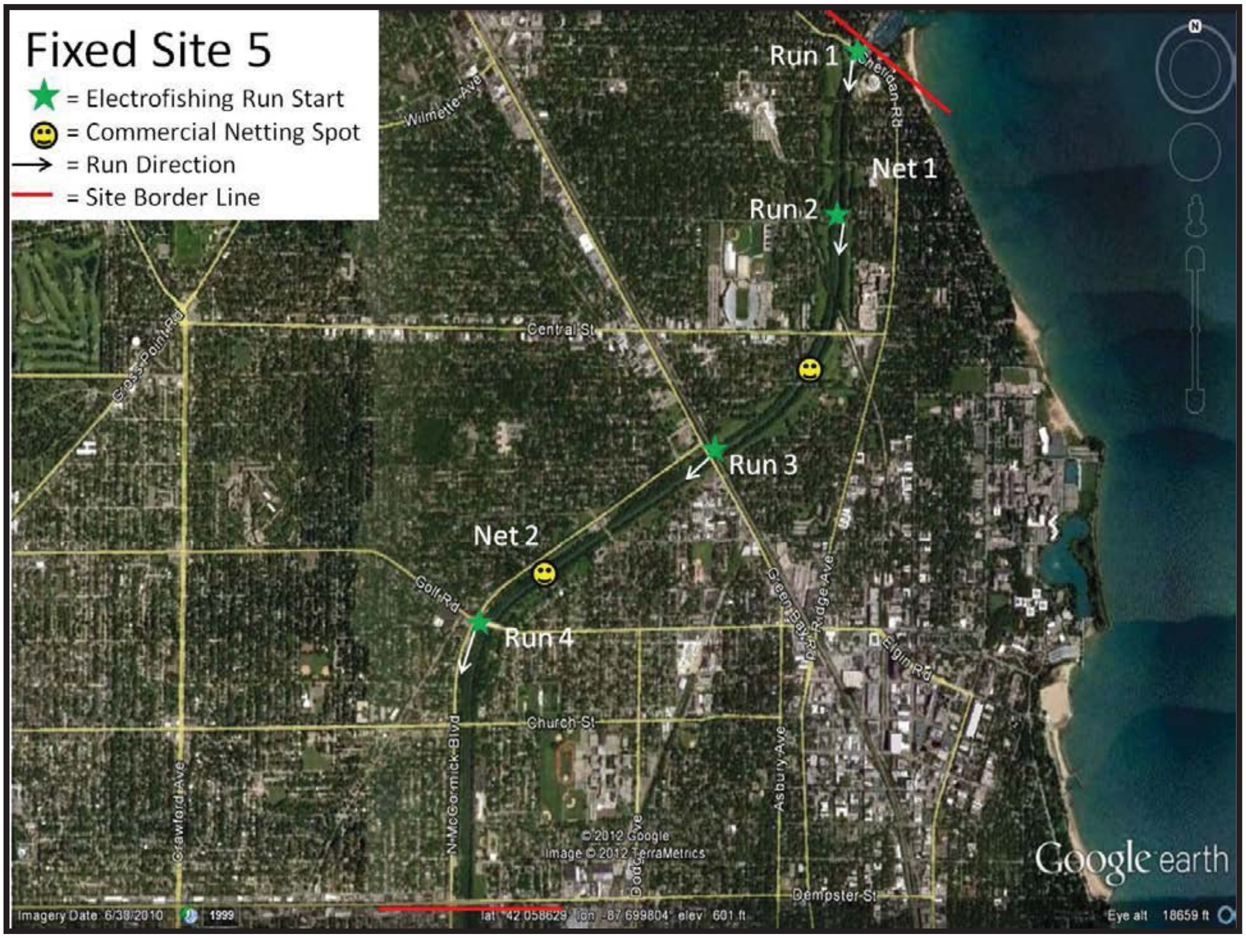
W Bryn Mawr Ave
W Foster Ave
W Lawrence Ave
W Montrose Ave
N Pulaski Rd
N Kimball Ave
N Kedzie Ave
N California Ave
N Western Ave
N Damen Ave
N Ashland Ave
© 2012 Google
Google earth


Fixed Site 5
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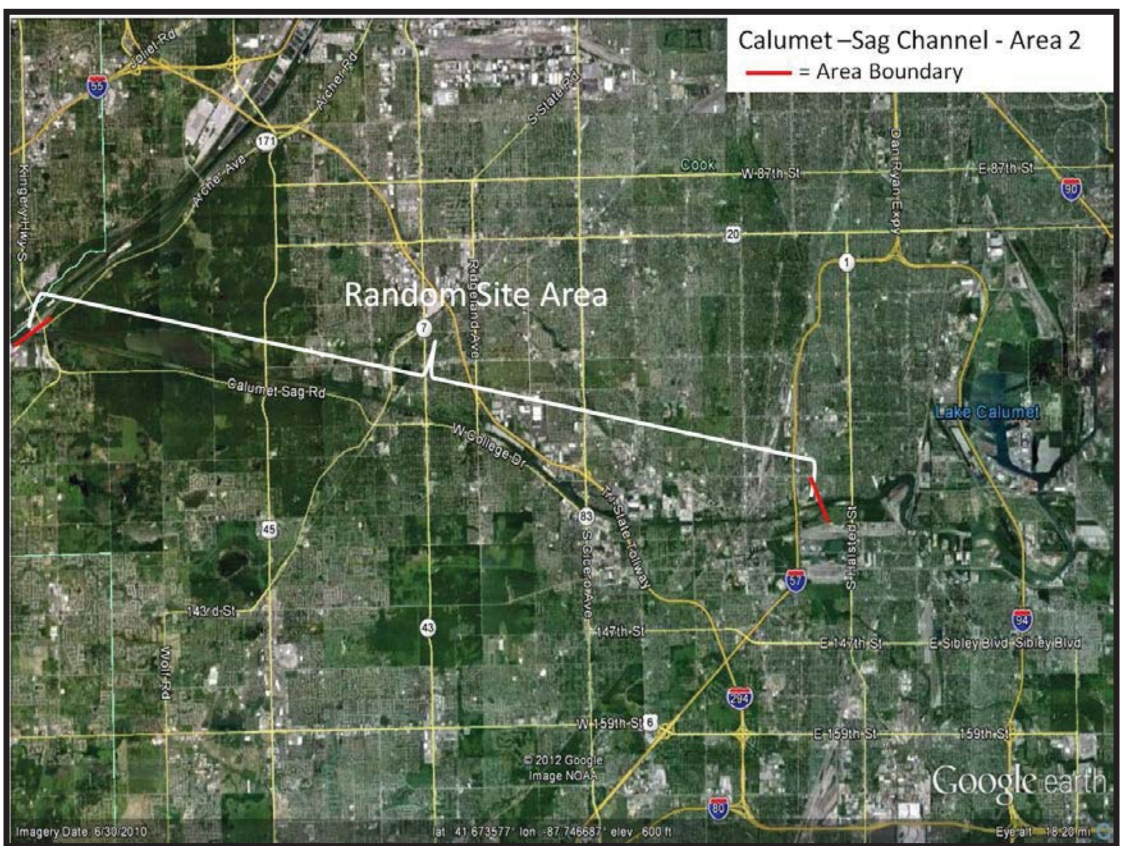
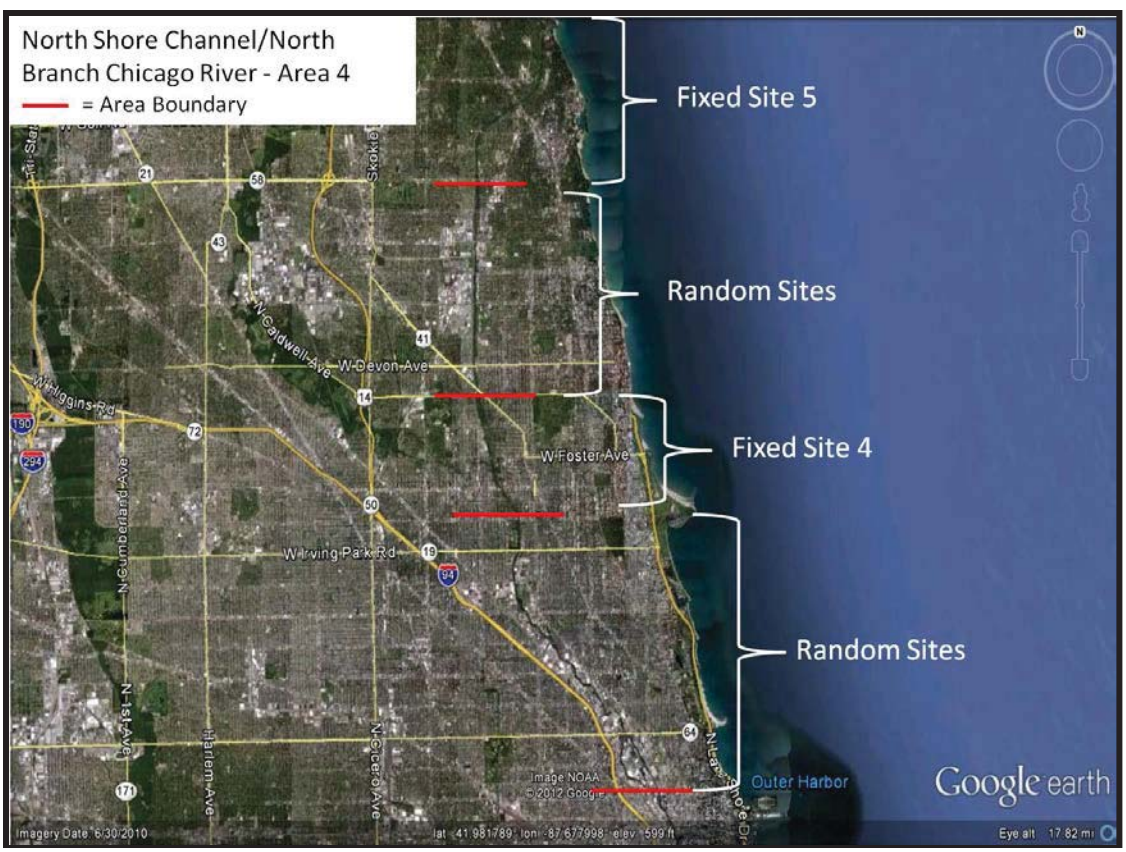
= Run Direction
= Site Border Line
Run 1
Run 2
Run 3
Run 4
Net 1
Net 2
Wilmette Ave
Sheridan Rd
Central St
Gross Point Rd
Golf Rd
Church St
N McCormick Blvd
Crawford Ave
Asbury Ave
Dodge Ave
Dempster St
Elgin Rd
© 2012 Google
Image © 2012 TerraMetrics
Google earth
Imagery Date: 6/30/2010
Eye alt 18659 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
E 87th St
© 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
Archer Rd
Joliet Rd
S State Rd
Ridgeland 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
S Cicero Ave
Tri-State Tollway
S Halsted St
Cook
© 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
W 135th St
E Romeoville Rd
Run 1
Run 2
Net 1
S Independence Blvd
Archer Ave
W 151st St
© 2012 Google
Google earth
Imagery Date 6/30/2010
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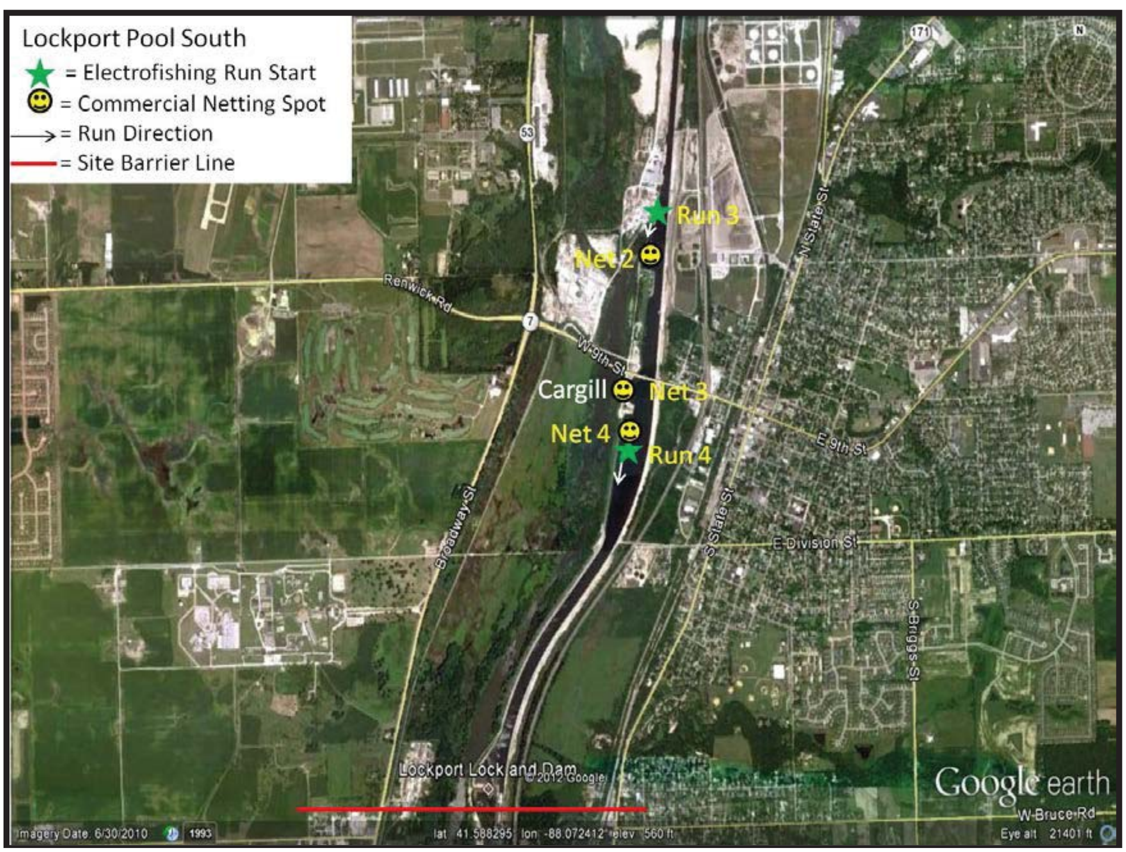
Eye alt 18091 ft


Lockport Pool South
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= Run Direction
= Site Barrier Line
Run 3
Net 2
Renwick Rd
W 9th St
Cargill
Net 3
Net 4
Run 4
E 9th St
N State St
S State St
E Division St
Broadway St
S Briggs St
Lockport Lock and Dam
© 2012 Google
Google earth
W Bruce Rd
Imagery Date 6/30/2010
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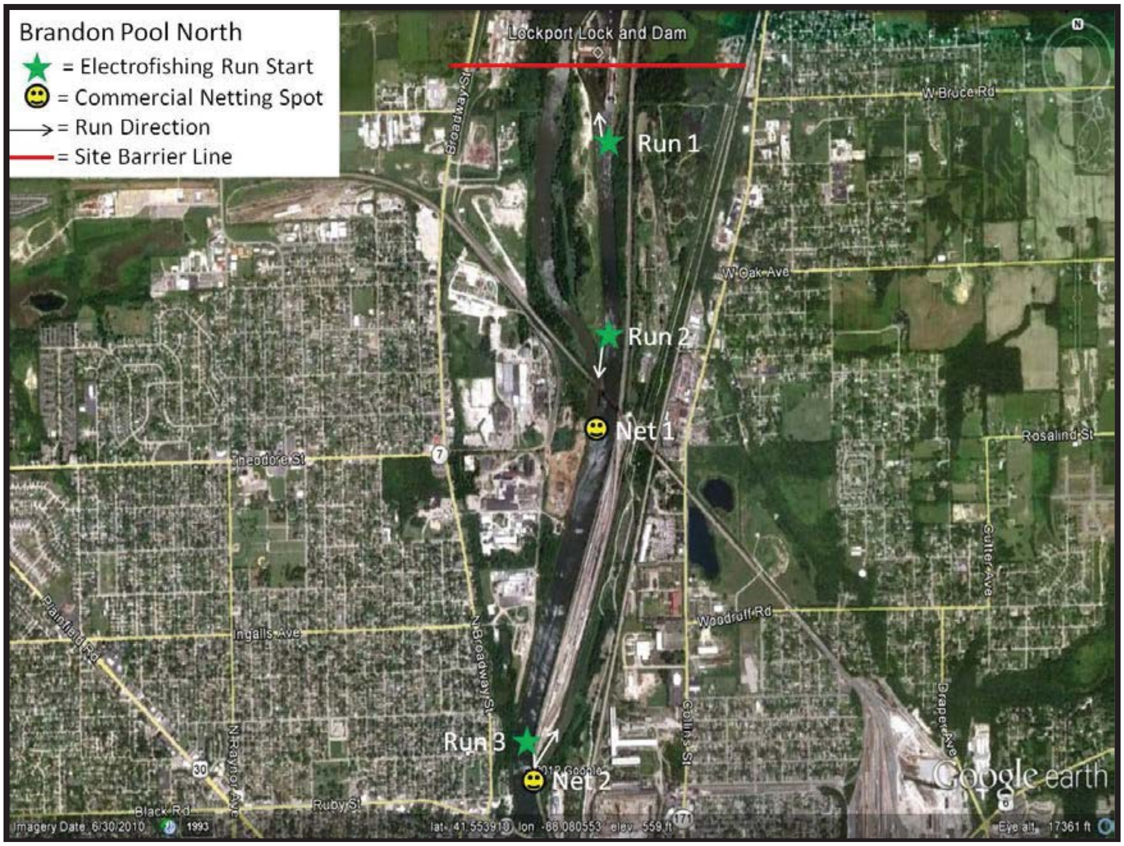
Eye alt 21401 ft


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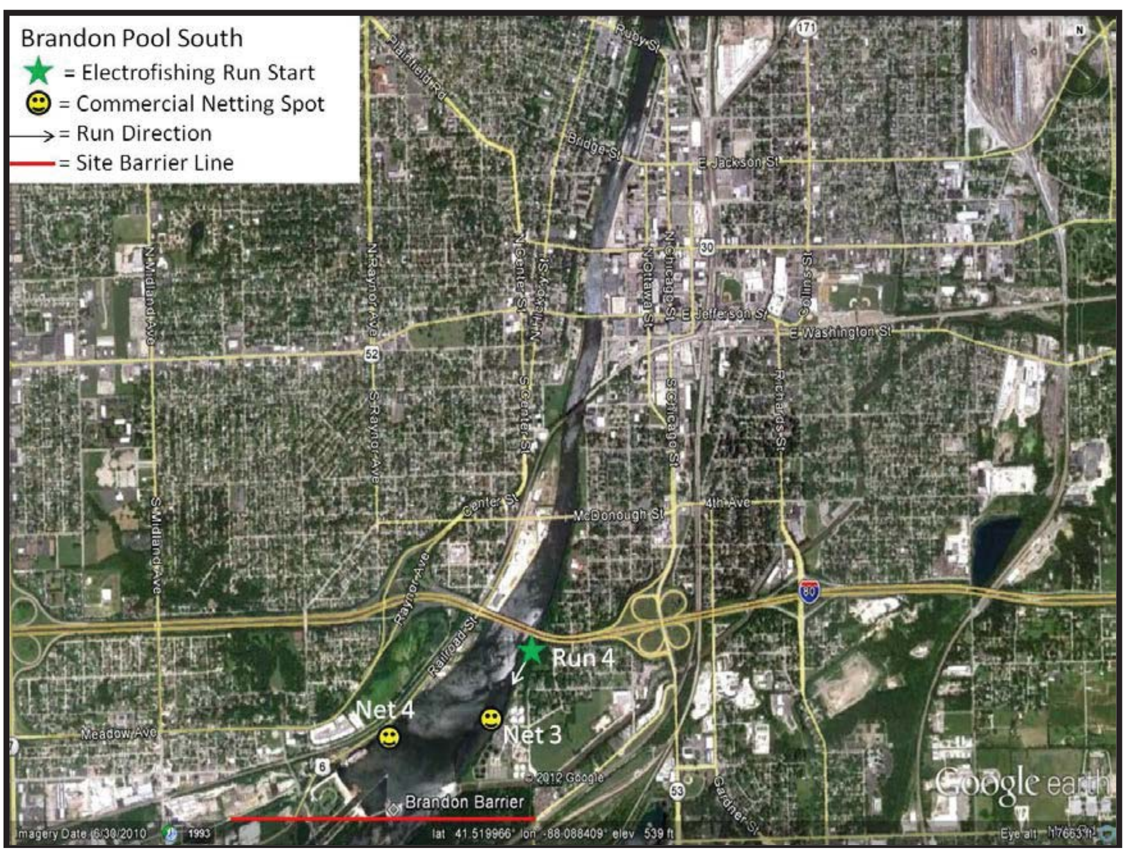
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Lockport Lock and Dam
Run 1
Run 2
Net 1
Run 3
Net 2
W Bruce Rd
W Oak Ave
Rosalind St
Theodore St
Ingalls Ave
Woodruff Rd
Broadway St
N Broadway St
Plainfield Rd
N Raynor Ave
Collins St
Draper Ave
Gutter Ave
Black Rd
Ruby St


Brandon Pool South
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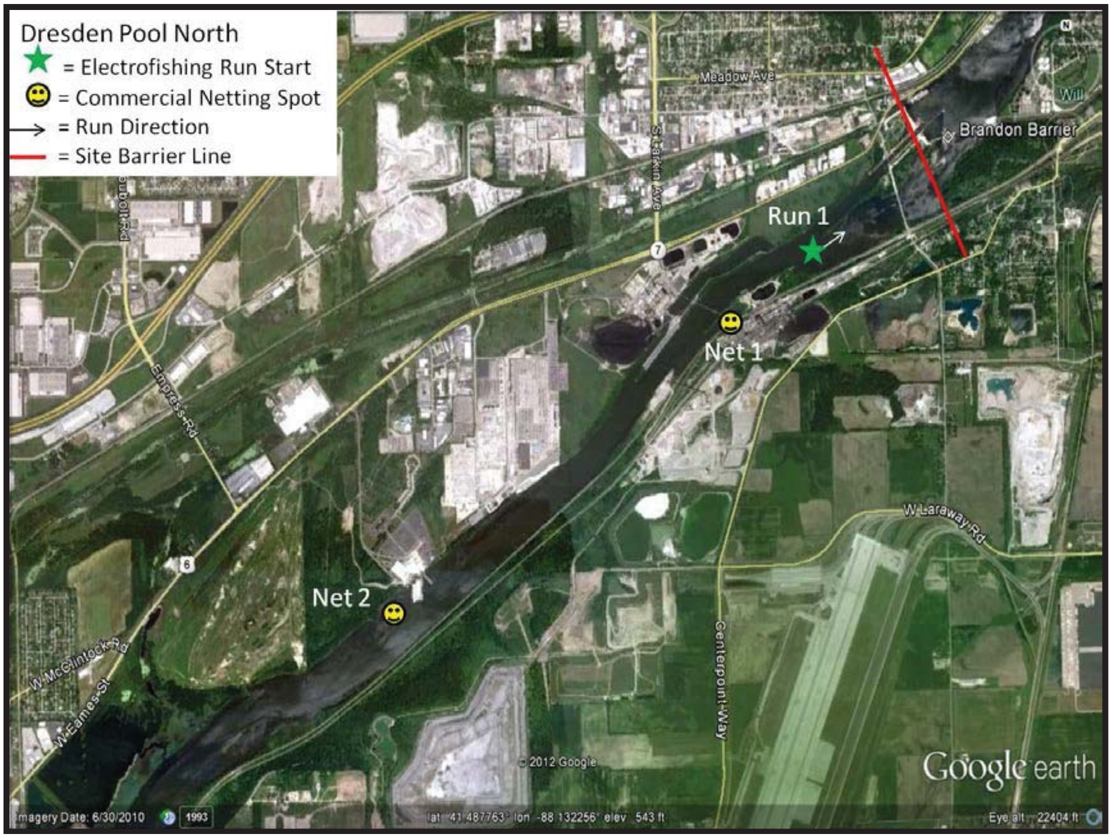
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 4
Net 4
Net 3
Brandon Barrier
Ruby St
Plainfield Rd
Bridge St
E Jackson St
N Midland Ave
N Raynor Ave
S Raynor Ave
S Midland Ave
E Jefferson St
E Washington St
McDonough St
4th Ave
Meadow Ave
Railroad St
Raynor Ave
Center St
Richards St
Gardner St


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


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


Marseilles Pool North
= Electrofishing Run Start
= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Run 2
Run 1
Dellos Rd
Negro Slough
Net 1
Image U.S. Geological Survey
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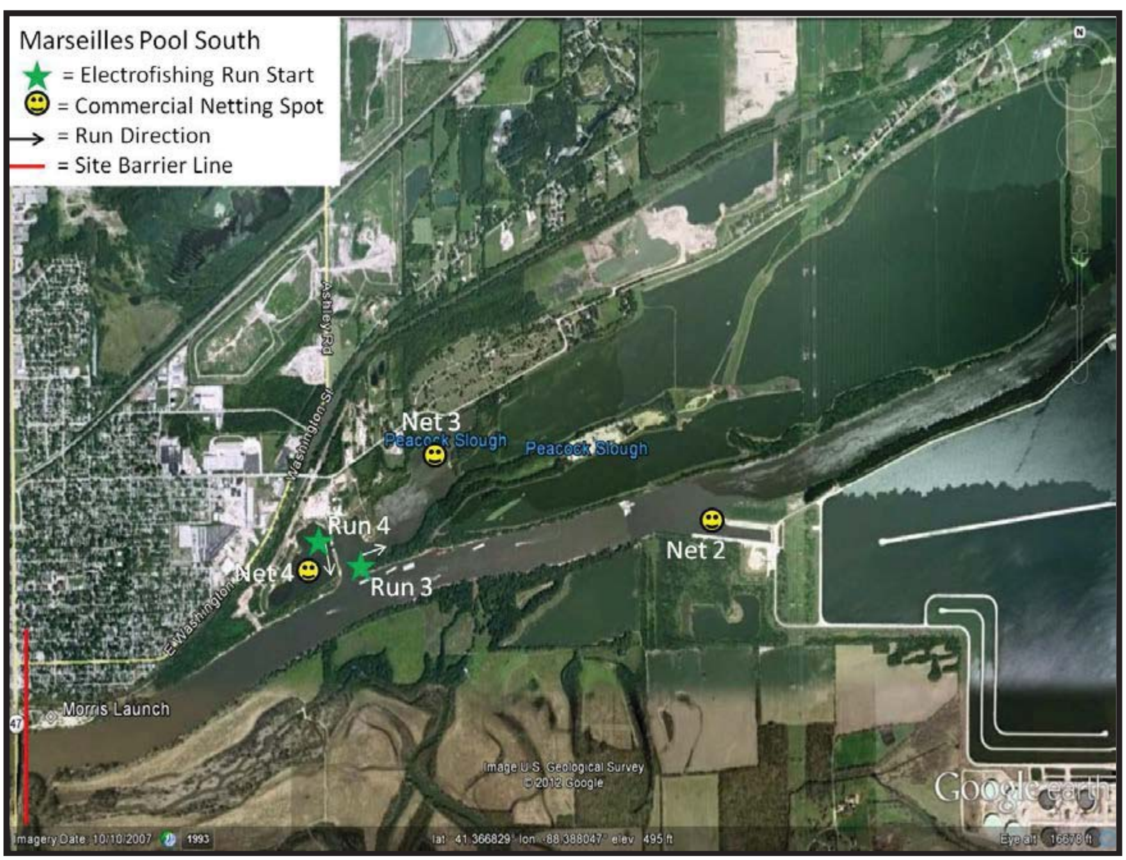
Marseilles Pool South
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= Commercial Netting Spot
= Run Direction
= Site Barrier Line
Ashley Rd
Net 3
Peacock Slough
Peacock Slough
Run 4
Net 4
Run 3
Net 2
E Washington St
Morris Launch
Image U.S. Geological Survey
© 2012 Google
Imagery Date 10/10/2007
1993
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Appendix E. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records

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

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

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

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

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

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

Specific Instructions for Handling Asian Carp:

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

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

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

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

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

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

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

	CHAIN OF CUSTODY RECORD	File No. Inv.

Date and Time of Collection:	River Reach:	Collected By:

Notes:

Collection No.	Description of Collection (include river reach, river mileage (if known), and any serial numbers):

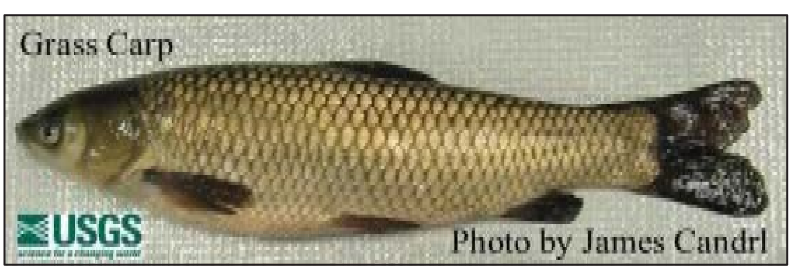
Collection No.	From: (Print Name, Agency) To: (Print Name, Agency)	Release Signature:	Release Date:	Delivered Via: □ U.S. Mail □ In Person □ Other:
Collection No.	From: (Print Name, Agency) To: (Print Name, Agency)	Release Signature:	Release Date:	Delivered Via: □ U.S. Mail □ In Person □ Other:
Collection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

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

Any suspect black carp collected in the wild in the United States and grass carp collected in the Great Lakes Basin, or other novel locations in the U.S., should be immediately reported to the appropriate resource management agency in the state where the fish was collected. Do ***not*** release suspect black or grass carp unless required by state laws or instructed to do so by the resource management agency.
Differentiating black carp from grass carp using diagnostic external characteristics can be very challenging, especially when the two species are not being compared side-by-side. An identification fact sheet is attached for your reference. Careful attention should be given in waters where grass carp are known to occur to confirm that captured individuals are indeed grass carp and not black carp. If you are not positive of the species identification you should report the collection to the appropriate resource management agency to get assistance and further instructions.
Collection information, basic biological data, and digital images should be collected for any suspect black or grass carp as soon as possible after capture. In addition to collection and basic biological data, we are interested in collecting multiple structures and organs from each fish for management and research purposes. Protocols are provided for 1) collection information, basic biological data, and digital images; 2) removal, preparation, and shipment of eyes for ploidy analysis; and 3) preparation and shipment of black and grass carp carcasses. These protocols are intended to provide resource management agencies, or authorized personnel, with streamlined instructions for the proper collection, preparation, and shipping of data, samples, and carcasses. It is important that all collections of black and grass carp (from the identified locations above) are immediately reported to the appropriate resource management agency in the state where the fish was collected before collecting more than collection information, basic biological data, and digital images.

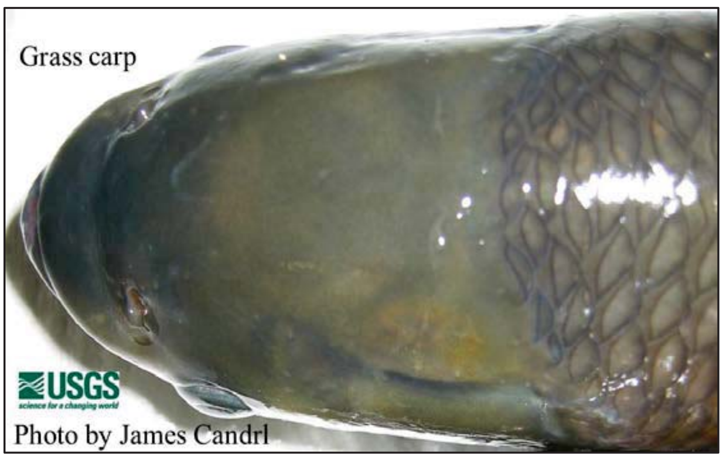
Step 1: Data Collection

1. Record GPS Location (if available, otherwise a description of collection location);
2. Record date and time of capture, method of capture, and collecting individual or agency;
3. Record fish weight, girth, length, and species (number samples if necessary);
4. Take high resolution digital pictures (see examples below):
   a. Lateral view of fish's entire left side,
   b. Close-up lateral view of head,
   c. Dorsal view of head with mouth ***fully*** closed (taken from directly above the fish's head).
5. Record name, telephone number, and/or email address for point of contact;
6. E-mail data and digital images to Sam Finney at sam_finney@fws.gov.
7. Proceed to Step 2.



Example of 4.a: Lateral view of fish's entire left

Example of 4.b: Close-up lateral view of



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

Step 2: Eyeball Removal, Sample Preparation, and Shipping Procedures for Ploidy Analysis

Materials:

- Forceps; scalpel; blunt or curved scissors
- 50-100 ml plastic containers with leak-proof screw top cap
- Sealable plastic bags to fit several 50-100 ml containers
- Contact lens solution or saline (0.8-1.0% NaCl in DI water)
- Permanent marking pen
- Cooler or insulated container with ice packs, packing tape to seal cooler
- Optional: methanol if freezing and storing samples longer than 8 days.

Procedure for Removing Carp Eyeballs**:**

1. Euthanize fish with an overdose of tricaine methanesulfonate (MS-222) or sharp blow to head.
2. Label small plastic container with collection date, species and sample number if applicable (e.g. 25MAR13, black carp, #12)
3. Insert scalpel blade between the eyeball and socket wall. Taking care not to puncture the eyeball, cut around the circumference of the eyeball, keeping the blade pointed toward the socket wall. You may use forceps to hold the eyeball steady. The goal is to cut the tissue responsible for holding and moving the eye.
4. Once you feel confident all the tissue around the eye is cut, use the blunt or curved scissors to reach behind the eyeball and cut the optic nerve. Once the optic nerve is cut, you should be able to pop the eye out and trim off any excess tissue.
5. Place eye in labeled container, fill to top with buffer solution, and put on ice or refrigerate at 4 to 8°C.
6. Follow Eyeball Sample Preparation and Shipping Procedures below.

Sample Preparation for Overnight Shipment or Storage 1 to 8 Days:

This option will provide the highest quality of samples for analysis.

1. Label a small, plastic container with collection date, species, and sample number if applicable (e.g. 25MAR13, black carp, #12)
2. Remove both eyeballs without puncturing from fish and place in labeled container. (See removal procedures above.) Fill to top with contact lens solution or saline.
3. Place container(s) in a sealable plastic bag to contain leaks and place on ice or in a cooler with ice packs.
4. Ship immediately following shipping procedures for Whitney Genetics Lab (below) or keep refrigerated (4°C - 8°C) up to 8 days.
5. Proceed to Step 3.

Eyeball Sample Preparation for Storage Longer than 8 Days:

If samples cannot be shipped within 8 days, or if many samples will be collected over a known period of time, you can store and ship all together.

1. Label a small, plastic container with collection date, species, and sample number if applicable (e.g. 25MAR13, black carp, #12)

2. Remove both eyeballs without puncturing from fish and place in labeled container. (See removal procedures above.) Fill to top with 20% methanol in contact lens solution or saline.
3. Place container(s) in a sealable plastic bag to contain leaks and place on ice or in a cooler with ice packs. Refrigerate (4°C - 8°C) overnight to allow methanol to diffuse into fish eyes.
4. Move samples to a freezer (-20°C). Store frozen until overnight shipment can be arranged. Sample quality will not degrade as long as sample remain frozen (-20°C) until shipment.
5. Ship to Whitney Genetics Lab following procedures below.
6. Proceed to Step 3.

Shipping Procedures:

1. Contact Whitney Genetics Lab personnel to make Overnight Priority (for morning delivery) shipping arrangements. If possible, ship samples on same day of catch.
2. Do ***NOT*** ship samples until arrangements have been made for receipt of package.
3. Pack samples in a Ziploc bag to prevent leakage and then enclose in a sealed, insulated container with ice packs to maintain 4 to 8°C. Do ***NOT*** use dry ice for shipping. Include collection data (and sample number if necessary) with package. If using a cooler for shipping, make sure lid is taped securely.
4. Ship priority overnight to the attention of Whitney Genetics Lab Contact.
5. Email confirmation of shipment and tracking numbers to recipient.

Contact Information:

Jennifer Bailey – fish biologist
608-783-8451
608-397-4416 (mobile)
jennifer_bailey@fws.gov

Maren Tuttle-Lau – fish biologist
608-783-8403
maren_tuttle-lau@fws.gov

Shipping Address:

Whitney Genetics Lab – La Crosse Fish Health Center
U.S. Fish and Wildlife Service Resource Center
555 Lester Ave, Onalaska, WI, 54650
608-783-8444

Step 3: Carcass Preparation and Shipping Procedures

Carcass Sample Preparation for Overnight Shipment:

If possible, *ship samples immediately on ice on same day of catch*. Otherwise, freeze the carcass before shipping.

1. Pack entire specimen (with eyes extracted) in an insulated container with plenty of ice packs, frozen water bottles, or ice to keep cool. Do ***NOT*** use dry ice for shipping.
2. Include collection data (and sample number if necessary) in double ziplock bag in container.
3. Seal container to contain leaks. If using a styrofoam cooler within a box, make sure the lid is taped and sealed securely.
4. Ship immediately or keep frozen until Overnight Priority shipping arrangements are made.

Shipping Procedures:

1. Contact Columbia Environmental Research Center personnel to make Overnight Priority (for morning delivery) shipping arrangements.
2. Do ***NOT*** ship samples until arrangements have been made for receipt of package.
3. Ship specimen in sealed, insulated container (see sample preparation instructions above) priority overnight to the attention of Duane Chapman or Joe Deters.
4. Email confirmation of shipment and tracking numbers to (dchapman@usgs.gov).

Contact Information:

Duane Chapman
573-875-5399
573-289-0625 (mobile)
dchapman@usgs.gov

Joe Deters
573-875-5399
573-239-9646 (mobile)
jdeters@usgs.gov

Shipping Address:

Duane Chapman or Joe Deters
Columbia Environmental Research Center
U.S. Geological Survey
4200 New Haven Road
Columbia, MO 65201
573-875-5399

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

Asian Carp Monitoring Project - Nets

Date: ____________________

Area Surveyed: ______________________________ Biologist (Crew): ________________________________

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

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

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

Asian Carp Monitoring Project

Date: ____________________

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

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

Nets (Describe Nets): ____

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

eDNA Field Data Sheet

DATE________________ NAME_____________________________________ START TIME______________ SHEET _____of______

ID	Volume	Latitude	Longitude	Temp	Depth	Habitat	Collect Time	Filter Time

Notes/Comments:

Appendix I. 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)**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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30										

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.

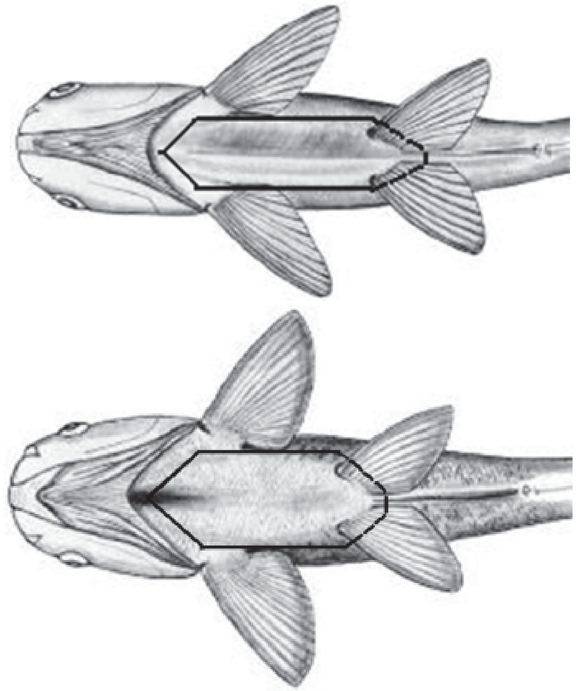

Figure 2. Areas to be preserved for analysis. Silver Carp on left, Bighead Carp on right. (FIRST FOLLOW ALL PROTOCOLS IN THIS MANUAL See: **Appendix C. Handling Captured Asian Carp and Maintaining Chain-of-Custody Records** for fish collected in the CAWS or the Great Lakes; **managers may not allow dissection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

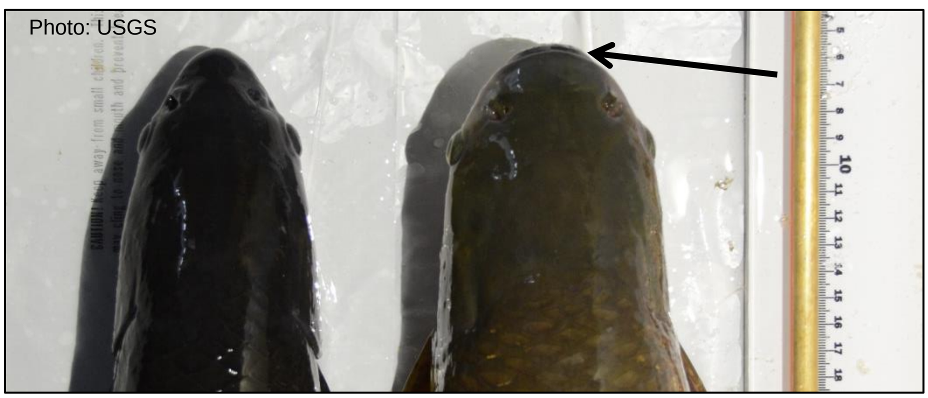

Photo: USGS

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

J-2

Photo: USGS

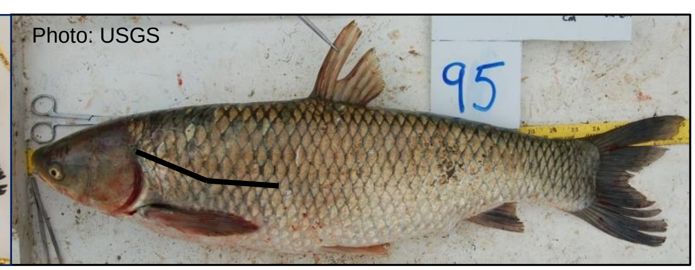

Photo: USGS

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

Black carp


Photo: Greg Whitledge, SIU


Photo: USGS


Photo: USFWS


Photo: USGS


Photo: Greg Whitledge, SIU

Grass Carp


Photo: USFWS


Photo: USGS


Photo: USGS

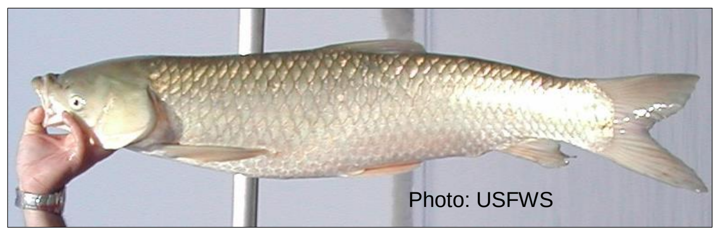
Photo: USFWS

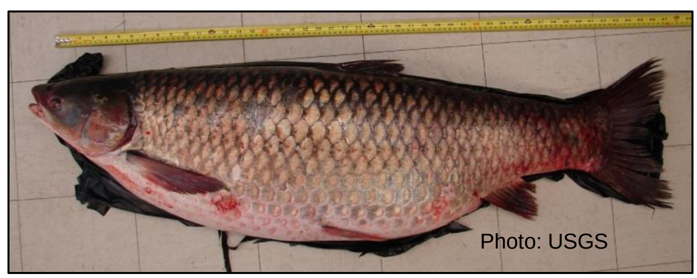
Photo: USGS

Photo: USGS

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

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ORIGINAL PAPER

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

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

Received: 13 December 2015 / Accepted: 29 June 2016

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.

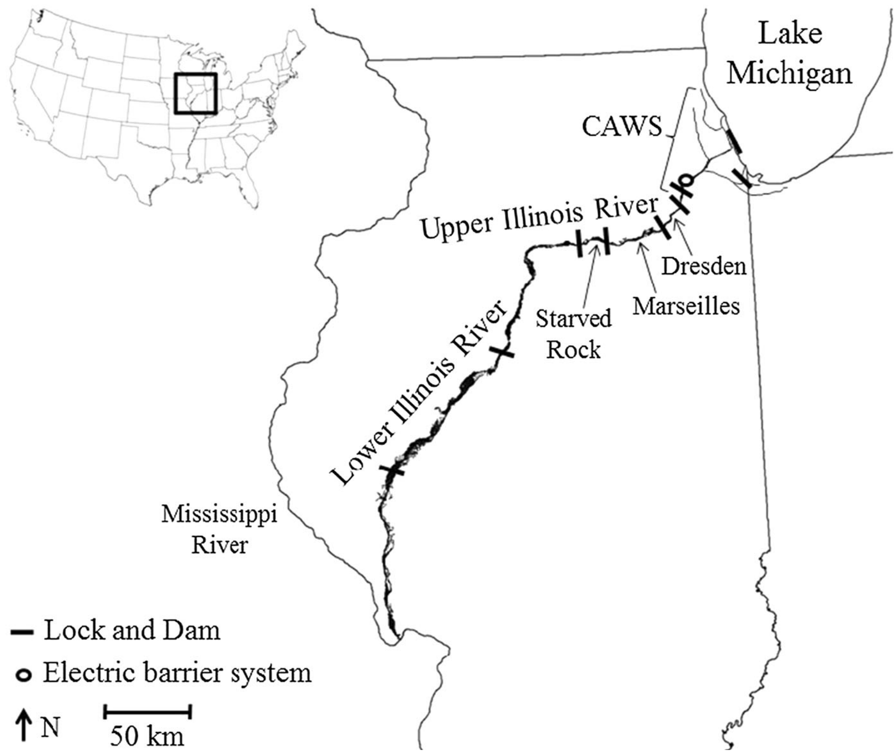

Fig. 1 The Illinois River in central USA. The lower river extends from the confluence with the Mississippi River (RKM 0) upstream to Starved Rock Lock and Dam (RKM 372). The study area consisted of three river reaches (Starved Rock, Marseilles and Dresden) in the Upper Illinois River, between RKM 372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

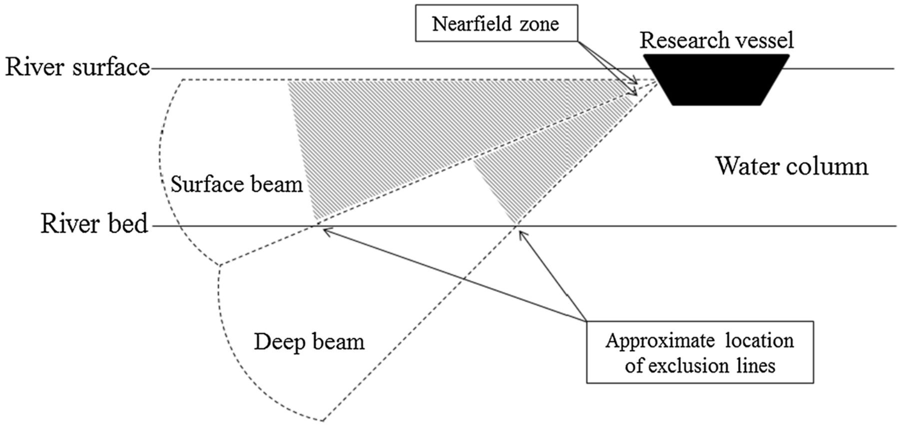

Fig. 2 Schematic (not to scale) depicting the orientation of the two hydroacoustic beams in the water column. Both transducers were deployed 0.4 m below the river surface. Maximum beam length was 50 m but exclusion lines were drawn at the point where the beams intersect the river bed. The areas in which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

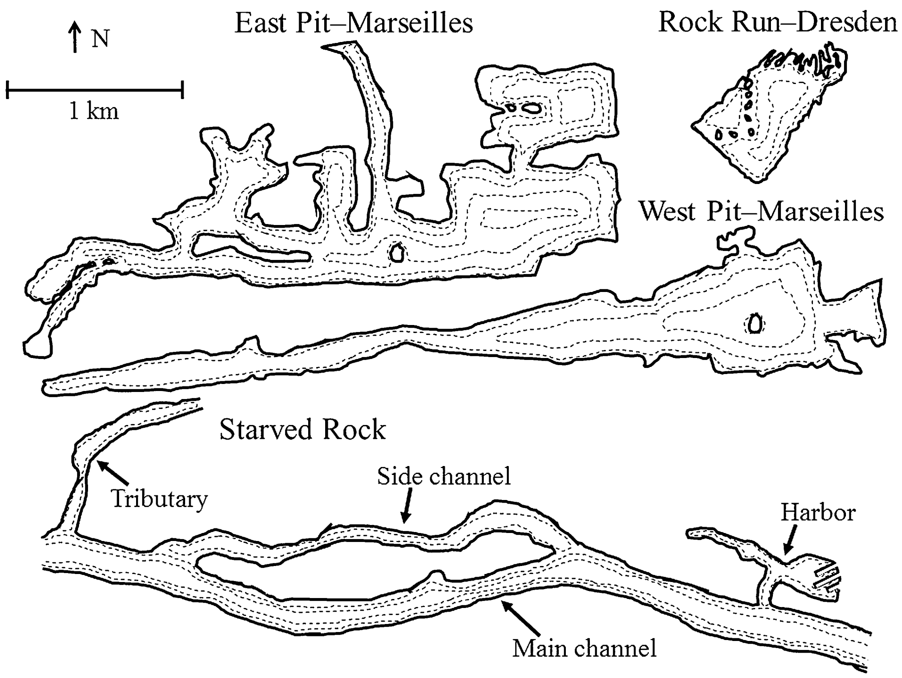

Fig. 3 Typical hydroacoustic transects (*dashed lines*) in three backwater lakes (East Pit, West Pit and Rock Run) and in a section of the Starved Rock reach (with examples of main channel, tributary, side channel and harbor habitat). Note that hydroacoustic transects during the before and after harvest 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 χ^2 test of independence was used to determine whether species composition (silver carp vs. bighead carp) changed. Due to error in both the *X* and *Y* variables, the relationship between harvest CPUE and hydroacoustic density estimates of bigheaded carps was examined using reduced major axis (RMA) regression (Sokal and Rohlf 1995). A non-parametric repeated-measures approach (Wilcoxon signed-rank test) was used to determine if hydroacoustic density estimates differed between sampling undertaken before and after harvest events (i.e. for each identical 0.463 km replicate). The critical level of significance was set at $P = 0.05$. All statistical analyses were performed using IBM SPSS Statistics 21, except for RMA regressions performed using RMA for JAVA v. 1.21: Reduced Major Axis Regression software (Bohonak and van der Linde 2004).

Results

Characterizing the advancing population

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

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

Significant longitudinal shifts in the size structure ($H = 501$–1319, all $P < 0.001$ (post hoc, all $P < 0.001$)) and species composition ($\chi^2 = 116$–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

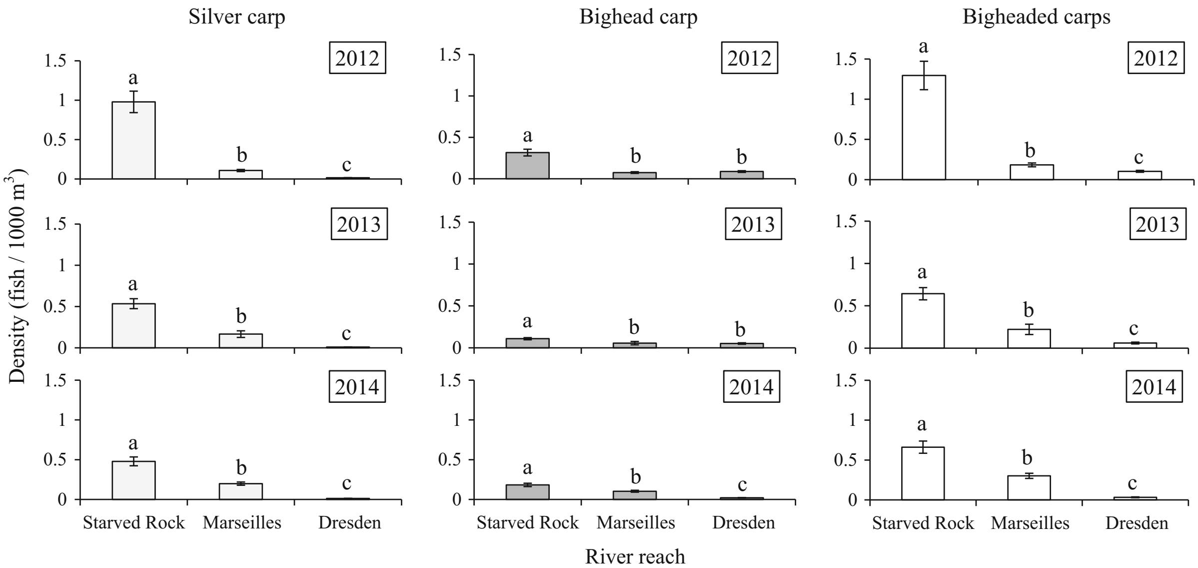

Fig. 4 Mean densities ±95 % confidence intervals of silver carp (*light grey bars*), bighead carp (*dark grey bars*) and bigheaded carps (i.e. both species combined) (*white bars*) in each sampled reach of the Upper Illinois River during 2012–2014. Significant differences ($P < 0.05$) are indicated by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

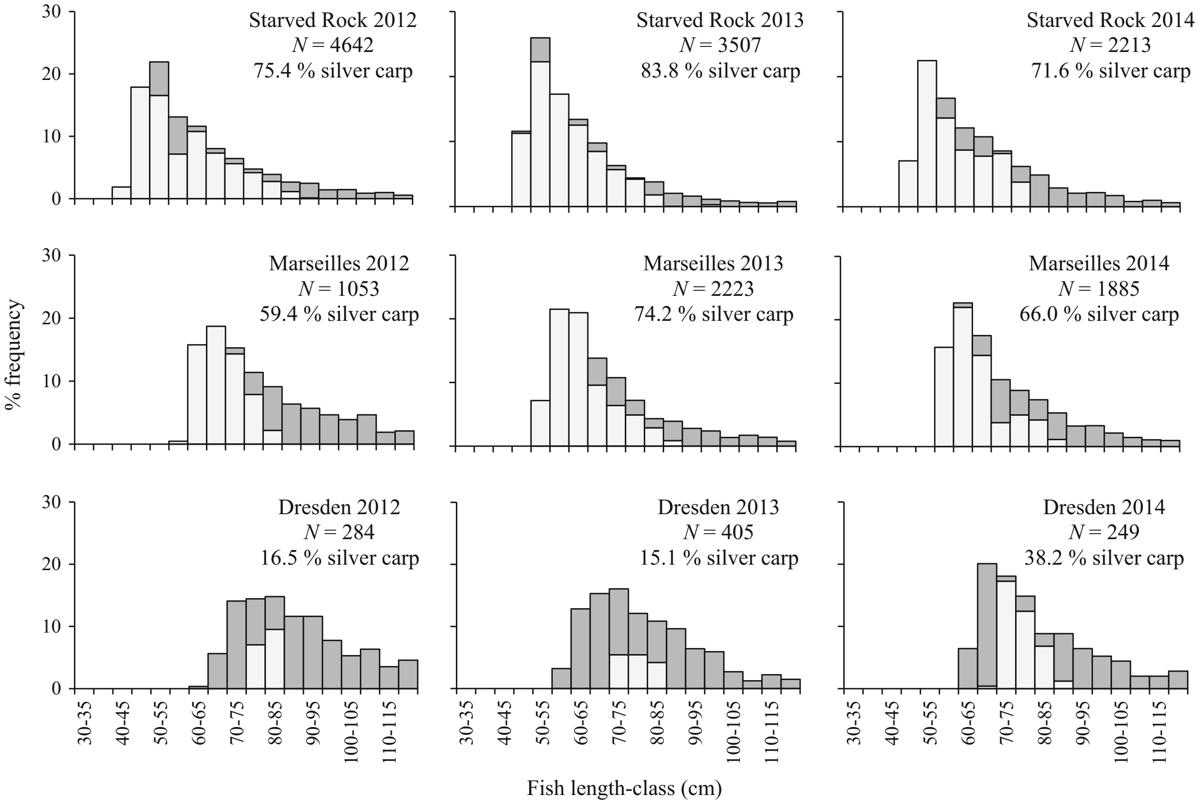

Fig. 5 Hydroacoustic-estimated size distributions of silver carp (*light grey bars*) and bighead carp (*dark grey bars*) sampled in each reach of the Upper Illinois River. Total number of bigheaded carps ensonified, and percent species composition (i.e. silver carp as a % of bigheaded carps), corresponding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

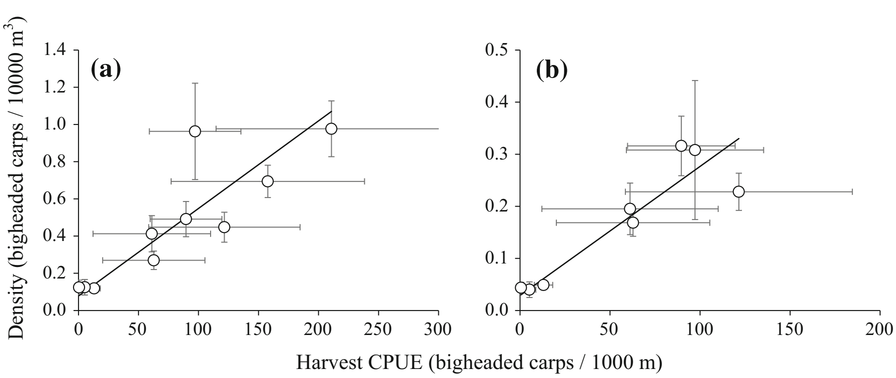

Fig. 6 Reduced major axis regression of **a** bigheaded carps density (before) and bigheaded carps harvest CPUE ($R^2 = 0.740$, $n = 10$) and **b** before–after difference in bigheaded carps density and bigheaded carps harvest CPUE ($R^2 = 0.823$, $n = 8$). All data-points are means ± 95 % confidence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

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

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

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

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

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

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

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

Discussion

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

Advancing population characteristics

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

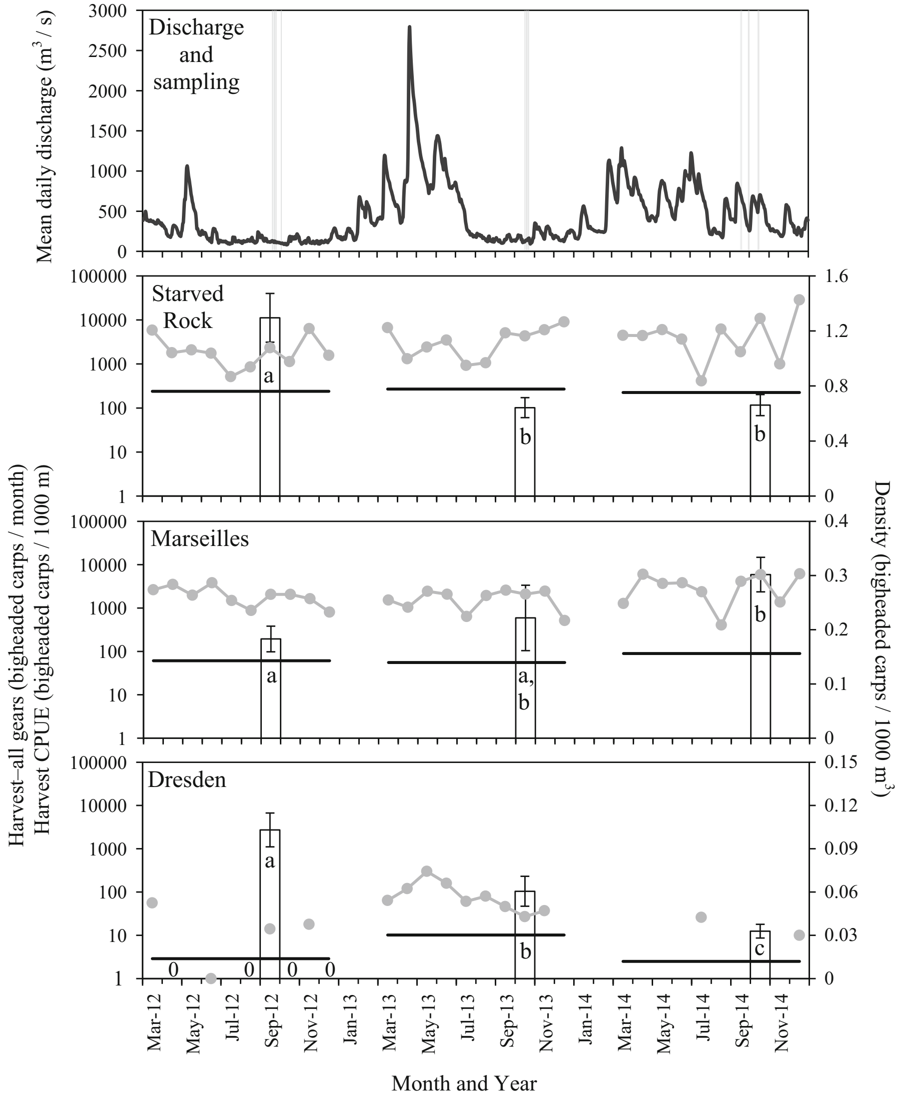

Fig. 7 *Top* Mean daily discharge (*solid black line*, Marseilles reach) and hydroacoustic sampling period (*grey shaded areas*). *Below* Each reach in the Upper Illinois River showing monthly harvest of bigheaded carps for all gears (joined *grey circles*, '0' indicates fishing but no catch, *blanks*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

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

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

Harvest evaluation (short-term, local scale)

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

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

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

Harvest evaluation (long-term, river-wide)

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

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

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

Conclusions

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

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

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

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Appendix M

Using zooplankton to measure ecosystem responses to Asian carp barrier defense and removal in the Illinois River

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

Participating Agencies: Illinois Natural History Survey (lead)

Location: Zooplankton sampling will take place in main channel and backwater habitats throughout the Illinois River from the downstream terminus of the Chicago Area Waterways in the vicinity of the Lockport Lock and Dam to the confluence of the Illinois and Mississippi Rivers near Grafton, Illinois.

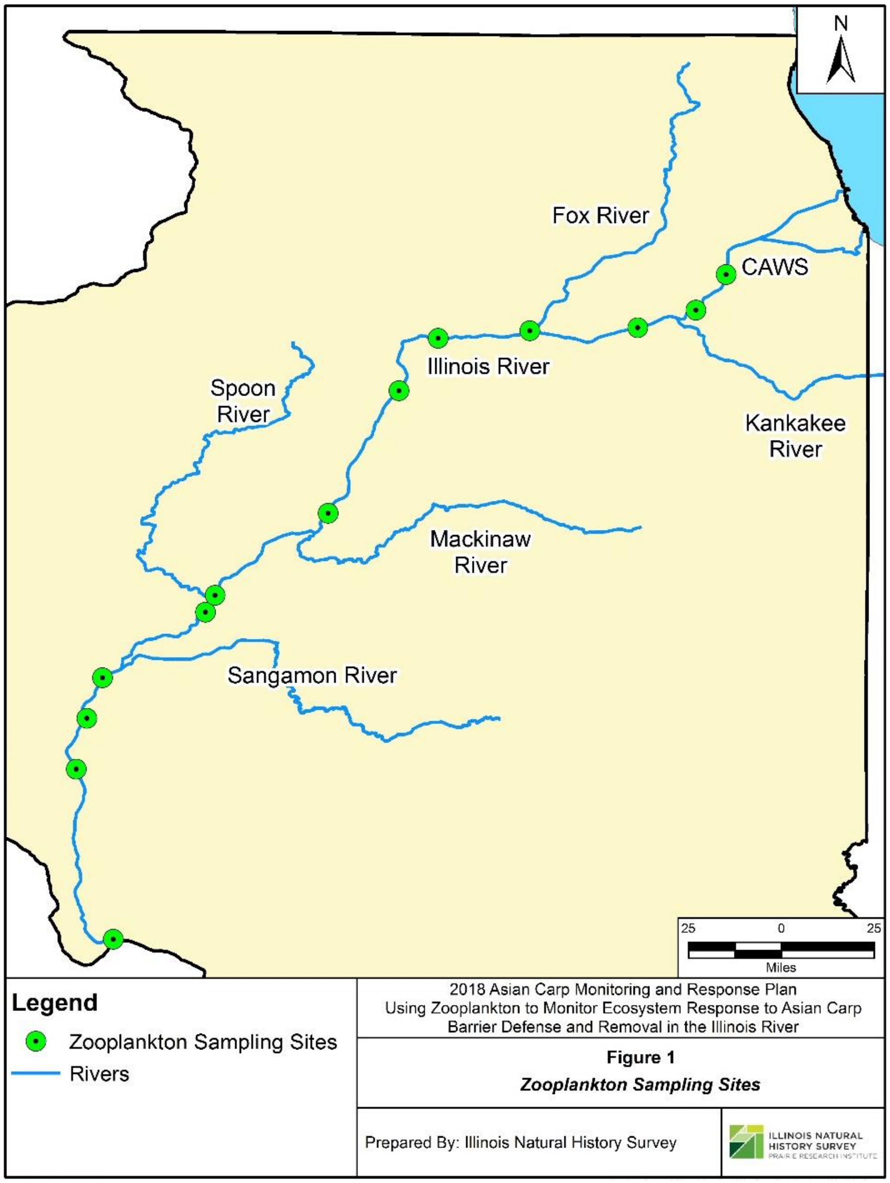

Figure 1. *Map of zooplankton sampling sites in the Illinois Waterway*.

Appendix M
Using zooplankton to measure ecosystem responses to Asian carp barrier defense and removal in the Illinois River

Introduction and Need:

The arrival and establishment of large numbers of Asian carp in the Illinois River poses a major threat to the Chicago Area Waterways System (CAWS) and the connected Great Lakes ecosystem. The ability of Asian carp to deplete planktonic food resources that support native species poses a substantial risk to recreational fisheries economies. An aggressive Asian carp removal strategy has been implemented to limit further advances but the extent and pace of ecosystem responses due to these removals is not yet clear. This project will help determine the extent to which the removal strategy is working to reverse ecosystem impacts from Asian carp and continue long-term monitoring of zooplankton in the Illinois River. Previous data have shown that plankton dynamics are a rapid index of ecosystem response, making these data an efficient tool for informing potential management strategies. Ultimately, this will benefit the Great Lakes region as well as other aquatic systems that Asian carp have or may eventually invade.

Objectives:

(1) Assess zooplankton abundance and community composition in the Illinois Waterway during 2018.

(2) Assess the magnitude and time lag for ecosystem responses to 2017 Asian carp removal operations.

(3) Identify changes in zooplankton assemblage composition and population dynamics of the LaGrange reach of the Illinois River coinciding with the establishment of Asian carp.

Status:

Zooplankton data were collected during 2017 from backwaters owned by Hanson Material Services where known numbers and biomass of Asian carp have been removed. Analysis of these data, along with long-term zooplankton community and abundance data is ongoing. Previous data collected during 2011-2015 along the Illinois River indicate that zooplankton abundance has been significantly reduced since the establishment of Asian carp and that backwaters may experience greater fluctuations in plankton densities than main channel sites where Asian carp are established. Community composition has also been affected by the establishment of Asian carp, with shifts in both macrozooplankton and rotifers. However, large-bodied crustacean zooplankton have been reduced to a greater extent than rotifers. A better understanding of ecosystem responses to Asian carp establishment and removal will come with further analysis of data collected during 2018.

Appendix M
Using zooplankton to measure ecosystem responses to Asian carp barrier defense and removal in the Illinois River

Methods:

Field sampling for assessment of zooplankton trends will take place between March and October of 2018 at established sites to maintain consistency and data comparability (Figure 1). Zooplankton will be collected by obtaining vertically-integrated water samples using a diaphragmatic pump. At each site, 90 L of water will be filtered through a 55 μm mesh to obtain crustacean zooplankton, whereas 10 L of water will be filtered through a 20 μm mesh to obtain rotifers. Organisms will be transferred to sample jars and preserved in either Lugols solution (4%; for macrozooplankton) or buffered formalin (10%; for rotifers). In the laboratory, individual organisms will be identified to the lowest possible taxonomic unit, counted, and measured using a digitizing pad. Zooplankton densities will be calculated as the number of individuals per liter of water sampled.

Zooplankton responses to removal will be assessed by comparing densities, community composition, and key demographic parameters (estimated birth rate, mortality rate, population growth rate) through time among sites where Asian carp removal has and has not occurred. Similar assessments will be used to evaluate the effects of the Asian carp invasion using archived samples and historical data sets from before the establishment of Asian carp in the Illinois Waterway.

Sampling Schedule:

In 2018 and subsequent years, zooplankton sampling will occur at bi-weekly intervals at all sites from March to October. At most sites, zooplankton will be sampled concurrently with ichthyoplankton sampling (collected to monitor for Asian carp eggs and larvae).

Deliverables:

Results of 2018 sampling and on-going assessments of patterns of zooplankton response to annual variations in Asian carp densities (2017 field data of zooplankton abundance and size distributions) and harvest operations will be provided to MRWG partners as relevant findings are produced. Data will be summarized and project plans updated for annual revisions of the MRP.

Appendix N
Detection Using Novel Gear

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

Collaborators: US Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office Wilmington substation

Location: Illinois River

Introduction and Need:

Invasive species are inherently difficult to manage and control because limited information exists. Many times the lack of information can be related to the inability to effectively capture the species. Effective sampling techniques that have a high probability to detect a species and correctly represent that specie's population are crucial for biologists and managers to correctly manage and control any invasive species. Currently several projects have evaluated techniques used to capture Asian carp in the Illinois River (Gear Evaluation for Removal and Monitoring of Asian Carp Species; Barrier Defense Using Novel Gear; Evaluation of Gear Efficiency and Asian Carp Detectability; Unconventional Gear Development; Monitoring Asian Carp Using Netting with Supplemental Capture Techniques). The results of these projects will be compiled to determine the most effective ways to capture bigheaded carp at all sizes and distributions. Additionally, standard methods for implementation and deployment for these gears will be developed so bigheaded carp sampling can be standardized across sites, pools, and rivers. The completion of this project will provide crucial information needed to effectively assess, manage, and remove bigheaded carp from the Illinois River and other systems that look to prevent or control bigheaded carp.

Objectives:

(1) Develop a framework for techniques used to capture bigheaded carp within the Illinois River.

Status:

Previous Templates:

- Gear Evaluation for Removal and Monitoring of Asian Carp Species (USFWS – Columbia)
- Barrier Defense Using Novel Gear (USFWS – Columbia)
- Evaluation of Gear Efficiency and Asian Carp Detectability (INHS)

Appendix N
Detection Using Novel Gear

- Unconventional Gear Development (INHS)
- Monitoring Asian Carp Using Netting with Supplemental Capture Techniques (USFWS – Wilmington; USFWS – Carterville)
- Barrier Defense Asian Carp Removal Project (Illinois Department of Natural Resources)

Currently collaborators are gathering data, reports, and publications of tools and techniques used to manage bigheaded carp.

Methods:

This will be a collaborative effort among several agencies that will require a thorough literature search and review for all tools and techniques used to capture bigheaded carp. A standard suite of questions will be developed and answered for each tool and technique allowing managers to make objective-driven decisions on which methods could be used to answer their questions.

Schedule:

January – September 2018: Conduct a thorough literature search and review on tools and techniques used to capture bigheaded carp.

September – December 2018: Provide a framework for publication.

January 2019: Present framework to MRWG.

Deliverables:

Deliverables produced by this project will include (1) a written framework for techniques used for the detection, management, and removal of bigheaded carp in the Illinois River; and (2) an oral presentation to fellow workgroup members and at the annual 2018-19 MRWG meeting and other venues.

APPENDIX O
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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Seth Love, Scott Collins, Joe Parkos (Illinois Natural History Survey)

Rebecca Neeley, Corey Anderson (U.S. Fish and Wildlife Wilmington)

Emily Pherigo, Jeremy Hammen (U.S. Fish and Wildlife Columbia)

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

Introduction:

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

Objective:

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

APPENDIX O
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Adult and juvenile fish capture gears

Active capture gears

Electrofishing (Figure 1):

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

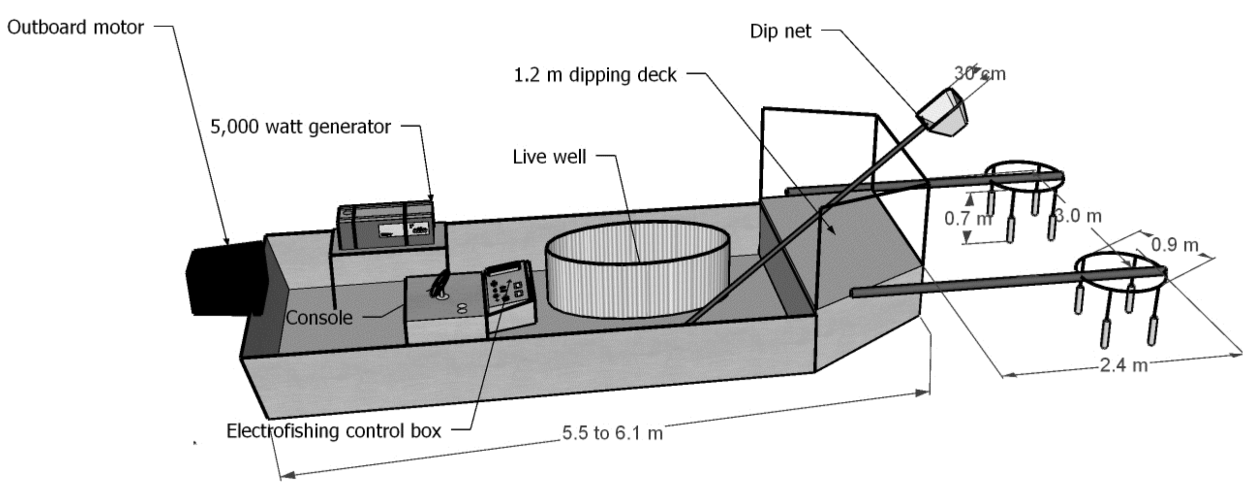

Figure 1. *Schematic of electrofishing boat.*

APPENDIX O
ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

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

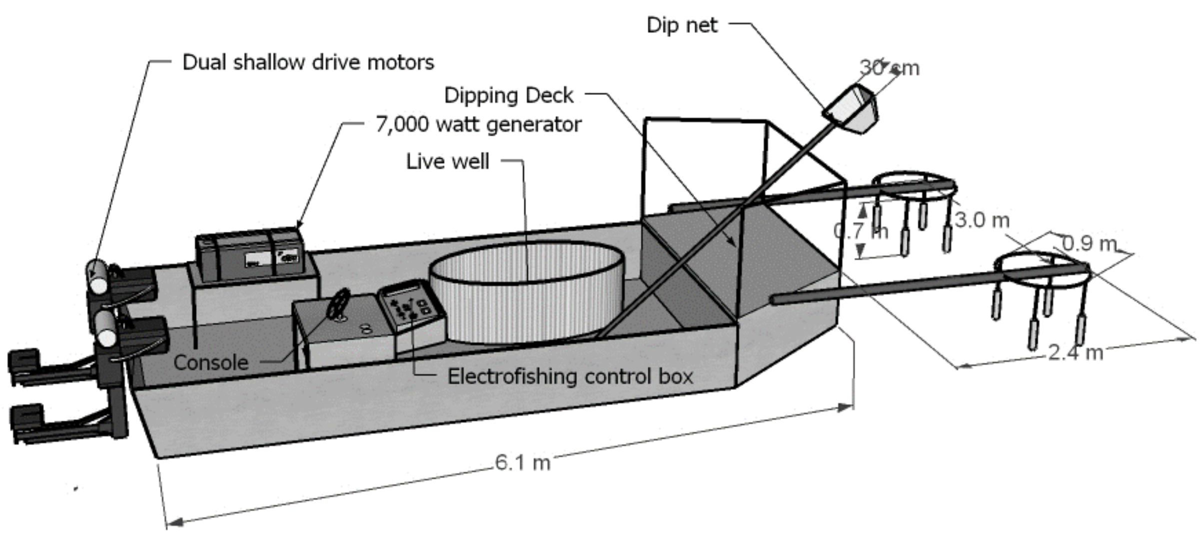

Figure 2. *Schematic of the shallow drive electrofishing boat.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Electrified dozer trawl (Figure 3):

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

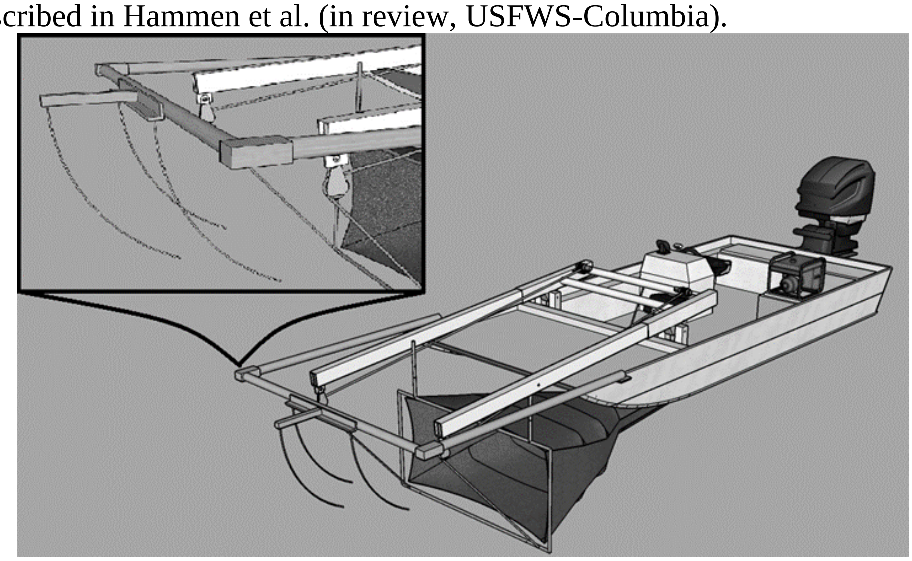

Figure 3. *Generalized schematic of the electrified dozer trawl.*

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ASIAN CARP MONITORING AND RESPONSE EQUIPMENT

Paupier trawl (Figure 4):

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

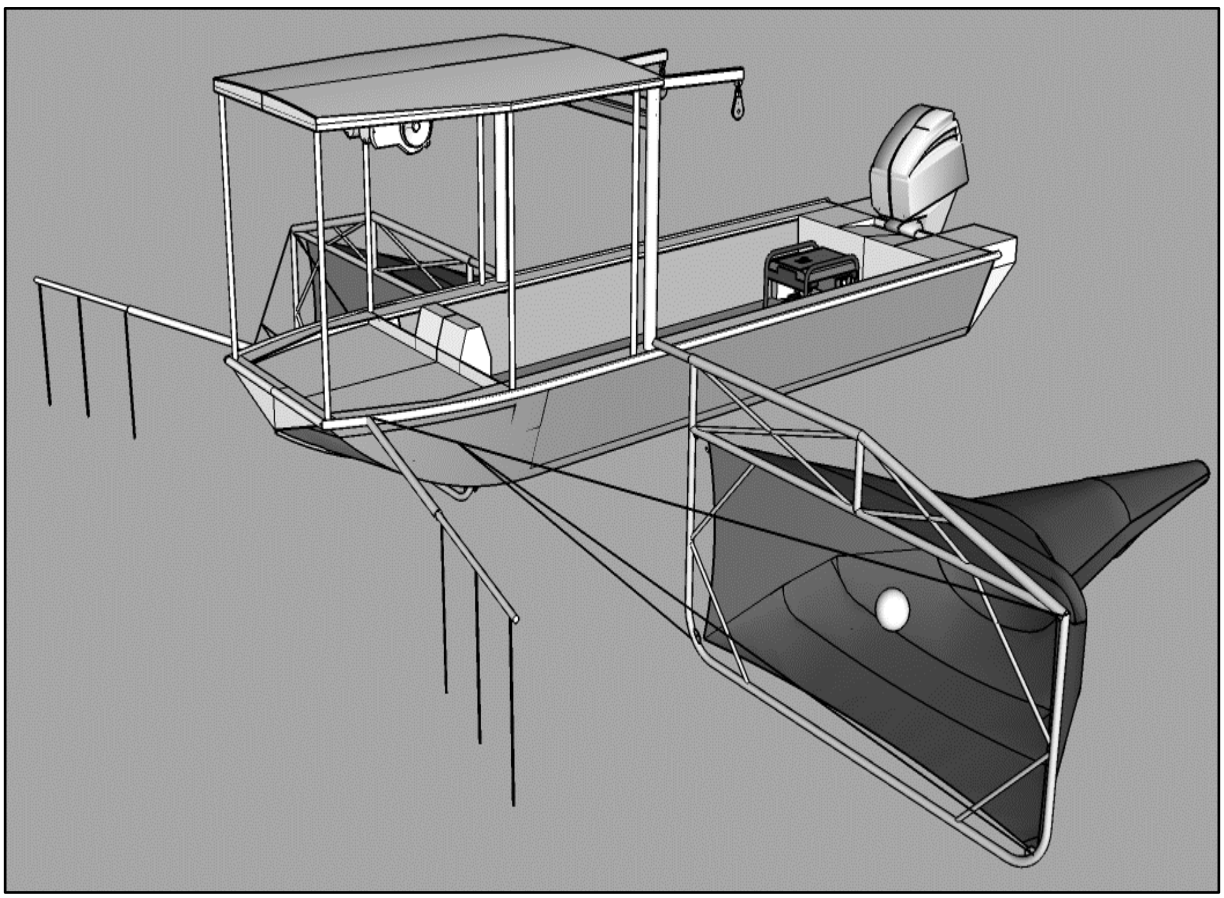

Figure 4. *Schematic of electrified Paupier trawl*

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Seine (Figure 5):
Seines consisted of two wings and a bunt section or a bag (extra material in the middle of the seine concentrating fish) secured to a float line and lead line. Floats were attached every 25.4 cm (10.0 in.) on the float line and a solid core lead line was used as the lead line. Floats were 41.3 mm x 111.0 mm (1.6 in. x 4.4 in.) hard orange foam that produced 85.0 g (3.0 oz.) of buoyancy. Bar measure of mesh was uniform within a seine, but two different mesh sizes of seines were used. The large mesh seine was 50.8 mm (2.0 in.) black asphalt coated bar-measured mesh and the small mesh seine was 1.6 cm (0.6 in.) black asphalt coated bar-measured mesh. Wings had a height of 3.2 m (10.0 ft.) tapering down to the bunt or bag section with a height of 9.1 m (30.0 ft.) for large mesh seines and 6.1 m (20.0 ft.) for small mesh seines. Total length of large mesh seines varied from 274.3 m (900.0 ft.) to 731.5 m (2400.0 ft.). Total length of the small mesh seine was 182.8 m (600.0 ft.).

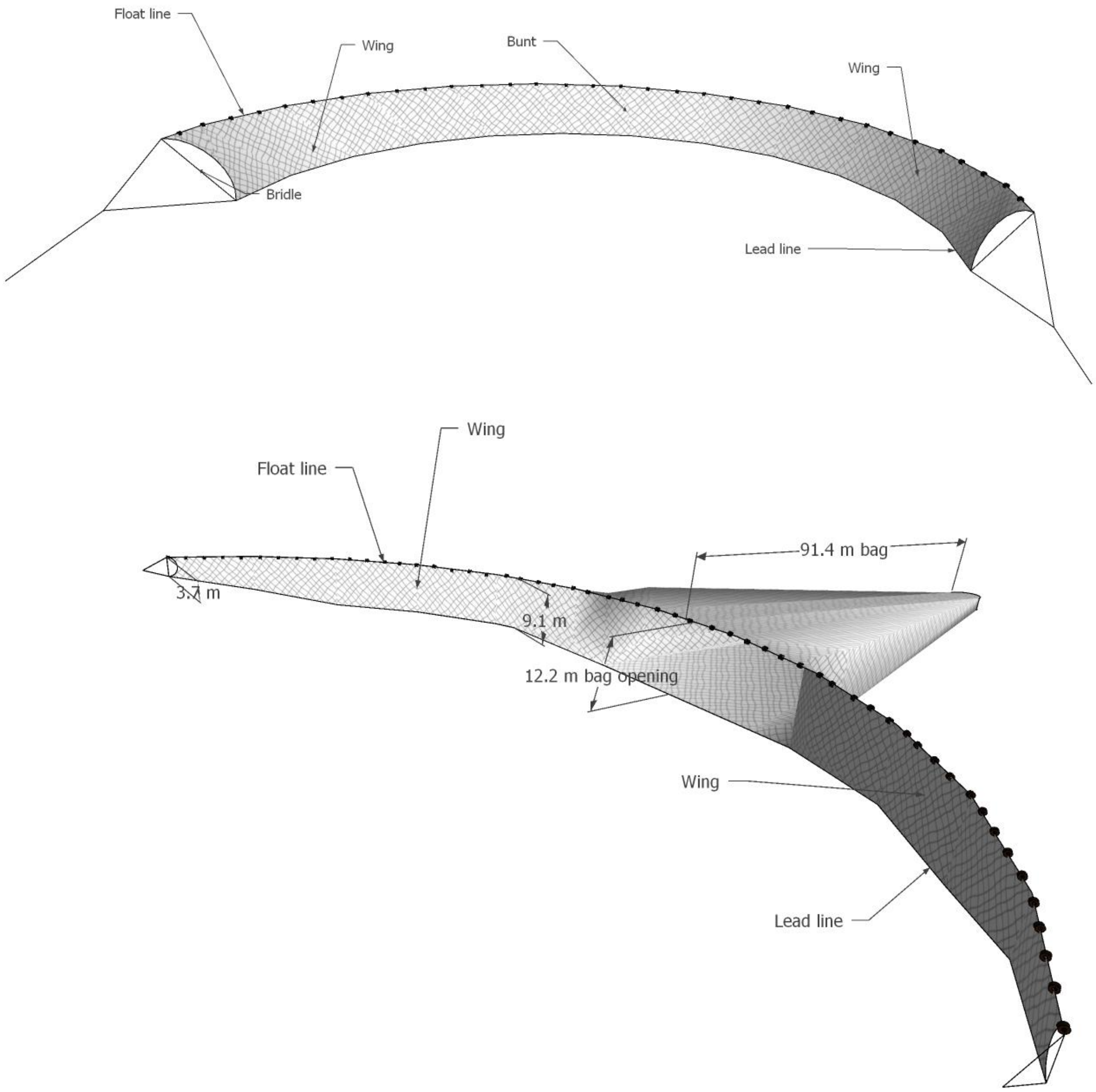

Figure 5. *Generalized schematic of a commercial seine without a bag (top) and with a bag (bottom).*

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Trawl (Figure 6):

The trawl was a two-seam balloon style trawl covered with 4.4 cm (1.8 in.) heavy delta-style bar measured mesh. The headrope was 19.8 m (65.0 ft.) long with floats spaced every 30.5 cm (12.0 in.). Floats were 41.3 mm by 111.0 mm (1.6 in. by 4.4 in.) orange hard foam which produced 85.0 g (3.0 oz) of buoyancy. The footrope was 22.3 m (73.0 ft) long with a 7.9 mm (0.3 in.) proof coil low carbon steel chain sewn to it. The mouth opening of the trawl tapered down from 1.8 m (6.0 ft.) at the brail ends to 3.7 m (12.0 ft.) at the mid-section. The 4.4 cm heavy delta-style asphalt coated mesh was attached to the headrope with 1.0 mm #72 black diameter nylon twine. The cod end of the trawl was 12.2 m (40.0 ft.) tarping down to a 2.1 m (7.0 ft.) stretched circumference catch area. Brail ends (sides of the trawl) of the trawl were 1.8 m (6.0 ft.) deep. Each bridle was attached to a 24.4 m (80.0 ft.) towrope that was securely fastened the stern of one of the towboats.

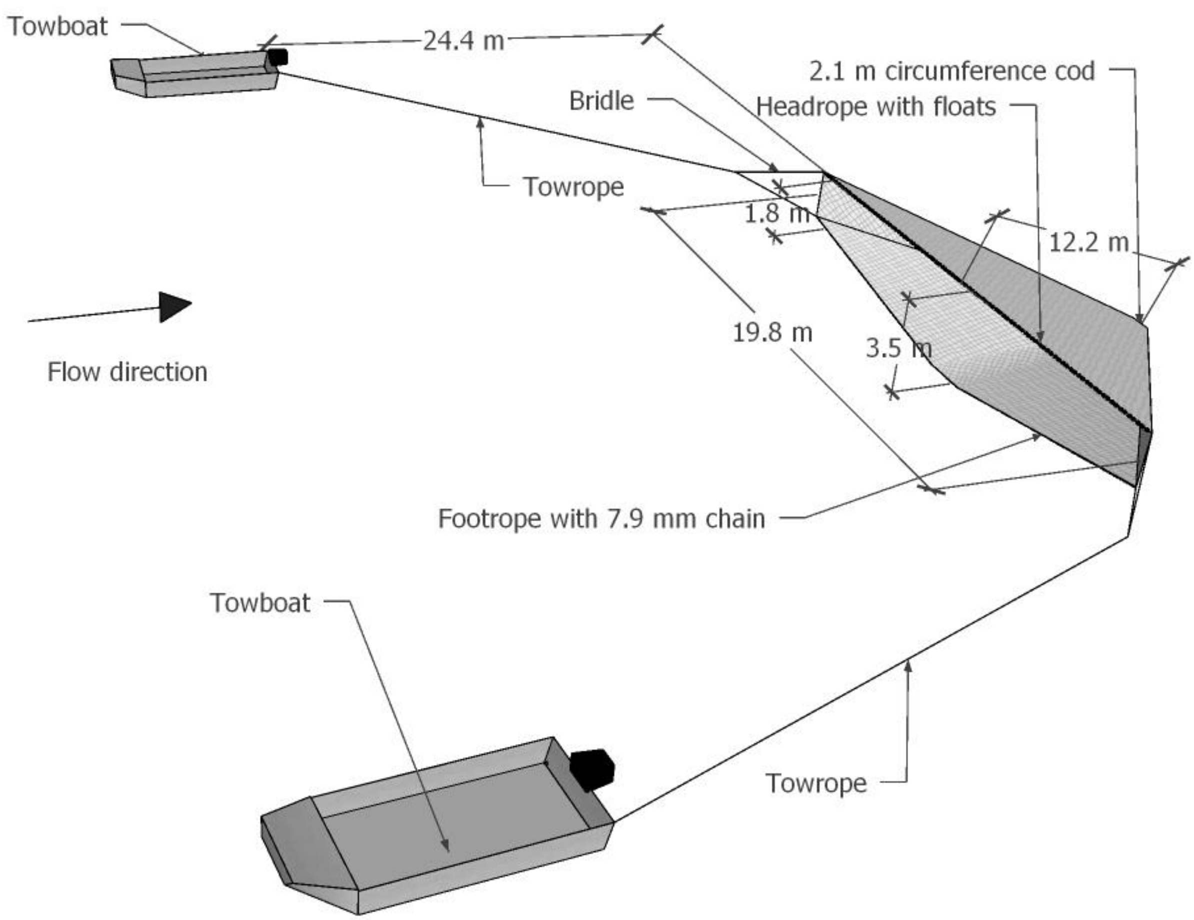

Figure 6. *Generalized schematic of a trawl.*

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Passive capture gears

Deep-water gill net (Figure 7):

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

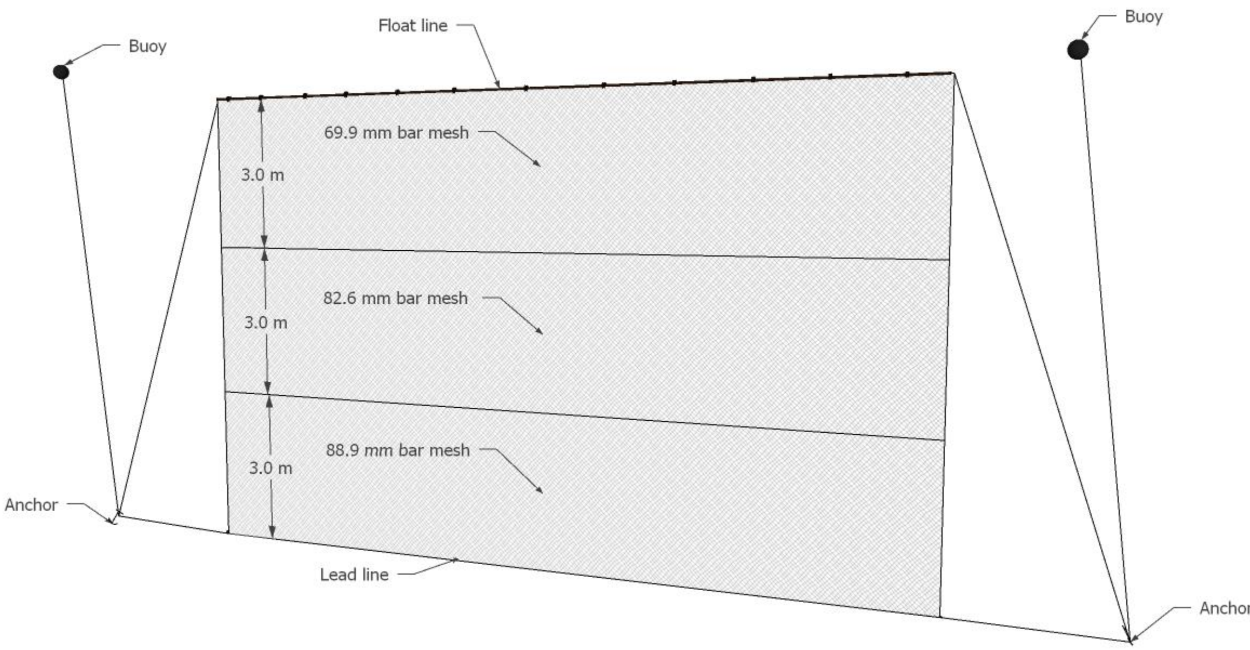

Figure 7. *Generalized schematic of a deep-water gill net.*

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Shallow gill net (Figure 8):

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

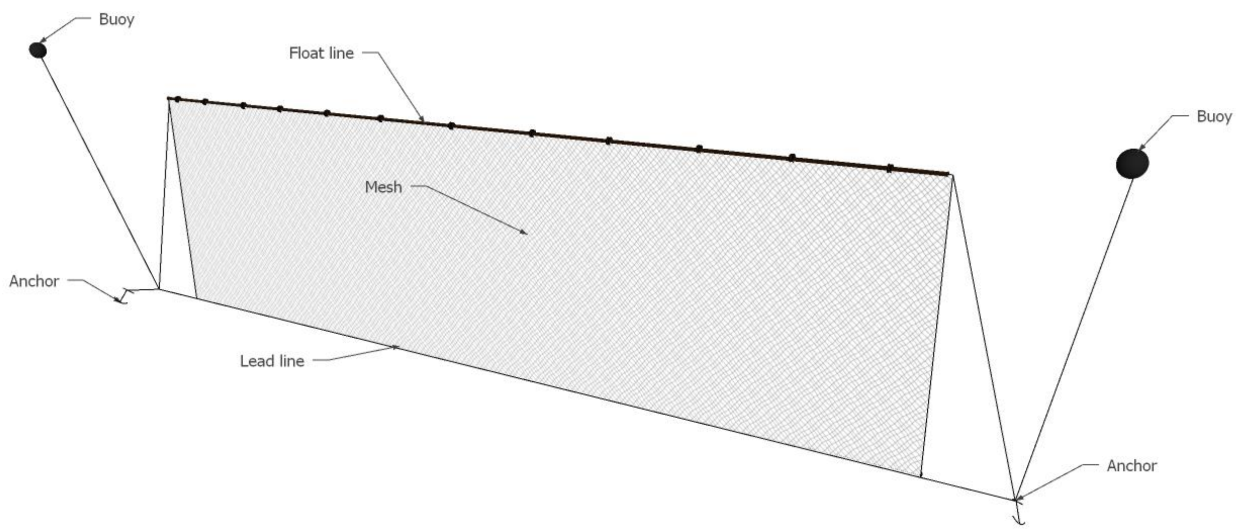

Figure 8. *Generalized schematic of a commercial shallow gill net.*

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Trammel net (Figure 9):

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

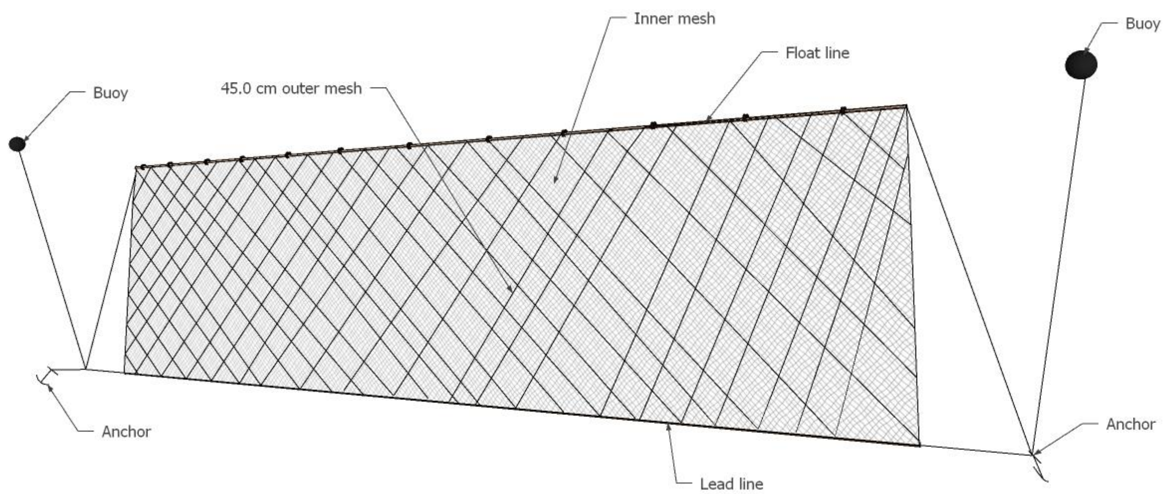

Figure 9. *Generalized schematic of a commercial trammel net.*

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Hoop net (Figure 10):

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

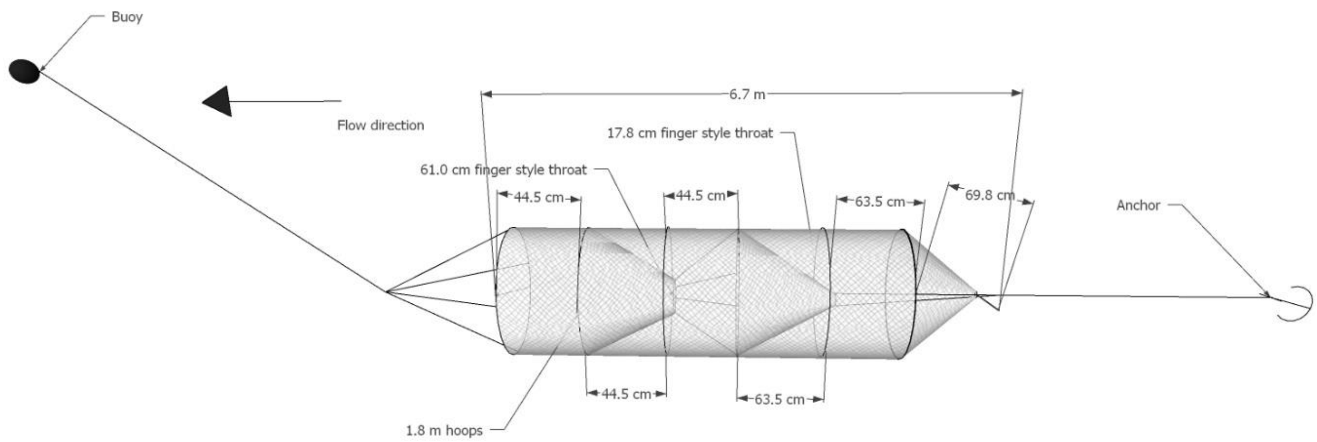

Figure 10. *Schematic of commercial hoop net*

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Great lakes style pound net (Figure 11):

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

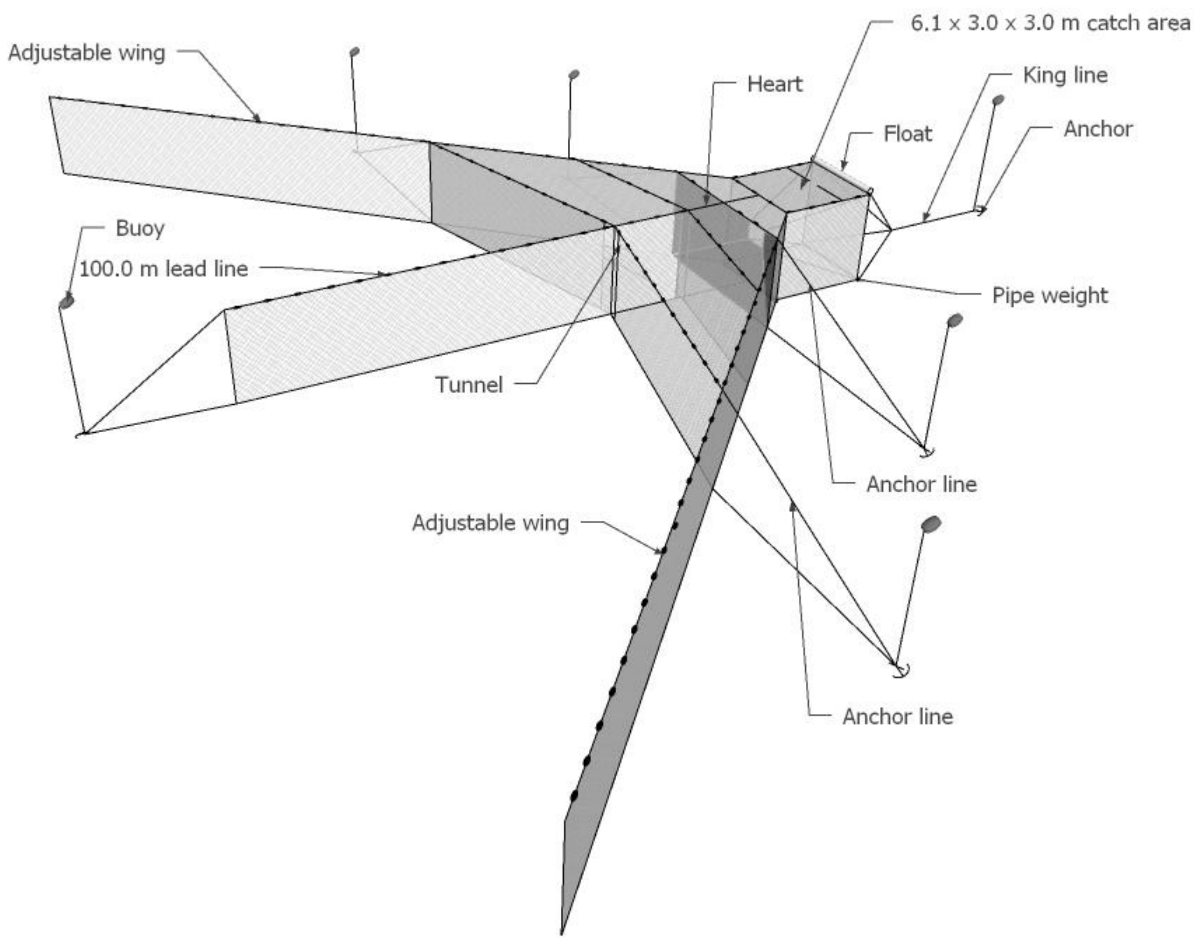

Figure 11. *Schematic of the great lakes style pound net*

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Mini modified fyke net (Figure 12):

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

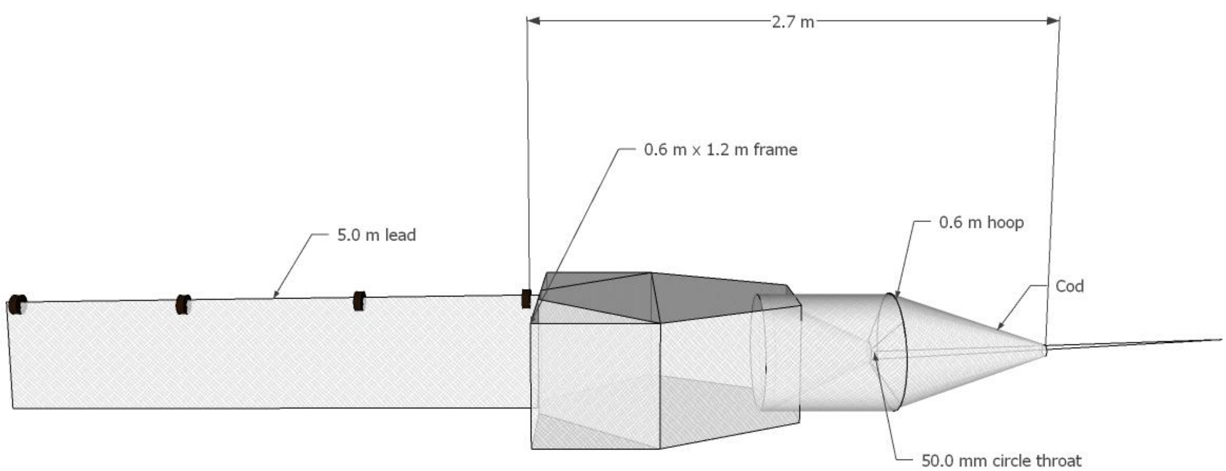

Figure 12. *Schematic of mini modified fyke net*

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Modified fyke net (Figure 13):

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

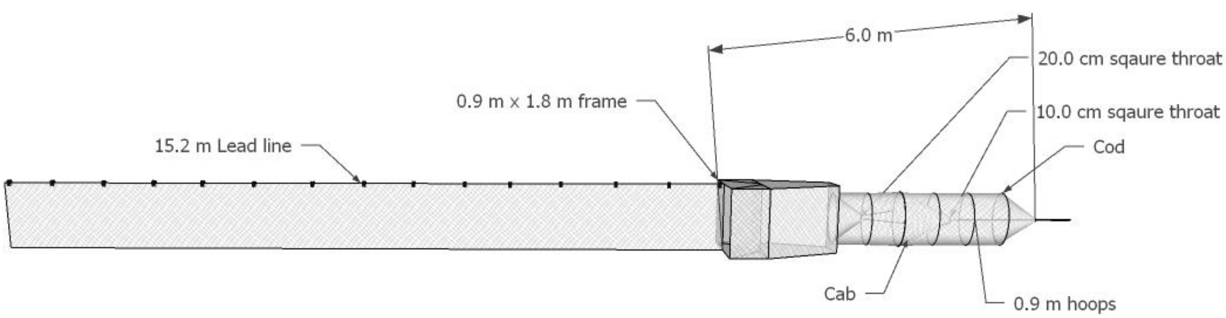

Figure 13. *Schematic of modified fyke net*

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Larval fish capture gears

Active capture gears

Larval pushnet (Figure 14):

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

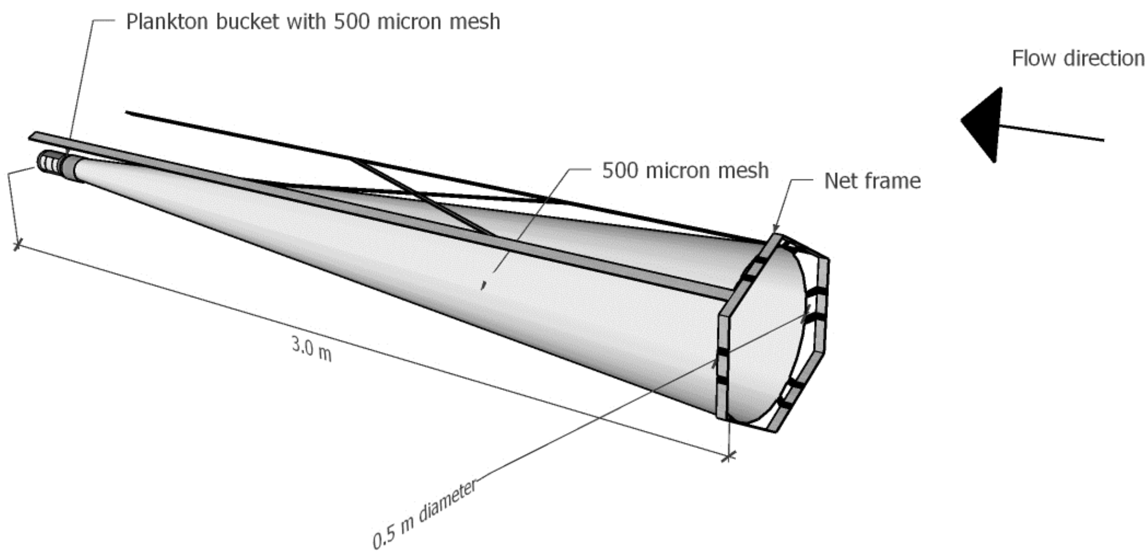

Figure 14. *Generalized schematic of a pushnet.*

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Passive capture gears

Larval driftnet (Figure 15):

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

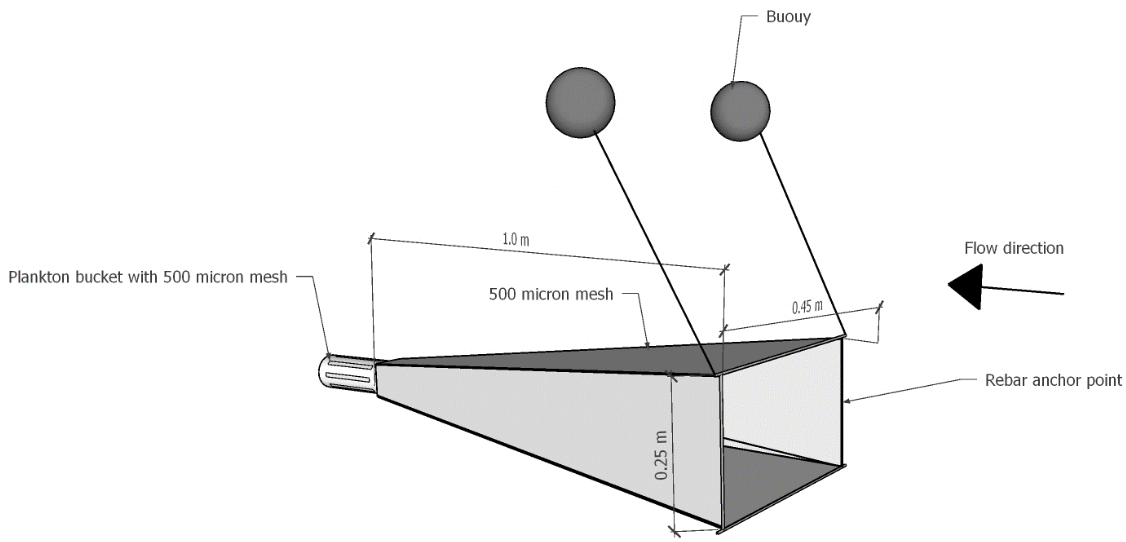

Figure 15. *Generalized schematic of a drift net.*

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

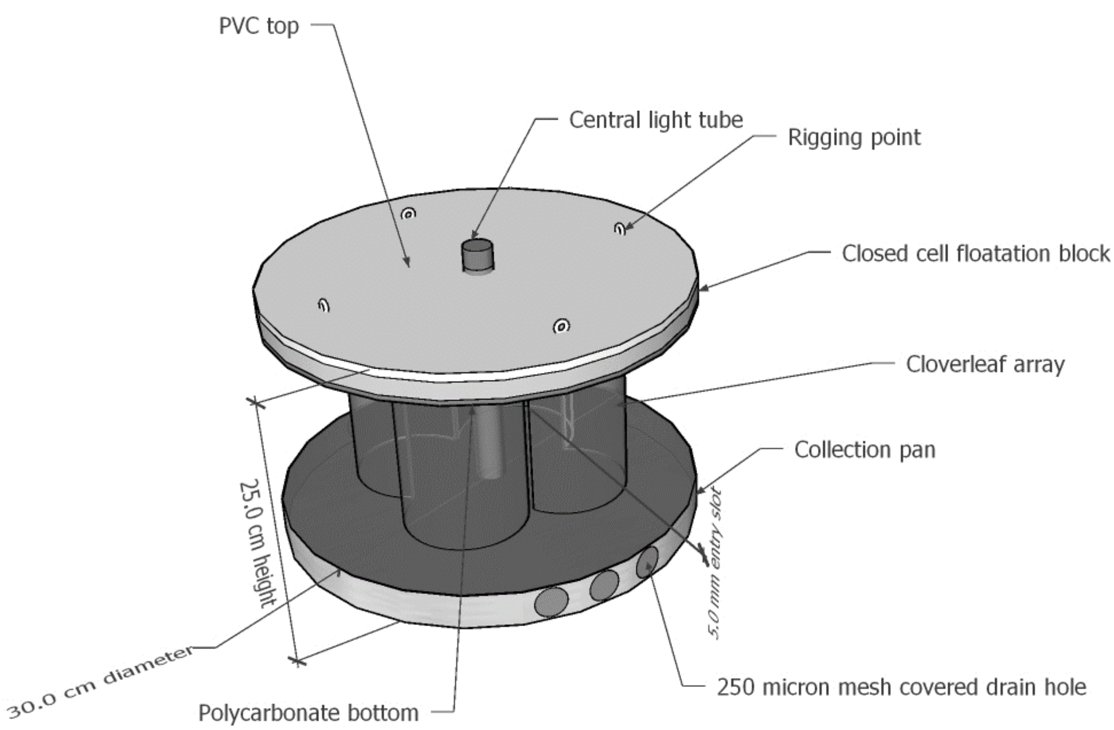

Figure 16. *Schematic of Quadrafoil light trap*

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Non-capture gears

Nets

Block net (Figure 17):

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

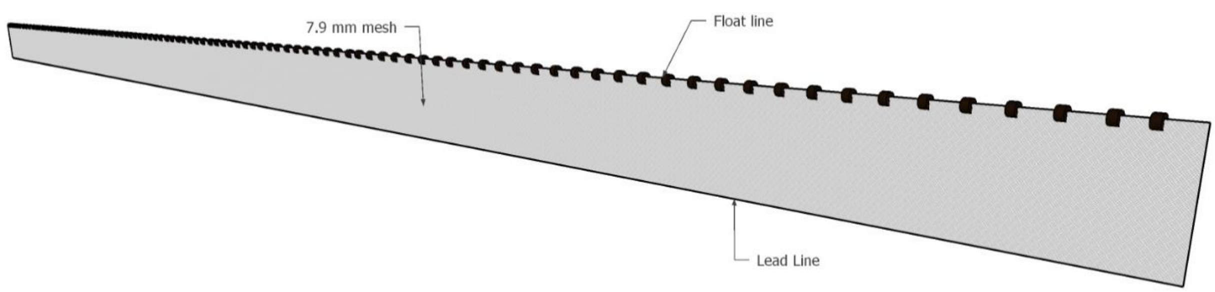

Figure 17. *Generalized schematic of a block net.*

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Sampling boats

Netting boat (Figure 18):

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

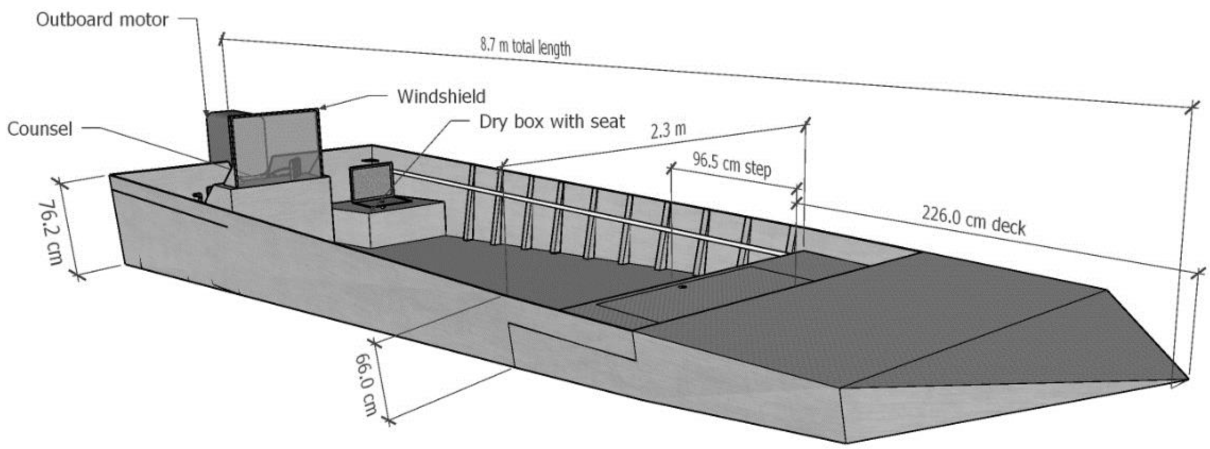

Figure 18. *Generalized schematic of netting boat.*

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Shallow drive boat (Figure 19):

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

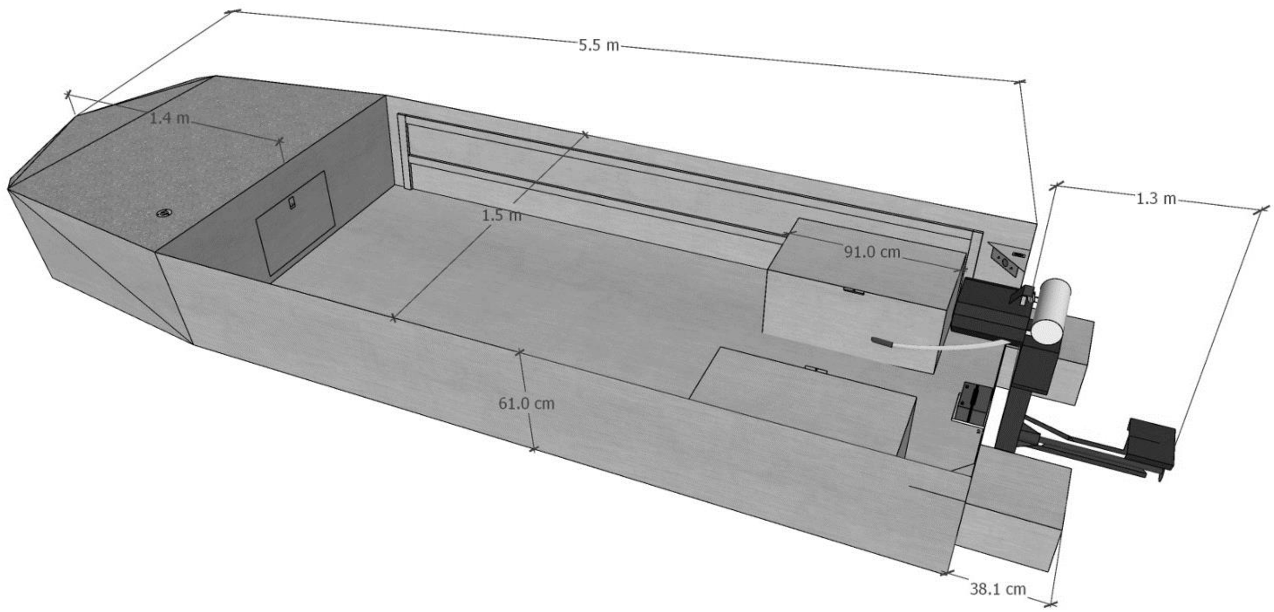

Figure 19. *Schematic of the shallow drive boat.*

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

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

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