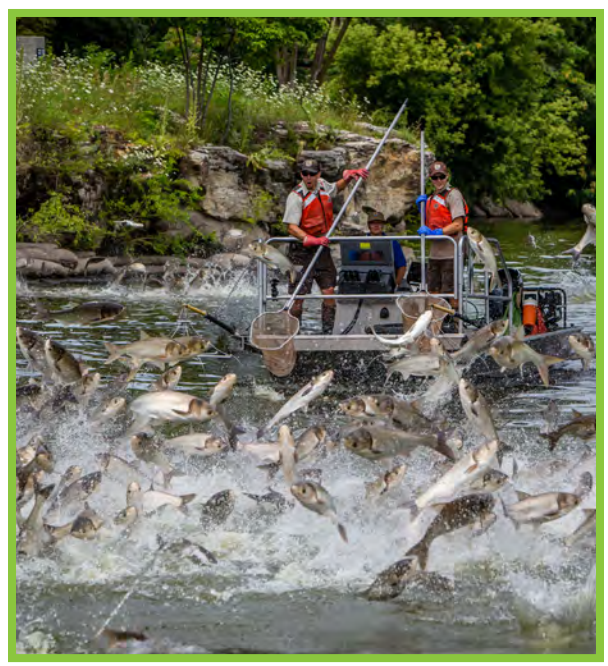
2016 Interim Summary Report

Asian Carp Monitoring and Response Plan



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

GLOSSARY

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

GLOSSARY

TERM	DEFINITION
LOQ	Limit of quantification
LTRMP	Long-Term Resource Monitoring Protocols
m	Meter
m^2	Square meters
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 Interim Summary Report (ISR) 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 ISRs, and present the most up-to-date results and analysis 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 the results of 22 projects, 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 summary report outlines the results of work that took place in 2016, and provides recommendations for next steps for each project.

This ISR builds upon prior plans developed in 2011, 2012, 2013, 2014, and 2015. More specifically, it is intended to act as an update to the 2015 ISR that was developed in 2016. This 2016 ISR is intended to be a living document, and will be updated at least annually. Updates will provide new project results, as well as incorporate new information, technologies, and methods as they are discovered and implemented. A companion document, the 2017 Asian Carp Monitoring and Response Plan (MRP), has also been completed by the MRWG. The 2017 MRP presents each project's plans for activities to be completed in 2017. Similar to the ISR, the MRP is intended to function as a living document, and will be updated at least annually. Together, the 2017 MRP and 2016 ISR present a comprehensive accounting of the projects being conducted to prevent the establishment of Asian carp in the CAWS and Lake Michigan. Through the synthesis of these documents, the reader can obtain a thorough understanding of the most recent project results and findings, as well as how these findings will be used to guide project activities in the future.

For the purpose of this ISR, the term 'Asian carp' refers to Bighead Carp (*Hypophthalmichthys nobilis*) and Silver Carp (*H. molitrix*), exclusive of other Asian carp species such as 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.

All ISRs to date, including the 2016 ISR, 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 various state and federal agencies.

As in the past, all projects discussed in this document have been selected and tailored to further the MRWG overall goal and strategic objectives.

Overall goal: Prevent Asian carp from establishing self-sustaining populations in the CAWS and Lake Michigan.

The five strategic objectives selected to accomplish the overall goal are:

1) Determination of the distribution and abundance of any Asian carp in the CAWS, and use this information to inform response and removal actions;
2) Removal of any Asian carp found in the CAWS to the maximum extent practicable;
3) Identification, assessment, and reaction to any vulnerability in the current system of barriers to prevent Asian carp from moving into the CAWS;
4) Determination of the leading edge of major Asian carp populations in the Illinois River and the reproductive successes of those populations; and
5) Improvement of the understanding of factors behind the likelihood that Asian carp could become established in the Great Lakes.

In keeping with the overall goal and strategic objectives, the 2016 results for 22 projects are included in this ISR. These summary reports document the purpose, objectives, and methods for each individual project, in addition to providing an analysis of results and recommendations for future actions. The projects are grouped into five general categories:

1) Monitoring Projects
2) Removal Projects and Evaluation
3) Barrier Effectiveness Evaluation
4) Gear Development and Effectiveness Evaluation
5) Alternative Pathway Surveillance.

A summary of the highlights of each project is presented below, intended to provide a brief snapshot of project accomplishments during 2016.

MONITORING PROJECTS

Seasonal Intensive Monitoring (SIM) in the CAWS **–** This project focuses on conducting two high-intensity monitoring events for Asian carp in the CAWS above the Electric Dispersal barrier. Monitoring is conducted in the spring and fall, in areas with historic detections of Asian carp or Asian carp eDNA.

- Completed 2-two week SIM events with conventional gears in the CAWS upstream of the Electric Dispersal Barrier in 2016.
- Estimated 2,278 person-hours were spent to complete 102 hours of electrofishing, set 85.8 km (53.3 mi) of trammel/gill net, 2.2 km (1.4 mi) of commercial seine and 3 tandem trap nets in 2016.
- Across all locations and gears in 2016, sampled 27,757 fish representing 59 species and 2 hybrid groups.

- Since 2010, an estimated 23,946 person-hours were spent to complete 977 hours of electrofishing, set 689.4 km (428.4 mi) of gill/trammel net and 6 km (5.1 mi) of commercial seine and tandem trap nets.
- A total of 342,476 fish representing 72 species and 6 hybrid groups were sampled, including 1,795 Banded Killifish (state threatened species) from 2010-2016
- Examined 106,290 young-of-year (YOY) Gizzard Shad since 2010 and found no Asian carp.
- Since 2010, 16 non-native species have been captured accounting for15% of the total fish caught and 22% of the total species.
- No Bighead Carp or Silver Carp have been captured or observed since 2011 (one Bighead Carp in Lake Calumet in 2010).
- Recommend continued use of SIM in the CAWS upstream of the Electric Dispersal Barrier for localized detection and removal of Asian carp.

***Strategy for eDNA Monitoring in the CAWS and Temporal eDNA Quantification Below the Electric Dispersal Barrier* –** This project continues eDNA monitoring in strategic locations in the IWW that will be used to provide information on the location of Asian carp.

CAWS Monitoring:

- One eDNA comprehensive sampling event took place in the CAWS at four regular monitoring sites in 2016, resulting in 240 samples collected and analyzed.
- Results: One positive detection for both species of carp DNA
- Since 2014, when more stringent disinfection protocols and new eDNA markers were implemented, 912 samples have been collected and processed. 31 samples were positive for Silver Carp and 2 samples were positive for Bighead Carp.

Below the Electric Dispersal Barrier Monitoring:

- Two eDNA sampling events took place in the Illinois Waterway from Lower Lockport Pool to the upper half of Dresden Island Pool and a portion of the Kankakee River above the dam in Wilmington, IL during April and September of 2016.
- 248 samples were collected pre-spawn in April: one sample was positive for Silver Carp DNA and zero samples were positive for Bighead Carp DNA. Three of the samples were inhibited, but were cleaned up to remove the inhibition and were still negative.
- 248 samples were collected in September, after the majority of spawning activity occurred: zero samples were positive for Silver or Bighead Carp DNA. 23 samples were inhibited, but clean up procedures removed inhibition and the samples were still negative. One sample was presumptively positive for Asian carp DNA, but did not confirm for either species.

***Larval Fish Monitoring in the Illinois Waterway* –** This project focuses on sampling larval Asian carp and Asian carp eggs. It provides crucial information on the location of breeding populations, the conditions that trigger spawning, and current population fronts.

- Over 770 ichthyoplankton samples were collected from 12 sites across the length of the Illinois Waterway during April – September 2016, capturing over 19,000 larval fish, including 2,000 larval Asian carp. Additionally, over 7,000 Asian carp eggs were collected in ichthyoplankton samples in 2016.
- Asian carp eggs were collected in the LaGrange, Peoria, Starved Rock, and Marseilles Pools during 2016. Asian carp larvae were only identified from the LaGrange and Peoria Pools. These results further confirm observations made in 2015 that Asian carp reproduction occurs in at least some years in the upper Illinois River. However, across 7 years of sampling, only 3 Asian carp larvae have ever been observed upstream of the Starved Rock Lock and Dam, suggesting that the majority of eggs spawned in the upper river are transported into downstream navigation pools before hatching.
- Asian carp had multiple spawning events in 2016, with eggs and larvae collected from late May to early July, and then again at the end of August. The early spawning activity appears to be associated with declining discharge. However, the late August spawn occurred following a rapid and steady increase in water levels.

Young-of-year and Juvenile Asian Carp Monitoring – Monitoring for small Asian carp is conducted during other sampling events, using gears targeted for small Asian carp. This project provides information on population fronts, recruitment, and the conditions and habitat required for successful recruitment.

- Sampled for young Asian carp from 2010 to 2016 throughout the CAWS, Des Plaines River, and Illinois River between river miles 83 and 334 by incorporating sampling from several existing monitoring projects.
- Sampled with active gears (trawls, pulsed-DC electrofishing, and beach seine) and passive gears (mini-fyke nets) in 2016.
- Completed 2,017 hours of electrofishing across all years and sites.
- Examined 343,922 Gizzard Shad <152 mm (6 in) long collected in the CAWS and Illinois Waterway upstream of Starved Rock Lock and Dam from 2010-2016.
- High catches of small Asian carp in 2014, moderate in 2015, and low in 2016 in the LaGrange Pool indicate three consecutive successful recruitment years despite limited to no recruitment in 2010-2013. However, total catch of small Asian carp varied by orders of magnitude between years.
- Farthest upstream catch was four Silver carp (6-12 inches) in the Marseilles Pool near Morris, IL, (river mile 263), which is consistent with observations from 2015 sampling.
- Recommend continued monitoring for young Asian carp

Distribution and Movement of Small Asian Carp in the Illinois Waterway – The purpose of this project is to establish where young Asian carp (YOY to age 2) occur in the IWW through intensive, directed sampling with gears that target these specific life stages.

- No small Asian carp (≤ 153 mm TL) were found above Peoria Pool during the 2016 field season.

- Nine juvenile Silver Carp (*Hypophthalmichthys molitrix*) were captured in Starved Rock Pool early in the 2016 field season (157–196 mm TL).

Monitoring Efforts Downstream of the Dispersal Barrier **–** This project includes monthly standardized monitoring with electrofishing gear and by commercial fishers at fixed and random sites downstream of the Electric Dispersal Barrier. It provides crucial information on the location of the Asian carp population front, population density, and specific habitats favored by Asian carp.

- From 2010 to 2016, an estimated 17,501 person-hours were spent sampling at fixed, random, targeted, and additional sites downstream of the Electric Dispersal Barrier.
- A project total of 700.5 hours of electrofishing, 1,092.7 km (679 miles) of trammel and gill nets, and 1,164 net nights of hoop netting and 552 net nights of mini-fyke netting were conducted.
- A project total of 234,064 fish were captured, representing 97 species and eight hybrid groups.
- Detectable population front of Asian carp located north of I-55 Bridge in Rock Run Rookery (near river mile 281; 46 miles from Lake Michigan). No appreciable change has been found in the upstream location of the population front in the past 10 years.

REMOVAL PROJECTS AND EVALUATION

Response Actions in the CAWS **–** This project uses a threshold framework to support decisions for response actions to remove any Asian carp from the CAWS upstream of the Electric Dispersal Barrier with conventional gear or rotenone.

- Based on the criteria of the Response Action Matrix no rapid response actions were conducted in the CAWS in 2016. Alternatively two SIM events were conducted in 2016 yielding no Bighead Carp or Silver Carp being captured or observed. Refer to the Seasonal Intensive Monitoring report for comprehensive results.
- A total of 240 early detection monitoring water samples for eDNA (250 ml each) were collected upstream of the dispersal barrier, centrifuged in the mobile lab, and analyzed at Whitney Genetics Lab. Two positive samples were found in 2016. Refer to the Strategy for eDNA Monitoring in the CAWS and Temporal eDNA Quantification Below the Electric Dispersal Barrier summary report for comprehensive results.
- From 2010-2012, there were eleven rapid response actions with conventional and experimental gears in the CAWS upstream of the Electric Dispersal Barrier Eight triggered by eDNA results. No Bighead or Silver Carp were captured or observed during these responses.
- We recommend full implementation of the Upper Illinois Waterway Contingency Response Plan to guide future responses.

Barrier Maintenance Fish Suppression **–** This project provides a fish suppression plan to support USACE during maintenance operations at the Electric Dispersal barrier. The plan includes sampling to detect Asian carp downstream of the barriers prior to turning off power, surveillance of the barrier zone with hydroacoustics, side-scan sonar, and DIDSON sonar during maintenance operations, and operations to clear fish from between barriers using mechanical or chemical means.

- The MRWG agency representatives met and discussed the risk level of Asian carp presence at the Electric Dispersal Barrier System at each primary barrier loss of power to water and determined that no barrier clearing actions were required.
- Two 15 minute electrofishing runs were completed between Barriers 2A and 2B to supplement existing data in support of the MRWG clearing decision.
- Split-beam hydroacoustics and side-scan sonar assessed the risk of large fish presence between the barriers on June 30, 2016; September 14, 2016; and January 11, 2017 indicating low fish abundance and no fish over 300 mm.
- No Asian carp were captured or observed during fish suppression operations.

Barrier Defense Asian Carp Removal Project – This program was established to reduce the numbers of Asian carp downstream of the Electric Dispersal Barrier through controlled commercial fishing. The intent of the project is to reduce the propagule pressure on the Electric Dispersal Barrier by reducing Asian carp populations in Dresden Island, Marseilles, and Starved Rock pools.

- Contracted commercial fishers deployed 1,803 miles (2901.6km) of gill/trammel net, 15.5 miles (24.9km) of commercial seine, 88 pound net nights and 1,354.2 hoop net nights in the upper Illinois Waterway since 2010.
- A total of 85,710 Bighead Carp, 474,264 Silver Carp, and 3,226 Grass Carp were removed by contracted commercial fishers from 2010-2016. The total weight of Asian carp removed was 2,504 tons.
- Recommend increased targeted harvest of Asian carp in the upper Illinois Waterway with contracted commercial fishers and assisting IDNR biologists. Potential benefits include reduced Asian carp abundance at and near the detectable population front and the possible prevention of further upstream movement of populations toward the Electric Dispersal Barrier and Lake Michigan.

Assessing Population, Movement, and Behavior of Asian Carp to Inform Control Strategies – This project encompasses multiple studies with the goal of determining estimates of Asian carp abundance, biomass, size structure, demographics, natal origin, and rates of hybridization. The results of the study will be used to create a spatially-explicit model of Asian carp populations, including an analysis of the probability of inter-pool travel.

- Water temperature and tailwater height are effective at predicting when Bighead and Silver Carp approach Starved Rock Lock and Dam, and gate openess is related to upstream passages through the dam. These predictors should be used to focus the use of additional barrier technologies (e.g., CO_2, complex sound) to specific times and river conditions, which would reduce costs and help minimize impacts on native species.

- Multistate models of Asian carp interpool movement rates were developed and used to parameterize the Asian carp population model. Long-term, pool-wide densities from hydroacoustic sampling were also used to parameterize the model.
- Marseilles pool underwent a 62% decrease in Asian carp density from 2015 to 2016. Declines occurred at three of the four areas sampled and were not driven solely by declines in the HMS West Pit following the unified fishing method. Asian carp densities in Dresden Island remained low in 2016 and were similar to 2015.
- Repeated hydroacoustic sampling in Dresden Island Pool during 2016 helped direct contracted fishing efforts to high-density sites as they changed throughout the year.
- A spatially explicit, stochastic, length structured population model was developed and used to predict the relative number of Asian carp in the vicinity of the Electric Dispersal Barrier on the Chicago Sanitary and Ship Canal under various harvest scenarios.
- Given limited available resources, model results indicate harvest in the upper pools may be the best strategy for reducing Asian carp approaching the CAWS.

BARRIER EFFECTIVENESS EVALUATION

***Telemetry*–** 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 or pass through navigation locks.

- To date, USACE has acquired 24.3 million detections from 557 tagged fish.
- No live tagged fish have crossed the Electric Dispersal Barriers in the upstream direction.
- High percentage of unique tags detected near the Electric Dispersal Barrier with low residency time.
- High percentage of detections occurred near fixed sites and low detections near the Electric Dispersal Barrier during winter months.
- Only two lock passages were observed with one Common Carp going up stream through the Brandon Road Lock and Dam and one Bighead Carp going downstream through the Dresden Island Lock and Dam.
- Asian carp continue to be detected throughout the Dresden Island Pool.
- The majority of Asian carp detections occur at Rock Run Rookery and near the Harborside Marina.
- A small percentage of Asian carp detections occurred in the Kankakee River.
- No Asian carp were detected at new receiver locations upstream of the Wilmington Dam.

***Understanding Surrogate Fish Movement with Barriers* -** This project monitors the movements of tagged surrogate species in Dresden Island, Brandon Road and Lockport pools and Rock Run Rookery to assess fish movement between barriers and structures (i.e. the Electric Dispersal

Barrier and locks and dams). Obtaining information on recapture rates of surrogate species helps verify sampling success using multiple gear types.

- Multiple agencies and stakeholders cooperated in successfully tagging 1,790 fish in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery (Between March 15, 2016 and December 02, 2016).
- A total of 192 fish were recaptured in 2016 using pulsed DC-electrofishing, gill nets, trammel nets and 6-foot diameter hoop nets.
- A total of 135 recaptures had tags but showed no movement between barrier structures, 47 recaptures were observed due to the presence of caudal fin clip but had no tag to show movement, and 10 recaptures showed movement through barrier structures and Lock and Dam Structures .
- One Common Carp with a floy tag showed upstream movement through the Lockport Lock.
- Recommend continued tagging of Common Carp, Bigmouth Buffalo, Smallmouth Buffalo, Black Buffalo and Common Carp x Goldfish hybrid using pulsed DC-electrofishing, gill nets, trammel nets and 6 foot diameter hoop nets to monitor fish movement between barrier structures.

Monitoring Fish Abundance and Spatial Distribution in Lockport, Brandon Road, and Dresden Island Pools and the Associated Lock and Dam Structures – This project uses numerous monitoring tools to assess fish populations near the Electric Dispersal Barrier in an attempt to identify seasonal and temporal trends for fish abundance near the barrier.

- Peak fish densities near the electric dispersal barrier were observed during late summer. Fish density remained relatively high during fall surveys.
- Fish surveys inside the Brandon Road lock suggested that density of fish was greater than observed in either Brandon Road or Dresden Island pool during all seasons.

Monitoring Fish Abundance, Behavior, and Barge Interactions at the Electric Dispersal Barrier, Chicago Sanitary and Ship Canal, Illinois – This project uses split-beam hydroacoustics, side-scan SONAR, DIDSON, and other monitoring tools to assess the ability of fish to pass through the Electric Dispersal barrier. In 2016, the project focused on assessing the possibility for barge movement to allow fish to pass through the Electric Dispersal Barrier due to entrainment.

- Based on the results of this study, the efficacy of the electric dispersal barrier in preventing upstream passage of small fish is compromised while tows are moving across the barrier system in the downstream direction. This observation of upstream fish passage identifies a potential pathway for the movement of invasive fishes through the electric dispersal barrier and into the Great Lakes.
- The identification of this pathway does not elevate the risk of invasive fish passage from current levels. Rather, it improves functional understanding of the efficacy of the electric

dispersal barrier, thereby enhancing the ability of invasive species managers to assess risk and implement appropriate actions.

Des Plaines River and Overflow Monitoring - This project included periodic monitoring for Asian carp presence and spawning activity, in the upper Des Plaines River downstream of the old Hofmann Dam site. In a second component, efficacy of the Des Plaines Bypass Barrier constructed between the Des Plaines River and CSSC was assessed by monitoring for any Asian carp juveniles that may be transported to the CSSC via laterally flowing Des Plaines River floodwaters passing through the barrier fence.

- Collected 6,656 fish representing 53 species and 3 hybrid groups from 2011-2015 via electrofishing (45.03 hours) and gill netting (131 sets; 16,084 yards).
- No Bighead or Silver Carp have been captured or observed through all years of sampling.
- One Grass Carp was captured in 2015. Analysis indicated it was triploid. All six Grass Carp tested since 2013 have been triploid.

Analysis of Feral Grass Carp in the CAWS and Upper Illinois River - In 2016, a new monitoring project was undertaken to analyze Grass Carp populations in the Upper IWW and CAWS. The primary goal of this project was to analyze Grass Carp within the IWW and CAWS through a protocol to determine life history traits and population dynamics. Due to the interest in Grass Carp movement, Grass Carp captured below the USACE Electric Dispersal Barrier were implanted with acoustic telemetry tags and monitored for movement patterns and habitat preference using the current telemetry array established within the Upper IWW.

- 35 total Grass Carp were captured and analyzed for ploidy and life history traits.
- 80% of the Grass Carp were diploid.
- The mean age of Grass Carp was 10.7 ± 1.1 years.
- 4 diploid Grass Carp were captured within the CAWS, above the USACE's electric dispersal barrier.
- No pool to pool movement from telemetered Grass Carp tagged in Marseilles Pool (n = 3) and Dresden Island Pool (n = 6).
- Mean upstream movement from release was 0.51 ± 0.08 (Standard Error (SE)) miles.
- Mean downstream movement from release was 2.87 ± 0.85 (SE) miles.

GEAR DEVELOPMENT AND EFFECTIVENESS EVALUATION

Evaluation of Gear Efficiency and Asian Carp Detectability - This project assessed the efficiency and detection probability of gears currently used for Asian carp monitoring (e.g., DC electrofishing, gill nets, and trammel nets) and others potential gears (e.g., mini-fyke nets, hoop nets, trap nets, seines, and cast nets) by sampling at 4 sites in the Illinois River selected to evaluate capture of juvenile Asian carp. Results will inform decisions on appropriate levels of sampling effort and monitoring regimes, and ultimately improve Asian carp monitoring and control efforts.

- Catches of juvenile Silver Carp were substantially lower in 2016 than in 2014 and 2015. Low catches of juvenile Asian Carp during 2016 reflect the overall lower number of larval Asian carp collected during larval monitoring (see Larval Fish Monitoring in the Illinois Waterway).
- During 2016, mini-fyke nets collected the highest total numbers of age-0 Silver Carp and detected Silver Carp in 8 of 8 sampling events, whereas beach seines collected much lower numbers of age-0 Silver Carp and detected Silver Carp in 5 of 8 sampling events. Pulsed-DC electrofishing only captured a single age-0 Silver Carp during 2016.
- Age-0 Silver Carp averaged 31 mm during August sampling and 50 mm during October sampling. Similar sizes of Silver Carp were captured in mini-fyke nets and beach seines in 2016.

Gear Evaluation for Removal and Monitoring of Asian Carp Species - Innovative techniques are being developed and evaluated for their ability to detect, monitor, and remove invasive carp of all sizes in varying habitats. If effective, gears may be incorporated into risk assessment and management plans of these nuisance fish. In 2016, this project focused on evaluating the effectiveness of novel trawling techniques for capturing different size classes of Asian carp.

- All gears are capable of catching Silver Carp but differences exist in the catch rates and the ability of each gear to sample all size classes.
- Early evidence demonstrates that the paupier and dozer trawl have the highest potential for detecting Silver Carp within a system.
- Early evidence demonstrates that the paupier has the highest potential for detecting Silver Carp less than 200 mm within a system.
- Paupier sampled all size classes of Silver Carp and had the highest catch rate for Silver Carp followed by the dozer trawl, traditional electrofishing, and finally the surface trawl.
- Surface trawl was limited to catching Silver Carp less than 400 mm.
- Traditional electrofishing Silver Carp catch rate was higher near shore than in the open water.

Unconventional Gear Development - The goal of this project is to develop an effective trap or netting method capable of capturing low densities of Asian carp in the deep-draft canal and river habitats of the CAWS, lower Des Plaines River, upper Illinois River, and possible Great Lakes spawning rivers.

- Pound nets are being used for ongoing research, monitoring, and control efforts on the Illinois Waterway. Pound nets are being used in collaboration with USGS to test feeding attractants and sound stimuli for attracting/deterring Asian carp, and are being used by ILDNR for Asian carp removal purposes

Monitoring Asian Carp Using Netting with Supplemental Capture Techniques - The purpose of this project is to evaluate the use of supplemental techniques to improve the effectiveness of net gears for capturing Asian carp. Electrofishing and sound are being evaluated as supplemental capture techniques.

- 55 net sets and 17,400 yards of net were deployed throughout 7 fixed sites
- 1,394 fish (1,229 Asian carp) were captured at fixed sites during technique evaluation
- Complex sound and electrofishing Asian carp CPUE were statistically different than control CPUE
- Supplemental capture techniques were not statically significant based on CPUE when neglecting control
- 72 Fish were captured during monitoring in the upper IWW pools
- The furthest upstream Silver carp captured was at RM 275 in Dresden Island
- Floating trammel nets deployed in the upper pools yeilded zero fish captures

Barrier Defense Removal of Asian Carp Using Novel Gear - This project used an electrified paupier in conjunction with other barrier defense efforts to remove Asian carp at their leading edge in the Illinois River. The paupier is a modified frame trawl developed specifically for the capture of Asian carp.

- Sixteen days of effort removed an estimated 29.8 tons of Asian Carp, 99.9% of which were comprised of Silver Carp, from the Starved Rock and Marseilles pools.
- The electrified paupier captured Silver Carp ranging from 183 millimeters (mm) to 850 mm from the Starved Rock and Marseilles pools.
- The electrified paupier performed in a variety of habitat types. Flowing habitats, typically too swift for gill nets to fish, had the least bycatch and highest percent Silver Carp catch.

ALTERNATIVE PATHWAY SURVEILLANCE

Alternative Pathway Surveillance in Illinois – Law Enforcement - This project creates 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. A second component conducts surveys at urban fishing ponds in the Chicago Metropolitan area included in the IDNR Urban Fishing Program as well as ponds with positive detections for Asian carp eDNA using conventional gears (electrofishing and trammel/gill nets) in an effort to remove potential accidentally stocked Bighead or Silver Carp.

- The ISU investigated a fish dealer in Northern Illinois who illegally imported over 600 Grass Carp from Arkansas into Illinois and stocked them in 27 different lakes and ponds.

The dealer submitted falsified documents to the IDNR, and still imported the fish after his application was denied. The Invasive Species Unit (ISU) also obtained invoices showing the dealer imported 1500 Crappie into Illinois from Missouri without the required VHS import permit. The case is currently pending with the Illinois Attorney General's Office.

- The ISU obtained business records and a confession from a Missouri fish dealer who illegally imported 1600 pounds of live Channel Catfish into Illinois from Arkansas without the required VHS import permit. The case is pending with the Illinois Attorney General's Office.
- A Kentucky bait dealer pled guilty in Federal court for selling Rusty Crayfish in Illinois and was fined $1,500. This was a result of covert investigation conducted by the ISU with the assistance of the USFWS.
- The ISU executed a search warrant on a fish processing plant and conducted a complex inventory audit of the plant records based upon allegations the fish dealer was selling Asian Carp provided by contracted IDNR commercial fishers for human consumption instead of fertilizer, in violation of the contract terms between the IDNR and the fish dealer. The investigation revealed the dealer sold over $10,500,000 in fish over a two year period without the required fish dealer's license or maintaining the proper business records; the company violated environmental regulations; the company had over 2.5 million pounds of bighead and silver carp acquisitions and disbursements unaccounted for from January 2014 through May 2016.
- ISU investigated a Kentucky fish dealer for importing and selling largemouth bass without VHS import permits or non-resident aquatic life dealer's license. The dealer imported 14,000 pounds of untested noncertified largemouth bass from a university aquaculture facility in Kentucky to Chinatown in Chicago. A tentative agreement between the company and the Illinois Attorney General's Office is for the company to pay $10,000 in restitution to the State of Illinois.
- ISU investigated a Kentucky resident for importing and selling largemouth bass without VHS import permits or a non-resident aquatic life dealer's license. A tentative agreement has been reached through the Illinois Attorney General's Office and the Kentucky fish dealer to pay $4,000 in restitution.

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring – This project focuses on sampling and removing Asian carp from urban fishing ponds in the Chicago area, to prevent the potential incidental or intentional transport of fish from these ponds to the CAWS or Lake Michigan.

- Thirty-two Bighead Carp have been removed from five Chicago area ponds using electrofishing and trammel/gill nets since 2011; three of which are on display at the Shedd Aquarium in Chicago.
- Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have also been removed from Chicago area ponds.

- Eighteen of the 21 IDNR Chicago Urban Fishing Program ponds have been sampled with nets and electrofishing.
- All eight Chicago area fishing ponds with positive Asian carp eDNA detections have been sampled with electrofishing and trammel/gill nets.

INTRODUCTION

The 2016 Interim Summary Report (ISR) presents a comprehensive accounting of project results from activities completed by the Asian carp Monitoring and Response Workgroup in 2016. These projects have been carefully selected and tailored to contribute to the overall goal of preventing Asian carp from establishing self-sustaining populations in the Chicago Area Waterway System (CAWS) and Lake Michigan. Efforts to prevent the spread of Asian carp to the Great Lakes have been underway for over 7 years. Over the course of this time, goals, objectives, and strategic approaches have been refined to focus on five key objectives:

1) Determination of the distribution and abundance of any Asian carp in the CAWS, and use this information to inform response removal actions;
2) Removal of any Asian carp found in the CAWS to the maximum extent practicable;
3) Identification, assessment, and reaction to any vulnerability in the current system of barriers to prevent Asian carp from moving into the CAWS;
4) Determination of the leading edge of major Asian carp populations in the Illinois River and the reproductive successes of those populations; and
5) Improvement of the understanding of factors behind the likelihood that Asian carp could become established in the Great Lakes.

The projects presented in this document represent the results of efforts undertaken during 2016 to further the implementation of each of these objectives.

BACKGROUND

The term "Asian carp" generally refers to four species of carp native to central and eastern Asia that were introduced to the waters of the United States and have become highly invasive. The four species generally referred to with the "Asian carp" moniker are Bighead Carp (*Hypophthalmicthys nobilis*), Silver Carp (*Hypophthalmicthys molitrix*), Grass Carp (*Ctenopharyngodon idella*), and Black Carp (*Mylopharyngodon piceus*). In this document, the term "Asian carp" refers only to Bighead Carp and Silver Carp, except where otherwise specifically noted.

Asian carp are native to central and eastern Asia, with wide distribution throughout eastern China. They typically live in river systems, and in their native habitats have predators and competitors that are well adapted to compete with Asian carp for food sources, thus limiting their population growth. In the early 1970s, Asian carp were intentionally imported to the US for use in aquaculture and wastewater treatment detention ponds. In these settings, Asian carp were used to control the growth of weeds and algae and pests. Flooding events allowed for the passage of Asian carp from isolated detention ponds to natural river systems. By 1980, Asian carp had been captured by fishers in river systems in states including Arkansas, Louisiana, and

Kentucky. Flooding events during the 1980s and 1990s allowed Asian carp to greatly expand their range in natural river systems. Asian carp are currently wide-spread in the Mississippi River basin, including the Ohio River, Missouri River, and Illinois River. Areas with large populations of Asian carp have seen an upheaval of native ecosystem structure and function. Asian carp are voracious consumers of phytoplankton, zooplankton, and macroinvertebrates. They grow quickly and are highly adapted for feeding on these organisms, allowing them to outcompete native species, and quickly grow too large for most native predators to prey upon. As a result, their populations have exploded in the Mississippi River basin.

The expansion of Asian carp populations throughout the central US has had enormous impacts on local ecosystems and economies. Where Asian carp are present, the native ecosystems have been altered, resulting in changes to the populations and community structure of aquatic organisms. The trademark leaping behavior of silver carp when startled has also impacted recreational activities where they are populous, presenting a new danger to people on the water. Current academic studies estimate that the adverse economic impact of Asian carp is in the range of billions of dollars per year. A central focus of governmental agencies is preventing the spread of Asian carp to the Great Lakes. Ecological and economic models forecast that the introduction of Asian carp to the Great Lakes could have enormous impacts.

In response to the threat posed to the Great Lakes by Asian carp, the Asian Carp Regional Coordinating Committee and the Asian Carp Monitoring and Response Workgroup present the following projects to further the understanding of Asian carp, improve methods for capturing Asian carp, and directly combat the expansion of Asian carp range.

MONITORING PROJECTS

Seasonal Intensive Monitoring in the CAWS

Kevin Irons, Matt O'Hara, Justin Widloe, Tristan Widloe, Blake Bushman, Brennan Caputo, Rebekah Haun, Nathan Lederman, Seth Love, Luke Nelson
(Illinois Department of Natural Resources)

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

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

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

Objectives:

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

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

Project Highlights:

- Completed 2-two week SIM events with conventional gears in the CAWS upstream of the Electric Dispersal Barrier in 2016.
- Estimated 2,278 person-hours were spent to complete 102 hours of electrofishing, set 85.8 km (53.3 mi) of trammel/gill net, 2.2 km (1.4 mi) of commercial seine and 3 tandem trap nets in 2016.
- Across all locations and gears in 2016, sampled 27,757 fish representing 59 species and 2 hybrid groups.
- Since 2010, an estimate 23,946 person-hours were spent to complete 977 hours of electrofishing, set 689.4 km (428.4 mi) of gill/trammel net and 6 km (5.1 mi) of commercial seine and tandem trap nets.
- A total of 342,476 fish representing 72 species and 6 hybrid groups were sampled, including 1,795 Banded Killifish (state threatened species) from 2010-2016
- Examined 106,290 YOY Gizzard Shad since 2010 and found no Asian carp.
- Since 2010, 16 non-native species have been captured accounting for15% of the total fish caught and 22% of the total species.
- No Bighead Carp or Silver Carp have been captured or observed since 2011 (one Bighead Carp in Lake Calumet in 2010).
- Recommend continued use of SIM in the CAWS upstream of the Electric Dispersal Barrier for localized detection and removal of Asian carp.

Methods:

Pulsed DC-electrofishing, trammel and gill nets, deep water gill nets, tandem trap nets and a commercial seine were used to monitor for Asian carp in the CAWS upstream of the Electric Dispersal Barrier (Figure 1). Trammel and gill nets were 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). Deep water gill nets were 9.1 m (30 ft) deep x 91.4 m (300 ft) long with bar mesh sizes ranging from 69.9-88.9 mm (2.75-3.5 in). The commercial seine was 9.1 m (30 ft) deep x 731.5 m (2400 ft) long and had a cod end made of 50.8 mm (2.0 in) bar mesh netting. The goal was to complete a minimum of 150 electrofishing runs and 150 net sets (trammel/gill nets, deep water gill nets) during each two week event.

Seasonal Intensive Monitoring in the CAWS

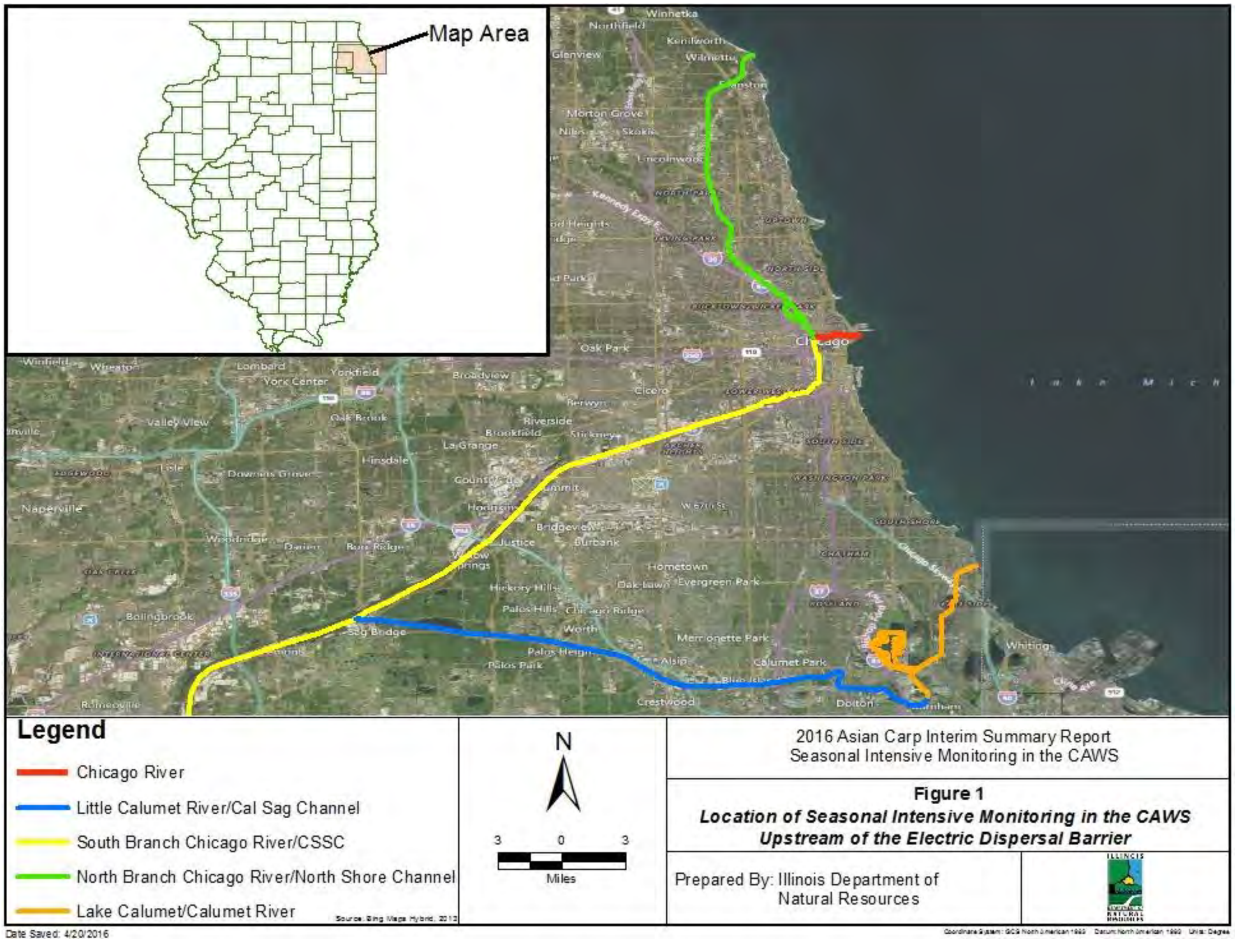

Figure 1. *Location of SIM in the CAWS upstream of the Electric Dispersal Barrier.*

Electrofishing Protocol – Each boat used pulsed DC-electrofishing with two dip-netters to collect stunned fish. Location of each electrofishing transect was identified with GPS coordinates. Electrofishing runs began at each coordinate and continued for 15 minutes in a downstream direction in waterway main channels (including following the shoreline into off-channel areas) or in a counter-clockwise direction in Lake Calumet. Adult Common Carp were counted without capture and all other fish were netted and placed in a holding tank and then identified and counted, after which they were be returned live to the water. Due to similarities in appearance and habitat use young-of-year (YOY) Gizzard Shad < 152.4 mm (6 in) long were examined closely for the presence of YOY Asian carp and enumerated.

Netting Protocol – Contracted commercial fishers were used for net sampling at fixed and random sites. Sets were 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 trimmed up motors). In Lake Calumet, a 731.5 m (2400 ft) commercial seine was also used. Nets were attended at all times. Locations for each net set were located and identified with GPS coordinates. Captured fish were identified to species, enumerated and released.

Decontamination Protocol: Consistent with findings from the 2013 ECALS, the potential for Asian carp genetic material in eDNA samples exists as the result of residual material on sampling equipment (boats, netting gear, etc.). Efforts were taken monitoring upstream of the Electric Dispersal Barrier in 2013 to minimize the potential for eDNA contamination. In response to these findings the MRWG developed a Hazard Analysis and Critical Control Points (HACCP) plan to address the transport of eDNA and unwanted aquatic nuisance species. The decontamination protocol included the use of hot water pressure washing and chlorine washing (10% solution) of boats and potentially contaminated equipment for all agency boats participating in the SIM (*see* Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System (MRP), Best Management Practices to Prevent the Spread of Aquatic Nuisance Species during Asian Carp Monitoring an Response Field Activities). Additionally, IDNR and contracted commercial fishers used nets that are site-specific to the CAWS and will only be used for monitoring efforts upstream of the Electric Dispersal Barrier.

Results and Discussion:

SIM took place during the weeks of June 13th, June 20th, September 19th and September 26th upstream of the Electric Dispersal Barrier. As established in the 2014 MRP, sampling for Bighead Carp and Silver Carp eDNA preceded SIM (*see* Strategy for eDNA Monitoring in the CAWS interim summary). To continually focus additional monitoring effort on the leading edge of the Asian carp population below the Electric Dispersal Barrier, the same reduced sampling effort protocols established in 2014 upstream of the barrier (CAWS) were followed in 2016 (Figure 2). Effort in 2016 was 102 hours of electrofishing (407 transects) with an estimated 990 person-hours, 85.8 km (53.3 mi) of trammel/gill netting (498 sets) and 2.2 km (1.4 mi) of commercial seine with an estimated 1,125 and 135 person-hours utilized (Table 1.) Across all locations and gears, 27,757 fish representing 59 species and 2 hybrid groups were sampled in 2016. Gizzard Shad and Common Carp were the predominant species, comprising 58% of all fish sampled. 10 non-native species were also sampled, which included Common Carp and hybrids, Round Goby, Alewife, Goldfish, White Perch, Oriental Weatherfish, Grass Carp, Chinook Salmon, Coho Salmon, and Rainbow Trout. Non-native species made up 17% of the total species collected and 21% of the total fish in 2016. Seventy-two (72) Banded Killifish, a state threatened species, were also collected. They were identified and returned to the water alive. No Bighead Carp or Silver Carp were captured or observed during SIM in 2016. In addition, we examined 6,976 young of the year (YOY) Gizzard Shad and found no YOY Asian carp.

Since 2010, an estimated 23,946 person-hours were expended monitoring fixed and random sites in the CAWS upstream of the Electric Dispersal Barrier. Total effort was 977 hours of electrofishing (3,893 transects), 689.2 km (428.3 mi) of gill/trammel net (3,634 sets), 8.2 km (5.1 mi) of commercial seine hauls and 25.2 net-days of hoop and trap nets (11sets) from 2010-2016

(Table 2). The use of hoop nets was suspended after 2013 due to low gear efficiency. A total of 342,476 fish representing 72 species and 6 hybrid groups have been sampled since 2010 (Table 3). Gizzard Shad, Common Carp, Bluegill, Largemouth Bass, Bluntnose Minnow, Pumpkinseed were the predominant species sampled, accounting for 80% of all fish collected. Since 2010, 16 non-native species have been caught, which include Common Carp and hybrids, Alewife, Goldfish, White Perch, Round Goby, Oriental Weatherfish, Chinook Salmon, Threadfin Shad, Rainbow Trout, Grass Carp, Brown Trout, Coho Salmon, Tilapia, Rainbow Smelt, Silver Arrowana and Threespine Stickleback. Non-native species constitute 15% of the total fish caught and 22% of the total species. Banded Killifish, a state threatened species, have been routinely collected during our monitoring efforts in the CAWS. To date, 1,795 Banded Killifish have been sampled at fixed and random sites upstream of the Electric Dispersal Barrier. No Bighead Carp or Silver Carp were captured or observed in the CAWS upstream of the Electric Dispersal Barrier from 2011-2016. One Bighead Carp was caught in a trammel net in Lake Calumet in 2010. Furthermore, 28,348 YOY Gizzard Shad have been examined since 2014 with no YOY Asian carp being identified.

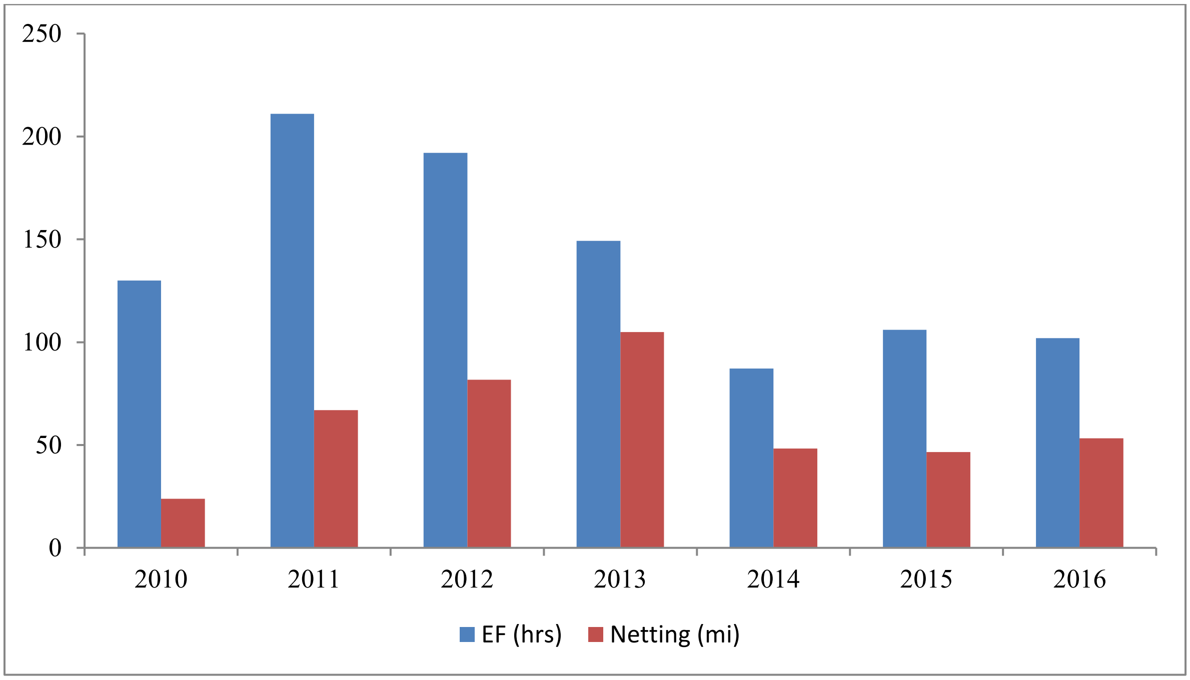

Figure 2. *Total electrofishing and trammel/gill netting effort at fixed and random sites in the CAWS upstream of the Electric Dispersal Barrier, 2010-2016.*

Recommendation:

We recommend continued use of SIM in the CAWS upstream of the Electric Dispersal Barrier. SIM with conventional gears represents the best available tool for localized detection and removal of Asian carp to prevent them from becoming established in the CAWS or Lake Michigan. Furthermore, we recommend continued assessment of experimental gears during SIM as an alternative means for capturing Asian carp.

Seasonal Intensive Monitoring in the CAWS

Table 1. *Summary of effort and catch data for Seasonal Intensive Monitoring in the CAWS upstream of the Electric Dispersal Barrier 2016.*

	Lake Calumet/Calumet River	Little Calumet River/Cal Sag	S. Branch Chi. River/CSSC	Chicago River	N. Branch Chi. River/N. Shore	Total
Electrofishing Effort						
Estimated person-hours	450	142.5	142.5	25	230	990
Samples (transects)	171	56	58	16	106	407
Electrofishing hours	42.75	14	14.5	4	26.5	102
Electrofishing Catch						
All fish (*N*)	7,328	5,789	3,174	835	5,431	22,557
Species (*N*)	48	40	24	15	37	59
Hybrids (*N*)	1	0	2	0	0	2
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/hr)	171.4	413.5	218.9	208.8	204.9	243.5

Netting Effort						
Estimated person-hours	350	220	260	30	265	1,125
Samples (net sets)	156	90	120	10	122	498
Miles of net	17.7	10.2	13.3	0.6	11.5	53.3
Netting Catch						
All fish (*N*)	494	225	257	26	281	1,283
Species (*N*)	15	13	5	4	5	17
Hybrids (*N*)	0	1	1	0	1	1
Bighead Carp (*N*)	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0
CPUE (fish/100 yds of net)	1.6	1.3	1.1	2.6	1.4	1.6

Seine Effort						
Estimated person-hours	135	-	-	-	-	135
Samples (seine hauls)	3	-	-	-	-	3
Miles of seine	1.4	-	-	-	-	1.4
Seine Catch		-	-	-	-	
All fish (*N*)	16	-	-	-	-	16
Species (*N*)	3765	-	-	-	-	3765
Hybrids (*N*)	0	-	-	-	-	0
Bighead Carp (*N*)	0	-	-	-	-	0
Silver Carp (*N*)	0	-	-	-	-	0
CPUE (fish/seine haul)	1,255	-	-	-	-	1,255

Table 1. *Continued.*

	Lake Calumet/Calumet River	Little Calumet River/Cal Sag	S. Branch Chi. River/CSSC	Chicago River	N. Branch Chi. River/N. Shore	Total
Tandem Trap Net						
Estimated person-hours	28	-	-	-	-	28
Samples	3	-	-	-	-	3
Net nights	12	-	-	-	-	12
Trap Net Catch		-	-	-	-	
All fish (*N*)	142	-	-	-	-	142
Species (*N*)	17	-	-	-	-	17
Hybrids (*N*)	0	-	-	-	-	0
Bighead Carp (*N*)	0	-	-	-	-	0
Silver Carp (*N*)	0	-	-	-	-	0
CPUE (fish/hr)	5	-	-	-	-	5

Seasonal Intensive Monitoring in the CAWS

Table 2. *Summary of effort and catch data for all fixed and random site monitoring in the CAWS upstream of the Electric Dispersal Barrier, 2010-2016.*

	2010	2011	2012	2013	2014	2015	2016	Total
Electrofishing Effort								
Estimated person-hours	1,280	2,180	4,330	1,528	945	990	990	12,243
Samples (transects)	519	844	765	588	348	422	407	3,893
EF (hrs)	130.0	211.0	192.0	149.3	87.1	106.0	102.0	977.4
Electrofishing Catch								
All fish (*N*)	33,688	52,385	97,510	45,443	24,492	28,549	22,557	304,624
Species (*N*)	51	58	59	56	56	61	59	69
Hybrids (*N*)	3	3	3	2	2	2	2	6
Bighead Carp (*N*)	0	0	0	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0	0	0	0
CPUE (fish/hr)	259.1	248.3	507.9	304.4	281.2	269.3	221.1	311.7
Netting Effort								
Estimated person-hours	885	1,725	3,188	1,932	1,125	1,125	1,125	11,105
Samples (net sets)	208	389	699	959	440	445	498	3,638
TRA/GIL (mi)	23.8	67.0	81.7	104.9	48.2	46.6	53.3	425.5
Netting Catch								
All fish (*N*)	2,439	4,923	3,060	4,195	1,461	1,062	1,283	18,423
Species (*N*)	17	20	20	30	18	13	18	32
Hybrids (*N*)	1	1	1	1	1	1	1	1
Bighead Carp (*N*)	1	0	0	0	0	0	0	1
Silver Carp (*N*)	0	0	0	0	0	0	0	0
CPUE (fish/100 yds of net)	5.8	4.2	2.1	2.3	1.7	1.3	1.4	3.2
Seine Effort								
Estimated person-hours	-	-	-	135	135	135	135	540
Samples (seine hauls)	-	-	-	3	2	3	3	7
Miles of seine	-	-	-	1.4	0.9	1.4	1.4	2.3
Seine Catch								
All fish (*N*)	-	-	-	7,577	1,725	5,989	3,765	19,056
Species (*N*)	-	-	-	15	11	14	15	16
Hybrids (*N*)	-	-	-	1	0	0	0	1
Bighead Carp (*N*)	-	-	-	0	0	0		0
Silver Carp (*N*)	-	-	-	0	0	0		0
CPUE (fish/seine haul)	-	-	-	2,525.7	862.5	1,996.3	1,255.0	2,722.3

Table 2. *Continued.*

	2010	2011	2012	2013	2014	2015	2016	Total
Hoop/Trap Net/Tandem Trap Net								
Estimated person-hours	-	-	-	-	-	30	28	-
Samples (sets)	-	-	-	11	-	4	3	11
Net-days	-	-	-	25.2	-	16	12	25.2
All fish (*N*)	-	-	-	93	-	172	102	367
Species (*N*)	-	-	-	17	-	17	15	17
Hybrids (*N*)	-	-	-	0	-	0	-	0
Bighead Carp (*N*)	-	-	-	0	-	0	-	0
Silver Carp (*N*)	-	-	-	0	-	0	-	0
CPUE (fish/net-day)	-	-	-	3.7	-	10.75	8.5	6.5

Table 3. *Total number of fish captured with electrofishing, trammel/gill nets and commercial seine in the CAWS upstream of the Electric Dispersal Barrier during Seasonal Intensive Monitoring, 2016. I = introduced species, ST = state threatened species.*

	Lake Calumet/ Calumet River				Little Calumet River/Cal Sag		S. Branch Chi River/CSSC		Chicago River		N. Branch Chi River/N. Shore		
Species	Electro-fishing	Trammel/Gill Net	Commercial Seine	Tandem Trap Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	All Sites
Gizzard Shad < 6 in	713				2840	24	1347		265		1787		6976
Common carp	980	250	26	58	1145	180	1016	253	468	25	1031	273	5705
Gizzard shad	344	1	1595	4	713	4	177		53		343		3234
Yellow perch	1285			1	30		6				6		1328
Largemouth bass	711	1	4	22	249	2	35		16		258		1298
Channel catfish	74	7	1045	22	34	2	11	2	1		17	4	1219
White sucker	114				38	1	14		2		943		1112
Pumpkinseed	606			4	235	1	52		5		86		989
Freshwater drum	89	138	704	1	44	5				1	3	3	988
Bluegill	298			2	49		141		15		247		752
Smallmouth buffalo	202	38	370	7	3	1		1					622
Golden shiner	101				73		122		3		299		598
Black bullhead	351		1		12		16				41		421
Smallmouth bass	360		4		12		25						401
Rock bass	342				1						15		358
Bluntnose minnow	199				25		4				95		323
Emerald shiner	75				67		34				65		241
Yellow bullhead	34			1	18		46		1		21		121
Green sunfish	74				5	1	4		1		28		113
Western mosquitofish							93						93
Brook silverside	45				36		5		2				88
Goldfish	28				22		8				29		87
Spotfin shiner	11				36		5				26		78
White bass	36		3	7	24		2				2		74
Banded killifish	40				19		4				9		72
Black buffalo	18	42	1										61
Round Goby	40				3				1		2		46
Fathead minnow	6				14						18		38
Brown bullhead	35												35
Black crappie	7		1		2						19		29
Quillback	26	1		1							1		29
Bowfin	24	1			1								26
Bigmouth buffalo	1	8	15			1							25
White perch	13			4	6								23
Alewife	11								2		7		20
Spottail shiner	1				3						11		15
Oriental Weatherfish	4						1				8		13
River carpsucker	7	1	3		1								12
Orangespotted sunfish	1			5	2						1		9
Flathead catfish	2	5	1										8
Northern pike			2	3							3		8
Yellow bass					7	1							8
Bullhead minnow					6						1		7
Skipjack herring	6										1		7
Carp x goldfish hybrid	1					2	1	1				1	6
Creek chub	2				4								6
Hybrid Sunfish							5						5
Walleye		1			1						3		5
Blackstripe topminnow	1										2		3
Longear sunfish					3								3
Rainbow trout	3												3
White crappie	1				2								3
Central mudminnow											2		2
Chinook Salmon	2												2
Grass carp					2								2
Central stoneroller	1												1
Coho salmon											1		1
Golden redhorse	1												1
Mottled sculpin	1												1
River shiner					1								1
Shortnose gar					1								1

Table 3. *Continued.*

	Lake Calumet/ Calumet River				**Little Calumet**		**S. Branch Chi**		**Chicago River**		**N. Branch Chi**		
Species	Electro-fishing	Trammel/Gill Net	Commercial Seine	Tandem Trap Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	Electro-fishing	Trammel/ Gill Net	
Silver redhorse	1												1
Total fish	7,328	494	3,775	142	5,789	174	3,174	175	835	26	5,431	281	35,728
Species (*N*)	47	11	14	16	48	10	36	3	10	1	32	4	61
Hybrids (*N*)	1	1	1	-	1	1	2	-	-	-	-	-	2

Strategy for eDNA Monitoring in the CAWS and Temporal eDNA Quantification Below the Electric Dispersal Barrier

Kelly Baerwaldt, Jenna Merry, and Emy Monroe
(U.S. Fish and Wildlife Service)

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

ADDITIONAL INFORMATION
- Link to mapping tool - Link to 2017 plan

Introduction and Need:
Monitoring has been essential to determine the effectiveness of efforts to prevent self-sustaining populations of Asian carp from establishing in the Great Lakes. Environmental DNA (eDNA) has been used as a surveillance tool to monitor for genetic presence of Bighead Carp and Silver Carp in the Chicago Area Waterway System (CAWS) and the Illinois Waterway since 2009.

Objectives:

(1) Monitor Asian carp DNA in strategic locations in the CAWS to potentially inform status of Asian carp.
(2) Detect Asian carp DNA in areas that have been monitored since 2009 to maintain annual data collection which may inform future work in the CAWS.
(3) Detect Asian carp DNA in areas of the Illinois Waterway below the electric dispersal barrier to compliment other field efforts in those areas and potentially inform future control or management actions.

Project Highlights:
CAWS Monitoring:

- One eDNA comprehensive sampling event took place in the CAWS at four regular monitoring sites in 2016, resulting in 240 samples collected and analyzed.
- Results: One positive detection for both species of carp DNA
- Since 2014, when more stringent disinfection protocols and new eDNA markers were implemented, 912 samples have been collected and processed. 31 samples were positive for Silver Carp and 2 samples were positive for Bighead Carp.

Below the Electric Dispersal Barrier Monitoring:

- Two eDNA sampling events took place in the Illinois Waterway from Lower Lockport Pool to the upper half of Dresden Island Pool and a portion of the Kankakee River above the dam in Wilmington, IL during April and September of 2016.
- 248 samples were collected pre-spawn in April: one sample was positive for Silver Carp DNA and zero samples were positive for Bighead Carp DNA. Three of the samples were inhibited, but were cleaned up to remove the inhibition and were still negative.

- 248 samples were collected in September, after the majority of spawning activity occurred: zero samples were positive for Silver or Bighead Carp DNA. 23 samples were inhibited, but clean up procedures removed inhibition and the samples were still negative. One sample was presumptively positive for Asian carp DNA, but did not confirm for either species.

Methods:
The CAWS was sampled for eDNA of Bighead Carp and Silver Carp on one occasion in June 2016. Sampling immediately preceded Seasonal Intensive Monitoring in the CAWS. The Illinois Waterway, below the electric dispersal barrier, was sampled in April and September. The timing of the events below the barrier was to capture pre- and post-spawn conditions.

Similar to previous years, sample collection and processing followed the Quality Assurance Project Plan (QAPP) (http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf). New in 2016, the use of iPads for data collection was implemented with success.

FWS crews collected 240 samples (including field blanks) in four reaches of the CAWS; 60 samples each from North Shore Channel, South Branch Chicago River to the Chicago Lock, Little Calumet River downstream of O'Brien Lock and Dam, and Lake Calumet. FWS crews also collected 248 samples (including blanks) in April and in September below the electric dispersal barrier from lower Lockport Pool to the upper half of Dresden Island Pool, and a portion of the Kankakee River above the dam in Wilmington, Illinois. All samples were procedurally collected and centrifuged in a mobile eDNA trailer according to the QAPP. Samples were preserved with ethanol until they were delivered to Whitney Genetics Lab (WGL) for analysis. Although sampling below the electric dispersal barrier was not considered part of the early detection and monitoring program, Asian carp have been historically scarce or undocumented in some portions of the 2016 sampling reach. Therefore sampling below the barrier differed from 2015 and samples were collected in a manner similar to early detection efforts, with each sample consisting of 250mL of water instead of 50mL as was done the previous year.

The state of Illinois was notified of results from the CAWS following our Communication Protocol (http://www.fws.gov/midwest/fisheries/eDNA/documents/QAPP.pdf) after sample processing was complete. Results (CAWS) were then posted online. Results from the Illinois Waterway below the electric dispersal barrier are provided in this report, and were not posted online.

Results and Discussion:
CAWS:
A total of 240 early detection monitoring samples (250ml each) were collected upstream of the electric dispersal barrier, centrifuged in the mobile lab, and analyzed at WGL. One sample was

positive for both Silver Carp and Bighead Carp DNA. All eDNA results are available at: http://www.fws.gov/midwest/fisheries/eDNA/Results-chicago-area.html. While it cannot be ruled out that live fish caused the positive sample, the low number of positive samples over the last two years seems to indicate that the system has an occasional low eDNA baseline, which can be contributed to by other vectors. Low detection rates over the last two years and are likely a reflection of improved eDNA markers, the change to clean nets by commercial fishers in 2013, and additional equipment decontamination protocols implemented at that time, which has resulted in a reduction of eDNA loading to the system and an overall lower baseline level of eDNA in the water.

Below the Electric Dispersal Barrier:
A total of 496 (split between April and September) samples were collected below the electric dispersal barrier in areas where Asian carp have been historically sparse or undocumented. This included lower Lockport Pool to the upper half of Dresden Island Pool, and a portion of the Kankakee River above the dam in Wilmington, IL. Samples were collected in April and September (Table 1; Figures 1-4). In April, one sample was positive for Silver Carp DNA in Brandon Road Pool near the confluence of the Des Plaines River and the Chicago Sanitary and Ship Canal. This was the first positive sample in this pool in two years of eDNA sampling. No samples were positive for either species in September. This may have been caused by transient fish moving in and out of the pool, or it may be a reflection of the occasional low baseline eDNA levels in the pool contributed to by other vectors like barges. Barges often travel upstream from carp-infested areas of the Illinois River and even deposit dead Asian carp on occasion. In late April, the U.S. Army Corps of Engineers observed a dead Silver Carp in Lockport Pool near the Cargill boat ramp. Due to the condition of the fish, it was likely transported to the pool by barge and was discarded into the pool by a deckhand.

Though unanticipated, the result of zero positive detections in Dresden Island Pool was similar to the 2015 eDNA results in this upper reach of the pool. Additionally, traditional gear data suggests that the upper portion of Dresden Island Pool (upstream of the I-55 bridge, excluding Rock Run Rookery) has a lower carp density than the bottom portion (2015 Asian Carp Monitoring and Response Plan Interim Summary Report). eDNA data from 2015 for the entire Dresden Island Pool supports this as well. It is possible that the population of Asian carp in Dresden Island Pool is more transient in the upper portion of the pool and more resident in the lower portion so a consistent eDNA signal is not maintained throughout the year in the upper.

Strategy for eDNA Monitoring in the CAWS and Temporal eDNA Quantification Below the Electric Dispersal Barrier

Table 1. *Number of environmental DNA (eDNA) samples positive for Silver Carp, Bighead Carp, or both species of invasive carp in areas sampled in the Illinois Waterway below the electric dispersal barrier in April and September, 2016. Sample values do not include blank samples.*

	April				September			
River Reach	N	Silver Carp	Bighead Carp	Both	N	Silver Carp	Bighead Carp	Both
Lockport Pool	49	0	0	0	50	0	0	0
Brandon Road Pool	50	1	0	0	50	0	0	0
Dresden Island Pool	101	0	0	0	100	0	0	0
Kankakee River	25	0	0	0	25	0	0	0
TOTAL	225	1	0	0	225	0	0	0

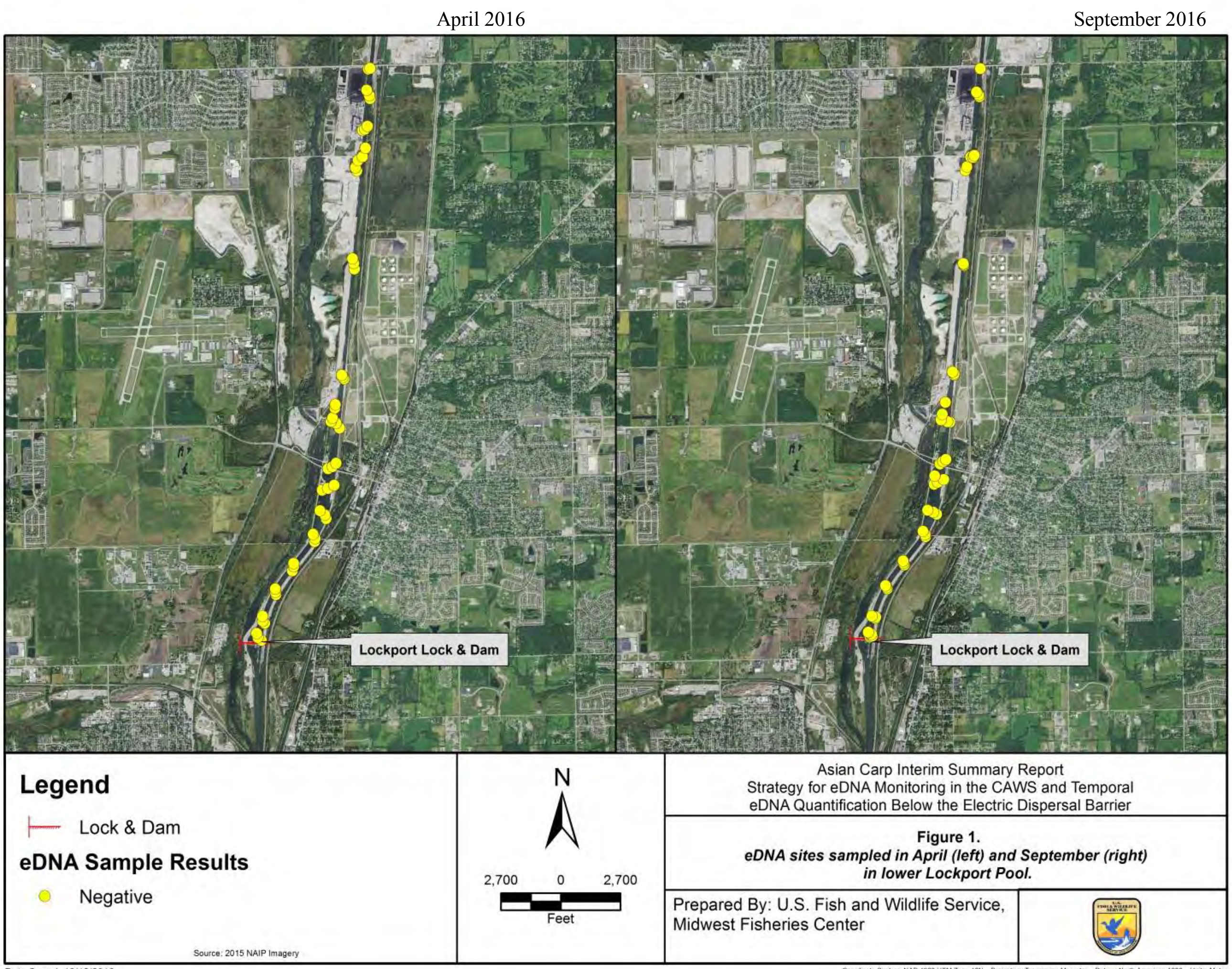

Figure 1. *Sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in April and September, 2016 in lower Lockport Pool. All sites were negative for both species of Asian carp.*

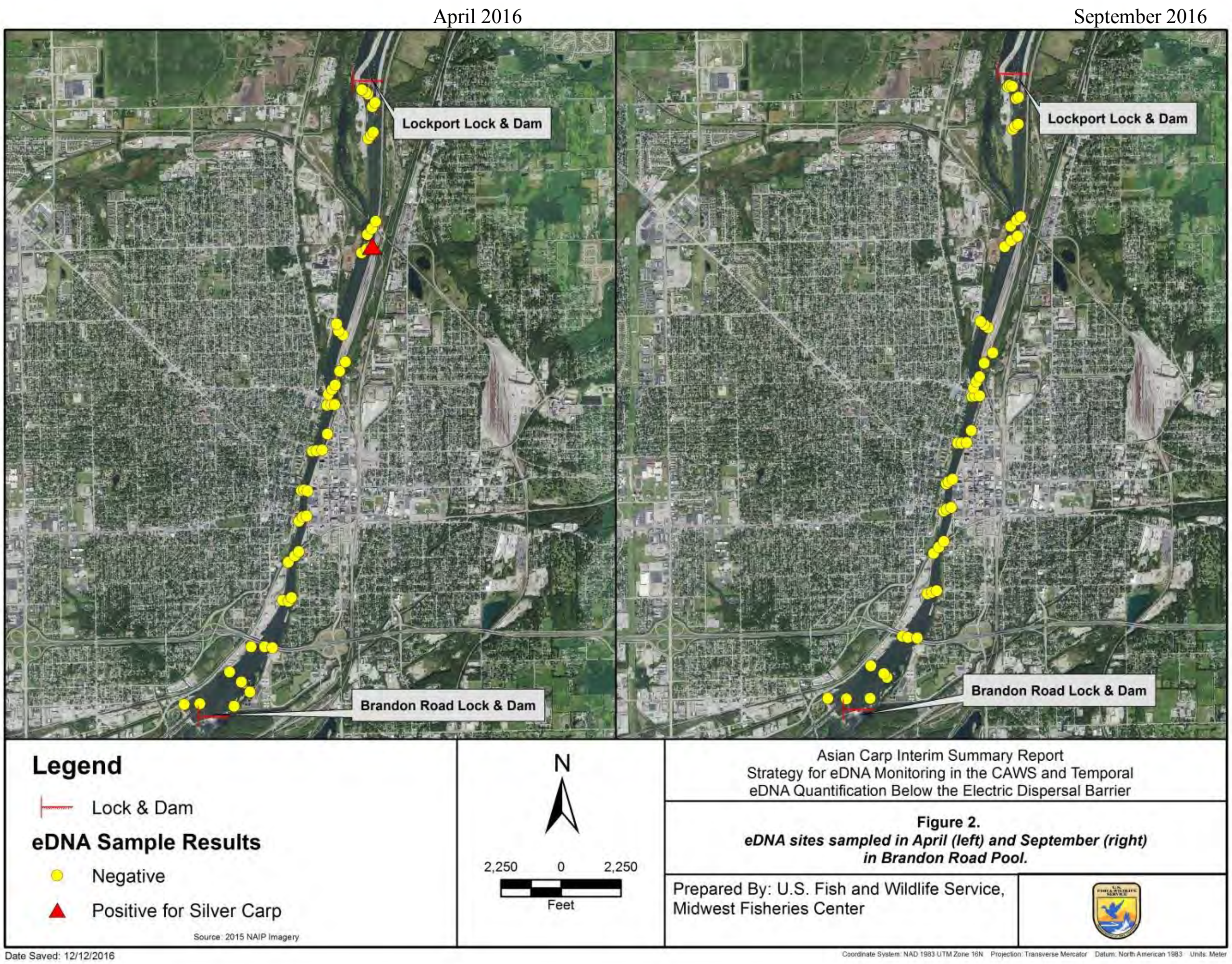

Figure 2. *Sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in April and September, 2016 in Brandon Road Pool. One site in April was positive for Silver carp DNA.*

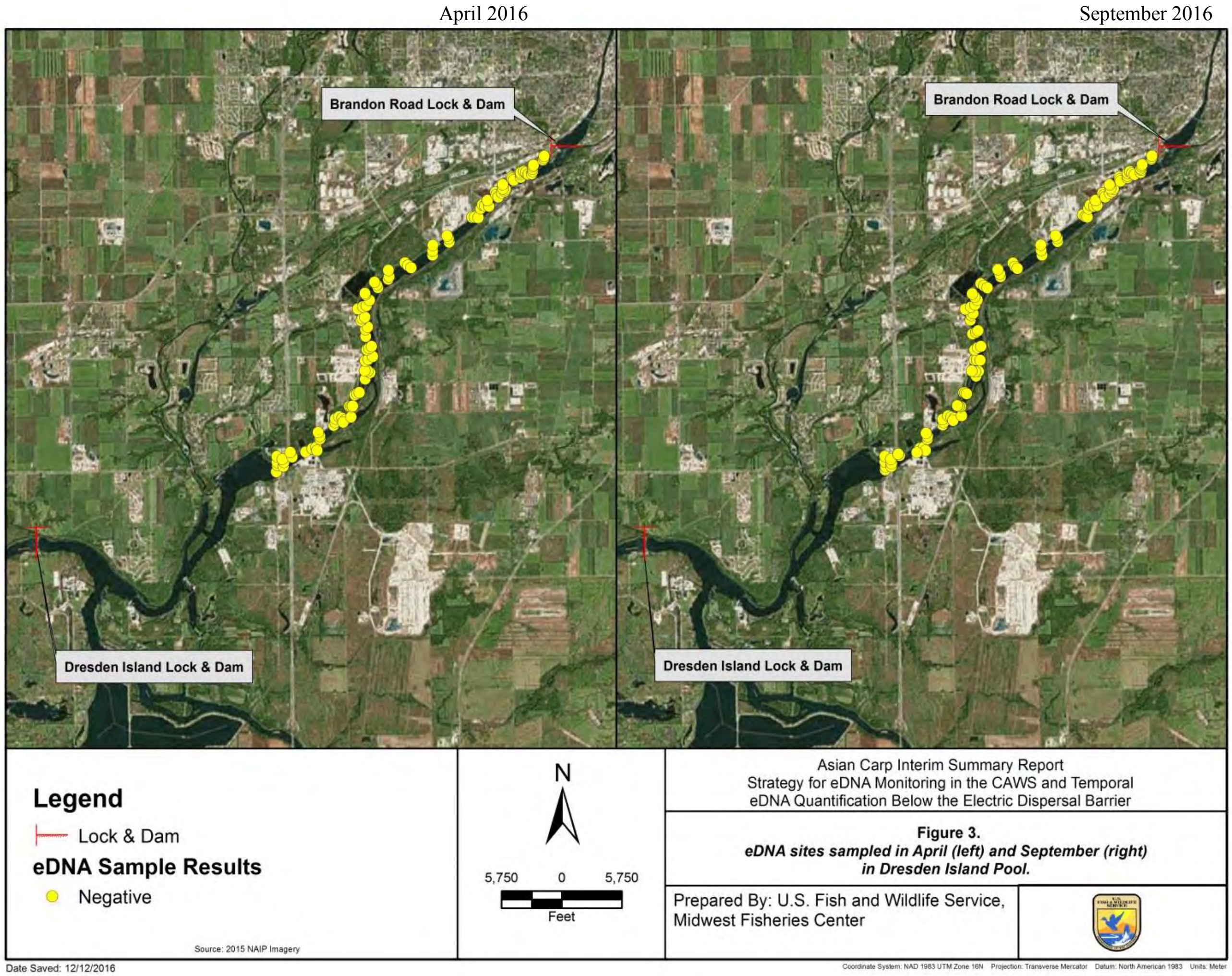

Figure 3. *Sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in April and September, 2016 in Dresden Island Pool. All sites were negative for both species of Asian carp.*

Strategy for eDNA Monitoring in the CAWS and Temporal eDNA Quantification Below the Electric Dispersal Barrier

Figure 4. *Sites sampled for Silver Carp and Bighead Carp environmental DNA (eDNA) in April and September, 2016 in the Kankakee River above the dam in Wilmington. All sites were negative for both species of Asian carp.*

Recommendation: In order to maintain vigilance within the CAWS, it is recommended to continue to monitor the four sites outlined above, with at least one sampling event per year. It is also recommended to continue monitoring the Illinois Waterway below the electric dispersal barrier, with one spring and one fall sampling event per year. Information from other project results in this report may drive changes in eDNA sampling below the barrier in 2017.

Larval Fish Monitoring in the Illinois Waterway

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

Participating Agencies: Illinois Natural History Survey (lead), Eastern Illinois University (field and lab support)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

Silver Carp and Bighead Carp are highly fecund, capable of producing hundreds of thousands of eggs, which are semibuoyant and drift in river currents for approximately a day before hatching. Larval and juvenile stages have previously been observed in the lower Illinois River, and recent evidence indicates that Asian carp spawning is occurring in the upper Illinois Waterway. Asian carp are also known to be present in several tributaries of the Illinois River, but the potential for these tributary rivers to serve as spawning locations or sources of recruitment has not previously been assessed. Information on the distribution of Asian carp eggs and larvae is needed to identify adult spawning areas, determine reproductive cues, and characterize relationships between environmental variables and survival of young Asian carp. The frequency of spawning in different pools of the Illinois Waterway and the eventual fate of eggs, larvae, and juveniles in these areas has important implications for Asian carp control strategies and electric dispersal barrier operation. This information 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: Larval fish sampling is being conducted to:

(1) Identify locations and timing of Asian carp reproduction in the Illinois Waterway;

(2) Monitor for Asian carp reproduction in the CAWS; and

(3) Determine relationships between environmental variables (e.g., temperature, discharge, habitat type) and the abundance of Asian carp eggs and larvae.

Project Highlights:

- Over 770 ichthyoplankton samples were collected from 12 sites across the length of the Illinois Waterway during April – September 2016, capturing over 19,000 larval fish, including 2,000 larval Asian carp. Additionally, over 7,000 Asian carp eggs were collected in ichthyoplankton samples in 2016.

Larval Fish Monitoring in the Illinois Waterway

- Asian carp eggs were collected in the LaGrange, Peoria, Starved Rock, and Marseilles Pools during 2016. Asian carp larvae were only identified from the LaGrange and Peoria Pools. These results further confirm observations made in 2015 that Asian carp reproduction occurs in at least some years in the upper Illinois River. However, across 7 years of sampling, only 3 Asian carp larvae have ever been observed upstream of the Starved Rock Lock and Dam, suggesting that the majority of eggs spawned in the upper river are transported into downstream navigation pools before hatching.
- Asian carp had multiple spawning events in 2016, with eggs and larvae collected from late May to early July, and then again at the end of August. The early spawning activity appears to be associated with declining discharge. However, the late August spawn occurred following a rapid and steady increase in water levels.

Methods:

Larval fish sampling occurred at 12 sites throughout the Illinois Waterway during 2016 (Figure 1). Additional sampling took place in five tributary rivers (Kankakee, Fox, Mackinaw, Spoon, and Sangamon Rivers). Sampling occurred at bi-weekly intervals from April to October, but weekly sampling occurred when Asian carp eggs and larvae were considered likely to be present (May – early July) or when temperature and flow conditions were thought to be conducive to Asian carp spawning. At main channel and backwater sites, four larval fish samples were collected at each site on each sampling date. Sampling transects were located on each side of the river channel, parallel to the bank, at both upstream and downstream locations within each study site. For backwater sites (Lily Lake in LaGrange Pool, Hanson Material Service Pit in Marseilles Pool), samples were collected at both backwater and adjacent main channel locations. Samples are collected using a 0.5 m-diameter ichthyoplankton push net with 500 um mesh. To obtain each sample, the net was pushed upstream using an aluminum frame mounted to the front of the boat. Boat speed was adjusted to obtain 1.0 – 1.5 m/s water velocity through the net. Flow was measured using a flow meter mounted in the center of the net mouth and was used to calculate the volume of water sampled. Fish eggs and larvae were collected in a meshed tube at the tail end of the net, transferred to sample jars, and preserved in 90-percent ethanol. The Kankakee and Fox Rivers were sampled at sites below the furthest downstream dam on each river. Upstream, mid-river, and downstream sites were sampled on the Mackinaw, Spoon, and Sangamon Rivers. Three samples (one mid-channel and one on each side of the channel) were taken at each tributary site on each sampling date. Downstream locations were sampled by boat-mounted push nets as for main-channel sites, whereas mid- river and upstream sites are sampled using stationary drift nets. Light traps were also used at all sites to supplement push- and drift-net sampling. Larval fish were identified to the lowest possible taxonomic unit in the laboratory. Fish eggs were 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 and egg densities were calculated as the number of individuals per m^3 of water sampled.

Larval Fish Monitoring in the Illinois Waterway

Figure 1. *Map of ichthyoplankton sampling sites in the Illinois Waterway. Sites on the main channel and backwaters of the Illinois Waterway are represented by circles. Sites in Illinois River tributaries are represented by triangles.*

Results and Discussion:

In 2016, a total of 744 ichthyoplankton samples were collected from main channel and backwater sites of the Illinois Waterway. From these, over 19,000 larval fish have been identified, including over 2,000 larval Asian carp. Additionally, over 7,000 Asian carp eggs have been identified. These numbers of Asian carp eggs and larvae are lower than those observed during 2014 and 2015, but still substantially higher than during 2010 – 2013 (Table 1). As in some previous years, Asian carp appear to have had multiple spawning events in 2016, as indicated by the timing and location of eggs and larvae (Figure 2). Asian carp eggs were first observed in samples from the LaGrange and Peoria Pools during late May through early June, with a small number of Asian carp larvae found in the lower LaGrange Pool during this time. These collections began to occur once water temperatures had risen above 20°C, although the hydrograph experienced a steady decline during this time period. Asian carp eggs continued to be detected in the Peoria Pool through mid-June, but larvae continued to be collected at LaGrange Pool sites through the beginning of July. These later collections occurred during a period of sustained high water temperatures and a fluctuating hydrograph (Figure 2). Asian carp eggs and larvae were not observed again until a prolonged rise in water levels at the end of August. At this time, high densities of eggs were collected in the Marseilles, Starved Rock, and Peoria Pools, and larvae were collected in the Peoria and LaGrange Pools. These collections only occurred during a single sampling week, and no other eggs or larvae were collected in the Illinois Waterway through the conclusion of sampling at the end of September. No Asian carp eggs were collected upstream of the Marseilles Pool, and no Asian carp larvae were collected upstream of the Peoria Pool during 2016.

Table 1. *Dates, effort, and number of larval fish captured during ichthyoplankton sampling activities on the Illinois Waterway during 2010 – 2016.*

Year	Sampling Dates	# Samples	# Larval Fish	# Asian Carp Larvae	# Asian Carp Eggs
2010	Jun 3 – Oct 2	240	2,050	78	-
2011	Apr 27 – Oct 13	560	7,677	2	-
2012	May 1 – Oct 19	722	28,274	490	-
2013	April 30 – Oct 9	614	30,101	327	-
2014	April 30 – Sep 29	558	18,572	5,231	19,704
2015	April 27 – Oct 15	558	79,113	62,170	71,367
2016	April 27 – Sep 28	744	19,513	2,064	7,183

Sampling in Illinois River tributaries collected over 3,500 larval fish during 2016, as well as numerous eggs. Potential Asian carp eggs were collected in the Sangamon, Spoon, Mackinaw, and Fox Rivers, but only 12 larval Asian carp were collected in the lower Sangamon River. These larvae were sampled in mid-September, following a rapid rise in discharge. No Asian carp eggs or larvae were collected in the Kankakee River during 2016. Potential Asian carp eggs are awaiting genetic verification, and more detailed summarization of patterns in Asian carp spawning in tributaries during 2016 will be reported once these results are available.

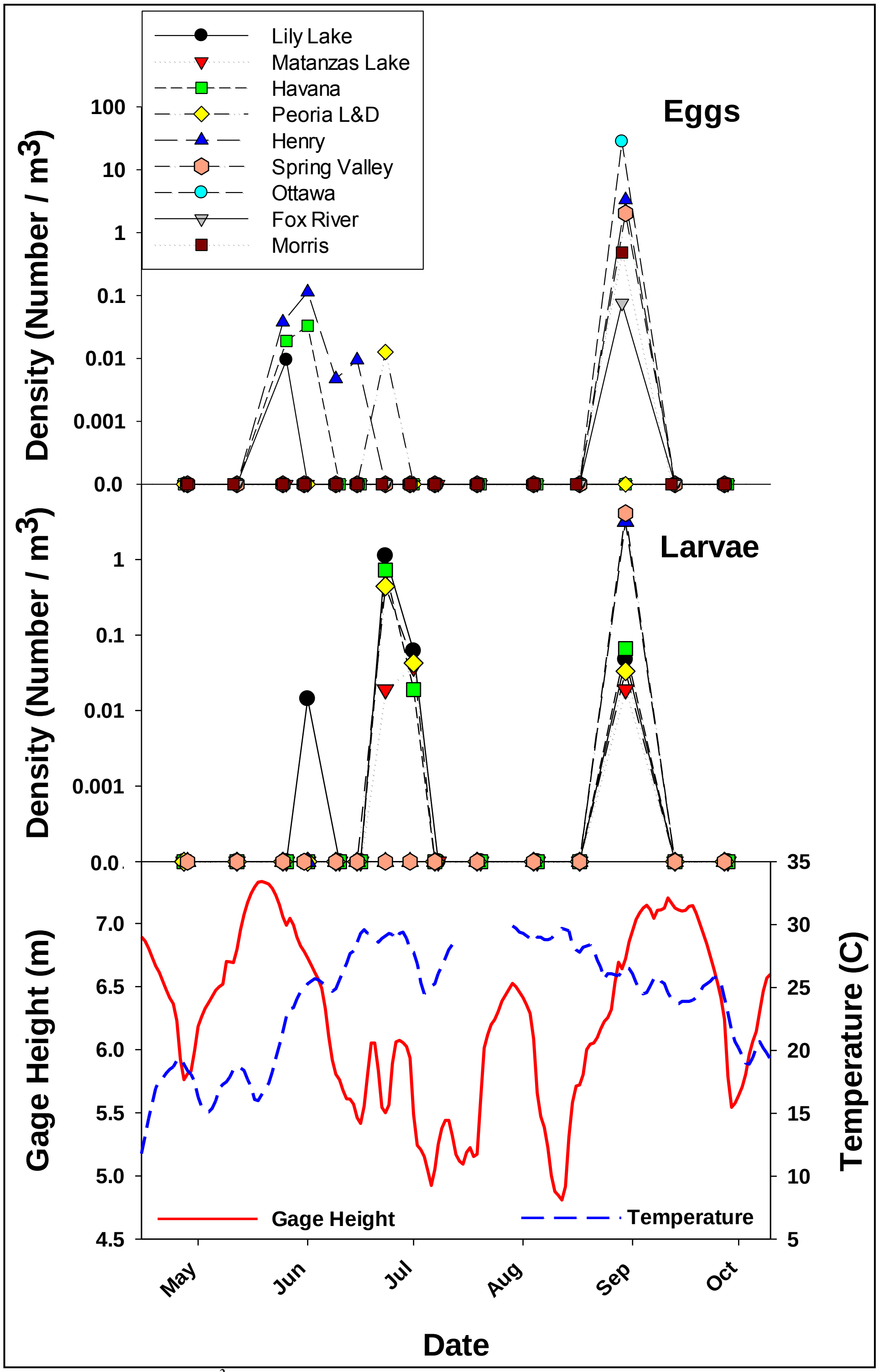

Figure 2. *Densities (number / m^3; note log scale) of Asian carp eggs (top panel) and larvae (middle panel) collected from sites throughout the Illinois Waterway during 2016. Mean daily gage height (m) and water temperature (° C) of the Illinois River during April – October 2016 (bottom panel) were obtained from USGS hydrograph 5586300 at Florence, IL.*

Larval Fish Monitoring in the Illinois Waterway

These data indicate that Asian carp successfully spawned in the Illinois River during 2016, although the numbers of eggs and larvae collected were lower than those observed in 2014 and 2015. Some of these larvae also appear to have recruited to juvenile life stages (see Young-of-Year and Juvenile Asian Carp Monitoring summaries). Determining factors that influence Asian carp reproduction and recruitment is important for understanding processes that affect the distribution and abundance of Asian carp populations in the Illinois Waterway. The hydrologic conditions that influence spawning may be particularly important, as they may affect both the density of eggs and larvae and their transport through navigation pools. Asian carp spawning is generally thought to be linked to a rising hydrograph during periods of appropriate water temperatures. Indeed, the largest numbers of eggs and larvae collected in 2014 - 2016 were associated with prolonged periods of rising water levels. However, many of the eggs and larvae observed during May and June 2016 were associated with a steadily declining hydrograph. Asian carp spawning cues may be more complicated than currently understood and a more detailed analysis of all seven years of sampling data, examining the relationships of temperature, water levels, and other environmental factors to the occurrence and densities of Asian carp eggs and larvae is warranted. Additionally, exploring relationships between egg and larval abundance and ensuing year class strength will aid our understanding of factors driving Asian carp recruitment.

Asian carp eggs and larvae had not been observed in the upper Illinois Waterway in any study year prior to 2015, although Asian carp spawning activity had previously been observed in the Marseilles Pool. The presence of Asian carp eggs in the Starved Rock and Marseilles Pools during both 2015 and 2016 confirms that some Asian carp reproduction takes place in the upper Illinois Waterway when conditions are conducive to spawning. However, other than the three larvae collected in the Dresden Island Pool in June 2015, all Asian carp larvae found to date have been collected at or downstream of Spring Valley (Peoria Pool). This suggests that even if spawning occurs in the upper Illinois River, the majority of eggs are likely transported downstream of the Starved Rock Lock and Dam before hatching. This may have important implications for control of Asian carp in the upper Illinois Waterway. If the lower Illinois River is the primary source of recruits that then immigrate into the upper river, then restricting movement of Asian carp past locks and dams could substantially reduce Asian carp populations in the upper Illinois Waterway over time. What level of potential internal recruitment versus immigration from downstream is necessary to maintain current population levels of Asian carp in upstream navigation pools is not fully understood. Regardless, successful reproduction and recruitment of Asian carp in or upstream of the Starved Rock Pool would be potentially troubling for management goals. Asian carp also appear to be reproducing in Illinois River tributaries, but what contribution these rivers have to the larger population remains uncertain. In particular, if upstream tributaries (Fox and Kankakee Rivers) provide a source of recruits to upper navigation pools in some years, this could hinder control objectives.

Larval Fish Monitoring in the Illinois Waterway

Recommendations:

Ichthyoplankton sampling should continue in future years in order to monitor for Asian carp reproduction, particularly upstream of the Peoria Pool. Additional analyses will also be required to adequately understand environmental factors that contribute to Asian carp reproduction and recruitment. Analysis of egg and larval fish drift (e.g. FluEgg model) is warranted to determine potential spawning locations throughout the Illinois River, and to understand where larvae are likely to settle out of the drift. Continued ichthyoplankton sampling in tributary rivers (Sangamon, Spoon, Mackinaw, Fox, and Kankakee Rivers) is also warranted to examine the potential for these systems to serve as sources for Asian carp populations in the Illinois Waterway, and to evaluate the potential for similar rivers in the Great Lakes region to serve as spawning tributaries.

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, 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 – Carterville, Columbia, and La Crosse Fish and Wildlife Conservation Offices and US Army Corps of Engineers – Chicago District (field support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction: Bighead Carp and Silver Carp are known to spawn successfully in larger river systems where continuous flow and moderate current velocities transport their semi-buoyant eggs during early incubation and development. Spawning typically occurs at water temperatures between 18 and 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.

Successful reproduction is considered an important factor in 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. Successful spawning in the upper Des Plaines River also could pose a threat because larval fish may be washed into the CSSC upstream of the Electric Dispersal Barrier during extreme flooding. The transport of larvae to the CSSC can occur despite the installation of concrete barrier and fencing between the waterways because larval fish are small enough to pass through the 6.4 mm (0.25 in) mesh fencing used for the separation project. Larvae washed into the CSSC would likely be transported downstream past the Electric Dispersal Barrier during flooding, these fish might become established in the lower Lockport pool, recruit to the juvenile life stage, and challenge the Electric Dispersal Barrier. An additional threat may occur if juvenile Asian carp from spawning events in downstream pools migrate to the Lockport pool via navigation locks. Even though there has been no evidence of successful Asian carp reproduction in the CAWS, Des Plaines River, or upper Illinois River, targeting young-of-year and juvenile Asian carp in monitoring efforts is needed because these life stages may not be detected in conventional sampling geared toward adults.

Objectives:

Multiple gears suitable for sampling small fish were used to:

Young-of-year and Juvenile Asian Carp Monitoring

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

(2) Determine the uppermost waterway reaches where young Asian carp are successfully recruiting.

Project Highlights:

- Sampled for young Asian carp from 2010 to 2016 throughout the CAWS, Des Plaines River, and Illinois River between river miles 83 and 334 by incorporating sampling from several existing monitoring projects.
- Sampled with active gears (trawls, pulsed-DC electrofishing, and beach seine) and passive gears (mini-fyke nets) in 2016.
- Completed 2,017 hours of electrofishing across all years and sites.
- Examined 343,922 Gizzard Shad <152 mm (6 in) long in the CAWS and Illinois Waterway upstream of Starved Rock Lock and Dam from 2010-2016.
- High catches of small Asian carp in 2014, moderate in 2015, and low in 2016 in the LaGrange Pool indicate three consecutive successful recruitment years despite limited to no recruitment in 2010-2013. However, total catch of small Asian carp varied by orders of magnitude between years.
- Farthest upstream catch was four Silver carp (6-12 inches) in the Marseilles Pool near Morris, IL, (river mile 263), which is consistent with observations from 2015 sampling.
- Recommend continued monitoring for young Asian carp

Methods:

As in the past, 2016 sampling for young-of-year and juvenile Asian carp took place through other projects of the MRRP. Young fish were 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 2016 MRP for specific locations of sampling stations.

Trawling, pulsed-DC electrofishing, beach seining, and mini fyke nets were the principal gears used to monitor for young Asian carp throughout the Illinois River during 2016. The intensive monitoring effort was the product of sampling by multiple agencies (IDNR, INHS, USFWS, USACE), and a summation of all catch and effort from 2010-2016 is presented here. Please refer to specific project summary reports for detailed sampling methods and protocols.

Electrofishing and fyke netting at fixed sites downstream of the Electric Dispersal Barrier occurred monthly from March-November in 2016 at four sites in each of the Lockport, Brandon Road, Dresden Island, and Marseilles pools (16 15-minute transects and 4 net nights per month).

Young-of-year and Juvenile Asian Carp Monitoring

Standard electrofishing protocols were modified such that schools of small fish <152 mm (6 in) long (typically Gizzard Shad) were subsampled by netting a portion of each school encountered during each electrofishing run. Counting Gizzard Shad < 152 mm (6 in) long provided a proxy estimate of the relative abundance of young Asian carp, if present in each sample of small fish.

The gear efficiency study targeted young Asian carp using pulsed DC-electrofishing, mini-fyke nets, and beach seines. DC electrofishing was conducted following the detection of larval Asian carp in ichthyoplankton pushes. Sites were sampled with all gears in the LaGrange Pool in two backwaters and two main channel locations in August and again in September/October. Each site visit included 4 15-minute DC electrofishing transects, 8 mini-fyke net-nights, and 4 beach seine hauls.

US Fish and Wildlife juvenile sampling was conducted monthly in the Dresden, Marseilles, and Starved Rock Pool. Sampling included monthly mini fyke netting, electrofishing and trawl sampling. This sampling targeted areas off the main channel including backwaters, isolated pools, side channels, side channel borders, and/or tributary mouths. For detailed methods see the project report for "Distribution and Movement of Small Asian Carp in the Illinois Waterway". In addition, USFWS deployed trawling gears monthly in the Dresden, Marseilles, Starved Rock, Peoria, and LaGrange Pools. These gears included Paupier Trawls, Dozer Trawls, Surface Trawls, and Push Trawls. The types and numbers of trawls varied by sampling location and date depending upon the presence of Asian Carp. For detailed methods see the project report for "Distribution and Movement of Small Asian Carp in the Illinois Waterway".

Results and Discussion:

Young Asian carp were targeted with six gears in 2010, eight gears in 2011, ten gears in 2012, six gears in 2013, seven gears in 2014, eleven gears in 2015, and six gears in 2016. Sampling during 2016 included both active gears, (trawling, electrofishing, and beach seining) and a passive gear (mini-fyke nets). The DC electrofishing was conducted in all segments of the Illinois River, Upper Des Plaines River and CAWS in 2016 and mini fyke net and trawling was conducted downstream of the electric barrier from the Lockport to the LaGrange Pools. In 2016, Asian carp <6 inches were detected in the LaGrange (n =462) and reduced numbers were found in the Peoria Pool (n = 4), and none in or above the Starved Rock Pool (n = 0). Asian carp between 6-12 inches were collected in the Starved Rock Pool (n = 16) and the Marseilles Pool (n = 4). These patterns of small (<6 and 6-12 inch) Asian carp among the Illinois River pools are consistent with patterns observed in 2015 (Table 5). All but 15 (3 Bighead carp, 12 hybrid) of the juvenile Asian carp collected during 2016 were identified as Silver carp in the field (Table 6). The greatest numbers of young-of-year (<6 in.) Silver carp were collected in mini-fyke nets (n = 332), followed by Paupier trawls (n = 81), surface trawls (n = 38) and with low catches for other gears. Total catch of for Silver carp 6-12 inches differed, as the greatest catch was observed in Paupier trawls (n = 232), followed by dozer trawls (n = 159), and DC-electrofishing (n = 34). A total of 115,671 Gizzard Shad <152 mm (6 in) were collected along the Illinois River (Table 6).

Young-of-year and Juvenile Asian Carp Monitoring

A total of 102,611 Gizzard shad were collected between the CAWS and the Marseilles Pool (Table 6).

During 2016, a total of 427 hours of active sampling effort were conducted across all pools. High level of effort was spent on DC electrofishing which accounted for 361.5 hours in all pools and mini-fyke nets with 165 net-nights and 44 seine hauls (Table 6). Trawling totaled 65.5 hours of active sampling effort. Sampling effort varied among pools and among gears from site to site, but adequately covered the CAWS upstream of the Electric Dispersal Barrier and all pools downstream. Although electrofishing did not produce the greatest numbers of Asian carp, it was able to detect them when they were present. Electrofishing, mini-fyke net, and trawl monitoring should be used together to adequately monitor for the presence of young-of-year Asian carp.

No juvenile Asian carp <305 mm long were captured in 2010 (note: La Grange, Peoria, and Starved Rock Pools were not sampled in 2010) and 2013 and low catches were reported in 2011 and 2012 (Tables 1, 2), which may reflect poor Asian carp recruitment in the waterway over these four years. During 2014, sampling across agencies detected the first year of substantial abundances of young-of-year Asian carp since monitoring started in 2010. Total numbers of small Asian carp were orders of magnitude lower in 2015 and 2016 when compared to 2014, but higher when compared to 2010-2013.

Recommendations:

The use of multiple gears was coordinated throughout several projects to monitor for young Asian carp in the CAWS, Des Plaines River, and Illinois River from 2010-2016. In 2016, total catch of Asian carp was low (n = 912) when compared to 2015 (n = 1,934) and especially to 2014 (n = 71,632). Numbers were greatly lower than from 2014, and only very low numbers of Asian carp had been detected downstream of the Starved Rock Lock and Dam prior to 2014. We detected small Asian carp in the Starved Rock Pool, similar to past segments, but total numbers were lower than in 2014-2015. While these results are encouraging in our efforts to track and prevent Asian carp from establishing populations in the CAWS and Lake Michigan, they are only temporary and may quickly change if conditions limiting recruitment success (e.g., flow, water quality, competition for food and space, and abundance of spawning stock) improve in the future. We recommend continued vigilance in monitoring for juvenile Asian carp in the CAWS and Illinois Waterway through existing monitoring projects and enhanced efforts. A development that will benefit the understanding of Asian carp recruitment demographics is the preparation of a white paper on the distribution of small Asian carp in the Mississippi Basin. This cooperative effort by IDNR, USACE, and USFWS will continue to gather data on Asian carp spawning and the distribution of young Asian carp from researchers and management biologists across the basin. These data will be summarized and made available in a living document that can be used to identify data gaps and track the Asian carp invasion.

Table 1. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2010 and 2011.*

			Number collected						
			Bighead Carp	Bighead Carp	Silver Carp	Silver Carp	Hybrid Carp	Hybrid Carp	Gizzard Shad
Year, location, (river mile)	Gear	Effort	<6 in.	6-12 in.	<6 in.	6-12 in.	<6 in.	6-12 in.	<6 in.
2010									
CAWS upstream of barrier (296-334)	DC electrofishing	208 hours	0	0	0	0	0	0	12,746
Barrier to Marseilles Pool (265-296)	DC electrofishing	34 hours	0	0	0	0	0	0	3,655
	Mini-fyke net	40 net-nights	0	0	0	0	0	0	65
	Trap net	8 net-nights	0	0	0	0	0	0	2
	Small mesh gill net	1,950 yards	0	0	0	0	0	0	77
	Purse seine	10 hauls	0	0	0	0	0	0	0
	Midwater trawl	10 tows	0	0	0	0	0	0	0
2011									
CAWS upstream of barrier (296-334)	DC electrofishing	330.5 hours	0	0	0	0	0	0	15,655
	Mini-fyke net	48 net-nights	0	0	0	0	0	0	6
	Trap net	70 net-nights	0	0	0	0	0	0	0
	Small mesh gill net	192 hours	0	0	0	0	0	0	6
	Purse seine	24 hauls	0	0	0	0	0	0	3
	Midwater trawl	24 tows	0	0	0	0	0	0	0
	Beach seine	24 hauls	0	0	0	0	0	0	4
	Cast net	48 throws	0	0	0	0	0	0	0
Upper Des Plaines River	DC electrofishing	10.5 hours	0	0	0	0	0	0	4
Dispersal Barrier to Starved Rock Pool (240-296)	DC electrofishing	50 hours	0	0	0	0	0	0	7,191
	Mini-fyke net	72 net-nights	0	0	0	0	0	0	13
	Trap net	72 net-nights	0	0	0	0	0	0	1
	Small mesh gill net	288 hours	0	0	0	0	0	0	10
	Purse seine	36 hauls	0	0	0	0	0	0	60
	Midwater trawl	36 tows	0	0	0	0	0	0	153
	Beach seine	36 hauls	0	0	0	0	0	0	14
	Cast net	144 throws	0	0	0	0	0	0	18
Illinois River La Grange and Peoria Pools (83-190)	DC electrofishing	22 hours	0	0	0	1	1	0	77
	Mini-fyke net	96 net-nights	0	0	0	0	0	0	22,773
	Trap net	96 net-nights	0	1	0	0	0	0	1
	Small mesh gill net	480 hours	0	0	1	3	0	0	23
	Purse seine	60 hauls	0	0	0	1	0	0	108
	Midwater trawl	60 tows	0	0	0	0	0	0	11
	Beach seine	60 hauls	0	0	0	0	0	0	307
	Cast net	96 throws	0	0	0	0	0	0	14

Table 2. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2012. River miles are in parentheses.*

			Number collected					
Year/location	Gear	Effort	Unidentified Asian Carp <6 in.	Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Gizzard Shad <6 in.
2012	DC electrofishing	268 hours	0	0	0	0	0	42,448
CAWS upstream	Mini-fyke net	48 net-nights	0	0	0	0	0	22
of barrier	Small mesh gill net	336 hours	0	0	0	0	0	5
(296-334)	Purse seine	48 hauls	0	0	0	0	0	6
	Midwater trawl	2 hours	0	0	0	0	0	0
	Beach seine	24 hauls	0	0	0	0	0	106
	Cast net	24 casts	0	0	0	0	0	3
	Fyke Net	48 net-nights	0	0	0	0	0	0
Upper Des Plaines River	DC electrofishing	12.6 hours	0	0	0	0	0	6
Dispersal Barrier	DC electrofishing	94 hours	0	0	0	0	0	14,439
to Starved Rock	Mini-fyke net	239 net-nights	0	0	0	0	0	642
Pool (240-296)	Push trawls	55 runs	0	0	0	0	0	157
	Small mesh fyke net	28 net-nights	0	0	0	0	0	1527
	Small mesh gill net	464 hours	0	0	0	0	0	37
	Purse seine	72 hauls	0	0	0	0	0	107
	Midwater trawl	3 hours	0	0	0	0	0	0
	Beach seine	36 hauls	0	0	0	0	0	2,708
	Cast net	36 casts	0	0	0	0	0	24
	Fyke Net	72 net-nights	0	0	0	0	0	1
Illinois River	DC electrofishing	40.5 hours	0	0	0	0	0	755
La Grange and	Mini-fyke net	181 net-nights	4	0	0	0	0	3,867
Peoria Pools	Small mesh gill net	752 hours	0	0	0	0	0	76
(83-190)	Push trawls	33 runs	0	0	0	0	0	49
	Small mesh fyke net	24 net-nights	0	0	0	0	0	288
	Purse seine	120 hauls	0	0	0	0	0	71
	Midwater trawl	2 hours	0	0	0	0	0	0
	Beach seine	60 hauls	0	0	0	0	0	2,331
	Cast net	60 casts	0	0	0	0	0	17
	Fyke Net	72 net-nights	0	0	0	0	0	2

Table 3. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2013.*

			Number collected							
Location	Gear	Effort	Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Hybrid Carp <6 in.	Hybrid Carp 6-12 in.	Gizzard Shad <6 in.	Gizzard Shad 6-12 in.
CAWS	DC Electrofishing	9 hours	0	0	0	0	0	0	23	109
	Small Mesh Gill Nets	96 hours	0	0	0	0	0	0	3	25
	Mini-Fyke Nets	48 net-nights	0	0	0	0	0	0	9	3
	Beach Seines	24 hauls	0	0	0	0	0	0	16	1
	Pound Nets	18 net-nights	0	0	0	0	0	0	0	9
Dresden Pool	DC Electrofishing	3 hours	0	0	0	0	0	0	0	8
	Small Mesh Gill Nets	32 hours	0	0	0	0	0	0	1	5
	Mini-Fyke Nets	16 net-nights	0	0	0	0	0	0	533	1
	Beach Seines	8 hauls	0	0	0	0	0	0	0	3
Marseilles Pool	DC Electrofishing	4 hours	0	0	0	0	0	0	34	73
	Small Mesh Gill Nets	32 hours	0	0	0	0	0	0	1	16
	Mini-Fyke Nets	16 net-nights	0	0	0	0	0	0	38	3
	Beach Seines	10 hauls	0	0	0	0	0	0	10	0
	Pound Nets	46 net-nights	0	0	0	0	0	0	0	61
Starved Rock Pool	DC Electrofishing	4 hours	0	0	0	0	0	0	0	11
	Small Mesh Gill Nets	32 hours	0	0	0	0	0	0	0	3
	Mini-Fyke Nets	16 net-nights	0	0	0	0	0	0	1	0
	Beach Seines	10 hauls	0	0	0	0	0	0	0	0
Peoria Pool	DC Electrofishing	4 hours	0	0	0	0	0	0	0	2
	Small Mesh Gill Nets	32 hours	0	0	0	0	0	0	2	31
	Mini-Fyke Nets	16 net-nights	0	0	0	0	0	0	5326	0
	Beach Seines	10 hauls	0	0	0	0	0	0	39	0
	Purse Seines	3 hauls	0	0	0	0	0	0	4	2
LaGrange Pool	DC Electrofishing	13 hours	0	0	0	0	0	0	4471	5
	Small Mesh Gill Nets	128 hours	0	0	0	0	0	0	18	55
	Mini-Fyke Nets	48 net-nights	0	0	0	0	0	0	4019	0
	Beach Seines	34 hauls	0	0	0	0	0	0	364	0
	Pound Nets	8 net-nights	0	0	0	0	0	0	0	16

Table 4. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2014.*

Location	Gear	Effort	Number Collected						
			Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Hybrid Carp <6 in.	Hybrid Carp 6-12 in.	Gizzard Shad
CAWS	DC Electrofishing	88.25 hours	0	0	0	0	0	0	9837
Lockport Pool	DC Electrofishing	43 hours	0	0	0	0	0	0	2505
	Mini Fyke	28 net nights	0	0	0	0	0	0	222
Brandon Road	DC Electrofishing	46.75 hours	0	0	0	0	0	0	2219
	Mini Fyke	28 net nights	0	0	0	0	0	0	78
Dresden Pool	DC Electrofishing	58.75 hours	0	0	0	0	0	0	4478
	Mini Fyke	64 net nights	0	0	0	0	0	0	11
	Push Trawls	30 pushes	0	0	0	0	0	0	NA
Marseilles Pool	DC Electrofishing	64.25 hours	0	0	0	0	0	0	4734
	Beach Seine	8 hauls	0	0	0	0	0	0	57
	Cast Net	8 throws	0	0	0	0	0	0	9
	Mini Fyke	83 net nights	0	0	0	0	0	0	72
	Small Mesh Gill Nets	16 hours	0	0	0	0	0	0	5
	Purse Seine	8 sets	0	0	0	0	0	0	190
	Push Trawls	30 pushes	0	0	0	0	0	0	NA
Starved Rock Pool	DC Electrofishing	12.75 hours	0	0	0	0	0	0	NA
	Mini Fyke	32 net nights	0	0	0	0	0	0	NA
	Push Trawls	30 pushes	0	0	0	0	0	0	NA
Peoria Pool	DC Electrofishing	4 hours	0	0	36	0	0	0	305
	Beach Seine	4 hauls	0	0	0	0	0	0	56
	Cast Net	4 throws	0	0	0	0	0	0	0
	Mini Fyke	8 net nights	0	0	11	0	0	0	670
	Small Mesh Gill Nets	16 hours	0	0	0	0	0	0	2
	Purse Seine	4 sets	0	0	2	0	0	0	0
LaGrange Pool	DC Electrofishing	10.75 hours	0	0	4,104	0	0	0	1831
	Beach Seines	32 hauls	0	0	7,240	0	0	0	329
	Cast Net	32 throws	0	0	135	0	0	0	5
	Mini Fyke	63 net nights	0	0	56,043	0	0	0	4643
	Small Mesh Gill Nets	96 hours	0	0	0	0	0	0	84
	Purse Seine	32 sets	0	0	4,060	1	0	0	591

Table 5. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2015.*

Location	Gear	Effort	Number Collected						
			Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Hybrid Carp <6 in.	Hybrid Carp 6-12 in.	Gizzard Shad
CAWS	Electrofishing (hours)	105.5	0	0	0	0	0	0	11,535
Brandon Road	Electrofishing (hours)	29	0	0	0	0	0	0	925
	Mini Fyke (Net Nights)	32	0	0	0	0	0	0	11
Lockport	Electrofishing (hours)	33	0	0	0	0	0	0	656
	Mini Fyke (Net Nights)	32	0	0	0	0	0	0	5
Dresden Island	Electrofishing (hours)	47.83	0	0	0	0	0	0	6,722
	Mini-fyke (night sets)	100	0	0	0	0	0	0	40
	Dozer Trawl (meters)	1,338	0	0	0	0	0	0	0
	Paupier Trawl (meters)	0	0	0	0	0	0	0	0
	Push Trawl (meters)	3,333	0	0	0	0	0	0	101
	Surface Trawl (meters)	0	0	0	0	0	0	0	0
	5/8" mesh seine (pulls)	3	0	0	0	0	0	0	69
	Bottom Electrified Trawls (pulls)	3	0	0	0	0	0	0	0
Marseilles	Electrofishing (hours)	68.70	0	0	0	2	0	0	6,079
	Mini-fyke (night sets)	93	0	0	0	0	0	0	121
	Dozer Trawl (meters)	15,252	0	0	0	0	0	0	1,610
	Paupier Trawl (meters)	17,215	0	0	0	0	0	0	4,250
	Push Trawl (meters)	6,841	0	0	0	0	0	0	269
	Surface Trawl (meters)	4,669	0	0	0	0	0	0	187
	5/8" mesh seine (pulls)	5	0	0	0	0	0	0	82,959
	Bottom Electrified Trawls (pulls)	3	0	0	0	0	0	0	0
Starved Rock	Electrofishing (hours)	18.27	0	0	8	5	0	0	552
	Mini-fyke (night sets)	75	0	0	0	0	0	0	159
	Dozer Trawl (meters)	6,246	0	0	0	1	0	0	321
	Paupier Trawl (meters)	44,171	0	1	94	438	0	0	4,561
	Push Trawl (meters)	10,483	0	0	0	0	0	0	251
	Surface Trawl (meters)	11,473	0	0	4	1	0	0	27
	Bottom Electrified Trawls (pulls)	3	0	0	0	0	0	0	0

Table 5 Cont.

Peoria	Electrofishing (hours)	4.9	0	0	2	0	0	0	86
	Mini-fyke (night sets)	41	0	0	9	0	0	0	19
	Dozer Trawl (meters)	14,179	0	0	8	0	0	0	12
	Paupier Trawl (meters)	11,109	0	0	38	5	0	0	49
	Push Trawl (meters)	5,955	0	0	2	0	0	0	12
	Surface Trawl (meters)	9,528	0	0	93	2	0	0	31
	Bottom Electrified Trawls (pulls)	5	0	0	0	0	0	0	0
La Grange	Electrofishing (hours)	15.6	0	0	19	6	0	0	432
	Mini Fyke (Net Nights)	105	1	2	75	0	0	0	1136
	Dozer Trawl (meters)	16,154	0	0	112	0	0	0	1,228
	Paupier Trawl (meters)	19,042	5	2	531	136	1	0	4,968
	Push Trawl (meters)	11,120	0	0	118	0	0	0	579
	Surface Trawl (meters)	13,549	2	0	140	8	0	0	326
	Cast Net (sets)	16	0	0	0	0	0	0	0
	Purse Seine (sets)	48	0	0	19	3	0	0	143
	1/8" Mesh Seine (Pulls)	44	0	0	1	0	0	0	195
	Small Mesh Gill Nets (hours)	36	0	0	7	24	0	0	323
	Bottom Electrified Trawls (pulls)	5	0	0	9	0	0	0	0

Table 6. *Number of juvenile Bighead Carp, Silver Carp, hybrid Bighead Carp x Silver Carp, and Gizzard Shad sampled with various gears in the CAWS and Illinois Waterway during 2016.*

Location	Gear	Effort	Number Collected						
			Bighead Carp <6 in.	Bighead Carp 6-12 in.	Silver Carp <6 in.	Silver Carp 6-12 in.	Hybrid Carp <6 in.	Hybrid Carp 6-12 in.	Gizzard Shad
CAWS	Electrofishing (hours)	101.5	0	0	0	0	0	0	6941
Brandon Road	Electrofishing (hours)	36.1	0	0	0	0	0	0	784
	Mini Fyke (net nights)	32.0	0	0	0	0	0	0	69
Lockport	Electrofishing (hours)	35.7	0	0	0	0	0	0	1854
	Mini Fyke (net nights)	32.0	0	0	0	0	0	0	179
Dresden Island	Electrofishing (hours)	86.2	0	0	0	0	0	0	13511
	Mini-fyke (night sets)	40.0	0	0	0	0	0	0	5
	Dozer Trawl (hours)	2.8	0	0	0	0	0	0	332
	Paupier Trawl (hours)	0.9	0	0	0	0	0	0	11
	Push Trawl (hours)	0.0	0	0	0	0	0	0	0
	Surface Trawl (hours)	0.0	0	0	0	0	0	0	0
	5/8" mesh seine (pulls)	3.0	0	0	0	0	0	0	4780
	Bottom Electrified Trawls (pulls)	0.0	0	0	0	0	0	0	0
Marseilles	Electrofishing (hours)	88.2	0	0	0	1	0	0	8158
	Mini-fyke (night sets)	32.0	0	0	0	0	0	0	1
	Dozer Trawl (hours)	11.6	0	0	0	3	0	0	9445
	Paupier Trawl (hours)	4.8	0	0	0	0	0	0	17350
	Push Trawl (hours)	0.0	0	0	0	0	0	0	0
	Surface Trawl (hours)	7.1	0	0	0	0	0	0	13922
	5/8" mesh seine (pulls)	9.0	0	0	0	0	0	0	25269
	Bottom Electrified Trawls (pulls)	0.0	0	0	0	0	0	0	0
Starved Rock	Electrofishing (hours)	6.4	0	0	0	1	0	0	499
	Mini-fyke (night sets)	19.0	0	0	0	0	0	0	17
	Dozer Trawl (hours)	7.0	0	0	0	2	0	0	411
	Paupier Trawl (hours)	3.2	0	0	0	0	0	12	612
	Push Trawl (hours)	0.0	0	0	0	0	0	0	0
	Surface Trawl (hours)	0.6	0	0	0	1	0	0	8
	Bottom Electrified Trawls (pulls)	0.0	0	0	0	0	0	0	0

Table 6 Cont.

Peoria	Electrofishing (hours)	0.0	0	0	0	0	0	0	0
	Mini-fyke (night sets)	0.0	0	0	0	0	0	0	0
	Dozer Trawl (hours)	0.4	0	0	4	14	0	0	60
	Paupier Trawl (hours)	0.0	0	0	0	0	0	0	0
	Push Trawl (hours)	0.0	0	0	0	0	0	0	0
	Surface Trawl (hours)	0.0	0	0	0	0	0	0	0
	Bottom Electrified Trawls (pulls)	0.0	0	0	0	0	0	0	0
La Grange	Electrofishing (hours)	7.5	0	0	0	32	0	0	200
	Mini Fyke (net nights)	42.0	0	0	328	0	0	0	240
	Dozer Trawl (hours)	13.5	0	1	7	142	0	0	2799
	Paupier Trawl (hours)	7.0	1	0	81	232	0	0	7663
	Push Trawl (hours)	0.0	0	0	0	0	0	0	0
	Surface Trawl (hours)	6.8	1	0	38	5	0	0	537
	Cast Net (sets)	0.0	0	0	0	0	0	0	0
	Purse Seine (sets)	0.0	0	0	0	0	0	0	0
	1/8" Mesh Seine (Pulls)	32.0	0	0	6	0	0	0	14
	Small Mesh Gill Nets (hours)	0.0	0	0	0	0	0	0	0
	Bottom Electrified Trawls (pulls)	0.0	0	0	0	0	0	0	0

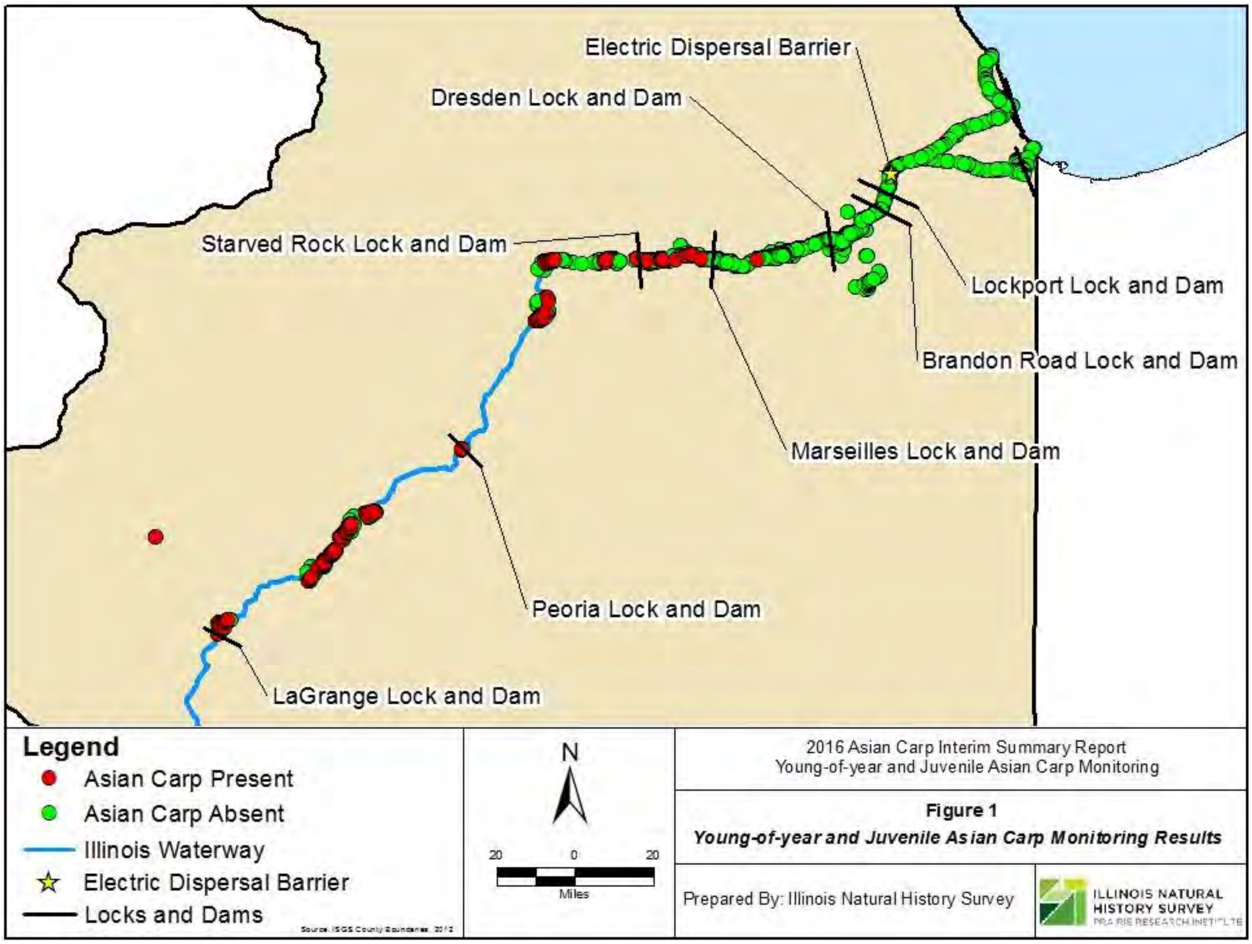

Figure 1: *Location of all juvenile sampling sites conducted by INHS, IDNR and FWS in the Illinois River and CAWS in 2016.*

Distribution and Movement of Small Asian Carp in the Illinois Waterway

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ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction:

Populations of Asian carp have become established in the lower and middle reaches of the Illinois River. Natural resource professionals remain concerned about the potential invasion of these species into the Great Lakes via the upper Illinois Waterway (IWW). These fish may pose a significant threat to established Great Lakes fisheries by competing with economically and recreationally important species for limited plankton resources. Kolar et al. (2007) noted the Chicago Sanitary and Shipping Canal (CSSC) as the most probable pathway for Asian carp entry into the Great Lakes. Therefore, the CSSC is critical to stopping Asian carp from expanding their range into Lake Michigan and the Great Lakes.

An Electric Dispersal Barrier System (EDBS) operated by the U.S. Army Corps of Engineers (USACE) in Lockport Pool is intended to block the upstream passage of Asian carp through the CSSC. Laboratory tests have shown the operational parameters used at the EDBS are sufficient for stopping large-bodied fish from passing through. However, testing of operational parameters using small Bighead Carp (*Hypophthalmichtys nobilis*) (51 to 76 mm TL) revealed these parameters may be inadequate for blocking small fish passage (Holliman et al. 2011). U.S. Fish and Wildlife Service (USFWS) research showed that Golden Shiner (*Notemigonus crysoleucas*) can be entrained in barge junction gaps upstream through the EDBS. Additional USFWS research, using a pair of Dual Frequency Identification Sonar units (DIDSON), showed that small fish (unknown species observed on sonar) are transported upstream through the EDBS concurrent with downstream barge movement. If Asian carp are present near the EDBS, these species may be capable of breaching the EDBS. As such, there is a critical need to determine the small Asian carp distribution and demographic characteristics below the EDBS. Additionally, there is an ongoing need to understand the reproduction of these species in the IWW so managers might better target small fish for eradication or other future management actions.

The purpose of this study is to establish the spatial distribution of small Asian carp in the IWW through intensive, directed sampling. Asian carp specimens ≤153 mm TL are considered "small fish" based on discussions within the Monitoring and Response Working Group. Fish between 153 and 200 mm are termed juvenile in this document. Traditional and novel sampling techniques were used in 2016, including electrofishing, fyke nets, and surface, mid-water, and benthic trawls.

Objectives:

(1) Determine the distribution, abundance, and age structure of small Asian carp in the middle and upper IWW.

(2) Use distribution and abundance data to characterize the risk of small Asian carp entry into the Great Lakes via the Chicago Area Waterway System.

Project Highlights:

- No small Asian carp (≤ 153 mm TL) were found above Peoria Pool during the 2016 field season.
- Nine juvenile Silver Carp (*Hypophthalmichthys molitrix*) were captured in Starved Rock Pool early in the 2016 field season (157–196 mm TL).

Methods:

Sampling sites were identified as backwaters, isolated pools, main channel border, side channels, side channel borders, marinas, or tributary mouths. Physical, water quality, and habitat measurements were made at each collection site. Physical measurements included: depth, Secchi depth, and substrate (i.e., boulder, cobble, gravel, sand, silt, and clay). Water quality measurements included: temperature, salinity, specific conductance, dissolved oxygen, and pH; these were taken with an analytical instrument (YSI Professional Series multi-meter). Habitat measurements were recorded at the time of each sampling event. GPS coordinates were recorded for all net sets, beginning and end of electrofishing runs, and trawl hauls.

All Bighead Carp, Silver Carp, Grass Carp (*Ctenopharyngodon idella*), and up to 10 Gizzard Shad (*Dorosoma cepedianum*) were measured (mm TL per sample). Most other fish were counted, and released. Fish not easily identifiable in the field, including some young-of-year fish, were preserved in Excell Plus or ethanol for laboratory identification to the lowest possible taxonomic level. Effort was quantified as net nights (fyke net), minutes electrofishing (boat electrofishing, dozer and paupier trawl), and minutes trawled (otter and surface trawl). The dozer, paupier, and surface trawl were developed and used by the USFWS Columbia office, and this sampling data is only included as summary data.

Electrofishing – Pulsed DC daytime electrofishing conducted for 15 minute periods.

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

Otter trawl – Two rectangle wooden doors were employed to force open the net mouth while moving downstream. Floats and weights were permanently attached to the top and bottom of the net. Net running depth was determined by rope length and boat speed, and fish were collected in the tied cod end. Length and duration of trawl was dependent on site characteristics.

Paupier trawl – Contained one 3.7m by 1.5m rigid frame on each side of a flat bottomed boat with 35mm mesh reducing to 4mm mesh. Frames were fished from 0.5m to 3m depth. Target habitat included open water >0.6m deep. Length and duration of trawl was dependent on site characteristics.

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

Surface trawl – A 10.7m long trawl net with 35mm mesh at the mouth reducing to 4mm mesh at the cod end. Towlines extended 38m to floating otter boards spreading the net approximately 6.5m wide. Able to fish up to 1m depth, target habitats included open water >1 meter. Length and duration of trawl was dependent on site characteristics.

Results and Discussion:

In 2016, no small Asian carp (≤153 mm TL) were captured upstream of Peoria Pool. Four Silver Carp (85 – 110 mm) collected on 29 September represent the only small fish captured by the USFWS during the 2016 field season (Table 1). However, nine juvenile Silver Carp (157 – 196 mm) were captured in Starved Rock Pool this spring (Table 1). These juvenile fish were captured in Heritage Harbor, Gobblers Knob, and Sheehan Island. These three locations produced small Asian Carp (≤153 mm TL) in 2015, and these 2016 captures are likely part of the large 2015 Silver Carp year class.

In 2016, small fish sampling effort shifted upriver. Brandon Road and Lockport pools were sampled for the first time as part of this project, and no sampling was completed in La Grange Pool (Table 2). Sampling decreased substantially in Peoria and Starved Rock pools, with these efforts being shifted to Marseilles and Dresden Island (Table 2).

More electrofishing was performed in Marseilles, Dresden Island, Brandon Road, and Lockport pools than any year prior (Table 3). This included a three-fold increase in sampling of Dresden Island Pool. Much of the electrofishing and paupier sampling was completed in early season efforts to locate juvenile fish produced in 2015 (Table 3 and 4). Fyke nets were used in 2016, but there was a general shift towards active gears (electrofishing and trawling) to cover more water (Table 5). Dozer and otter trawling efforts increased while paupier and surface trawling decreased in 2016 (Table 3, Table 4, Table 6, and Table 7).

In 2015 and 2016, there were 199 samples with Silver Carp <200 mm captured by USFWS personnel from La Grange upstream through lower Marseilles pool. Gizzard Shad were captured in 85% of these samples, Emerald Shiner (*Notropis atherinoides*) in 77%, Adult Silver Carp in 51%, and Threadfin Shad (*Dorosoma petenense*) in 29% (Table 8). While Gizzard Shad and Emerald Shiner are probably the most common species in the Illinois River, Threadfin Shad represent only 4% of the fish captured during this period (Table 9). These results suggest that when field personnel are catching these pelagic species they may also be sampling the right locations to detect juvenile Asian carp. Efforts to successfully capture these pelagic species should continue to include open water sampling techniques.

Distribution and Movement of Small Asian Carp in the Illinois Waterway

Recommendation: It remains critical to monitor the leading edge of small Asian carp in the Illinois Waterway. Information leading to improved capture efficiency and further understanding of Asian carp early life history remains necessary. This project will continue in conjunction with the small fish telemetry project started by the Carterville FWCO Wilmington Office in 2016.

Table 1. *Juvenile Silver Carp (≤200mm) caught by date, pool, and gear in Starved Rock and Peoria Pools.*

	Heritage Harbor	Gobblers Knob	Sheehan Island	Depue Lake
Mean (mm)	187	172	192	99
n	2	4	3	4
Range (mm)	186-188	157-188	186-196	85-110
Dates caught	4/5-4/12	5/4	4/5-6/9	9/29
Pool	Starved Rock	Starved Rock	Starved Rock	Peoria
Gear	Surface, Electrofishing	Dozer	Paupier, Electrofishing	Dozer

Table 2. *Total 2016 sampling effort by pool and gear. Effort recorded as (events/minutes) unless otherwise noted.*

	Peoria	Starved Rock	Marseilles	Dresden Island	Brandon Road	Lockport
Electrofishing	-	23/345	172/2,568	117/1,737	20/291	13/192
Paupier trawl	-	25/159	4/29	10/55	-	-
Dozer trawl	7/26	47/390	65/296	49/166	-	6/20
Surface trawl	-	3/14	-	-	-	-
Otter trawl	-	-	30/260	3/30	-	-
Fyke net (night sets)	-	19	-	8	-	-

Table 3. *Total 2016 electrofishing (events/minutes) by pool and month.*

Pool	April	May	June	July	September	October	Total
Starved Rock	15/225		5/75	3/45			23/345
Marseilles	56/840	33/492		18/270	46/681	19/285	172/2,568
Dresden Island	27/396	40/600	26/381	24/360			117/1,737
Brandon Road		5/68	15/223				20/291
Lockport		5/72	8/120				13/192

Table 4. *Total 2016 paupier trawls (events/minutes) by pool and month.*

Pool	April	June	August	Total
Starved Rock	5/38	13/83	6/38	24/159
Marseilles	3/22		1/7	4/29
Dresden Island	10/55			10/55

Table 5. *Total 2016 fyke net night sets by pool and month.*

Pool	June	July	Total
Starved Rock		19	19
Dresden Island	8		8

Table 6. *Total 2016 dozer trawls (events/minutes) by pool and month.*

Pool	April	May	June	July	August	September	October	Total
Peoria						4/11	3/15	7/26
Starved Rock		3/17			31/104	13/74		47/390
Marseilles		18/105	14/35		20/94	13/62		65/296
Dresden Island	13/77		14/30	22/59				49/166
Lockport				6/20				6/20

Table 7. *Total 2016 otter trawls (events/minutes) by pool and month.*

Pool	October	Total
Marseilles	30/260	260
Dresden Island	3/30	30

Table 8. *Bycatch species present during any 2015 and 2016 samples (n = 199) with at least one juvenile Asian carp (≤200mm) captured throughout the Illinois River.*

Species	Bycatch presence
Gizzard Shad	85%
Emerald Shiner	77%
Adult Silver Carp	51%
Threadfin Shad	29%
Smallmouth Buffalo	28%
Bluegill	22%
Spottail Shiner	4%
Bullhead Minnow	<0.1%
Spotfin Shiner	<0.1%
Largemouth Bass	<0.1%

Table 9. *Total number and percentage of fish collected by species in 2015 and 2016.*

Species	Number	Percent of total
Gizzard Shad	44,204	37%
Emerald Shiner	10,642	9%
Adult Silver Carp	9,827	8%
Spotfin Shiner	5,185	4%
Bluegill	5,069	4%
Spottail Shiner	4,342	4%
Bullhead Minnow	4,235	4%
Threadfin Shad	4,032	4%
Smallmouth Buffalo	2,701	2%
Largemouth Bass	2,595	2%
Total (all species)	120,432	

Monitoring Efforts Downstream of the Electric Dispersal Barrier

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Participating Agencies: Illinois Department of Natural Resources (lead); Illinois Natural History Survey – Illinois River Biological Station (field Support); U.S. Fish and Wildlife Service – Carterville, Colombia, and La Crosse Fish and Wildlife Conservation Offices (field support); U.S. Army Corps of Engineers – Chicago District (field support)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need: Standardized sampling can provide useful information to managers tracking population growth and range expansion of aquatic invasive species. Information gained from regular monitoring (such as presence, distribution, and population abundance of target species) is essential to understanding the threat of possible Asian carp invasion upstream of the Electric Dispersal Barrier. We used electrofishing, hoop netting, mini-fyke netting, and contracted commercial fishers to sample for Asian carp in four pools downstream of the Electric Dispersal Barrier. The primary goal of this monitoring effort was to identify the location of the detectable population front of advancing Asian carp in the Upper Illinois Waterway and track changes in distribution and relative abundance of leading populations over time. ("Detectable population" is defined as the farthest upstream location where multiple Bighead or Silver Carp have been captured in conventional sampling gears during a single trip or where individuals of either species have been caught in repeated sampling trips to a specific site.) Monitoring data from 2010 to 2016 have contributed to our understanding of Asian carp abundance and distribution downstream of the Electric Dispersal Barrier and the potential threat of upstream movement toward the Electric Dispersal Barrier.

Objectives: Standardized sampling with conventional gears was used to:

(1) Monitor for the presence of Asian carp in four pools below the Electric Dispersal Barrier

(2) Determine the 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 (for example, the Asian Carp Barrier Defense Project and Telemetry Master Plan)

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

Monitoring Efforts Downstream of the Electric Dispersal Barrier

Project Highlights:

- From 2010 to 2016, an estimated 17,501 person-hours were spent sampling at fixed, random, targeted, and additional sites downstream of the Electric Dispersal Barrier
- A project total of 700.5 hours of electrofishing, 1,092.7 km (679 miles) of trammel and gill nets, and 1,164 net nights of hoop netting and 552 net nights of mini-fyke netting were conducted
- A project total of 234,064 fish were captured, representing 97 species and eight hybrid groups
- No Bighead or Silver Carp were captured in Lockport pool in all years sampled, but were collected in Dresden and Marseilles pools with project totals of 2,553 and 2,052 respectively. Historically, Rock Run Rookery, Mobil Bay and the downstream end of Treats Island within the Dresden Pool have received relatively higher amounts of sampling than other locations within the pool (Figure. 1)
- Detectable population front of Asian carp located north of I-55 Bridge in Rock Run Rookery (near river mile 281; 46 miles from Lake Michigan). No appreciable change has been found in the upstream location of the population front in the past 10 years.

Methods: The sampling design included electrofishing, gill and trammel netting, hoop netting, and mini-fyke netting at fixed, random and targeted sites in four pools downstream of the Electric Dispersal Barrier (Lockport, Brandon Road, Dresden Island, and Marseilles pools). The fixed sites (four sites/pool) were located primarily in the upper portions of each pool below lock and dam structures and in habitats where Asian carp are likely to be found (such as backwaters and side-channels). Electrofishing random sites were computer generated in main-channel habitats. As in 2015, targeted commercial netting in 2016 replaced random netting (employed from 2010 to 2014) to increase catches of Bighead and Silver Carp.

Electrofishing Protocol – Fixed and random electrofishing samples in 2016 occurred once per month from April to November. All electrofishing was pulsed-DC current and included one or two netters (two netters were preferred). Electrofishing was conducted in a downstream direction in areas with noticeable current velocity. Electrofishing runs were 15 minutes in length and generally parallel to shore (including following shoreline into off channel areas). The operator was encouraged to switch the pedal on and off at times to prevent pushing fish in front of the boat and increasing the chance of catching an Asian carp. Common Carp were counted without capture and all other fish were netted and placed in a tank where they were identified and counted, after which they were returned live to the water. Gizzard Shad young-of-year (YOY) were examined closely for the presence of Asian carp and counted to provide an assessment of any young Asian carp in the waterway.

Gill and Trammel Netting Protocol – In 2016, contracted commercial fishers assisted IDNR biologists with net sampling at fixed and targeted sites downstream of the Electric Dispersal Barrier. Commercial fishers (3 fishers per week) set gill and trammel nets in Lockport, Brandon

Road and Dresden Island pools (including Rock Run Rookery) two weeks per month from March through December.

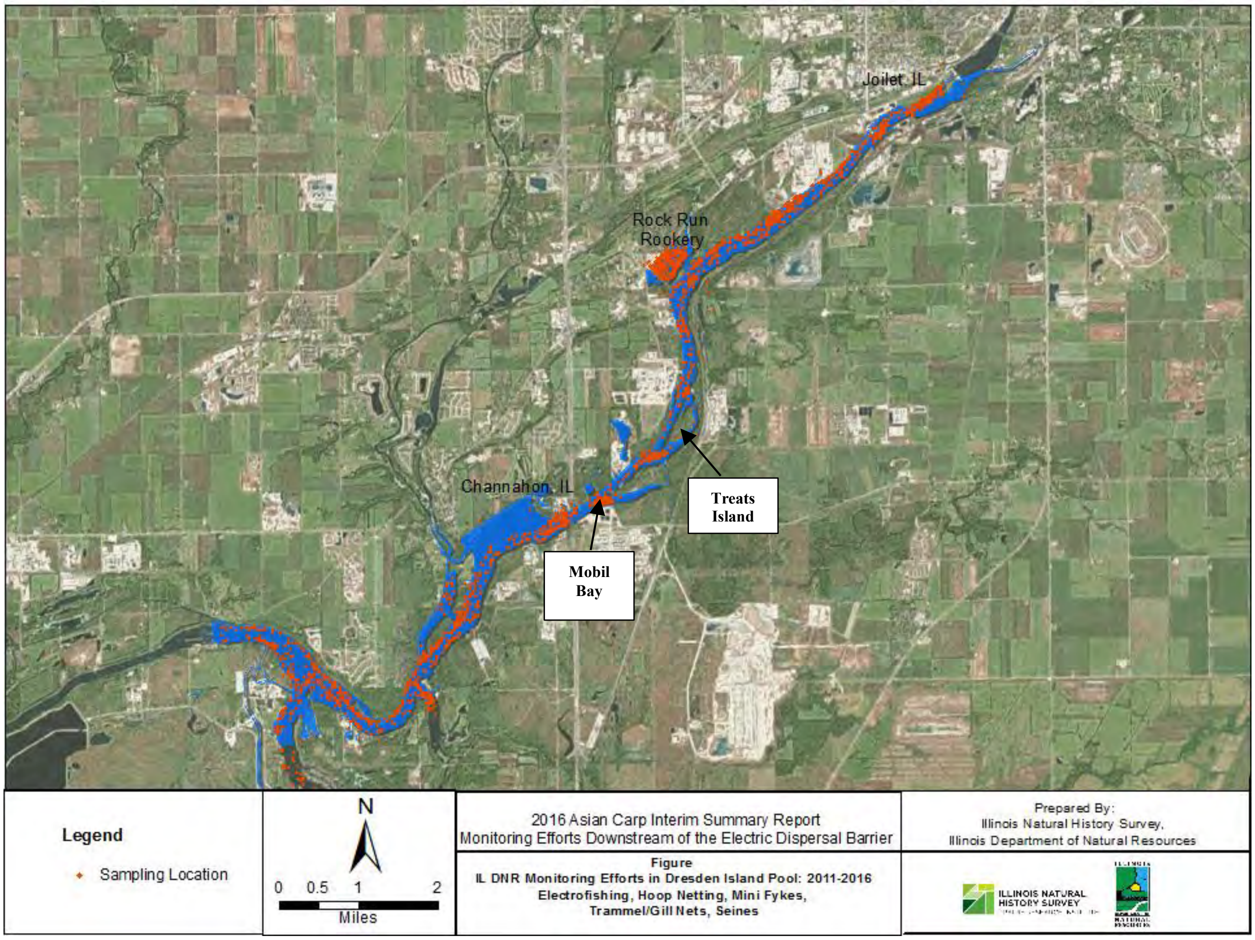

Figure 1. *Cluster map showing monitoring sites for all gear types (electrofishing, hoop netting, mini-fyke netting, trammel/gill netting, and seines) from 2011-2016.*

An IDNR/INHS biologist was aboard each commercial net boat to monitor operations, record data, check for ultrasonic- or jaw-tagged bighead or silver carp (left pelvic or anal fin clips or telemetry surgery wounds on the left ventral area of the fish, posterior to the pelvic fin and anterior to the anus) and Floy tag all Buffalo spp. and common carp (*see* Surrogate Fish Movement With Barriers interim report). Targeted sites were determined by commercial fisher discretion. Nets were attended at all times. Net sets were short duration and utilized noise to drive fish into nets (e.g., "pounding" with plungers on the water surface, banging on boat hulls or revving trimmed-up motors). Netting effort was standardized as 15- to 20- minute long sets with "pounding" no further than 137 m (150 yd) from the net. Captured fish were identified to species, counted and recorded on data sheets. All captured Asian carp were harvested and bycatch were returned to the water unharmed. All field data were entered into a Microsoft Access Fish App database.

Monitoring Efforts Downstream of the Electric Dispersal Barrier

Hoop and Mini-Fyke Netting Protocol – In 2016, IDNR/INHS biologists conducted hoop netting and mini-fyke netting at fixed sites downstream of the Electric Dispersal Barrier. Netting took place 1 week per month from March through October in Lockport, Brandon Road, Dresden Island, and Marseilles pools.

Hoop nets were composed of seven fiberglass hoops with 64 mm (2.5 inch) bar mesh (1.8 meters [6 feet] in diameter, 6.7 meters [7.3 yards] in length). An anchor was attached to the cod end of the net with a 15.2 meter (16.6 yard) anchor line. Typically, nets were kept open by the water current but sometimes required a bridle and weight on the downstream end of the net during low water velocities. Nets were set in main-channel borders and below locks and dams in waters ≥1.8 meters (6 feet) deep. Hoop nets were set for 48 hours (two net nights). Captured fish were identified to species, counted, and recorded on data sheets. All captured Asian carp were harvested, and bycatch were returned to the water alive. All field data were entered into a Microsoft Access Fish App database.

Mini-fykes were a Wisconsin-type net composed of a lead 0.6 meter (2 feet) in height, 5 meters (5.5 yards) in length, rectangular frame and cab 3 meters (3.3 yards) in length) with 3 mm (0.1 inch) nylon-coated mesh. Mini-fyke nets were set on main-channel borders or backwater areas perpendicular to shore. Mini-fyke nets were set for 24 hours (one net night). Captured fish were identified to species, counted, and recorded on data sheets. All field data were entered into a Microsoft Access Fish App database

Results and Discussion:

Electrofishing Effort and Catch – From 2010-2016, an estimated 6,030 person-hours were expended completing 700.5 hours of electrofishing. A total of 161,358 fish were sampled representing 97 species and seven hybrid groups at fixed and random electrofishing sites downstream of the electric dispersal barrier (Table 1).

Fixed site electrofishing catch-per-unit-effort (CPUE) in 2016 was 430 fish/hour, an increase from the 2015 fixed site electrofishing CPUE (170 fish/hour, Table 2). Random site electrofishing CPUE in 2016 was 200 fish/hour, an increase from the 2015 random site CPUE (100 fish/hour, Table 2). Increases in 2016 are likely attributed to an increase in Gizzard Shad detection (n = 28,329 in 2016 compared to n = 6,965 in 2015). Fixed sites were selected based on habitats likely preferred by Asian carp (tailwater, backwater and side-channel habitats) thus yielding higher CPUE, while computer generated random electrofishing sites were distributed on main-channel border habitat resulting in lower CPUE. No Bighead Carp or Silver Carp were sampled by electrofishing in Lockport or Brandon Road pools for all years sampled. In the Dresden Island Pool, 2 Bighead Carp and 10 Silver Carp were caught at fixed sites, with no Bighead Carp and 23 Silver Carp caught at random sites. In Marseilles Pool, fixed electrofishing sites yielded no Bighead Carp and 372 Silver Carp, while random electrofishing sites yielded 1 Bighead Carp and 512 Silver Carp in 2016. In 2015, random and fixed sites yielded 3 Asian Carp in Dresden Island pool and 276 Asian Carp in Marseilles Pool. A total of 20,290 Gizzard Shad ≤ 152 mm (6 in) were examined at fixed and random electrofishing sites downstream of the Electric Dispersal Barrier in 2016 with no Asian Carp YOY detected. This has been consistent for all years sampled. In 2015, a total of 5,200 Gizzard Shad ≤ 152 mm (6 in) were examined with no Asian Carp YOY detected. Species with the greatest overall abundance were Gizzard Shad (*Dorosoma cepedianum*; 66%), Smallmouth Buffalo (*Ictiobus bubalus*; 5.1%), Threadfin Shad (*Dorosoma petenense*; 3.7%), and Common Carp (*Cyprinus carpio*; 3.6%) for random and fixed site electrofishing in all pools sampled in 2016 (Table 2).

Gill and Trammel Netting Effort and Catch – From 2010-2016, 1,092.7 km (679 miles) of gill and trammel nets were set at fixed, random, targeted and additional sites downstream of the Electric Dispersal Barrier. During the same time period, 8,783 person-hours were spent gill and trammel netting. Commercial netting yielded 21,857 fish representing 30 species and 2 hybrid groups.

In 2016, 305 km (189.3 miles) of gill and trammel nets were set at fixed and targeted sites in Lockport, Brandon Road, and Dresden Island pools. Commercial netting yielded 7,319 fish representing 24 species and 2 hybrid groups, of which Common Carp (42%) and Smallmouth Buffalo (40%) comprised 82% of the total catch and Bighead (3%) and Silver (3%) Carps comprised 6% of the total catch (Table 3). No Asian carp were captured in Lockport or Brandon Road pools, but were captured at fixed and targeted sites in the Dresden Island pool (*n*=466; Table 2). Catches of Bighead and Silver Carps in the Dresden Island pool were higher at fixed and targeted sites sampled in 2016 (*n*=230 and *n*=236, respectively) than fixed and targeted sites sampled in 2015 (*n*=262 and *n*=165, respectively) (Table 2). Differences in Asian carp catches may be attributed to an increase in effort in 2016 (304.6 km compared to 281 km in 2015). The increase in effort was due to an additional commercial fisher (3 total) being added to the commercial netting schedule in 2016 (only 2 scheduled commercial fishers in 2015). Gill and trammel netting CPUE (No. fish/100 yards of net) of all fish species was 2.0 at targeted sites and 3.6 at fixed sites in 2016 (Table 2), compared to 2.2 at targeted sites and 0.60 at fixed sites in 2015. CPUE of Bighead Carp was 0.08 at targeted sites and 0.003 at fixed sites in 2016 (Table 2), compared to 0.10 at targeted sites and 0.008 at fixed sites in 2015. CPUE of Silver Carp was 0.08 at targeted sites and 0.03 at fixed sites in 2016 (Table 2), compared to 0.06 at targeted sites and 0.02 at fixed sites in 2015.

Hoop and Mini-Fyke Netting Effort and Catch – From 2012 to 2016, an estimated 2,688 person hours were expended setting and running 588 hoop nets and 552 mini-fyke nets (1,164 net nights hoop and 400 net nights mini-fyke) downstream of the Electric Dispersal Barrier. Hoop netting yielded 2,304 fish representing 23 species and 2 hybrid groups (Table 4). Smallmouth Buffalo comprised the largest proportion of the catch (n = 837; 36.3%), followed by Channel Catfish (n = 667; 28.9%) and Common Carp (n = 376; 16.3%). Mini-fyke netting yielded 48,545 fish representing 63 species and 1 hybrid group (Table 5). Bluegill constituted the largest proportion of the catch (n = 20,423; 42.1%) followed by Bluntnose Minnow (n = 6,958; 14.3%) and Spotfin Shiner (n = 3,441; 7.1%).

In 2016, hoop netting yielded 212 fish representing 14 species, with Smallmouth Buffalo comprising most of the catch (33.5%; n = 71), followed by Silver Carp (22.2%: n = 47), and Common Carp (16.0%; n = 34; Table 4). No Asian Carp were captured in Lockport or Brandon Road pools, but they were captured at fixed sites in Dresden Island (1 Grass Carp) and Marseilles Pools (19 Bighead and 47 Silver Carp; Table 4). Catches of Bighead Carp were lower in 2016 (n = 19) compared to 2015 (n = 102), while catches of Silver Carp were higher in 2016 (n = 47) than in 2015 (n = 29). Hoop netting CPUE (No. fish/net night) of all fish species was 0.83 at fixed sites in 2016 (Table 2), compared with 5.3 at fixed and additional sites in 2015. Bighead Carp hoop netting CPUE was 0.074 at fixed sites in 2016, compared with 0.33 at fixed and additional sites in 2015. Silver Carp hoop netting CPUE was 0.18 at fixed sites in 2016, compared with 0.094 at fixed and additional sites in 2015. It should be noted that contrasting 2015 sampling, additional hoop net sampling was not a project component in 2016 (i.e., sampling occurred only at fixed sites) which potentially explains catch variation in CPUE between the two years.

In 2016, mini-fyke netting yielded 7,064 fish representing 37 species and one hybrid group. The majority of the catch was comprised of Bluegill (49.2%; n = 3,473), followed by Bluntnose Minnow (14.5%; n = 1,026), and Banded Killifish (9.6%; n = 677), which is a State threatened species (Table 5). Mini-fyke netting CPUE (No. fish/net night) of all species captured was 55 at fixed sites in 2016 (Table 2), much greater than in 2015 (CPUE = 35). No Asian carp were captured.

Results of standardized sampling revealed patterns of Asian carp distribution and relative abundance in the Upper Illinois Waterway. Based on monitoring results to date, we characterized abundance of Bighead and Silver Carp as absent in Lockport pool (river mile 291- 296) and Brandon Road pool (river mile 286-291), both downstream of the Electric Dispersal Barrier. The detectable adult population front to date is located in the Dresden Island pool at Treats Island just north of the I-55 Bridge where it crosses over the lower Des Plaines River (river mile 280). This location is about 47 miles from Lake Michigan (Chicago Harbor; river mile 327). The USACE first identified a small population of Bighead Carp in Dresden Island pool near Moose Island in 2006 (river mile 276; Kelly Baerwaldt, personal communication). For reasons unknown, the detectable population front has made little upstream progress. The Marseilles Pool (river miles 245-272) contained moderately abundant populations of both Bighead and Silver Carp relative to downstream locations (such as at Starved Rock pool; *see* Barrier Defense Removal Report). Populations of adults were located within 55 miles of Lake Michigan and have historically showed potential for spawning— gravid females and males were observed running ripe in the Marseilles Pool from 2010 to 2012. Spawning activity was observed on 22 May 2013 by B. Ruebush and J. Zeigler in the Marseilles pool (river mile 269.5). Increased commercial fishing efforts were directed to the Starved Rock pool when catch rates were low in the Marseilles pool.

Monitoring Efforts Downstream of the Electric Dispersal Barrier

In 2015, juvenile Asian carp (>6 inches) were detected by USFWS at two sites in in Peoria pool (above Henry; river mile 190), two sites in the Starved Rock pool, and one site in the Marseilles. In 2016, four juvenile Asian carp (<6 inches) were captured by INHS in Peoria pool (*see* Young-of-year and Juvenile Asian Carp Monitoring).

Recommendation: Extensive monitoring and removal efforts have allowed us to characterize and manage the risk of Asian carp populations moving upstream toward the Electric Dispersal Barrier and Lake Michigan. Similar patterns in Asian carp abundance among sampling gears (electrofishing and gill and trammel netting) and monitoring/removal projects (*see* Barrier Defense Removal report) add confidence to the finding that the relative abundance of Asian carp decreased with upstream location in the Upper Illinois Waterway. Continued sampling efforts will provide invaluable real-time information about the detectable population front. Therefore, we recommend continued sampling below the Electric Dispersal Barrier using electrofishing, hoop netting, mini-fyke netting, and gill and trammel netting using the same protocols as in 2016.

Table 1. *Fixed and random electrofishing catch summaries for 2016, including 2010-2016 in the pools below the Electric Dispersal Barrier.*

	2016 Fixed Electrofishing						2016 Random Electrofishing						2010-2016	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Alewife													10	0.01%
American eel			1		1	<0.01%							3	<0.01%
Banded darter									3		3	0.01%	6	<0.01%
Banded killifish	41	18	19	2	80	0.35%	37	14	5	11	67	0.33%	308	0.19%
Bighead carp			2		2	0.01%				1	1	<0.01%	29	0.02%
Bigmouth buffalo			5	27	32	0.14%			6	14	20	0.10%	484	0.30%
Black buffalo			2		2	0.01%			2	3	5	0.02%	192	0.12%
Black bullhead							1				1	<0.01%	16	0.01%
Black crappie			1	14	15	0.07%		1	9	4	14	0.07%	136	0.08%
Black redhorse									10		10	0.05%	16	0.01%
Blacknose dace													2	<0.01%
Blackside darter			1		1	<0.01%			1		1	<0.01%	8	<0.01%
Blackstripe topminnow		4	2		6	0.03%		1		2	3	0.01%	59	0.04%
Blue catfish													1	<0.01%
Bluegill	7	10	356	100	473	2.05%	1	8	529	75	613	3.06%	9,292	5.76%
Bluegill x Green sunfish hybrid													30	0.02%
Bluntnose minnow	24	13	30	25	92	0.40%	16	22	80	25	143	0.71%	3,637	2.25%
Bowfin			5	3	8	0.03%			4		4	0.02%	32	0.02%
Brassy minnow													6	<0.01%
Brook silverside			2	4	6	0.03%	2		11	4	17	0.08%	248	0.15%
Brown bullhead													14	0.01%
Bullhead minnow				12	12	0.05%			33	27	60	0.30%	1,109	0.69%
Carp x goldfish hybrid		1	2		3	0.01%			1		1	<0.01%	57	0.04%
Central mudminnow													3	<0.01%
Central stoneroller													7	<0.01%
Channel catfish	3	22	31	19	75	0.33%	3	4	63	58	128	0.64%	1,086	0.67%
Channel shiner				2	2	0.01%			1	1	2	0.01%	33	0.02%
Common carp	244	77	248	84	653	2.84%	51	94	581	155	881	4.40%	8,919	5.53%

Table 1 (*Continued)*

	2016 Fixed Electrofishing						2016 Random Electrofishing						2010-2016	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Common shiner													29	0.02%
Creek chub													4	<0.01%
Emerald shiner	41	62	135	214	452	1.96%	37	65	200	596	898	4.48%	9,988	6.19%
Fathead minnow							1		1		2	0.01%	20	0.01%
Flathead catfish				1	1	<0.01%			3	6	9	0.04%	96	0.06%
Freshwater drum		4	48	68	120	0.52%	1	4	130	200	335	1.67%	1,512	0.94%
Gizzard shad	1,383	639	11,709	3,692	17,423	75.65%	900	843	5,143	4,020	10,906	54.46%	84,015	52.07%
Golden redhorse			22	67	89	0.39%			159	79	238	1.19%	1,199	0.74%
Golden shiner	9		34	1	44	0.19%	2	4	49	3	58	0.29%	594	0.37%
Goldeye													3	<0.01%
Goldfish	10	1	8		19	0.08%	3	8	19		30	0.15%	483	0.30%
Grass carp			1	12	13	0.06%			2	22	24	0.12%	77	0.05%
Grass pickerel		1	1		2	0.01%			2		2	0.01%	41	0.03%
Greater redhorse				2	2	0.01%							5	<0.01%
Green sunfish	16	6	42	10	74	0.32%		11	28	5	44	0.22%	2,380	1.47%
Greenside darter									1		1	<0.01%	7	<0.01%
Highfin carpsucker				3	3	0.01%			1		1	<0.01%	43	0.03%
Hornyhead chub													2	<0.01%
Hybrid Sunfish	1	1	2		4	0.02%			3		3	0.01%	312	0.19%
Johnny darter									9		9	0.04%	21	0.01%
King salmon													1	<0.01%
Largemouth bass	24	28	332	122	506	2.20%	12	20	597	85	714	3.57%	5,170	3.20%
Logperch				8	8	0.03%			41	2	43	0.21%	181	0.11%
Longear sunfish			8		8	0.03%			23	1	24	0.12%	50	0.03%
Longnose gar	2	2	52	91	147	0.64%			63	30	93	0.46%	1,013	0.63%
Mimic shiner				3	3	0.01%							22	0.01%
Mooneye									4		4	0.02%	9	0.01%
Muskellunge													2	<0.01%

Table 1 (*Continued)*

	2016 Fixed Electrofishing						**2016 Random Electrofishing**						**2010-2016**	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Northern hog sucker				10	10	0.04%			3	5	8	0.04%	77	0.05%
Northern pike	3	3	1	3	10	0.04%		2	4		6	0.03%	62	0.04%
Orangespotted sunfish			3	1	4	0.02%			6	1	7	0.03%	211	0.13%
Oriental Weatherfish	4		1		5	0.02%	3	29			32	0.16%	210	0.13%
Paddlefish													1	<0.01%
Pumpkinseed	24	5	73	2	104	0.45%		16	121	1	138	0.69%	2,095	1.30%
Pumpkinseed x bluegill hybrid			8		8	0.03%							15	0.01%
Quillback			7	29	36	0.16%			33	31	64	0.32%	547	0.34%
Red shiner													3	<0.01%
Redear sunfish			13		13	0.06%						0.00%	21	0.01%
River carpsucker			18	163	181	0.79%		1	50	213	264	1.32%	1,436	0.89%
River redhorse				3	3	0.01%			1		1	<0.01%	13	0.01%
River shiner													30	0.02%
Rock bass		2	4		6	0.03%		1	15	2	18	0.09%	104	0.06%
Round Goby	1	10	1		12	0.05%		3	3	3	9	0.04%	155	0.10%
Sand shiner				2	2	0.01%			11	9	20	0.10%	272	0.17%
Sauger		1	1	2	4	0.02%		2		4	6	0.03%	37	0.02%
Shorthead redhorse			8	28	36	0.16%			44	26	70	0.35%	413	0.26%
Shortnose gar			1	15	16	0.07%			2	5	7	0.03%	105	0.07%
Silver carp			10	372	382	1.66%			23	512	535	2.67%	1,842	1.14%
Silver chub													2	<0.01%
Silver redhorse			11	11	22	0.10%			49	10	59	0.29%	192	0.12%
Skipjack herring				5	5	0.02%				2	2	0.01%	55	0.03%
Slenderhead darter									5		5	0.02%	7	<0.01%
Smallmouth bass		18	43	99	160	0.69%		13	116	178	307	1.53%	1,806	1.12%
Smallmouth buffalo			204	317	521	2.26%		1	536	1,124	1,661	8.30%	6,887	4.27%
Spotfin shiner	3	1	44	38	86	0.37%		2	101	74	177	0.88%	3,094	1.92%
Spottail shiner		1	36	10	47	0.20%	2	8	173	13	196	0.98%	1,341	0.83%

Table 1 (*Continued)*

	2016 Fixed Electrofishing						2016 Random Electrofishing						2010-2016	
	Pool						Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Lockport	Brandon	Dresden	Marseilles	No. Cap.	Percent	Captured	Percent
Spotted gar				1	1	<0.01%							7	<0.01%
Spotted sucker			3		3	0.01%			14		14	0.07%	39	0.02%
Stonecat													1	<0.01%
Striped bass x white bass hybrid				1	1	<0.01%				4	4	0.02%	33	0.02%
Striped shiner													2	<0.01%
suckermouth minnow													3	<0.01%
Tadpole madtom									1		1	<0.01%	4	<0.01%
Threadfin shad	122	52	473	128	775	3.37%	377	145	280	10	812	4.06%	5,394	3.34%
Trout perch									1		1	<0.01%	5	<0.01%
Unidentified Catostomid (suckers)			2		2	0.01%			19	2	21	0.10%	44	0.03%
Unidentified Cyprinid													4	<0.01%
Unidentified Moronid													3	<0.01%
Unidentified Percid													1	<0.01%
Walleye			5		5	0.02%			23	1	24	0.12%	66	0.04%
Walleye x Sauger hybrid													1	<0.01%
Warmouth			1		1	<0.01%			4		4	0.02%	16	0.01%
Western mosquitofish	8				8	0.03%	2				2	0.01%	47	0.03%
White bass		1	15	47	63	0.27%			7	32	39	0.19%	541	0.34%
White crappie				11	11	0.05%			3	1	4	0.02%	83	0.05%
White perch	3		2		5	0.02%	1		2	1	4	0.02%	31	0.02%
White perch hybrid													1	<0.01%
White sucker		28	19	7	54	0.23%		15	31	8	54	0.27%	407	0.25%
Yellow bass			1	10	11	0.05%				2	2	0.01%	53	0.03%
Yellow bullhead	3	2	27		32	0.14%	3	6	21	1	31	0.15%	502	0.31%
Yellow perch	1		1	2	4	0.02%			3		3	0.01%	15	0.01%
Total Caught	1,977	1,013	14,137	5,903	23,030	100%	1,455	1,343	9,522	7,704	20,024	100%	161,358	100.00%
Species	23	28	55	50	68		20	28	66	51	73		97	
Hybrid Groups	0	1	2	1	4		0	0	1	1	3		7	

Table 2. *Fixed and random electrofishing, fixed and targeted gill and trammel netting, and fixed hoop netting and mini-fyke netting efforts and catch summaries for 2016 in the pools below the Electric Dispersal Barrier.*

Fixed Electrofishing Effort-2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	6 April - 23 November				
Estimated person-hours	97.5	107.5	200	130	535
Electrofishing hours	9.75	10.75	20	13	53.5
Samples (transects)	39	43	80	52	214
All Fish (*N*)	1977	1013	14137	5903	23030
Species (*N*)	23	28	55	50	68
Hybrids (*N*)	0	1	2	1	4
Bighead Carp (*N*)	0	0	2	0	2
Silver Carp (*N*)	0	0	10	372	382
CPUE (fish/hour)	200	94	710	450	430

Random Electrofishing Effort-2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	6 April - 23 November				
Estimated person-hours	190	180	350	260	980
Electrofishing hours	19	18	35	26	98
Samples (transects)	76	72	140	104	392
All Fish (*N*)	1455	1343	9522	7704	20024
Species (*N*)	20	28	66	51	73
Hybrids (*N*)	0	0	1	1	3
Bighead Carp (*N*)	0	0	0	1	1
Silver Carp (*N*)	0	0	23	512	535
CPUE (fish/hour)	77	75	270	300	200

Fixed Gill and Trammel Netting Effort - 2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	15 March - 2 December				
Estimated person-hours	26.3	26.3	26.3	0	78.9
Samples (net sets)	72	45	57	0	174
Total miles of net	8.2	5.4	7.8	0	21.4
All Fish (N)	63	986	310	0	1359
Species (N)	2	2	13	0	13
Hybrids (N)	0	0	0	0	0
Bighead Carp (N)	0	0	1	0	1
Silver Carp (N)	0	0	10	0	10
CPUE (No. fish/100 yards of net)	0.44	10	2.3	0	3.6

Targeted Gill and Trammel Netting Effort - 2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample dates	15 March - 2 December				
Estimated person-hours	648.7	648.7	1053.7	0	2351.1
Samples (net sets)	412	394	507	0	1313
Total miles of net	49	46.9	72	0	167.9
All Fish (N)	222	503	5235	0	5960
Species (N)	5	8	21	0	24
Hybrids (N)	1	1	2	0	2
Bighead Carp (N)	0	0	229	0	229
Silver Carp (N)	0	0	226	0	226
CPUE (No. fish/100 yards of net)	0.26	0.61	4.1	0	2.0

Hoop Netting Effort - 2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	30 March - 30 October				
Estimated person-hours	80	80	80	80	320
Net nights	64	64	64	64	256
Samples (net sets)	32	32	32	32	128
All Fish (*N*)	7	13	73	119	212
Species (*N*)	2	4	9	10	14
Hybrids (*N*)	0	0	0	0	0
Bighead Carp (*N*)	0	0	0	19	19
Silver Carp (*N*)	0	0	0	47	47
CPUE (No. fish/net night)	0.11	0.20	1.1	1.9	0.83

Mini Fyke Netting Effort - 2016

	Pool				
	Lockport	Brandon	Dresden	Marseilles	Total
Sample Dates	30 March - 30 October				
Estimated person-hours	80	80	80	80	320
Net nights	32	32	32	32	128
Samples (net sets)	32	32	32	32	128
All Fish (*N*)	1,413	1,674	3,046	931	7,064
Species (*N*)	19	25	27	23	37
Hybrids (*N*)	1	1	1	0	1
Bighead Carp (*N*)	0	0	0	0	0
Silver Carp (*N*)	0	0	0	0	0
CPUE (No. fish/net night)	44	52	95	29	55

Table 3. *Catch totals and species composition of fish captured during fixed and targeted gill and trammel netting in 2016 and total number of fish*

captured from 2010-2016 in the pools below the Electric Dispersal Barrier.

	2016 Fixed Gill and Trammel Netting Catch					2016 Targeted Gill and Trammel Netting Catch					2010 - 2016	
	Pool					Pool						
Species	Lockport	Brandon	Dresden	No. Captured	Percent	Lockport	Brandon	Dresden	No. Captured	Percent	Captured	Percent
Bighead Carp			1	1	0.1%			229	229	3.8%	1,922	8.8%
Bigmouth Buffalo			13	13	1.0%			307	307	5.2%	1,008	4.6%
Black Buffalo								56	56	0.9%	326	1.5%
Bowfin								1	1	<0.1%	1	<0.01%
Bluegill											1	<0.01%
Channel Catfish			27	27	2.0%	1	10	88	99	1.7%	452	2.1%
Common Carp	62	982	158	1202	88.4%	216	465	1,214	1895	31.8%	9,089	41.6%
Common Carp x Goldfish Hybrid						1	5	3	9	0.2%	127	0.6%
Flathead Catfish			1	1	0.1%		1	19	20	0.3%	68	0.3%
Freshwater Drum	1	4	5	10	0.7%	2	5	79	86	1.4%	347	1.6%
Gizzard Shad								1	1	<0.1%	5	<0.01%
Goldeye											3	<0.01%
Goldfish			4	4	0.3%	1	1		2	<0.1%	49	0.2%
Grass Carp			1	1	0.1%		1	17	18	0.3%	74	0.3%
Largemouth Bass								3	3	0.1%	25	0.1%
Longnose Gar			1	1	0.1%			40	40	0.7%	116	0.5%
Muskellunge								1	1	<0.1%	2	<0.01%
Northern Pike								3	3	0.1%	10	<0.01%
Quillback								28	28	0.5%	47	0.2%
River Carpsucker			1	1	0.1%			81	81	1.4%	171	0.8%
Sauger							1		1	<0.1%	1	<0.01%
Shortnose Gar											1	<0.01%
Silver Carp			10	10	0.7%			226	226	3.8%	545	2.5%
Silver Redhorse											3	<0.01%
Skipjack Herring											4	<0.01%
Smallmouth Buffalo			87	87	6.4%		14	2829	2843	47.7%	7,435	34.0%
Spotted Gar								6	6	0.1%	7	<0.01%

Table 3 (*Continued*)

	2016 Fixed Gill and Trammel Netting Catch					2016 Targeted Gill and Trammel Netting Catch					2010 - 2016	
	Pool					Pool						
Species	Lockport	Brandon	Dresden	No. Captured	Percent	Lockport	Brandon	Dresden	No. Captured	Percent	Captured	Percent
Striped Bass x White Bass Hybrid								2	2	<0.1%	5	<0.01%
Unidentified Catostomid										0.0%	4	<0.01%
White Bass								1	1	<0.1%	1	<0.01%
Walleye								1	1	<0.1%	3	<0.01%
White Crappie										0.0%	1	<0.01%
Yellow Bullhead			1	1	0.1%	1			1	<0.1%	4	<0.01%
Total Captured	63	986	310	1,359	100%	222	503	5,235	5,960	100%	21,857	100.0%
No. Species	2	2	13	13		5	8	21	24		30	
No. Hybrid Groups						1	1	2	2		2	

Table 4. *Catch totals and species composition of fish captured during fixed hoop netting in 2016 and total number of fish captured from 2012-2016 below the Electric Dispersal Barrier.*

	2016 Hoop Netting Catch						2012-2016	
	Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Captured	Percent	Captured	Percent
Bighead Carp				19	19	9.0%	160	6.9%
Bigmouth Buffalo							1	<0.1%
Black Buffalo							7	0.3%
Black Crappie				1	1	0.5%	2	0.1%
Channel Catfish		1	3	6	10	4.7%	667	28.9%
Common Carp	6	9	18	1	34	16.0%	376	16.3%
Common Carp x Goldfish Hybrid							4	0.2%
Flathead Catfish			1	11	12	5.7%	44	1.9%
Freshwater Drum		2	5	2	9	4.2%	41	1.8%
Gizard Shad	1				1	0.5%	1	<0.1%
Golden Redhorse			1		1	0.5%	3	0.1%
Goldfish							4	0.2%
Grass Carp			1		1	0.5%	2	0.1%
Largemouth Bass							1	0.0%
Longnose Gar							1	<0.1%
Quillback							2	0.1%
River Carpsucker			3	1	4	1.9%	32	1.4%
Shorthead Redhorse			1		1	0.5%	1	<0.1%
Silver Carp				47	47	22.2%	107	4.6%
Silver Redhorse							1	<0.1%
Smallmouth Bass							1	<0.1%
Smallmouth Buffalo		1	40	30	71	33.5%	837	36.3%
Striped Bass x White Bass Hybrid							2	0.1%
White Bass				1	1	0.5%	4	0.2%
White Crappie							3	0.1%
Total Captured	7	13	73	119	212	100.0%	2,304	100.0%
No. Species	2	4	9	10	14		23	
No. Hybrid Groups					0		2	

Table 5. *Catch totals and species composition of fish captured during fixed mini-fyke netting in 2016 and total number of fish captured from 2012-2016 below the Electric Dispersal Barrier.*

	2016 Mini-Fyke Netting Catch						2012-2016	
	Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Captured	Percent	Captured	Percent
Banded Killifish	374	116	178	9	677	9.6%	960	2.0%
Black Buffalo							1	<0.1%
Black Bullhead							6	<0.1%
Black Crappie			1	2	3	<0.1%	31	0.1%
Blackstripe Topminnow		9	10	24	43	0.6%	317	0.7%
Bluegill	130	623	2,186	534	3,473	49.2%	20,423	42.1%
Bluntnose Minnow	194	468	263	101	1,026	14.5%	6,958	14.3%
Bowfin							1	<0.1%
Brook Silverside							35	0.1%
Brown Bullhead							1	<0.1%
Bullhead Minnow							363	0.7%
Central Mudminnow							4	<0.1%
Channel Catfish	2	1	5	5	13	0.2%	91	0.2%
Common Carp	4	37	4		45	0.6%	767	1.6%
Common Shiner	2		2		4	0.1%	4	<0.1%
Creek Chub							5	<0.1%
Emerald Shiner	10	6	39	37	92	1.3%	637	1.3%
Fathead Minnow							4	<0.1%
Flathead Catfish							2	<0.1%
Freshwater Drum							6	<0.1%
Gizzard Shad	179	38	1	1	219	3.1%	734	1.5%
Golden Shiner	1	4	6	3	14	0.2%	105	0.2%
Goldfish			2		2	<0.1%	21	<0.1%
Grass Pickerel							3	<0.1%
Green Sunfish	262	35	75	27	399	5.6%	2,962	6.1%
Hybrid Sunfish	51	20	33		104	1.5%	253	0.5%
Johnny Darter				4	4	0.1%	23	<0.1%
Largemouth Bass	2	2	6	2	12	0.2%	297	0.6%
Logperch							14	<0.1%
Longear Sunfish							7	<0.1%

Table 5 (*Continued)*

	2016 Mini-Fyke Netting Catch						2012-2016	

Table 5 (*Continued*)

	2016 Mini-Fyke Netting Catch						2012-2016	
	Pool							
Species	Lockport	Brandon	Dresden	Marseilles	No. Captured	Percent	Captured	Percent
Longnose Gar			4	5	9	0.1%	15	<0.1%
Northern Pike							2	<0.1%
Orangespotted Sunfish		3			3	<0.1%	1,170	2.4%
Oriental Weatherfish	65	2	1	1	69	1.0%	195	0.4%
Pumpkinseed	63	25	131		219	3.1%	3,330	6.9%
River Shiner							24	<0.1%
Rock Bass		1	9		10	0.1%	36	0.1%
Round Goby	5	197	12	3	217	3.1%	1,409	2.9%
Sand Shiner		4	4	50	58	0.8%	581	1.2%
Sauger		1			1	<0.1%	14	<0.1%
Shorthead Redhorse							2	<0.1%
Shortnose Gar				1	1	<0.1%	10	<0.1%
Skipjack Herring							1	<0.1%
Slenderhead Darter							1	<0.1%
Smallmouth Bass			1		1	<0.1%	15	<0.1%
Smallmouth Buffalo							7	<0.1%
Spotfin Shiner	3	1	13	59	76	1.1%	3,441	7.1%
Spottail Shiner		34	17	38	89	1.3%	613	1.3%
Stonecat							1	<0.1%
Striped Shiner							3	<0.1%
Suckermouth Minnow							1	<0.1%
Tadpole Madtom	1		3		4	0.1%	87	0.2%
Threadfin Shad							6	<0.1%
Unidentified Catostomid							15	<0.1%
Unidentified Centrarchid			30	20	50	0.7%	50	0.1%
Unidentified Cyprinid							10	<0.1%
Unidentified Darter				1	1	<0.1%	1	<0.1%
Unidentified Moronid							1	<0.1%
Unidentified Notropis							35	0.1%
Walleye				1	1	<0.1%	1	<0.1%
Warmouth							18	<0.1%

Monitoring Efforts Downstream of the Electric Dispersal Barrier

Species	Pool				No. Captured	Percent	Captured	Percent
	Lockport	Brandon	Dresden	Marseilles				
Western Mosquitofish	18	7	1		26	0.4%	1,700	3.5%
White Bass							2	<0.1%
White Crappie		4	2	1	7	0.1%	48	0.1%
White Perch				1	1	<0.1%	11	<0.1%
White Sucker		2		1	3	<0.1%	45	0.1%
Yellow Bass		3			3	<0.1%	33	0.1%
Yellow Bullhead	45	31	7		83	1.2%	568	1.2%
Yellow Perch	2				2	<0.1%	8	<0.1%
Total Captured	1,413	1,674	3,046	931	7,064	100.0%	48,545	100.0%
No. Species	19	25	27	23	37		63	
No. Hybrid Groups	1	1	1		1		1	

REMOVAL PROJECTS AND EVALUATION

Response Actions in the CAWS

(Illinois Department of Natural Resources)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

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

Introduction and Need:

Preventing Asian carp from gaining access to Lake Michigan via the CAWS requires monitoring to detect and locate potential invaders and removal efforts to reduce population abundance and the immediate risk of invasion. Removal actions that capture or kill Asian carp once their location is known may include the use of conventional gears (e.g., electrofishing, nets, and commercial fishers), experimental gears (e.g., Great Lake pound nets, and deep water gill nets), and chemical piscicides (e.g., rotenone), or all strategies. Decisions to commence removal actions, particularly rotenone actions, often are difficult due to high labor, equipment, and supply costs. Furthermore, a one-size-fits-all formula for rapid response actions is not possible in the CAWS because characteristics of the waterway (e.g., depth, temperature, water quality, morphology, and habitat) are highly variable. A threshold framework for response actions with conventional gear or rotenone was developed in the 2011 MRRP. Proposed thresholds were meant to invoke consideration of removal actions by the MRWG, and were not intended to be rigid triggers requiring immediate action. Final decisions to initiate response actions and the type and extent of each action were ultimately based on the best professional judgment of representatives from involved action agencies.

Objectives:

1) Remove Asian carp from the CAWS upstream of Lockport Lock and Power Station when warranted.
2) Determine Asian carp population abundance through intense targeted sampling efforts at locations deemed likely to hold fish.

Project Highlights:

- Based on the criteria of the Response Action Matrix no rapid response actions were conducted in the CAWS in 2016. Alternatively two Seasonal Intensive Monitoring (SIM) events were conducted in 2016 yielding no Bighead Carp or Silver Carp being captured or observed. Refer to the Seasonal Intensive Monitoring report for comprehensive results.

Response Actions in the CAWS

- A total of 240 early detection monitoring samples (250 ml each) were collected upstream of the dispersal barrier, centrifuged in the mobile lab, and analyzed at WGL. Two positive samples were found in 2016. Refer to Strategy for eDNA Monitoring in the CAWS and Below Electric Dispersal Barrier summary report for comprehensive results.
- From 2010-2012, eleven rapid response actions with conventional and experimental gears in the CAWS upstream of the Electric Dispersal Barrier Eight of the response actions were triggered by positive detections of Asian carp eDNA. No Bighead or Silver Carp were captured or observed during these responses.
- We recommend full implantation of the Upper Illinois Waterway Contingency Response Plan to guide future responses.

Methods:

The tools utilized for response actions are conventional gears, experimental gears and/or rotenone to capture and remove Asian carp from the CAWS upstream of Lockport Lock and Power Station. Each response action will be unique to location, perceived severity of the threat, and likelihood of successfully capturing an Asian carp. For example, observation of a live Asian carp from a credible source at the shallow North Shore Channel might elicit a 2- to 3-day conventional gear response with two electrofishing and netting crews. Capture of a live Asian carp at the same location might initiate a 2-week response with 5-10 sampling crews and additional types of gear. Furthermore, capture or credible observations of multiple Asian carp in a deep-draft channel, such as the Little Calumet River below O'Brien Lock, might call for an emergency rotenone action to eradicate the local population. In general, small-scale removal actions will require fewer sampling crews and gear types than larger events, although all events will include multiple gears for more than one day of sampling and participation by commercial fishers, if available.

New methods to drive capture, and kill Asian carp are constantly being developed and evaluated as part of the ACRCC Framework (see water gun, gear evaluation, and alternative gear projects in this plan and pheromone research outlined in the 2014 Framework). Such techniques may allow biologists to drive or attract Asian carp to barge slips or other backwater areas where they can be captured more easily or killed. We will incorporate new technologies in response actions when they have been sufficiently vetted and shown to be of practical use.

Threshold Framework-

Data from ECALS has revealed the uncertainty of eDNA positive detections originating from a live, free swimming fish, and several vectors have been identified as potential sources in addition to a live fish. Intensive sampling over the past seven years, including response actions triggered by detection of Asian carp DNA, has resulted in no Asian carp being observed or captured. At present, the detection of eDNA evidence within a sampled reach cannot verify whether live Asian carp are present, whether the DNA may have come from a dead fish, or whether water containing Asian carp DNA may have been transported from other sources such as boat hulls, storm sewers, sediment, piscivorous birds or nets used by contracted commercial fishers. It is also not fully understood how environmental variables (e.g. temperature, conductivity, pH, etc.) impact the detection rate, degradation rate, or persistence of DNA in the environment. In light of this information, the MRWG proposes a new framework to guide management decisions on response actions in the CAWS where eDNA is no longer a response trigger. Therefore, the observation or capture of a live Asian carp by a credible source would be the lone trigger for initiating a response.

The proposed thresholds for response actions with conventional gears and rotenone apply to monitoring efforts in the CAWS upstream of Lockport Lock and Power Station. Again, this threshold framework is meant to inform decisions to initiate response actions and guide the level of sampling effort put forth during such actions. Actual decisions to respond and the type, duration, and extent of response actions will be made by agency representatives with input from the MRWG. Action agencies also may conduct targeted response actions at selected locations in the CAWS outside the rapid response threshold framework when information gained from such actions may benefit monitoring protocols, research efforts, or Asian carp removal and control efforts.

The threshold framework includes three levels of response triggers and a feedback loop that advises for continued sampling or an end to the action (Figure 1). The first threshold level (Level 1) includes the observation of live Asian carp by a credible source (i.e., fisheries biologist or field technician). A suggested response for Level 1 might include 2-4 electrofishing boats and crews and 1-2 commercial fishing boats and crews sampling for 2-3 days. A Level 2 threshold

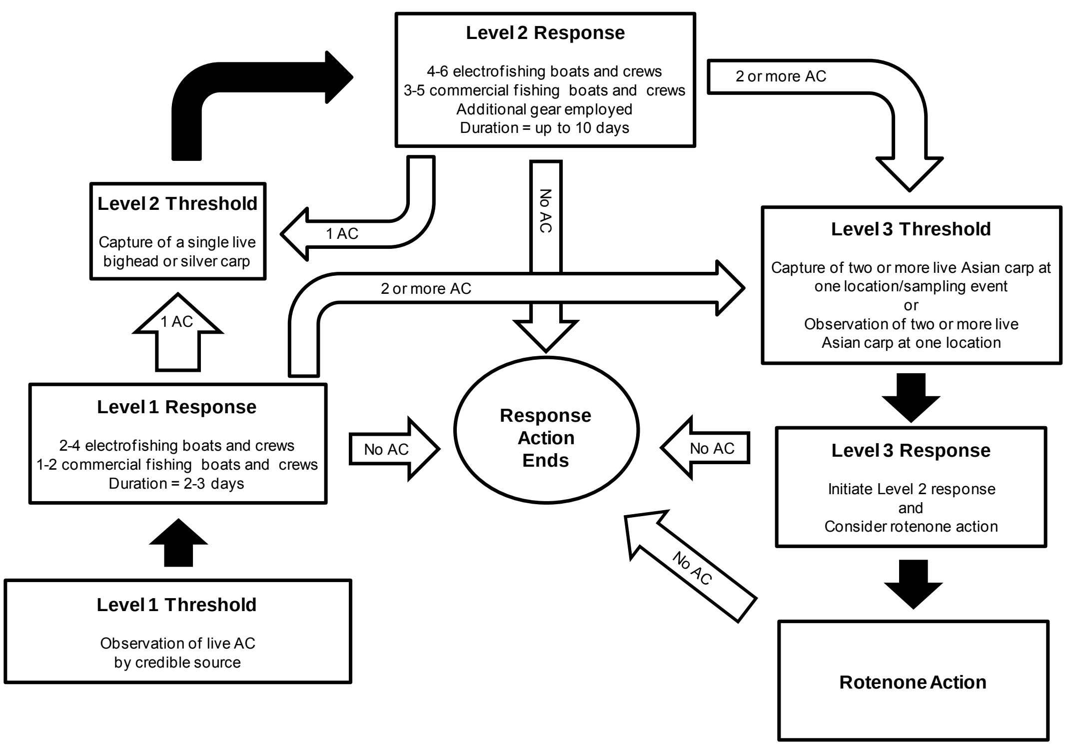

Figure 1. *Thresholds for Asian carp (AC) response actions with conventional gears and rotenone.*

would include the capture or creditable sighting of a single live Bighead or Silver Carp. A Level 2 response might employ 4-6 electrofishing boats and crews, 3-5 commercial fishing boats and crews, and additional gears (e.g., hydroacoustics, commercial seines, and trap or fyke nets). Level 2 events might last up to 10 days. The capture of two or more Asian carp from a single sampling event-location or the credible observation of two or more Asian carp at one location would signify a Level 3 threshold. Crossing the Level 3 threshold would trigger an immediate Level 2 conventional gear response action and consideration of a rotenone response. Where feasible (e.g., non-navigation reaches, barge slips, backwater areas), block nets will be used in an attempt to keep Asian carp in the area being sampled. The final decision to terminate a response will rely on best professional judgment of participating biologists, managers, and agency administrators.

Results and Discussion:

In 2016 no "Response" actions were utilized in the CAWS based on the established thresholds put forth in the 2016 MRP. However two Seasonal Intensive Monitoring events were completed in the CAWS. Each of these events were strategically planned and developed according to the area sampled and its unique habitat characteristics. The results and details of these seasonal intensive monitoring events are summarized within this report in the "*Seasonal Intensive Monitoring"* section.

Consistent with findings from the 2013 ECALS, the potential for Asian carp genetic material in eDNA samples exists as the result of residual material on sampling equipment (boats, netting gear, etc.). Efforts were taken in in the last three years above the Electric Dispersal Barrier to minimize the potential for eDNA contamination and the MRWG has developed a Best Management Practices (BMP) to address the transport of eDNA and unwanted aquatic nuisance species. The 2016 decontamination protocol included the use of hot water pressure washing and chlorine washing (10% solution) of boats and potentially contaminated equipment. Additionally, IDNR and contracted commercial netters used netting gear that was site-specific to the CAWS and was only used for monitoring efforts above the Electric Dispersal Barrier.

In 2016 total of 240 early detection monitoring samples (250 ml each) were collected upstream of the dispersal barrier, centrifuged in the mobile lab, and analyzed at WGL. Two samples were found positive for both species of carp DNA. The "*Strategy for eDNA Monitoring*" report summarizes the events from 2016 and the results from these events are available at:

http://www.fws.gov/midwest/fisheries/eDNA/Results-chicago-area.html

Recommendation: With the results from 2014, 2015 and 2016 Seasonal Intensive Monitoring events and several previous Response actions, we would recommend continuing the seasonal intensive monitoring approach in the CAWS. This approach is considered a hybrid of the previous Fixed and Random Site Monitoring Upstream of the Dispersal Barrier and Planned Intensive Surveillance in the CAWS plans. The plan would continue monitoring intensively during a two week period in the spring and fall using conventional and experimental gears that have been utilized during previous years and events. Ongoing monitoring results demonstrate no fish captured in the Lockport and Brandon Road pool, the data suggest Asian carp abundance are either nonexistent or extremely low upstream of the Electric Dispersal Barrier system. With these two pools acting as a critical buffer, the Lockport and Brandon Road Pool areas have been integrated within the current response matrix. This will allow responses to be executed within these pools when the response criteria are met. Also we do recommend the full implementation of the Upper Illinois Waterway Contingency Response Plan to guide future responses.

Barrier Maintenance Fish Suppression

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

Introduction: The US Army Corps of Engineers (USACE) operates three electric aquatic invasive species dispersal barriers (Demonstration Barrier, 2A and 2B) in the Chicago Sanitary and Ship Canal at approximate river mile 296.1 near Romeoville, Illinois. The Demonstration Barrier became operational in April 2002 and is located farthest upstream at river mile 296.6 (about 244 meters above Barrier 2B). The Demonstration Barrier is operated at a setting that has been shown to induce behavioral responses in fish over 137 mm in total length (Holliman 2011). Barrier 2A became operational in April 2009 and is located 67 meters downstream of Barrier 2B which went online in January 2011. Both Barrier 2A and 2B can operate at parameters shown to repel or stun juvenile and adult fish greater than 137 mm long at a setting of 0.79 volts per centimeter or fish greater than 63 mm long at a setting of 0.91 volts per centimeter (Holliman 2011). The higher setting has been in use since October 2011. USACE is currently constructing a permanent upgrade to the Demonstration Barrier which will be regarded as Permanent Barrier 1 (Barrier 1). Barrier 1 will be capable of increased operational settings in comparison to Barriers 2A and 2B.

Barriers 2A and 2B must be shut down independently for maintenance approximately every 12 months and the Illinois Department of Natural Resources has agreed to support maintenance operations by conducting fish suppression and/or clearing operations at the barrier site. Fish suppression can vary widely in scope and may include application of a piscicide such as rotenone to keep fish from moving upstream past the barriers when they are down. Rotenone was used December 2009 in support of Barrier 2A maintenance, 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.

Barrier 2B operated as the principal barrier from the time it was brought on line and tested in January 2011 through December 2013. During that time, Barrier 2A was held in warm standby mode (so it could be energized to normal operating level in a matter of minutes) unless 2B experienced an unexpected outage or planned maintenance event. In January 2014, standard operating procedure was changed to run Barriers 2A and 2B concurrently. This change further increased the efficacy of the Electric Dispersal Barrier System as a whole by maintaining power in the water continuously regardless of a lapse in operation at any single barrier. Because the threat of Asian carp invasion is from downstream waters, there is a need to clear fish from the 67 meter length of canal between Barrier 2A and 2B each time Barrier 2A loses power in the water for a time sufficient to allow fish passage. Without a clearing evaluation and potential action, there is a possibility that fish may utilize barrier outages to 'lock through' the Electric Dispersal Barrier System. Locking through happens if an outage were experienced at 2A. This would allow fish present just downstream to move up to barrier 2B. If 2A were to then come back online, those fish that moved below 2B would then be trapped between the barriers. If an outage is then experienced at 2B, the fish trapped between the barriers would then be able to move past into the area between 2B and the Demonstration Barrier or into upper Lockport pool if the Demo were de-energized. The suppression plan calls for an assessment of the risk of Asian carp passage at the time of the reported outage and further clearing actions if deemed necessary. A more detailed description of the suppression plan is outlined in the methods section below.

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

(1) Remove fish >300 mm (12 inches) in total length between Barrier 2A and 2B before maintenance operations are initiated at 2B or after maintenance is completed at 2A by collecting or driving fish into nets from the area with mechanical technologies (surface noise, surface pulsed-DC electrofishing and surface to bottom gill nets) or, if needed, a small-scale rotenone action.

(2) Assess fish assemblage <300 mm (12 inches) in total length between Barrier 2A and 2B for species composition to ensure Asian 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 Asian carp until further evidence from downstream monitoring suggests the presence of this size class upstream of Brandon Road Lock and Dam.

Project Highlights:

- The MRWG agency representatives met and discussed the risk level of Asian carp presence at the Electric Dispersal Barrier System at each primary barrier loss of power to water and determined that no barrier clearing actions were required.

Barrier Maintenance Fish Suppression

- Two 15 minute electrofishing runs were completed between Barriers 2A and 2B to supplement existing data in support of the MRWG clearing decision.
- Split-beam hydroacoustics and side-scan sonar assessed the risk of large fish presence between the barriers on 30 June, 14 September 2016 and 11 January 2017 indicating low fish abundance and no fish over 300 mm.
- **No Asian carp were captured or observed during fish suppression operations**

Methods:

An "outage" is defined as any switch in operations at the Barriers that would allow for upstream movement of fishes within the safety zone of the CSSC or any complete power loss in the water. At the occurrence of any barrier outage, the MRWG was notified as soon as possible by the USACE and convened with key agency contacts to discuss the need for a barrier clearing action. The decision to perform a clearing action based on a barrier outage was based on factors related to the likelihood of Asian carp passing the barrier, under the conservative assumption that they may be present in Lockport Pool and near or at the barriers. If Asian carp exist near the barriers, the MRWG currently expects only adult fish (> 300 mm) to be present. This risk evaluation may change however if small Asian carp are detected upstream of the Brandon Road Lock and Dam. Based on the current and joint understanding of the location of various sizes of Asian carp in the CAWS and upper Illinois Waterway and the operational parameters of Barriers 2A and 2B, the MRWG believes that either the wide or narrow array of each Barrier provides a minimally effective short-term barrier for juveniles or adults. Thus, the MRWG views a total outage of both wide and narrow arrays as a situation of increased risk for Asian carp passing a given barrier. The MRWG decision to initiate a clearing action at the barriers was made only during heightened risk of Asian carp passage based on the most up to date monitoring results and current research.

A cut-off of 300 mm in total length was selected for fishes to be removed from the barriers area when a clearing action was recommended by the MRWG. By selecting a cut-off of 300 mm, sub adult and adult Asian carp were targeted and young-of-year and juvenile fish were excluded. Excluding young-of-year and juvenile Asian carp from the assessment was based on over four years of sampling in the Lockport Pool with no indication of any young of the year Asian Carp present or any known locations of spawning. However, continued monitoring in the lower reaches of the Illinois Waterway in the spring of 2015 indicated that small Asian carp less than 153 mm were being collected progressively upstream over time. Juvenile Silver Carp were reported from the Starved Rock Pool beginning in April in substantial numbers with several individual captures of similar sized juvenile Silver Carp reported from the Marseilles Pool by October. These new records prompted resource managers to take a more conservative approach at the barriers by sampling all sizes of fishes between the barriers during a clearing event. It was determined that all fishes over 300 mm still be 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.

Barrier Maintenance Fish Suppression

A key factor to any response is risk of Asian carp being at or in the barrier. The MRWG has taken a conservative approach to barrier responses in that there is little evidence that Asian carp are directly below the barrier, but with the understanding that continued work and surveillance below the electric barriers is necessary to maintain appropriate response measures. Considering budgetary costs, responder safety and continued monitoring in reaches directly below the barrier, the MRWG will continue to discuss the need for a clearing action as best professional judgment suggests. A barrier maintenance clearing event will be deemed successful when all fish >300 mm are removed from the barrier or until MRWG deems the remaining fish in the barrier a low risk and a sub-sample of fish <300 mm have been identified to species.

Initially a clearing action will use split beam hydroacoustics and side scan SONAR imaging to determine if fish are present in the target area of the electric barrier array, including the area between Barrier IIA and IIB or between the active barrier array and the demonstration barrier, to identify the number of fish over 300 mm. If one or more fish targets over 300 mm are present, the MRWG recommends clearing the area between affected barriers. Initial response (remote sensing) should occur within a week of an outage; upon completion of this survey, fish detections, sizes, and locations will help formulate timely clearing efforts. Additional clearing actions can range from nearly “instantaneous” response with electrofishing to combined netting and electrofishing, or any combination of water gun or other efforts that may or may not require US Coast Guard (USCG) closures of the Canal/Waterway. The USCG generally requires at least 45 days notice for requests to restrict navigation traffic in the waterway.

Results and Discussion:

During 2016 Barrier 2A was the primary barrier within the Electric Dispersal Barrier System to fish passage in the upstream direction. Barrier 2A experienced a loss of power in water at both arrays for an extended duration (min=37 minutes; max=18 days) a total of 8 times (Table 1). Barrier 2B was operational during each of 2A’s outages and effectively served as the secondary barrier to upstream fish passage. The risk for Asian carp presence at the barrier and the likelihood of fish moving upstream to Barrier 2B was communicated to the MRWG at each primary barrier outage. The MRWG determined physical clearing actions between the barriers were not required due to a very low risk of Asian carp presence. There were two occasions in which additional monitoring actions were taken at the electric dispersal barrier system to further support the MRWG decision. Extreme cold temperatures, seasonal movement patterns of Asian carp and sufficient evidence from downstream sampling were all factors which supported the conclusion that Asian carp were likely not in the vicinity of the barriers during the reported losses of power. Safety was an additional factor in the decision to not perform clearing actions. Extreme cold temperatures or abnormally high flow within the canal restrain the ability of the workgroup to effectively deploy clearing teams. During such instances, the workgroup relied on best professional judgment, downstream sampling efforts and telemetry results to assess the risk of breach.

Barrier Maintenance Fish Suppression

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

In addition to the outages reported in the 2016 calendar year, USACE coordinated with the MRWG on a planned outage event at Barriers 2A and 2B in January of 2017. A concurrent shutdown of Barrier 2A and 2B was needed to support dive operations and inspection of the in water component at those barriers. USACE planned this outage to occur at a time of the year when fish activity and water temperatures are expected to be the lowest. The Demonstration Barrier was also operated continuously during the planned outages. The MRWG convened a call on 29 November 2016 to discuss the risk for Asian carp presence and the need for clearing actions. It was determined that USACE would complete a download of telemetry receivers in the vicinity of the Barriers and that USFWS would complete a sonar scan to supplement existing monitoring data. The MRWG provided a letter to the ACRCC in support of the diving effort without the need for a barrier clearing action (Appendix A). A USFWS sonar scan was performed on 11 January in advance of the dive operations. The results indicated there were no large fish in vicinity of the barriers and a low abundance of small fish. USACE telemetry data was downloaded on 11 and 15 January at the Romeoville Road Bridge. Telemetry data indicated low activity of tagged fish as well.

Table 1: *Loss of power to the water at the primary active Barrier 2A in 2016; the secondary Barrier 2B was in full operation at each of the time and dates listed below.*

Barrier	Date	Outage Time
IIA	4-Jan-16	18 d
IIA	20-Jun-16	46 min
IIA	21-Jun-16	3 d 2 h 30 min
IIA	12-Jul-16	2 h
IIA	7-Aug-16	4 h
IIA	18-Aug-16	13 d
IIA	1-Sep-16	3 h
IIA	16-Dec-16	37 min

Barrier Maintenance Fish Suppression

Recommendations:

The MRWG agency representatives should continue to assess the risk of Asian carp presence at the primary downstream barrier. The group should take into consideration the most recent downstream monitoring data, known locations of Asian carp (adults and juveniles) and other biotic and abiotic factors relative to Asian carp movement and dispersal patterns. This summary also recommends continued use of hydroacoustics to survey in between the Demonstration Barrier and Barrier 2A for fish of all sizes as a primary means of identifying risk for potential Asian carp presence prior to any other clearing action. Clearing actions that address removal of fish from between the barriers should include surface, pulsed DC-electrofishing and noise scaring tactics (tipped up motors, push plungers, hull banging, etc). It is recommended to continue the removal of all fishes greater than 300 mm in total length and to sub-sample fishes less than 300 mm in total length for species identification. Identification of fishes less than 300 mm will help further inform decision makers on the risk of juvenile Asian carp presence. Deep water gill net sets and other submerged bottom deployed gears are not recommended for further use between the barriers as a removal action due to safety concerns for personnel. However, these tools should continue to be used in the immediate downstream area to enhance understanding of fish species assemblage and risk of Asian carp presence. Additionally, this summary recommends continued research and deployment of novel fish driving and removal technologies such as water cannons, low dose piscicides, complex noise generation, etc.

Barrier Defense Asian Carp Removal Project

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Rebekah Haun, Nate Lederman, Ryan Young, Seth Love (Illinois Natural History Survey)

Participating Agencies: Illinois Department of Natural Resources, Illinois Natural History Survey.

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

This project uses controlled commercial fishing to reduce the number of Asian carp in the upper Illinois and lower Des Plaines Rivers downstream of the electric dispersal barriers. By decreasing Asian carp numbers, we anticipate decreased migration pressure towards the electric dispersal barriers and reduced chances of Asian 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 abundance and movement between pools of the upper Illinois Waterway. The removal project was initiated in 2010 and is ongoing, utilizing ten contracted commercial fishing crews to remove Asian carp primarily with large mesh (2.5 - 5.0 inch (63.5mm-127mm)) gill nets and trammel nets. However, with the program identifying efficiencies, additional gears are being fished such as commercial seines, modified hoop nets and Great Lakes trap nets.

Objectives:

(1) Harvest as many Asian carp as possible in the area between Starved Rock Lock and Dam and the electric dispersal barrier. Harvested fish will be transported and used by private industry for purposes other than human consumption; and

(2) Gather information on Asian carp population abundance and movement in the Illinois Waterway downstream of the electric dispersal barrier, as a supplement to fixed site monitoring.

Project Highlights:

- Contracted commercial fishers deployed 1,803 miles (2901.6km) of gill/trammel net, 15.5 miles (24.9km) of commercial seine, 88 pound net nights and 1,354.2 hoop net nights in the upper Illinois Waterway since 2010.

Barrier Defense Asian Carp Removal Project

- A total of 85,710 Bighead Carp, 474,264 Silver Carp, and 3,226 Grass Carp were removed by contracted commercial fisherman from 2010-2016. The total weight of Asian carp removed was 2,504 tons.
- Recommend increased targeted harvest of Asian carp in the upper Illinois Waterway with contracted commercial fishers and assisting IDNR biologists. Potential benefits include reduced Asian carp abundance at and near the detectable population front and the possible prevention of further upstream movement of populations toward the Electric Dispersal Barrier and Lake Michigan.

Methods:

Contracted commercial fishing occurred in the target area of Dresden Island, Marseilles, and Starved Rock pools. Dresden Island Pool is located on the Illinois River from RM 271 to 286, Marseilles Pool RM 245 to 271, and Starved Rock Pool RM 231 to 245, each pool is located downstream of the electric dispersal barrier 10, 24 and 51 river miles, respectively (Figure1). This target area is closed to commercial fishing by Illinois Administrative Rule: Part 830 Commercial Fishing and Musseling in certain water of the state; Section 830.10(b) Waters open to commercial harvest of fish; therefore an IDNR biologist is required to accompany commercial fishing crews in this portion of the river. Contracted commercial fishing took place from June-September 2010, April-December 2011, March-December 2012, March-December 2013, March-December 2014, March-December 2015 and March-December 2016. Commercial Fishing also occurred December 2012 through March 2013 as part of a winter harvest project (*see* 2013 Monitoring and Response Plan Interim Summary Report).

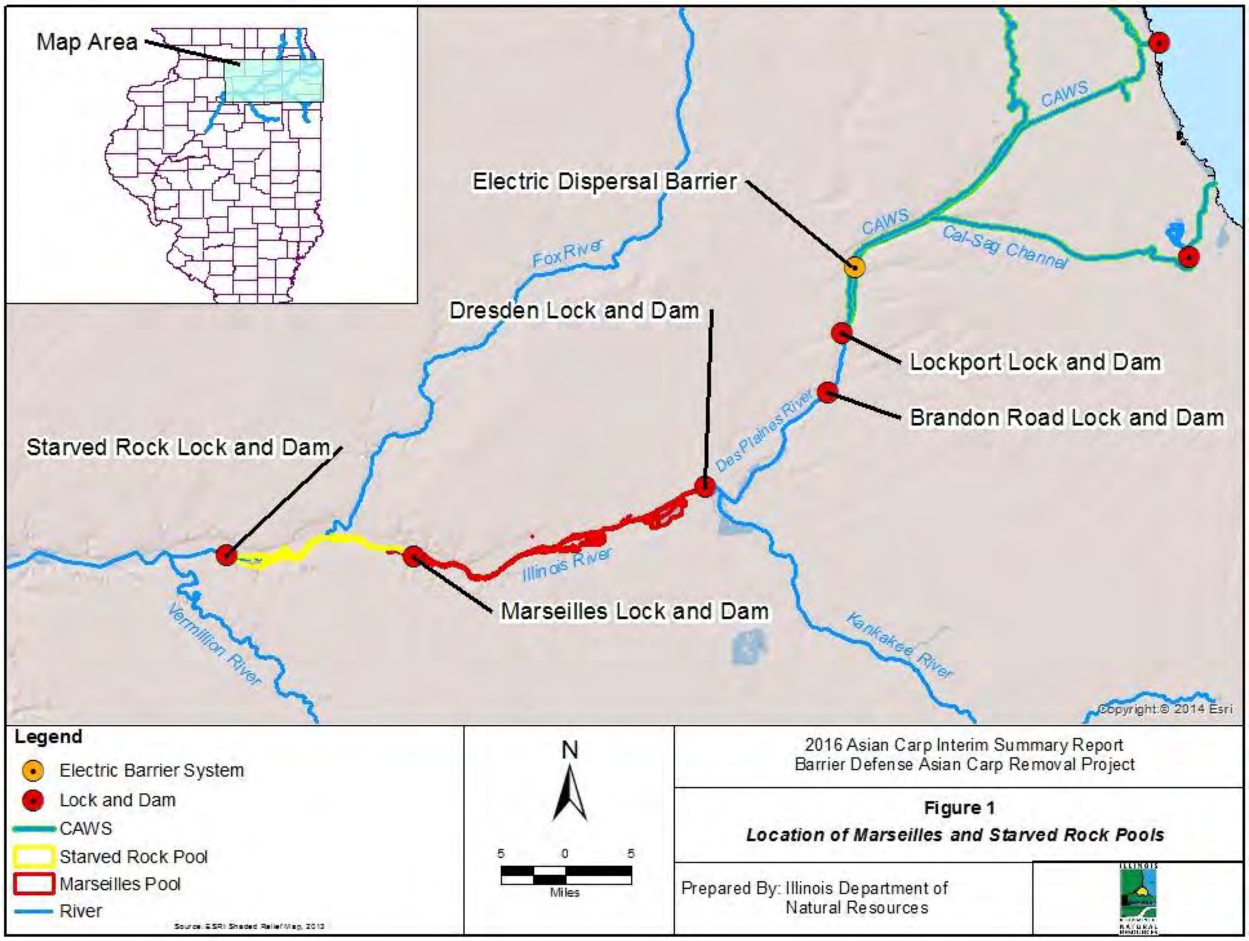

Figure 1. *Location of SIM in the CAWS upstream of the Electric Dispersal Barrier.*

Five to six commercial fishing crews per week fished 4 days of each scheduled week. Fishing weeks were scheduled, 1 or 2 weeks each month during the field season. Due to fishing pressure driving fish out of areas and greatly reducing catches, fishing weeks were scheduled at every-other week intervals to allow fish to repopulate preferred habitats in between events. Fishing occurred in backwater, main channel, and side channel areas which are favored Asian carp habitats. Specific netting locations were 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)) gill and trammel nets were typically used and set 20-30 minutes with fish being driven towards nets by the commercial fishing boats with noise (e.g., pounding on boat hulls, hitting the water surface with plungers, running with motors tipped up). Occasionally nets were set overnight off the main channel in non-public backwaters with no boat traffic. Beginning in 2014, hoop nets (2.0-8.0 feet (0.60-2.44 m) in diameter) and commercial seines (300-800 yards (0.27-0.73km) in length) were used in addition to the gill and trammel nets. Great Lakes pound nets were added in 2015. Biologists on board identified, enumerated and recorded Asian carp and bycatch to species. Asian carp and common carp were checked for ultrasonic tags. Fish implanted with ultrasonic tags, along with all bycatch, were returned to the water alive. Harvested Asian carp were transferred to a refrigerated truck and subsequently delivered to a processing plant and utilized for non-consumptive purposes (e.g., converted to liquid fertilizer). During each harvest event a representative subsample of 30 Bighead Carp and 30 Silver Carp from each pool were measured in total length (mm) and weighed (g) to provide estimates of total weight harvested.

Results and Discussion:

An estimated 4,140 person-hours in 2010, 6,750 person-hours in 2011, 7,650 person-hours in 2012 and 2013, 7,312 person-hours in 2014, 7,650 person-hours in 2015, and 10,980 person-hours in 2016 have been spent netting Asian carp during barrier defense removal efforts. A total of 1,870.1 miles (3,009.6km) of gill/trammel net, 15.5 miles (24.9km) of commercial seine and 1,354.2 hoop net nights have been deployed in the upper Illinois Waterway since 2010 (Table 1). The total weight of Asian carp caught and removed from 2010-2016 was 5,039,800 pounds (2,519.9 tons) (Table 1). Silver Carp, Bighead Carp, and Grass Carp accounted for 69.5%, 30.3%, and 0.2% of the total tons harvested since 2010, respectively.

The combined catch of Asian carp (Bighead Carp, Silver Carp, and Grass Carp) since 2010 was 564,705 (Table 1). Bighead Carp accounted for 82.0% of all Asian carp harvested in 2010, 56.3% in 2011, 39.4% in 2012, 20.1% in 2013, 11.5% in 2014, 5.7% in 2015, and 5.2% in 2016. Silver Carp accounted for 17.7% of all Asian carp harvested in 2010, 43.4% in 2011, 63.0% in 2012, 79.4% in 2013, 88.0% in 2014, 93.7% in 2015 and 94.4% in 2016. Grass Carp accounted for 0.4% of all Asian carp harvested in 2010, 0.4% in 2011, 0.6% in 2012, 0.5% in 2013, 0.5% in 2014, and 0.6% in 2015, and0.4% in 2016. The total harvest of Asian carp 2010-2016 consisted of 84% Silver Carp, 15.4% Bighead Carp, and 0.6% Grass Carp.

The annual gill/trammel catch per unit effort for Asian carp (CPUE; No fish/1000 yards of net) of all pools combined was lower in 2016 (301.3) than in 2015 (316.9) but higher than in 2014 (121.7), 2013 (97.0) 2012 (87.6) and 2011 (86.9). Monthly gill/trammel CPUE for all pools combined demonstrates an increasing trend since 2011 (Figure 2).

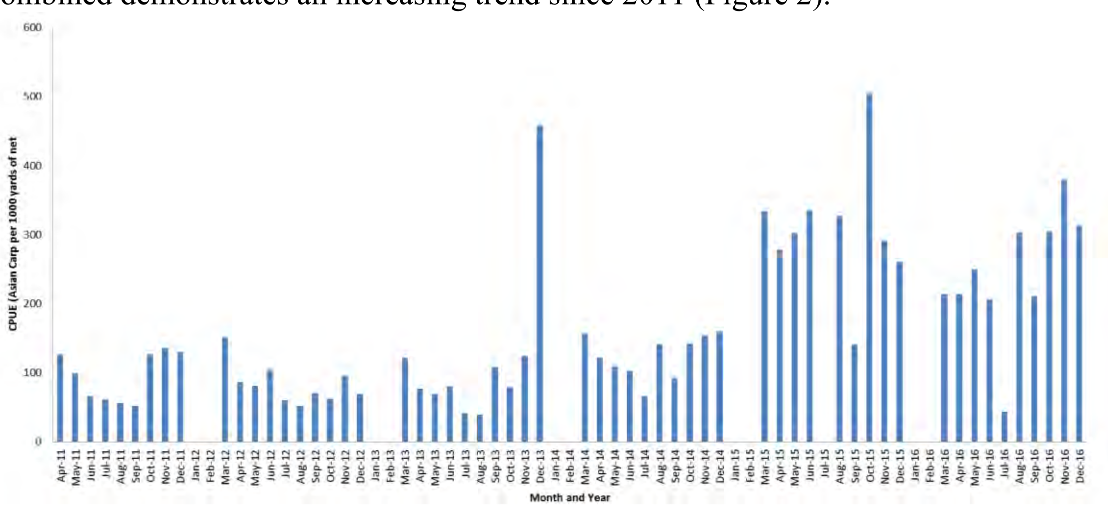

Figure 2. *Monthly catch per unit effort (CPUE; Asian carp/1000 yards of gill/trammel net) for all pools combined in 2011- 2016.*

Barrier Defense Asian Carp Removal Project

Catch of Asian carp within Pools –

Dresden Island Pool:

The Dresden Island pool was not fished as part of the Barrier Defense Project in 2016 due to increased effort in the Fixed Site Monitoring downstream of the Dispersal Barrier Project. A total of 517 Asian carp (3.5 tons) were removed from the Dresden Island Pool in 2016. Further detail on monitoring efforts in the Dresden Island pool in 2016 can be found in the Fixed Site Monitoring downstream of the Dispersal Barrier section of this report.

Marseilles Pool:

Commercial fisherman removed Asian carp in the Marseilles pool from March through December in 2016. A total of 357,456 yards (326.9km) of gill/trammel net, 8.1 miles (13km) of commercial seine and 85.7 hoop net nights were deployed in 2016. A total of 62,490 Silver Carp, 5,924 Bighead Carp, and 76 Grass Carp were harvested in 2016 (Table 1). The commercial seine hauls yielded 15,399 Silver Carp and 888 Bighead Carp. Silver Carp dominated the catch (91.2%) in 2016, (92.6%) in 2015, (78.2%) in 2014 and 2013 (58.5%). Hoop nets caught 429 Silver Carp and 38 Bighead Carp. Prior to 2013, Bighead Carp was the dominate species caught in the Marseilles pool (Table 1). The annual CPUE of Asian carp from gill/trammel nets in the Marseilles Pool was 166 Asian carp per 1000 yards. Monthly gill/trammel CPUE for Asian carp captured in the Marseilles pool from 2013-2016 can be found in Figure 3.

Starved Rock Pool:

Commercial fisherman removed Asian carp in the Starved Rock Pool March through December in 2016. A total of 155,408 yards (142.1km) of gill/trammel net, 2.1 miles (3.4km) of commercial seine, and 683.1 hoop net nights were deployed in 2016. A total of 83,383 Silver Carp, 2,048 Bighead Carp and 605 Grass Carp were harvested in 2016 (Table 1). Hoop nets accounted for 4,216 Silver Carp, 113 Bighead Carp, and 32 Grass Carp while the commercial seine haul accounted for 8,518 Silver Carp, 40 Bighead Carp, and 4 Grass Carp. Silver Carp were the dominate species harvested in 2016 (96.9%). Annual gill/trammel CPUE of Asian carp per 1000 yards of net increased from 174.4 in 2011 to 221.9 in 2012 and 246.19 in 2013, it decreased in 2014 to 205.6 then increased to 441.5 in 2015 and 553.6 in 2016. Monthly gill/trammel CPUE for Asian carp captured in the Starved Rock pool from 2013-2016 can be found in Figure 3.

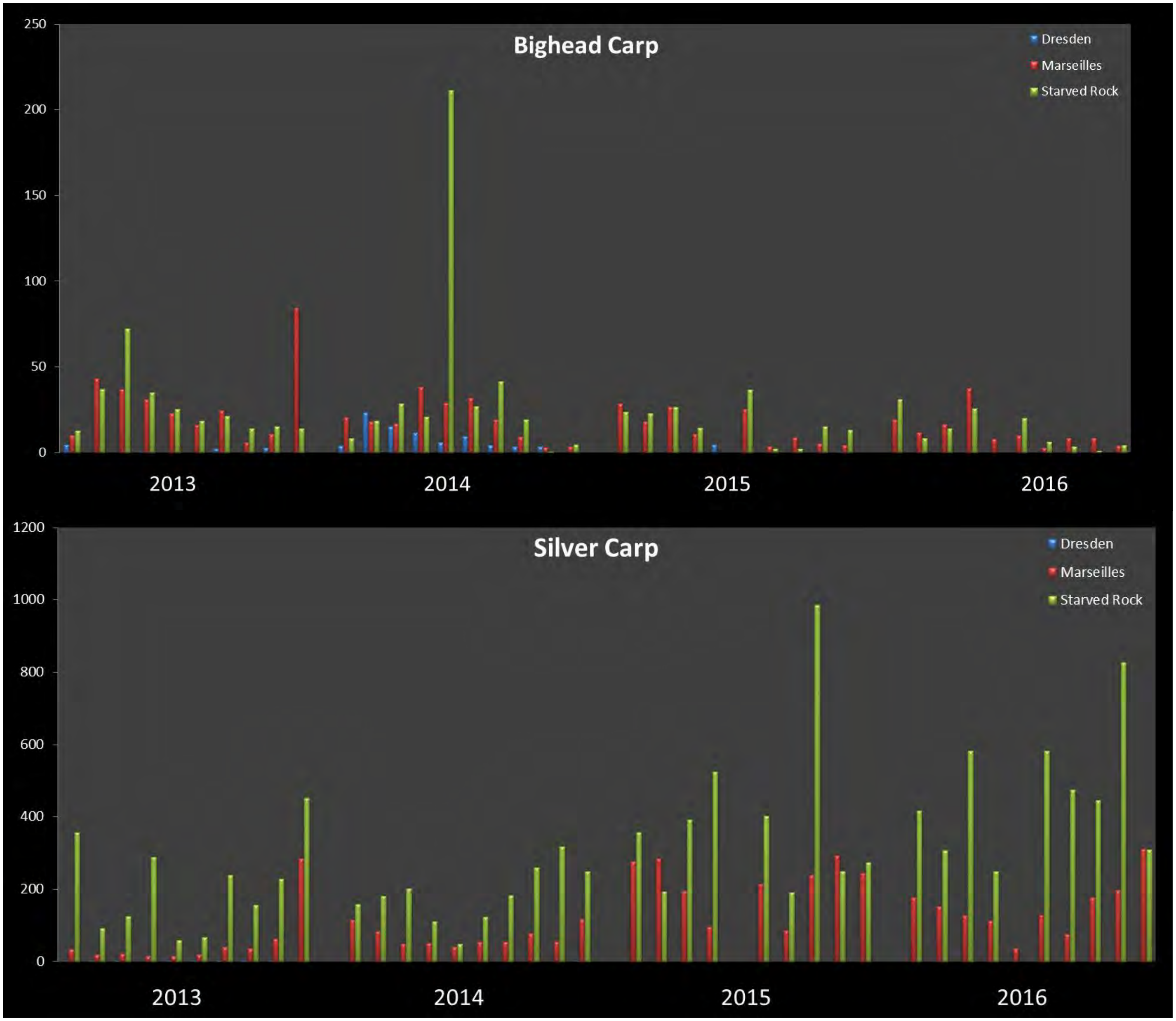

Figure 3. *Yearly trends in Catch per unit effort (CPUE; Asian carp/1000 yards of gill/trammel net) in 2013-2016.*

Catch of Bycatch Species –

Gill and Trammel nets:

A total of 155,896 fish representing 35 species and 3 hybrid groups were caught in gill\trammel nets during the 2016 Asian carp removal effort (Table 2). Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 77.5% of the catch while *Ictiobus* spp. (Bigmouth Buffalo, Smallmouth Buffalo, and Black Buffalo) along with Common Carp made up an additional 20.1% of the total catch. A total of 987 fish from 11 species and 2 hybrid species made up the game fish species captured in 2016. Game fish represented 0.6 % of the total catch in 2016. Similar to previous years, Flathead and Channel Catfish were the most dominate game fish captured in 2016 accounting for 87.7 % of the game fish captured.

Hoop Nets: A total of 7,592 fish representing 17 species and one hybrid species were caught in hoop nets in 2016. Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 63.6% of the catch while *Ictiobus* spp. (Bigmouth Buffalo, Smallmouth Buffalo, and Black Buffalo) made up an additional 22% of the total catch.

Commercial Seine:

A total of 29,718 fish representing 33 species were caught in commercial seines in 2016. Asian carp (Bighead Carp, Silver Carp, and Grass Carp) made up 54.5% of the catch while *Ictiobus* spp. (Smallmouth Buffalo, Bigmouth Buffalo, and Black Buffalo) made up an additional 11.2% of the total catch. Game fish represented 3.8% of the catch with *Moronidae* spp. making up 65.2% of the game fish captured.

Great Lakes Pound Net:

A total of 11,397 fish (8,812 fish in 2015), representing 22 species and 1 hybrid group were caught in pound nets in 2016. Asian carp (Bighead Carp, Silver Carp) made up 8.6% of the catch (38.2% in 2015), while Freshwater drum made up an additional 46%. Game fish represented 7.3% of the catch with *Moronidae* spp. making up 91% of the game fish captured.

Recommendation:

We recommend increased Asian carp removal in the upper Illinois Waterway to reduce carp abundance at and near the detectable population front and prevent further upstream movement of populations toward the Electric Dispersal Barrier and Lake Michigan. Utilizing contracted commercial fishing crews with assisting IDNR biologists has been a successful approach for Asian carp removal in areas of the waterway not open to permitted commercial fishing. Multiple years of harvest data, will provide insight into tracking and modeling changes in relative abundance of Asian carp populations over time and between pools in the upper Illinois Waterway. This information will assist in determining the risk of further upstream invasion of Asian carp and challenges to the barrier. There is also a need to assess the effects of the removal program on actual Asian carp population densities and patterns of immigration and emigration at the population front.

Table 1: *Asian carp removal effort and harvest of Asian carps from Dresden, Marseilles, and Starved Rock pools during 2010-2016 using contracted commercial fishermen.*

	Effort						Harvest							
Year and River Pool	Net Sets (*N*)	Miles of Net	Seine Hauls (*N*)	Miles of Seine	Hoop net Nights (*N*)	Pound Net Nights	Bighead Carp (*N*)	Silver Carp (*N*)	Grass Carp (*N*)	Total (*N*)	Bighead Carp (tons)	Silver Carp (tons)	Grass Carp (tons)	Total (tons)
2010														
Marseilles	1,316	75.5					4,888	1,075		5,963	53.11	8.11		61.22
Starved Rock														
All pools	1,316	75.5					4,888	1,075		5,963	53.11	8.11		61.22
2011														
Marseilles	671	219.2					20,087	7,023	34	27,144	229.39	46	0.16	275.55
Starved Rock	151	44.6					2,964	10,730	132	13,826	21.36	53.32	0.65	75.33
All pools	822	263.8					23,051	17,753	166	40,970	250.75	99.32	0.81	350.88
2012														
Marseilles	599	222.1					12,126	8,744	75	20,945	110.38	54.42	0.02	164.82
Starved Rock	198	62.1					4,358	19,875	233	24,466	24.67	94.23	0.18	119.08
All pools	797	284.2					16,484	28,619	308	45,411	135	149	0.2	283.9
Winter Harvest 2012-2013														
Marseilles	151	41.8	4	1.8			2,378	3,588	284	6,250	23.8	22.2	2	48
Starved Rock	61	15.9					34	2,671	106	2,811	0.2	9.9	0.7	10.8
All pools	212	57.7	4	1.8			2,412	6,259	390	9,061	24.0	32.1	2.7	58.8
2013														
Marseilles	457	210.5					7,134	10,154	76	17,364	66.17	49.06	0.33	115.56
Starved Rock	236	93.33					3,794	36,398	224	40,416	21.69	159.76	1	182.44
All pools	693	303.83					10,928	46,552	300	57,780	87.85	208.82	1.33	298
2014														
Marseilles	488	216	3	1.1			7,549	27,516	108	35,173	69.33	112.29	0.05	181.67
Starved Rock	290	91	1	0.2	421.7		4,220	63,132	416	67,768	19.74	222.73	0.72	243.19
All pools	778	307	4	1.3	421.7		11,769	90,648	524	102,941	89.07	335.02	0.77	424.86
2015														
Marseilles	420	141.2	14	1.62	22.5	24	5,298	68,804	216	74,318	38.90	236		274.90
Starved Rock	225	78.3	4	0.53	141.2		2,908	68,681	641	72,230	13.2	198.1		211.3
All Pools	645	219.5	18	2.15	163.7		8206	137,485	857	146,548	52.1	434.1		486.2
2016														
Marseilles	553	203.1	37	8.1	85.7	64	5,924	62,490	76	68,490	46.9	251.3		298.16
Starved Rock	291	88.3	14	2.1	683.1		2,048	83,383	605	86,036	9.6	232.0		241.62
All Pools	844	291.434	51	10.2	768.8	64	7,972	145,873	681	154,526	56.5	483.3		539.78
2010-2016														
Marseilles	4,655	1,329	58	12.6	108	88	65,384	189,394	869	255,647	638	779	3	1,420
Starved Rock	1,452	474	19	2.9	1,246		20,326	284,870	2,357	307,553	110	970	3	1,084
All pools	6,107	1,803	77	15.5	1,354.2	88	85,710	474,264	3,226	563,200	748	1,749	6	2,504

Barrier Defense Asian Carp Removal Project

Table 2: Asian carp and by-catch captured with trammel and gill nets in the Dresden Island , Marseilles and Starved Rock Pools of the upper Illinois waterway in 2011 -2016. All Species other than Asian carp and Common Carp were returned to the River immediately after capture.

Island, Marseilles,
r than Asian carp

	2011		2012		2013		2014		2015		2016	
Species	Number Captured	Percent %	Number Captured	Percent %	Number Captured	Percent %	Number Captured	Percent %	Number Captured	Percent %	Number Captured	Percent %
Bighead Carp	23,117	43.68%	16,560	28.36%	11,777	15.67%	10,625	11.15%	6,318	4.05%	7,962	3.62%
Silver Carp	17,776	33.59%	28,632	49.03%	46,597	62.01%	57,302	60.15%	116,411	74.67%	145,790	66.29%
Smallmouth Buffalo	3,853	7.28%	3,749	6.42%	7,397	9.84%	12,717	13.35%	23,989	15.39%	31,588	14.36%
Freshwater Drum	573	1.08%	689	1.18%	1,055	1.40%	1,091	1.15%	1,510	0.97%	11,685	5.31%
Bigmouth Buffalo	3,850	7.27%	5,043	8.64%	3,567	4.75%	4,670	4.90%	3,174	2.04%	3,707	1.69%
Unidentified Buffalo Species					137	0.18%					3,446	1.57%
Common Carp	2,574	4.86%	2,386	4.09%	2,685	3.57%	6,699	7.03%	1,819	1.17%	3,137	1.43%
Gizzard Shad	6	0.01%	22	0.04%	5	0.01%	3	< 0.01%	4	< 0.01%	2,193	1.00%
Unidentified Catostomidae											2,062	0.94%
River Carpsucker	61	0.12%	26	0.04%	105	0.14%	229	0.24%	467	0.30%	2,028	0.92%
Channel Catfish	201	0.38%	137	0.23%	321	0.43%	430	0.45%	616	0.40%	1,679	0.76%
Unidentified Moronidae											865	0.39%
Grass Carp	171	0.32%	299	0.51%	303	0.40%	524	0.55%	823	0.53%	681	0.31%
White Bass	13	0.02%	11	0.02%	40	0.05%	23	0.02%	14	0.01%	505	0.23%
Quillback	37	0.07%	46	0.08%	49	0.07%	84	0.09%	134	0.09%	497	0.23%
Unidentified Carpsucker											470	0.21%
Gizzard Shad < 6 in											375	0.17%
Flathead Catfish	313	0.59%	299	0.51%	417	0.55%	301	0.32%	233	0.15%	331	0.15%
Yellow Bass	3	0.01%	5	0.01%	9	0.01%	9	0.01%	4	< 0.01%	157	0.07%
Black Crappie	1	< 0.01%	1	< 0.01%	2	< 0.01%	4	< 0.01%	7	< 0.01%	133	0.06%
Longnose Gar	11	0.02%	25	0.04%	68	0.09%	91	0.10%	40	0.03%	110	0.05%
Black Buffalo	188	0.36%	262	0.45%	432	0.57%	318	0.33%	133	0.09%	81	0.04%
Sauger	19	0.04%	31	0.05%	12	0.02%	11	0.01%	31	0.02%	65	0.03%
White Crappie	1	< 0.01%	2	< 0.01%	1	< 0.01%	4	< 0.01%	7	< 0.01%	65	0.03%
Largemouth Bass	28	0.05%	22	0.04%	28	0.04%	26	0.03%	34	0.02%	61	0.03%
Skipjack Herring	9	0.02%	14	0.02%			6	0.01%	6	< 0.01%	39	0.02%
Shortnose Gar	16	0.03%	37	0.06%	44	0.06%	13	0.01%	29	0.02%	36	0.02%
Walleye	9	0.02%	12	0.02%	7	0.01%	5	0.01%	15	0.01%	35	0.02%
Golden Redhorse			2	< 0.01%	6	0.01%	30	0.03%	5	< 0.01%	30	0.01%
Paddlefish	78	0.15%	51	0.09%	37	0.05%	37	0.04%	31	0.02%	27	0.01%
Shorthead Redhorse		< 0.01%	1	< 0.01%			4	< 0.01%	1	< 0.01%	15	0.01%
Hybrid Striped Bass	2	< 0.01%	7	0.01%	2	< 0.01%	5	0.01%	12	0.01%	12	0.01%
Smallmouth bass											11	0.01%
Bluegill			1	< 0.01%			1	< 0.01%	1	< 0.01%	10	<0.01%
Silver Redhorse							1	< 0.01%	3	0.00%	8	<0.01%
Green Sunfish x Bluegill Hybrid											8	<0.01%
Northern Pike	1	< 0.01%	1	< 0.01%	2	< 0.01%			1	< 0.01%	5	<0.01%
Bowfin					4	0.01%			3	< 0.01%	5	<0.01%
River Redhorse	1	< 0.01%					1	< 0.01%	1	< 0.01%	4	<0.01%
White Perch					1	< 0.01%					4	<0.01%
Blue Catfish	8	0.02%	7	0.01%	8	0.01%	2	< 0.01%	5	< 0.01%	3	<0.01%
Mooneye			6	0.01%	3	< 0.01%	1	< 0.01%	8	0.01%	3	<0.01%
Common Carp x Goldfish Hybrid	1	< 0.01%	4	0.01%	2	< 0.01%					2	<0.01%
Black Bullhead											2	<0.01%
Highfin Carpsucker											2	<0.01%
American Brook Lamprey											1	<0.01%
White Sucker											1	<0.01%
Rock Bass			1	< 0.01%								
Muskellunge	1	< 0.01%			2	< 0.01%	1	< 0.01%	2	< 0.01%		
Goldeye	1	< 0.01%							3	< 0.01%		
Goldfish					20	0.03%			2	< 0.01%		
Total All Species	52,924		58,391		75,145		95,268		155,896		219,936	

Assessing Population, Movement, and Behavior of Asian Carp to Inform Control Strategies

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Participating Agencies: Southern Illinois University (lead); The Ohio State University (population model lead); Illinois Department of Natural Resources (field support); US Fish and Wildlife Service (support); U.S. Army Corps of Engineers–Chicago District (field support); US Geological Survey (support), Illinois Natural History Survey (support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

Decreasing dispersal of Asian carp towards the electric barrier and developing or enhancing other barriers to fish movement are priorities of Asian carp control efforts in the Illinois River. The two primary mechanisms currently in place to deter Asian carp movement toward the Great Lakes are the electric barrier in the Chicago Area Waterway System and contracted fishing in the upper pools (Dresden Island, Marseilles, Starved Rock). Additionally, existing dams may serve to limit the upstream spread of individuals. Neither the rates at which Asian carp move among Illinois River pools nor the effectiveness of control efforts have been quantified but will be necessary to effectively manage Asian carp and prevent establishment in the CAWS and Lake Michigan.

The Illinois River is divided by a series of wicket and gated dams that likely limit population connectivity and therefore provide potential control points for the deployment of barrier or repellent technologies to limit movement among pools. Asian carp may move relatively freely through the wicket-style dams of the lower river while fewer individuals may move upstream through Starved Rock Lock and Dam (SRLD) and other gated dams in the upper river. SRLD is the most downstream structure on the Illinois River utilizing fixed gates, which may be a substantial impediment to fish movement. Contracted fishing catches in the Starved Rock pool are routinely high, suggesting that immigration to the pool is occurring and results from mark-recapture studies (SIU unpublished data) support this conclusion. Increased knowledge of the environmental variables related to Bighead and Silver Carp approaching and passing through SRLD and the route that individuals take when passing (lock vs. dam gates) could be used to focus control efforts (e.g., complex sound, CO_2) spatially and temporally which would reduce deterrent costs. Additionally, estimating the probability of Asian carp movement among Illinois River pools will help quantify which dams most restrict movement and identify relationships among subpopulations in different river pools. Therefore, it is necessary to document and quantify the amount of movement Asian carp exhibit among Illinois River pools.

Inter- and intra-pool movements help determine Asian carp densities within each Illinois River pool in addition to contracted fishing in the upper pools. Estimates of pool-wide densities can monitor how all of these measures impact the larger Asian carp population and, when compared to data from past years, whether population trajectories are decreasing through time. Over a finer scale, knowledge of Asian carp densities in specific habitats where control efforts (e.g., contracted harvest, unified fishing method) are employed can help target efforts to key locations where densities are highest, with the goal of maximizing removal effectiveness while minimizing costs. Density hot spots may shift through time and require monitoring on multiple occasions within a year as environmental conditions and fish behavior change. Therefore, it is vital to monitor pool-wide changes in Asian carp density and target harvest and control efforts to specific locations, especially at the leading edge of the invasion.

Prospects for harvest-induced collapse of Asian carp at the scale of the entire length of the Illinois River are considered to be poor (Tsehaye et al. 2013). Thus, directed removal efforts must focus on population control in the upper Illinois River to minimize the likelihood of Asian carp breaching the Electric Dispersal Barrier and invading Lake Michigan. Therefore, a quantitative Asian carp population model for the Illinois River system is needed that will help inform decisions about where to direct harvest, the effects of different harvest intensities, and quantify the impact of fish passage barriers. The model should make use of all available demographic data that has been, and will be, collected from different sources (including hydroacoustic density estimates), especially the recently developed, empirically derived movement model that predicts among pool transition probabilities across the entire Illinois River (developed from fish movement data).

Objectives:

(1) Quantify the amount of upstream passage of Asian carp through Illinois River lock and dam structures.

(2) Determine the mechanism (lock, dam, or both) of Asian carp passage through Starved Rock Lock and Dam and the associated environmental conditions at the time of passage.

(3) Identify patterns of Asian carp distributions through space and time in the Illinois River to assess the effectiveness of harvest and to direct harvest toward the most effective locations at the leading edge of the invasion.

(4) Parameterize a spatially explicit Asian carp population model and use the model to identify harvest scenarios that maximize reductions in Asian carp approaching the CAWS.

Project Highlights:

- Water temperature and tailwater height are effective at predicting when Bighead and Silver Carp approach Starved Rock Lock and Dam, and gate openess is related to upstream passages through the dam. These predictors should be used to focus the use of additional barrier technologies (e.g., CO_2, complex sound) to specific times and river conditions, which would reduce costs and help minimize impacts on native species.

- Multistate models of Asian carp interpool movement rates were developed and used to parameterize the Asian carp population model. Long-term, pool-wide densities from hydroacoustic sampling were also used to parameterize the model.
- Marseilles pool underwent a 62% decrease in Asian carp density from 2015 to 2016. Declines occurred at three of the four areas sampled and were not driven solely by declines in the HMS West Pit following the unified fishing method. Asian carp densities in Dresden Island remained low in 2016 and were similar to 2015.
- Repeated hydroacoustic sampling in Dresden Island Pool during 2016 helped direct contracted fishing efforts to high-density sites that changed throughout the year.
- A spatially explicit, stochastic, length structured population model was developed and used to predict the relative number of Asian carp in vicinity of the Electric Dispersal Barrier on the Chicago Sanitary and Ship Canal under various harvest scenarios.
- Given limited available resources, model results indicate harvest in the upper pools may be the best strategy for reducing Asian carp approaching the CAWS.

Methods:

Movement and Dam Passage

To determine the frequency, density, and timing of Asian carp movement upstream, individuals must be tagged with transmitters and tracked with a telemetry network. SIUC has implanted acoustic tags into > 900 Bighead and Silver Carp while maintaining an array of > 50 stationary receivers from 2012 – 2016. This stationary receiver array has been used to observe the longitudinal movements of Bighead and Silver Carp from the Alton – Dresden Island Pools. Using the accumulated telemetry data, upstream passage events through all dams within the study area were quantified (La Grange, Peoria, Starved Rock, Marseilles, and Dresden Island Lock and Dams). Additional stationary receivers were placed around SRLD from 2015 – 2016 to monitor Asian carp approaching SRLD, quantify number of individuals passing upstream through SRLD, determine the route individuals take through the dam (lock vs. dam gates), and relate these observed behaviors to conditions such as temperature, tailwater height, and dam gate openness (For additional details see Lubejko 2016)

Using telemetry data collected by the SIUC telemetry network from 2012 - 2015, program MARK was used to develop a multi-state model examining movement probabilities among pools. Separate movement probabilities were developed for Bighead and Silver Carp and the combinations of model components (detection probability, apparent survival, transition probability) were tested varying by pool, season, both, or neither as possible models. Possible multi-state models were evaluated using Akaike's Information Criterion (AIC) and bootstrap and median- $\hat{c}$ to determine the best model(s) (Lebreton et al. 1992; Cooch and White 2015). See Coulter et al. 2016 for full details regarding the construction of these multi-state models. The top multi-state models were used to generate data that were incorporated into a spatially explicit population model. Variability around movement probability estimates were generated using Markov Chain Monte Carlo (MCMC; 1,000 burn-in; 4,000 tuning, 10,000 retained iterations) in program MARK. MCMC chains have been generated but have not yet been incorporated into the population model results presented herein.

Spatial and Temporal Patterns in Density

Asian carp densities were assessed during fall of 2016 from the Alton – Dresden Island pools. Main channel, side-channel, tributary, backwater lake, and marina sites were sampled using two 200 kHz, split-beam transducers oriented horizontally. Species-specific size distributions and relative abundance were obtained from electrofishing and gillnet sampling in each pool. Sampling sites, data collection, and data analysis followed the approach outlined in MacNamara et al. (2016), consistent with procedures used in previous years. In addition, hydroacoustic surveys were conducted in the Dresden Island Pool in April, June, and August 2016 (in addition to standardized fall sampling in October) in order to identify key areas for contracted harvest to target throughout the year. Hydroacoustic sampling was also conducted in the Hanson Material Services West Pit in the Marseilles Pool before and after the unified fishing method in spring 2016 to assess its effectiveness at reducing Asian carp abundance. Those results are presented in the Unified Fishing section of this document.

Population Model to Evaluate Harvest Scenarios

The spatially explicit, stochastic, length-based population model was parameterized using updated demographic rates estimated from all possible data sources (state and federal agencies and universities). Most demographic rates (i.e., growth, length-weight, maturation schedule) were estimated using Bayesian hierarchical models. In all models, river pool was treated as the random effect. Natural mortality was estimated using the Jensen method (Jensen 1996), an indirect method which relates natural mortality to the growth coefficient from the von Bertalanffy growth function (i.e., *k*). Average inter-reach transition probabilities were estimated using a multistate model (e.g., Hayden et al. 2014). Lastly, to derive a stock-recruitment function for Illinois River Asian carp we used a combination of acoustic data and relative abundance data from the LTRMP. To account for differences in catchability among adults and recruits in the LTRMP data, we limited our analysis to ages (i.e., ≥ age-3) that have recruited to the gear and used assumptions regarding annual natural mortality rates to hind-cast abundance at early ages and, therefore, recruitment. Proportions of recruits (i.e., age-3 fish) and adults represented in the LTRMP catch data were estimated using mixture models fit to length-frequency data (e.g., Hoxmeier and Dieterman 2011).

Updated demographic rates were used to parameterize the spatially explicit, stochastic, length-structured population model. The model tracked size- and pool-specific abundance through time and was used to evaluate different harvest scenarios. Estimating demographic rates using a Bayesian framework allowed for incorporation of parameter uncertainty in model simulations. In comparison to other data sets (e.g., growth data), data on spawning stock biomass and recruitment (e.g., LTRMP) were found to be insufficient to derive an empirically based relationship. Consequently, each scenario was evaluated using a range of plausible values for the strength of compensatory density dependence using the Ricker stock recruitment function (Ricker 1954). Consistent with field observations, recruitment in the model was limited to the lower three pools. Recruitment was calculated as a function of spawning stock biomass and scaled to pool length. Vulnerability to fishing was set to species-specific size at 50 percent maturity. The simulation model was used to track the abundance of Asian carp located in the Dresden Island Pool, the uppermost pool included in the movement model under different scenarios. Population dynamics were simulated over a 25-year time period. Uncertainty in demographic rates was incorporated by repeating the 25-year simulations using 1,000 combinations of parameter estimates. The initial numbers of Asian carp in each pool of the Illinois River were specified using data from hydroacoustics. Lengths of the initial population were determined by first assuming a stable age distribution and then calculating length at age using mean estimates from the von Bertalanffy growth analysis.

Harvest scenarios evaluated included, but were not limited to, four levels of exploitation (0 to 0.9 by 0.3 increments) in the upper (i.e., Starved Rock, Marseilles, Dresden Island) and lower river pools (i.e., Alton, La Grange, Peoria). All possible combinations of upper and lower river harvest were evaluated, resulting in a total of 16 different harvest scenarios, including the no-harvest scenario. Under each harvest strategy, the abundance of Asian carp located in the Dresden Island pool at the end of the simulation period was estimated and used to examine the relative improvement of one strategy relative to the others. This was accomplished by plotting median values with confidence intervals (i.e., first, third quantiles) for each scenario. To isolate variation associated with harvest, estimates from each fishing scenario (N = 1,000 iterations/ estimates) were divided by the estimates from the no-fishing scenario.

Results and Discussion:

Movement and Dam Passage

Upstream passage events through Illinois River lock and dams showed a declining trend in the upstream direction (Figure 1). Each gated dam (Starved Rock, Marseilles, Dresden Island) had < 15 observed upstream passage events over five years while each wicket dam (La Grange and Peoria) in the lower Illinois River had > 35 upstream passages.

A detailed examination of passage at SRLD (the most downstream of the gated dams) revealed that upstream passage occurred in only two of the five observation years (2013 and 2015), indicating that dispersal among pools may be sporadic. Of the 13 passages observed at SRLD, only two of these occurred through the lock chamber. Passage through lock chambers may be limited due to lack of attraction flow (Zigler et al. 2004) or noises associated with barge traffic

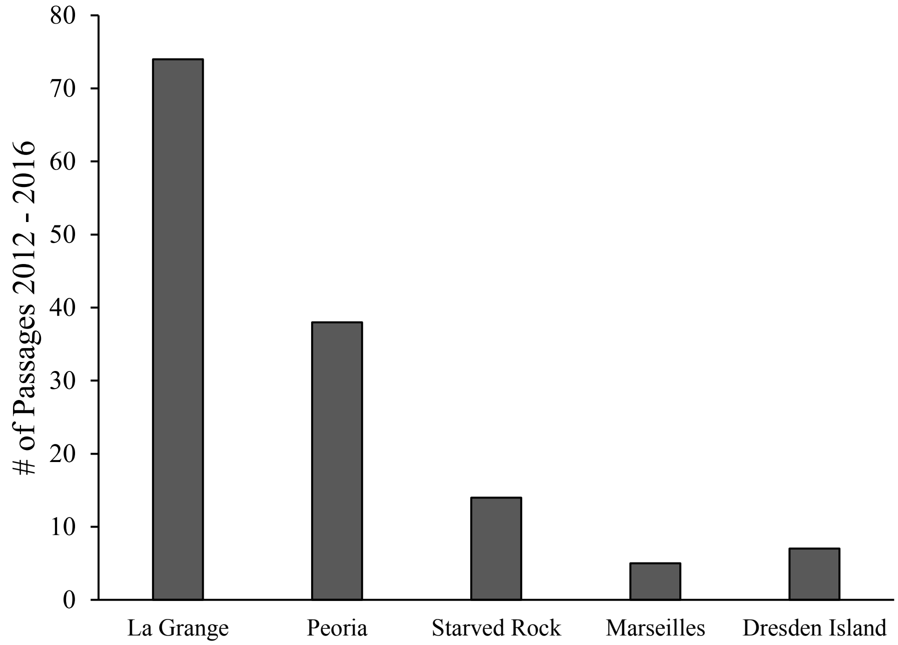

Figure 1. *Observed upstream passages through Illinois River lock and dams by tagged Bighead and Silver Carp from 2012 – 2016.*

that affect fish movement. Of the Bighead and Silver Carp passing upstream through the dam gates, eight individuals passed when the gates were completely open. Open gates may reduce turbulence and allow fish to pass upstream more easily. Any additional barrier or deterent technologies that may be used at SRLD in the future would need to limit passage through the gates when they are completely open (e.g., high flow) which would reduce potential costs when compared to continuous operation. Three individuals passed upstream through the dam gates when they were partially open; two of these remained upstream < 1 day before passing back downstream and one continued moving further upstream. The fish that continued moving upstream passed < 2 days after open river conditions and the gates were moderately open (0.9 – 1.8m). Timing of the use of additional barrier, deterent, and control can be further refined using change in water temperature, mean water temperature, and tailwater height from a previous two week period to predict whether Bighead and Silver Carp will approach SRLD in the next two week period with 79% accuracy. These results are summarized in Lubejko 2016 which also contains additional details.

Following AIC evaluation of multi-state models, one Silver Carp model and two Bighead Carp models had ΔAIC < 2. Bootstrap and median-ĉ for the top Silver Carp model were 1.6 and 1.7, respectively. Bootstrap and median-ĉ for the top Bighead Carp model were1.8 and 1.5, respectively, and 2.0 and 1.6 for the second best model. Silver Carp showed higher single pool movement probabilities, usually about 2 times higher, moving between pools in a downstream direction (0.116 ±0.064 SE) compared to an upstream direction (0.061 ±0.024 SE) on most occasions, whereas Bighead Carp did not (top model [winter]: Downstream - 0.067±0.022 SE;

Upstream - 0.091 ±0.043 SE). Movement probabilities for Bighead Carp in the top model through the upper river dams (Lock and Dams at Starved Rock, Marseilles, and Dresden Island) were lower (upstream: 0.059 ±0.023 SE; downstream: 0.063 ±0.028 SE, Figure 2) compared to lower river dams (Peoria and La Grange Lock and Dam; upstream: 0.139 ±0.132 SE; downstream: 0.072 ±0.057 SE). Similar trends among the upper and lower river pool movement probabilities were apparent in the second best Bighead Carp model. Movement probabilities of Silver Carp did not show the same trend for upstream passage among upper (Upstream: 0.094 ±0.038 SE; Downstream: 0.063 ±0.052 SE) and lower river dams (upstream: 0.028 ±0.003 SE; downstream: 0.197 ±0.175 SE) due to the upstream movement probability through Dresden Island Lock and Dam. Due to the infrequency with which Bighead and Silver Carp pass upstream through gated dams, it is necessary to continue to observe passage using acoustic telemetry. Observations of additional passages across other years will refine movement probability estimates, reducing error around those estimates and within the population model.

Spatial and Temporal Patterns in Density

Standardized fall sampling indicated that 2016 Asian carp densities in the Dresden Island Pool continue to remain low compared to downstream pools. Long-term density data from previous years indicated that Asian carp in Dresden Island decreased from 2012 – 2014 and have since remained relatively stable (Figure 3). Density estimates from 2016 remained similar to 2015 values but were slightly elevated from the lowest density observered in 2014. Contracted fishing in Dresden Island Pool appears to be contributing to the rather stable population over the past four years, considering the relatively high probability of Asian carp moving from the Marseilles Pool into Dresden Island Pool (Figure 2). Long-term density data also revealed that Asian carp density in Marseilles Pool during 2016 was the lowest observed in five years. Marseilles Pool densities increased from 2012 – 2014 and remained stable in 2015 before undergoing a 62% decrease in 2016. This decrease is likely attributable, at least in part, to the increased harvest efforts occuring throughout Marseilles Pool in 2016, particularly the unified fishing method. The unified fishing method took place in the Hanson Material Services West Pit during spring 2016; however, fall densities were lower throughout most sites in Maresilles Pool. Future work will aim to determine the role of contracted harvest, in addition to environmental variables, at explaining annual trends in Asian carp densities. Hydroacoustic data collected during 2016 in the Alton – Starved Rock Pools are currently being analyzed.

Spatial and temporal patterns in Asian carp densities were examined in more detail in Dresden Island Pool to help focus harvest efforts near the invasion front. Asian carp densities fluctuated throughout the year, with observed densities being highest in late summer and fall and Bighead Carp and Silver Carp displaying similar trends (Figure 4a). Low observed densities in April and June could be caused by Asian carp using shallow areas that were not sampled (e.g., Rock

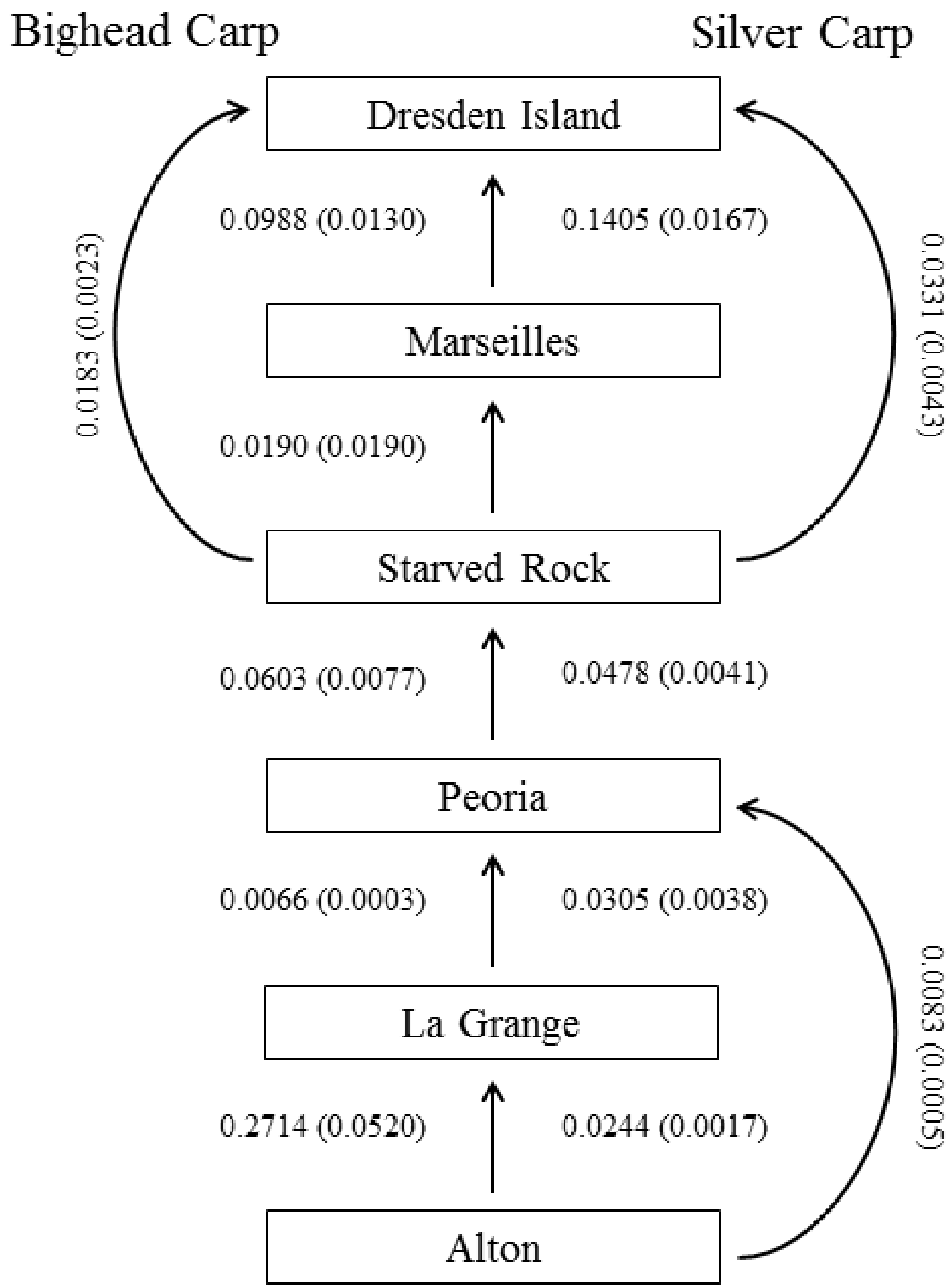

Figure 2. *Monthly upstream movement probabilities among Illinois River pools estimated using multi-state models in program MARK. Fish could move between all pools and movement probabilities not visualized with arrows were estimated as < 0.000000001. Full results are included in Coulter et al. 2016.*

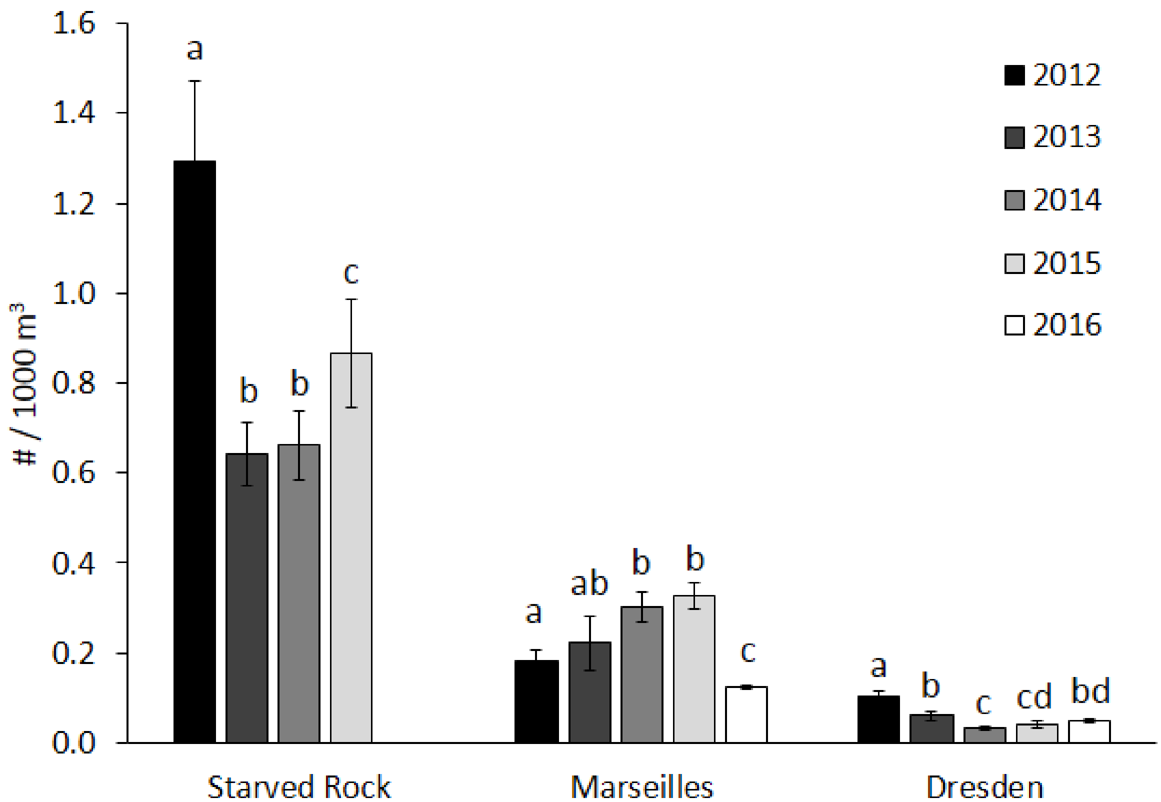

Figure 3. *Asian carp densities in the upper Illinois River from 2012 – 2016. Note that 2016 densities for Starved Rock are currently being analyzed.*

Run Rookery) or were far upstream in the Kankakee River tributary. Removal efforts during these months should also be aimed at these areas, particularly Rock Run Rookery. Densities in the Mobil Bay backwater were high in each month sampled and should be targeted for future contracted harvest effort (Figure 4b; Figure 5). Mobil Bay should also be considered for future unified fishing events in Dresden Island Pool. Repeated sampling of these sites throughout the year also revealed that Asian carp densities rebound in these areas even after being continually harvested. The Kankakee River tributary, especially near the mouth, and Treats Island side channel had relatively high densities and should also be targeted for harvest, although densities at these sites were highly variable. Identifying relationships between Asian carp densities and changes in environmental conditions through space and time will help predict when Asian carp become abundant in different habitats and, therefore, when specific sites should be heavily fished. It is also unclear whether the spatial and temporal patterns in Dresden Island pool exhibited by Asian carp in 2016 will be similar in future years when environmental and biological (e.g., Asian carp densities) conditions are different. Site-specific density data were reported to the MRWG within no more than 30 days after hydroacoustic sampling to help identify specific sites to harvest.

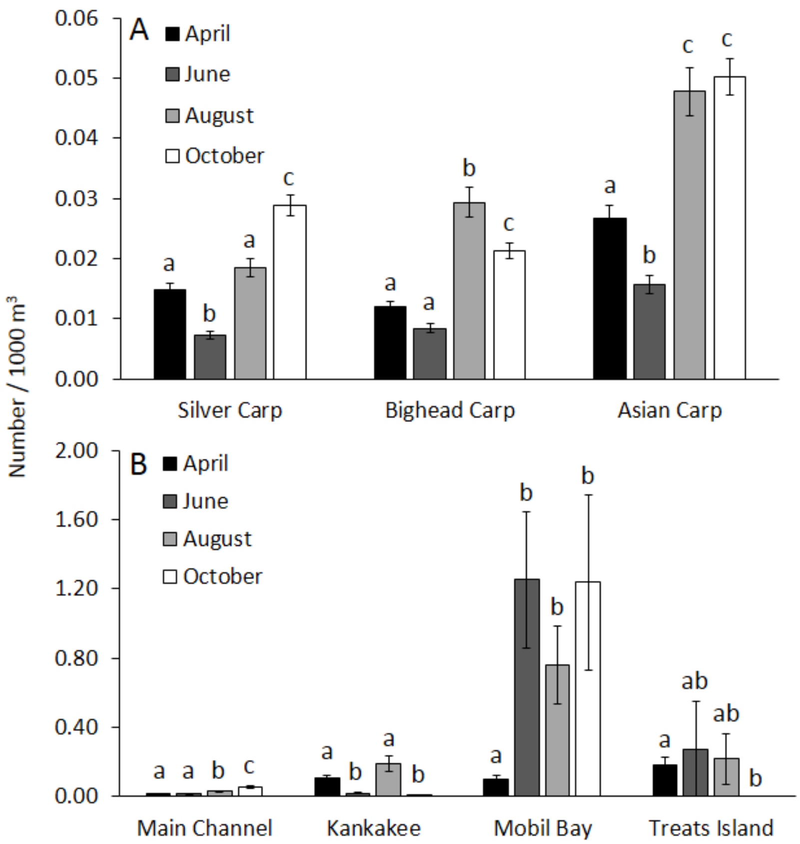

Figure 4. *Temporal (A) and spatial (B) variation in the densities of Asian carp in the Dresden Island pool of the Illinois River in 2016. Different letters indicate statistical differences between months within a given species or site.*

Population Model to Evaluate Harvest Scenarios

Estimated ages ranged from 0 – 12 and 0 – 19 for Bighead and Silver Carp. Both species exhibited high growth during the first years of life and slower growth at older ages (Table 1). Although both species approached asymptotic length at similar rates, asymptotic length was lower for Silver Carp. Estimated natural mortality, which was a function of growth coefficient (*k*) from the von Bertalanffy function was somewhat higher for Silver Carp relative to Bighead Carp (Table 1). The difference in the relationship between length and weight for the two species was negligible; however, size at maturity differed substantially. Length at 50% maturity was 502 and 786 mm TL for Bighead and Silver Carp, respectively, indicating that under equal vulnerability schedules populations of Silver Carp would be more resistant to harvest than Bighead Carp.

Determining the strength of density-dependence in recruitment is crucial for understanding how a population will respond to harvest. Despite our best efforts, we were unable to assemble reliable stock-recruitment data for Illinois River Asian carp. Mixture models could not reliably

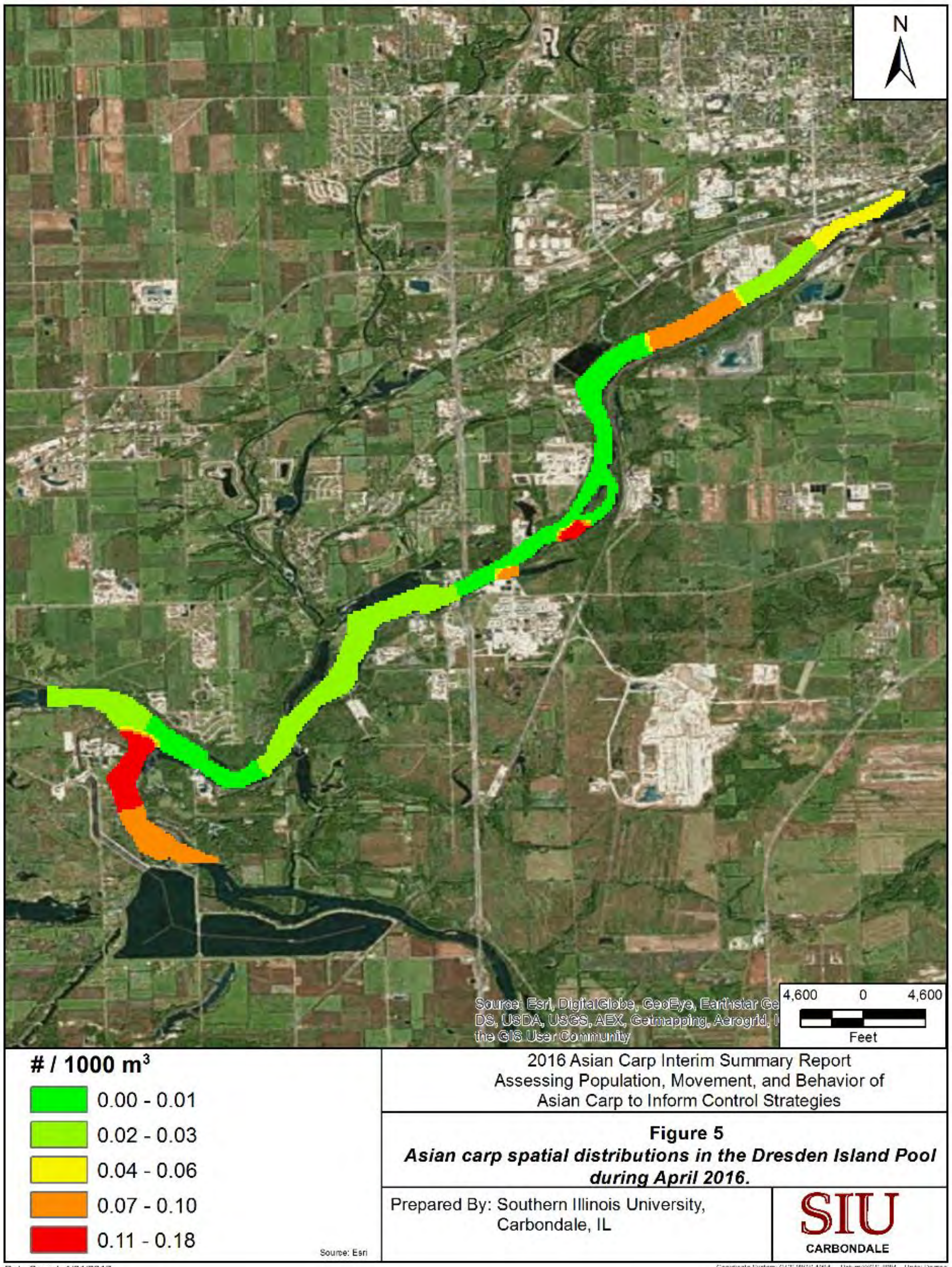

Figure 5. *Example heat map of Asian carp spatial distributions in the Dresden Island Pool during April 2016.*

distinguish between stock and recruits, let alone among the different age classes. Had we been able to assemble reliable stock-recruitment information from the above approaches, parameter estimates would likely be biased due to the large number of years required for estimating reliable stock-recruitment relationships. The Asian carp population in the Mississippi and Illinois rivers is still a relatively young population that has unlikely reached stable population dynamics. Available data would bias productivity estimates due to the exponential growth experienced early in the arrival of Asian carp to the Mississippi and Illinois Rivers. As such, we also considered using the approach used in previous Asian carp research (Tshaye et al. 2013); however, this approach relies on data from exploited marine stocks and may not be appropriate for Illinois River Asian carp and is also highly variable. Consequently, we evaluated the different harvest strategies across a range of compensatory density-dependence and highlight results that are within the plausible range for Asian carp.

Herein we focus on results derived from year 25 of the simulation and a steepness value of one, which is at the upper extreme range of plausible values (Meyers et al. 1999; Figure 6). Although Dresden Island pool abundance was highly variable during the initial years of the simulation and at high steepness values, overall patterns were stable. Further, patterns in Dresden Island pool abundance estimates were similar for both species of Asian carp. Abundance declined with increasing harvest rates, although the effects associated with lower river harvest were stronger than an equivalent level of harvest allocated to the upper river. Scenarios that included lower-river harvest dramatically reduced (> 50%) Dresden Island pool abundance. Scenarios that did not include lower-river harvest, however, had comparably limited effects – reductions were typically less than 50%, even when upper river harvest was set to extremely high levels (e.g., 0.9). Nevertheless, Dresden Island pool abundance declined with increasing upper river harvest, especially at low lower river harvest rates. These results indicate that maximizing lower-river harvest mortality is the best strategy for long-term control and containment of Illinois River Asian carp. Achieving long-term goals, however, will be difficult under current levels of resources (i.e., fishing effort). Relative to upper-river pools, pools in the lower-river are larger and densities of fish are higher. In contrast to long-term control and containment strategies, for short-term purposes, maximizing upper-river harvest appears to be the best strategy. At current levels of lower-river harvest, which is believed to be no more than 0.3, the effects associated with upper river harvest are greatest.

Although general patterns in the response to fishing were similar for the two species, the Silver carp response was stronger and less variable than the Bighead carp response. These differences were attributed to species-specific differences in vulnerability schedules and movement rates. Relative to Silver Carp, Bighead Carp move upstream at higher rates, resulting in an overall lower and more variable response to fishing. In addition, vulnerability to fishing was set to size at 50% maturity. Silver Carp mature at substantially smaller sizes, and were therefore more vulnerable to harvest. Although setting vulnerability to size at 50% maturity is interesting from population dynamics perspective, a more realistic threshold based on field data is preferable. Consequently, we are using commercial and contract harvest data to determine more suitable vulnerability schedules for Bighead and Silver Carp.

Recommendations: Given the episodic nature of Asian carp passage among upper Illinois River pools, continued observations using acoustic telemetry are necessary to decrease uncertainty around the movement probability estimates within the population model. Downstream passage through Illinois River dams also needs to be quantified as well as route of passage at dams other than SRLD. Hydroacoustic sampling to assess Asian carp densities is needed to determine population trajectories of Asian carp throughout the Illinois River, but especially near the

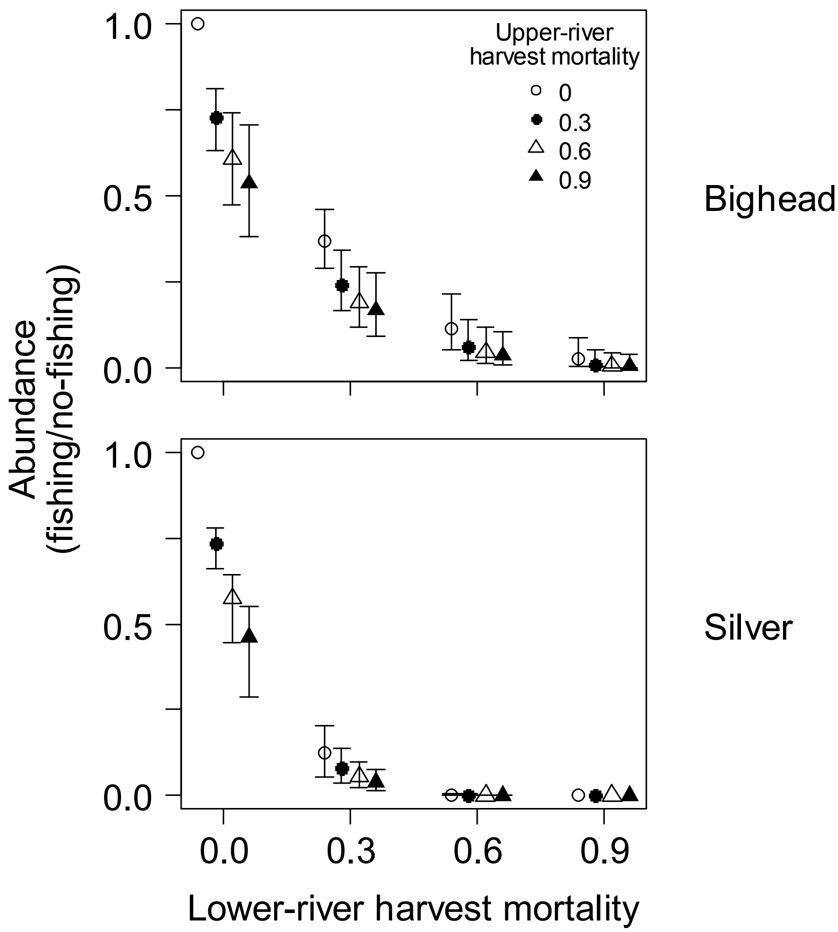

Figure 6. *Asian carp abundance in Dresden Island Pool at year 25 of the simulation as a function of lower and upper river harvest mortality. Points are median values and error bars are first and third quantiles. Data were derived using a steepness value of 1 and relativized by the no-harvest scenario.*

invasion front. Relating fine-scale environmental conditions to Asian carp densities is necessary to predict conditions (i.e., times and locations) when densities are high and should be targeted for harvest. Assessing densities in Starved Rock and Marseilles Pools, in addition to Dresden Island Pool, across seasons will help focus contracted fishing efforts to specific locations in order to maximize removal and minimize costs. A spatially-explicit stochastic length-structured population model was coded and used to run baseline harvest scenarios. Next steps for this model include: 1) incorporating uncertainty from the movement model, 2) adding fish-passage barriers at key pinch points (e.g., Starved Rock Lock and Dam), and 3) updating vulnerability thresholds using harvest-based data, and 4) developing new harvest scenarios using input from managers. Efforts will then shift toward model validation and determining which factors contribute most to uncertainty to prioritize research.

Table 1. *Demographic rates (and associated uncertainties) estimated using Bayesian heirarchical models of Bighead and Silver Carp collected from the Illinois and Mississippi Rivers.*

Species	Analysis	Parameter	Mean	Lower 95% CI	Median	Upper 95% CI	SD
Bighead	Maturity	slope	0.02	0.01	0.02	0.02	0.00
		intercept	-13.60	-18.28	-13.50	-9.45	2.26
	Growth	L_∞	1049.52	662.43	1021.87	1601.90	243.19
		K	0.24	0.10	0.22	0.47	0.10
		t_0	-1.08	-2.91	-1.15	1.15	1.03
	Length-weight*	slope	2.93	2.70	2.93	3.15	0.11
		intercept	-11.01	-12.47	-11.01	-9.56	0.73
	Natural mortality	M	0.33	0.18	0.34	0.61	0.11
Silver	Maturity	slope	0.01	0.01	0.01	0.01	0.00
		intercept	-5.12	-6.27	-5.11	-4.03	0.57
	Growth	L_∞	940.09	599.37	909.95	1460.18	224.28
		K	0.29	0.12	0.27	0.60	0.13
		t_0	-0.78	-2.08	-0.81	0.69	0.71
	Length-weight*	slope	2.98	2.84	2.98	3.11	0.07
		intercept	-11.26	-12.14	-11.27	-10.37	0.44
	Natural mortality	M	0.41	0.18	0.43	0.90	0.20

Parameter symbols: L_∞ = asymptotic length, K = growth coefficient; t_0 = age at zero length; M = instantaneous natural mortality rate (Jensen method).
* log scale

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BARRIER EFFECTIVENESS EVALUATION

Telemetry Interim Summary Report

Matthew Shanks, Nicholas Barkowski (US Army Corps of Engineers – Chicago District)

Participating Agencies: US Army Corps of Engineers (USACE; lead), US Fish and Wildlife Service (USFWS), Southern Illinois University at Carbondale (SIUC), Illinois Department of Natural Resources (IDNR), US Geologic Survey (USGS) and Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) (field and project support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction: Acoustic telemetry has been identified within the Asian Carp Regional Coordinating Committee (ACRCC) Control Strategy Framework as one of the primary tools to assess the efficacy of the electric dispersal barrier system. The following report summarizes methods and results from implementing a network of acoustic receivers supplemented by mobile surveillance to track the movement of Bighead Carp, *Hypopthalmichthys nobilis*, and Silver Carp, *Hypopthalmichthys molitrix*, in the Dresden Island Pool and associated surrogate fish species (locally available non-Asian carp fish species which most similarly mimic body shape and movement patterns) in the area around the electric dispersal barriers in the Upper Illinois Waterway (IWW). This network was installed and is maintained through a partnership between the U.S. Army Corps of Engineers and other participating agencies as part of the Monitoring and Response Workgroup's (MRWG) monitoring plan (MRWG, 2016).

The purpose of the telemetry program is to assess the effect and efficacy of the electric dispersal barriers on tagged fishes in the Chicago Sanitary and Ship Canal (CSSC) and to assess behavior and movement of fishes in the CSSC and IWW using ultrasonic telemetry. The goals and objectives are identified as:

Goal 1: Determine if fish are able to approach and/or penetrate the electric dispersal barrier system (Barrier Efficacy);

- **Objective** Monitor the movements of tagged fish (large and small) in the vicinity of the electric dispersal barrier system using receivers placed immediately upstream and immediately downstream of the barriers.
- **Objective** Support fish-barge interaction studies at the Barriers through supplemental data collection of tagged fish in the vicinity during controlled experimental trials.

Goal 2: Determine if and how Asian carps and surrogate species pass 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.

Telemetry Interim Summary Report

Goal 3: Determine the leading edge of the Asian carp range expansion;

- **Objective** Determine if the leading edge of the Asian 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 Asian 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** Examine seasonal movement and habitat use of Asian carp and other surrogates.

Project Highlights:

- To date, USACE has acquired 24.3 million detections from 557 tagged fish.
- No live tagged fish have crossed the Electric Dispersal Barriers in the upstream direction
- High percentage of unique tags detected near the Electric Dispersal Barrier with low residency time
- High percentage of detections occurred near fixed sites and low detections near the Electric Dispersal Barrier during winter months
- Only two lock passages occurred with one Common Carp going up stream through the Brandon Road Lock and Dam and one Bighead Carp going downstream through the Dresden Island Lock and Dam
- Asian carp continue to be detected throughout the Dresden Island Pool.
- The majority of Asian carp detections occur at Rock Run Rookery and near the Harborside Marina
- A small percentage of Asian carp detections occurred in the Kankakee River
- No Asian carp were detected at new receiver locations upstream of the Wilmington Dam

Methods:

Based on MRWG expert opinion, it was recommended that a total of 200 active transmitters in fish be maintained within the study area for telemetry monitoring. At the end of the 2015 season there were approximately 190 tagged fishes (V16 Vemco transmitters) that remained active and 110 of these transmitters were scheduled to expire within calendar year 2016. Additional tagging was required to sustain the recommended levels of the target sampling size as battery life expired and mortalities occurred in previously tagged fish. Because increases in transmitters deployed also increase the burden to stationary receivers for detection, the USACE decided to limit the amount of new tags to be implanted within certain high detection zones of the study area. A total of 25 transmitters (V16 (n=76); 69 kHz) were implanted into surrogate species in 2016 to maintain adequate transmitter saturation within the Lower Lockport Pool and downstream of the electric dispersal barrier system. This increased the number of transmitters to 215 that were active for at least a portion of calendar year 2016. Tagged surrogate fishes have been released both above and below the Dispersal Barrier System; however, no tagged Asian carp were released above the Brandon Road Lock. It was determined that no Asian carp caught in Lockport or Brandon Road pools would be tagged and returned as these areas are above the known upstream extent of the invasion front and could interfere with eDNA surveillance. Most fish were released at or near point of capture only after they were deemed viable and able to swim under their own power. A portion of the surrogate fishes released within Dresden Island pool were originally captured from the Brandon Road pool in an effort to induce higher approaches to the Brandon Road Lock through site fidelity as those displaced fishes attempt to return to their original capture location. This method was used in previous years at the electric dispersal barriers location and has been found to increase barrier approaches. Table 1 identifies all fishes containing active transmitters within the winter of 2015 and the field season of 2016 along with their release point within the system.

Table 1: *Active Fishes and Release Points within the Study Area in 2016*

Release Location	Species Implanted	Number of Fish Implanted
Upper Lockport Pool (Upstream of Barriers)	Common Carp	15
Upper Lockport sub-total		**15**
Between Barriers	Common Carp	7
Lower Lockport Pool (Downstream of Barriers)	Common Carp	74
	Freshwater Drum	1
Lower Lockport sub-total		**82**
Brandon Rd Pool	Common Carp	44
Brandon Rd Lock Chamber	Common Carp	6
Brandon Road sub-total		**50**
Dresden Island Pool	Bighead Carp	36
	Silver Carp	13
	silver-bighead hybrid	1
	Common Carp	18
Dresden Island sub-total		**68**
Total		**215**

Methods for transmitter implantation, stationary receiver deployment and downloads as well as mobile tracking were maintained from previous years effort. Data retrieval occurred bi-monthly throughout the season by mobile tracking techniques and downloading stationary receivers. A detailed description of methods can be found in the MRRP Interim Summary Report (2012) with surgical implant procedures adapted from DeGrandchamp (2007), Summerfelt and Smith (1990) and Winter (1996). A portion of stationary receivers removed for winter in December 2015 were redeployed in March 2016 with revisions to the layout of receiver positions within the study area based off of lessons learned from previous data collected. USACE receiver coverage within the Dresden Island pool increased from thirteen in 2015 to sixteen in 2016. New coverage within the Dresden Island pool has allowed for more detailed measurements of tagged fish movement and habitat use at the leading edge of the invasion front. New receiver locations included two additional receivers located upstream of the Wilmington Dam on the Kankakee River and one at the mouth of the DuPage River. Additionally, a USACE receiver below the Brandon Road Dam which had been vandalized in 2015 was not replaced; instead, a receiver was added to the lower pool at the Harborside Marina. This location offered a pinch point in the system and full channel detection coverage. The revised study area was covered by 33 USACE stationary receivers extending for approximately 33.5 river miles from the Calumet-Saganashkee Channel in Worth to the Dresden Island Lock on the Illinois River (Appendix A – Receiver Network Maps). All stationary receiver locations were identified by a station name. Station names were labeled with a two to three letter indicator of either pool or tributary location (i.e. LL for Lower Lockport or DUP for DuPage River) and numbered from upstream to downstream in the main channel and downstream to upstream within the tributaries. Station identifications allow the database to track all detections made at a single location regardless of the unique receiver ID that may have been deployed at that location at any given time. Finally, USACE worked with USGS to install a real-time receiver upstream of the electric dispersal barrier system. A VR2C cabled receiver (Vemco) was installed at the end of the season within the canal and connected to a land side modem. The receiver will upload detections to a USGS maintained website providing real-time results.

The Dresden Island Pool was also included within the telemetry receiver networks for concurrent studies led by USFWS, USGS and USFWS. USGS installed two real-time receivers within the pool; one at the approach channel to the Brandon Road Lock and one at the mouth of the Kankakee River just upstream of the Dresden Island Lock. SIUC installed three stationary receivers within the upper pool in proximity to the lock and dam. One receiver was placed within the tail waters of the dam and the remaining two were positioned in the main channel within 1.5 miles of the lock. Finally, USFWS began a Grass Carp monitoring project within the Upper Illinois Waterway and deployed four stationary receivers within the Dresden Island Pool and one receiver within the Brandon Road Pool. The USFWS receivers in the Dresden Island Pool are focused on the backwater areas of Treats Island and the Brandon Road Pool receiver is located within the I&M backwater just upstream of the Ruby Street Bridge. Data were shared between agencies to allow for continuous tracking of transmitters across the system as a whole. These additional receivers bring the total within the Dresden Island Pool to twenty five.

Barrier Efficacy – Barrier efficacy was assessed through a system of twelve stationary receivers with five upstream and seven downstream of the electric dispersal barrier system within the Lockport Pool. Receivers were placed at the lock entrance, in areas offering shallow habitat, in proximity to the electric dispersal barriers and at the confluence of the CSSC and Cal-Sag Channel (Appendix A). Receiver data were analyzed for individual fish detections that would indicate an upstream or downstream passage through the electric dispersal barrier system. Additionally, data were analyzed to assess temporal and spatial distribution patterns within the Lower Lockport Pool. Mobile tracking utilizing the VR100 supplemented the stationary receiver data as needed throughout the year. Mobile tracking was used to track individual fish or areas of interest that were not covered by the stationary receiver network. All detections were recorded and compiled into the detection data set.

As of 1 January 2016, there were a total of 50 tagged surrogate fishes (Common Carp; n=49 and Freshwater Drum; n=1) active within the Lower Lockport Pool (mean ± SD; 562 ± 60 mm). In order to maintain a similar number of tagged fish within the Lower Lockport pool across years, an additional 25 Common Carp (624 ± 80 mm) were tagged and released in 2016 to increase transmitter density bringing the total up to 75. These additional Common Carp were tagged using Vemco V16 transmitters with an estimated battery life of 1,616 days. These Common Carp were captured from the Upper Lockport Pool and released at the Cargill boat launch within the Lower Lockport Pool downstream of the electric dispersal barrier system. This increases the likelihood of barrier interaction by displacing these surrogate fish on the opposite side of the barrier system as they attempt to return to their home range.

Detections on each receiver in the Lower Lockport Pool were first screened for false transmitter detections. False detections may occur on a receiver during overlapping ping trains from multiple transmitters or through environmental noise interfering with a ping train of a single transmitter. Detection patterns for each detected transmitter were reviewed bi-monthly following data collection per a standardized screening process. Transmitters were removed from the database if they contained only a single detection, if all detections were separated by prolonged periods or detection patterns across multiple receivers indicated movement that was not feasible considering the swim speed of the fish and barriers to passage. For example, a transmitter may be considered to be a false detection if multiple detections were recorded within the same hour but detected several navigation pools apart from one another. Finally, remaining transmitters were verified with the existing database of deployed transmitters compiled by all participating agencies conducting telemetry work within the IWW and CAWS. Once all false transmitters were removed from the database, the remaining transmitter detections are also reviewed using the same screening criteria to eliminate any false movement or detection patterns.

Detection data were compiled for all stations within the Lower Lockport pool by the number of detections for all transmitters and the total number of unique transmitters detected. The total number of detections was calculated for each of the seven stations from the electric dispersal barrier system to the Lockport Lock for the full year and by season. Seasons were defined by monthly data with December to February representing winter, March to May for spring, June to August for summer and September to November for fall. Each station detection sub-total was then summed across the pool to calculate the total number of detections in 2016 and then further detailed by season. Similarly, the total number of unique transmitters was recorded for each station independently. Detection data for all stations combined was also reviewed to determine the total number of unique transmitters detected annually. This process was repeated for each season to obtain total number of unique detections by station and totaled for the entire pool. Due to a low transmitter density in the late summer and the loss of a receiver in September caused by a barge strike, 2015 data were added to the analyses.

The total annual detections and total seasonal detections across the pool were used to calculate the percentage of detections by each station for the year and within each season. Calculating this percentage metric allows for a better analysis of the data by removing the bias of variable active transmitters throughout the period under review. The total number of detections viewed alone is dependent upon how many active transmitters were present within the pool on any given day. The total number of transmitters present is dependent on immigration/emigration rates, battery life of the transmitters and new transmitters implanted and released within the pool. This same logic applies to the unique transmitters detected at each station and across the pool for both the full year and within each season. Percentage metrics were calculated for unique transmitters detected at each station and across the entire pool respectively for each season and annually.

The Vemco Positioning System utilized in previous years to calculate fine scale movement patterns at the electric dispersal barrier system was discontinued in 2016. Battery life for each VR4 receiver began to expire in the winter of 2015-2016. Barrier efficacy monitoring was maintained through the system of stationary receivers upstream and immediately downstream of the barrier system. The VR4 receivers were retrieved during dive inspection of the Barrier IIA and Barrier IIB electrodes in January of 2017. These receivers may be utilized in future years to assess changes in fine scale movement patterns once Permanent Barrier I goes online. To further supplement the VR2W receiver system however, a real-time receiver station was established in cooperation with USGS. This station was positioned strategically upstream of the electric dispersal barrier system and will be capable of providing hourly detection data through an easily accessible website.

Inter-pool Movement – There are four pools defined within the study area which are demarcated by the lock and dams present within the system and the electric dispersal barriers. Lockport pool is defined as all waters upstream of the Lockport Lock including the CSSC and Cal-Sag Channel. Within this analysis the pool is further separated into Upper Lockport and Lower Lockport which are separated by the electric dispersal barriers. The remaining pools include the Brandon Road pool of the CSSC and the Dresden Island pool which includes the Des Plaines and Kankakee Rivers. While the Marseilles pool was outside of the study area this year, additional data was collected at that location by SIUC which was shared with USACE. VR2W receivers were placed above and below each lock and dam as well as any other potential transfer pathways between pools. Data from the VR2W receivers and mobile tracking were analyzed for probable inter-pool movement. Dates with the nearest time interval and the pathway used for each passage were recorded for each tagged fish found to move between pools. Lockage data were retrieved for each passage where a specific time of occurrence could be determined.

Greater emphasis was placed on the Brandon Road Lock as this is the first physical barrier to upstream migration of Asian carp from the known invasion front. Previous years efforts have increased the receiver coverage surrounding the Brandon Road Lock to better understand fish behavior during an approach in the upstream direction. In 2015, depth sensor transmitters were introduced to the system and implanted into 9 Common Carp. These fish were captured from the Brandon Road Pool and released in groups of three within (n=6) and below the Brandon Road Lock Chamber (n=3). These nine transmitters had estimated battery lives through 27 June 2016 and remained active within the Brandon Road and Dresden Island Pools to that time.

Asian carp Movement Analysis – A total of 47 USACE tagged Asian carp (Bighead, Silver, and hybrids) are active within the Dresden Island pool. All Asian carp were tagged following the same methods previously mentioned. Movement of individual fish were tracked via Vemco VR2W stationary receivers (Appendix A) strategically placed throughout the Des Plaines, DuPage, and Kankakee Rivers. VR2W detections were then uploaded into Vemco VUE. Each station detection sub-total was then summed across the pool to calculate the percent of total detections in 2016 and then further detailed by season. Detections of unique tags were recorded and percent unique tags detected at each station was calculated for each season of winter (Dec-Feb), spring (Mar-May), summer (June-Aug) and fall (Sept-Nov). Total unique tags and total detections at each receiver by season were used to observe any movement patterns. Detections for each unique tag detected were individually analyzed to determine if any fish potentially died during 2016. Fish that demonstrated only downstream movement after tagging or were detected at a single receiver at a consistent rate over several months, were removed from the analysis.

Results and Discussion: The results discussed in this section will address the three goals of the study. As of December 2016, 24.3 million detections from 557 tagged fish have been recorded within the study area. Results to date have shown that zero live fish have crossed the electric dispersal barrier system in the upstream (northward) direction. Two transmitters that were implanted into Common Carp released below the barriers were detected upstream of the barriers as was reported in previous reports (2014 MRP Interim Summary, 2015). These transmitters had been presumed to be either expelled from the host fish or the host fish had expired due to lack of movement on the detected transmitters. The following sections provide new results from data collected in the 2016 sampling season in support of the three project goals: barrier efficacy, lock passage and leading edge status.

Goal 1: Determine if fish approach and/or penetrate the electric dispersal barrier system (Barrier Efficacy)

Large Fish Testing above barriers: No fishes were tagged or released within the Upper Lockport pool during the 2016 field season. Three transmitters remained active above the barriers through April of 2016. These fish included Common Carp captured from the Cal-Sag Channel which were tagged in November 2013 and released at a barge slip approximately 3.5 miles upstream of the barriers. One of these fish (Common Carp; TL 696 mm) was detected downstream of the I-355 overpass on two separate occasions before returning upstream. These furthest downstream detections occurred on 19 and 28 March 2016. Discharge rates as measured at the USGS Lemont stream gage (USGS 05536890) did not exceed 4,000 cfs for either day. All three transmitters were most active in proximity to the Cal-Sag Confluence.

Large Fish Testing at and below barriers: There were a total of 75 tagged surrogate fishes with batteries still active in 2016 between Lockport Lock and the Electric Dispersal Barrier System. Seven stationary receivers (VR2W) detected movement on 49% (n=37) of the tagged surrogate fishes throughout the pool in 2016. There were a total of 1.25 million detections within Lower Lockport Pool and 37,347 detections in the Upper Lockport Pool January through December indicating no tagged fish passage in either direction.

Spatial and temporal distribution patterns were tabulated for combined data from the 2015 and 2016 seasons to fill in information gaps created by low transmitter density or disruptions in receiver coverage. There were a total of 53 transmitters detected within the receiver network of the Lower Lockport pool from 1 January 2015 to 31 December 2016. The percentage of total detections at each station were used to compare residency time and habitat use across the pool (Figure 1; top). The percentage of unique transmitters at each station provided an indication of relative movement patterns within the pool by the population of tagged fishes (Figure 1; bottom). The results of both metrics were reviewed relative to one another to describe how tagged fishes are utilizing the habitat within the Lower Lockport Pool.

Residency time was lowest at the electric dispersal barrier system downstream boundary (LL01) and just upstream of the Lockport Lock (LL06) across all seasons. The highest detection rates occurred at the Hanson Material Services (HMS) slip (LL03) and the Lockport Controlling Works spillway (LL04) approximately 0.75 and 3.0 miles respectively downstream of the electric dispersal barrier system. Detection coverage at these locations include both shallow and deep water habitat off of the main channel. Residency time varied seasonally as well across the pool. Winter detections were highest in the mid to upper pool at locations offering deep water habitat (LL02, LL03 and LL04) and lowest at the Cargill Boat Launch (LL05) and the Lockport Lock (LL06) with zero detections. Spring and fall detections were similar across all sites indicating a more even distribution of the population across the pool. Summer detections were greatest at sites offering shallow water habitat (LL03, LL04 and LL05) and lowest in deep water, main channel habitats (LL01, LL02, LL03a and LL06).

Unique transmitter detection rates were high at all sites within the pool during the spring and summer months. This suggests the population of tagged fish was most active during these seasons. Fall detection ranges were also high at most sites with depressed levels only observed at the Lockport Lock (LL06) and within the main channel between HMS and the spillway (LL03a). Although 2015 and 2016 data were used in this analysis, it should be noted that the receiver at LL03a was damaged in September of 2016 causing the loss of data for the remainder of the year. This area is also heavily transited by barges and is within a fleeting area for HMS which could also reduce detection range. These variable may help explain some of the variation observed in the fall and winter months. No tagged fish were detected at the Cargill boat launch (LL05) or Lockport Lock (LL06) in the lower pool during the winter. Detection of unique transmitters was also relatively low within the upper pool at the remaining stations indicating lower activity and less intra-pool movement.

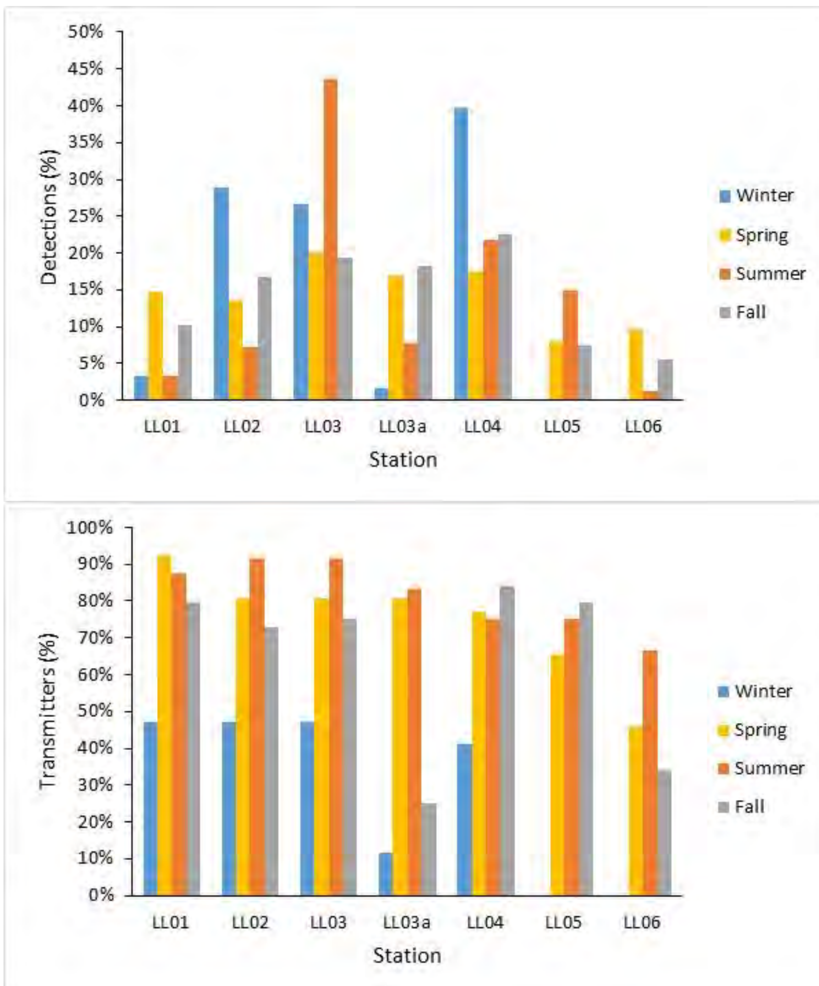

Figure 1: *Graphs depicting the percentage of total detections (top) and unique transmitters detected (bottom) within the Lower Lockport Pool from 1 January 2015 to 31 December 2016 categorized by station and season.*

Goal 2: Determine if Asian carp pass through navigation locks in the Upper IWW

There were only two occurrences of inter-pool movement by tagged fishes in calendar year 2016. One instance included a Bighead Carp moving downstream through the Dresden Island Lock. This passage occurred on 25 August in conjunction with a single downstream barge lockage and had passed through the lock within a period less than 45 minutes. The second inter-pool movement was recorded on 11 May at the Brandon Road Lock in the upstream direction by a Common Carp. This fish took four hours to pass through the lock chamber during which time there were three separate upstream lockage events involving one barge and two recreational vessels. The Common Carp was originally captured from the Brandon Road Pool near the Ruby Street Bridge and was released within the approach channel to the lock in the Dresden Island Pool.

From 2010 to 2016, there have been 53 occurrences of tagged fish moving downstream and 32 occurrences of upstream movement between navigation pools by a total of 69 individual tagged fish (Table 2). Inter-pool movement was greatest between the Lockport and Brandon Road pools accounting for 52% (n=44) of all inter-pool movements (upstream n=13; downstream n=31). The majority of downstream movement into the Brandon Road Pool occurred through the Lockport Controlling Works spillway approximately two miles upstream of the Lock (65%; n=20). Movement between the Dresden Island and Marseilles Pools comprised 35% (n=30) of all inter-pool movement (upstream n=14; downstream n=16). The lowest inter-pool movement occurred through the Brandon Road Lock and Dam accounting for 13% (n=11) of the total. Additionally, all upstream movement through the Brandon Road Lock has occurred by Common Carp originally captured within the Brandon Road Pool and released within the Dresden Island Pool. This method was used to increase the number of upstream lock passage attempts by fishes in the Dresden Island Pool and is not representative of the population originating from the Dresden Island Pool.

Table 2: *Tagged fish inter-pool movement from 2010 to 2016. Downstream is defined as DS and upstream is defined as US.*

Interpool Movement Data			
	US	DS	Total
Lockport	13	11	24
Lockport Spillway	0	20	20
Brandon Road	5	6	11
Dresden Island	14	16	30

Goal 3: Determine the leading edge of the Asian carp range expansion

A total of 30 USACE tagged Asian Carp were detected within the Dresden Island Pool throughout 2016. However, based on further observations of detections, it is assumed that 3 tagged fish succumbed to post-release mortality and were removed from the analysis resulting in a 57% detection rate. The remaining 27 tagged Asian carp consisted of 22 Bighead Carp (Mean TL ± SD; 933 ± 84 mm), 4 Silver Carp (735 ± 37 mm), and 1 hybrid (878 mm). In addition, 11 active tags from Southern Illinois University were detected throughout Dresden Pool and used within this analysis.

In total, the receivers placed in Dresden Island and the adjacent tributaries collected 298,596 detections from a total of 38 tagged Asian Carp. The percent of total detections at each receiver ranged from 0 to 57% (Figure2). The stations that had the greatest percent of total detections included DI09a (57%), RR01 (15%), DIO4 (7%), DI10 (7%), and DI07 (5%). The placement of DI07 is located in side channel habitat between a large area of shallow backwater habitat and may be detecting fish moving between the upper and lower portions of the pool. Station DI10 is located upstream of the Dresden Island lock. Data from 2015 demonstrated several fish were using the power plant outflow located near the receiver and may be detecting fish demonstrating similar behavior. Station DI04 is just upstream of Rock Run Rookery where Asian Carp have been detected previously and captured by contracted commercial fishermen. The station at Rock Run Rookery has consistently captured a majority of detections over the past several years. The location of the receiver detects fish as they move in and out of the backwater and would likely have increased detections if it were strategically placed within the lake. Finally, DI09a was a new placement for 2016. The receiver was strategically placed near a constriction point of the river where Asian carp have been detected in previous years. The data demonstrated the importance of the area near DI09a to Asian carp within the pool. The myriad of habitat types within and adjacent to station DI09a combined with the constriction point may help explain for the increased number of detections. The receiver is near shallow vegetated habitat, side channel habitat, backwater habitat (harbor slips) and close to an outfall from the I&M Canal. These habitat types may be an attractant to Asian carp, and the placement allows for fish to be detected as they move from the upper portion of the pool to the lower pool as well. Further investigations of fish detections at station DI09a, showed fish that tended to move through the area with only a few detections, other fish seemed to stage in the area for several days before moving up or downstream, and some fish appeared to use the area for a majority of the year and make minor movements into the Kankakee or upstream before returning to the area.

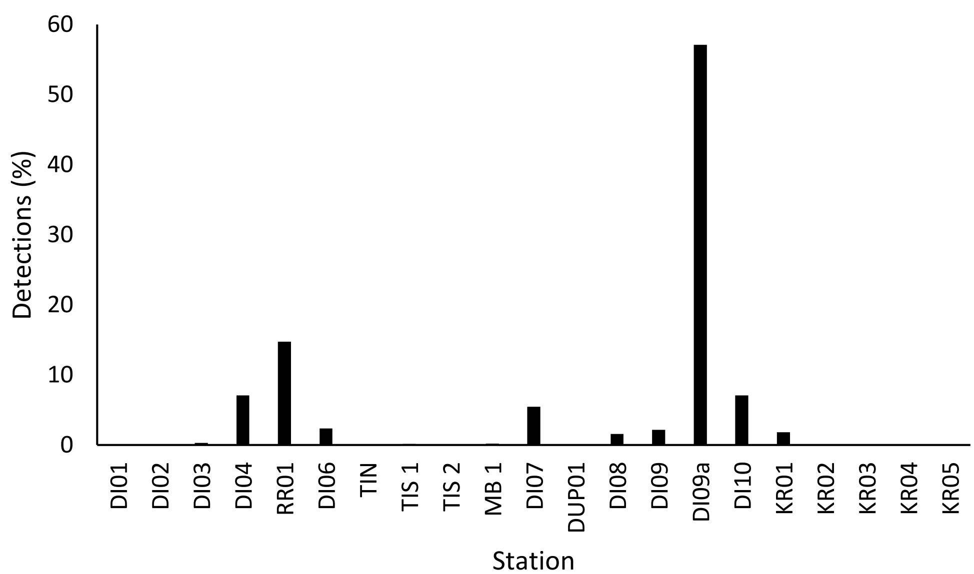

Figure 2: *Percent of total detections from each station within the Dresden Island Pool and the connecting tributaries.*

Percent active tags detected at each receiver and the percent of total detections were used in conjunction to acquire inferences of seasonal fish movement within the Dresden Island pool. Percent active Asian carp tags detected ranged from 0 to 80% throughout the Dresden Island Pool (Figure 3a). Winter detections were low due to the decreased number of receivers within the pool. During the winter, a limited number of receivers are left in the pool to prevent loss from ice. Additional receivers may be left out in the winter for future years after analyzing data from DI09a. In all seasons excluding winter, DI09a had the greatest percent of total detections followed by RR01 (Figure 3b). As expected, increases in detections and percent of active tags detected increased during the spring and summer while fish are most active. As much as 76% of the active tags were detected in spring with 15% of the detections occurring at DI09a and 4% at RR01. Similarly, up to 80% of the active tags were detected during summer with 30% of the detections occurring at DI09a and 6% at RR01. Finally, active tags detected in fall dropped to 53% with 12% of the detections occurring at DI09a and 3% of the detections occurring at RR01. By comparing and contrasting percent tags detected and percent total detections, some patterns start to emerge on where fish may be spending a majority of their time within the Dresden Island pool across different seasons. With the new information regarding DI09a and the amount the area is utilized by tagged fishes, a receiver will be left in over the 2017-2018 winter to determine its use across all seasons.

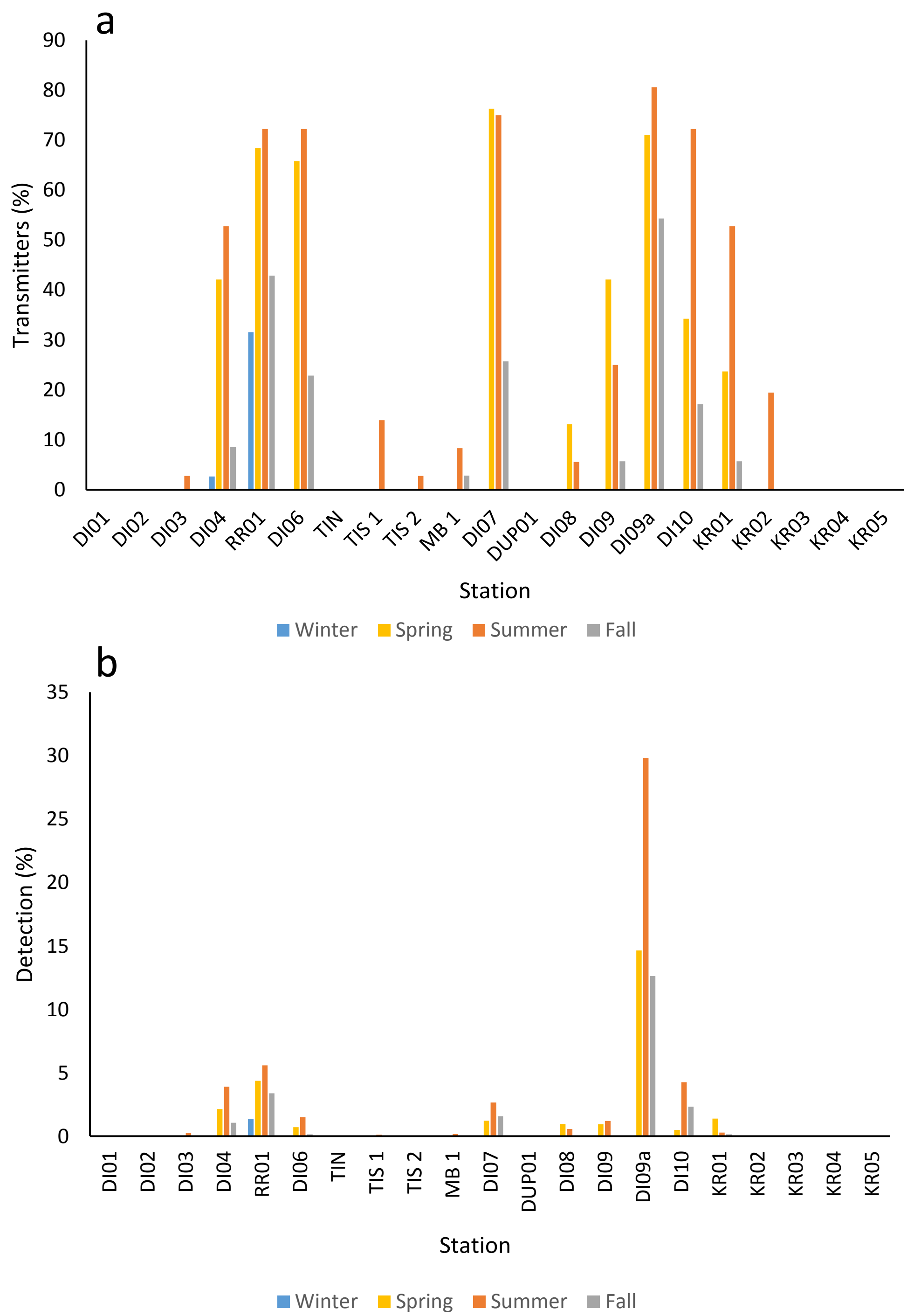

Figure 3: *Percentage of unique active tags detected by each station (a) and percentage of total detections by station (b) across seasons within the Dresden Island Pool and connecting tributaries.*

In 2016, USACE placed several new receivers within the Kankakee River after analyzing the data from 2015. In 2015, tagged Asian carp were detected near the Wilmington Dam, further upstream than previously observed by tagged fish. In response to determine if Asian carp can bypass the Wilmington dam, a receiver was placed upstream at Custer Park in conjunction with the USGS stream gage. In addition, a receiver was placed just 1.5 miles downstream of the Kankakee Dam in Kankakee, Illinois. Tagged Asian carp were only detected at two stations within the Kankakee: KR01 and KR02. Up to 52% of the active tags within Dresden Island Pool were detected at KR01 and only 19% of the active tags were detected in KR02. A combined total of 1.9% of the detections from Dresden Island pool occurred at these two stations. While over 50% of active tags were detected in the Kankakee River, fish spent limited time near the confluence of Kankakee and did not travel as far upstream as fish in 2015. Differences in the upstream movement of Asian carp between 2015 and 2016 is likely due to the differences flood stage (Figure 4). In 2015, the Kankakee River basin received a large amount of rainfall which resulted in the river to remain at flood stage for an extended period of time. It was during this increased flow that Asian carp were detected near the Wilmington Dam. During 2016, the Kankakee River barely reached over 20,000 cfs compared with more than 30 days over 20,000 cfs with a peak near 47,200 cfs during 2015. Receivers will continue to be deployed upstream of Wilmington Dam to confirm if any tagged Asian carp have moved upstream and are utilizing different parts of the river.

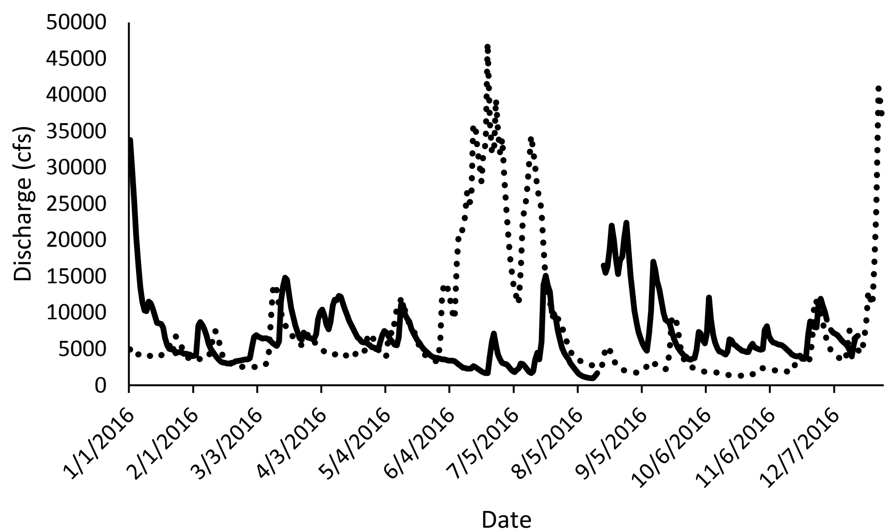

Figure 4: *Daily mean discharge (cfs) of the Kankakee River at Wilimington, Illinois (USGS stream gage 05527500) for 2015 (dotted line) and 2016 (solid line).*

Due to ongoing work at Brandon road Lock and Dam, additional emphasis has been placed on Asian carp movements within and around the lock. In 2016, a single Bighead Carp was detected on the receiver within the Brandon Road approach channel in the Dresden Island Pool. This fish was first detected in the approach channel on 9 August at 14:15 and remained near the receiver for approximately 7 hours. This fish then heads downstream (2.8 miles) and is detected just upstream of Rock Run Rookery before returning to the approach channel at 10:01 on 10 August. The Bighead Carp then stages within the approach channel for close to 7 hours again before returning downstream. This is the first Asian carp to be detected within the approach channel since 2013. Continued monitoring of Brandon Road Lock and Dam is necessary to track any movements of Asian carp into Brandon Road pool.

Recommendations:

USACE recommends continuation of the telemetry program and maintaining the current level of surrogate species tags within the system by replacing expired tags within the Lower Lockport pool in early 2017. The number of Asian carp currently tagged within Dresden Island Pool should also be maintained but supplemental and replacement transmitters for these species should include depth and temperature sensors to improve on the current data on habitat use. USACE will continue to collaborate with MRWG partners to maximize our understanding of Asian carp movement and biology within the Dresden Island Pool. USACE will also continue to investigate the large expanse of data collected over the last 6 years to examine study area wide movement and habitat use for both Asian carp and surrogate species.

Continued analysis should occur at the Brandon Road Lock chamber for the telemetry program and continue the collaboration with partner agencies performing parallel studies. Continued collaboration with MRWG partners has helped fill in receiver coverage. USACE recommends continued collaboration with these partners to further investigate knowledge gaps in fish movement and behavior near Brandon Road Lock and Dam. Additional collaboration is recommended for the planned 7 day complex noise trail at Brandon Road in April 2017.

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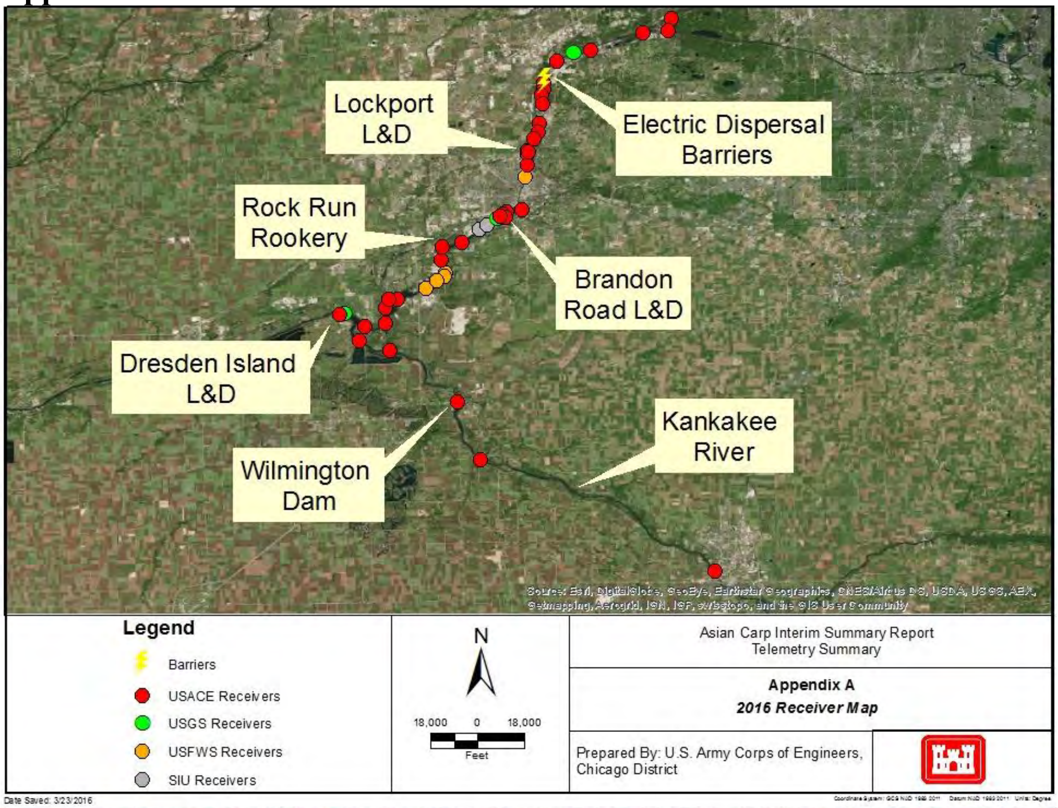
Appendix A


Lockport L&D
Electric Dispersal Barriers
Rock Run Rookery
Brandon Road L&D
Dresden Island L&D
Kankakee River
Wilmington Dam
Legend
Barriers
USACE Receivers
USGS Receivers
USFWS Receivers
SIU Receivers
N
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Feet
Asian Carp Interim Summary Report
Telemetry Summary
Appendix A
2016 Receiver Map
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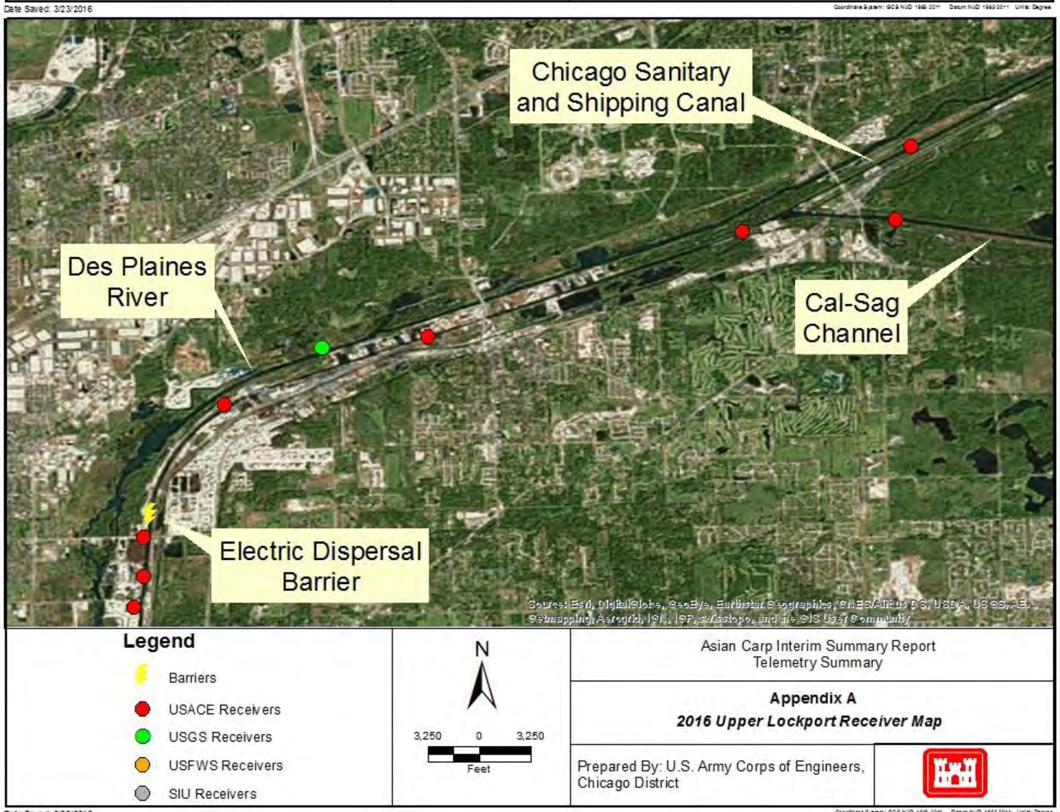
Date Saved: 3/23/2016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Des Plaines River
Cal-Sag Channel
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Legend
Barriers
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Telemetry Summary
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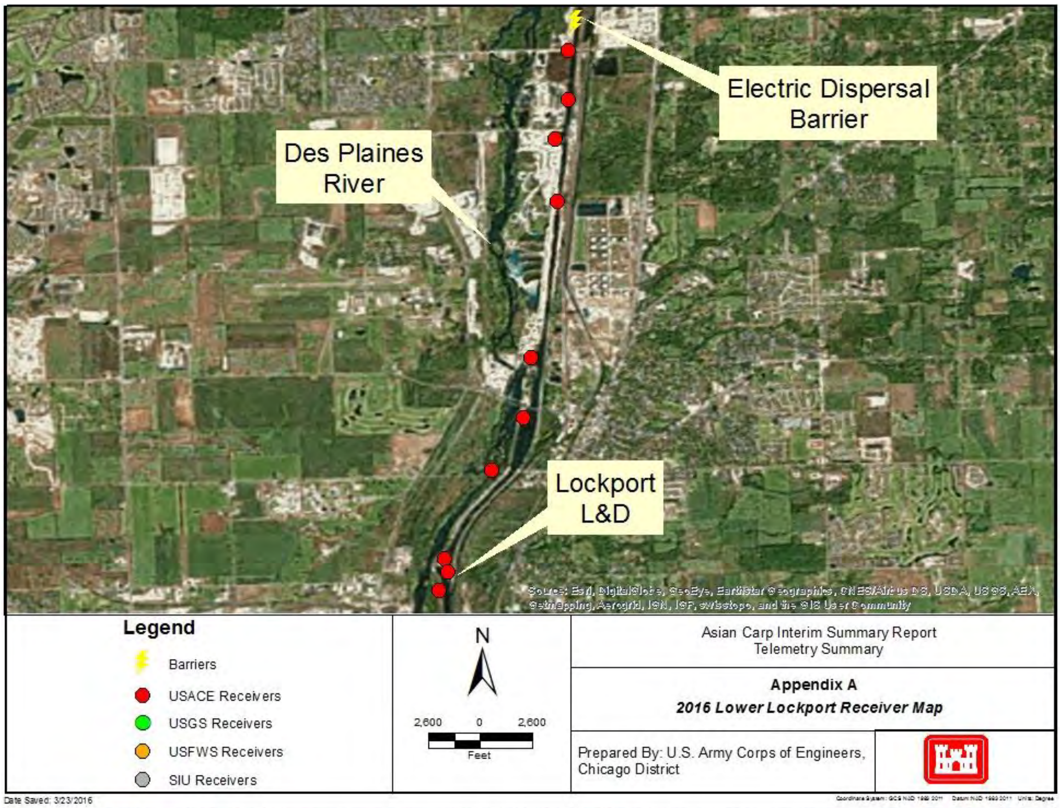
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Lockport L&D
Legend
Barriers
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USGS Receivers
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SIU Receivers
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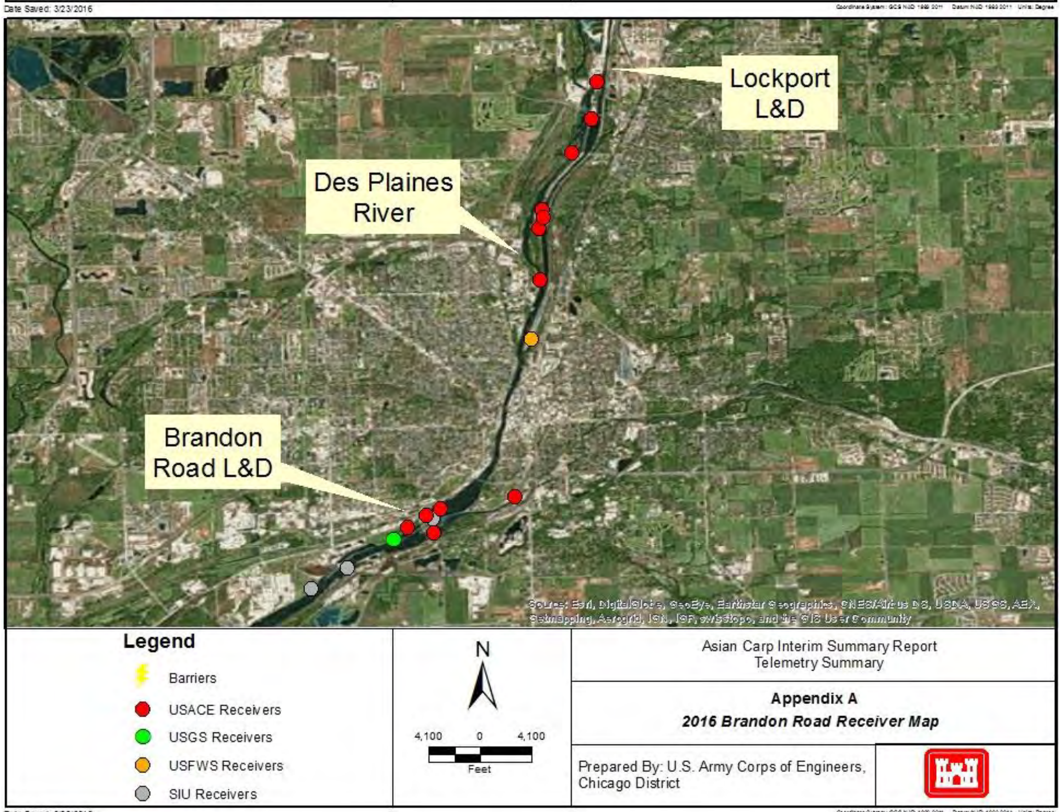
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Brandon Road L&D
Legend
Barriers
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USGS Receivers
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Telemetry Summary
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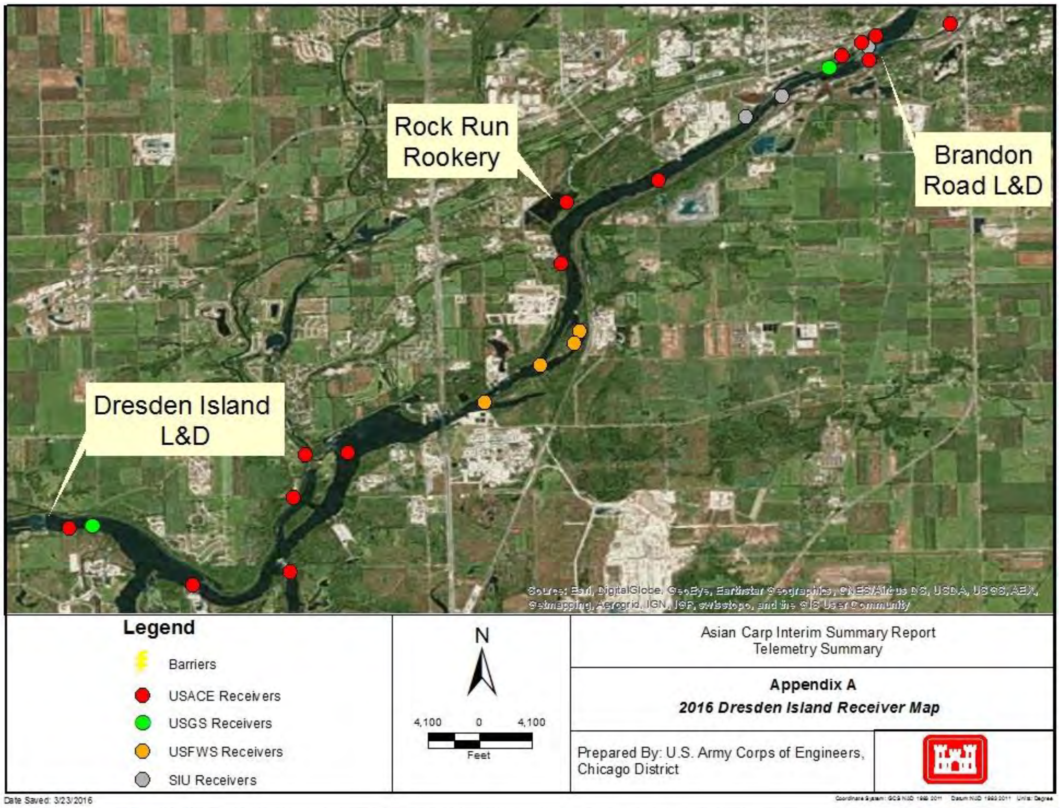

Rock Run Rookery
Brandon Road L&D
Dresden Island L&D
Legend
Barriers
USACE Receivers
USGS Receivers
USFWS Receivers
SIU Receivers
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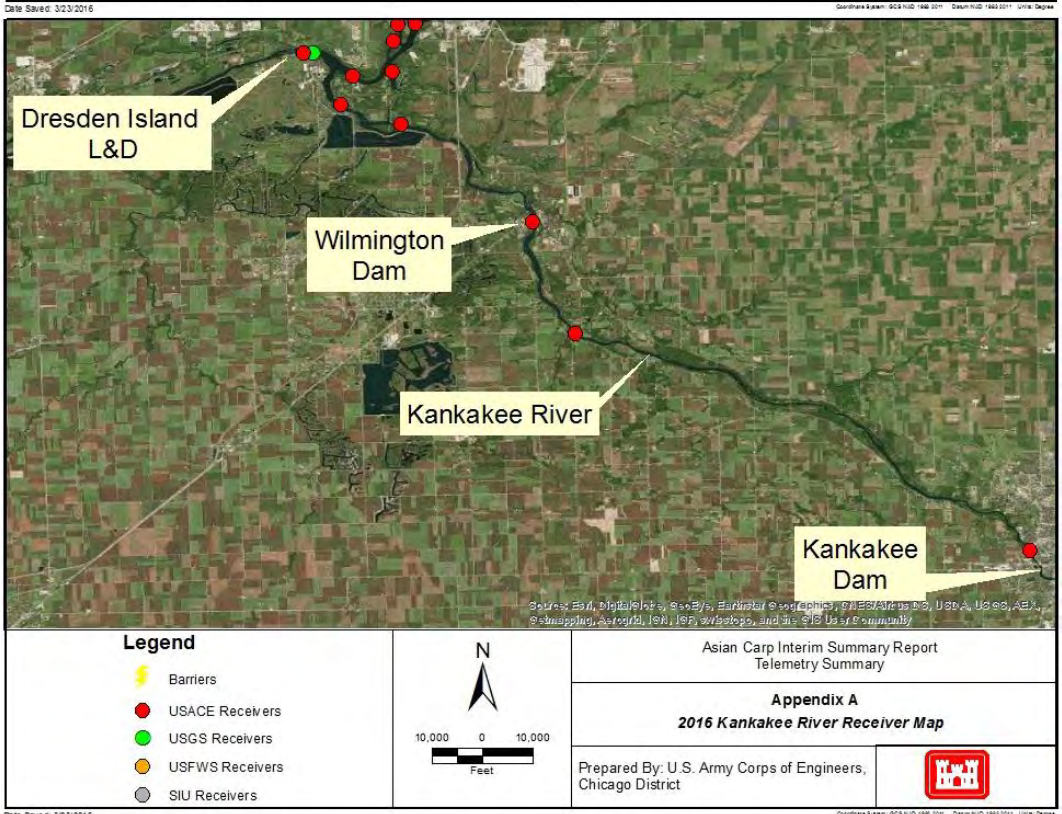
Feet
Asian Carp Interim Summary Report
Telemetry Summary
Appendix A
2016 Dresden Island Receiver Map
Prepared By: U.S. Army Corps of Engineers, Chicago District
Date Saved: 3/23/2016



Dresden Island L&D
Wilmington Dam
Kankakee River
Kankakee Dam
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USACE Receivers
USGS Receivers
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SIU Receivers
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Asian Carp Interim Summary Report
Telemetry Summary
Appendix A
2016 Kankakee River Receiver Map
Prepared By: U.S. Army Corps of Engineers, Chicago District
Date Saved: 3/23/2016

Understanding Surrogate Fish Movement with Barriers

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Nick Bloomfield, Rebecca Neeley (US Fish and Wildlife Service – Carterville Fish and Wildlife Conservation Office)
Mathew Shanks, Nicholas Barkowski (US Army Corps of Engineers)

Participating Agencies: Illinois Department of Natural Resources (lead); US Fish and Wildlife Service, US Army Corps of Engineers, Illinois Natural History Survey, and the Forest Preserve District of Will County.

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

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

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

(1) Monitor the movements of tagged surrogate species in Dresden Island, Brandon Road and Lockport Pools and Rock Run Rookery to assess fish movement between barrier structures; and

(2) Obtain information on recapture rates of surrogate species to help verify sampling success using multiple gear types.

Project Highlights:

- Multiple agencies and stakeholders cooperated in successfully tagging 1,790 fish in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery (Between March 15, 2016 and December 02, 2016)
- A total of 192 fish were recaptured in 2016 using pulsed DC-electrofishing, gill nets, trammel nets and 6 foot diameter hoop nets
- A total of 135 recaptures had tags but showed no movement between barrier structures, 47 recaptures where observed due to caudal fin clip but had no tag to show movement and 10 recapture showed movement through barrier structures and Lock and Dam Structures
- One Common Carp with a floy tag showed upstream movement through the Lockport Lock
- Recommend continued tagging of Common Carp, Bigmouth Buffalo, Smallmouth Buffalo, Black Buffalo and Common Carp x Goldfish hybrid using pulsed DC-electrofishing, gill nets, trammel nets and 6 foot diameter hoop nets to monitor fish movement between barrier structures.

Methods:

Sampling for Common Carp, Bigmouth Buffalo, Smallmouth Buffalo and Black Buffalo will be obtained through Fixed and Random Site Monitoring Downstream of the Barrier and Barrier Maintenance Fish Suppression projects (see Monitoring and Response Plan for Asian Carp in the Upper Illinois River of Chicago Area Waterway 2015). The sample design includes electrofishing at four fixed sites and twelve random sites in each of the three pools below the Electric Dispersal Barrier (see Figure 1). Contracted commercial netting will include four fixed sites in each pool along with targeted sampling determined by the commercial fisherman in Brandon Road, Lockport Pools, and Dresden Island Pool each week sampled. Contracted commercial netting will also include targeted sampling in Rock Run Rookery each week sampled from March to December. Hoop and minnow fyke netting will take place at four fixed sites in each pool once per month. The fixed sites in each of the three pools are located primarily in the upper end of each pool below lock and dam structures, in habitats where Asian carp are likely to be located (backwaters and side-channels), or both. Random electrofishing and contracted commercial fishing sites occur throughout each pool, including the lower portions of each pool as well as in the Kankakee River, from the Des Plaines Fish and Wildlife Area boat launch downstream to the confluence with the Des Plaines River.

Understanding Surrogate Fish Movement with Barriers

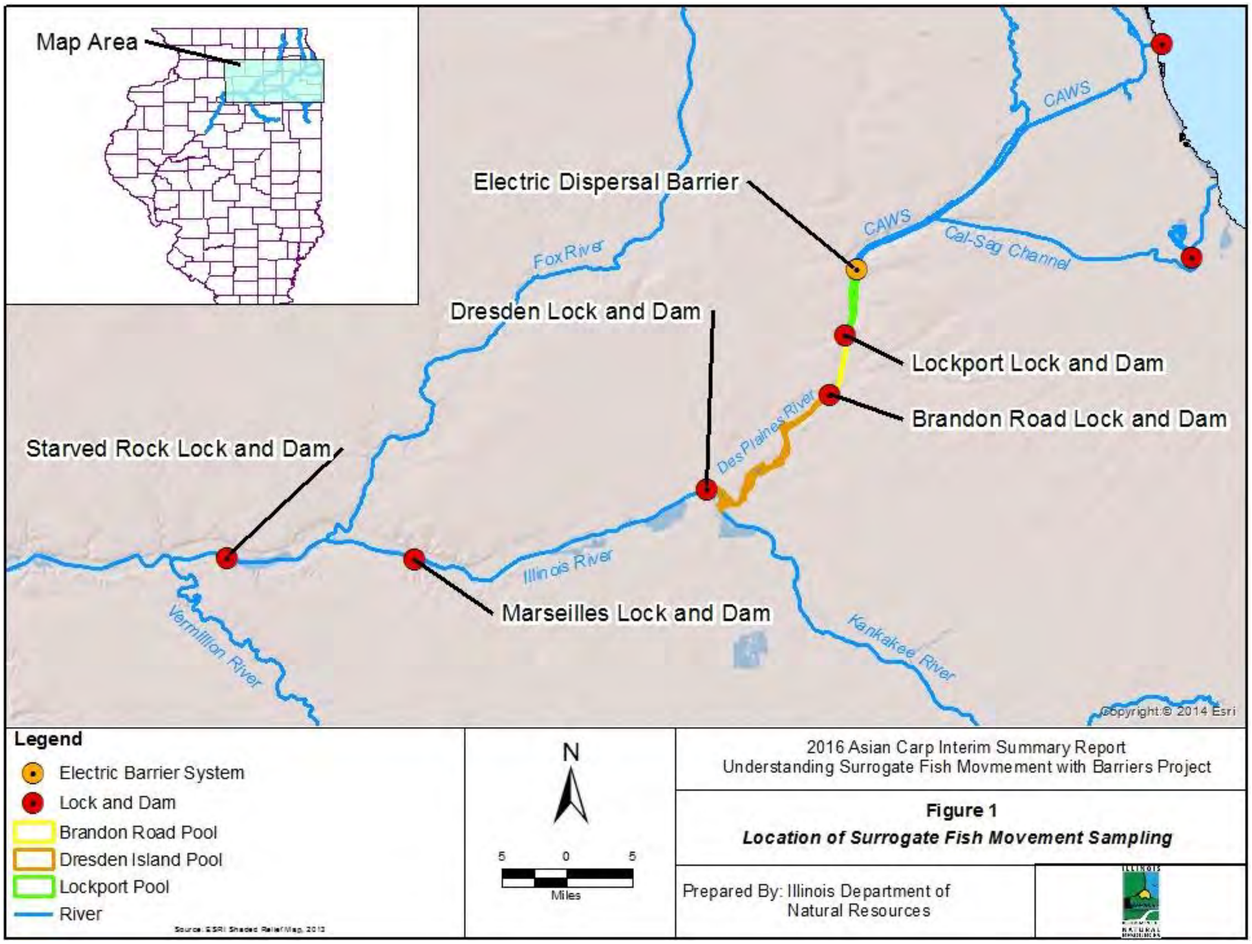

Figure 1. *Location of surrogate fish movement with barriers sampling.*

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

Results and Discussion:

Between March 15, 2016 and December 2, 2016, a total of 1,790 Common Carp, Smallmouth Buffalo, Bigmouth Buffalo, Black Buffalo and Common x Goldfish hybrids were tagged in

Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery. Of the total 5,717 fish tagged in 2014, 2015, and 2016, 369 were recaptured which gave a recapture percentage of 6.45% (Table 1). Individual recapture percentages from 2014 to 2016 for Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery were 7.11%, 6.88%, 3.68% and 15.54%, respectively (Table 1). Of the 192 recaptures in 2016, 10 showed movement from the original pool from which they were captured (Table 2). One Smallmouth Buffalo (530mm) was initially captured and tagged in Dresden Pool on November 17, 2014 and was recaptured on May 11, 2016, in Marseilles Pool. This fish travelled 14.12 miles downstream from the tagging location through the Dresden Lock and Dam. Another recaptured fish, a Common Carp (645mm), was tagged June 26, 2015 in Brandon Road Pool then travelled upstream through the Lockport Lock before being recaptured in Brandon Road Pool on June 09, 2016 (Table 2). These surrogate fish demonstrated the ability for movement downstream through the Dresden Island Lock and Dam and also upstream through the Lockport Lock chamber. Eight of the 10 recaptured that travelled through a barrier structure travelled through the Dresden Island Pool and Rock Run Rookery connection. Of these 8 recaptures, 3 of the recaptured fish moved from Rock Run Rookery into Dresden Island Pool and 5 of the recaptured fish moved from Dresden Island Pool into Rock Run Rookery (Table 2). The hydrological data between March 13, 2015 and July 17, 2015 at Brandon Road Lock and Dam, showed 1 large spike in flow that was above the 2016 average of 3,781 cubic feet per second (CFS) (Figure 2).

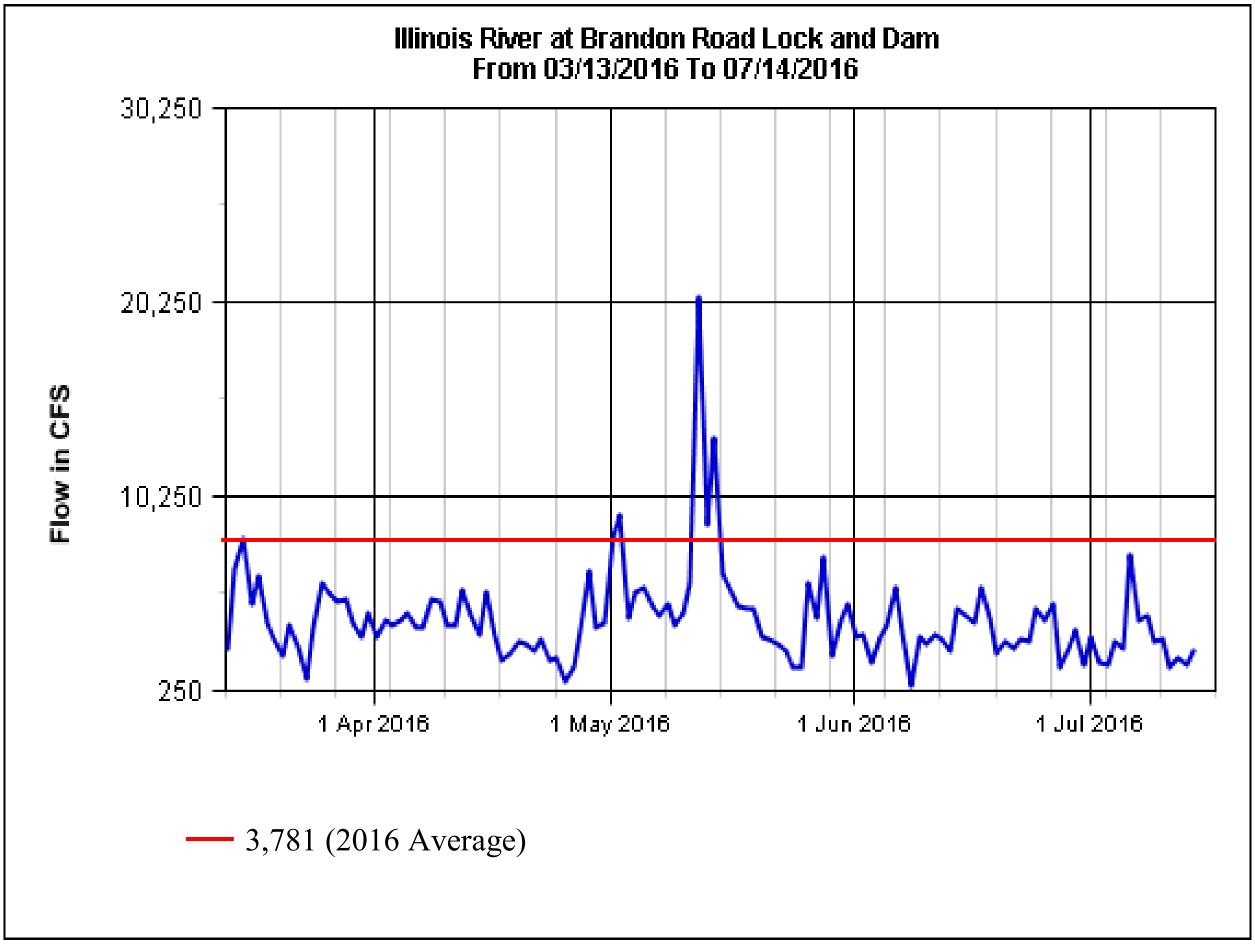

Figure 2. *Brandon Road Lock and Dam flow rates in cubic feet per second (CFS) between the time 3 recaptured species moved from Rock Run Rookery into Dresden Island Pool and 2 recaptured species moved from Dresden Island Pool into Rock Run Rookery.*

The spike in flow might have attributed to the 3 recaptured species moved from Rock Run Rookery moving into Dresden Island Pool. This Large spike in flow then relatively low flow rates after might have attributed to the recaptured species move from Dresden Island Pool into Rock Run Rookery. With the 192 recaptured fish in 2016, we feel floy tag retention has met expectations.

Recommendations: The continuation of this project will help us better understand the threat of Asian carp movement through barrier structures. With more data we will also be able to determine if there is a correlation with fish movement and hydrological data. We recommend the continuation of Floy tagging surrogate species through electrofishing, hoop nets, and commercial fishing for all sampling projects in Lockport Pool, Brandon Road Pool, Dresden Island Pool and Rock Run Rookery. Data collected on surrogate species movement and recapture rates will provide valuable information on how Asian carp may potentially move through barrier structures.

Table 1. *Number Of Fish Floy Tagged and Recaptured in 2014, 2015, and 2016*

	Total Tagged Fish			Total Recaptured Fish			Recapture %
	2014	2015	2016	2014	2015	2016	Total %
Lockport Pool							
Common carp	177	130	205	3	10	24	
Smallmouth buffalo	1						
Bigmouth buffalo							
Black Buffalo							
Common X Goldfish hyb.	2	4	1				
Total	180	134	206	3	10	24	7.11%
Brandon Pool							
Common carp	276	440	292	7	48	13	
Smallmouth buffalo	4	14	9		4	1	
Bigmouth buffalo							
Black Buffalo							
Common X Goldfish hyb.	5	17	4				
Total	285	471	305	7	52	14	6.88%
Dresden Pool							
Common carp	466	510	240	1	24	10	
Smallmouth buffalo	565	737	586	4	28	46	
Bigmouth buffalo	24	20	45	1	2	2	
Black Buffalo	16	29	8		1	1	
Common X Goldfish hyb.	1	14					
Total	1072	1310	879	6	55	59	3.68%
Rock Run Rookery							
Common carp	9	26	45		4	2	
Smallmouth buffalo	86	261	279	2	28	73	
Bigmouth buffalo	21	53	62		5	14	
Black Buffalo	1	18	14		3	5	
Common X Goldfish hyb.							
Total	117	358	400	2	40	94	15.54%
Marseilles Pool							
Smallmouth Buffalo				1		1	
Total				1		1	
Starved Rock Pool							
Common Carp					1		
Total					1		
Overall Total	1654	2273	1790	19	158	192	6.45%

Table 2. *Distance Recaptured Fish Travelled in Miles Through a Barrier System*

Downstream Movement	Species	Date Captured	Date Recaptured	Distance Travelled (miles)
Rock Run Rookery to Dresden Pool	Smallmouth Buffalo	4/29/2016	7/7/2016	0.63
	Smallmouth Buffalo	3/18/2016	7/12/2016	1.23
	Smallmouth Buffalo	6/10/2016	7/14/2016	6.96
Dresden Pool to Rock Run Rookery	Smallmouth Buffalo	4/1/2014	7/5/2016	6.17
	Smallmouth Buffalo	3/17/2016	6/10/2016	8.93
	Smallmouth Buffalo	4/2/2015	5/26/2016	7.49
	Smallmouth Buffalo	11/5/2015	10/21/2016	4.19
	Smallmouth Buffalo	4/28/2016	7/5/2016	6.59
Dresden Pool to Marseilles Pool	Smallmouth Buffalo	11/17/2014	4/02/2015, 5/11/2016	14.12

Upstream Movement	Species	Date Captured	Date Recaptured	Distance Travelled (miles)
Brandon Pool to Lockport Pool	Common Carp	6/26/2015	6/9/2016	8.62

Literature Cited:

Guy, C. S., H. L. Blankenship, and L. A. Nielsen. 1996. Tagging and Marking. Pages 353-383 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

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Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison, Wisconsin. 1052 pages.

Monitoring of Fish Abundance and Spatial Distribution in Lockport, Brandon Road, and Dresden Island Pools and the Associated Lock and Dam Structures

Jeremiah J. Davis, Cory A. Anderson, Jimmie S. Garth, and Rebecca N. Neeley (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

Participating Agencies USACE-Chicago District (field/logistical support).

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

The Electric Dispersal Barrier System (EDBS) located within the Chicago Sanitary and Ship Canal (CSSC) operates with the purpose of preventing inter-basin transfer of invasive fish species between the Mississippi and Great Lakes basins. Observational evidence from previous studies suggests that fish congregate below the EDBS at different times throughout the year, primarily during the summer and fall (Parker et al. 2015). How fish interact with the EDBS over varying temporal scales (e.g., diel to seasonal) is not well understood. Having a greater understanding of the temporally varying densities and spatial distributions of fish below the EDBS is important to barrier management as it allows operational and maintenance decisions to be made in sync with potential risk factors. To determine these periods of elevated risk, split-beam hydroacoustic surveys were performed on a bi-weekly to monthly basis throughout 2016.

Additionally, split-beam hydroacoustic surveys of the Lockport, Brandon Road, and Dresden Island navigation pools were undertaken in the upper Illinois Waterway during spring, summer, and fall in 2014, 2015, and 2016. This work allowed for a greater understanding of the spatio-temporal changes in fish densities size distributions of the fish community in these study areas. Understanding fish community dynamics throughout the upper Illinois Waterway will allow the findings from a range of other research activities at the EDBS to be put into a system-wide context. This will then enable more refined interpretations of results and allow mangers to make better informed decisions. Additionally, identification of areas of high fish density may facilitate ongoing Asian carp removal efforts.

The Great Lakes Mississippi River Interbasin Study (GLMRIS) was released in January 2014 and presents a comprehensive range of options and technologies available to prevent the inter-basin transfer of aquatic nuisance species (ANS) between the Great Lakes and Mississippi River Basins through aquatic pathways. A study of the feasibility of implementation of ANS control measures at Brandon Road Lock and Dam is being undertaken by the U.S. Army Corps of Engineers (USACE). Gaining a greater understanding of fish abundance, behavior, and movements in and adjacent to the Brandon Road Lock will help to inform potential GLMRIS actions at the Brandon Road Lock and allow for evaluations of the efficacy of any measures that are implemented. Hydroacoustic surveys within and near the Brandon Road Lock chamber were conducted to quantify the extent of fish utilization of the structure and evaluate the potential for lock chamber-mediated fish dispersal between pools. Additionally, physical fish capture events took place during the spring, summer, and fall of 2016 to determine the community composition of fishes present inside the Brandon Road Lock.

Objectives:

(1) Evaluate the density and size structure of the fish community directly below the EDBS throughout the year.

(2) Determine the density and distribution of fish in upper navigation pools on the Illinois Waterway throughout the year.

(3) Evaluate size structure of fish in the study reaches and quantify seasonal changes.

(4) Determine the extent of fish utilization of the Brandon Road Lock structure.

(5) Identify trends in movement patterns into and out of the Brandon Road Lock chamber.

(6) Identify large fish targets in the study pools suspected of being Asian carp to direct targeted sampling efforts at these fish for removal.

Project Highlights:

- Peak fish densities near the EDBS were observed during late summer. Fish density remained relatively high during fall surveys.
- Fish surveys inside the Brandon Road lock suggested that density of fish was greater than observed in either Brandon Road or Dresden Island pool during all seasons

Methods:

Acoustic Fish Surveys below the Electric Dispersal Barrier: A series of side-looking split-beam hydroacoustic surveys were conducted below the CSSC EDBS to assess fish density and distribution patterns near the barrier on a fine temporal scale. Surveys below the EDBS took place between March and October 2016 on a bi-weekly to monthly basis. Survey transects began below the EDBS (≈ 300 m) at 41^0 38.200 N, 88^0 03.664 W. The survey vessel traversed a path close to the west wall traveling north with the side looking hydroacoustic transducers aimed towards the east wall. Each transect continued through the EDBS, turned south, and then traveled closely along the east wall back to 41^0 38.200 N. Three consecutive replicate hydroacoustic surveys took place on each survey date.

The hydroacoustic survey equipment consisted of a pair of Biosonics® 200 kHz split-beam transducers. The two split-beam hydroacoustic transducers were mounted in parallel on the starboard side of the research vessel 0.15 m below the water surface on Biosonics® dual axis automatic rotators. The rotators repositioned the transducers to preset positions every 45 seconds. One transducer was set to -3.3˚ and the other to -9.9˚ below parallel from the water surface. Split beam acoustic data was collected using Visual Acquisition v.6® from 1.15- 55 m from the transducer face, at a ping rate of 5.0 pings per second, and a 0.40 ms pulse duration. Data collection was set to begin at 1.15 m from the transducer face in order to avoid near-field interference. To compensate for the effect of water temperature on two-way transmission loss via its effect on the speed of sound in water, temperature was recorded with a YSI® environmental meter and input into Visual Acquisition v.6® prior to all data collections. The split-beam acoustic transducers were calibrated on-axis with a tungsten carbide calibration sphere before sampling following Foote et al. (1987).

Split-beam hydroacoustics data were post-processed in Echoview® v. 6.0. After a calibration offset was applied to account for measured and theoretical target strength (-TS) response from each transducer, data was loaded into a mobile survey template. The template used angular position and -TS to identify and estimate the size and location of single fish targets. Data post processing followed standard methods (Glover et al. unpublished data). Data that were collected outside of the analysis bounds (between 41^0 38.200 N and the IIA Electric Dispersal Barrier's lower parasitic structure) were removed from further analysis, a bottom line was digitized by hand, areas of bad data caused by air bubbles were removed, single targets were identified using a threshold of > -70db for target acceptance, fish tracks were identified using algorithms within the the Echoview Fish Tracking Extension®, and single target -TS was converted from -db to target length using equations derived from Love (1977). Calculation of target density within the canal was performed using the wedge volume sampled method whereby the number of targets encountered was divided by the total volume of water in a wedge encompassing the survey transect for each transducer (T. Jarvis, personal communication 4-7-2014). Each individual target and fish track was also spatially located within the water column using the split-beam transducers capabilities and assigned X, Y, and Z positional coordinates.

Statistical data analyses were performed to determine if significant differences in fish abundance immediately downstream of the EDBS existed between different survey dates. Density data were tested for normality using the Shapiro-Wilk W test. Data were normalized to meet assumptions of parametric tests where necessary using $\log_{10}$ transformations. One-way Analysis of Variance (ANOVA) with significance at $\alpha = 0.05$ was used to test for differences in mean densities between sampling dates with pairwise comparisons using the Holm-Sidak post-hoc test.

Illinois Waterway Pool Surveys: To quantify the density and spatial distribution of the fish community in the upper Illinois Waterway, a series of hydroacoustic remote sensing surveys were conducted throughout the Lockport, Brandon Road, and Dresden Island navigation pools seasonally between 2013 and 2016. The surveys were conducted using the same equipment, collection techniques, and analysis methods as were employed during other hydroacoustic surveys. Within the navigation channel, each pool was surveyed by maneuvering the research vessel on clockwise transects around the pool near the channel margin. In areas where the navigation channel was wider than the range of the survey equipment (≈55 m) several concentric transects were conducted.

Brandon Road Lock Mobile Acoustic Surveys: Acoustic remote sensing surveys were conducted within and adjacent to the Brandon Road Lock structure during spring, summer, and fall 2016 using the same equipment and methods described for other hydroacoustic surveys. Data processing and analysis methods also remained consistent between surveys. Briefly, the research vessel entered the lock chamber from downstream with the lock chamber emptied (depth over sills ≈ 5 m). The vessel then conducted three replicate transects around the inside of the lock chamber in a clockwise fashion staying as close as possible to the wall while surveying the opposite side of the chamber. Additionally, physical fish sampling events utilizing gill and trammel nets were conducted concurrently with these surveys to characterize the fish community present within the lock chamber. During each survey 100 yards of 6’ tall experimental gill net (0.25”-2.5” stretched mesh panels) was deployed into the lock chamber and fished on the bottom. Additionally, 200 yards of 3.0” 12’ high trammel net was fished simultaneously. Fish were driven into nets using an electrofishing boat.

Results and Discussion:

Fish Surveys below the Electric Dispersal Barrier: Results from acoustic surveys conducted directly below the EDBS during 2016 suggested that fish density during late winter was very low (mean = 0.08 fish/1000m^3 SD = 0.03, n=5). During the spring, fish density below the EDBS increased (mean = 0.81 fish/1000m^3 SD = 0.57, n=10). During summer, fish density below the EDBS increased further (3.46 fish/1000m^3 (SD = 4.23, n=4). During fall, fish density decreased from levels observed during summer but remained greater than winter or spring densities (2.31 fish/1000m^3 S.D. = 0.75 n=3) (Fig. 1). The fish targets ensonified during the surveys were estimated to be primarily < 150 mm (93.4%). However, several larger fish targets were observed during the surveys. These results follow trends that were previously observed in the Lockport navigation pool near the EDBS during 2014 and 2015 (Asian Carp Regional Coordinating Committee Monitoring and Rapid Response Workgroup, 2015). Increased fish density during the summer was likely driven by an influx of YOY fishes into the community.

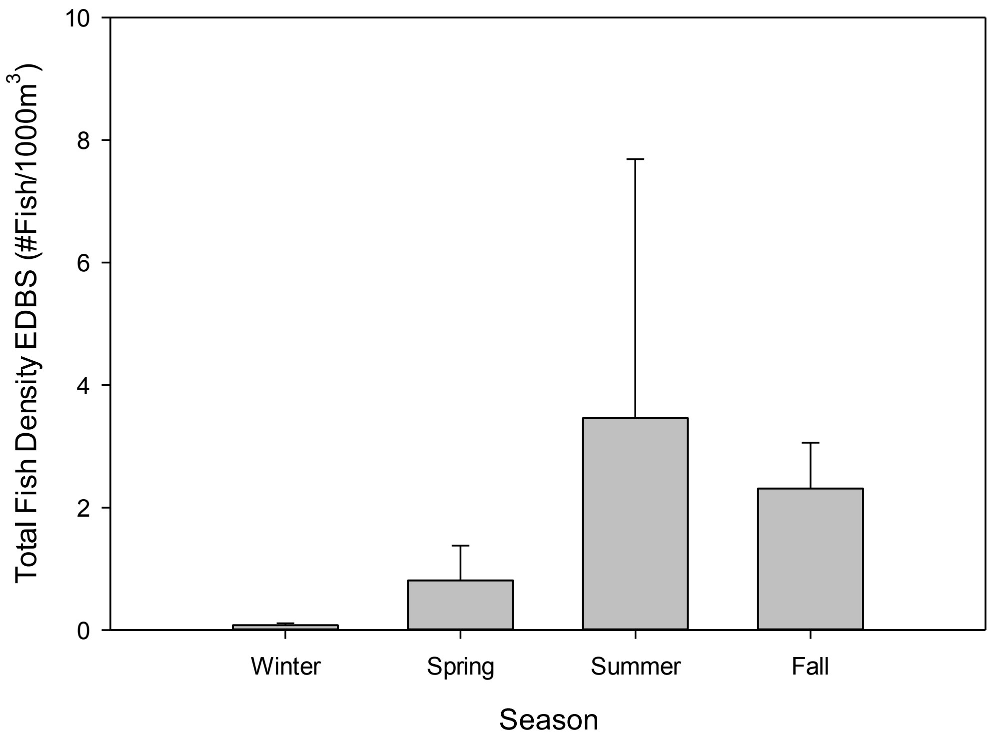

Figure 1. *Fish density (# / 1000m3) observed from the downstream edge of the barrier IIA parasitic structure to 500 m below (except during 1 June 2015; from the downstream edge of barrier IIB) during weekly split-beam hydroacoustic surveys conducted during 2015 . Error bars denote S.D.*

Illinois River Pool Surveys: Results from the intensive acoustic remote sensing survey conducted in the Lockport navigation pool between 2013-2015 showed relatively stable and low fish densities throughout the winter and spring. Fish densities were then observed to increase in July and peak in August; this was followed by substantial declines as fall progressed. These trends remained consistent among years. Results from the 2016 surveys suggested that during the late winter, total fish density was greater in the Lockport (0.57 fish / 1000 m^3) and Dresden Island (0.78 fish / 1000 m^3) pools than in the Brandon Road Pool (0.10 fish / 1000 m^3). During summer, fish density increased in all study pools. The greatest fish density during summer was observed in Lockport Pool (0.61 fish/1000m^3). Although the majority of the increases in fish density appeared to be driven by YOY recruitment, substantial increases in the density of large fish were observed during the summer in the Lockport and Brandon Road pools and during the fall in Dresden Island Pool.

Brandon Road Lock Mobile Acoustic Survey: Results from surveys conducted inside the Brandon Road Lock structure indicated that fish are utilizing the Brandon Road Lock structure as habitat and were present at densities greater than were observed in the Lockport, Brandon Road, or Dresden Island study pools during the same season, despite the lock doors being closed except to receive in-coming vessel traffic. Mean total fish densities in the Brandon Road Lock were greater than any densities observed throughout our study (mean = 24.43 fish / 1000 m^3). Fish species that were physically captured inside the lock chamber included Gizzard Shad (*Dorosoma cepedianum*), Freshwater Drum (*Aplodinotus grunniens*), Common Carp (*Cyprinus carpio*), and Longnose Gar (*Lepisosteus osseus*). The acoustic gear proved very efficient at observing and quantifying fish density within the lock chambers both at the empty stage and at the full stage. It was also very efficient at surveying inside the lock during the emptying cycle. During the filling cycle air bubbles obscure the equipment for approximately ten minutes after filling when surveying inside the chamber. Air bubbles are also problematic during emptying when positioned outside of the chamber on the downstream side.

Conclusion: These studies provided insights on the dynamics of fish communities throughout the upper portion of the Illinois Waterway that would be unattainable using traditional fisheries survey gear. These studies also allowed changes in density across large spatial areas and throughout multiple temporal scales to be examined and these insights will be useful for identifying risk and designing further studies.

Recommendations:

(1) Continue monitoring spatio-temporal dynamics of fish within the Upper Illinois Waterway to detect changes in biomass or habitat utilization that could be indicative of changes in community structure.

(2) Continue monitoring and rapid reporting of survey data to inform management agencies of suspected ANS observations.

References:

Asian Carp Regional Coordinating Committee- Monitoring and Response Work Group, (2015), Monitoring and Rapid Response Plan Interim and Summary Report, accessed December 1, 2015, at http://www.asiancarp.us/documents/MRP2014-InterimSummary.pdf

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

Jeremiah J. Davis, Rebecca N. Neeley (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

Participating Agencies: U.S. Geological Survey, Illinois Water Science Center, Urbana, IL., U.S Army Corps of Engineers, Construction Engineering and Research Laboratory, Champaign, IL., U.S. Army Corps of Engineers, Chicago District, Chicago, IL

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

The most substantial pathway for the movement of invasive fishes between the Mississippi River Basin and the Great Lakes Basin is the Chicago Area Waterways System (CAWS) including the Chicago Sanitary and Ship Canal (CSSC) in the Upper Illinois Waterway. An Electric Dispersal Barrier System (EDBS) was constructed in the CSSC to prevent the movement of invasive fish species between the Mississippi River Basin and the Great Lakes Basin while maintaining the continuity of this important shipping route. This study examined the physical effects of transiting barge vessels over the EDBS (flow velocity and electric voltage gradients). Additionally, multi-beam sonar observations of wild fish behavior were made near the EDBS during tow transiting.

Objectives:

(1) Determine the influence of commercial barge vessels on the efficacy of the EDBS in preventing fish passage.
(2) Quantify flow velocities at the EDBS during tow transit events.
(3) Quantify electrical voltage gradients at the EDBS during tow transit events.

Project Highlights:

- Based on the results of this study, the efficacy of the EDBS in preventing upstream passage of small fish is compromised while tows are moving across the barrier system in the downstream direction. This observation of upstream fish passage identifies a potential pathway for the movement of invasive fishes through the EDBS and into the Great Lakes.

- The identification of this pathway does not elevate the risk of invasive fish passage from current levels. Rather, it improves functional understanding of the efficacy of the EDBS, thereby enhancing the ability of invasive species managers to assess risk and implement appropriate actions.

Methods:

Two DIDSON multi-beam sonar systems, mounted on the west canal wall and aimed toward the wall (Figs. 2 & 4), were used to monitor wild fish behavior during the study. Simultaneously, flow velocities were measured using hydroacoustic instruments mounted on the canal wall and the tow. Additionally, as the tow transited the EBDS, the voltage gradient was measured at Barrier IIB (Fig. 2).

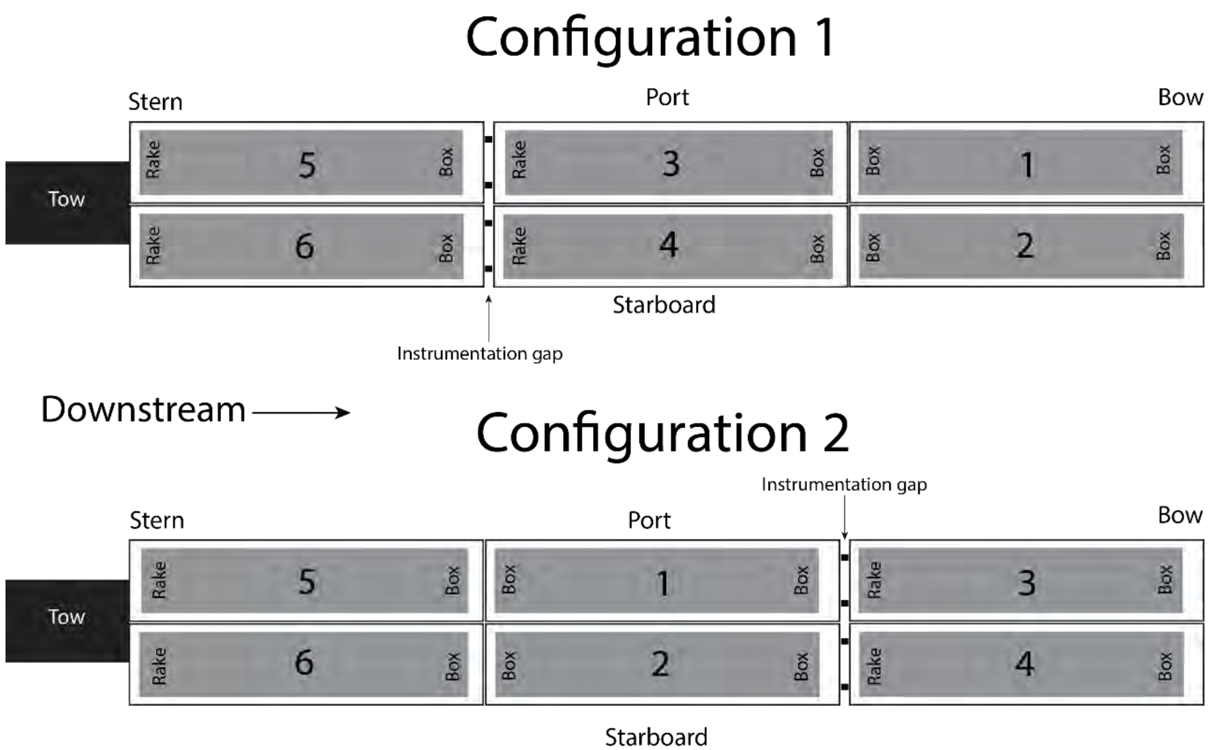

Figure 1. *Tow configurations utilized during downstream transit trials at the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System.*

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

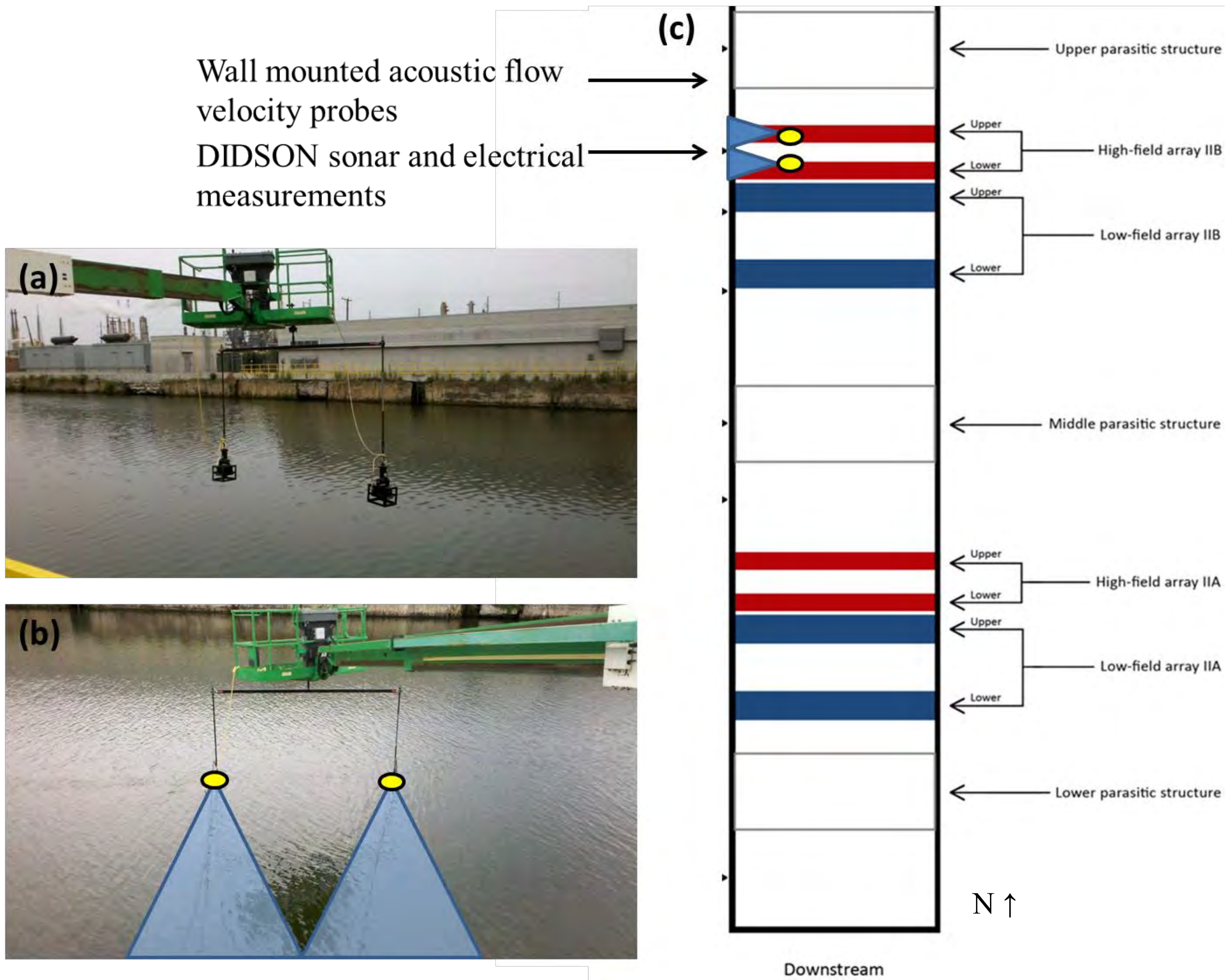

Figure 2. *Telescopic boom lift that was utilized to deploy two DIDSON multi-beam sonar units in parallel at the Chicago Sanitary and Ship Canal Electric Dispersal Barrier System (panels a and b). Blue shading indicates approximate field of view obtained from the sonar system (panel b). The sonar units and electrical field measurement probe were positioned directly over the Barrier IIB narrow array, as shown in panel (c). Wall mounted acoustic flow velocity probes were positioned just upstream of the Barrier IIB narrow array (panel c).*

Results and Discussion:

Velocity measurements indicated that loaded tows transiting the EDBS in the downstream direction created a return current between the tow and the canal wall that travelled in the upstream direction at a mean velocity of 0.18 m/s (n = 21) (Table 1 & Fig. 3, top panel). Additionally, as the tow transited the EBDS, the voltage gradient was measured at Barrier IIB (Fig. 2). These measurements show that the passage of a tow caused a distinct decrease in voltage gradient within the canal (Fig. 3, bottom panel). Schools of juvenile fish moved upstream and completely crossed the peak electrical field of the EDBS concurrent with the passage of downstream transiting tows in 89.5% (n = 19) of trials (Table 2). These schools were not observed to breach the EDBS under ambient conditions and showed no signs of incapacitation in the barrier field during downstream tow passage. The number of fish passages observed during each downstream tow transit ranged from 0 to 822 (Mean = 120 fish, S.D. = 199). Sonar-based size estimates of a subsample of fish that achieved passage of the EDBS ranged from 37.7 mm to 92.3 mm (Mean = 61.4 mm, S.D. = 7.4 mm, n = 170).

Fish that were physically captured in the area immediately downstream of the EDBS concurrent with tow transit trials were Gizzard Shad (*Dorosoma cepedianum*) (n = 304) and Threadfin Shad (*Dorosoma petenense*) (n = 6). The mean size of physically captured Gizzard Shad was 54.0 mm TL (S.D. = 8.95 mm). Gizzard Shad sizes ranged from 33.0 to 94.0 mm.

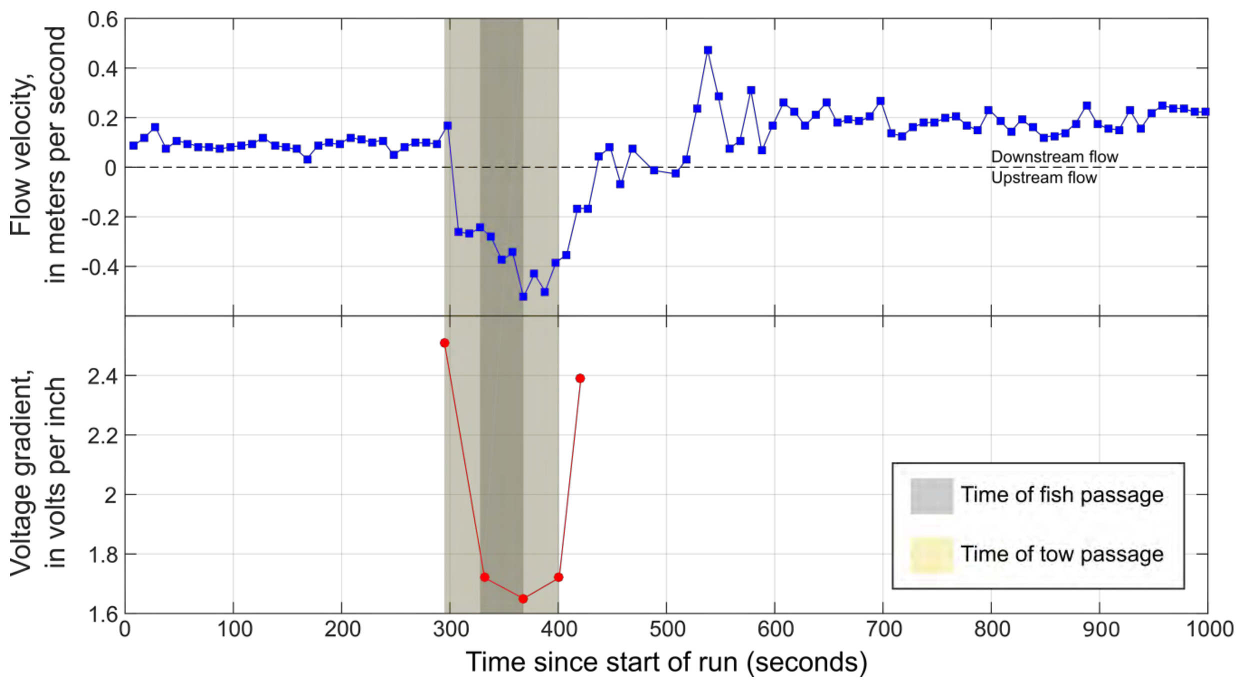

Figure 3. *Flow velocity and voltage gradient plotted against time for a downbound tow transit of the Electric Dispersal Barrier System (EDBS) on 8 August 2016. As the tow transited EDBS Barrier IIB, reverse flows (negative flow velocity, top panel) were initiated concurrent with substantial reductions in voltage gradient (bottom panel).* ***Top panel:*** *the streamwise component of velocity was measured 5.3 meters from the west wall of the canal. Positive flow velocity indicates downstream flow and negative flow velocity indicates upstream flow.* ***Bottom panel:*** *the voltage gradient during tow passage. The yellow shading indicates the time during which six loaded barges passed the DIDSON multi-beam sonar units. The grey shading indicates the time during which wild fish were observed fully traversing the EDBS Barrier IIB in the upstream direction.*

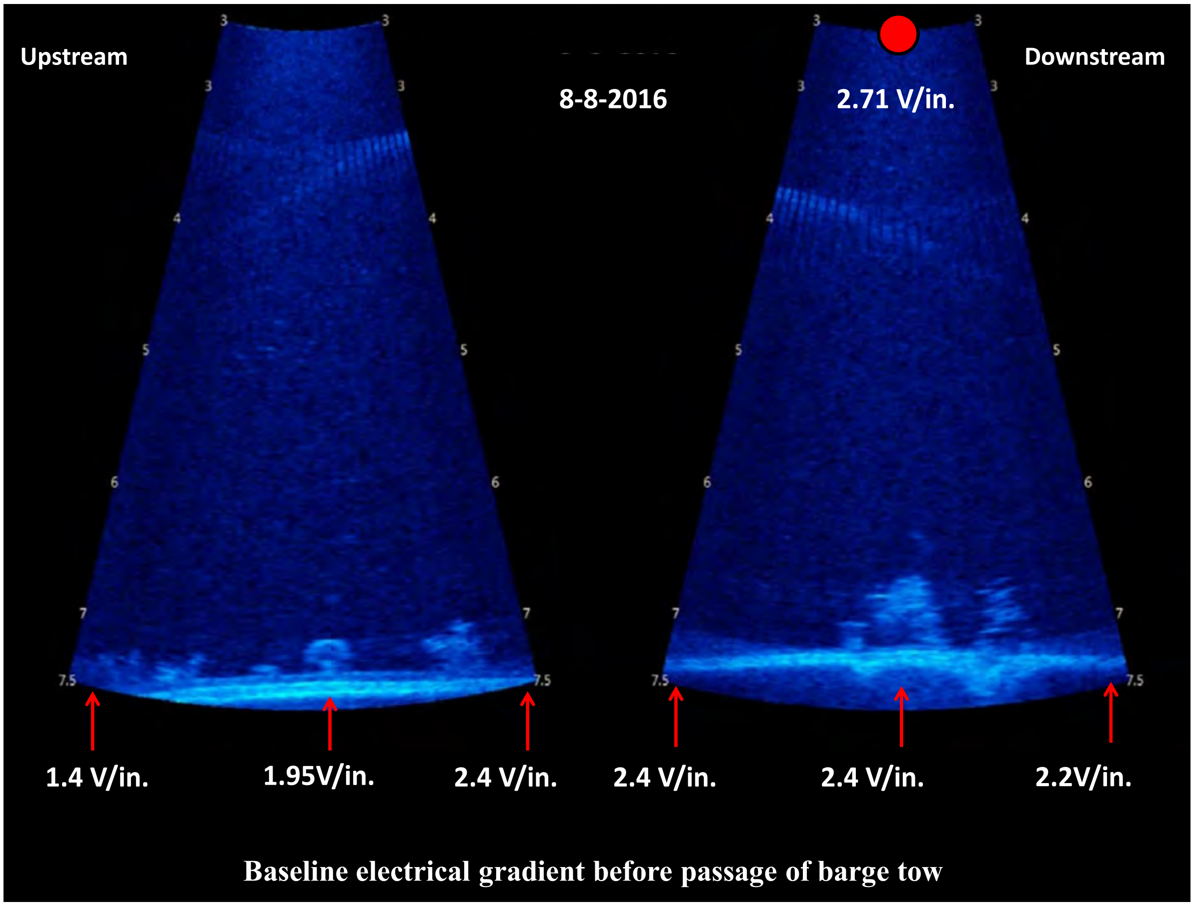

Figure 4A. *Example of two parallel DIDSON multi-beam sonar echograms collected at the Electric Dispersal Barrier System. Red arrows indicate locations of baseline electric voltage gradient measurements at the west canal wall. Red dot indicates the approximate location of baseline electric voltage gradient collected from DIDSON boom with a 3-D electrical probe.*

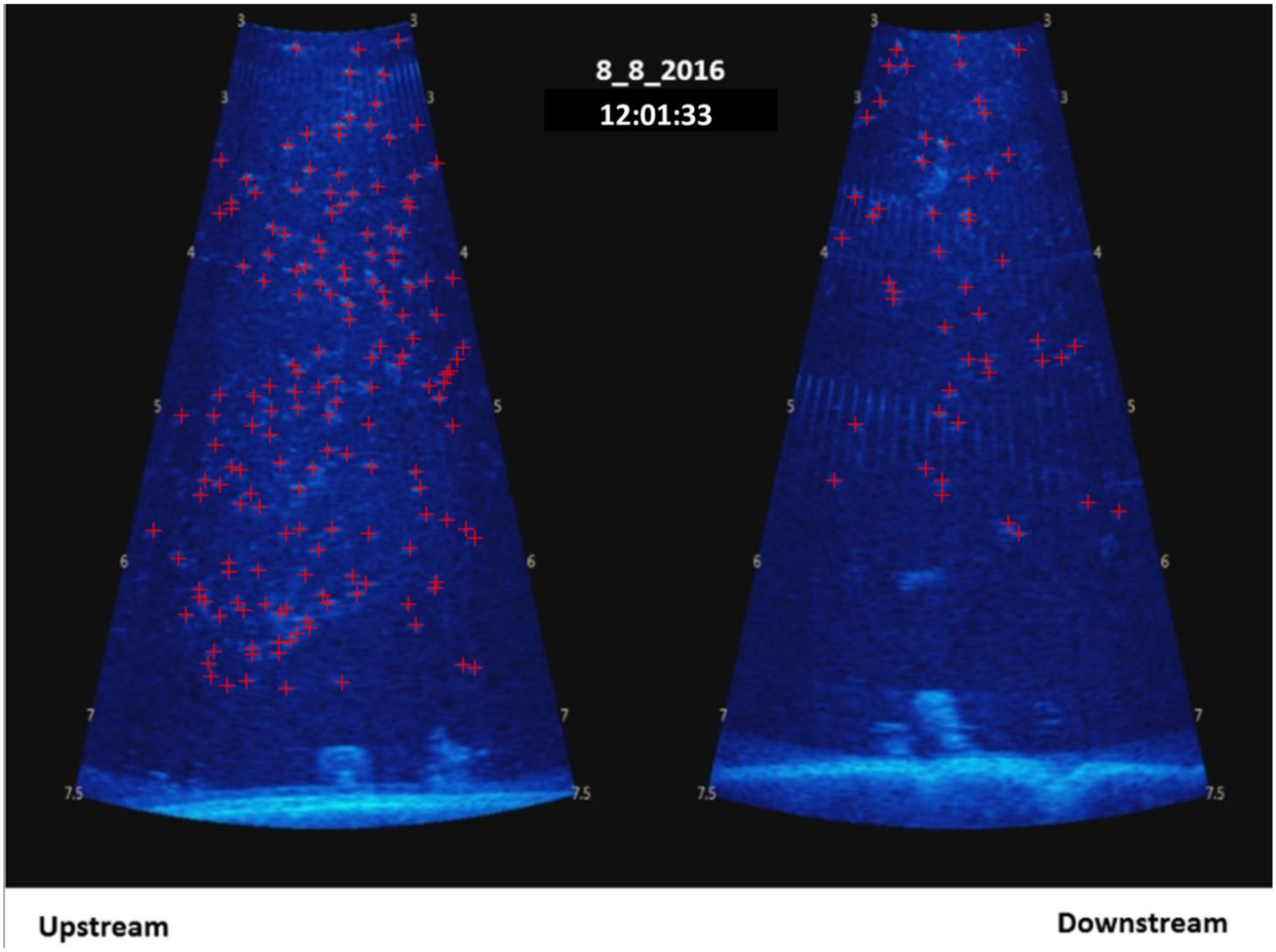

Figure 4B. *Example of two parallel DIDSON multi-beam sonar echograms showing fish passage at the Electric Dispersal Barrier System. Red crosshairs denote fish locations on the echograms.*

Table 1. *Minimum, maximum, mean, and standard deviation of the return current velocity measured by the tow-mounted hydroacoustic velocity meter (statistics computed for all trials with sufficient velocity data; $n_{downbound}$ = 21, $n_{upbound}$ = 21). The return current velocity was calculated by averaging the streamwise velocity profile measured by the tow-mounted hydroacoustic velocity meter over the period of time that the tow passed the wall-mounted instruments, which gives a time-averaged velocity profile, then averaging over the time-averaged velocity profile over the distance between 1.8 m from the tow and the farthest measurement cell.*

	Return current velocity, in meters per second	
	Upstream-bound tows (n = 21)	Downstream-bound tows (n = 21)
Minimum	0.38	0.06
Maximum	0.80	-0.29
Mean	0.50	-0.18
Standard Deviation	0.09	0.08

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

Table 2. *Mean number of upstream fish passages through the Electric Dispersal Barrier System, Barrier IIB narrow array during each downstream tow passage event. Observations were made with DIDSON multi-beam sonar and validated by three independent readers. Mean length is the mean of 10 randomly selected fish from each tow transit as measured on sonar echograms.*

Date	Direction	Time bow of tow at Barrier IIB	Time first fish Passage	Time Last Fish Passage	Number Fish Passages	S.D.	Mean Length (mm)
8/2/2016	Downstream	16:15:34	N/A	N/A	0	0.00	N/A
8/3/2016	Downstream	15:38:16	15:38:37	15:40:40	66	20.21	61.53
8/3/2016	Downstream	16:43:17	16:44:18	16:45:27	20	6.66	54.96
8/4/2016	Downstream	10:04:59	10:05:36	10:06:52	126	18.68	49.76
8/4/2016	Downstream	11:25:56	11:26:52	11:28:23	29	9.50	48.13
8/4/2016	Downstream	15:14:00	15:15:42	15:16:15	2	1.00	52.93
8/4/2016	Downstream	16:31:45	16:32:08	16:33:53	18	11.93	51.66
8/8/2016	Downstream	12:00:32	12:01:09	12:01:50	427	30.35	69.13
8/8/2016	Downstream	15:44:00	N/A	N/A	0	0.00	N/A
8/8/2016	Downstream	16:50:00	16:50:10	16:51:12	75	3.51	62.66
8/9/2016	Downstream	10:57:42	10:58:07	10:59:49	33	1.53	73.60
8/9/2016	Downstream	14:53:15	14:53:23	14:54:25	39	6.43	68.40
8/9/2016	Downstream	15:59:43	16:00:14	16:01:34	140	16.56	63.60
8/10/2016	Downstream	10:06:42	10:07:03	10:08:23	227	16.65	61.36
8/10/2016	Downstream	11:13:12	11:13:44	11:15:00	822	40.08	67.43
8/10/2016	Downstream	15:00:08	15:00:59	15:02:00	82	10.02	63.58
8/10/2016	Downstream	16:13:53	16:14:30	16:15:46	49	3.21	67.60
8/11/2016	Downstream	11:37:55	11:39:25	11:39:46	3	1.00	63.50
8/11/2016	Downstream	15:39:55	15:40:37	15:41:52	118	9.85	64.16

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

Trevor W. Cyphers and Rebecca N. Neeley (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

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

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

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

The Great Lakes Panel (GLP) on Aquatic Nuisance Species (GLP, April 2015) has suggested that actions need to be implemented to better understand the current status of Grass Carp in the Great Lakes Basin to determine sources and potential risks of introduction. The GLP (2015) also determined that movement studies to examine preferred habitat, home range and seasonal movement patterns of Grass Carp could be useful in future management strategies. Whitledge (2015) stated that a surveillance program to gather life history traits of feral Grass Carp in the Great Lakes region would be a vital tool to assessing short-term risk of introduction from areas not currently known to have self-sustaining populations.

In 2016, the U.S. Fish and Wildlife Service (USFWS) Carterville Fish and Wildlife Conservation Office Wilmington Substation started a new monitoring project to analyze Grass Carp populations in the Upper Illinois Water Way (IWW) and Chicago Area Waterway System

(CAWS). The primary goal of this project was to analyze Grass Carp within the IWW and CAWS through a protocol to determine life history traits and population dynamics. Historical capture data of Grass Carp was analyzed to determine potential areas of increased densities, which then could be targeted for sampling. Due to the interest in Grass Carp movement, Grass Carp captured below the U.S. Army Corps of Engineers (USACE) Electric Dispersal Barrier System (EDBS) were implanted with Vemco acoustic telemetry tags and monitored for movement patterns and habitat preference using the current telemetry array established within the Upper IWW.

Objectives:

(1) Quantify relative abundance and potential distribution of Grass Carp in the CAWS and Upper IWW using historical data.
(2) Determine the spatial extent of the Grass Carp population in the Upper IWW based on historical data.
(3) Determine life history traits (e.g., age, ploidy, maturation status) of Grass Carp in the Upper IWW.
(4) Quantify habitat preference, home range and seasonal movements of Grass Carp below the USACE's Electric Dispersal Barrier System.

Project Highlights:

- 35 total Grass Carp were captured and analyzed for ploidy and life history traits
- 80% of the Grass Carp were diploid
- The mean age of Grass Carp was 10.7 ± 1.1
- 4 diploid Grass Carp were captured within the CAWS, above the USACE's EDBS
- No pool to pool movement from telemetered Grass Carp tagged in Marseilles Pool (n = 3) and Dresden Island Pool (n = 6)
- Mean upstream movement from release was 0.51 ± 0.08 (Standard Error (SE)) miles
- Mean downstream movement from release was 2.87 ± 0.85 (SE) miles

Methods:

Historical Data Analysis

Prior to the 2016 field season, historical Grass Carp captures in the CAWS and Upper IWW from 2011 to 2015 were requested from the Illinois Department of Natural Resources (ILDNR). These data were used to generate kernel density maps to estimate relative abundance and potentially high distribution areas that could be used during targeted sampling of Grass Carp.

Due to the limited number of historical captures in the CAWS and Lockport Pool, maps could only be generated for Brandon Road and Dresden Island Pools (Figures 1 and 2).

Incidental Grass Carp Collection

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

During the 2016 field season, any Grass Carp captured in the Upper IWW and CAWS by USFWS and other partner agencies were analyzed for life history traits according to the following protocol. Upon collection, total length, fork length, girth and weight were recorded. Eyeballs and whole gonads were removed, stored in saline solution, and shipped to the La Crosse Fish Health Center (FHC) within eight days after capture. Eyeballs were used to determine ploidy, whereas gonads were transferred to formalin to perform histological analyses and determine a gonadostomatic index at a later date. Grass Carp heads were removed just in front of the pectoral fins to include the first vertebrae. Whole heads were sent to the U.S. Geological Survey (USGS) - Columbia Environmental Research Center (CERC) for otolith microchemistry analysis and age determination.

Targeted Sampling

Targeted sampling with the intent of capturing fish for telemetry purposes began in August 2016. Areas predetermined by past Grass Carp captures below the EDBS were targeted using pulsed DC electrofishing. Any Grass Carp that perished during surgery was processed for life history traits according to the above protocol.

Determination of Life History Traits

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

Aging - Aging structures were collected from Grass Carp during non-targeted, lethal sampling efforts, but were not collected from Grass Carp used for telemetry. Age structures (whole heads) were shipped to partners at CERC to be processed for analysis. Aging was determined by using vertebral sections with scales and whole vertebrae as reference structures.

Gonadosomatic Index and Histology - Gonads were collected from non-targeted, lethally sampled Grass Carp, removed and covered in saline, and shipped cold for pre-processed along with eyeball or blood samples for future processing.

Grass Carp Telemetry

Telemetry Array – This project utilized the current acoustic telemetry array in the Upper IWW being maintained through a partnership among the USACE, USFWS, Metropolitan Water Reclamation District, Southern Illinois University Carbondale and the IDNR developed by the Asian Carp Regional Coordinating Committee as part of the Monitoring and Response Work Group (MRWG). Implemented in 2010, it was developed to determine the efficacy of EDBS within the Upper IWW and monitor inter-pool movements, the leading edge of the population, and potential invasion of bigheaded carps into the Great Lakes. Additional receivers were placed in backwater areas by USFWS personnel within Brandon Road, Dresden Island and Marseilles Pools to supplement the current array (Figure 3).

Grass Carp Telemetry – Grass Carp were initially targeted within Dresden Island Pool for telemetry purposes in early August. Targeted sampling for telemetry was initially slated to begin in May. However, a delay in equipment availability postponed the project until late summer. Captured Grass Carp were anesthetized and implanted with Vemco V16 (6H) tags set to a varying 30-90 second ping frequency. Following tag implantation, blood was drawn from the caudal fin for ploidy analysis and fish were jaw tagged. Once fish recovered from surgery, they were released into the pool of capture. An initial goal of 20 tagged Grass Carp in the Upper IWW was attempted for the 2016 field season. Grass Carp movement was monitored through the use of stationary Vemco receivers (VR2Ws) and a Vemco mobile acoustic receiver (VR100). Stationary receivers were downloaded every other month and analyzed using Vemco VUE software. Manual tracking using a VR100 was done on a monthly basis once adequate numbers of fish were tagged within the Upper IWW.

Results and Discussion:

Grass Carp Collection Analysis

During the 2016 field season, 35 Grass Carp were captured and analyzed for ploidy and other life history traits (Figure 4-7). Of the 35 fish captured, 6 were used for telemetry purposes and could only be analyzed for ploidy via a blood sample. Ploidy analysis indicated that 28 of the 35 Grass Carp, or 80%, were diploid (Table 1). The mean age (± SE) of Grass Carp currently analyzed by CERC was 10.7 ± 1.1 (Table 2). Gonad histology and gonadostomatic indices are still being processed at this time and will be made available at a later date. Triploid fish (n = 7) were observed in Dresden Island and Marseilles Pools, with the eight fish sampled from the CAWS and Starved Rock Pool being diploid (Table 1, Figure 8). The four Grass Carp collected within the CAWS, which is considered part of the Great Lakes Basin, were captured during the ILDNR's Seasonal Intensive Monitoring effort on 20 September 2016. Two of the fish were captured in a gill net by contracted commercial fisherman within Lake Calumet, whereas the two were captured via electrofishing by USFWS personnel within the Cal-Sag Channel (Figure 4). Based on the size and age of these fish, they were most likely sexually mature (Chilton and Muoneke 1992), and could have been reproducing within the Great Lakes Basin (Table1, 2). Based on the number of diploid Grass Carp that were captured within a short time period within the CAWS, increased sampling in areas where these fish were captured is warranted for the 2017 field season.

Grass Carp Telemetry

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

Targeted sampling with the intention of catching Grass Carp for telemetry reasons was primarily focused in Dresden Island pool where 29 hours of electrofishing effort yielded 6 fish (Table 3). Much of the pool was targeted, especially presumed high density areas (Figure 2). However, most of the fish implanted were captured on the spillway side below the Brandon Road Lock and Dam and subsequently released at RM 285.2 (Figure 5). Near the end of the field season when captures in Dresden Island Pool became sparse, sampling began in Marseilles Pool to investigate large scale movement between pools. During this effort, three Grass Carp were tagged and released following 2.75 hours of electrofishing (Table 3). Stationary receivers and manual tracking efforts in both pools resulted in a 100% detection rate following fish release.

Large scale movement of Grass Carp from August through November 2016 indicated that there was no pool to pool movement for fish tagged in Dresden Island and Marseilles pools. Fish within Dresden Island Pool had a mean (± SE) upstream movement of 0.51 ± 0.08 miles and downstream movement of 2.87 ± 0.85 miles (Table 4). Based on data from a realtime receiver managed by the USGS at RM 285.6, most of the fish tagged in Dresden Island are using habitat around the approach channel near Brandon Road Lock and Dam. USFWS stationary receivers in backwater areas in Dresden Island (Figure 3) and Marseilles Pools did not detect any Grass Carp, indicating that these backwater habitats were not preferred habitat for the telemetered fish. Movement observations within Marseilles Pool were minimal due to project duration within the pool.

Recommendation: Analysis of Grass Carp from incidental sampling events from USFWS and agency partners should continue into 2017 to increase the knowledge of the population in the Upper IWW. Increasing awareness of the project and protocol should result in higher numbers of Grass Carp that are evaluated. Targeted sampling for Grass Carp in the Upper IWW will continue based on kernel density maps that encompass 2016 capture data. Grass Carp captured will be implanted with acoustic transmitters until all transmitters belonging to USFWS (50 total) are used. Stationary receivers will be downloaded bimonthly and processed for large scale movement. Active tracking events will take place monthly to supplement the stationary array and determine fine scale movement and habitat preference. Detections of non-USFWS fish will be disseminated to their proper agency. Any Grass Carp that are not able to be implanted or captured during indirect sampling events will processed for life history traits. This will include the pools in the Upper IWW above Starved Rock and within the CAWS. Targeted sampling for Grass Carp should increase in the CAWS in areas where prior captures occurred and within Grass Carp designated habitat. Any Grass Carp captured within the CAWS will be euthanized and processed for life history traits. This sampling will supplement the current effort being done above the USACE's EDBS during Seasonal Intensive Monitoring events, thus providing a better understanding of the current Grass Carp population within the CAWS. Telemetry efforts could be moved to the CAWS, specifically in the Cal-Sag Channel and Calumet River if partners deem it a priority.

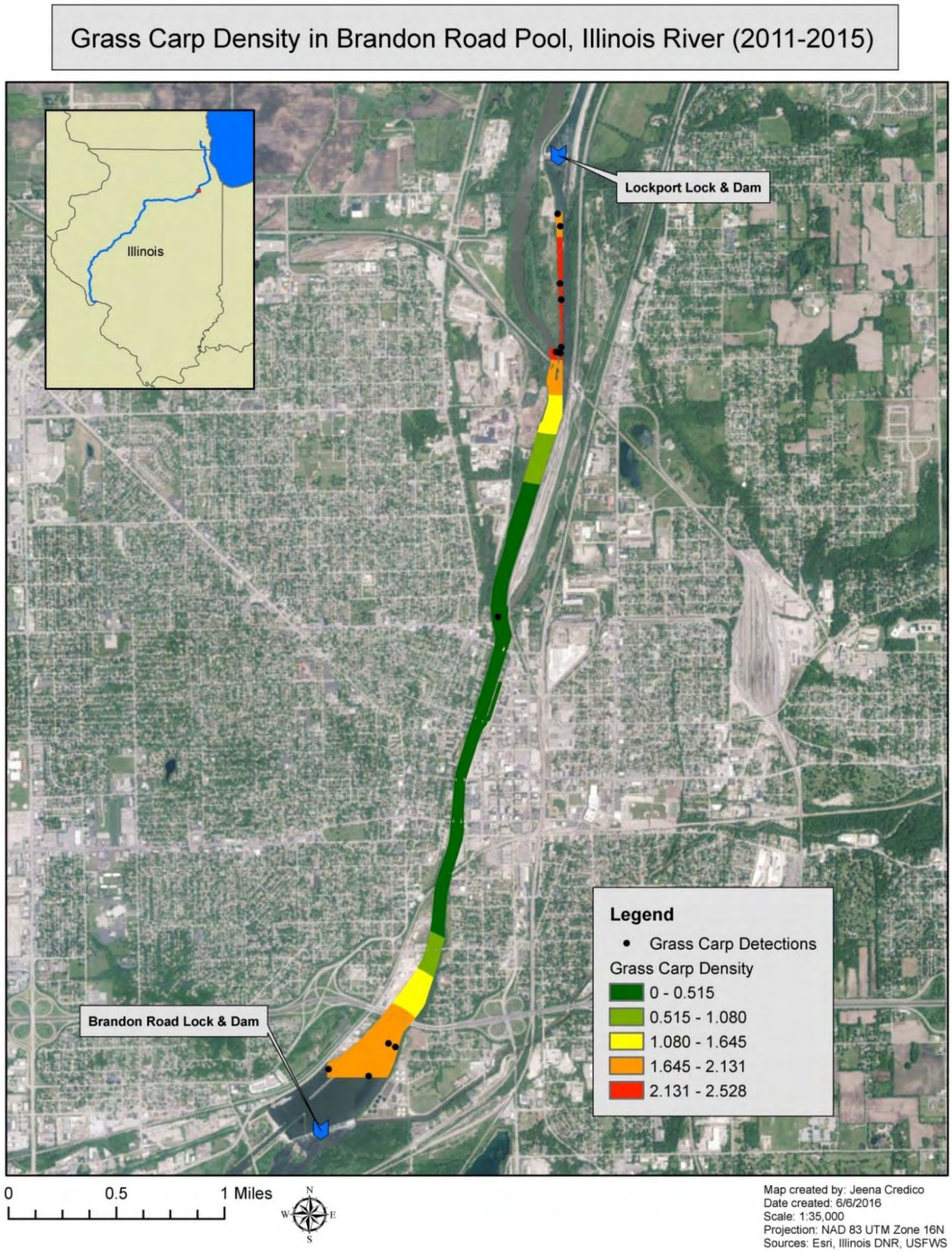

Figure 1. *Kernel density of Grass Carp for Brandon Road Pool based on capture data from 2011-2015.*

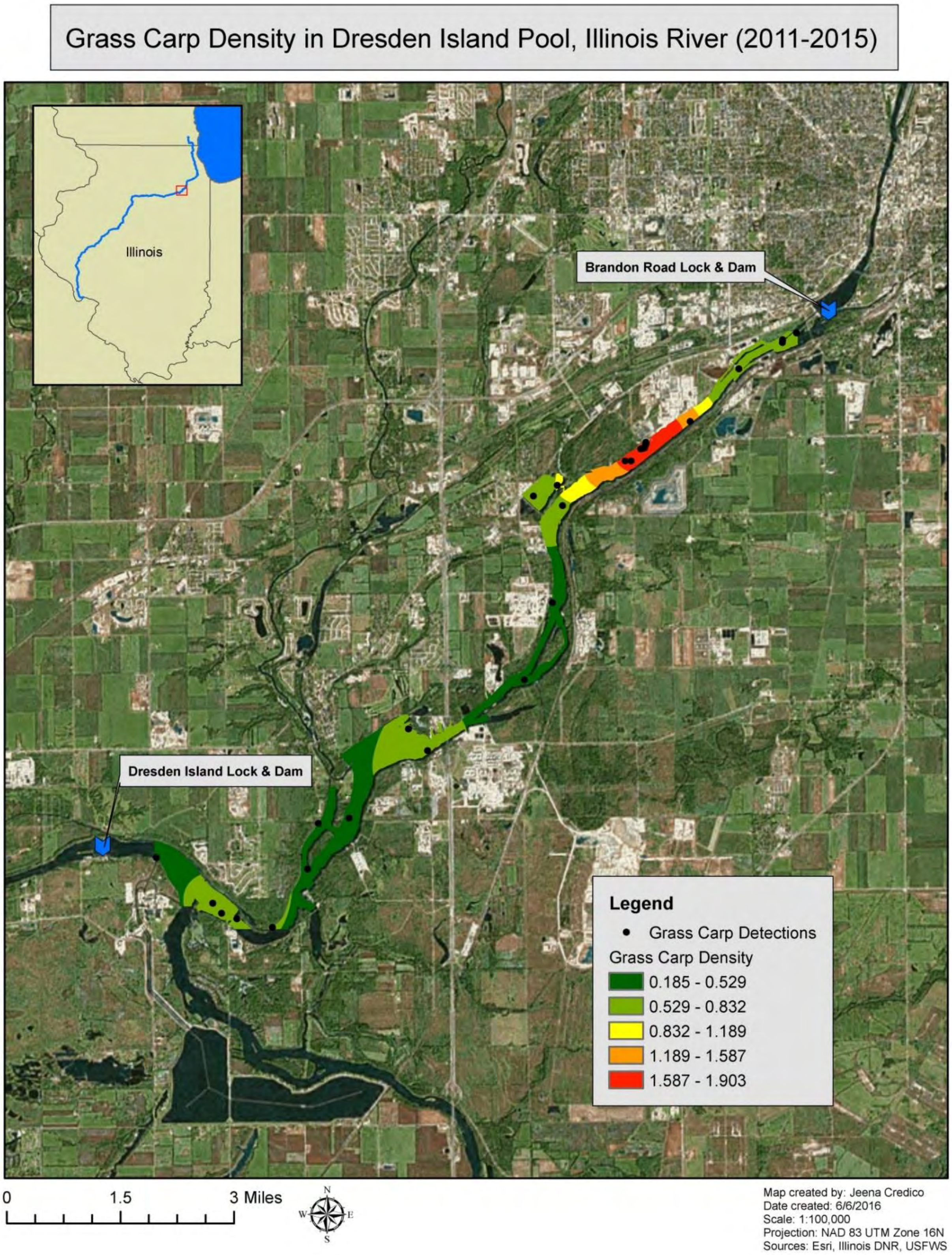

Figure 2. *Kernel density of Grass Carp for Dresden Island Pool based on capture data from 2011-2015.*

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

Trevor W. Cyphers and Rebecca N. Neeley (U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

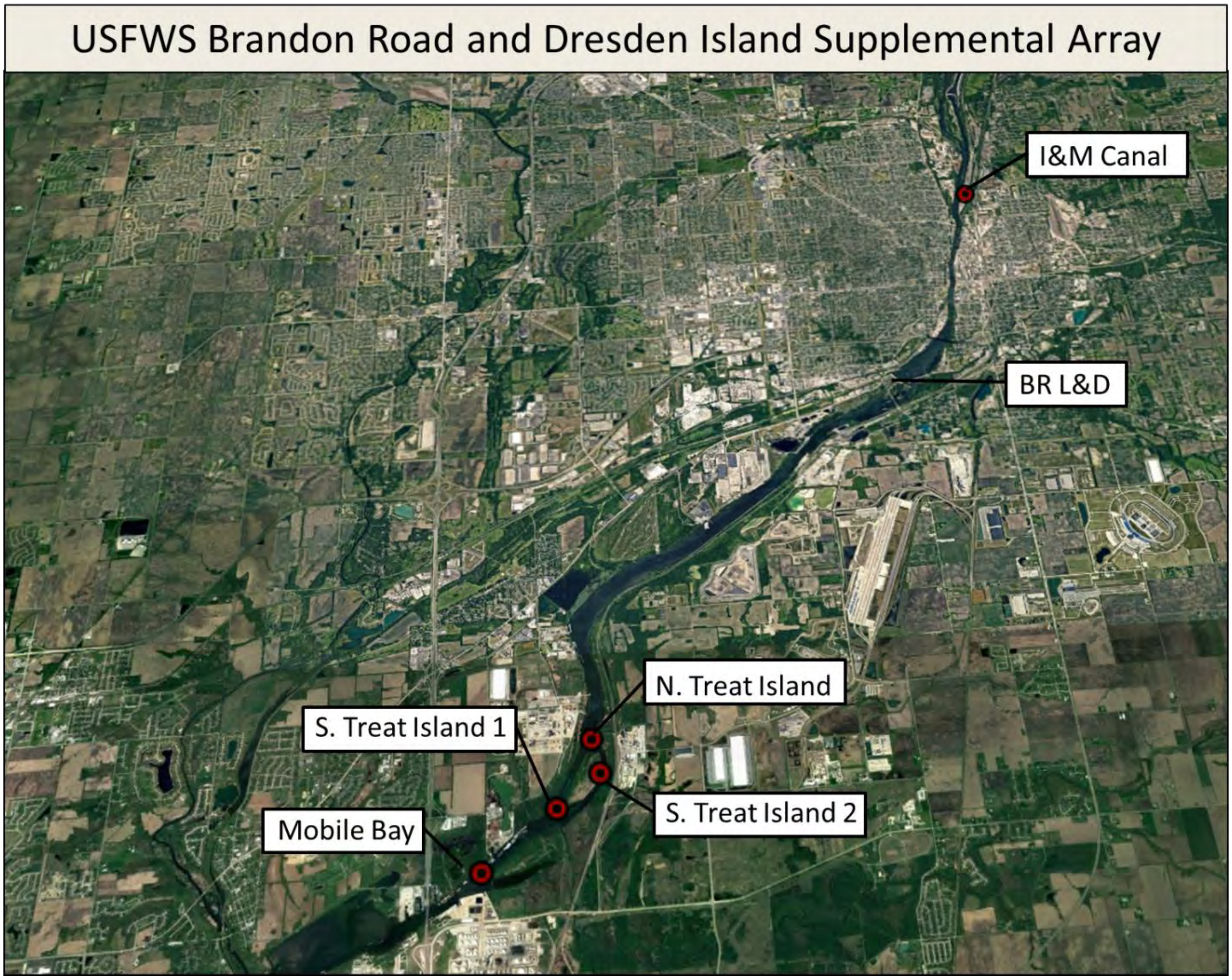

Figure 3. *VR2W receiver locations for Brandon Road and Dresden Island, which were used in conjunction with the current telemetry array within the IWW.*

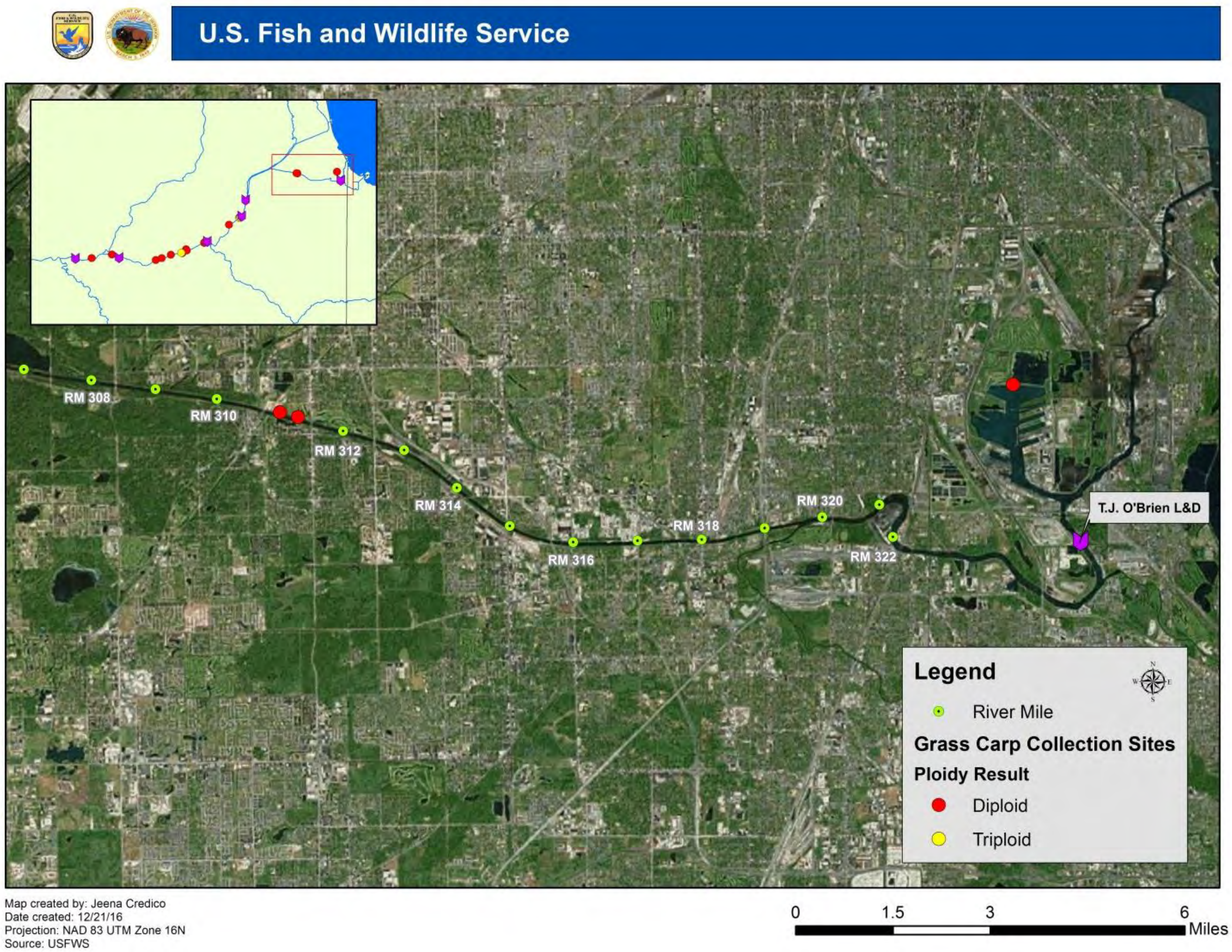

Figure 4. *Grass Carp capture locations and ploidy designation for the CAWS during the 2016 field season.*

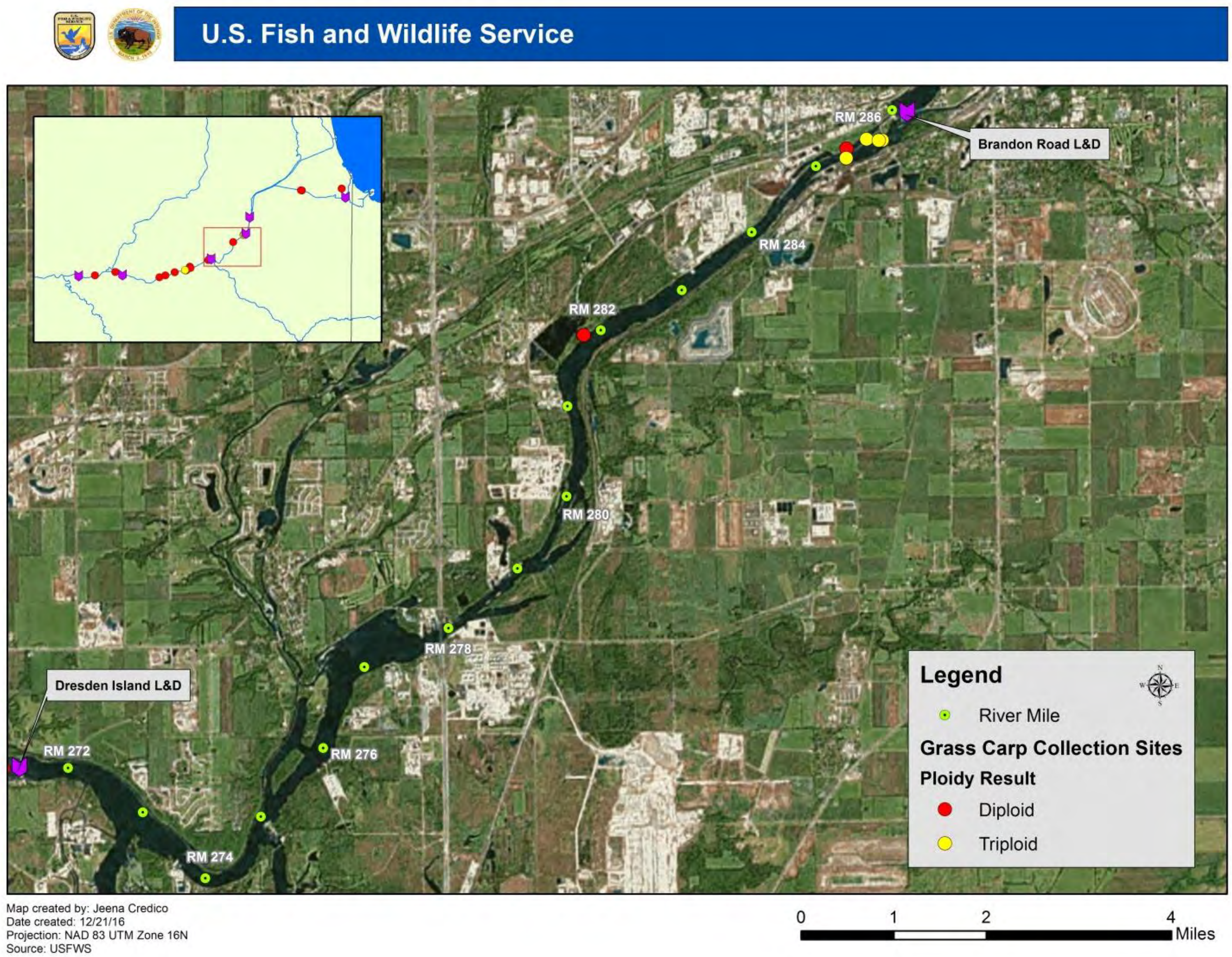

Figure 5. *Grass Carp capture locations and ploidy designation for Dresden Island Pool during the 2016 field season.*

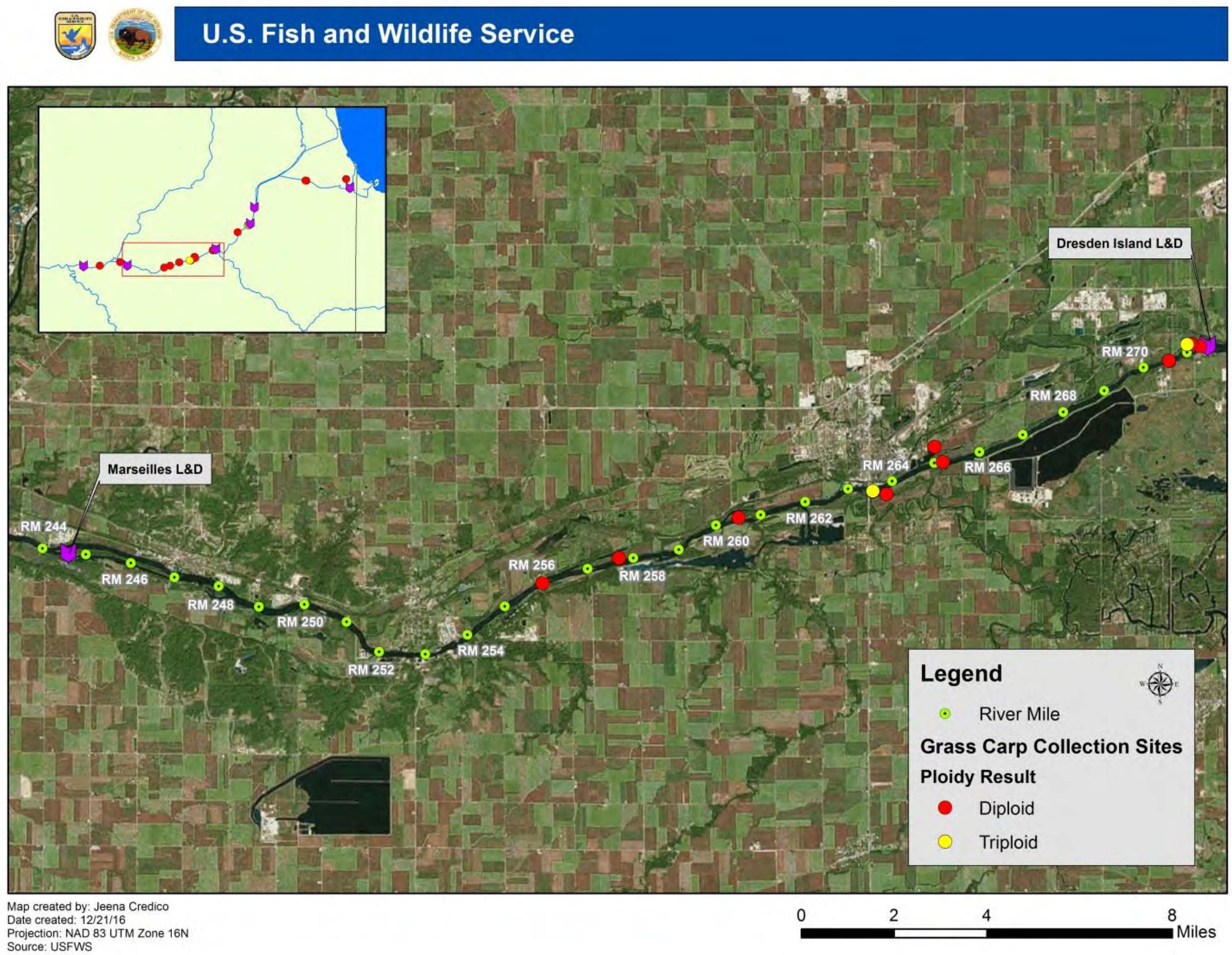

Figure 6. *Grass Carp capture locations and ploidy designation for Marseilles Pool during the 2016 field season.*

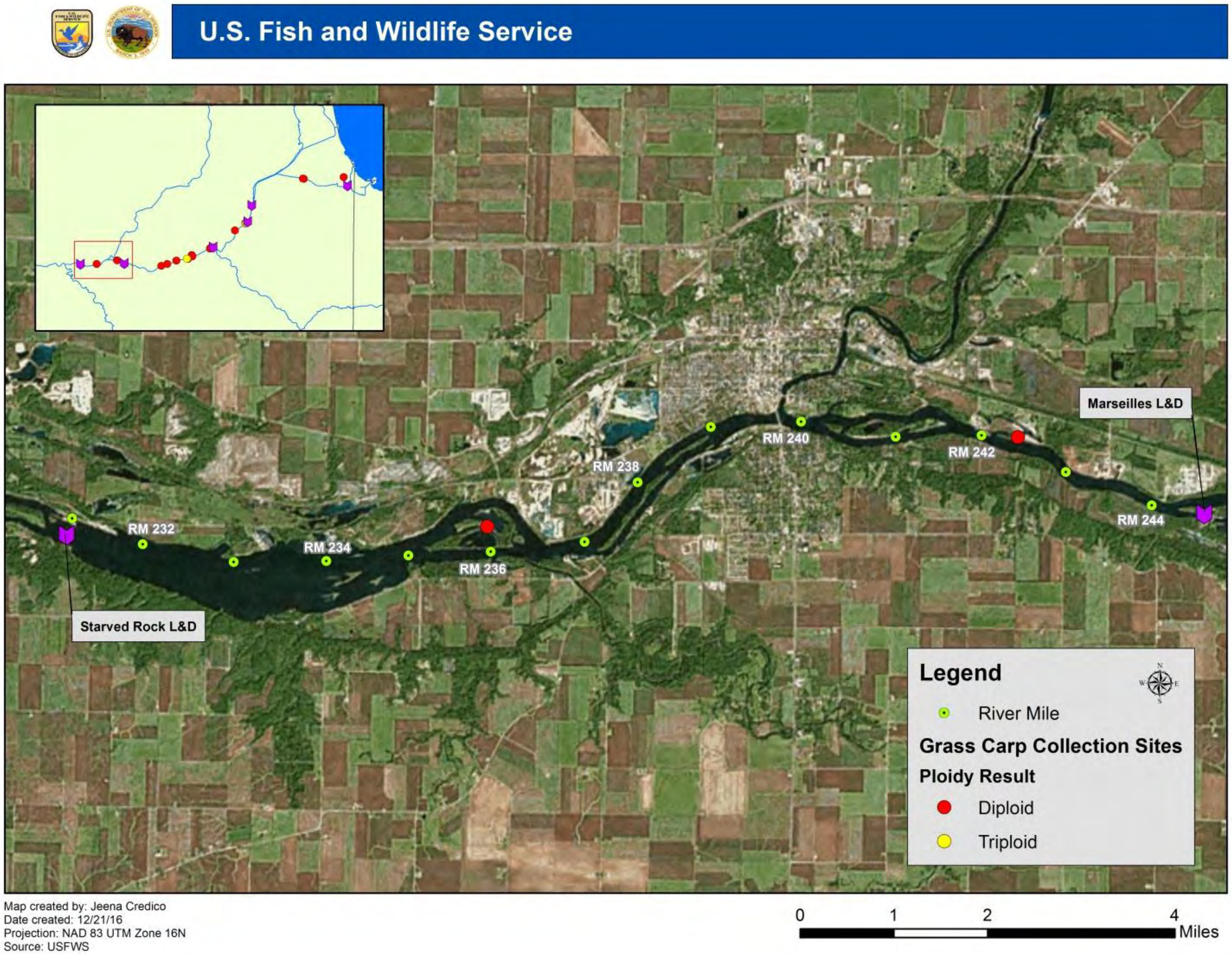

Figure 7. *Grass Carp capture locations and ploidy designation for Starved Rock Pool during the 2016 field season.*

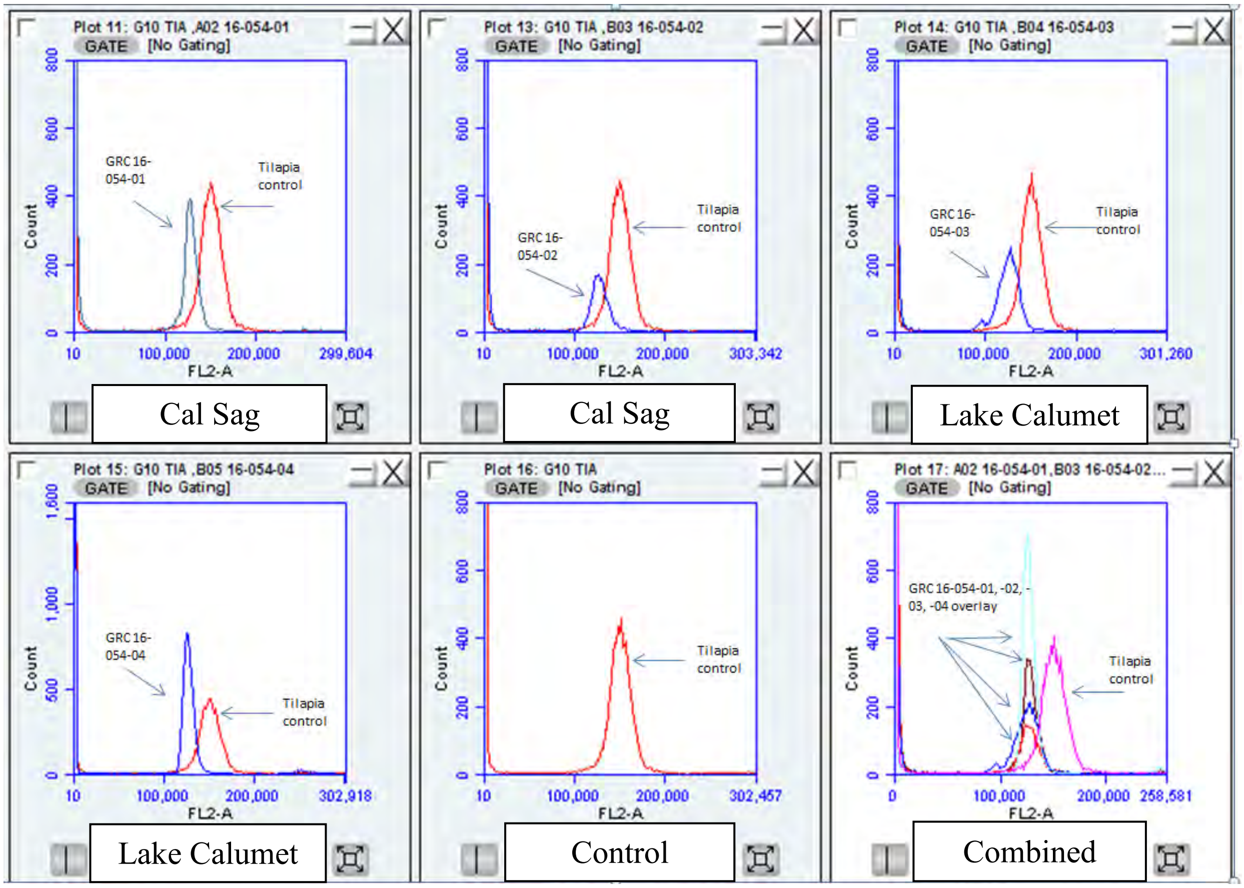

Figure 8. *Ploidy results of the four Grass Carp captured within the CAWS during the 2016 field season. Spikes to the left of the control are indicative of a diploid specimen.*

Table 1. *Grass Carp captures and life history analyses (±SE) from the CAWS and pools within the IWW for the 2016 field season.*

Pool	N	% Diploid	Avg. Length (mm)	Avg. Weight (g)
CAWS	4	100	1018.8 ± 69.8	12987.5 ± 2440.7
Dresden Island	6	33.3	970.8 ±75.1	12441.7 ± 2017.9
Marseilles	21	85.7	924.1± 22.9	10214.8 ± 811.1
Starved Rock	4	100	666.5 ± 105.2	4025.0 ± 1454.9
Total	35	80	913.5 ± 27.4	10204.2 ± 838.5

Table 2. *Grass Carp age analysis (±SE) by pool for the 2016 field season.*

Pool	N	Average Age
CAWS	4	13.0 ± 1.6
Dresden Is.	3	11.3 ± 1.2
Marseilles	3	7.9 ± 1.8
Total	10	10.7 ± 1.1

Table 3. *Effort and catches of Grass Carp for telemetry tagging based on pool during the 2016 field season.*

Pool	Brandon Road	Dresden Island	Marseilles
Effort (hrs)	1.77	28.99	2.75
Grass Carp	0	6	3
CPUE (fish/hr)	0	0.21	1.09

Table 4. *Downstream and upstream movement of Grass Carp in Dresden Island Pool from stationary receivers and manual tracking effort for the 2016 field season.*

Tag #	RM Release	↑ RM Detection	US (miles)	↓ RM Detection	DS (miles)
17344	285.4	285.8	0.4	284.5	0.9
17345	285.6	285.8	0.3	279.5	6.1
17346	285.2	285.8	0.5	282.8	2.4
17347	285.2	286.0	0.8	282.6	2.6
17348	285.2	285.8	0.5	282.8	2.4
17349	285.2	285.8	0.6	-	-

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GEAR DEVELOPMENT AND EFFECTIVENESS EVALUATION

Evaluation of Gear Efficiency and Asian Carp Detectability

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

Participating Agencies: Illinois Natural History Survey (lead)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction:

A variety of sampling gears are being used by various agencies to monitor and control Asian carp populations, but the relative efficiency of each of these gears, and the amount of effort required to detect Asian carp when they are present in low densities, has not previously been evaluated. Evaluating the ability of traditional and alternative sampling gears to capture both juvenile and adult Asian carp will allow managers to customize monitoring regimes and more effectively determine relative abundances of Asian carp. Data gathered from gear evaluations can also be used to model the probability of detecting Asian carp with each sampling gear in different areas of the Illinois Waterway, which will allow for determination of appropriate levels of sampling effort and help improve the efficiency of monitoring programs. Results of this study will help improve Asian carp monitoring and control efforts in the Illinois River and the CAWS, and will contribute to a better understanding of the biology of these invasive species in North America.

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

(1) Evaluate the effectiveness of traditional and alternative sampling gears at capturing both 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 each gear;

(4) Supplement Asian carp sampling data being collected by other agencies; and

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

Project Highlights:

- Catches of juvenile Silver Carp were substantially lower in 2016 than in 2014 and 2015. Low catches of juvenile Asian Carp during 2016 reflect the overall lower number of larval Asian carp collected during larval monitoring (see Larval Fish Monitoring in the Illinois Waterway).

Evaluation of Gear Efficiency and Asian Carp Detectability

- During 2016, mini-fyke nets collected the highest total numbers of age-0 Silver Carp and detected Silver Carp in 8 of 8 sampling events, whereas beach seines collected much lower numbers of age-0 Silver Carp and detected Silver Carp in 5 of 8 sampling events. Pulsed-DC electrofishing only captured a single age-0 Silver Carp during 2016.
- Age-0 Silver Carp averaged 31 mm during August sampling and 50 mm during October sampling. Similar sizes of Silver Carp were captured in mini-fyke nets and beach seines in 2016.

Methods:

Spawning success and subsequent recruitment of Asian carp to the juvenile life stage was lower in the Illinois River during 2016 when compared to 2014 and 2015 (see Larval Fish Monitoring and Young-of-Year and Juvenile Asian Carp Monitoring summaries), but still provided the opportunity for continued evaluation of gears for capturing juvenile Asian carp at low densities. Following the detection of larval Asian carp by ichthyoplankton sampling during June - July and August - September, gears were deployed to sample for juvenile Asian carp during summer (August) and fall (October) at paired main channel and backwater sites within the LaGrange Pool of the Illinois River (Figure 1).

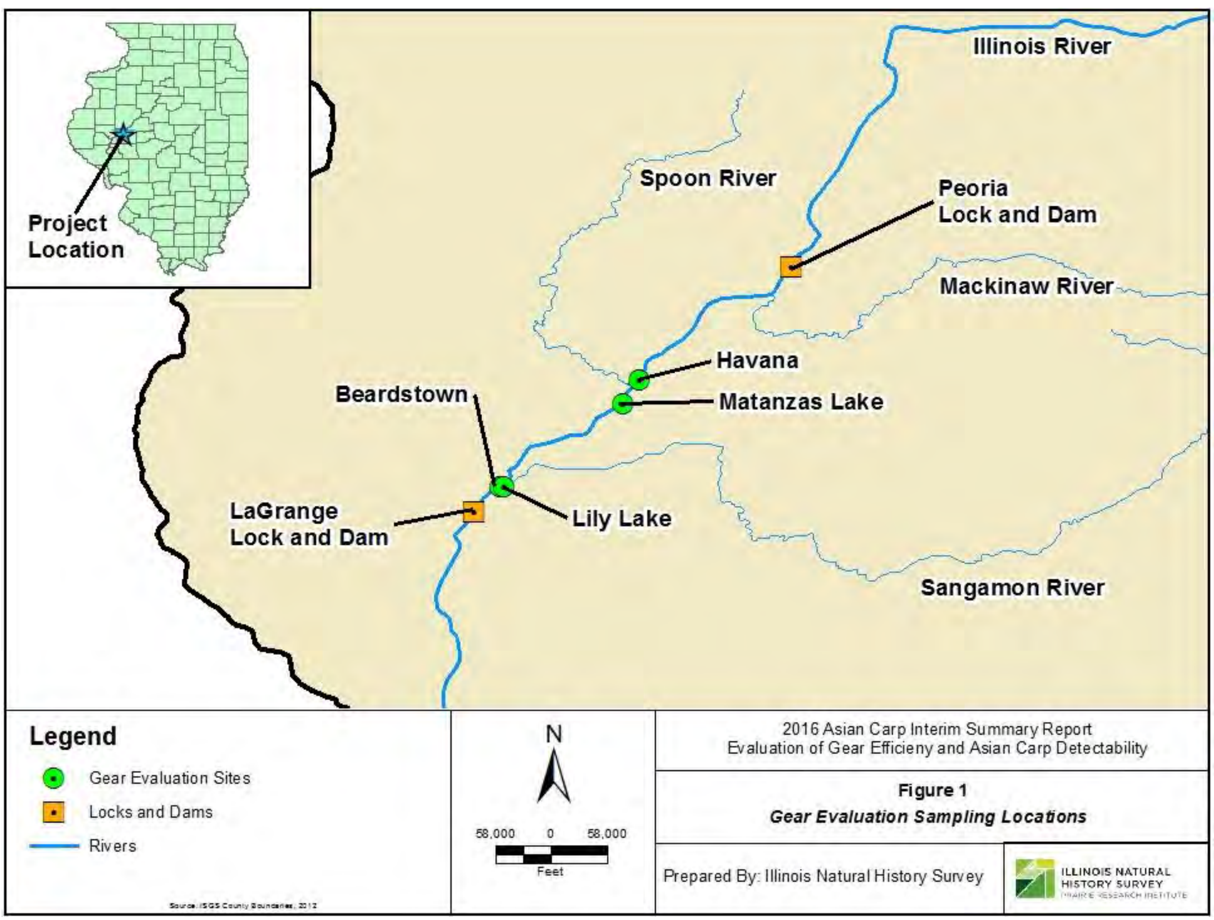


Figure 1. *Map of 2016 gear evaluation sampling locations in the LaGrange Reach of the Illinois Waterway. Navigation dams are represented by squares. Sampling sites are represented by circles.*

The first pair of sites was located at river kilometer 133.6, near Beardstown, Illinois, where gears were deployed in main channel (Beardstown) and backwater lake (Lily Lake) habitats. The second pair of sites was at river kilometer 186.7 for the backwater lake (Matanzas Lake) and 193.1 for main channel habitats (Havana). Gears used in 2016 were determined from experimental comparisons of multiple gears conducted in 2014 and 2015 (Collins et al. 2017). All fish captured in 2016 were identified to species, and measured for total length (mm). Subsamples of juvenile Asian carp were retained for later diet and age analysis.

Gears used to target juvenile Asian carp in 2016 included:

- Pulsed-DC electrofishing (250 V, 8 – 10 A, varied pulse width; four 15-minute transects per site-visit)
- Wisconsin-type mini-fyke nets (4.5 m x 0.6 m lead, 0.6 m x 1.2 m trap, 3 mm mesh; 8 net-nights per site-visit)
- Beach seines (various lengths, 3 mm mesh; minimum 4 hauls per site-visit)

Results and Discussion:

Only small numbers of age-0 and age-1 Asian carp were captured in 2016. Evaluation of mini-fyke nets and beach seines during 2016 resulted in the capture of 8,613 fish, including 336 age-0 Silver Carp. A total of 328 age-0 Silver Carp were captured in mini-fyke nets (65 in August; 263 in October) and 8 age-0 Silver Carp were captured in beach seine hauls (7 in August; 1 in October). In general, average catch per net night in mini-fyke nets was higher in backwater lake habitats in comparison to the main channel, however catches were highly variable (Table 1). Higher catch rates in mini-fykes were strongly influenced by the October sampling in Matanzas Lake, which averaged 30.1 Silver Carp per net night. Mini-fyke nets captured the highest total numbers of juvenile Silver Carp in 2016, a pattern consistent with previous gear evaluations (Collins et al. 2017). Beach seine hauls had higher mean catches in main channel habitats when compared to backwater habitats, however catch rates were very low. Pulsed-DC electrofishing primarily captured age-1 and older Silver Carp (≥ 215 mm; n = 201). Only a single age-0 Silver Carp (23 mm) was captured by pulsed-DC boat electrofishing during 2016.

Table 1. *Mean ± SD catches of age-0 Silver Carp in mini-fyke sets (fish per net night) and beach seine hauls (fish per haul) at sites along the Illinois River during 2016.*

Year	Habitat	Mini-fyke	Beach seine
2016	Backwater	12 ± 16	0.25 ± 0.1
	Main channel	1.2 ± 1.8	0.63 ± 0.2

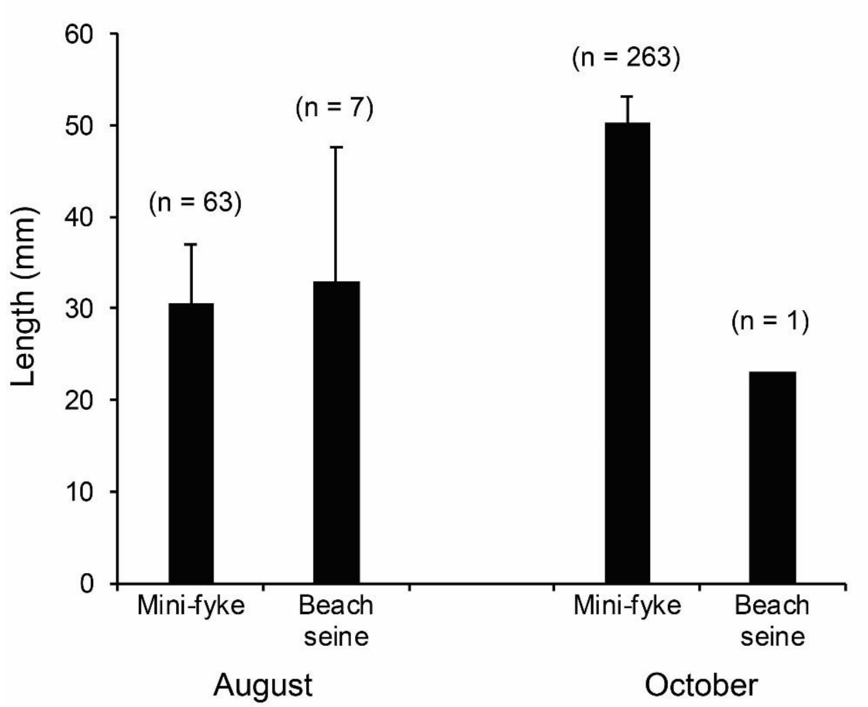


Figure 2. *Average body length of juvenile Silver Carp collected in mini-fyke and beach seine gears during August (16th - 19th) and October (18th - 21st) of 2016. Numbers in parenthesis indicate the number of Silver Carp used to determine the mean size.*

Silver Carp body lengths were similar between mini-fyke and beach seines during August sampling (Figure 2). Average lengths of Silver Carp increased from 31 mm in August to 50 mm in October. Because only 1 Silver Carp was collected in the beach seine sampling during October, confident comparisons could not be made between gears for the fall sampling period.

Although high numbers of larval and juvenile Asian carp were collected in 2014 and 2015, considerably fewer were captured during 2016 sampling. Despite low total numbers, both mini-fyke nets and beach seining collected age-0 Silver Carp. Total catches of Silver Carp within mini-fyke nets were low compared to previous years, however Silver Carp were detected during each sampling event (8 of 8 events). Similarly, Silver Carp were detected in beach seine hauls in 5 of 8 sampling events. Each gear is particularly useful in shallow-water and other near-shore areas, and appears to be a consistent and effective tool for targeting smaller sizes of juvenile Asian carp. Continued evaluation of mini-fyke nets and beach seines will be required to determine the effectiveness of these sampling gears, and to serve as a comparison with other new and unconventional sampling gears. Additional years of sampling with differing offshore gears will be required to target the age-1 and age-2 Asian carp from the 2015 and 2016 cohorts.

Over the past three years (2014-2016), only a few juvenile Bighead Carp have been collected. None were detected during 2016 sampling events. Bighead Carp reproduction and recruitment may have been low, or the behavior and habitat use of this species may differ from that of Silver Carp during the juvenile stage, making them less vulnerable to the sampling gears being evaluated. Further study will be necessary to determine vulnerability of juvenile Bighead Carp to various sampling gears, and to evaluate patterns of Bighead Carp recruitment.

Recommendations:

Evaluation of sampling gears targeting juvenile Asian carp was possible during both 2014 and 2015 due to high reproductive output and subsequent recruitment to juvenile stages. Mini-fyke nets consistently sample Silver Carp at greater abundances that beach seines based on findings from 2016, and from preview years (Collins et al. 2017). Based on the lengths of Silver Carp collected in both mini-fyke nets and beach seines, it appears that no age-1 or age-2 Silver Carp were collected by these gears during 2016. Previous findings indicate that larger age-0 and age-1 Asian carp are unlikely to inhabit nearshore environments. Monitoring these larger individuals in offshore areas thus requires differing gears that sample deeper water. Numerous questions remain concerning Bighead Carp reproduction and recruitment, habitat use by juvenile Bighead Carp, and the most effective gears for targeting juvenile Bighead Carp. Results of this future research will be reported as they become available to allow for adaptation of monitoring and control activities.

References

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

Gear Evaluation for Removal and Monitoring of Asian Carp Species

Jeremy Hammen, Jason Breeggemann, Emily Pherigo, Jason Goeckler (US Fish and Wildlife Service)

Participating Agencies: US Fish and Wildlife Service, Columbia Fish and Wildlife Conservation Office

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

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

Objectives:

(1) Evaluate ability of electrified paupier, electrified dozer trawl, surface trawl, and traditional boat electrofishing to detect and estimate abundances of all sizes of Silver Carp.

Project Highlights:

- All gears are capable of catching Silver Carp but differences exist in the catch rates and the ability of each gear to sample all size classes.
- Early evidence demonstrates that the paupier and dozer trawl have the highest potential for detecting Silver Carp within a system.
- Early evidence demonstrates that the paupier has the highest potential for detecting Silver Carp less than 200 mm within a system.
- Paupier sampled all size classes of Silver Carp and had the highest catch rate for Silver Carp followed by the dozer trawl, traditional electrofishing, and finally the surface trawl.
- Surface trawl was limited to catching Silver Carp less than 400 mm.
- Traditional electrofishing Silver Carp catch rate was higher near shore than in the open water.

- Traditional electrofishing would require 5-6 times more sampling effort than the paupier and dozer trawl if the goal is to assess the Silver Carp population based on size structure
- Traditional electrofishing would require 2-3 times more sampling effort than the paupier and dozer trawl to achieve a precision in catch rates

Methods:

Sampling Sites: In June, July, September, and October of 2016, three innovative trawling methods and traditional boat electrofishing were deployed twice per month in the Illinois River where one week was spent downstream of Starved Rock Lock and Dam in the LaGrange Pool and the second week was spent upstream of Starved Rock Lock and Dam in the Marseilles and/or Starved Rock pools. Sites in the LaGrange Pool included: Chautauqua National Wildlife Refuge (RM 128), Quiver Lake (RM 122), Spoon River (RM 120), Lake Matanzas (RM 114), Bath Chute (RM 107-113), and Lily Lake (RM 83). Sites upstream of Starved Rock Lock and Dam included Peacock Slough (RM 264), and Hanson Material Service East and West Pits in the Marseilles Pool (RM 260) as well as Gobblers Knob (RM 241) and Sheehan Island backwater (RM 236) in the Starved Rock Pool (Figure 1). All sites are known to have persistent populations of Silver Carp but size classes and densities differ longitudinally along the Illinois River.

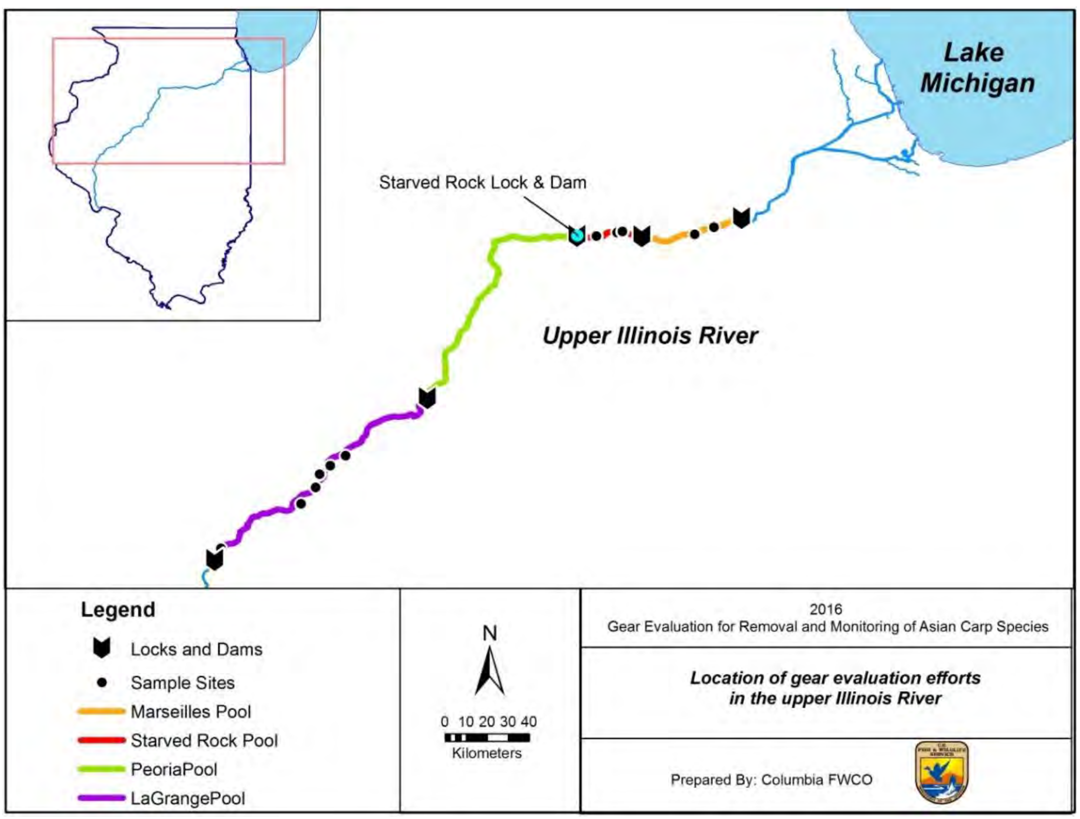


Figure 1. *Sample locations during the gear evaluation study in the Illinois River, IL 2016.*

Gear Evaluation for Removal and Monitoring of Asian Carp Species

Gears: A suite of gears were utilized to capture Asian carp in Illinois River backwaters. Following is a list of sampling techniques and specifications.

Dozer trawl: The dozer trawl is a conical net attached to a rigid frame that is pushed in front of the boat. The frame is 2 meter (m) wide by 1 m tall. The net has 38 millimeter (mm) body mesh at the opening reducing to 6 mm mesh at the cod end. The net extends under the boat and is 2.5 m long. Two booms extend in front of the dozer frame with three cable anode droppers, similar to a traditional electrofishing boat. Electrofishing settings were set at 30 hertz and 15% duty cycle.

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

Paupier: The paupier is an electrified butterfly trawl with 4.0 m wide by 1.5 m deep rigid frames on either side of the boat. Conical nets with 38 mm mesh in the body reducing to 6 mm mesh in the cod attach to the frames and extend back approximately 7 meters. Three cable dropper anodes were affixed to booms 3-4 m in front of the paupier frames. An 18 centimeter (cm) hemisphere anode was suspended in each paupier frame approximately 1 m back from the net opening. Electrofishing settings used were 30 hertz and 15% duty cycle.

Surface trawl: A 10.7 m net with 38 mm mesh in the body reducing to 6 mm mesh in the cod attaches to floating boards and is towed behind a boat in a zigzag pattern to avoid prop wash from the motor. Standard trawls were five minutes and conducted in a relatively straight line. No electricity is used.

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

A goal of four transects for each gear was run in both the near shore and open water zones. Sampling technique, total time and whether the transect was near shore or open water was recorded for each deployment. All fish were identified to species and enumerated. The total length (mm) of up to ten Silver Carp from 100 mm size classes were measured per sample.

Data analysis: Catch rate (fish/5 min) and size distributions of Silver Carp were evaluated for each gear. Catch rate data were $\log_{10}(x + 1)$ transformed to correct for proportionality between the standard deviations and means and compared via repeated-measures analysis of variance (ANOVA) with a Tukey's test for multiple comparisons. Differences in length-frequency distributions were determined among gears using nonparametric Kolmogorov-Smirnov tests. Species richness and percentage of Silver Carp catch was calculated for each gear.

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

All analyses were performed in R (R Development Core Team, 2013) and statistical significance for all analyses was declared at $\alpha = 0.05$. Figures remain in the most simplistic form for ease of interpretation.

Detection probabilities ($P_{detection}$) of Silver Carp captured via novel trawling techniques and standard electrofishing in June 2016 were determined using program PRESENCE. Probabilities were calculated for all Silver Carp as well as Silver Carp less than 200 mm.

Results and Discussion:

Catch Rates: Silver Carp catch rates ranged from 0.09 to 14.66 fish/5 min across all gears (Figure 1). The paupier captured more Silver Carp than any other gear followed by the dozer trawl, traditional electrofishing, and surface trawl, respectively (Figure 2; ANOVA, $F_{3,532}$, $P < 0.05$).

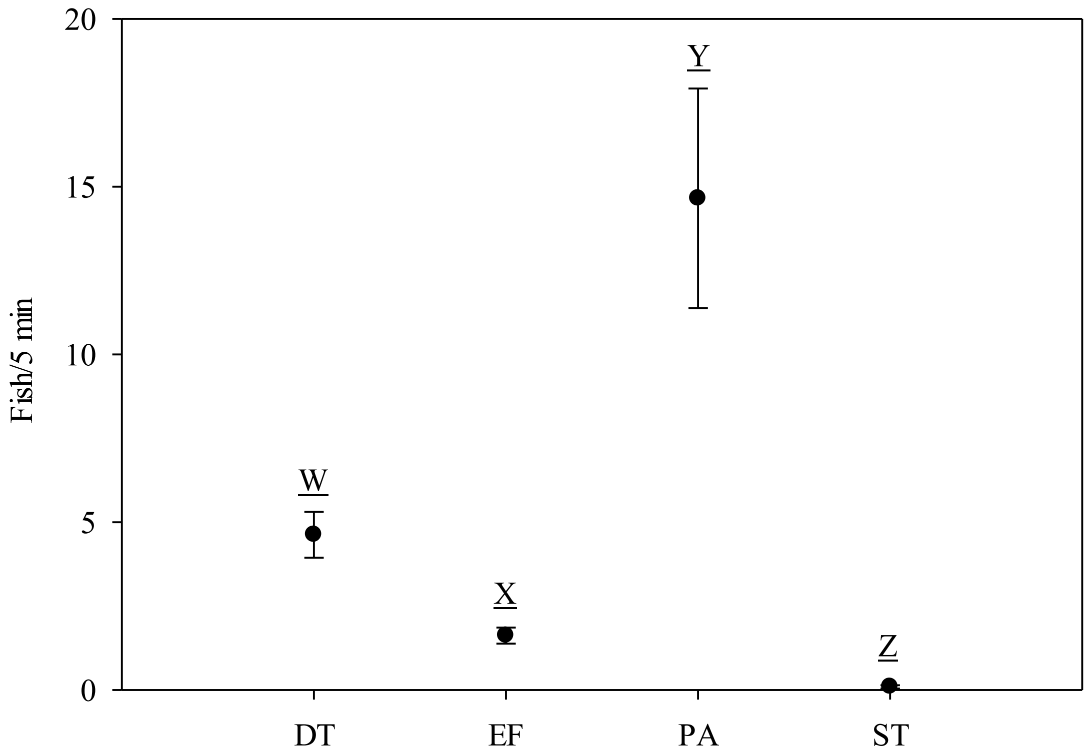


Figure 2. *Catch rate (mean ± standard error) of Silver Carp for each gear (DT – Dozer Trawl, EF – Traditional Electrofishing, PA – Paupier, ST – Surface Trawl) in the Marseilles, Starved Rock, and LaGrange pools of the Illinois River from June, July, September and October 2016. Different letters represent significantly different catch rates.*

Silver Carp less than 200mm were only captured in the LaGrange Pool and therefore analysis for this size class was only conducted on effort in the LaGrange Pool. The paupier had the greatest catch rate of Silver Carp less than 200 mm compared to all other gears (Figure 3; ANOVA, $F_{3,269}$, $P < 0.05$) while no differences in catch rates were found among remaining gears.

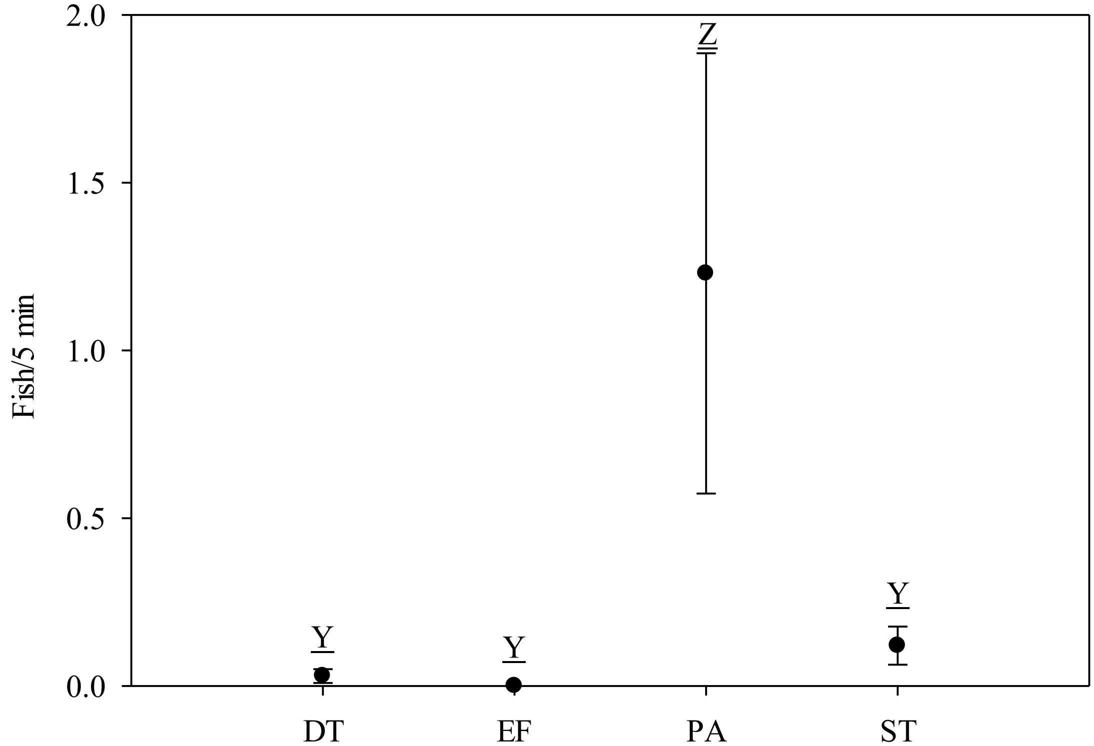


Figure 3. *Catch rates (mean ± standard error) of Silver Carp less than 200 mm for each gear (DT – Dozer Trawl, EF – Traditional Electrofishing, PA – Paupier, ST – Surface Trawl) in the LaGrange Pool of the Illinois River from June, July, September and October in 2016. Different letters represent significantly different catch rates.*

Gears were also compared at near shore (< 10 meters to bank) and open water zones (> 10 meters to bank). For traditional electrofishing, the near shore zone had higher catch rates of Silver Carp than the open water zone (Figure 4; ANOVA, $F_{1,145}$, $P < 0.01$). No other gear demonstrated differences in regards to distance to shore (Figure 3; ANOVA, $P > 0.05$).

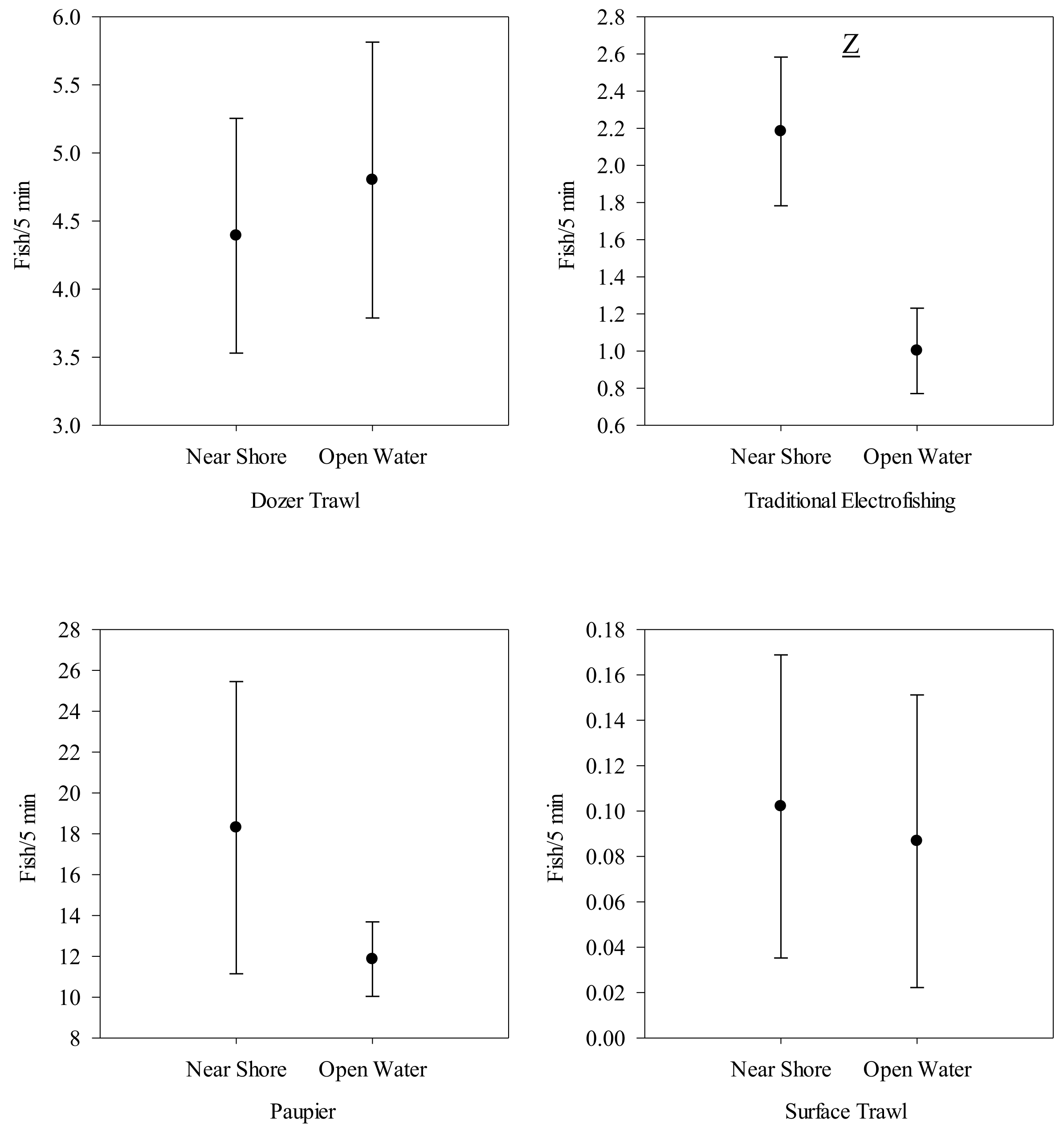
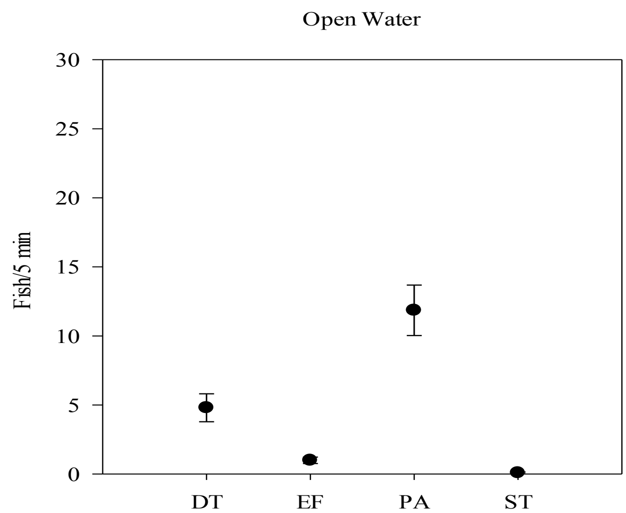


Figure 4. *Catch rates (mean ± standard error) of Silver Carp in the near shore and open water zones for each gear in the Marseilles, Starved Rock, and LaGrange pools of the Illinois River from June, July, September, and October in 2016. Traditional electrofishing was the only technique exhibiting a significant difference (indicated by letter Z) in catch rates between the two habitat types (ANOVA,* $F_{1,145}$*,* $P < 0.01$*). Note that y-axis scale varies by gear.*

Open water habitat had different catch rates for all gears (Figure 5; ANOVA, $F_{3,293}$, $P < 0.05$) while the near shore habitat had different catch rates for all gears except dozer trawl and traditional electrofishing (Figure 5; ANOVA, $F_{3,235}$, $P = 0.09$). The paupier had the greatest catch rates of Silver Carp in both open water (ANOVA, $F_{3,293}$, $P < 0.01$) and near shore habitat (Figure 5; ANOVA, $F_{3,235}$, $P < 0.01$).



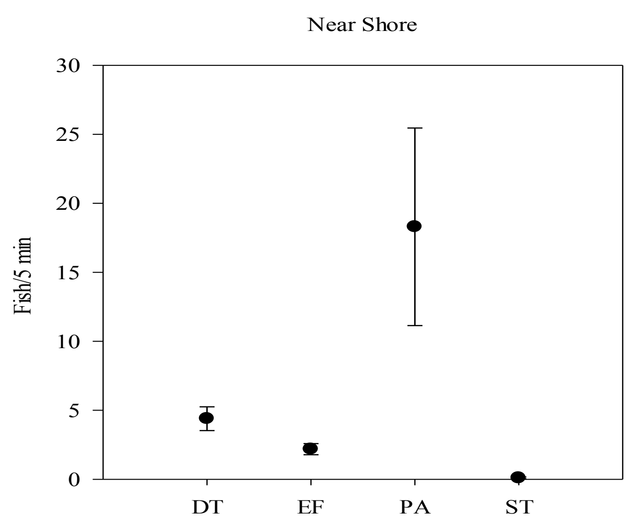


Figure 5. *Catch rates (mean ± standard error) of Silver Carp for each gear in near shore and open water zones in the Marseilles, Starved Rock, and LaGrange pools of the Illinois River from June, July, September, and October in 2016. Different letters represent significantly different catch rates.*

Length Frequencies: Silver Carp lengths ranged from 23 mm to 940 mm for all gears. The distributions of Silver Carp lengths captured were similar between the paupier, dozer trawl, and traditional electrofishing (Figure 6; Kolmogorov-Smirnov, $P > 0.05$). Surface trawl length distribution of Silver Carp was significantly different (Kolmogorov-Smirnov, $P < 0.01$) than all other gears.

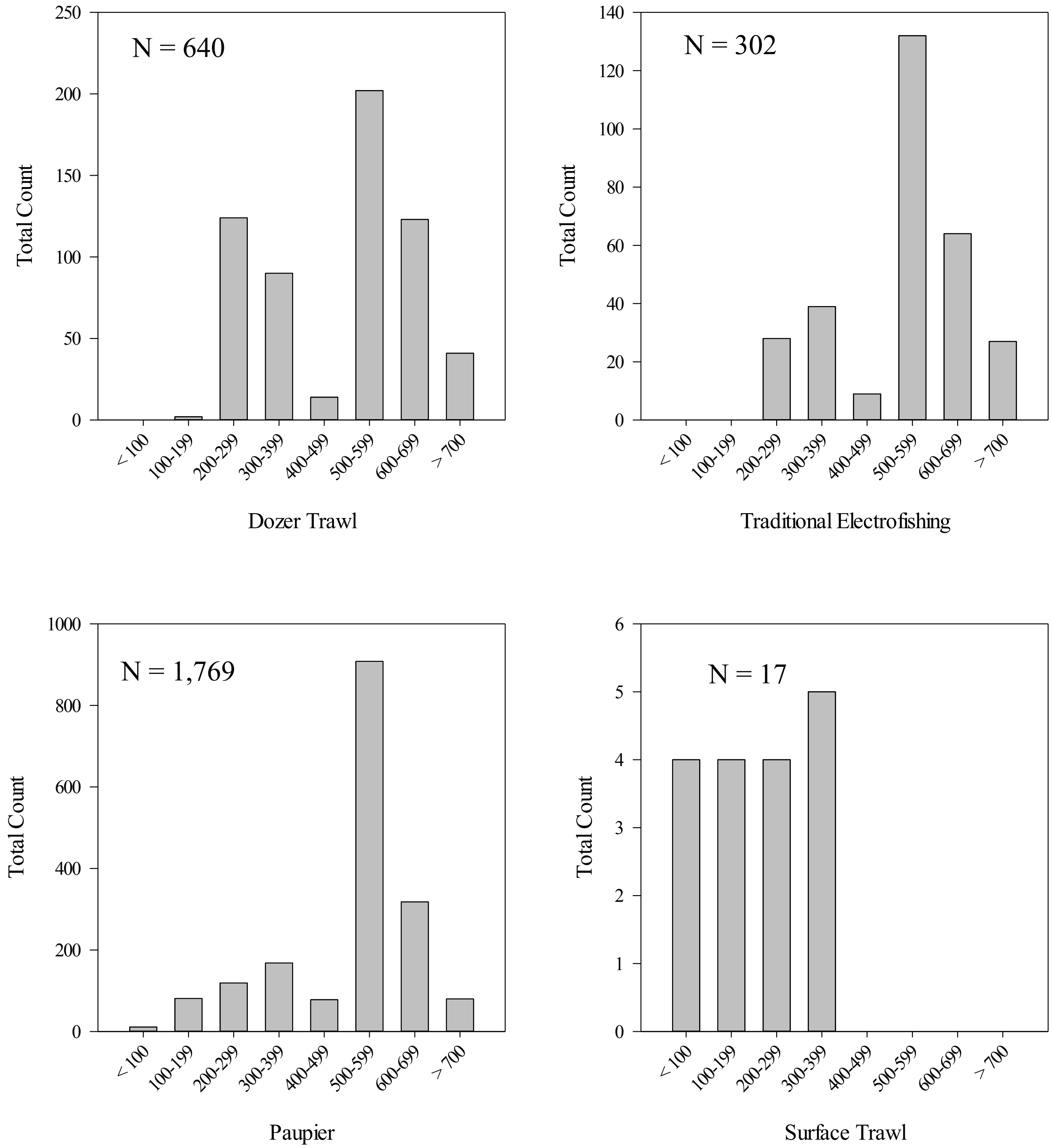


Figure 6. *Length frequencies of Silver Carp for each gear in the Marseilles, Starved Rock, and LaGrange pools of the Illinois River from June, July, September, and October in 2016. Surface trawl length distribution of Silver Carp was significantly different (Kolmogorov-Smirnov, $P < 0.01$) than all other gears length distribution of Silver Carp. Note that y-axis scale varies by gear.*

Detection: Early results from the detection analysis focused exclusively on the month of June but will expand to all sampling months in the future. The paupier had the greatest detection probability for all size classes of Silver Carp (Detection Probability ± SE = 0.67 ± 0.11), followed by dozer trawl (Detection Probability ± SE = 0.58 ± 0.09), traditional electrofishing (Detection Probability ± SE = 0.26 ± 0.07) and surface trawl (Figure 7; Detection Probability ±

SE = 0.05 ± 0.05), respectively. The paupier was at least three times greater than any other gear for detecting Silver Carp less than 200 mm (paupier Detection Probability ± SE = 0.30 ± 0.12; Figure 8). However, all detection rates for Silver Carp less than 200 mm were small due to low capture rates throughout June.

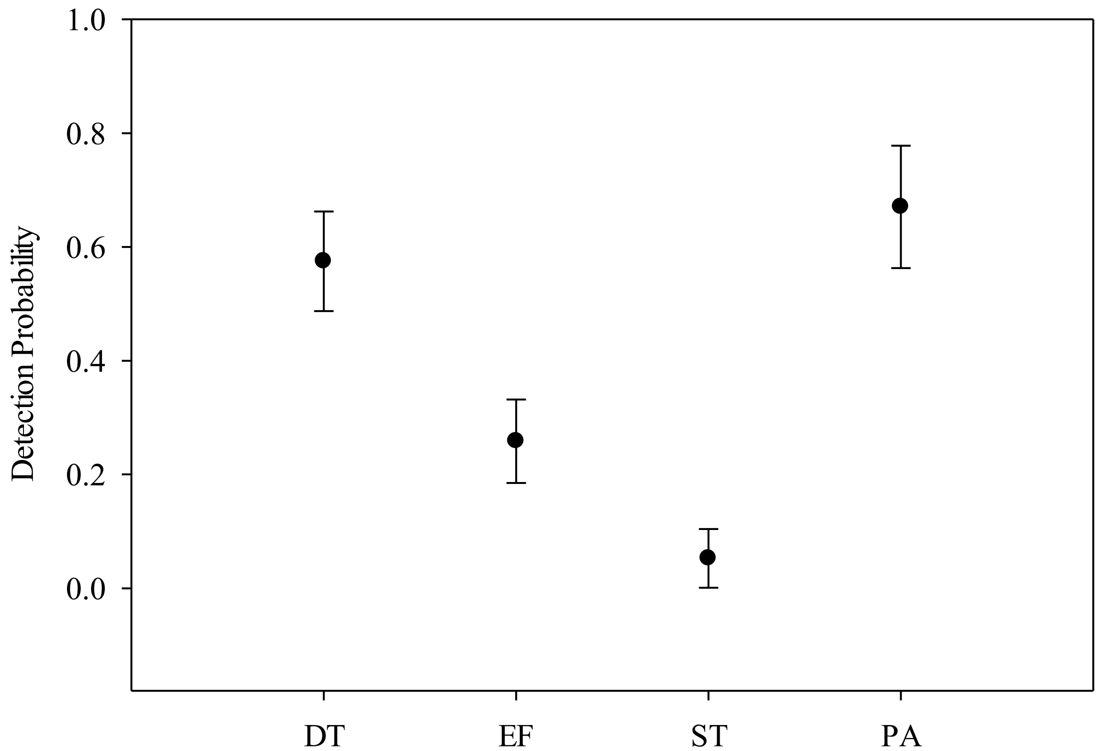


Figure 7. *Detection probabilities with standard errors for Silver Carp for each gear (DT – Dozer Trawl, EF – Traditional Electrofishing, PA – Paupier, ST – Surface Trawl) in the Marseilles and LaGrange pools of the Illinois River from June in 2016.*

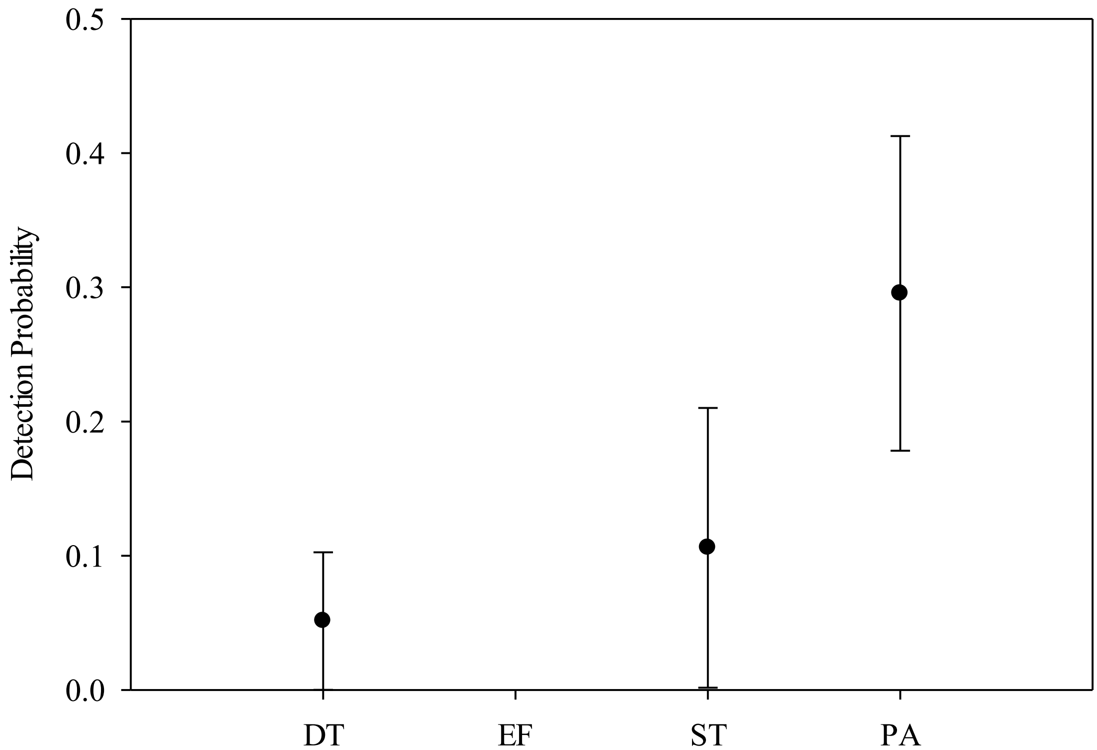


Figure 8. *Detection probabilities with standard errors for Silver Carp less than 200 mm for each gear (DT – Dozer Trawl, EF – Traditional Electrofishing, PA – Paupier, ST – Surface Trawl) in the LaGrange Pool of the Illinois River in June 2016.*

Sample Size: Sample sizes were only calculated in the LaGrange Pool due to the higher abundance of stock size Silver Carp. The paupier required the least amount of samples (n = 38) to obtain 125 stock size Silver carp followed by dozer trawl (n = 42). Traditional electrofishing (n = 250) required more than six times more samples then either the paupier or dozer trawl (Figure 9). This trend was similar when sample sizes were estimated to reduce the relative standard error around the mean catch rate of stock size Silver Carp to 25% or less. The paupier required the least amount of samples (n = 22) followed by the dozer trawl (n = 33). Traditional electrofishing (n = 62) required 2-3 times more samples to achieve the same reduced relative standard error (Figure 9).

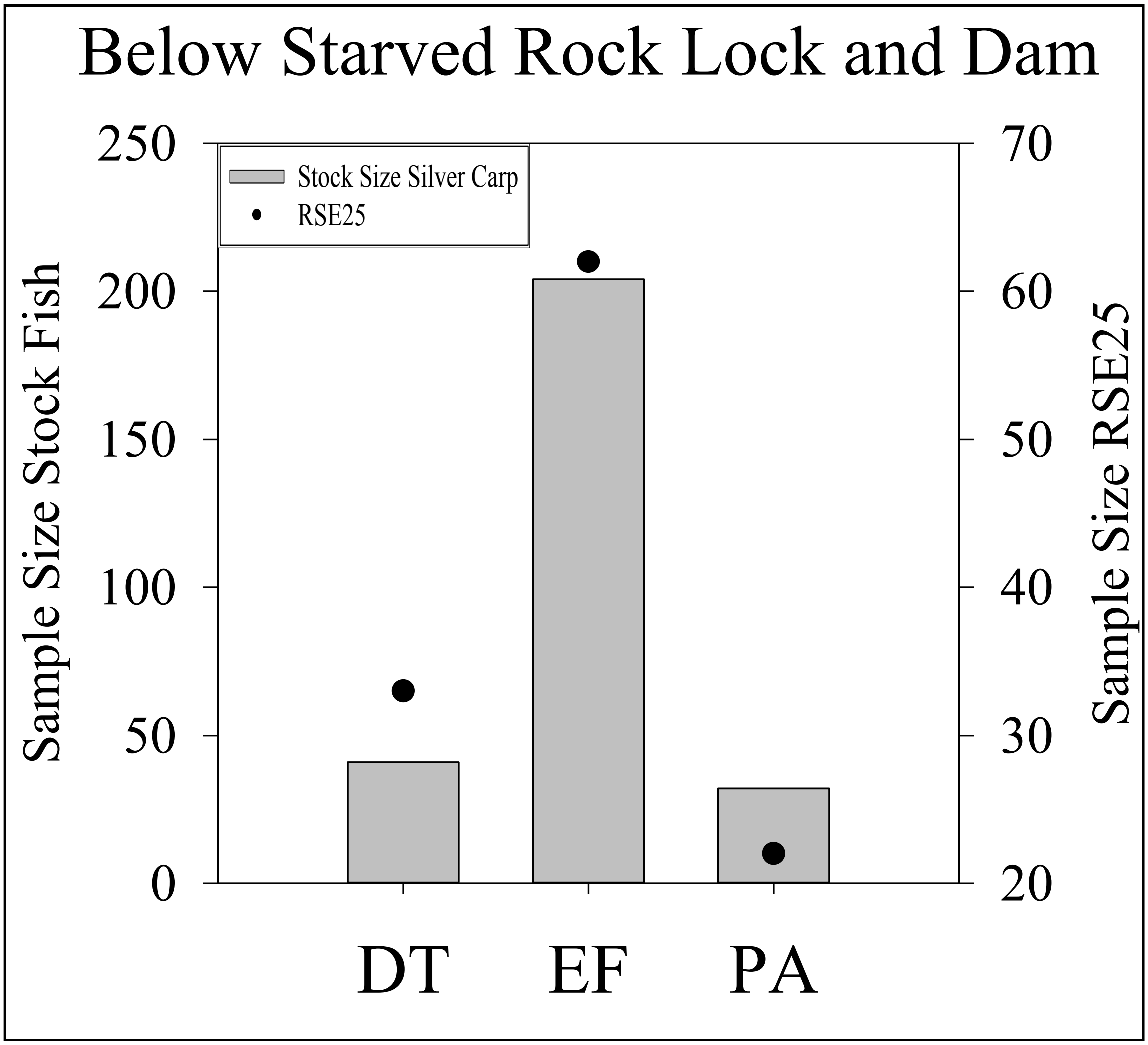


Figure 9. *Sample size estimates for capturing 125 stock size Silver Carp (left y-axis) and obtaining a relative standard error of 25% around the mean catch rate of stock sized Silver Carp for 80% of samples (right y-axis) in all gears (DT – Dozer Trawl, EF – Traditional Electrofishing, PA – Paupier) in the LaGrange Pool of the Illinois River.*

Species Richness: Average species richness for a five minute transect was greatest for the paupier (mean ± SE = 7.85 ± 0.36) followed by the dozer trawl (mean ± SE = 5.15 ± 0.27; ANOVA, $F_{3,532}$, $P < 0.01$). There was no difference in average species richness for a five minute transect between traditional electrofishing (mean ± SE = 3.28 ± 0.22) and surface trawl (mean ± SE = 2.46 ± 0.22; ANOVA, $F_{3,532}$, $P = 0.22$). The abundance of specific species varied among all gears, however, Gizzard Shad was the most abundant species caught in all four gears comprising 40 – 77% of fish captured. Silver Carp was the second most abundant species captured in traditional electrofishing, third most abundant species captured by the dozer trawl and paupier, and sixth most abundant species captured by the surface trawl.

Recommendations:

- One more year of data collection is needed to validate the following preliminary results:
  - The paupier demonstrated the greatest ability to catch a large size range of Silver Carp with the least amount of effort compared to other techniques
  - The dozer trawl also captured a large size range of Silver Carp with minimal effort compared to traditional electrofishing
  - Traditional electrofishing did not capture Silver Carp less than 200 mm and required 2 – 6 times more sampling effort to catch 125 stock size individuals and achieve a low relative standard error around the mean catch rate
- Surface trawl sampling was restricted to capturing Silver Carp less than 400 mm and therefore should be removed from future consideration as a population monitoring tool
- To establish sample sizes and effort needed to detect Asian carp species, detection probabilities should be determined for each gear in 2017
- Collaborations with Illinois Natural History Survey gear evaluation efforts would help develop a monitoring plan for Silver Carp in the Illinois River

Literature:

Koch, J. D., B. C. Neely, and M. E. Colvin. Evaluation of precision and sample sizes using standardized sampling in Kansas reservoirs. North American Journal of Fisheries Management 34:1211-1220.

Phelps, Q. E., and D. W. Willis. 2013. Development of an Asian carp size structure index and application through demonstration. North American Journal of Fisheries Management 33:338-343.

Quist, M. C., K. I. Bonvecchio, and M. S. Allen. 2009. Statistical analysis and data management. Pages 13-25 *in* S. A. Bonar, W. A. Hubert, and D. W. Willis, editors. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

R Core Development Team. 2013. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.

Unconventional Gear Development

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

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

Introduction and Need:

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. Additionally, the conditions present in the CAWS present numerous challenges that limit the ability of many gear types to effectively sample for Asian carp in this system. Sampling gears or combination systems that are effective in such habitats or that substantially increase the probability of detecting Asian carp in areas where they occur in low abundance are needed to enhance monitoring and control efforts. Capture efficiency and size selectivity of several new methods is being evaluated and compared with selected traditional gears to determine the utility of these techniques for monitoring and controlling Asian carp populations.

Objectives: To enhance sampling success for low-density Asian carp populations, we are:

(1) Investigating alternative techniques to enhance capture of rare Asian carp in deep-draft canals, such as in the CAWS; and

(2) Evaluating gear and combination system prototypes in areas with low to moderate Asian carp population densities.

Project Highlights:

- Pound nets are being used for ongoing research, monitoring, and control efforts on the Illinois Waterway. Pound nets are being used in collaboration with USGS to test feeding attractants and sound stimuli for attracting/deterring Asian carp, and are being used by ILDNR for Asian carp removal purposes

Methods:

In 2016, unconventional gear efforts focused on the use of Great Lakes trap (pound) nets as part of an ongoing collaboration with ILDNR and USGS partners to achieve various monitoring and research objectives. Pound nets (100 m lead, 6.1 × 3.0 × 3.0 m pot, 7.6-9.1 m wings, 3.8-6.4 cm mesh) were deployed for two-week periods at Lily Lake (LaGrange Pool; May) and at the Hanson Material Service pit (Marseilles Pool; September - October) in collaboration with USGS to test the effectiveness of feeding attractants and sound stimuli for capturing/deterring large Asian carp.

Results and Discussion: Findings from previous years' pound net evaluation activities were published during 2015 (see Collins et al. 2015). Results of feeding attractant and sound stimuli trials during 2016 will be reported by USGS. Catch totals from monitoring and removal activities in the upper Illinois Waterway will be reported by ILDNR.

Recommendations: The use of pound nets has proven useful for a variety of monitoring, control, and research purposes. The continued use of pound nets instead of traditional entrapment gears may increase efficiencies and help save natural resource agencies considerable personnel time (Collins et al. 2015). Evaluation of alternate configurations of pound nets are needed for deployment in larger backwater environments where pound net wings cannot extend from shoreline to the opposing shoreline.

Literature Cited:

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

Monitoring Asian Carp using Netting with Supplemental Capture Techniques

Trevor Cyphers and Rebecca Neeley
(U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

Participating Agencies: USGS Columbia Environmental Research Center (field and technical support)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

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

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

Netting for adult Asian carp with the addition of supplemental capture techniques (electrofishing, complex sound, and commercial technique) was first implemented and analyzed for efficiency during the 2015 field season. In 2015, field crews collected 802 total fish, 451 of which were adult Asian carp. Electrofishing was the most efficient technique at driving fish into nets, with a catch per unit effort (CPUE) of 6.12 fish/100 yards of net. No adult Asian carp were captured above RM 276 in Dresden Island Pool. Project objectives remained similar for 2016; however, the analysis of supplemental capture techniques were refined and standardized through fixed sampling sites.

Objectives:

(1) Determine the most efficient supplemental capture technique at driving adult Asian carp into trammel and gill nets.
(2) Refine the use of bioacoustics as a means to herd Asian carp to a desired location or area.
(3) Determine (in conjunction with ongoing projects) the distribution and abundance of Asian carp that may be present in the upper Illinois River.

Project Highlights:

- 55 net sets and 17,400 yards of net were deployed throughout 7 fixed sites
- 1,394 fish (1,229 Asian carp) were captured at fixed sites during technique evaluation
- Complex sound and electrofishing Asian carp CPUE were statistically different than control CPUE
- Supplemental capture techniques were not statically significant based on CPUE when neglecting control
- 72 Fish were captured during monitoring in the upper IWW pools
- The furthest upstream Silver carp captured was at RM 275 in Dresden Island
- Floating trammel nets deployed in the upper pools yeilded zero fish captures

Methods:

During the 2016 field season an increased effort was taken to standardize supplemental capture techniques to determine which technique is most effective at herding Asian carp into nets, thus increasing harvest rates. For this study trammel and gill nets were used in conjunction with supplemental capture techniques to attempt to drive Asian carp into nets and increase catch rates. Technique effectiveness was assessed in Marseilles and Starved Rock Pools via standardized sampling at fixed sites. Upon determining the most efficient technique, nets were deployed in Dresden Island, Brandon Road and Lockport Pools. Floating trammel nets were implemented without additional techniques to target main channel habitats in the upper pools.

Supplemental Capture Techniques

Electrofishing – Electrofishing as a supplemental capture technique involved using pulsed-DC with the intent of driving fish into nets. Electrofishing runs were standardized for time 12 minutes at fixed sites and stunned fish were be collected by dip-netters with priority given to Asian carp over native species when time and personnel allowed.

Complex Sound – The use of complex sound as a herding technique was accomplished with the assistance of field personnel from USGS Columbia Environmental Research Center (CERC). Two acoustic underwater transducers (Lubell LL9162T) were mounted to the boat bow and lowered into the water column. Transducers were plugged into an amplifier employed with a high frequency broadband (2-10 KHz) complex tone audio file of a 100 HP boat motor. Complex sound was with a standardized at 180 dB from the source and implemented for 12 minute increments at fixed sites. Following net sets and implementation, mobile sound arrays were mapped using hydrophones. This information was used to determine if bioacoustics using a complex tone is a viable option for herding adult Asian carp to desired locations or areas.

Commercial Technique - A technique frequently employed by commercial fishermen involved driving fish into nets by noise created from pounding on boat hulls with rubber mallets and revving tilted boat motors. Commercial technique was standardized and implemented for 12 minute increments at fixed sites.

Control – To assess incidental catches within fixed sites, nets were set for at least 12 minutes and not given a supplemental capture technique.

Supplemental Capture Technique Evaluation

Seven fixed sites were established in Marseilles (5) and Starved Rock Pool (2) in backwater habitats that were known to contain adult Asian carp (Figure 1). Nets were used to block off backwater habitats and supplemental capture techniques were used to drive fish into nets for a 12 minute time period prior to net retrieval. Mobile split-beam hydroacoustic surveys were used at fixed sample sites following net deployment before and after the use of supplemental capture techniques for 12 minutes each. Hydroacoustic surveys were performed using a Biosonics® 200 kHz split-beam, stationary, side-looking transducer and one 1200 kHz side-scan SONAR unit. Split-beam data were collected using Visual Acquisition v.6® from 1.15- 55 m from the transducer face, utilizing 5.0 pings per second, and a 0.40 ms pulse duration. Water temperature was taken prior to scan implementation and imputed into Visual Acquisition v.6® to insure accurate data. Data from hydroacoustic surveys were used to assess fish densities through wedge volume analysis pre- and post-capture technique. Mapping software (ReefMaster PRO®) was used to create bathymetry maps and determine volume of each fixed site based on tracks from a down-looking side-scan SONAR unit (Figure 2). Fish density based on wedge volume was extrapolated to site volume to determine a population estimate for each site. The proportion of Asian carp captured during fixed sites was applied to population estimates to account for native fishes that may have been observed during hydroacoustic scans. Supplemental capture technique effectiveness was evaluated based on population estimates pre and post hydroacoustic surveys. Capture technique efficiency was also assessed by comparing CPUE for all fish and Asian carp based on catch data. A higher CPUE should be indicative of a more effective capture technique. Data analysis for CPUE and Asian carp length were done using statistics software JMP.

Asian carp collected from fixed sites were numerated, measured for length (mm), and disposed of. Observed Asian carp length was recorded to determine a target range of catchable Asian carp and to assess comparisons between length and pool. When processing hydroacoustic survey fish lengths were estimated based on target strength and equations derived from Love (1977). Native fish captured during sampling events were enumerated and released. Fixed sites were given at least two days between sampling events to ensure reestablish. Fixed sites were sampled at least twice using each supplemental capture technique and once as a control.

Monitoring the Extent of Adult Asian Carp

Nets were deployed throughout Dresden Island, Brandon Road and Lockport pools in predetermined areas based on river current, topography and suggestions from commercial fisherman contracted by the Illinois DNR. Once nets were deployment, GPS coordinates were recorded and supplemental capture techniques were used throughout the entire sampling area. Capture technique implementation was determined by results from fixed site sampling and gear and crew availability. Most of this effort consisted of using electrofishing and the commercial technique for these reasons. Floating trammel nets of 150’ long by 8’ deep with varying square bar mesh sizes were used to target main channel habitats in Dresden Island, Brandon Road and Lockport Pools. Asian carp captured within Dresden Island Pool and above were measured for length (mm), weight (g), sexed and lapilli otoliths were excised for microchemistry and subsequent age determination. Native fish captured during sampling events were enumerated and released.

Results and Discussion:

Supplemental Capture Techniques

During 2016, 55 net sets were deployed with the intent of quantifying supplemental capture technique effectiveness. 17,400 yards of gill and trammel nets were deployed between the 7 fixed sites in Marseilles and Starved Rock Pools. This effort resulted in the in the capture of 1,394 total fish, 1,229 being Asian carp or 88.2%. Of the three capture techniques that were used, electrofishing had the highest CPUE based on 100 yards of net for total fish captured (11.27 ± 4.37), followed by complex sound (9.25 ± 2.05), commercial technique (6.07 ± 1.49) and control (1.77 ± 0.61), respectively (ANOVA, df=3, p=0.025, Table 1, Figure 3). Differences in CPUE were observed between complex sound and control (Tukey-Kramer HSD, p=0.023). Focusing on Asian carp CPUE revealed a similar trend (ANOVA, DF=3, p=0.016, Table 1, Figure 3), with differences between complex sound and control (Tukey-Kramer HSD, p=0.015) and electrofishing and control (Tukey-Kramer HSD, p=0.041). Omitting the control variable as a capture technique indicated no significance in CPUE for all fish (ANOVA, DF= 2, p=0.057) and Asian carp (ANOVA, DF=2, p=0.60). Analysis of catch data suggests that there was no significant increase in catch effectiveness of Asian carp based on the supplemental capture technique that was utilized. Based on catch data alone, there is no single capture technique that is most effective. At this time, analysis of hydroacoustic data to determine capture technique effectiveness is still being processed. Once complete, hydoacoustic data should solidify or dispute what has already been found regarding supplemental capture technique effectiveness.

During fixed site sampling 718 Silver Carp and 282 Bighead Carp were measured for length, which can be used to better understand population dynamics of the Asian carp in the Upper Illinois River. The minimum length Silver Carp that was captured was 522 mm and maximum length of Bighead Carp was 1120 mm. These lengths were used to interpolate a lower and upper-end length cutoff for hydroacoustic data to determine Asian carp densities within fixed sites. Comparing Silver and Bighead Carp length to the pool they were captured in indicates a significant correlation (Kolmogrov-Smirnov, $p<0.0001$). Asian carp harvested within Marseilles Pool were significantly larger than those harvested from Starved Rock Pool during fixed site sampling for both Silver and Bighead Carp (Figure 4, Figure 5). Taking more life history trait (e.g., weight, sex, age structures) moving forward would allow for a better understanding of the Asian carp population within the Upper Illinois River.

Monitoring the Extent of Adult Asian Carp

Netting with supplemental capture techniques in the upper pools of the IWW involved 50 net sets for a total effort of 7,466 yards (Table 2). During this effort a total of 72 fish were captured, one of which was a Silver Carp capture in Dresden Island near RM 275. A majority of these captures occurred within Dresden Island Pool (94.4%). Using floating trammel nets in the main channels of Upper IWW pools resulted in the capture of zero fish during the 2016 sampling effort. Monitoring effort in the upper pools was less than originally anticipated due to the lack time and precedence given to fixed site sampling. In 2017 more effort will be dedicated to apply techniques used during fixed site sampling in order to monitor the presence front for adult Asian carp.

Recommendations:

Catch data alone indicated that there was no supplemetal capture technique that was most effective at increasing catch rates based on CPUE. Even though there was no clear-cut technique that should be implemented, futher effort needs to be done in the Upper IWW to determine the presence front of adult Asian carp. Electrofishing yeilded the highest CPUE of the three capture techniques based on 2015 and 2016 data and therefore should be utilized most often in this effort. Complex sound and the commercial technique should also be implemented when time allows, especially in areas where electrofishing is less effective (e.g. deepwater habitat). Sampling should increase in main channel habiats within the upper pools where effort is not usually done. Moving forward, sampling should be focused to Brandon Road and Lockport pools.

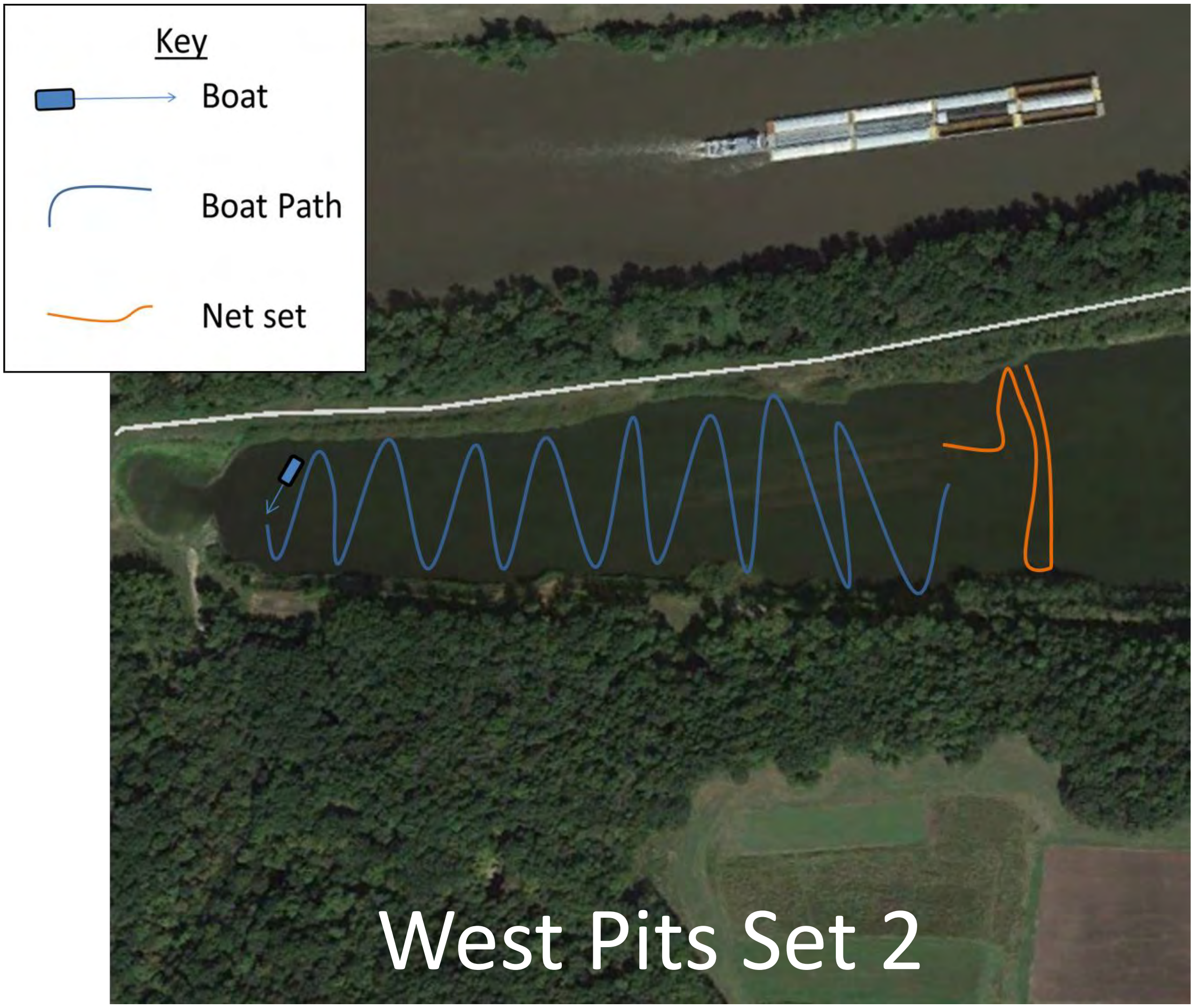


Figure 1. *An example of a fixed site used for this study, and how supplemental capture techniques were employed to drive fish into nets.*

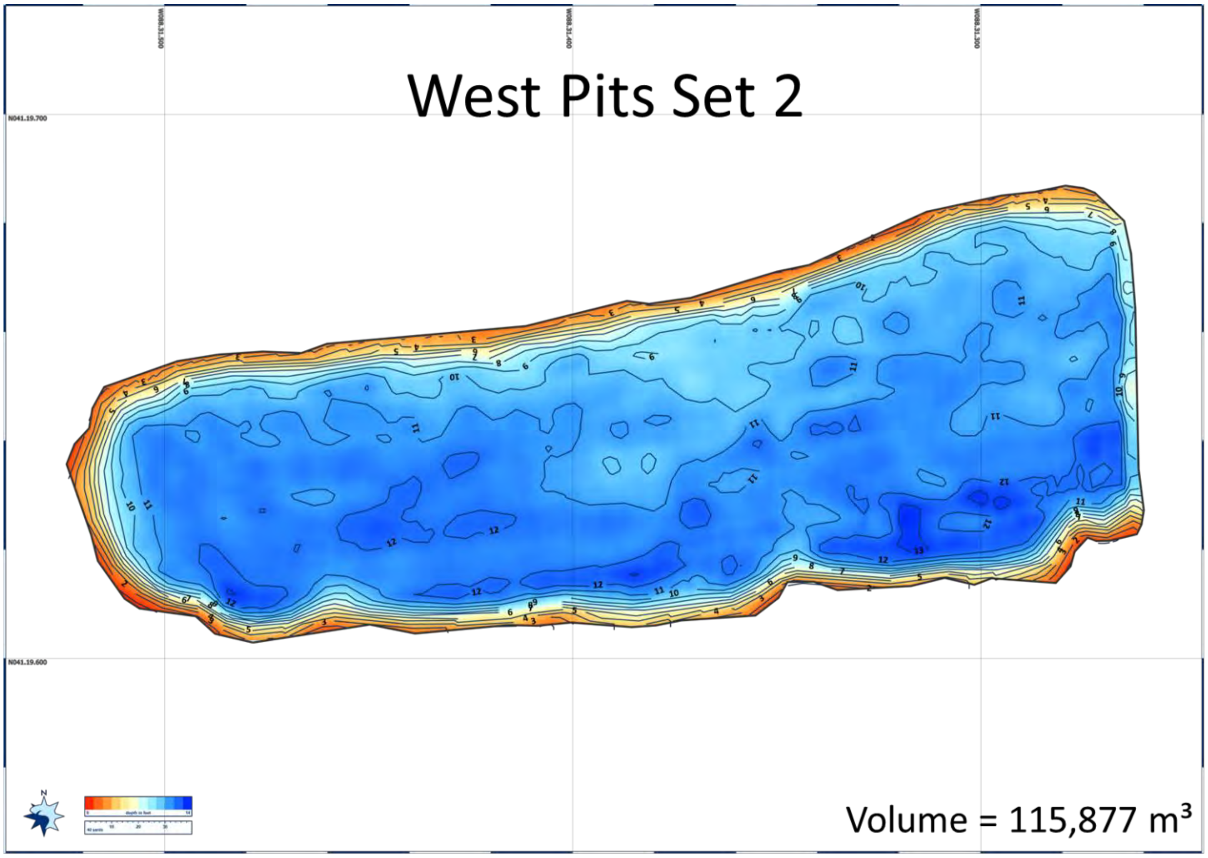


Figure 2. *Bathymetry map of a fixed site used to analyze supplemental capture techniques.*

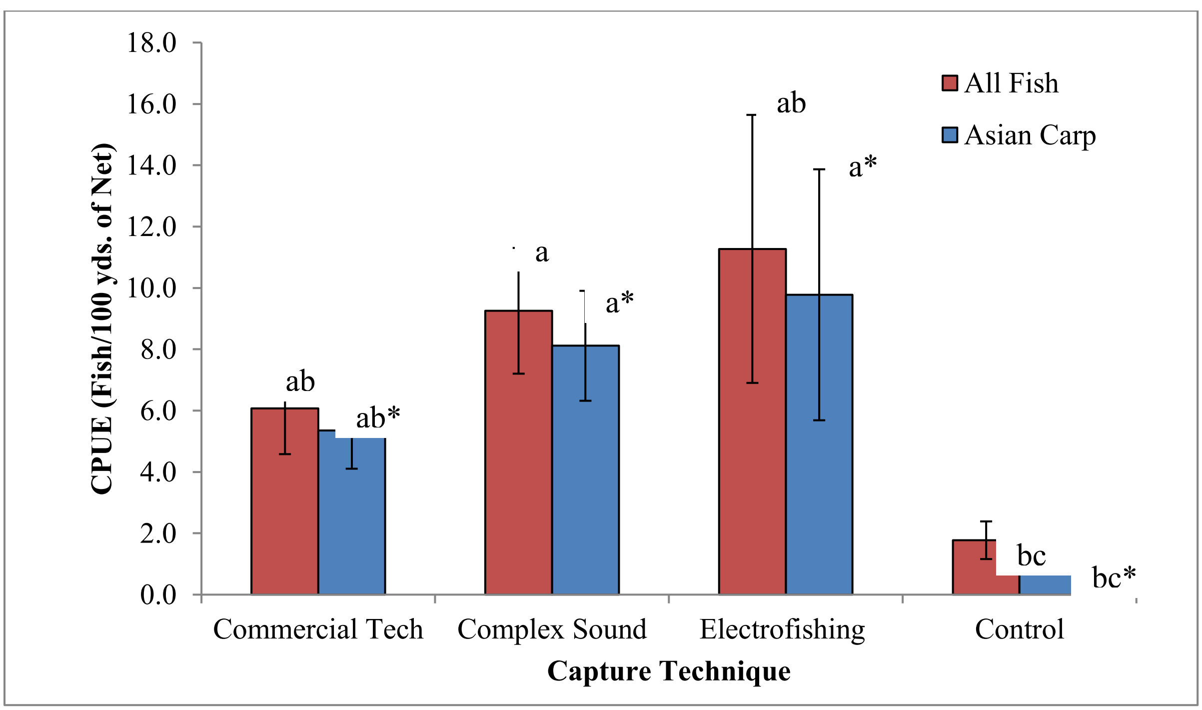


Figure 3. *Mean CPUE (±SE) of each capture technique used throughout the seven fixed sites for all fish and Asian carp during the 2016 field season.*

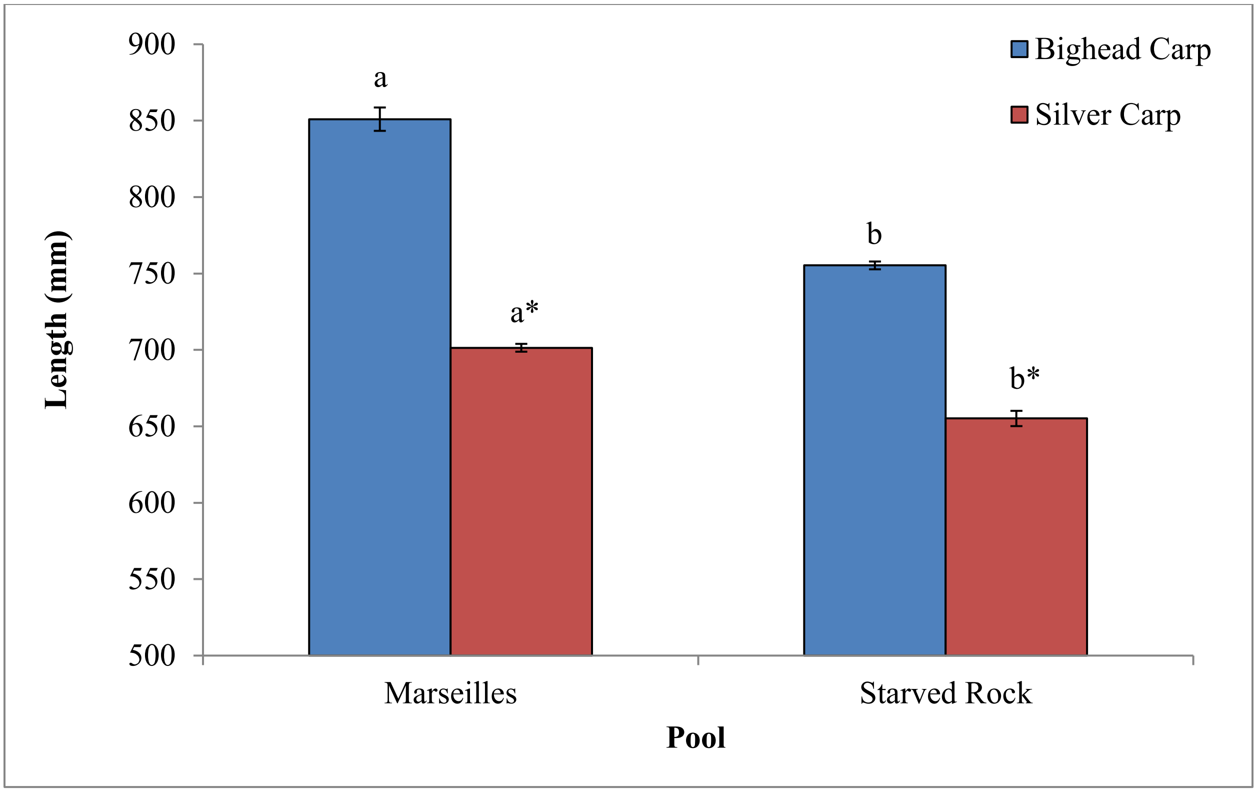


Figure 4. *Mean length of Asian carp species based on pool from the seven fixed sites during the 2016 field season.*

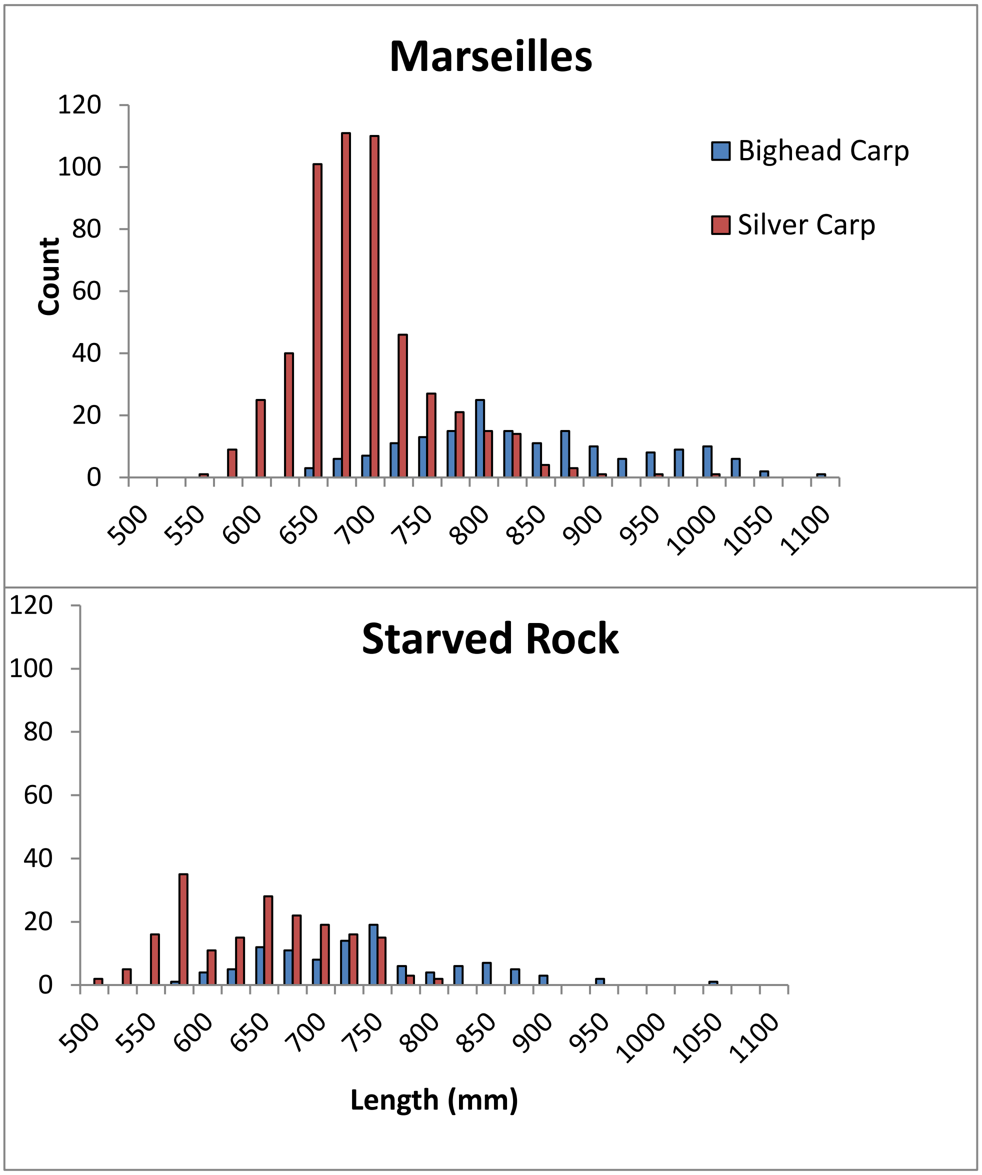


Figure 5. *Length distribution based on mesh size for Asian carp captured during fixed sites.*

Table 1. *Analysis of catch data for capture technique from fixed sites sampling during the 2016 field season. CPUE analysis based on 100 yard of net.*

Capture Tech.	Net Sets	Effort (yds)	Fish Count	CPUE	AC Count	CPUE
Commercial Tech.	16	5400	341	6.07 (±1.49)	299	5.36 (±1.25)
Complex Sound	13	4100	359	9.25 (±2.05)	320	8.18 (±1.83)
Electrofishing	18	5600	653	11.27 (±4.37)	580	9.78 (±4.09)
Control	7	2300	41	1.77 ± (0.61)	30	1.31 ± (0.50)

Table 2. *Analysis of catch data from effort based on monitoring the adult Asian carp presence front during the 2016 field season. – Fish counts in parentheses denote Asian carp captures.*

Pool	Net Sets	Effort (yds)	Fish Count	CPUE/(100 yds)	Effort (hrs)
Dresden Island	18	3366	68 (1)	2.02	16.31
Brandon Road	27	3050	3	0.10	11.64
Lockport	5	1050	1	0.10	5.32

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Barrier Defense Removal of Asian Carp Using Novel Gear

Josey Ridgway, Emily Pherigo, Ryan Long (US Fish and Wildlife Service)

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

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

In 2015, the Columbia FWCO electrified paupier contributed to Barrier Defense collecting a wide size range of Silver Carp, including juveniles, from the Starved Rock and Marseilles pools downstream of the electric dispersal barrier. Those efforts continued through 2016 and have removed several tons of invasive carp from the upper Illinois River leading edge in hopes of alleviating propagule pressure to the electric dispersal barrier.

Objectives:

(1) Remove adult and juvenile Asian carp from the Starved Rock and Marseilles pools of the Illinois River.
(2) Assess Asian carp size structure and percent of Silver Carp catch using the electrified paupier in the Starved Rock and Marseilles pools of the Illinois River.

Project Highlights:

- Sixteen days of effort removed an estimated 29.8 tons of Asian Carp, 99.9% of which were comprised of Silver Carp, from the Starved Rock and Marseilles pools.
- The electrified paupier captured Silver Carp ranging from 183 millimeters (mm) to 850 mm from the Starved Rock and Marseilles pools.
- The electrified paupier performed in a variety of habitat types. Flowing habitats, typically too swift for gill nets to fish, had the least bycatch and highest percent Silver Carp catch.

Methods:

From May to November 2016, Columbia FWCO conducted removal efforts using an electrified butterfly frame trawl, or 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 were affixed to booms 3–4 m in front of the paupier frames. An 18 centimeter (cm) diameter hemisphere anode was suspended in each paupier frame approximately 1 m back from the net opening (Figure 1). Anodes were powered with a 72-amp ETS box. Duty cycle and frequency (pulses per second) were 15% and 30 hertz, respectively. Power output was adjusted until Silver Carp immobilization was observed resulting in watts ranging from 5,560–20,250.

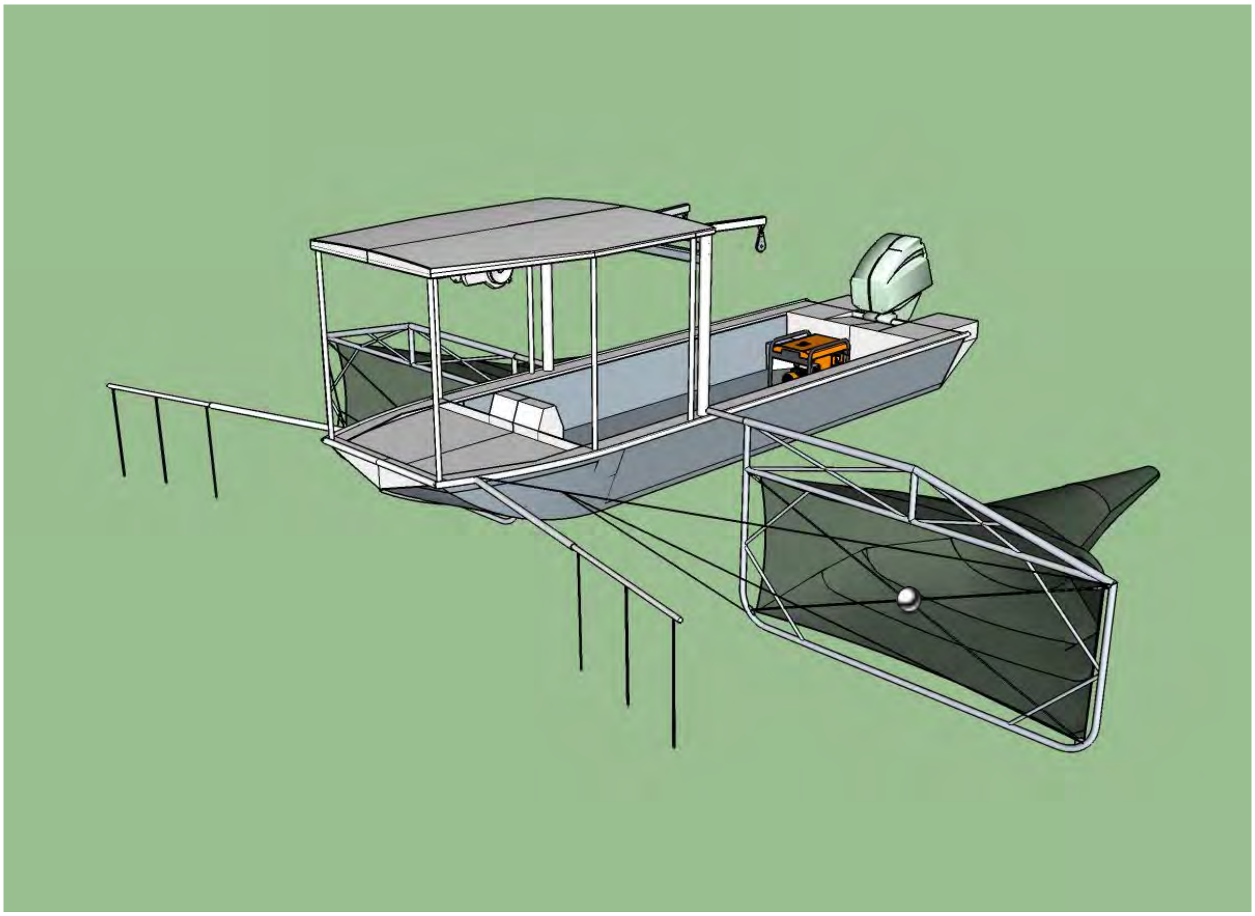

Figure 1. *Electrified paupier boat illustration used in Barrier Defense May through November 2016, depicting booms attached to each corner of the bow with cable dropper anodes, a hemisphere anode in the port-side frame, and conical nets.*

Crews varied between three and four people depending on staff availability. Electrofishing time varied depending on available habitat and/or when nets reached maximum capacity of fish. Habitats with known aggregations of invasive carp were targeted in the Starved Rock and Marseilles pools of the upper Illinois River. Sites selected in the Starved Rock Pool included Delbridge Island (river mile [RM] 234), Sheehan Island backwater (RM 236), Sheehan Island side channel (RM 236), Fox River (RM 240), and Heritage Harbor Marina (RM 242). Peacock Slough (RM 264) in the Marseilles Pool was sampled during a single day's effort (Figure 2).

Barrier Defense Removal of Asian Carp Using Novel Gear

Josey Ridgway, Emily Pherigo, Ryan Long (US Fish and Wildlife Service)

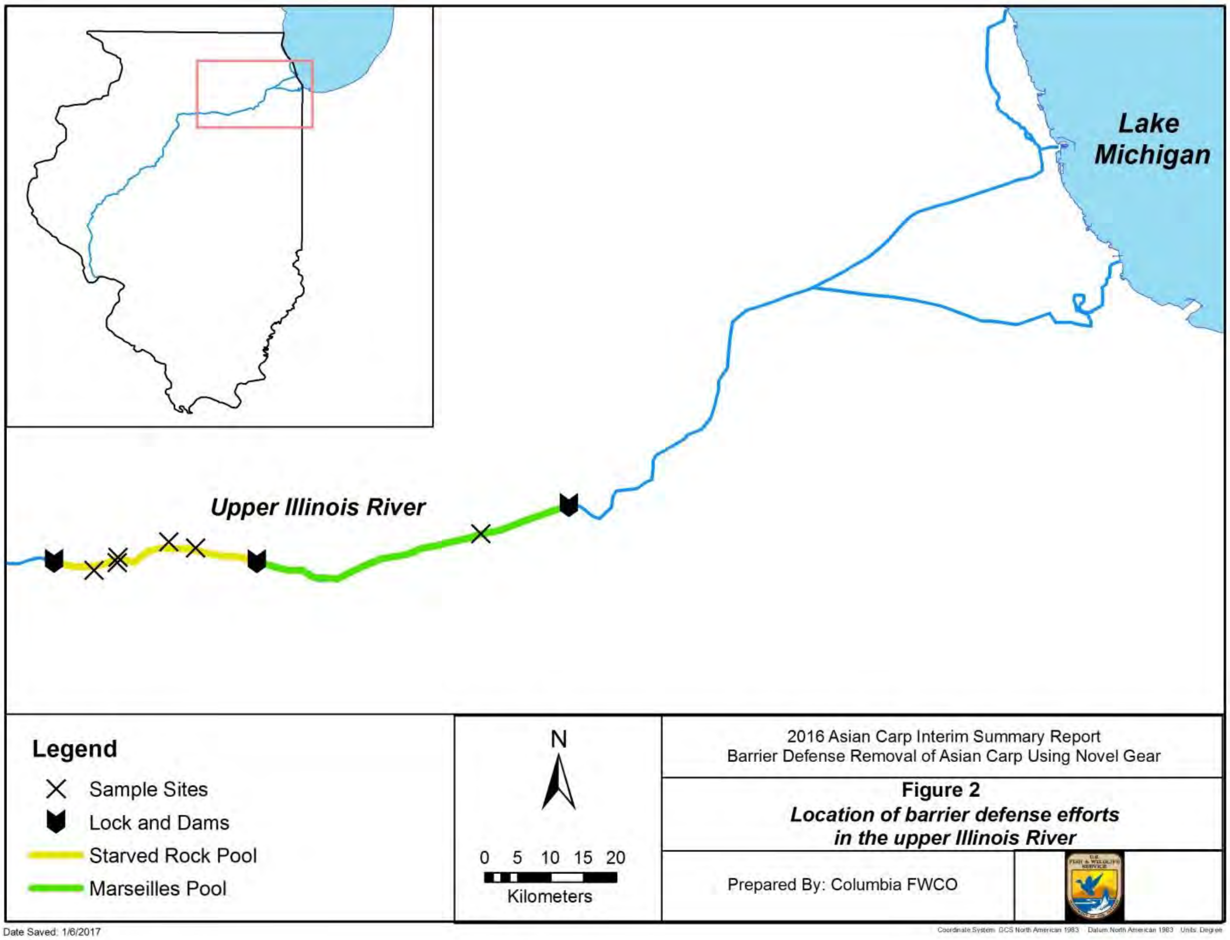

Figure 2. *Sample locations during Barrier Defense using the electrified paupier in the Starved Rock and Marseilles pools of the upper Illinois River, May through November 2016. Sample sites moving upstream included Delbridge Island (river mile (RM) 234), Sheehan Island backwater (RM 236), Sheehan Island side channel (RM 236), Fox River (RM 240), Heritage Harbor Marina (RM 242) and Peacock Slough (RM 264).*

All fish collected were identified to species and enumerated. Silver Carp, Bighead Carp, Grass Carp, and Common Carp were removed and all other fish were released. The first 50 Silver Carp of the day were measured in total length (TL; mm) and weighed (g). All Silver Carp less than 400 mm were measured. When time allowed, Silver Carp were categorized into 100 mm TL groups and other non-native carp species were measured.

Asian carp biomass was calculated using recorded weights and average Silver Carp weight for each 100 mm TL group. Silver Carp percent of catch was calculated as the number of Silver Carp relative to the total number of fish collected in each sample.

Josey Ridgway, Emily Pherigo, Ryan Long (US Fish and Wildlife Service)

Results and Discussion:

The electrified paupier removed several tons of Asian carp from the upper Illinois River in 2016. A total of 16 days of sampling were conducted May through November (Table 1). Total electrofishing time was 15.7 hours which captured 11,103 Silver Carp, 17 Bighead Carp, eight Grass Carp, and 1,461 other fish. Total Asian carp biomass removed was 29.8 tons, 99.9% of which were solely Silver Carp. Samples ranged from two to 30 minutes (mean = 9.932; SE = 0.666) depending on available habitat and net capacity.

Table 1. *Summary of electrified paupier effort and Asian carp captured during Barrier Defense in the Starved Rock and Marseilles pools of the upper Illinois River, May through November 2016.*

Number of Days Fished	16
Electrofishing Hours	15.7
Crew Size	3–4
Number of Grass Carp	8
Number of Bighead Carp	17
Number of Silver Carp	11,103
Asian Carp Tons	29.8

The electrified paupier removed a wide size range of Silver Carp from the upper Illinois River (Figure 3). Silver Carp mean TL was 596 mm (n = 869; SE = 2.113). Bighead Carp mean TL was 649 mm (n = 15; SE = 30.054) and Grass Carp mean TL was 641 mm (n = 2). The two Silver Carp greater than 800 mm were captured from Peacock Slough in the Marseilles Pool. The six Silver Carp less than 410 mm were collected from sample sites in the Starved Rock Pool. The smallest Silver Carp (183 mm) was captured in the Sheehan Island backwater in May 2016.

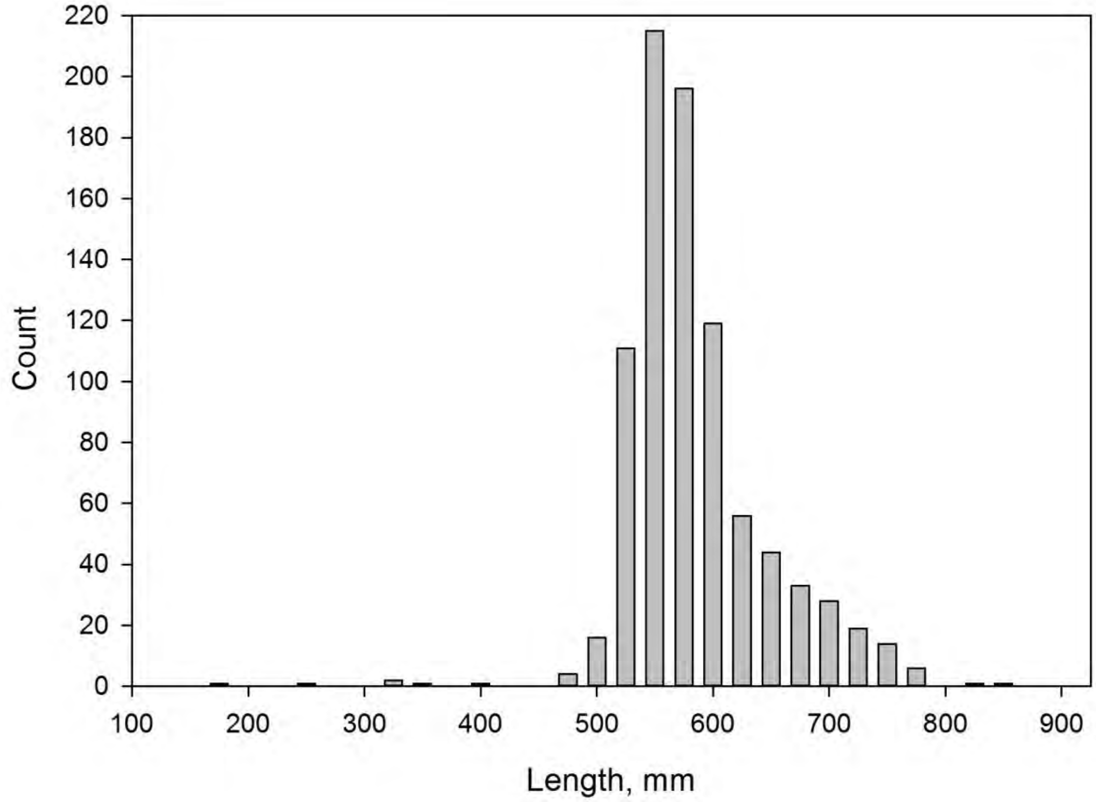

Figure 3. *Length frequency histogram of Silver Carp captured with electrified paupier during Barrier Defense in the Starved Rock and Marseilles pools of the upper Illinois River, May through November 2016.*

On average, Silver Carp comprised 85% of each sample (n = 84 runs, SE = 1.993), but this varied by location (Figure 4). Samples conducted in Sheehan Island side channel captured the highest percentage of Silver Carp at 92% (25 runs; SE = 1.257) followed by the Fox River at 88% (32 runs; SE = 2.281), Delbridge Island at 73% (8 runs; SE = 8.912), Heritage Harbor Marina at 68% (4 runs; SE = 7.478), Sheehan Island backwater at 64% (12 runs; SE = 4.919), and Peacock Slough at 46% (3 runs; SE = 8.187).

Josey Ridgway, Emily Pherigo, Ryan Long (US Fish and Wildlife Service)

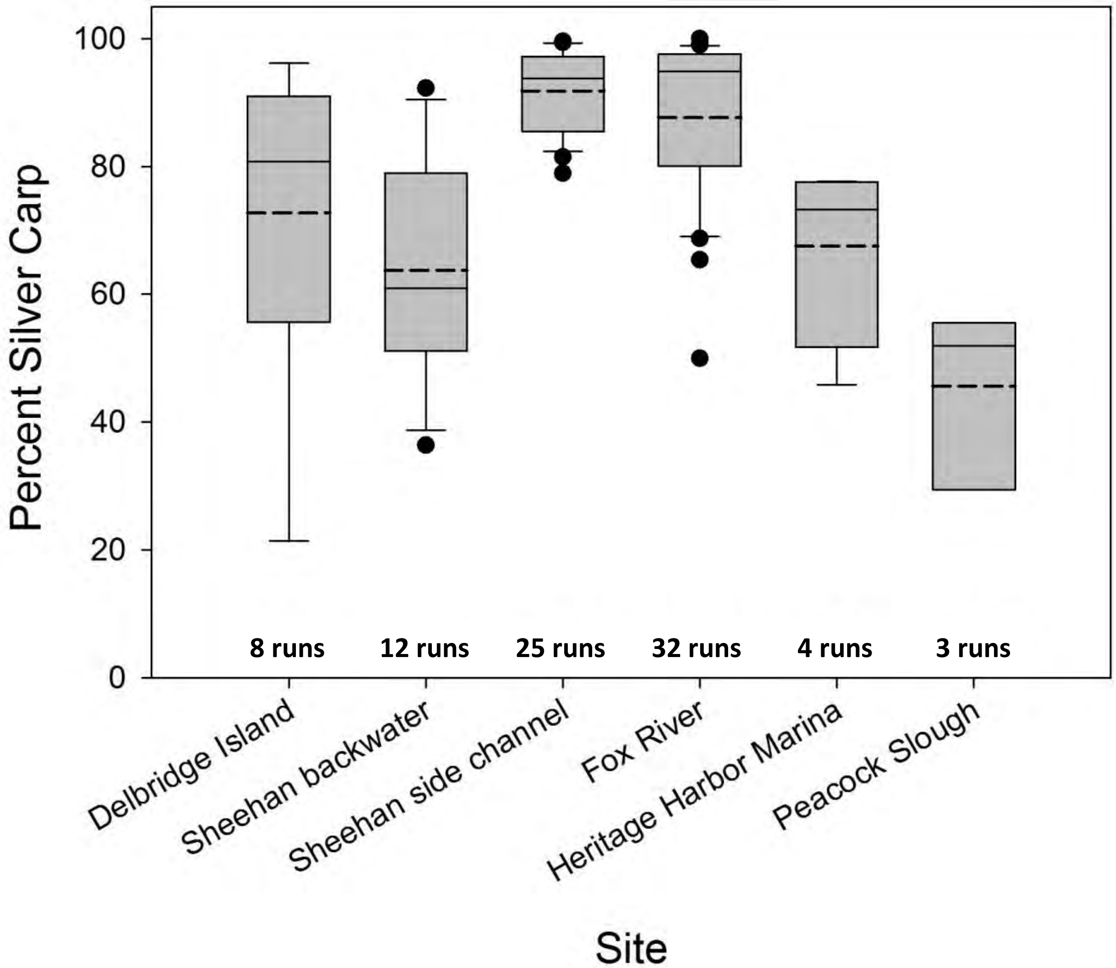

Figure 4. *Percent of electrified paupier catch that was Silver Carp by site during Barrier Defense in the Starved Rock and Marseilles pools of the upper Illinois River, May through November 2016. The horizontal dashed lines in the plot represent the mean, and the horizontal solid lines represent the 10th, 25th, median, 75th, and 90th percentiles. The number of samples at each site (n) are reported as runs.*

Sheehan Island side channel and the Fox River were targeted most often because catch rates were high and bycatch was low. Those two sites are similar in that they typically have flowing water. Such lotic habitats are difficult for gill nets to fish. Therefore, the electrified paupier continues to be an important component of Barrier Defense as it supplements commercial fishing efforts—removing a wide size range of invasive carp from a variety of habitat types of the upper Illinois River.

Recommendations:

- 29.8 tons of Asian carp were removed in 16 hours of electrofishing pedal time. Offloading catches onto a tender boat to process fish will allow for increased pedal time and removal of invasive carp.

- Cost-effectiveness of the electrified paupier as a removal tool should be evaluated in terms of Asian carp catch and expenditure of labor (Collins et al. 2015 & 2017).
- Determine the optimal diel period for mass removal with the electrified paupier. Preliminary research suggests Asian carp occupy the upper water column at night (Lamer personal communication 2017) and are then more susceptible to capture using the electrified paupier (Columbia FWCO unpublished data).

Literature Cited:

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ALTERNATIVE PATHWAY SURVEILLANCE

Alternate Pathway Surveillance in Illinois - Law Enforcement

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

Participating Agencies: Illinois Department of Natural Resources (lead)

Introduction and Need:

The IDNR Invasive Species Unit (ISU) is determined to use all available resources to prevent the spread of invasive species through intentional and non-intentional human activities. A watchful eye must be kept on the pet trade, environmental terrorism threats, live fish markets, the transportation and propagation of aquatic life, and the fishing industry. They are all potential risks for the spread of invasive species, and past cases made by the ISU demonstrate they are credible threats. Typically, violators of invasive species laws don't comply with regulations either because they don't know the regulations exist or they feel the monetary gains and personal gratification of breaking the laws outweigh the risks and/or punishment of getting caught. Enforcement of invasive species laws is necessary to educate the unknowing violator and apprehend and successfully prosecute the intentional violator to deter future unwanted behaviors. The ISU is a necessary component to the overall efforts of protecting the Great Lakes Basin and other areas from the spread of Asian carp and other invasive species. The Unit has built a strong reputation and working relationships with other agencies throughout the United States and Canada and continues to help make our environment a safer place.

Objectives:

(1) Educate field officers on invasive species regulations and enforcement techniques.
(2) Increase the Unit's ability to search for illegal sales of invasive species on the Internet.
(3) Watch for illegal sales or importation of invasive species within the bait industry.
(4) Perform commercial inspections of aquaculture facilities within Cook County, IL utilizing the aquaculture inspection operations plan developed in 2015.
(5) Conduct surveillance operations in Chinatown to develop new leads.
(6) Perform random and targeted inspections on fish trucks.
(7) Enforce regulations on aquatic life dealers who illegally operate without licenses and intentionally mislabel aquatic life.
(8) Complete training relevant towards invasive species enforcement.
(9) Represent Illinois, the IDNR, and the Invasive Species Unit at various conferences, meetings, and seminars related to invasive species enforcement.

Project Highlights:

- The ISU investigated a fish dealer in Northern Illinois who illegally imported over 600 Grass Carp from Arkansas into Illinois and stocked them in 27 different lakes and ponds. The dealer submitted falsified documents to the IDNR, and still imported the fish after his application was denied. The ISU also obtained invoices showing the dealer imported

1500 Crappie into Illinois from Missouri without the required VHS import permit. The case is currently pending with the Illinois Attorney General's Office.

- The ISU obtained business records and a confession from a Missouri fish dealer who illegally imported 1600 pounds of live Channel Catfish into Illinois from Arkansas without the required VHS import permit. The case is pending with the Illinois Attorney General's Office.
- A Kentucky bait dealer pled guilty in Federal court for selling Rusty Crayfish in Illinois and was fined $1,500. This was a result of covert investigation conducted by the ISU with the assistance of the USFWS.
- The ISU executed a search warrant on a fish processing plant and conducted a complex inventory audit of the plant records based upon allegations the fish dealer was selling Asian Carp provided by contracted IDNR commercial fishermen for human consumption instead of fertilizer in violation of the contract terms between the IDNR and the fish dealer. The investigation revealed the dealer sold over $10,500,000 in fish over a two year period without the required fish dealer's license or maintaining the proper business records; the company violated environmental regulations; the company had over 2.5 million pounds of bighead and silver carp acquisitions and disbursements unaccounted for from January 2014 – May 2016.
- ISU investigated a Kentucky fish dealer for importing and selling largemouth bass without VHS import permits or non-resident aquatic life dealer's license. The dealer imported 14,000 pounds of untested noncertified largemouth bass from a university aquaculture facility in Kentucky to Chinatown in Chicago. A tentative agreement between the company and the Illinois Attorney General's Office is for the company to pay $10,000 in restitution to the State of Illinois.
- ISU investigated a Kentucky resident for importing and selling largemouth bass without VHS import permits or a non-resident aquatic life dealer's license. A tentative agreement has been reached through the Illinois Attorney General's Office and the Kentucky fish dealer to pay $4,000 in restitution.

Methods:

The specific details of arrests, operations, and surveillance activities cannot be discussed in this document because of the necessity to keep law enforcement information confidential. Most case leads came from tips or were generated from detailed record reviews of businesses. Surveillance operations and commercial inspections were useful methods. Working relationships with other agencies and educating field officers provided additional information and resources.

Results and Discussion:

- The ISU provided training and materials for Conservation Police Officers that patrol Chicago and surrounding suburbs in the following: inspecting aquatic life dealer businesses and records; aquaculture facility inspections and generating new cases from the aquaculture records; and fish truck inspections.

Alternate Pathway Surveillance in Illinois - Law Enforcement

- The ISU sits as an advisory member on the committee of the Great Lakes Fishery Commission's efforts to develop an Internet search tool to detect aquatic invasive species for trade on the Internet. In 2016, the ISU helped test the initial version of the program and provided input to further advance the development of it. ISU is looking forward to benefits this search tool will provide for improving enforcement efforts.
- The ISU monitored several bait shops and bait deliveries to those shops in 2016. All the deliveries were from licensed and permitted bait suppliers. No bait shops were found to be selling bait without a license or illegally importing bait without the proper permits. The vast improvement in compliance is believed to be a result of 2015 efforts.
- A total of 6 aquaculture facilities were inspected in Cook County resulting in the following discoveries: a non-resident aquatic life dealer importing live Tilapia (via FedEx) into Illinois without the required aquatic life dealer's license or restricted species transportation permit; the discovery of an illegal aquaculture facility in Illinois; two aquaculture facilities operating with expired aquaculture permits; and three record keeping violations.
- Surveillance operations were conducted in Chinatown throughout the year. The ISU did not observe any illegal shipments of live fish. However, ISU learned more about specific delivery times, off-load locations, and which fish importers were distributing to what stores.
- Fish truck inspections were less frequent than in the previous year. This was mainly because of fewer encounters with unidentified fish haulers, and a heavier case load dealing with complex investigations. Most cases in 2016 were generated from tips within the aquatic life industry or from complaints.
- Enforcement efforts on aquatic life dealers resulted in 7 written warnings and 6 citations being issued to unlicensed facilities and/or to dealers for record keeping violations. Case files were distributed to field officers to investigate.
- The ISU received training and equipment from the U.S. Geological Survey for portable e-DNA testing for the presence of Bigheaded Carp in fish trucks, bait shops, and water bodies throughout the State.
- The ISU attended the Great Lakes Fishery Commission Law Enforcement Committee meetings in Wisconsin and Illinois, and the Upper Mississippi River Conservation Law Enforcement Conference.

Recommendations: Seek out new training opportunities to better the Unit. Conduct an annual review of current regulations and note any discrepancies or loop holes in the laws. Communicate with other agencies to learn from their successes and mistakes. Prioritize educating the public on invasive species.

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

Tristan Widloe, Brennan Caputo, Justin Widloe, Kevin Irons, Matthew O'Hara
(Illinois Department of Natural Resources)

Participating Agencies: Illinois Department of Natural Resources (lead); Southern Illinois University at Carbondale

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

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 Bighead Carp captures in all fishing ponds included in the IDNR Urban Fishing Program located in the Chicago Metropolitan area which revealed, at that point in time, that three additional ponds in the program had verified reports of Bighead Carp from either pond rehabilitation with piscicide or natural die offs (Columbus Park, Garfield Park, Lincoln Park South) (Table 1). One pond had reported sightings of Bighead Carp that were not confirmed by sampling (McKinley Park). The distance from Chicago area fishing ponds to Lake Michigan ranges from 0.2 to 41.4 km (0.1 to 25.7 miles). The distance from these ponds to the Chicago Area Waterway System (CAWS) upstream of the Electric Dispersal Barrier ranges from 0.02 to 23.3 km (0.01 to 14.5 miles). Although some ponds are located near Lake Michigan or the CAWS, most are isolated and have no surface water connection to the Lake or CAWS upstream of the dispersal barrier. Ponds in Gompers Park, Jackson Park, and Lincoln Park are the exceptions. The Lincoln Park South and Jackson Park lagoons are no longer potential sources of Bighead Carp because they were rehabilitated with piscicide in 2008 and 2015, respectively. Gompers Park never had a report of Asian carp, nor have any been captured or observed during past sampling events. Nevertheless, examining all urban fishing ponds close to the CAWS or Lake Michigan was 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) (Table 1).

The distance from ponds with positive eDNA detections to Lake Michigan ranges from 4.8 to 31.4 km (3 to 19.5 miles). The distance from these ponds to the CAWS upstream of the Electric Dispersal Barrier ranges from 0.05 to 7.6 km (0.03 to 4.7 miles). The lake at Harborside International Golf Course has surface water connectivity to the CAWS. However, no Asian carp have been reported, observed or captured. Though positive eDNA detections do not necessarily represent the presence of live fish (e.g., may represent live or dead fish, or result from sources other than live fish, such as DNA from the guano of piscivorous birds or boats/sampling gear utilized in Asian carp infested waters) they should be examined for the presence of live Asian carp given the proximity to CAWS waterways.

Objectives:

(1) Sample fishing ponds in the Chicago Metropolitan area included in the IDNR Urban Fishing Program as well as ponds with positive detections for Asian carp eDNA using conventional gears (electrofishing and trammel/gill nets) for the presence of Asian carp.

Project Highlights:

- Thirty-two Bighead Carp have been removed from five Chicago area ponds using electrofishing and trammel/gill nets since 2011; three of which are on display at the Shedd Aquarium in Chicago.
- Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have also been removed from Chicago area ponds since 2008.
- One Bighead Carp was incidentally caught by a fisherman in a Chicago area pond in 2016.
- Eighteen of the 21 IDNR Chicago Urban Fishing Program ponds have been sampled with nets and electrofishing.
- All eight Chicago area fishing ponds with positive Asian carp eDNA detections have been sampled with electrofishing and trammel/gill nets.

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

Methods:

Pulsed DC-electrofishing and trammel/gill nets were used to sample urban fishing ponds. Trammel and gill nets used are approximately 3 m (10 ft.) deep x 91.4 m (300 ft.) long in bar mesh sizes ranging from 88.9-108 mm (3.5-4.25 in). Electrofishing, along with pounding on boats and revving tipped up motors, are used to drive fish into the nets. Upon capture, Asian carp were removed from the pond and the length and weight was recorded. The head of each fish is then removed for age estimation and otolith microchemistry analysis by Dr. Greg Whitledge at SIUC.

Results and Discussion:

A total of 41 Bighead Carp and one Silver Carp have been removed from nine ponds (Table 1). Fifty hours of electrofishing and 11 miles of gill/trammel net were utilized to sample 24 Chicago area fishing ponds, resulting in 32 Bighead Carp removed from five ponds since 2011. Eight Bighead Carp and one Silver Carp killed by either natural die-off or pond rehabilitation with piscicide have been removed since 2008. One Bighead Carp was incidentally caught by a fisherman in 2016. The lagoons at Garfield and Humboldt Park have had Bighead Carp removed following both 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. A boat will likely need to be lowered in using a wench, which will be attempted in 2017. 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.

Alternative Pathway Surveillance in Illinois – Urban Pond Monitoring

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

Approximately 80% of the Bighead Carp otoliths examined to date exhibited a decline in Sr:Ca from high values in the otolith core (750-1,900 umol/mol; within 50-150 microns of the otolith center) to lower values (range 400-650 umol/mol) toward the edge of the otolith (mean 618 umol/mol within 50 microns of the otolith edge) (Figure 2). Mean otolith Sr:Ca of 618 umol/mol near the otolith edge is consistent with expected otolith Sr:Ca for a resident fish in these Chicago fishing ponds based on Sr:Ca of water samples taken from these sites during 2010-2012 (range 1.5-1.8 mmol/mol) and a regression relating water and Asian carp otolith Sr:Ca (Norman and Whitledge, in press). The higher Sr:Ca near the otolith core suggests these fish were transferred into the lagoons during age-0 or age-1. These data indicate that the fish spent their early life in water(s) with higher Sr:Ca and the remainder of their life as residents of the urban ponds. In addition, the otolith core Sr:Ca values are high when compared to that of

Bighead Carp of Illinois River origin as well as other sites previously examined in northern Illinois (Figure 3) (Whitledge 2009). A similar trend was observed when comparing otolith core $\delta^{18}O$ and $\delta^{13}C$ values for Bighead Carp, which showed no overlap between Chicago pond fish and Illinois River fish (Figure 4). Therefore, Bighead Carp removed from Chicago area ponds were likely not transplanted adult fish nor bait bucket introductions of juveniles from the Illinois River or other nearby rivers. In contrast, otolith core $\delta^{18}O$ and $\delta^{13}C$ values and Sr:Ca of the Silver Carp collected from Sherman Park Pond fell within the range of otolith $\delta^{18}O$ and $\delta^{13}C$ values and Sr:Ca for Illinois River fish (Figure 3 and 4). Thus, we cannot rule out the possibility that this fish may have been transported (via bait bucket or as an adult) from the Illinois River system to Sherman Park Pond. Given the size (age) of the Bighead Carp at the time of introduction its plausible that they were contaminants in shipments of desirable fish species stocked in the lagoons, likely before the State of Illinois banned transport of live Bighead Carp in 2002-2003. This corresponds to a time when Bighead Carp were raised for market in ponds with Channel Catfish in certain regions of the U.S. (Kolar et al. 2007). Shipments of Channel Catfish may be the most likely source of contamination in Illinois urban fishing ponds as catchable-sized catfish are stocked frequently and extensively in these waters throughout the State (IDNR 2010).

Recommendation:

We will investigate reports of Asian carp sightings or captures in Chicago area ponds based on photographic evidence or reports from credible sources. We will also attempt to sample Elliot Lake in 2017, which is the last remaining pond that needs to be sampled.

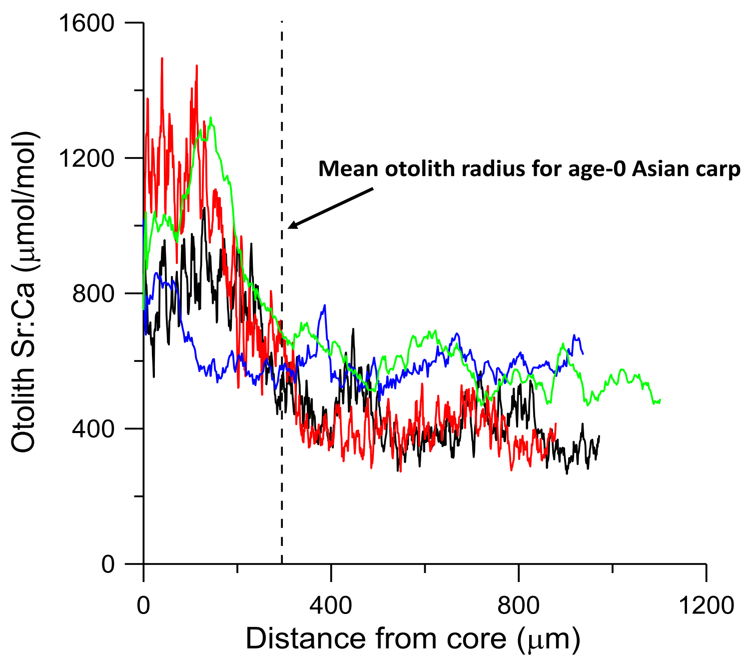

Figure 2. *Example of laser ablation transects for four Chicago pond Bighead Carp otoliths. The dashed line represents the mean otolith radius for age-0 Asian carp taken from nearby rivers.*

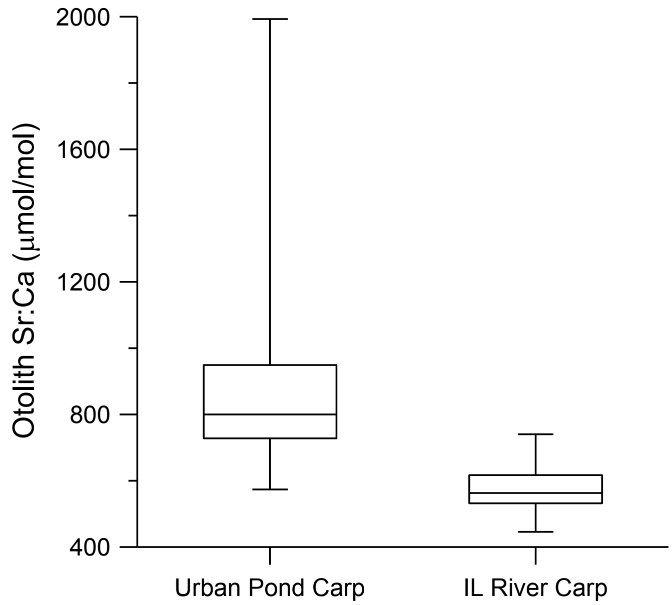

Figure 3. *Boxplots of otolith core Sr:Ca for Chicago pond (N = 24) and Illinois River (N = 81) Asian Carp. The minimum value for urban pond carp represents the Silver Carp collected from Sherman Park.*

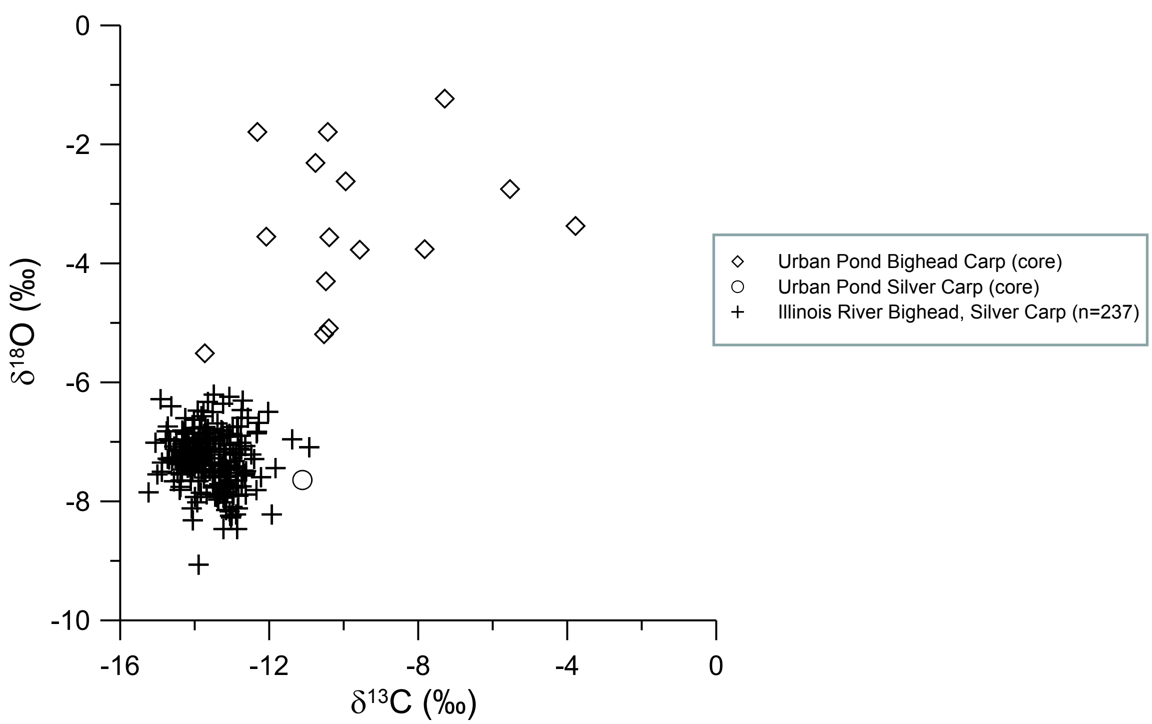

Figure 4. *Otolith Core $\delta^{18}O$ and $\delta^{13}C$ comparing Urban Pond and Illinois River Bighead and Silver Carps.*

Literature Cited

IDNR. 2010. Illinois Urban Fishing Program Division of Fisheries fiscal year 2010 annual report. Illinois Department of Natural Resources, Springfield. http://www.ifishillinois.org/programs/Urban/10URBAN_FISHING_ANNUAL_REPORT.pdf

Kolar, C. S., D. C. Chapman, W.R. Courtenay, Jr., C. M. Housel, J. D. Williams, and D. P. Jennings. 2007. Bigheaded carps: a biological synopsis and environmental risk assessment. American Fisheries Society, Special Publication 33, Bethesda, Maryland.

Whitledge, G. W. 2009. Otolith microchemistry and isotopic composition as potential indicators of fish movement between the Illinois River drainage and Lake Michigan. Journal of Great Lakes Research 35:101-106.

Table 1. *Sampling location, boat electrofishing effort (hrs.) and gill/trammel netting effort (miles), number of sampling events, number of Bighead Carp and Silver Carp collected, number of Asian carp removed following natural die-off, pond rehabilitation with rotenone or incidental take. 1 = IDNR urban fishing ponds that had positive eDNA detections, 2 = ponds with positive eDNA detections that are not IDNR urban fishing ponds, 3 = pond that is neither an IDNR urban fishing pond nor had a positive eDNA detection, * = location of the only Silver Carp collected*

	Sampling Results					
Location	Electrofishing (hrs.)	Gill/trammel netting (miles)	Sampling events (*N*)	Bighead carp (*N*)	Silver carp (*N*)	Asian carp collected post die-off, rotenone rehab or incidental take
Cermak Quarry	1.0	-	1	-	-	-
Columbus Park	0.8	0.1	1	-	-	3
Commissioners Park	0.5	0.1	1	-	-	-
Community Park	0.5	0.1	1		-	1
Douglas Park	0.8	0.2	1	-	-	-
Flatfoot Lake[1]	13.0	2.7	6	18	-	-
Garfield Park	3.6	0.1	1	2	-	1
Gompers Park	0.3	-	1	-	-	-
Harborside Golf Course Lake[2]	2.8	0.9	1	-	-	-
Horsetail Lake[2]	1.0	0.3	1	-	-	-
Humboldt Park	2.3	0.5	2	8	-	1
Jackson Park[1]	4.3	1.8	3	-	-	-
Joe's Pond [2]	0.5	0.3	1	1	-	-
Lake Owens	1.0	0.3	1	-	-	-
Lake Shermerville	1.0	0.3	1	-	-	-
Lincoln Park South	-	-	-	-	-	3
Marquette Park	1.3	0.4	1	-	-	-
McKinley Park	1.0	0.3	1	-	-	-
Powderhorn Lake[2]	2.0	0.7	1	-	-	-
Riis Park	0.2	-	1	-	-	-
Sag Quarry West[2]	0.6	0.3	1	-	-	-
Saganashkee Slough[3]	2.0	0.6	1	-	-	-
Schiller Pond	2.0	-	1	3	-	-
Sherman Park*	1.0	0.3	1	-	-	1
Tampier Lake[2]	5.5	0.6	1	-	-	-
Washington Park	1.5	0.3	1	-	-	-
Totals	50.2	11.2	33	32	0	10

APPENDICES

Des Plaines River and Overflow Monitoring

Nicholas Bloomfield (US Fish and Wildlife Service- La Crosse)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

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

Introduction and Need:

The upper Des Plaines River rises in Southeast Wisconsin and joins the Chicago Sanitary and Shipping Canal (CSSC) in the Brandon Road Pool immediately below the Lockport Lock and Dam. Asian carp have been observed in this pool up to the confluence and have free access to enter the upper Des Plaines River. In 2010 and 2011, Asian carp eDNA was detected in the upper Des Plaines River (no samples were taken in 2012-2016). It is possible that Asian carp present in the upper Des Plaines River could gain access to the CSSC upstream of the electric dispersal barrier during high water events when water flows laterally from the upper Des Plaines River into the CSSC. The construction of a physical barrier to reduce the likelihood of this movement was completed in the fall of 2010. The physical barrier was constructed by the US Army Corps of Engineers (USACE) and consists of concrete barriers and 0.25 inch mesh fencing built along 13.5 miles of the upper Des Plaines River where it runs adjacent to the CSSC. It is designed to stop adult and juvenile Asian carp from infiltrating the CSSC, although it will likely allow Asian carp eggs and fry to pass. Overtopping events in 2011 and 2013 created breaches in the fencing and allowed fish to pass. These areas and other low lying areas were reinforced with chicken wire buried in gravel and/or cement to prevent scouring during future overtopping events. It is important to understand the Asian carp population status, monitor for any potential spawning events, and determine the effectiveness of the physical barrier to help inform management decisions and direct removal actions.

Objectives:

(1) Monitor Bighead and Silver Carp and their potential spawning activities in the Des Plaines River above the confluence with the CSSC; and

(2) During high flow events when water moves laterally from the Des Plaines River into the CSSC, monitor for Bighead and Silver Carp eggs and larvae around the physical barrier and monitor the effectiveness of the barrier.

Project Highlights:

- Collected 9,696 fish representing 53 species and 3 hybrid groups from 2011-2016 via electrofishing (51.19 hours) and gill netting (134 sets; 17,584 yards).

Des Plaines River and Overflow Monitoring

- No Bighead or Silver Carp have been captured or observed through all years of sampling.
- Six Grass Carp tested since 2013 have been triploid.
- Two overtopping events since 2011 have resulted in several improvements to the barrier fence.

Methods:

In 2016, sampling was conducted in the upper Des Plaines River from Romeoville, IL upstream to the Columbia Woods area near Willow Springs, IL (Figure 1). Sampling was performed using pulsed-DC electrofishing and short term top to bottom gill net sets. Electrofishing runs included one or two dippers and proceeded for 15 minutes or until the backwater shoreline was competed. Gill net sets included 3 inch, 3.5 inch, 4 inch, 4.25 inch, and 5 inch bar mesh. Fish were driven to the nets using electrofishing boats and/or pounding. Sampling was performed in accessible backwaters using gill nets and electrofishing gear in addition to channel habitat that was accessible with electrofishing gear. All fish were identified and released.

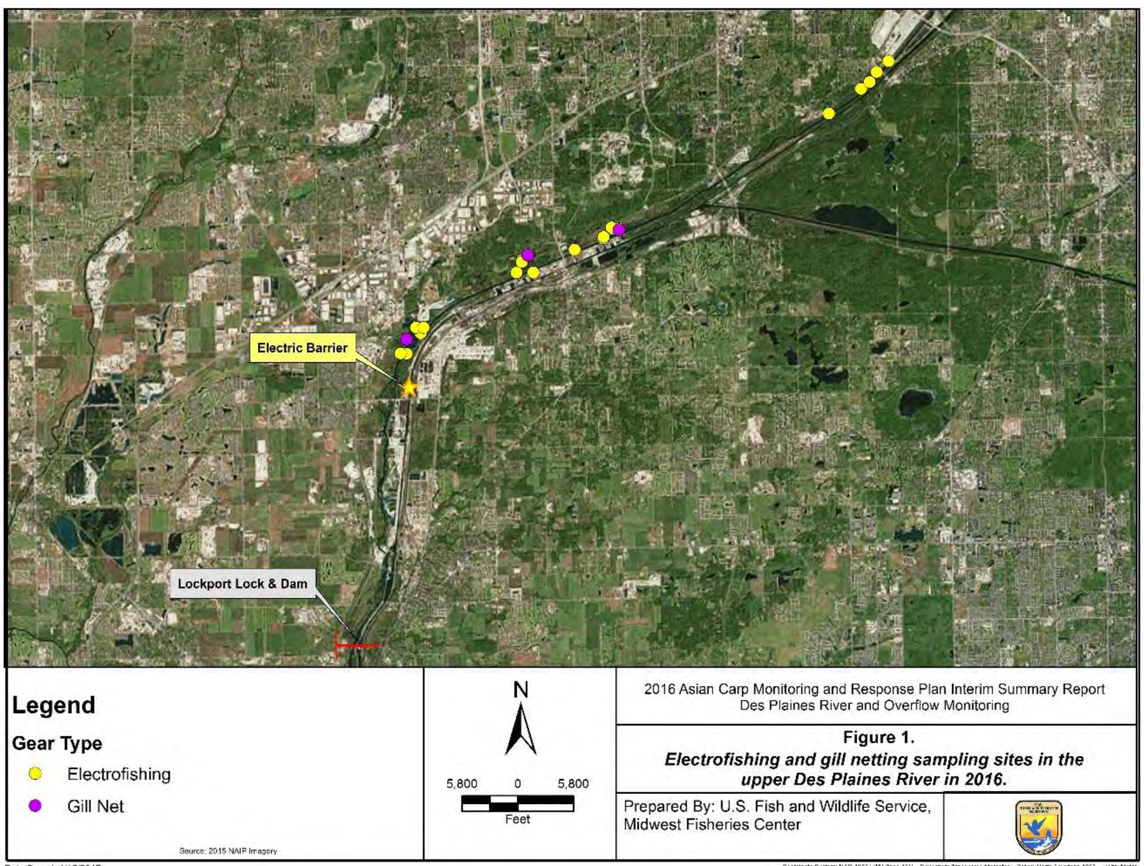

Figure 1: *Electrofishing and gill netting sampling sites in the upper Des Plaines River in 2016.*

Results and Discussion:

During the 6 years of sampling (2011-2016), 51.19 hours of electrofishing and 134 sets covering 17,584 yards of gill net resulted in a total catch of 9,696 fish. Fifty five species and three hybrid groups have been collected. Common carp have been the most commonly collected species, followed by Bluegill and Spotfin Shiner. In 2016, sampling occurred during two weeks: 3/28/16 and 10/10/16. 6.16 hours of electrofishing resulted in 1647 fish representing 36 species. 1500 yards of gill net resulted in 140 fish representing 7 species and 1 hybrid group. 2016 sampling yielded 39 species and one hybrid group overall. Backwaters and much of the channel was inaccessible during the October sampling event due to low water. No Bighead or Silver Carp have been seen or captured during the six years of sampling. Sampling over the six year period has focused on backwater areas in spring and fall which would likely target resident fish. This approach may not effectively sample for Asian carp that may only ascend the upper Des Plaines River to spawn before returning to the lower Des Plaines River. In response, sampling in 2017 will include electrofishing "float trips" during the spawning season, which will include sampling in traditionally inaccessible areas.

To date, six Grass Carp have been tested for ploidy out of seven total collections (Figure 2). All six have been determined to be triploid, or sterile. Therefore, it is likely that Grass Carp captured in the upper Des Plaines were stocked escapees as opposed to migrants from the Illinois River/lower Des Plaines River, where a diploid population exists, or from a breeding population from within the upper Des Plaines River that would include diploid fish.

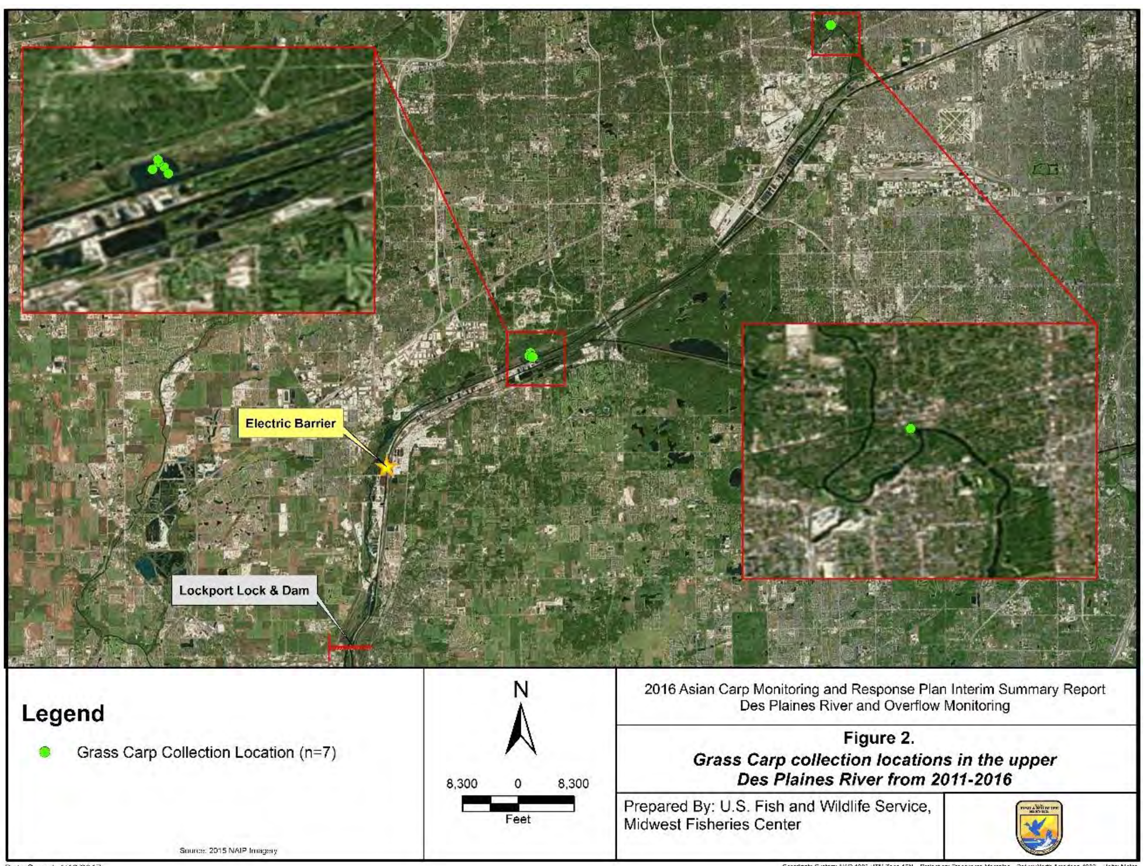

Figure 2: *Grass Carp collection locations in the Upper Des Plainest River from 2011-2016.*

Des Plaines River and Overflow Monitoring

No overtopping events, defined by water flowing laterally from the Des Plaines River to the CSSC, occurred in 2016. Previous overtopping events in 2011 and 2013 resulted in breaches of the barrier fence that have since been re-enforced.

Recommendation: Continue monitoring for adult and juvenile Bighead and Silver Carp in the upper Des Plaines River with emphasis on backwater habitat. Gill netting and electrofishing in backwater habitat will continue when accessible. Additional electrofishing during typical spawning season in channel habitat will be attempted over a larger area via “float trips”. Des Plaines River stage will continue to be monitored during heavy rainfall events and investigations of the physical barrier will be conducted, as needed, in areas where overflow has occurred.

Illinois River Small Silver Carp Telemetry

Kjetil Henderson, Cory Anderson, and Rebecca Neeley
(U.S. Fish and Wildlife Service, Carterville Fish and Wildlife Conservation Office)

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

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

Objectives:

(1) Quantify movement distance and direction of juvenile Asian carp

(2) Identify macrohabitats selection by juvenile Asian carp

(3) Determine if juvenile Asian carp movement is related to temperature or flow

Project Highlights:

- Half of the 86 tagged fish detections occurred in the main channel. This is concerning given how difficult it is to sample fish in this habitat type.
- The farthest observed movement was 19 kilometers downstream from the release site.
- Juvenile Silver Carp (*Hypophthalmichthys molitrix*) telemetry was successful (53% of tagged fish detected); this research has the potential to answer a number of management-relevant research questions (e.g., dam interactions, habitat use, and identifying environmental factors related to movement).

Methods:

Peoria Pool was classified Peoria Pool into four macrohabitat categories: main channel, island side channel, backwater, and marina. The proportion of available habitat (via surface area) was derived from digital raster graphic topographic maps obtained from the Illinois State Geological Survey, ArcMap 9.2, and U.S. Army Corps of Engineers navigation maps. Areas between the channel border and islands were classified as island side channel. Artificial backwaters dredged for boat traffic were classified as marinas.

Seventy-five juvenile Asian carp were captured using boat electrofishing near Henry, Illinois. All fish were collected from Illinois River Mile 198 to 194, with 70 of the Silver Carp being tagged on August 3rd and 4th (release sites: 41.11564°N, -89.33460°W for 23 fish on 3 August, and 41.10965°N, -89.3509°W for 57 fish on 4 August 2016). The final five fish were tagged on 31 August 2016 (release site: 41.110534°N, -89.34977°W). All tagged Asian Carp were released between Illinois River Mile 197 and 196. Fish were left in an aerated, salted tank prior to surgery, and only active fish were selected for surgery. All fish were measured for total length (mm) prior to surgery. Ultrasonic transmitters (180kHz, 0.38 g in water, 12.7 mm long, <2%; Vemco Ltd., Halifax, Nova Scotia; Model V5) were tested for recognition prior to surgery. Each transmitter provides a unique identification number when detected by the receiver. V5 transmitters had a minimum life expectancy of 113 days. Fish were placed in a hard foam jig during surgery, with a wet towel placed over the head and cool river water circulating over the gills. Transmitters, scalpels, sutures, and forceps were soaked in 70% isopropyl alcohol prior to each surgery. Scales were removed from the ventral left side of each fish anterior to the pelvic fin. A drop of betadine was placed on the affected area prior to surgery. A 1 cm incision was made in the ventral left side of the fish, anterior to the pelvic fin, taking care not to cut the inner peritoneum. Transmitters were inserted through the incision into the musculature of the body. Small nylon Oasis Brand (Mettawa, IL) non-absorbable sutures were used to place a single suture in each fish after placing the activated transmitter. Fish were placed into a small holding tank with river water until equilibrium was reestablished then promptly returned to the river.

Fish were tracked throughout the study area by boat using an omnidirectional portable hydrophone and receiver to quantify movement and habitat selection (Vemco Model VH180 Hydrophone and VR100). Transects were driven at idle speed parallel to river flow while an observer listened for tag detections. Shallow areas were tracked by conducting transects roughly 500 m apart. Four weeks were devoted to active tracking in August, and one week per month in September through October. The entire study area required three days, and was completed each week of telemetry concurrent with receiver downloads. Active tracking was conducted from Illinois River Mile 231 to 156, which encompassed the range of movement of all tagged fish.

Receivers were placed four days after the release of tagged fish. Six receivers were affixed to navigation buoys located on the perimeter of the main channel. Navigation buoy hydrophones were attached to a 4 m section of 3/16" steel cable using two screw-tighten hose clamps. The steel cable was then swaged to have a loop at the ends and attached to the buoy ribs using a 5/16" steel quick-link. Two receivers were placed at the upper (Starved Rock State Park, RM 228) and lower extent of the study area (Chillicothe Railroad Bridge, RM 182). Three hydrophones were placed between Hennepin, Goose Lake, and Chillicothe to quantify main channel passage (RM 209, RM 190, and RM 182). Sawmill Lake was selected as the study site because it is one of the furthest upstream backwaters in the pool, and juvenile Silver Carp were observed in the area. Three receivers were mounted on navigation buoys in the adjacent main channel to evaluate fish movement in and out of Sawmill Lake. Another receiver was set in Sawmill Lake proper (RM 197). The final two receivers were placed in nearby side channels (RM 196 and RM 194). Stationary receivers were downloaded weekly in August, and at least monthly in September through November.

Results and Discussion:

During the 14 week study, 40 of the 75 tagged fish were detected by active or stationary telemetry (53%). Data from 34 Silver Carp were used to quantify movement data; fish omitted from analysis were either not located during this project (n = 35), or were detected by a single receiver attached to a navigation buoy that dislodged and drifted during high water (n = 6). When combining mobile and stationary telemetry, 86 detections were used for analysis. Of these 86 detections, mobile tracking accounted for 29 tagged fish detections. All stationary receiver and active tracking detections were between Sawmill Lake (RM 198) and Chillicothe, IL (RM 181). No tagged fish were detected above Sawmill Lake during this project.

The proportion of total area by habitat type was: main channel (64.9%), backwater (33.9%), island side channel (1.1%), and marina (0.1%; Table 2). The numbers of fish detections by habitat type were: main channel (43), backwater (9), island side channel (29), and marina (5). All island side channel detections were in Henry Island side channel or the abandoned Henry Lock. All marina detections were in the Henry, IL or Lacon, IL Marinas.

The mean TL ± SE of the detected 34 tagged Silver Carp was 247 ± 5 mm (range = 208–326 mm). The largest weekly movement of a tagged fish was 1032 meters observed during the third week of August (Table 1). Weekly river discharge was lowest during the first week of August (7,581 cf/s), and increased nearly fivefold by the end of August (37,527 cf/s) before dropping. Weekly water temperature peaked the second week of August for 2016 (29° C), and dropped to 13° C by mid-November. No relationship was observed between temperature ($r = 0.09$; $P = 0.43$) or discharge ($r = 0.05$; $P = 0.54$) and weekly movement of juvenile Silver Carp.

The number of detections substantially decreased after the first few weeks of the study. Increased river flows inundated many shallow backwaters, and may have encouraged more downstream movement than would have otherwise occurred. During mid-August through mid-September high flows, detection distances were reduced from 322 meters during range testing to less than 200 meters. The farthest recorded fish movement was 19 kilometers downstream from the day 2 tagging site. The lack of detections upstream of Sawmill Lake was also surprising. Researchers generally document downstream movements immediately after tagging. It is possible that tagged fish moved upstream of Sawmill Lake, but never reached the next closest receiver located 12 miles upstream. However, fish were never observed farther upstream than Sawmill Lake with manual tracking.

Half of 86 detections were in the main channel; clearly juvenile Asian carp use these habitats with regularity. Two small island side channels represented 34% of all the detections in this study. Where available, island side channels may provide relatively stable habitat despite substantial changes in flow (compared to backwaters and main channel habitats). Five detections were recorded in the two marinas found within the study area. Successful monitoring efforts in the upper pools should sample all habitat types, particularly when marina and island side channel habitats are available.

The numerous Peoria Pool backwaters are shallow during base flow (<3–4 feet). The effective range for acoustic telemetry was substantially reduced in these backwaters, and may be more effectively sampled with radio telemetry. Dual tagging using acoustic and radio telemetry would improve shallow-water habitat coverage, increase active tracking efficiency (only 35 detections in approximately 75 hours of active tracking using acoustic telemetry), and potentially expand movement and habitat selection data valuable for monitoring programs and removal efforts.

All fish tagged were suspected to be from the 2015 year class. A few small Silver Carp were captured in Peoria Pool this field season (85–110 mm), and tagging in early spring of 2017 could enable tracking of small Asian carp (≤153 mm). Tagged fish did not appear to move in response to changes in temperature or discharge. Dual tagging could increase detection rates to the point where factors potentially affecting movement (i.e., discharge, temperature, or chlorophyll) may be quantified.

Juvenile Asian Carp telemetry is novel, and allowed us to address questions relevant to removal and monitoring efforts. Substantially smaller Asian carp could be tagged with readily available VEMCO tags, and potentially even extend past the 2% of fish dry weight guideline. Barriers and direct removals remain the primary tools for Asian carp management. Such removal and monitoring efforts could be aided by clarifying environmental factors related to movement, and advancing our understanding of habitat usage laterally and horizontally within the study system. Barrier efficacy could also be evaluated as has been researched with salmonid in the Columbia River basin.

Recommendation:

Juvenile Asian carp telemetry can answer some valuable questions related to Asian carp management and it is recommended that this approach be continued. Dual tagging with both radio and acoustic tags should be considered for future movement studies as this will provide opportunities to increase detection rates under a variety of conditions.

Table 1. *Daily movement rate and total movement range in meters for Silver Carps tagged with transmitters in Peoria Pool during August through November 2016.*

Week	Mean (SE)	Maximum	Maximum total range
8/1 - 8/7	316 (27)	343	54
8/8 - 8/14	297 (130)	638	630
8/15 - 8/21	459 (197)	1032	895
8/22 - 8/28	690	690	
8/29 - 9/4	135 (111)	245	222
9/5 - 9/11	327	327	
9/12 - 9/18			
9/19 - 9/25	214 (11)	225	22
9/26 - 10/2			
10/3 - 10/16	225	225	
10/17 - 10/23			
10/24 - 10/30			
10/31 -11/6			
11/7 - 11/14	224	224	

Table 2. *Peoria Pool proportion of total area by habitat type, and total number and percent of fish observed by habitat type.*

Habitat	Proportion of total area	Number of fish observed	Percent of fish observed
Main Channel	0.6489	43	50%
Backwater	0.3392	9	10%
Island Side Channel	0.0112	29	34%
Marina	0.0007	5	6%
Total		86	

Performance measures for Barrier Defense: Evidence from Ecosystem response of plankton and native planktivore fish that removal is effective

ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Haun R, Lederman N, Love S, DeBoer J, Zalay B, and A Casper (Illinois River Biological Station – Illinois Natural History Survey)

Participating Agencies: Illinois Natural History Survey, a division of the Prairie Research Institute

ADDITIONAL INFORMATION

- Link to mapping tool
- Link to 2017 plan

Introduction and Need:

The ultimate goal of the GLRI sponsored Barrier Defense removal of Asian carp is to prevent this invader from outcompeteing native fish for zooplankton food resources. Removal efforts of Asian carp from backwater habitats of the CAWS and upper Illinois River consistenly eliminates large amounts of carp. While the mass of Asian carp removed is one measure of performance, a second complementary measure would be to look at the response of the plankton that Asian carp feed on and the other planktivorous native fish they compete with.

Objectives:

(1) Use the response of native zooplankton and planktivorous fish to demonstrate performance of the Asian carp removal projects.

Project Highlights:

- High Asian carp harvest levels lead to significant increases all taxa/sizes of zooplankton
- Change in body condition (plumpness) of native planktivorous fish confirms that their popultions are improving

Methods:

Zooplankton: 10 backwaters located between river mile X and Y were choosen for analysis. Each backwater received a different harvest pressure from contract fishermen between July and October (recorded seperately by IL DNR staff). Zooplankton are collected with pump samples and filtered onsite; five 90L samples per backwater filtered through 55 screens for macrozooplankton and an additional five filtered through 20 micron screens for rotifers and nauplii. Identification and enumeration are done with dissecting and compound scope methods, respectively. Results were analyzed statistically using a 2-factor ANOVA of harvest intensity and month and the interaction of havest and month.

Native Planktivores (Gizzard Shad): Mean body condition of the pre-carp, transitional, and high density periods of Asian carp numbers was compared. A long-term database collected by INHS and Illinois DNR (Dingall-Johnson funded) was used for all native fish data.

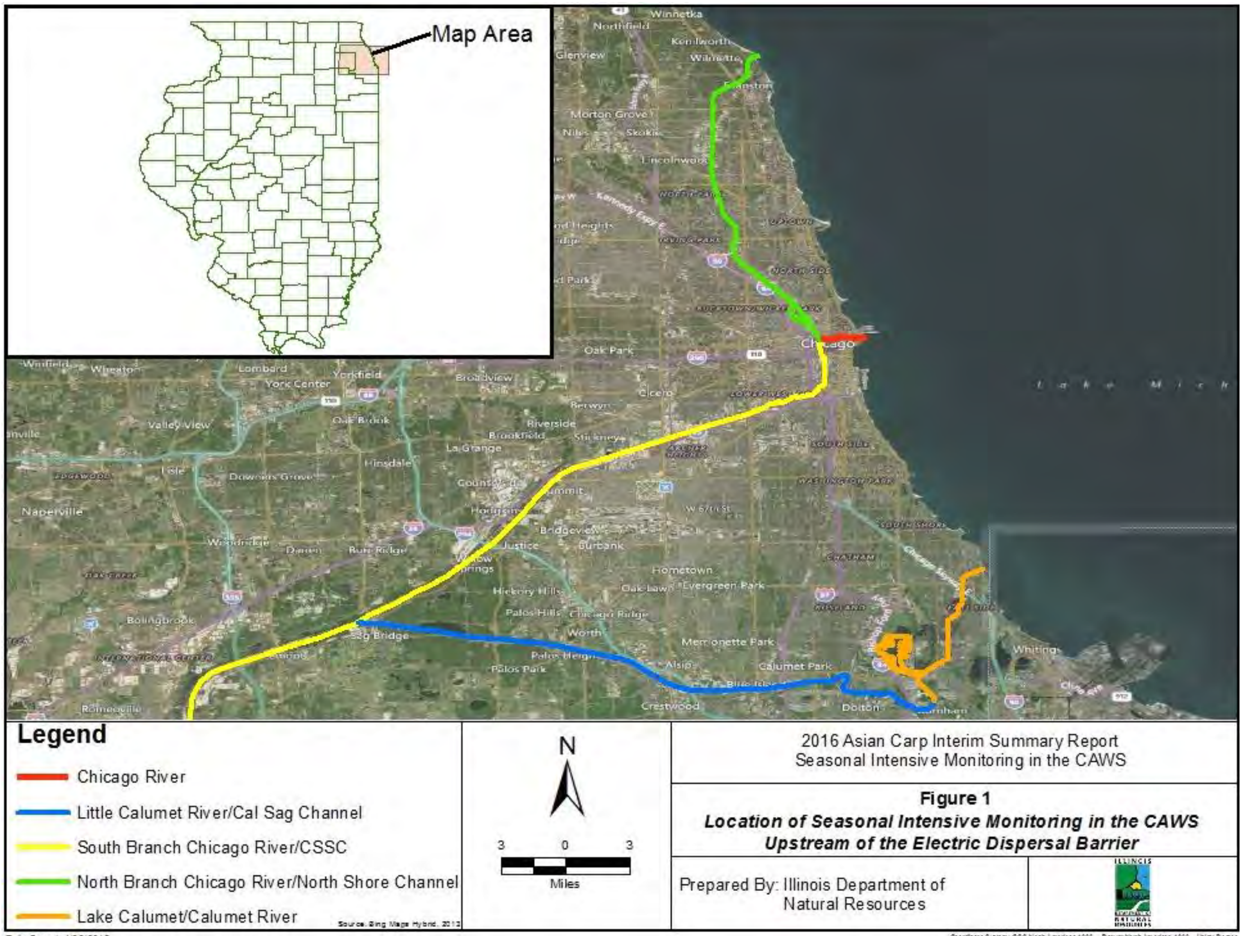

Figure 1. *Location of SIM in the CAWS upstream of the Electric Dispersal Barrier.*

Results and Discussion:

The statisitically strongest positive response for all four types of zooplankton examined was associated with high intensity harvest (Figure 2). This suggests that high levels of harvest are removing enough Asian carp to prevent the ecosystem from degrading completely.

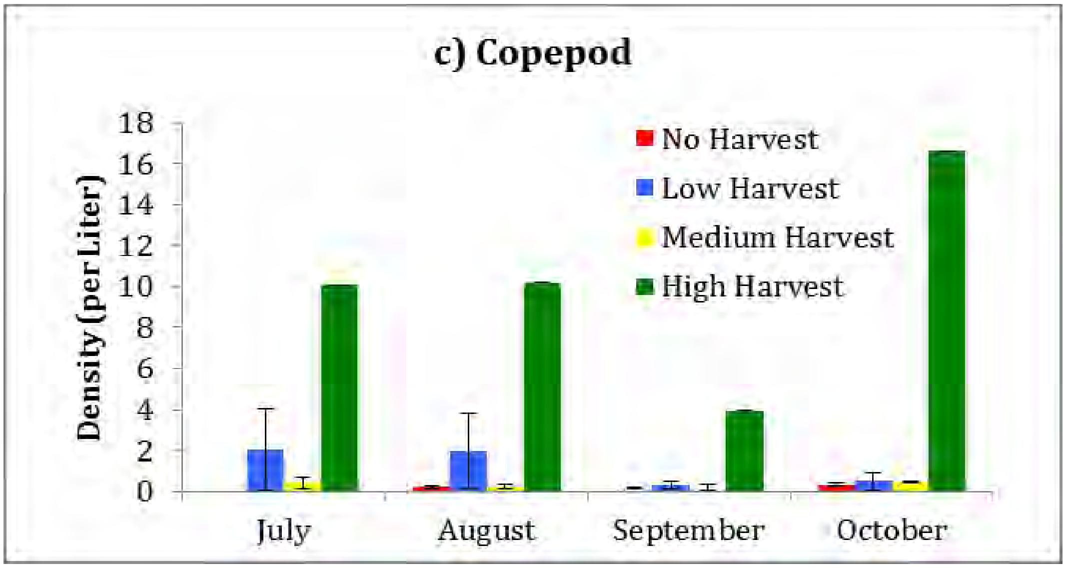

Figure 2. *Comparison of the density of Copepoda from the different harvest levels. Note: the same pattern is seen for cladocerans, nauplii, and to a lesser extent Rotifera.*

Examining the differences in the body condition of the other highly abundant planktivorous competitor for zooplankton, the Gizzard Shad (*Dorosoma cepedianum*) from the upper river (where Barrier Defense removals occur) to the lower river (where only commercial fishing occurs) suggests that removals have also had a positive effect (Figure 2).

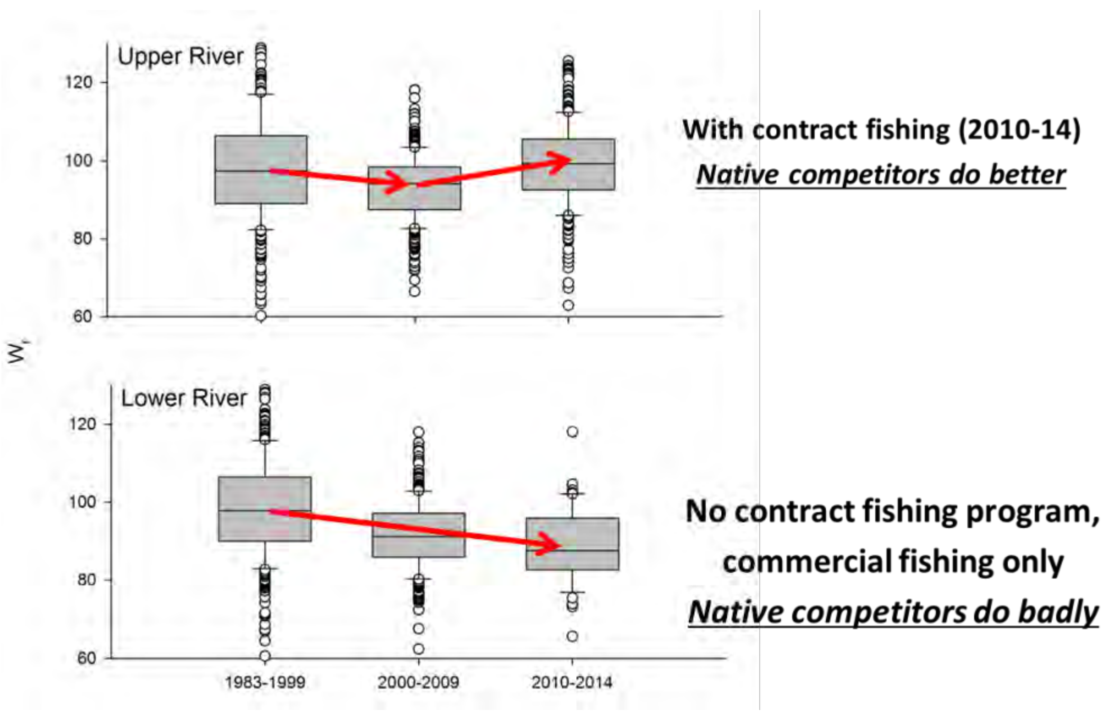

Figure 3. *Demonstrating that where Barrier Defense is active (the upper river), native planktivores body condition improves over that of native planktivores from where Barrier Defense removals do not occur.*

Recommendation:

First, we recommend that the Barrier Defense removals of Asian carp be carried out at the highest level of intensity possble. Second, we sugggest addition of other native fish-based performance measures for efficient tracking of changes in Asian carp in relation to control and management. Specifically, assesing the internanual difference in growth and condition of either larval/juvenile fish (facultative planktivores) or adult obligate planktivores like the Large mouthed buffalo should be effective and efficient.

Stress and Condition of Silver Carp in the Illinois River: Exploring the Potential for a Natural Fish Barrier

Dr. Cory Suski (University of Illinois)
Dr. Jennifer Jeffrey

Participating Agencies: University of Illinois Urbana-Champaign (lead), Illinois Department of Natural Resources

Introduction and Need:
There are a number of potential hypothesis that could explain why bigheaded carp in the Illinois River have advanced little beyond their current distribution over the past decade, despite few physical obstructions. For example, a lack of upstream movement within the Illinois River could be related to a lack of food resources within the upper reaches of the river, such that bigheaded carp cannot spread further upstream due to a lack of food and/or nutritional stress. Similarly, the upstream movement of bigheaded carp within the Illinois River may be constrainted by season, such that water temperatures in the summer may exceed the 'comfort' zone of bigheaded carp, preventing their movement as they 'choose' to remain in cooler water. Additonal factors specific to the CAWS could be preventing upstream movement. Poor water quality due to toxins from stormwater and/or sewage effluent, for example, could result in several aspects of 'stress' (e.g., oxidative stress, heavy metal stress, or general 'stress' due to habitat quality), and the distribution of animals could be confined to winter with elevated water quality. Together, there are a number of potential mechanisms by which water within CAWS itself could be acting as a barrier to prevent the upstream movement of bigheaded carp, via mechanisms such as reduced habitat quality, reduction in access to food resources or a general upregulation of 'stress'. If this is the case, it would provide a natural 'barrier' to prevent the upstream movement of bigheaded carp, and deter their movement into the Great Lakes.

Many of the biomarkers that would differentiate between these different hypotheses (i.e., biomarkers of stress vs. biomarkers of reduced condition vs. biomarkers of toxins) can be detected in tissue samples collected from animals in the field. For example, a technique known as RNA-Seq uses the capabilities of next generation sequencing to reveal a 'snapshot' of the presence and quantity of RNA, which in turn, provides a 'digital measurement' of gene expression (i.e., if a gene is 'turned on' or 'turned off' to generate RNA). Using this tool and quantifying gene activity, RNA-Seq analyses have the potential to define activity in biological pathways associated with general 'stress', oxidative stress, DNA damage, or exposure to toxins that could be preventing the movement of invasive bigheaded carp. In this way, physiological tools that assay wild-caught bigheaded carp have the potential to define mechanisms that could be contributing to the reduction in movement of bigheaded carp.

Objectives:
The overall objective of this project is to define the physiological condition and stress level of silver carp in the Illinois River. We will compare individuals at the leading edge of the invasion front with individuals from the center of the population, in an effort to define mechanisms

responsible for the lack of upstream movement of individuals. The hypothesis being tested is that upstream migration of silver carp within the Illinois/Des Plaines River (CAWS) is being deterred by reduced water quality (i.e., presence of toxins, lack of food resources), such that the water in the CAWS is acting as a 'natural' movement barrier.

Project Highlights:
Sample collection was completed in 2016 (Table 1). The initial set of fish sampling was completed in September. Two silver carp were caught and sampled for tissues (blood, brain, liver, and gill) at Rock Run Rookery, and eight silver carp were sampled at each additional sampling site (Morris, Starved Rock, and Havana), with the exception of Dresden pool. Bigheaded carp were also sampled, where possible. The second set of fish sampling was completed at the beginning of December. Three silver carp were sampled from Dresden pool, five silver carp were sampled from Rock Run Rookery, and eight silver carp were sampled at each additional sampling site (Morris, Starved Rock, and Havana). Again, bighead carp were sampled where possible.

Table 1. Number of Male and female bigheaded carp (both silver and bighead carp) collected during the 2016 sampling period (Fall: 09/01–09/14, Winter: 11/07 to 12/6)

	Silver Carp				Bighead Carp			
Location	Fall Sampling		Winter Sampling		Fall Sampling		Winter Sampling	
	M	F	M	F	M	F	M	F
Rock Run Rookery	2	0	4	1	0	0	1	2
Dresden and Kankakee	0	0	2	2	3	1	3	0
Morris East Pit	8	6	8	8	2	2	0	0
Starved Rock Pool	8	8	8	8	7	4	3	0
Havana	8	8	10	8	0	0	0	0

Due to the sampling outcomes, this study will focus on male silver carp. In addition, Rock Run Rookery and Dresden and Kankakee locations will be considered together as the leading edge of the invasion front.

To date, physiological assays are on-going. Briefly, we are focusing on blood variables that are representatitve of nutrional status (e.g., cholesterol, alkaline phosphatase), oxidative stress (e.g., total antioxidant capacity and lipid peroxidation), and overall stress (e.g., cortisol). In addition, RNA has been extracted from liver tissue and is in preparation for submission to the Roy J. Carver Biotechnology Center at the University of Illinois for RNA-sequencing. Pending results from the RNAseq, additional blood or tissue analyses may be carried out (e.g., liver metallothionein to assess metal toxicity).

Carbon Dioxide as a Barrier to the Movement of Bigheaded Carp

Dr. Cory Suski (University of Illinois)
Drs. Caleb Hasler and Jennifer Jeffrey
Kelly Hannan, Eric Schneider, John Tix

Participating Agencies: University of Illinois Urbana-Champaign (lead), Engineer Research and Development Center, U.S. Army Corps of Engineers; Upper Midwest Environmental Sciences Center, U.S. Geological Survey; Illinois Department of Natural Resources

ADDITIONAL INFORMATION

- Copies of all available peer-reviewed journal articles have been provided to IDNR

Introduction and Need:

In past studies conducted by the Suski Laboratory at the University of Illinois, Urbana-Champaign, high concentrations of dissolved carbon dioxide have resulted in the observation of avoidence by a range of freshwater fishes in both laboratory and field settings, including both Bighead and Silver Carp. In addition to the avoidence of high concentrations of carbon dioxide, physiological stress has also been observed in Asian carp. For these reasons, carbon dioxide has been considered as a potential 'tool' that could be used to control the spread of Asian carp in the Chicago Area Waterway System with the ultimate goal of preventing an invasion into the Great Lakes. Prior to the deployment of a carbon dioxide barrier, however, further experimentation was needed to define the impacts to non-target fish species (e.g., Largemouth Bass, Bluegill) and other potentially sensitive freshwater taxa (e.g., mussels). There was also a need to understand how carbon dioxide might 'behave' in flowing environments and if any differences in the avoidence response might occur, as past studies have focused on static water.

Objectives:

(1) Determine impacts of using carbon dioxide as fish barrier on (a) behavior of non-target fishes and (b) mussel physiology

(2) Characterise the efficiency of carbon dioxide in flowing water

(3) Support ongoing development of carbon dioxide as a barrier to the movements of Asian Carp

Project Highlights:

- Objective 1(a) was completed in 2016. Non-target freshwater fish behavior was generally found to be minimally impacted by exposure to elevated carbon dioxide. Some evidence suggests that the alarm cue response of fathead minnows is dampened by exposure to high carbon dioxide, but this dampening recovered following exposure to water at ambient carbon dioxide. Bluegill personality, measured as boldness and lateralization, were unchanged following exposure to high carbon dioxide. In addition, the movements of largemouth bass exposed to high carbon dioxide only differed from fish not exposed to high carbon dioxide for a few days following exposure. Lastly, largemouth bass feeding behavior remained consistent across a range of carbon dioxide exposures. Further details are provided in the following peer-reviewed journal publications:

- Midway SR, CT Hasler, T Wagner, CD Suski. In press. Predation of freshwater fish in elevated carbon dioxide environments. Marine and Freshwater Research 00:000–000.
- Tix JA, CT Hasler, C Sullivan, JD Jeffrey, CD Suski. In press. The effects of exposure to elevated carbon dioxide on behaviour in bluegill sunfish (*Lepomis macrochirus*). Journal of Fish Biology 00:000–000.
- Tix JA, CT Hasler, C Sullivan, JD Jeffrey, CD Suski. In press. Effects of elevated carbon dioxide on alarm cue responses in freshwater fishes. Aquatic Ecology 00:000–000.
- Hasler CT, SR Midway, JD Jeffrey, JA Tix, C Sullivan, CD Suski. 2016. Exposure to elevated pCO_2 alters post-treatment diel movement patterns of largemouth bass over short time-scales. Freshwater Biology 61:1590–1600.

- Objective 1(b) was completed in 2016, though some laboratory analyses are on-going and will be completed early in 2017. Overall, multiple species of local mussel species were found to exhibit physiological disturbances during and after exposure to CO_2 levels similar to what could potentially be used as a barrier to fish movement. In particular cases, the physiological disturbance was transient and indicators of recovery were observed. Adults and juveniles were both tested, as well as a range of conditions including acute, fluctuating, and chronic exposure to high pCO_2. Several more manuscripts are being prepared that investigate the possiblity of interaction effects between high temperature and high pCO_2, as well as determine gene expression and protein synthesis following exposure to high pCO_2. Further details are provided in the following peer-reviewed journal publications:
  - Hasler CT, KD Hannan, JD, Jeffrey, CD Suski. In review. Valve gaping behaviour of three species of freshwater mussels exposed to elevated carbon dioxide. Journal of Experimental Biology. Submitted November 2016.
  - Hannan KD, JD Jeffrey, CT Hasler, CD Suski. In press. The physiological resposnes of three species of unionid mussels to intermittent exposure to elevated carbon dioxide. Conservation Physiology 00:000–000.
  - Jeffrey, JD, KD, Hannan, CT Hasler, CD Suski. In press. Response to elevated CO_2 exposure in a freshwater mussel, *Fusconaia flava*. Journal of Comparative Physiology-B 00:000–000.
  - Hannan KD, JD Jeffrey, CT Hasler, CD Suski. 2016. The response of two species of unionid mussels to extended exposure to elevated levels of carbon dioxide. Comparative Biochemistry and Physiology-A 201:173–181.
  - Hannan KD, JD Jeffrey, CT Hasler, CD Suski 2016. Physiological effects of short- and long-term exposure to elevated carbon dioxide on a freshwater mussel, *Fusconaia flava*. Canadian Journal of Fisheries and Aquatic Sciences 73:1538–1546.

Carbon Dioxide as a Barrier to the Movement of Bigheaded Carp

- **Objective 2.** Work aimed at understanding the efficiency of CO_2 as a barrier in flowingwater is currently ongoing and initial studies are expected to be finished in Spring 2017. To date, the Suski Lab has visited the Cognitive Ecology and Ecohydraulics Laboratory in the Engineer Research and Development Center (ERDC) at Vicksburg, MS to complete a study designed to understand how bighead carp respond to high concentrations of dissolved carbon dioxide in flowing water environemnts. The study used a large custom-built flume where we successfully increased pCO_2 levels to over 200,000 µatm and monitored the response of small Bighead Carp to the CO_2 plume as it moved aroudn the flume. Data for this project are currently being analyzed and will be shared in Spring 2017. Furthermore, small scale studies designed to understand fish swimming behaviour and activity patterns in flowing water enriched with carbon dioxide have also been undertaken at the Suski Labortory. Again, data for this project are currently being analyzed and will be shared in Spring 2017.
- **Objective 3.** Work associated with the devlopment of dissolved carbon dioxide as a barrier to fish movement has focused on attaining suitable levels of carbon dioxide in flowing water. As part of this, the Suski Laboratory in collaboration with the Upper Midwest Environmental Sciences Center (UMESC) have undertaken preliminary experiments to explore how carbon dioxides dissipate downstream of injection points, and have attemted, led by UMESC, to reach high levels of carbon dioxide in the Emiquon spillway off of the Illinois River. Briefly, dissolved carbon dioxide off-gasses as water flows away from the injection point, and high levels (likely levels suitable to induce avoidence resposnes in bigheaded carp) can be generated.